OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL COVER SHEET
Complete Only Applicable Items

1. QA: QA

2. ☒ Analysis — Check all that apply		3. ☐ Model — Check all that apply	
Type of Analysis	☐ Engineering ☒ Performance Assessment ☐ Scientific	Type of Model	☐ Conceptual Model ☐ Abstraction Model ☐ Mathematical Model ☐ System Model ☐ Process Model
Intended Use of Analysis	☐ Input to Calculation ☒ Input to another Analysis or Model ☒ Input to Technical Document ☒ Input to other Technical Products	Intended Use of Model	☐ Input to Calculation ☐ Input to another Model or Analysis ☐ Input to Technical Document ☐ Input to other Technical Products
Describe use: Abstraction of in-drift thermodynamic environment such as temperature and relative humidity and percolation flux in the near-field host rock.		Describe use:	

4. Title:
Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux

5. Document Identifier (including Rev. No. and Change No., if applicable):
ANL-EBS-HS-000003 Rev 00

6. Total Attachments:
3

7. Attachment Numbers - No. of Pages in Each:
Attachment I – 39, Attachment II – 4, Attachment III – 7

		Printed Name	Signature	Date
8.	Originators	Nicholas D. Francis	Nicholas D. Francis	04/03/00
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11.	Responsible Manager	Clifford K. Ho	Clifford K. Ho	4/6/00

12. Remarks: Input Transmittals for CKHo 4/6/00
The AMR references ^ AMRs currently being developed.
Nicholas Francis is responsible for sections 1. through 5., 6.1, portions of 6.2, portions of 6.3.7, section 7., section 8., Attachment I.
Michael T. Itamura is responsible for portions of section 6.2, section 6.3, and Attachments II and III.
Michael L. Wilson also contributed to this analysis (section 6.2).

Per Section 5.5.6 of AP-3.10Q, the responsible manager has determined that the subject AMR is not subject to AP-2.14Q review because the analysis does not affect a discipline or area other than the originating organization (Performance Assessment). The upstream supplier for this AMR was Tom Buscheck (LLNL), and he worked closely with the originator in the development of the subject AMR to ensure that the inputs were used properly. Additionally, the originators of this abstraction AMR also worked closely in the development of the process models themselves. The downstream user of the information resulting from this AMR is Performance Assessment (PA), which is also the originating organization of this work. PA leads, such as Mike Wilson, have worked closely with the originator during the development of this AMR. Nevertheless, both the upstream supplier and downstream customers were given the opportunity to provide informal comments on draft copies and to request a formal review if desired. However, it was determined that this analysis does not directly affect other organizations other than the originating organization. Therefore, no formal AP-2.14Q reviews were requested or determined to be necessary.

NMSS07

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL REVISION RECORD

Complete Only Applicable Items

2. Analysis or Model Title:

Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux

3. Document Identifier (including Rev. No. and Change No., if applicable):

ANL-EBS-HS-000003 Rev 00

4. Revision/Change No.	5. Description of Revision/Change
Rev 00	Initial Issue

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This contractor document was prepared for the U.S. Department of Energy (DOE), but has not undergone programmatic, policy, or publication review, and is provided for information only. The document provides preliminary information that may change based on new information or analysis, and represents a conservative treatment of parameters and assumptions to be used specifically for Total System Performance Assessment analyses. The document is a preliminary lower level contractor document and is not intended for publication or wide distribution.

Although this document has undergone technical reviews at the contractor organization, it has not undergone a DOE policy review. Therefore, the views and opinions of authors expressed may not state or reflect those of the DOE. However, in the interest of the rapid transfer of information, we are providing this document for your information per your request.

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TABLES

1. PURPOSE

The purpose of this analysis and model report (AMR) is to provide abstraction of the process-level thermal hydrology (TH) model that characterizes the in-drift thermodynamic environment. Specifically, this AMR details the abstraction of the multiscale TH model described in CRWMS M&O 2000a Sections 6.1 through 6.6. The multiscale TH model describes how repository heating effects the engineered barrier system (EBS) as well as the near-field environment (NFE) host rock. Subsequently, it provides a description of the how the temperature changes in the engineered materials and host rock, the magnitude and direction of liquid and gas phase flows (in the EBS and NFE), and how corrosive the emplacement drift environment is (e.g., by providing an estimate of the temporal variability of the relative humidity (RH) near the drip shield and waste package). The abstraction characterized by this AMR provides a simplified view of the process-level description and the data that is fed into the total system performance assessment (TSPA) model. The TSPA TH data feed will require development of appropriately averaged quantities of temperature, liquid saturation, relative humidity, evaporation rate, and percolation flux. It will also require converting certain raw values (from the process-level model) into other physical quantities: a simple example is changing the liquid water velocity (in mm/yr) in the invert to a volume flow rate (m^3/yr) in the invert by multiplying the velocity by the appropriate flow area. In addition, the maximum and minimum temperature waste packages will be identified. Finally, the process-level model "raw" output will be rewritten into a format that is readily input into the TSPA model. It is noted that the abstraction of TH data must be able to characterize the potential variability and uncertainty in the thermal hydrologic system. Therefore, the abstraction AMR will provide not only a qualitative and quantitative description of the potential TH variability (e.g., host rock waste emplacement, edge proximity, waste type, spatial infiltration rate variability, and climate state), it will also provide an assessment of the uncertainty of the TH data based on different infiltration rate characterizations and property sets (e.g., corresponding to the low, mean, and high flux maps). This is addressed in the analysis section of this AMR.

The abstracted quantities used by TSPA will be based on a division of the repository by a specified method developed to preserve and highlight the variability and uncertainty in the TH system. In the viability assessment TSPA (CRWMS M&O 1998a, Chapter 3, Figure 3-52), this was done by subdividing the repository into six spatial regions based roughly on areas that contain similar infiltration rates that encompassed the footprint of the potential repository. Abstracted data similar to that described above were based on these six subregions. The current AMR specifies the subdivision of the repository footprint by glacial infiltration rate instead of repository subregion. For this methodology, any number of infiltration rate ranges (e.g., 0 – 3, 3-10 mm/yr, … , ranges) can be defined. The definition of the infiltration rate ranges (or "bins") will provide the basis for abstraction such that each of the abstraction quantities will be averaged based on an appropriate infiltration rate range. As an example, consider that for a given infiltration rate bin, 100 out of 623 total waste package locations fall within the infiltration range specified for a bin. A set of TH abstractions for this bin will be based on the TH characteristics of those 100 waste package locations. In order to assemble all relevant TH data that belongs in an particular infiltration bin, a procedure is developed to sort the process-level TH results driven by the local glacial infiltration rate data that had been implemented as variable boundary conditions in the multiscale TH model.

All of the abstraction quantities described above will be computed (or reformatted) using a software routine developed for this AMR. The routine has the capability to, based on infiltration rate binning requirements, accept input commands, and create the abstracted data file used for input into the TSPA model on a per bin basis. That is, the averaged quantities (e.g., waste package RH), maximum/minimum waste package surface temperature, and reformatted raw data will be computed (or abstracted) by the routine for each of the infiltration bins as defined by TSPA.

Finally, the abstracted TH data used by the TSPA model will be analyzed in this AMR for trends and possible indicators of potential repository performance. In particular, analysis of the resulting time-histories of temperature, liquid saturation, percolation flux, evaporation rates, and maximum and minimum waste package surface temperatures will be considered, for each infiltration bin, for both EBS materials and NFE host rock. This abstraction AMR is for a repository design that includes backfill emplacement at the time of repository closure (CRWMS M&O 2000a, Section 4.1.1.5 through 4.1.1.8).

Caveats and Limitations

The caveats and limitations associated with this AMR primarily stem from the assumptions made in CRWMS M&O 2000a, Sections 5.1 through 5.6, since any assumption applied to the process model also apply to the TH abstraction as well. In addition, the abstraction itself will create averaged data that may be based on a large number of waste package results. In cases where the average values may hide the variability of the data (e.g., an average waste package surface temperature for an infiltration bin that may contain hundreds of waste packages), maximum and minimum quantities will also be abstracted in order that an appropriate range of variability will be captured in this AMR for the TSPA model.

Ultimately, the purpose of the AMR is to provide an abstraction of the TH processes in the engineered barrier system and the near-field environment host rock. It will provide an assessment of potential TH variability and uncertainty. This abstracted data will be used by the TSPA model to compute waste package and drip shield corrosion rates, in-drift geochemical environment, and the transport of radionuclides out of the EBS. The abstraction analysis for this AMR is outlined in detail in the development plan, TDP-EBS-HS-000003, (CRWMS M&O 1999a).

2. QUALITY ASSURANCE

This analysis was prepared in accordance with the Civilian Radioactive Waste Management System (CRWMS) Quality Assurance program. The performance assessment operations (PAO) responsible manager has evaluated this activity in accordance with QAP-2-0, *Conduct of Activities*. The QAP-2-0 activity evaluation (CRWMS M&O 1999b) determined that the development of this analysis is subject to the requirements in the *Quality Assurance Requirements and Description* (DOE 2000). The analysis was conducted and this report developed in accordance with AP-3.10Q, *Analyses and Models*. According to procedures QAP-2-3, *Classification of Permanent Items*, and NLP-2-0, *Determination of Importance Evaluations*, quality level of permanent items or the determination of importance evaluation do not apply to this abstraction AMR.

3. COMPUTER SOFTWARE AND MODEL USAGE

The software routines developed for and applied in this abstraction AMR are listed in Table 1. The routines are developed and used in this abstraction AMR in accordance with Section 5.1.1 (option 1) in the administrative procedure, AP-SI.1Q, *Software Management*. The software routines are developed using SUN OS FORTRAN 77 SC4.2. The software routines provide the correct results for the specified range of input parameters as shown in the figures given in the Section 6.1 of this AMR. The documentation of these routines is included both in this technical product (e.g., Attachments I-III), and in the data submittal (to the technical data management system, TDMS).

Table 1. Software Routine Usage

Software Routine Name	Version	Data Tracking Number (DTN)	Computer Platform
TH-msmabs_ver_1	1.0	DTN: SN0001T0872799.006	SUN w/ UNIX OS
maxtwp	1.00, 1.01, 1.02	DTN: SN0001T0872799.006	SUN w/ UNIX OS
pillart	1.00	DTN: SN0001T0872799.006	SUN w/ UNIX OS

NOTE: The software routine source code used in this AMR is identified and included in the data submittal DTN listed in the table.

Additionally, Microsoft Excel 97 is used to graphically display the results and comparisons contained within this abstraction AMR. Commercially available software for spreadsheets and visual display graphics programs, which do not have additional applications developed using them, are not subject to software quality assurance requirements per Section 2.1 of AP-SI.1Q, *Software Management*. Models were not developed or used in this development of this AMR. Output results from upstream thermal hydrology process models are used as inputs in this AMR as listed in Table 2.

4. INPUTS

The inputs to this abstraction AMR are results from the process-level models described in CRWMS M&O 2000a, Section 6. The abstraction and comparative analysis inputs are summarized in Table 2.

Table 2. Analysis Inputs

Title	DTN	Status	Description
Multiscale Thermohydrologic Model Results (with backfill) CRWMS M&O 2000a	Low infiltration flux case: LL000113904242.089 Mean infiltration flux case: LL000114004242.090 High infiltration flux case: LL000114104242.091 Input file names: csnf_xA_yB_data, hlw_xA_yB_data	All Data NQ; Input Data Submitted to TDMS on January 28, 2000	In-drift thermodynamic environment (refer to Table 3 below) from the process-level model results for low, mean, and high infiltration flux cases.

NOTE: The wild cards A, B in the input file names represent numbered locations for different repository footprint locations. An example of this is csnf_x23_y19_data which approximately represents repository easting coordinate location 171,221m and northing coordinate location 234,098m. There are 623 csnf files and 623 hlw files per infiltration flux case. Input file headers in both csnf_xA_yB_data, hlw_xA_yB_data include repository footprint location and glacial transition climate state infiltration rate (used in Figures 18, 19, and 20).

4.1 DATA AND PARAMETERS

The input data for this AMR are listed in Table 2. The input data (applied directly into the abstraction routine developed for this AMR) are the process-level model results from the multiscale TH model (CRWMS M&O 2000a). Each of the data inputs along with their subsequent usage in this comparative analysis are described in detail in Section 6.0 of this AMR. It is re-emphasized that this AMR is an abstraction of process-level data along with a comparative analysis. Therefore, the data inputs are typically few since they are limited to the results of the appropriate process-level models.

4.2 CRITERIA

Standard requirements are specified in AP-3.10Q (*Analyses and Models*) regarding the documentation, review, and records. In addition, the Engineered Barrier System Process Model Report and the TSPA-SR may use the results of this analysis. These two reports have specific criteria as follows:

The U.S. Nuclear Regulatory Commission's (NRC's) Total System Performance Assessment and Integration (TSPA&I) Issue Resolution Status Report (IRSR) (NRC 1998) establishes generic technical acceptance criteria considered by the NRC staff to be essential to a defensible, transparent, and comprehensive assessment methodology for the repository system. These regulatory acceptance criteria address five fundamental elements of the U.S. Department of Energy (DOE) TSPA model for the Yucca Mountain site, namely:

1. Data and model justification (focusing on sufficiency of data to support the conceptual basis of the process model and abstractions);

2. Data uncertainty and verification (focusing on technical basis for bounding assumptions and statistical representations of uncertainties and parameter variabilities);

3. Model uncertainty (focusing on alternative conceptual models consistent with available site data);

4. Model verification (focusing on testing of model abstractions using detailed process-level models and empirical observations); and

5. Integration (focusing on appropriate and consistent coupling of model abstractions).

4.3 CODES AND STANDARDS

No specific formally established standards have been identified as applying to this analysis activity.

This AMR was prepared to comply with the DOE interim guidance (Dyer 1999) which directs the use of proposed NRC high-level waste rule, 10 CFR Part 63. Relevant requirements for performance assessment from Section 114 of that document are: "Any performance assessment used to demonstrate compliance with Sec. 113(b) shall: (a) Include data related to the geology, hydrology, and geochemistry ... used to define parameters and conceptual models used in the assessment. (b) Account for uncertainties and variabilities in parameter values and provide the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. ... (g) Provide the technical basis for the models used in the performance assessment such as comparisons made with outputs of detailed process-level models ... ."

5. ASSUMPTIONS

The standard working assumptions for the TH process-level model detailed in CRWMS M&O 2000a (Sections 5.1 through 5.6, and each of the subsections) also apply to the abstraction AMR as well. There are no critical assumptions contained within the process model documentation that need additional confirmation in the abstraction AMR. The details of the assumptions given in the above document will not be repeated here. Additional assumptions applied directly to the TH abstraction analysis are the following.

5.1 TH ABSTRACTION

The abstraction results can, in theory, be computed for any number of infiltration rate bins defined over the entire range of infiltration rate variability/uncertainty. The range of infiltration rate uncertainty considered in the TH process-level model, and subsequently its abstraction, is captured in the local percolation flux as well as the low, mean, and high infiltration flux cases (described in CRWMS M&O 2000a, Table 5-3).

5.1.1 Infiltration Rate Bin Ranges

It is assumed in this AMR that the same (variable) infiltration rate bin definitions can be applied to each of the three infiltration rate cases (low, mean, and high) considered in the multiscale TH model. With this assumption, consistent comparisons can be made across the entire range of infiltration uncertainty. The infiltration rate bins used in each case of the TH abstraction are defined as the following:

- 0 – 3 mm/yr
- 3 – 10 mm/yr
- 10 – 20 mm/yr
- 20 – 60 mm/yr
- 60+ mm/yr

This assumption is applied in Section 6.2 of the current AMR. The basis for this assumption is a result of the seepage abstraction which showed that certain ranges in percolation flux would result in different seepage rates. More detail is found in Section 6.2.

5.1.2 Infiltration Rate Bin Basis

It is assumed that the five binning ranges given in Section 5.1.1, and hence the basis of the abstraction itself, is applied to the infiltration rate for the glacial transition period of the future climate state. That is, the TH abstraction is based on the infiltration rate of the climate state that is in force in the process-level TH model from 2×10^3 years to 10^6 years of simulation time. This assumption is applied in Section 6.2 of this AMR. The basis for this assumption is that the infiltration flux that is used in the model will be from the glacial transition climate during the time that radionuclide transport is important to dose.

5.1.3 Conversion Assumptions

The evaporation rates given in kg/yr can be converted to volume flow rates using a constant water density of 1000 kg/m^3. This assumption removes a subtle dependence of the liquid water density on temperature. This is used in Section 6.1 of this AMR. The basis for this assumption is that the density changes by only 4% from 27°C to 100°C.

6. ANALYSIS

The analysis section of the TH abstraction AMR is summarized as the following. In Section 6.1, the development of the TH abstraction routine is described. This section will provide the details of the routine itself including the inputs required, the calculations performed, the printing specifications, and any raw data reformatting/extracting necessary for input into the TSPA model. This section also discusses the averaged quantities necessary for the TSPA model. Section 6.2 describes the abstraction itself including the selection of the infiltration bins. This section will display the resulting subdivison of the repository footprint by infiltration bin for each of the three infiltration flux cases considered in the abstraction (low, mean, and high). Section 6.3 describes the details of a comparative analysis of the TH abstraction data applied in the TSPA model.

6.1 TH ABSTRACTION ROUTINE

The main abstraction routine computes/assembles the abstracted TH data in a format required by the TSPA model. The routine input calls for the number of infiltration bins (ninf = 5, refer to Section 5.1.1) and the bin ranges (refer to Section 5.1.1). The primary TH abstraction routine (see Attachment I for complete source code methods) then reads the raw input files (from DTN: LL000113904242.089, LL000114004242.090, LL000114104242.091, Table 2) and sorts them into the predefined infiltration rate bins based on the infiltration rate during the glacial transition (see Section 5.1.2) future climate state (for waste emplacement times greater than 2000 years). Each raw data file is assigned to an infiltration bin where it is processed/reformatted into the TSPA model data files. Each "raw" location data file (contained within an infiltration bin) represents the conditions that would be associated either a commercial spent nuclear fuel (CSNF) waste package or a defense high-level (HLW) waste package located at its specified northing or easting coordinate (e.g., the location specifically within the repository footprint). The sum of the areas associated with the waste package locations in a particular infiltration rate bin (e.g., each waste package location file contains an area weighting factor which results in the area of the repository represented by that location) result in the total repository area represented by that bin. Due to the nature of the multiscale TH model grids, each waste package does not represent the same sized area.

Therefore, the first set of data required by the TSPA model is taken directly from the raw data files of the results of the multiscale TH model (refer to Table 2 for file names used as abstraction inputs) and reformatted for TSPA uses. For example, a single file contains a set of time-histories for each waste package location in a particular infiltration bin. The data is unchanged from the process model results with the possible exception of unit conversion. A maximum of five files per infiltration case are generated. The raw process model values used directly in the TSPA model are listed in the Table 3 below.

Table 3. TSPA Inputs Directly from Multiscale TH Model Data

TH Variable Used in the TSPA Model	Abstraction Routine Variable Name
Time (year)	timeyr (*j*)
Waste package surface temperature (°C)	T_wp(*i,j*)
Drip shield temperature (°C)	T_ds(*i,j*)
Drift wall temperature (°C)	T_dw(*i,j*)
Invert temperature (°C)	T_inv(*i,j*)
Waste package relative humidity	RH_wp(*i,j*)
Drip shield relative humidity	RH_ds(*i,j*)
Drift wall relative humidity	RH_dw(*i,j*)
Backfill relative humidity	RH_bfp(*i,j*)
Invert relative humidity	RH_inv(*i,j*)
Drip shield liquid saturation	Sl_ds(*i,j*)
Invert liquid saturation	Sl_inv(*i,j*)
Drip shield air mass fraction	xa_ds(*i,j*)
Drift wall water vapor flux (kg/yr/m of drift)	qw_dw(*i,j*)
Drift wall air flux (kg/yr/m of drift)	qa_dw(*i,j*)
Top of drip shield evaporation rate[a] (m^3/yr/m-drift)	qvpdsT(*i,j*)/rho
Backfill evaporation rate[a] (m^3/yr/m-drift)	qvpbfp(*i,j*)/rho
Invert evaporation rate[a] (m^3/yr/ m-drift)	qvpinv(*i,j*)/rho
Percolation flux at 5 m above drift crown (mm/yr)	ql_5m(*i,j*)
Percolation flux at 3 m above drift crown (mm/yr)	ql_3m(*i,j*)
Volume flow rate at top of drip shield[b] (m^3/yr/m-drift)	ql_dsT(*i,j*)*(a_dsT/1000.)
Volume flow rate at invert[c] (m^3/yr/m-drift)	ql_inv(*i,j*)*(a_inv/1000.)
Top of drip shield temperature (°C)	Tdstop(*i,j*)

NOTES: a. Converted from kg/yr by dividing by 1000 kg/m^3 (assumption 5.1.3).
b. Converted from mm/yr by (0.57m^2/1000).
c. Converted from mm/yr by (0.92m^2/1000).
i = The number of location entries in an infiltration bin (*i* varies, see Table 5).
j = The time point (maximum possible = 442 time points for low, 352 mean, and 457 high—this number is changed in the parameter statement of the software routine TH-msmabs_ver_1 and re-compiled).

It is noted that dummy values are given in the raw data when the variable has no meaning (e.g., there can be no drip shield temperature or relative humidity during the repository preclosure period before the dripshield has been installed) and have been set to –99.9. These values are not used by the TSPA model.

In addition to the raw data indicated in Table 3, the TSPA model requires infiltration bin averaged quantities for the transport model and the in-drift geochemical models. The averaged quantities are based on the location specific data contained within an infiltration rate bin. The average quantity (e.g., waste package surface temperature) is based on the sum of all the area factors (f_i) contained within the infiltration bin. That is, the relative weight of a specific location contained within a particular infiltration bin (including all of its entries) is given by:

$$f_{avg-i} = \frac{f_i}{\sum_{bin-i} f_i} \qquad \text{(Eq. 1)}$$

and the average is computed as the following:

$$X_{avg}(j) = \sum_{bin-i} f_{avg-i} X_i(j) \quad \text{(Eq. 2)}$$

where X_{avg} is an average quantity, X is its raw value, and i and j are as defined in Table 3 above. Equations 1 and 2 are computed separately for each predefined infiltration bin. The values of X used in the TSPA model are given in Table 4 below. Additional average quantities, such as temperature and relative humidity, adjacent to the drift wall are computed for the submodels of the TSPA model.

Table 4. Average and Raw[a] Quantities used in the TSPA Model

TH Variable Used in the TSPA Model	Abstraction Routine Variable Name
Waste package surface temperature (°C)	TavgRIP(*k,j*)
Invert liquid saturation	S_lavgRIP(*k,j*)
Percolation flux at 5 m above the drift crown (mm/yr)	ql_5mavgRIP(*k,j*)
Maximum[a] waste package surface temperature (°C)	Tmaxrip(*k,j*)
Minimum[a] waste package surface temperature (°C)	Tminrip(*k,j*)
Invert temperature (°C)	TavgRIPinv(*k,j*)
Invert relative humidity	RHavgRIPin(*k,j*)
Invert evaporation rate (m^3/yr/m-drift)	qvpavgRIPinv(*k,j*)
Top drip shield temperature (°C)	TavgRIPdstop(*k,j*)
Invert volume flow rate (m^3/yr)	ql_invavgRIP(*k,j*)*(a_inv/1000.)
Absolute invert volume flow rate [b] (m^3/yr/m-drift)	ql_invavgabs(*k,j*)*(a_inv/1000.)
Drift wall relative humidity	RH_dw1a(j)
Drift wall temperature (°C)	T_dw5a(j)

NOTES: a-The raw quantities don't use the Equations 1 and 2 defined above. The max/min waste package surface temperature curves correspond to the time histories for the waste packages with the highest and lowest peak waste package temperature for each bin.
b-The absolute value of the raw quantity is taken before the average.
k = An infiltration bin (=5 total).
j = The time point.

As indicated in Section 1.0, this abstraction will create average time history data that may be based on a number of very different results. In cases where variability may be averaged out (e.g., an infiltration bin that may contain hundreds of waste package locations with different surface temperatures), the files that contained the waste package locations with the maximum and minimum peak temperature values will also be abstracted in order that an appropriate range of variability may be defined by this AMR for the TSPA model.

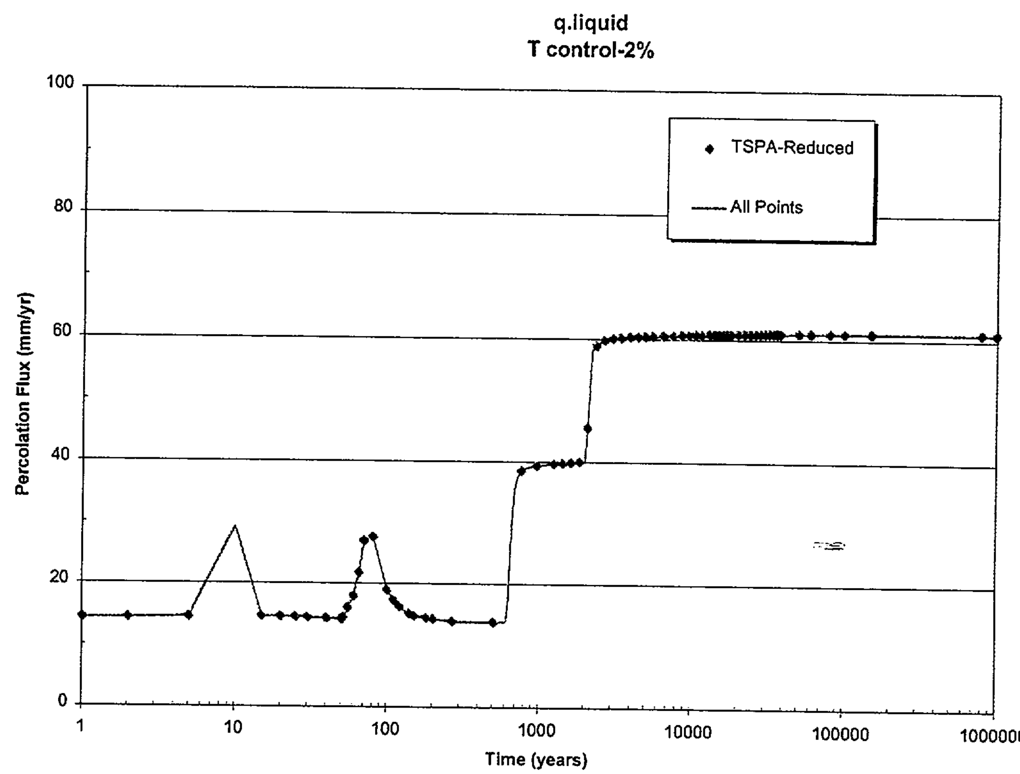
The abstraction routine made one final change to the data sets (both raw and averaged) due to requirements set forth by the TSPA model. The use of the large number of time points (denoted in the tables above as *j*) given in the multiscale TH model results would result in very long runtimes in the TSPA model. A method has been developed to reduce the number of time points while still maintaining the time varying nature of the data. This is done by only printing variables when any one of two key TSPA variables (waste package temperature and percolation flux at 5 meters into near-field host rock) changes by some predetermined fraction. The rate-of-change (ROC) parameter is defined in general as:

$$ROC = \frac{X_j - X_r}{X_r} \qquad \text{(Eq. 3)}$$

where X_r, the last retained value (the last value printed), is not in general j-1. Since much of the TSPA input data, as given in Table 3, is applied to the waste package degradation model, the total number of time points is reduced but kept identical for each variable listed in the table (e.g., each of the variables given in Table 3 had the same total number of j's and at identical time points). Since both flux and state variable dependence can be used to maintain the integrity of the data, the time rate of change of the waste package surface temperature and the liquid flux 5 m above the crown of the drift are used as the controlling parameters.

The software routine (TH-msmabs_ver_1) test cases and results are described as the following. In order to determine the best method of time print control, three methods are considered. The first uses a temperature rate of change only, the second uses percolation flux change only, and the third uses both (this is the method chosen for the abstraction). The results of each method are shown in the following figures. In the time print control study, rates of change are selected in the range of 3 to 5%. For changes in the control variables that are less than this range, the value would not be retained as TSPA input and the j^{th} time point (from the raw data) is discarded (for all the variables listed in Table 3), for changes greater than or equal this range, the values are saved in the TSPA input files.

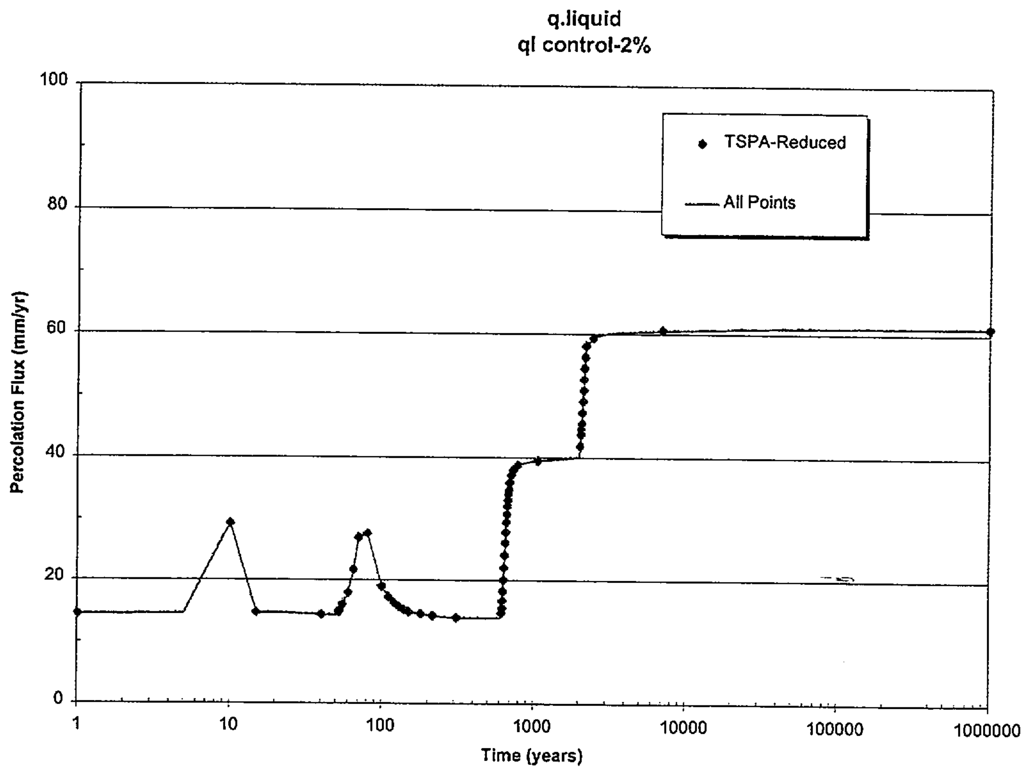
For temperature control, one need only look at the time-histories of the liquid flux variable to conclude that this control parameter is insufficient by itself. Figure 1 contains the full and reduced percolation flux time history for an actual waste package location using the mean infiltration flux map. The reduction is based on a print out for a 2% change in waste package surface temperature.



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 1. Percolation Flux for a TSPA Reduced Number of Time Points Based on a 2% ROC Temperature Control

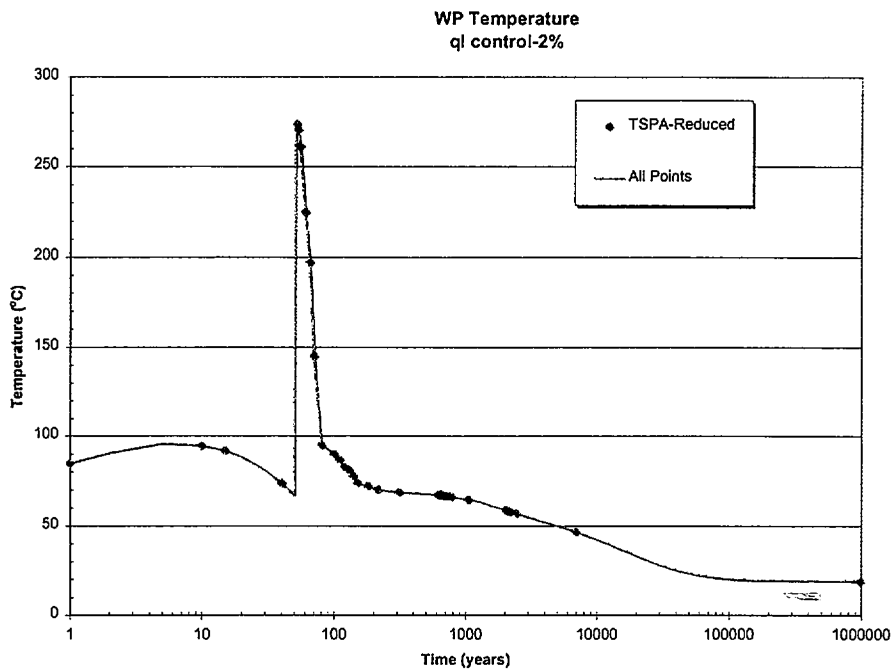
From Figure 1 it is evident that at 10 years the initial pulse of liquid water (e.g., during initial heat-up and moisture movement period) above the crown of the emplacement drift is not captured when a changing waste package surface temperature is used to determine the time print data for use in the TSPA model. Therefore, using only the waste package surface temperature to control the time print outs is not sufficient to capture the variability in the percolation flux. Figures 2 and 3 show the percolation flux and waste package temperature for the same waste package location when a 2% change in percolation flux is used as the controlling parameter.



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

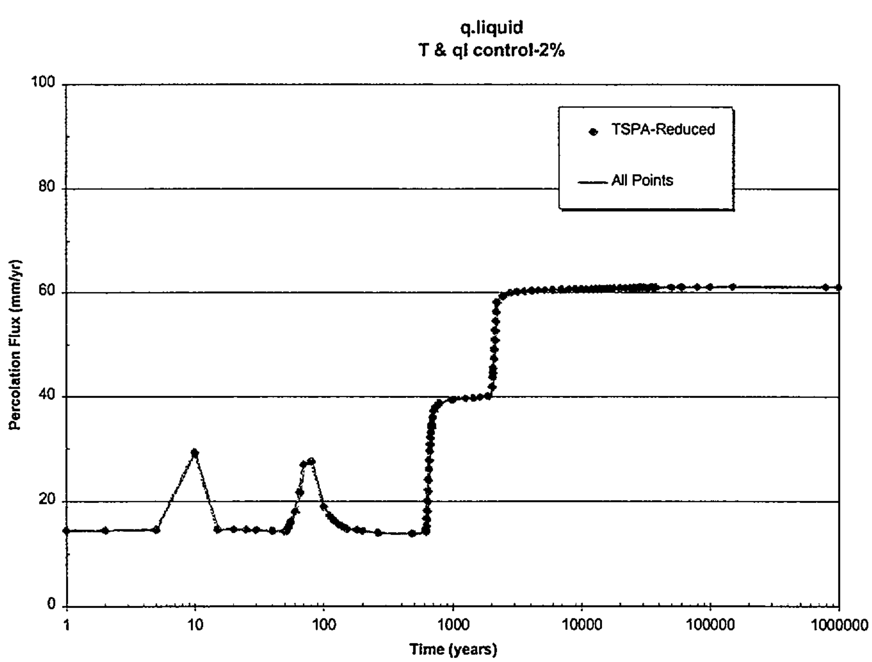
Figure 2. Percolation Flux for a TSPA Reduced Number of Time Points Based on a 2% ROC Percolation Flux Control

In Figure 2, the initial pulse (at 10 years) of water at the crown of the emplacement drift is captured in the reduced files. From this figure and Figure 3, this method is too coarse both at late and early times for both the flux and state variables. There are no data points between 10,000 and 1,000,000 years when the percolation flux is nearly constant but the waste package surface temperature drops from approximately 40°C back to its ambient value. Alternate methods that would result in more time points in the required variables are reducing the rate-of-change factor when using the percolation flux control parameter or using both a flux and a state variable when specifying the points retained for the TSPA model. The later method is used in Figures 4 and 5 for the percolation flux and the waste package temperature, respectively.



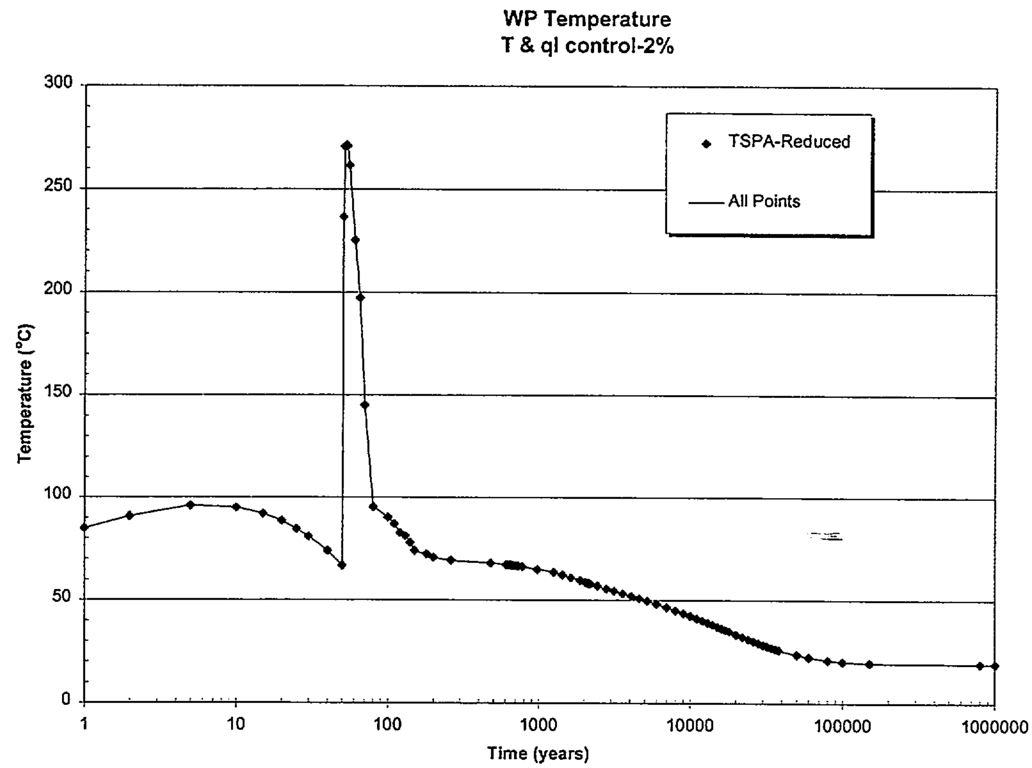
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 3. Waste Package Surface Temperature for a TSPA Reduced Number of Time Points Based on a 2% ROC Percolation Flux Control



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

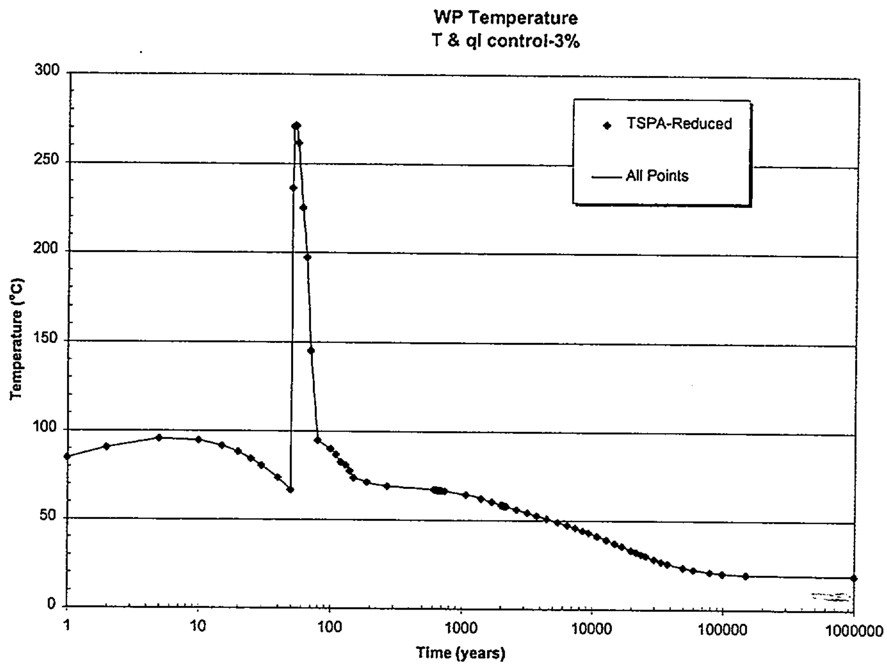
Figure 4. Percolation Flux for a TSPA Reduced Number of Time Points Based on a 2% ROC Percolation Flux and Temperature Control



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

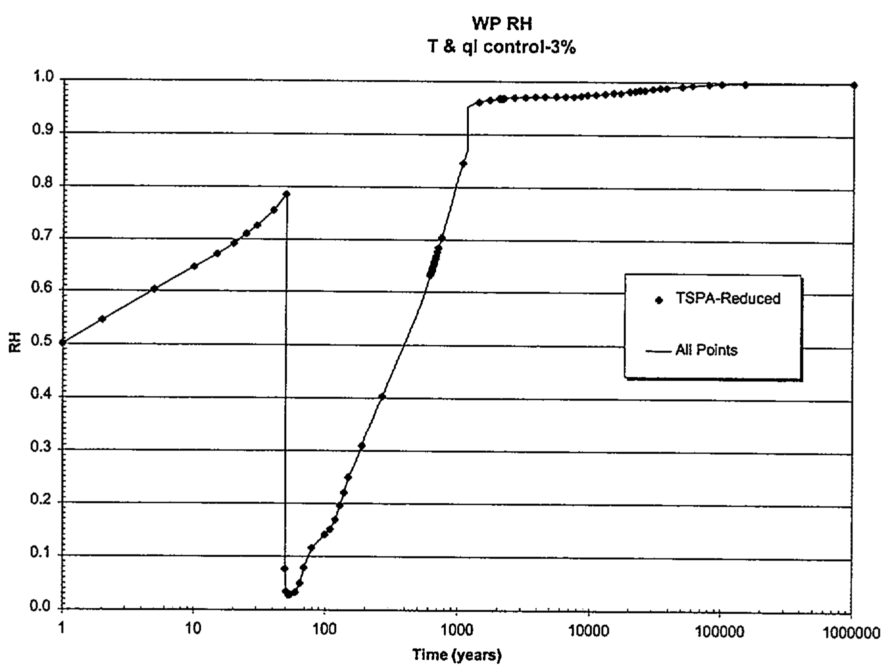
Figure 5. Waste Package Surface Temperature for a TSPA Reduced Number of Time Points Based on a 2% ROC Percolation Flux and Temperature Control

Figures 4 and 5 show the percolation flux and waste package surface temperature when a 2% rate-of-change factor is utilized for both parameters (state and flux). In order to reduce the number of time points even further, the flux and state variable control is increased to 3%. For this case, the number of time print outs is reduced from 102 for 2% change to 83 for a 3% change. This represents about 25% of the original data while still maintaining the integrity of the data and its trends. The results of this specification are shown in the following figures. Figures 6 through 12 indicate both flux and state variables based on a combination of temperature and percolation flux rate of changes specified as 3%. The results are for an arbitrary waste package location within an infiltration bin as defined above. This criteria is selected for the abstraction. (Note: for the low infiltration rate case, the ROC criteria is specified as 5% since to minimize the number of data points passed to the TSPA model since a 3% reduction did not remove a sufficient number of points for the TSPA model.)



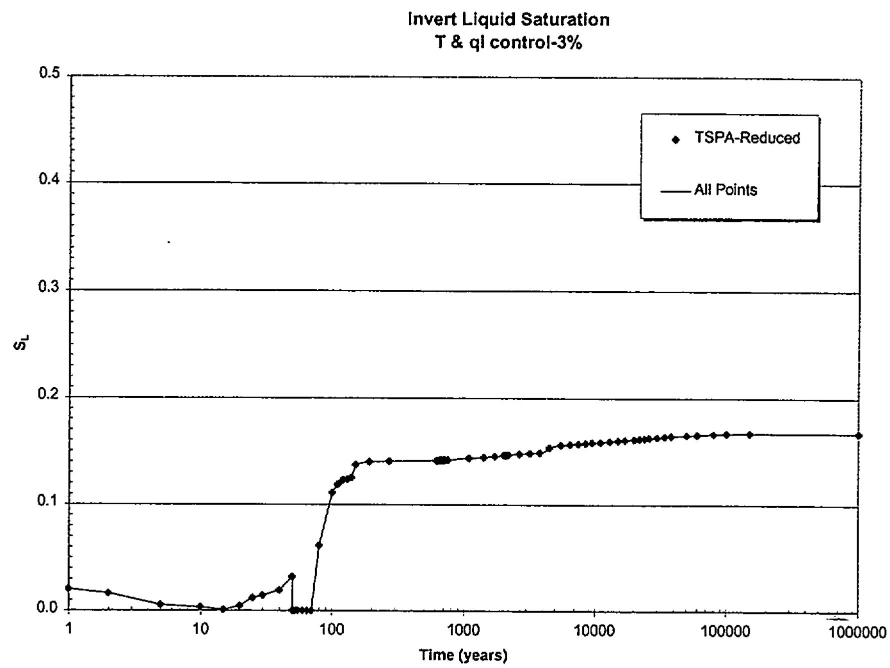
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 6. Waste Package Surface Temperature for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control



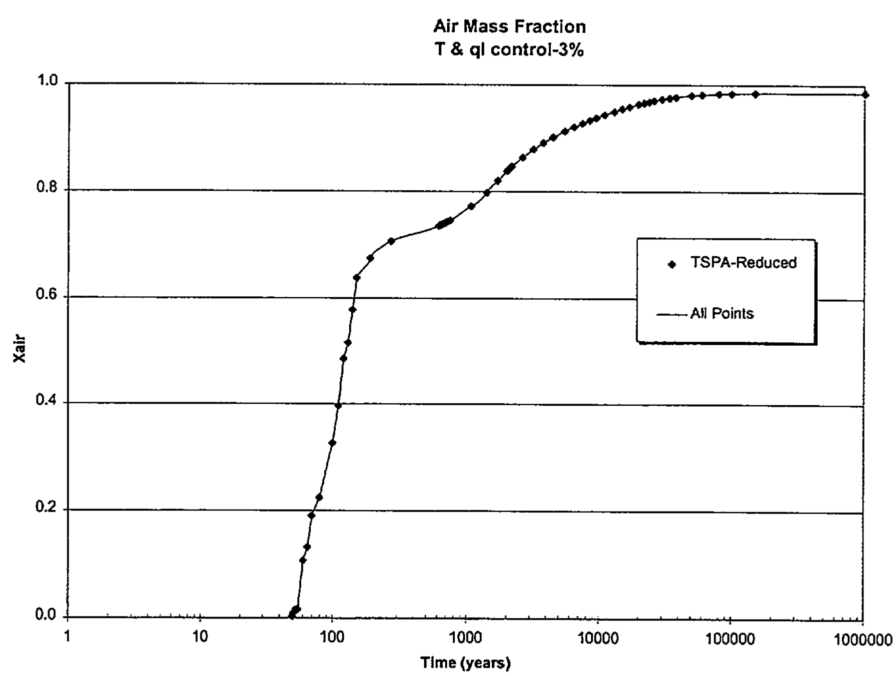
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 7. Waste Package Relative Humidity for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control



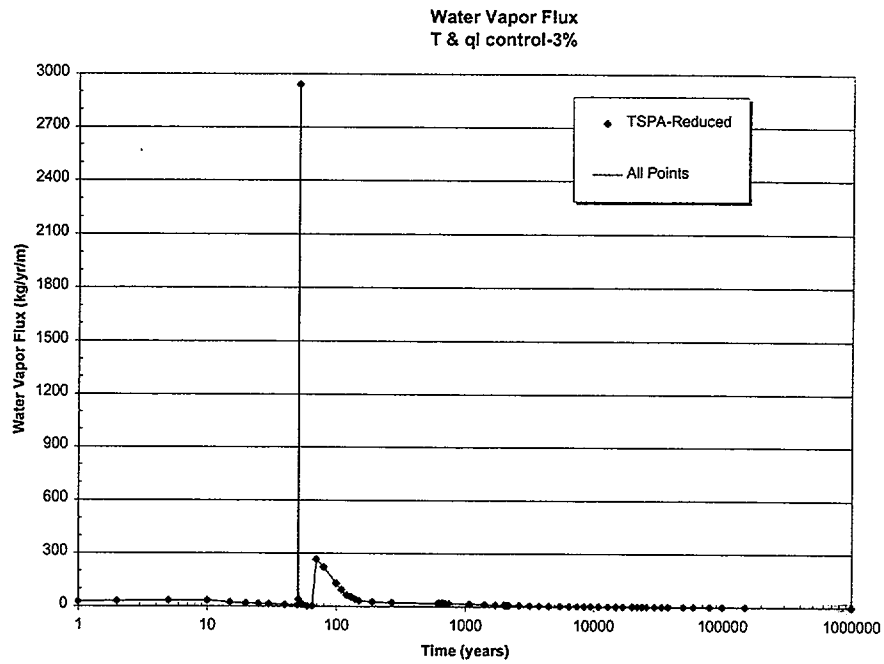
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 8. Invert Liquid Saturation for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control



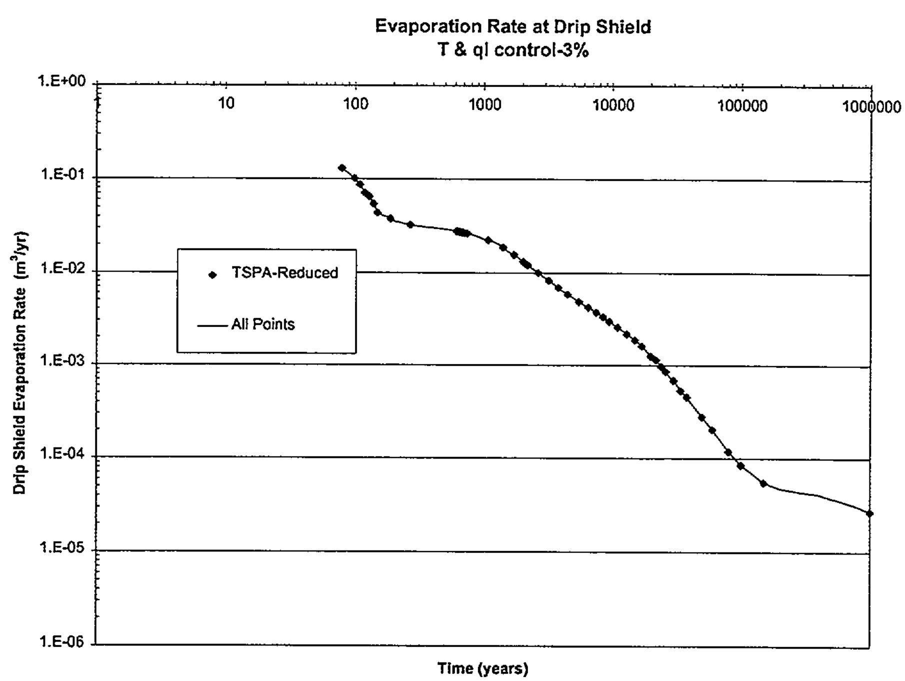
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 9. Air Mass Fraction for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control



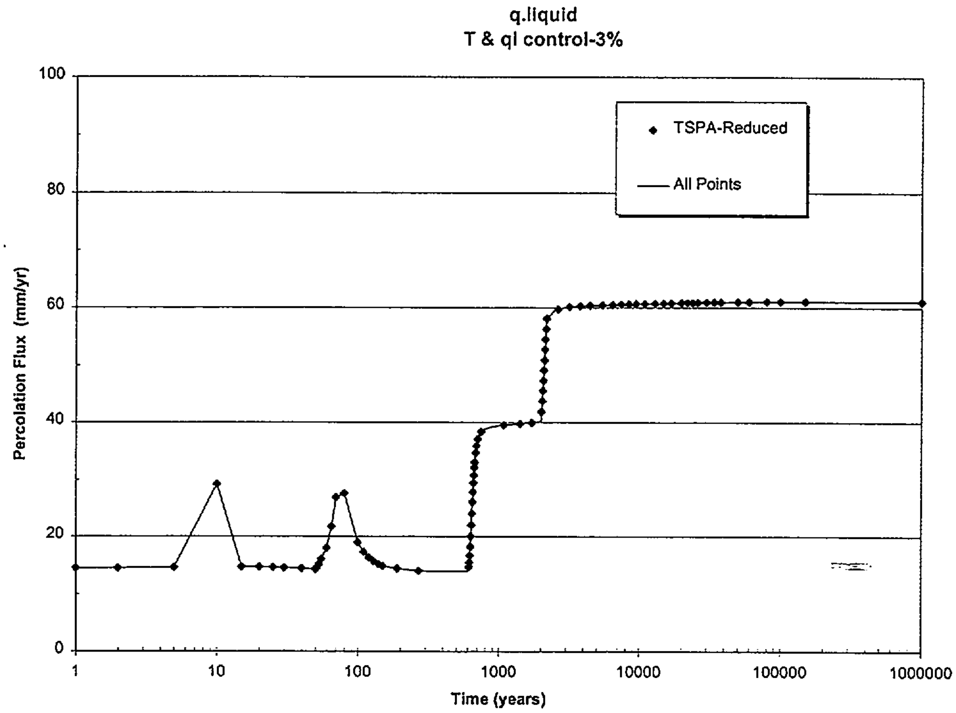
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 10. Water Vapor Flux for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 11. Drip Shield Evaporation Rate for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control

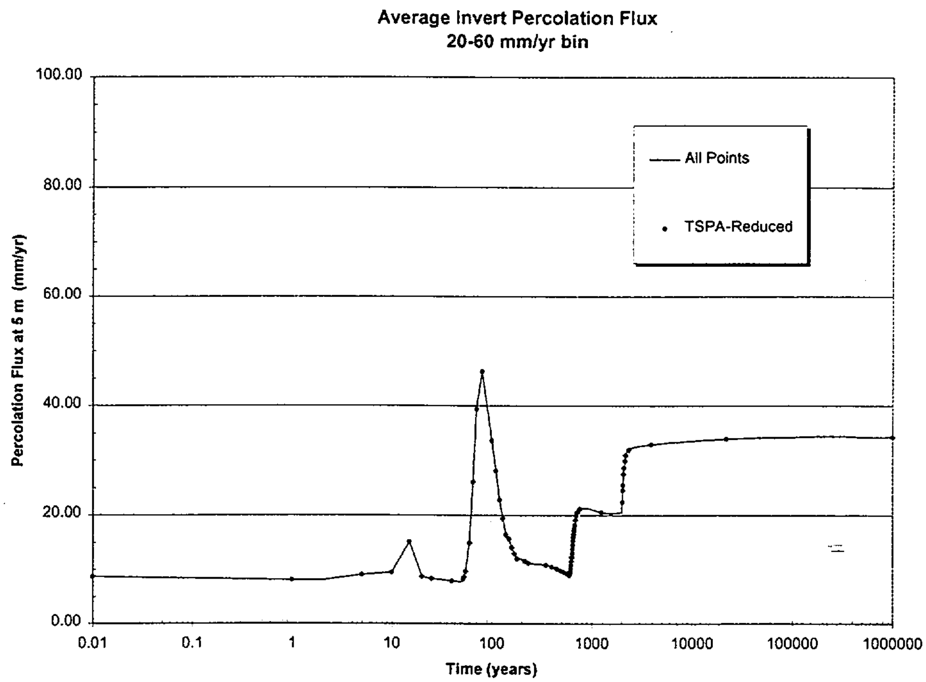


DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 12. Percolation Flux for a TSPA Reduced Number of Time Points Based on a 3% ROC Percolation Flux and Temperature Control

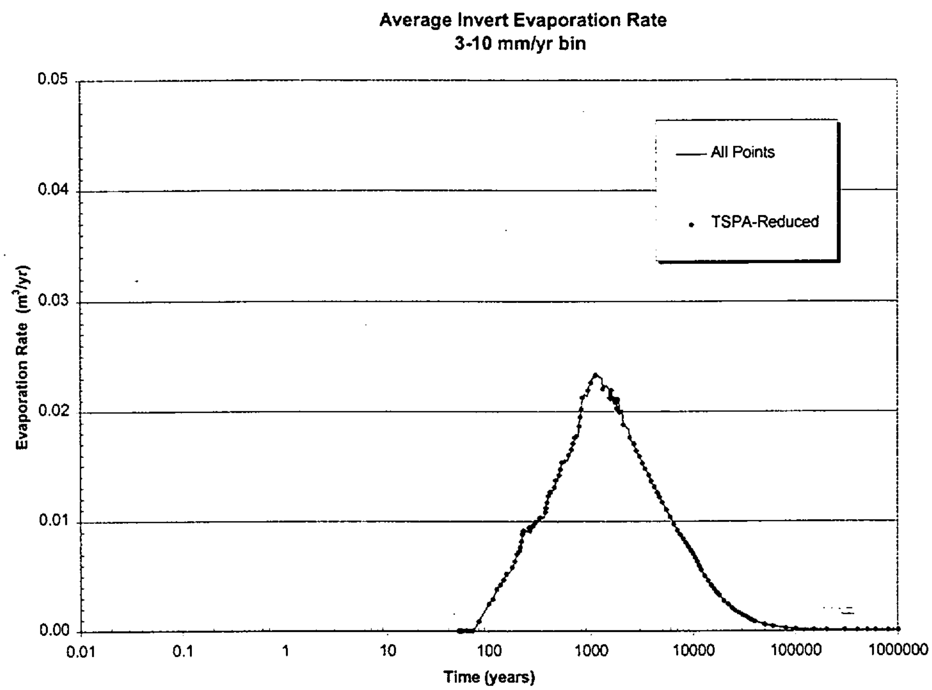
The raw data reduction described above is implemented in order to minimize runtime of the waste package corrosion model contained in the TSPA model. The seepage model also uses the percolation flux at the crown of the emplacement drift at each of the individual raw data locations (as contained within an infiltration bin). Since the variability in time point representation (from location-to-location within an infiltration bin) will not allow for a consistent data input into the seepage model, an additional raw file is needed for the TSPA model that contains all of the percolation flux data at both 3 and 5 m above the crown of the drift.

Similar time print restrictions are placed on the averaged (or max and min) results specified in Table 4. In the case of the averaged data, time print control for that parameter is based on Equation 3 where X is the parameter itself (not necessarily waste package temperature or percolation flux at 5 m, although these happen to be required as well). Using a 3% rate of change (recall actual abstraction uses 5% for the low infiltration case, 3% for the mean and high infiltration rate cases), the averaged results are the following. In the cases where zero is the result maintained over a specific time period (e.g., invert liquid saturation that remains dry for a number of years), the duration of the zero result is retained in the file used by the TSPA model. Some examples follow in Figures 13 through 17 of various infiltration bins for the mean infiltration rate case.



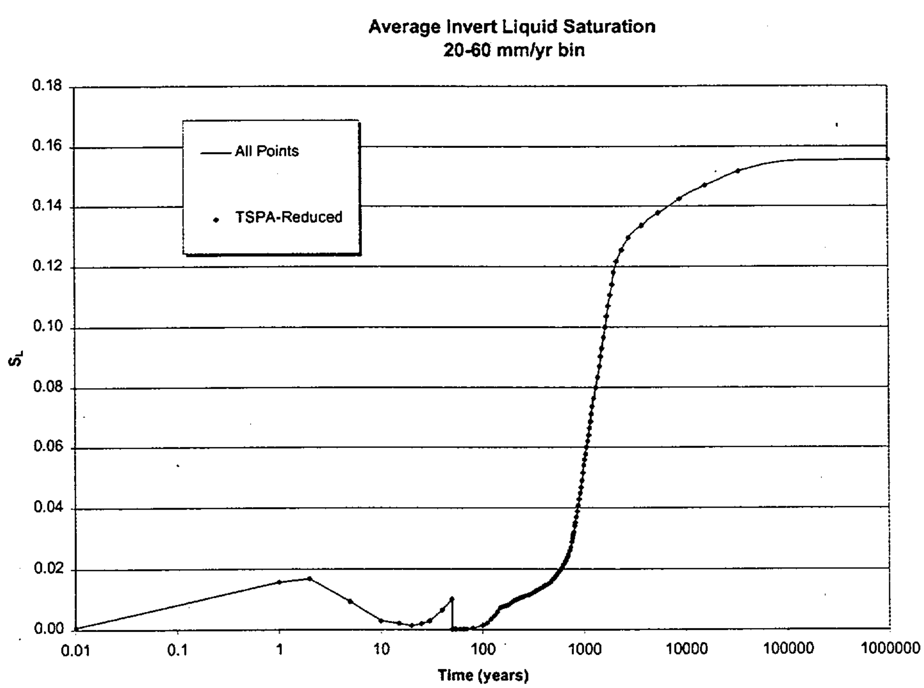
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 13. Average Percolation Flux for a TSPA Reduced Number of Time Points Based on a 3% ROC



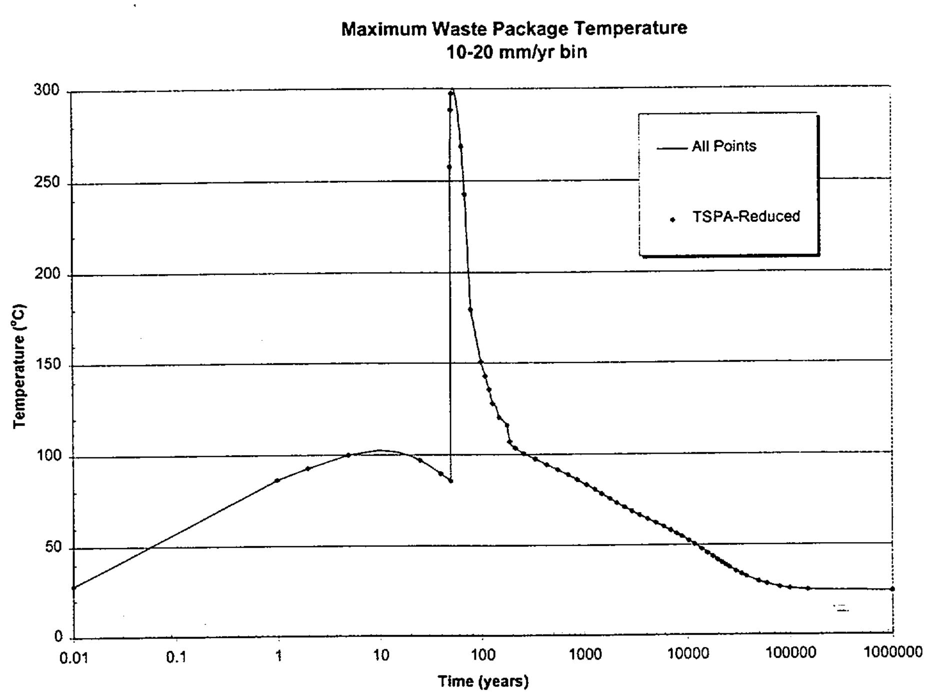
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 14. Average Invert Evaporation Rate for a TSPA Reduced Number of Time Points Based on a 3% ROC



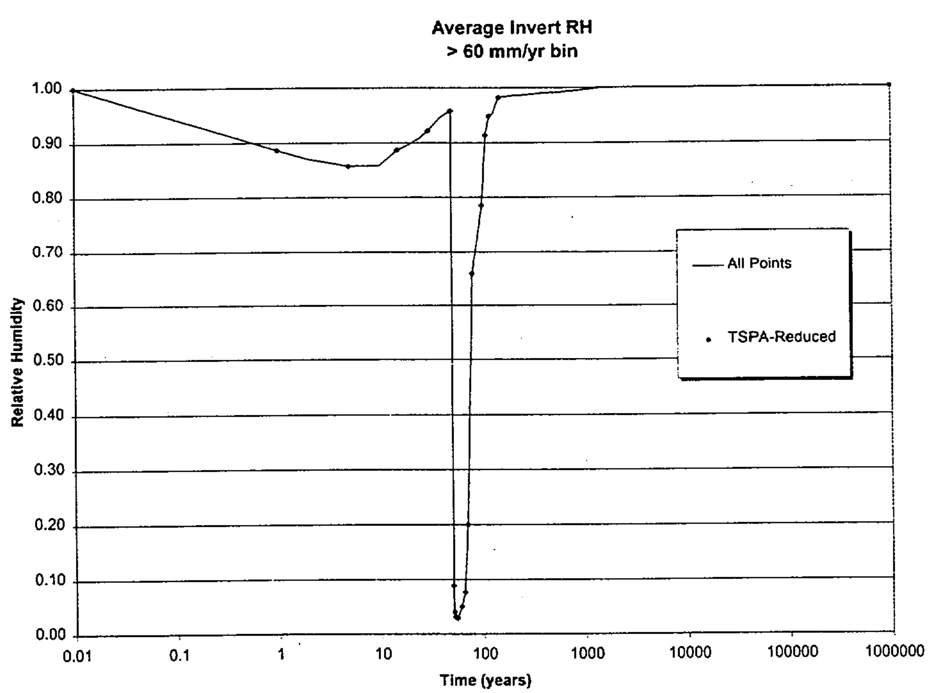
DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 15. Average Invert Liquid Saturation for a TSPA Reduced Number of Time Points Based on a 3% ROC



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 16. Maximum Waste Package Surface Temperature for a TSPA Reduced Number of Time Points Based on a 3% ROC



DTN: LL000114004242.090 (All Points), DTN: SN0001T0872799.006 (TSPA)

Figure 17. Average Invert Relative Humidity for a TSPA Reduced Number of Time Points Based on a 3% ROC

There are very few limitations/restrictions on this software routine (TH-msmabs_ver_1) or its validity. The routine is completely flexible. The parameter statement in the routine can easily be changed as needed as the number of location dependent raw files (process-level inputs, in this case 623—see next section), time points in the raw files (442 time points for low, 352 mean, and 457 high), or infiltration bins (=5), change. The routine is verified for the ranges given in parenthesis above. If the format of the resulting process-level model data files change (e.g., new variables are added as columns to the process-level model outputs—which are the abstraction routine inputs), format statements in the routine would have to be changed to reflect the new variables so that an accurate read can be made. This only requires minor modifications to the read/write statements of the routine.

The TH abstraction results reside in the technical data management system (TDMS) under the data tracking number, DTN: SN0001T0872799.006 and DTN: SN0002T0872799.008. These TH data submittals to the TDMS are unqualified since their source inputs are unqualified.

6.2 INFILTRATION RATE BINNING

For waste-package-degradation calculations within a TSPA simulation, the full range of environmental conditions is used. That is, each waste package for which degradation is modeled has its own histories of temperature, relative humidity, etc., drawn from the population of histories provided by the multiscale thermal-hydrologic model. However, the calculation of radionuclide releases within a TSPA simulation is simplified by lumping waste packages together into groups. In the release calculations, all waste packages in a group have common environmental conditions—that is, the same histories of temperature, relative humidity, etc. (Note that the waste packages in a group do not all fail at the same time, though, because of the additional variability in the waste-package-degradation calculation.)

For the Viability Assessment, waste-package groups were based on physical location (six repository subregions), waste type (commercial spent nuclear fuel, vitrified high-level waste, or DOE spent nuclear fuel), and seepage (always exposed to seepage, exposed to seepage during the wettest two climates, exposed to seepage only during the wettest climate, or never exposed to seepage) (CRWMS M&O 1998b, Section 11.2.1.3). For the Site Recommendation, the waste-package groups are based on infiltration rather than physical location, because radionuclide dissolution and release depend more directly on infiltration than on repository location.

The five infiltration "bins" used are as follows: 0–3 mm/yr, 3–10 mm/yr, 10–20 mm/yr, 20–60 mm/yr, and 60+ mm/yr. They were chosen based on the distributions of glacial-transition infiltration for the three infiltration cases and on important flux levels in the seepage abstraction. (Glacial-transition infiltration is used because the glacial-transition climate is in effect most of the time during a TSPA simulation, and it is in effect during later times when radionuclide releases are more likely.) The considerations in choosing the bins were as follows.

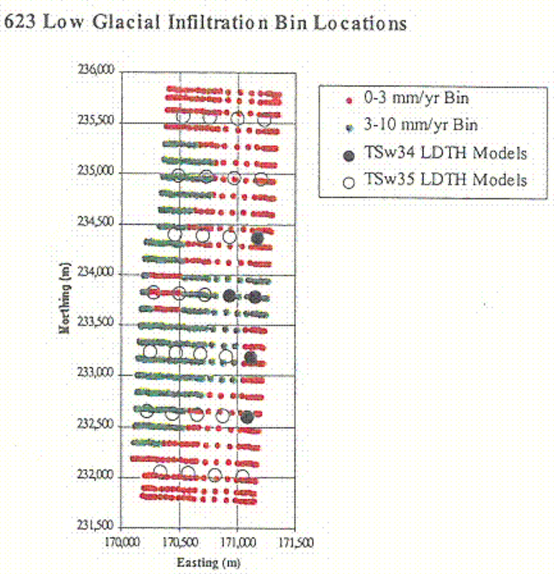
Three sets of seepage curves were defined for the seepage abstraction, corresponding to a lower-bound case, a most-likely case, and an upper-bound case for seepage (CRWMS M&O 2000b, Section 6.4 and Table 11). Each of those cases has a percolation-flux threshold, below which there is no seepage: 3.4 mm/yr for the upper bound case, 9.9 mm/yr for the most likely case, and 97.9 mm/yr for the lower bound case (DTN: SN9912T0511599.002). The first two bin boundaries (3 mm/yr and 10 mm/yr) were rounded from the seepage thresholds for the upper-bound and most-likely cases. The seepage threshold for the lower-bound case is so high that few waste-package locations have infiltrations above it, so it was not used in defining the bins. Instead, the other bin boundaries were chosen primarily in order to differentiate among the three infiltration cases (complete differentiation is not possible since the infiltration distributions for the three cases have considerable overlap). With the bins as defined above, waste packages in low-infiltration realizations are all in the first two bins (i.e., between 0 and 10 mm/yr), waste packages in mean-infiltration realizations are mostly in the third and fourth bins but with some in the other bins as well, and waste packages in high-infiltration realizations are mostly in the fourth and fifth bins but with some in the second and third bins (refer to Table 5).

The infiltration rate bins defined by TSPA are distributed over the repository footprint as shown (for the low, mean, and high infiltration rate cases) in Figures 18-20. Each infiltration rate case (e.g., the mean infiltration rate) contains 623 location dependent data results from the process-level model (refer to CRWMS M&O 2000a, Sections 6.10 and 6.11). The plotted result below is representative of the infiltration rate during the glacial transition climate state. The spatial location (or repository coverage) of each infiltration bin is given in Figures 18 through 20 for each infiltration rate case considered in the abstraction. The figures also indicate the location of the line-averaged, drift-scale, thermal hydrology (LDTH) models (CRWMS M&O 2000a, Section 6.3.1). The number of waste package locations that fall into particular infiltration rate bins for all three infiltration flux cases (information extracted from waste package files in DTN: LL000114004242.090, LL000114104242.091, and LL000113904242.089) are presented in Table 5.

Table 5. Distribution of Process-Level Model Results within Infiltration Bins

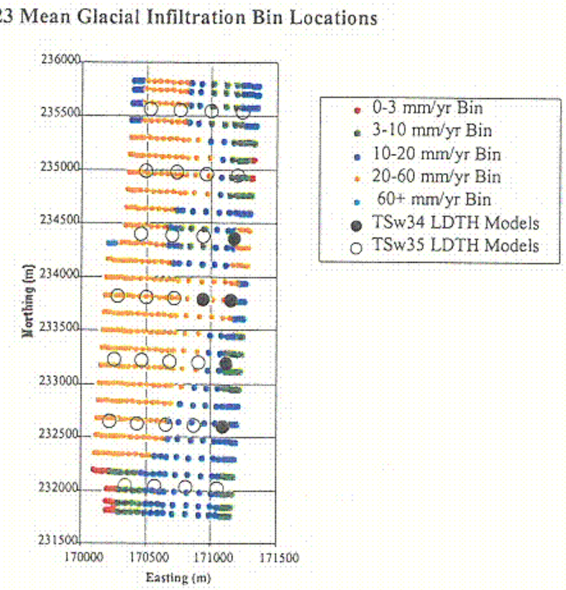
Low Infiltration Case	Number of Process-Level Model Entries in the Bin	Repository Area Fraction (%)
0-3 mm/yr	368	59.7
3-10 mm/yr	255	40.3
10-20 mm/yr	0	0
20-60 mm/yr	0	0
60+ mm/yr	0	0
Mean Infiltration Case	**Number of Process-Level Model Entries in the Bin**	**Repository Area Fraction (%)**
0-3 mm/yr	21	1.6
3-10 mm/yr	91	13.2
10-20 mm/yr	174	32.1
20-60 mm/yr	334	52.9
60+ mm/yr	3	0.3
High Infiltration Case	**Number of Process-Level Model Entries in the Bin**	**Repository Area Fraction (%)**
0-3 mm/yr	0	0
3-10 mm/yr	14	1.2
10-20 mm/yr	98	13.4
20-60 mm/yr	318	54.8
60+ mm/yr	193	30.6

DTN: LL000114004242.090, LL000114104242.091, and LL000113904242.089



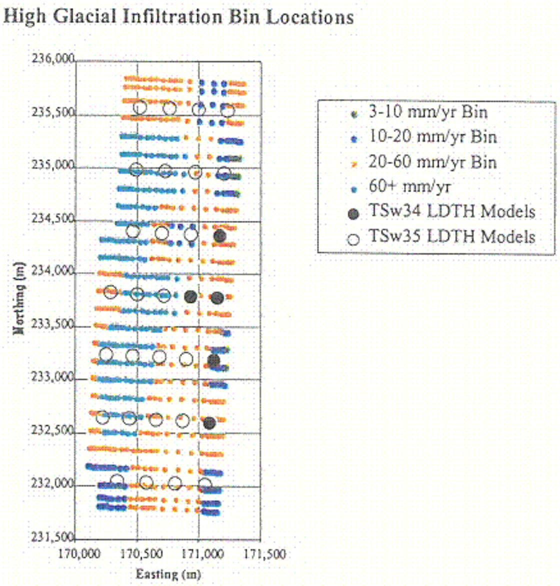
DTN: LL000113904242.089

Figure 18. The Location of All of the Waste Packages in the Different Infiltration Bins for the Low Glacial Infiltration Map



DTN: LL000114004242.090

Figure 19. The Location of All of the Waste Packages in the Different Infiltration Bins for the Mean Glacial Infiltration Map



DTN: LL000114104242.091

Figure 20. The Location of All of the Waste Packages in the Different Infiltration Bins for the High Glacial Infiltration Map

The process-level model location dependent data distributions are given in Table 5. Also included are the total repository area fraction for each infiltration bin associated with an infiltration rate case.

Since the location dependent data (623 different process-level model results) from the process-level model are representative of different footprint area fractions, the repository represented (by a particular bin) is not computed as the fraction of the number of entries (e.g., repository area fraction is not equal to 174/623 for the 10-20 mm/yr bin in the mean infiltration rate case). The results in Table 5 are based on the sum of each of the individual area fractions of the data that fall into a particular infiltration bin.

The waste package thermal environment as described by the resulting location dependent process model data is strongly dependent upon the results from the mountain scale thermal-conduction model (CRWMS M&O 2000a, Section 6.2). Consequently, the variability of temperature and relative humidity within each bin will be a strong function of the spatial distribution of the waste packages within the repository. The waste packages at the edge of the repository will cool off quicker than those near the center of the repository due to higher lateral heat losses. As a result, the number of waste packages located near the center and near the edge of the repository will strongly affect the variability of the temperature and relative humidity time-histories in each bin. The 31 LDTH models have been placed on the plots. Five of the LDTH models were located in the repository horizon geology called middle non-lithophysal (TSw34 using UZ flow model nomenclature) with the other 26 located in the lower-lithophysal repository host unit (TSw35 using UZ flow model nomenclature).

For the low infiltration flux case, only the driest two infiltration bins are populated. Waste packages are located in the interior and near the edges of the repository in both infiltration bins. For the mean infiltration map, all five bins are populated. Over half of the waste packages are in the 20-60 mm/year bin and only three waste packages fell in the 60+ mm/year bin. The 21 waste packages in the lowest infiltration bin and the 3 waste packages in the highest infiltration rate bin are all located at edge locations while the other three infiltration bins contain waste packages near the center of the repository as well as at the edge of the repository.

For the high infiltration flux case, only the four highest infiltration bins are populated with waste packages. The 3-10 mm/year infiltration flux bin contains 14 waste packages, all of which are on the eastern edge of the repository. The other three infiltration rate bins contain waste packages at the center and at the edge of the repository footprint.

The TSPA required quantities from the TH abstraction as given in Table 4 are average values based on the location dependent results that fall within a given infiltration bin (accounting for the appropriate area fraction "weight" of the location dependent data from the process-level model). The figures below provide a visual representation of the spatial locations of an average value for the low, mean, and high infiltration rate cases. The TSPA raw files, a total of 623 location dependent results as specified in Table 3, are used in the waste package corrosion model and are located within the infiltration bins as shown below for each of the three cases. So, as an example, the 60+ mm/yr bin for the mean infiltration rate case contains TSPA averaged and raw data based on the results of three process-level model locations as shown in Figure 36.

6.3 TH ABSTRACTION RESULTS

6.3.1 CSNF Temperature Profiles

There is considerable variability in the peak waste package temperatures throughout the repository for different glacial infiltration flux cases. The highest, the mean, and the lowest peak waste package temperatures for all of the bins and infiltration flux cases for both HLW and CSNF are presented in Table 6. The peak waste package temperatures all occurred during the first 10 years after closure (50-60 year simulation times). The highest peak waste package temperature of 316°C was a CSNF waste package in the 0-3 mm/year bin of the low infiltration flux case. The lowest maximum waste package temperature of 235°C was for a HLW waste package in the 20-60 mm/year bin in the high infiltration flux case. The bin averaged CSNF waste package peak temperatures were between 14 and 21°C higher than the corresponding HLW bin averaged waste package peak temperatures. This table illustrates the variability in the peak temperature contained inside individual bins as well as the variability in thermal response throughout the repository.

Table 6. The Minimum, Mean, and Maximum of the Peak CSNF and HLW Waste Package Temperatures (°C) for All Bins for the Three Infiltration Flux Cases

Bin (mm/yr)	Infiltration Rate Map	HLW Min (°C)	HLW Mean (°C)	HLW Max (°C)	CSNF Min (°C)	CSNF Mean (°C)	CSNF Max (°C)
0-3	High	-	-	-	-	-	-
	Mean	259	273	286	276	288	299
	Low	246	279	298	263	296	316
3-10	High	242	271	283	259	285	296
	Mean	243	278	287	261	292	300
	Low	254	278	301	273	299	319
10-20	High	240	269	284	257	283	296
	Mean	239	267	287	257	282	300
	Low	-	-	-	-	-	-
20-60	High	235	254	283	253	270	296
	Mean	240	268	287	257	283	299
	Low	-	-	-	-	-	-
60+	High	249	252	258	266	269	274
	Mean	256	256	257	274	274	275
	Low	-	-	-	-	-	-
Overall	High	235	-	284	253	-	296
	Mean	235	-	287	257	-	300
	Low	246	-	301	263	-	319
Overall	Overall	235	-	301	253	-	319

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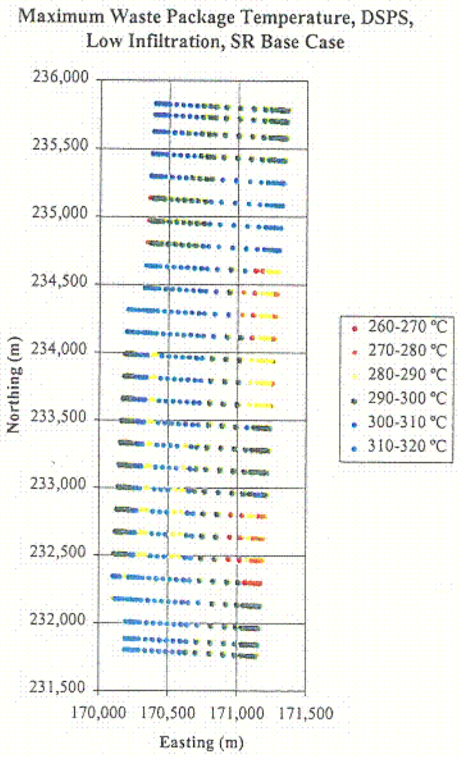
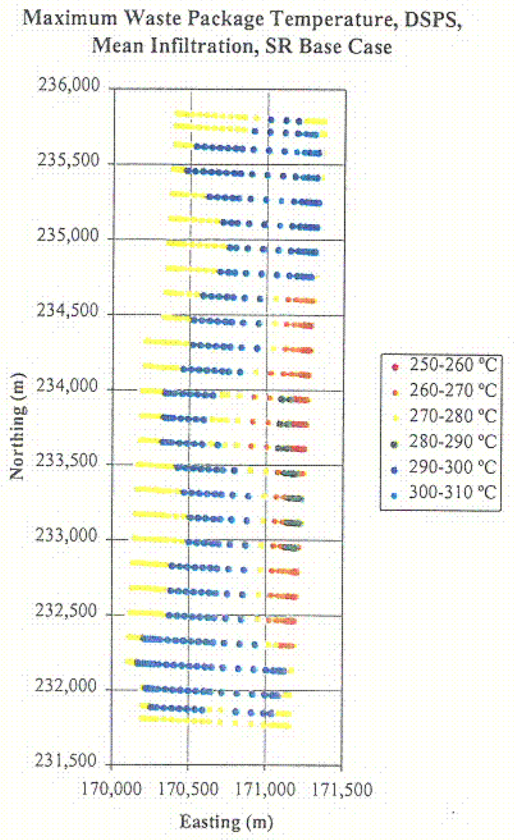
NOTE: A Dash in the Table Means that There Were No Waste Package Locations in that Infiltration Flux Bin.

Figures 21-23 contain the peak temperature of the 623 CSNF waste package locations in the repository for the three infiltration flux cases. Note that the peak temperatures are higher for the lower infiltration flux cases. Peak temperatures are also higher at the center repository locations and lower at edge repository locations. The average temperature difference between the low and the high infiltration flux case waste package peak temperatures at 623 locations was 26°C.



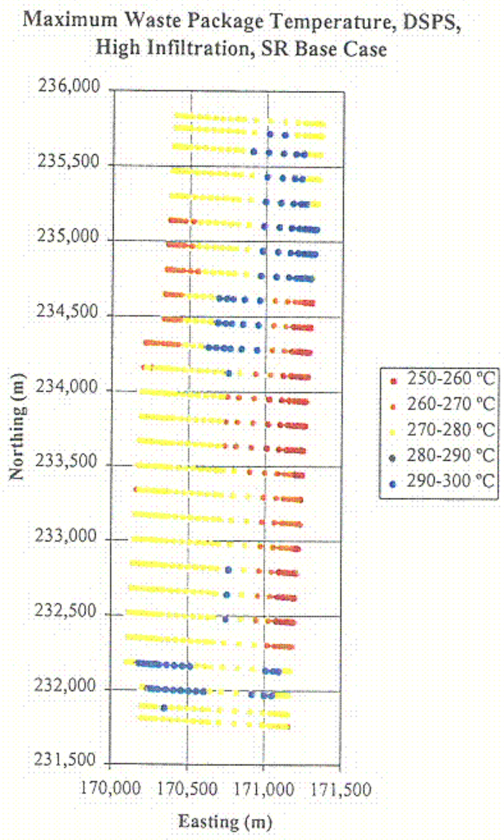
DTN: LL000113904242.089

Figure 21. The Peak Waste Package Temperatures for All 623 Waste Package Locations for the Low Infiltration Flux Case



DTN: LL000114004242.090

Figure 22. The Peak Waste Package Temperatures for All 623 Waste Package Locations for the Mean Infiltration Flux Case



DTN: LL0001141004242.091

Figure 23. The Peak Waste Package Temperatures for All 623 Waste Package Locations for the High Infiltration Flux Case

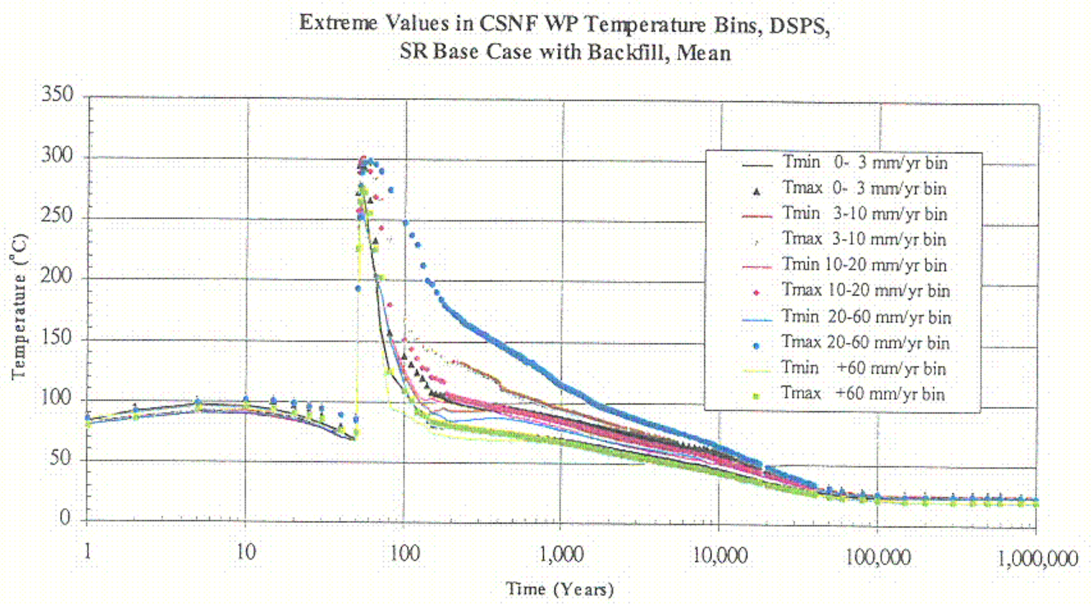
Table 7 contains the difference between the highest and lowest peak waste package temperature for each of the bins. The variability within each bin was as high as 52°C (HLW) and 53°C (CSNF) for the 0-3 mm/year in the low infiltration flux case. The small variability (1°C) in the 60+ mm/year mean infiltration flux bin is directly attributable to there being only three waste packages in this bin. They were also adjacent to each other with nearly identical local infiltration fluxes.

Table 7. The Difference Between the Highest and the Lowest Maximum Temperature (°C) in Each Bin for Each Infiltration Flux as well as the Overall Temperature Difference for Each Infiltration Flux Case

Bin mm/yr	Infiltration Rate	HLW (°C)	CSNF (°C)	CSNF+HLW (°C)
0-3	High	-	-	-
	Mean	27	23	41
	Low	52	53	69
3-10	High	41	37	55
	Mean	44	39	57
	Low	47	47	66
10-20	High	44	39	56
	Mean	48	43	61
	Low	-	-	-
20-60	High	48	43	61
	Mean	47	42	60
	Low	-	-	-
60+	High	9	8	25
	Mean	1	1	18
	Low	-	-	-
Overall	High	48	48	61
	Mean	52	52	65
	Low	54	54	73
Overall	Overall	65	65	84

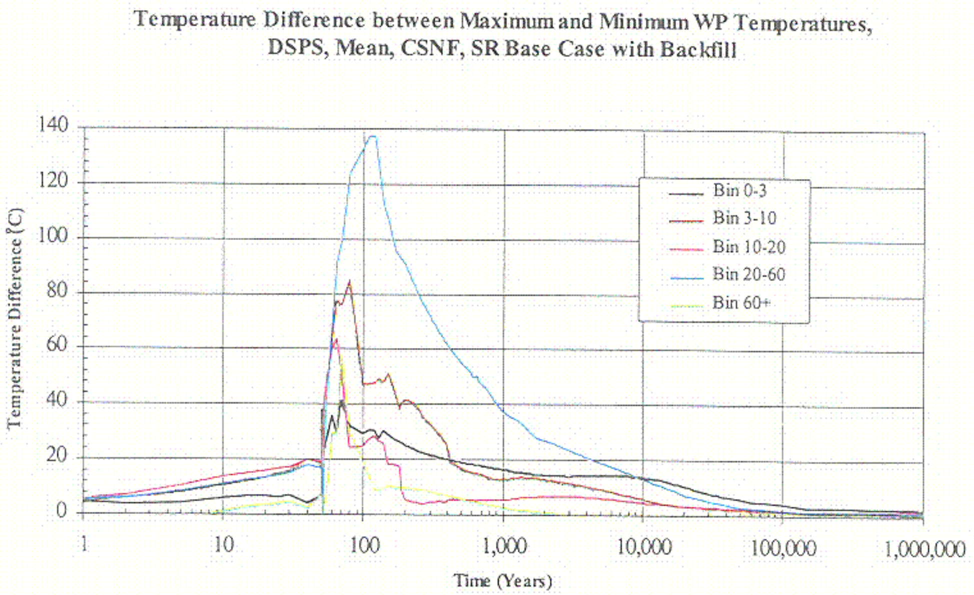
DTN: SN0001T0872799.006

Figure 24 shows the CSNF waste package temperature time history for the highest and lowest peak temperature curves in each of the five infiltration case bins for the mean infiltration flux case. Figure 25 shows the difference between the highest and lowest infiltration flux time-history curves for each of the bins. The largest difference between curves was 138°C just after 100 years for the 20-60 mm/year infiltration bin. The difference is still present after 1000 years at which time there is a 38°C difference between the two time-histories in the 20-60 mm/year infiltration bin. The largest bin averaged temperature difference does not drop below 10°C until after 20,000 years.



DTN: SN0001T0872799.006

Figure 24. The Ten Waste Package Temperature Time Histories That Had the Lowest and Highest Peak Temperature in Each Mean Infiltration Flux Bin



DTN: SN0001T0872799.006

Figure 25. The Difference Between the Temperature Time Histories That Had the Highest and Lowest Peak Temperature in Each of the Infiltration Bins for the Mean Infiltration Flux Case andthe SR Base Case Design with Backfill

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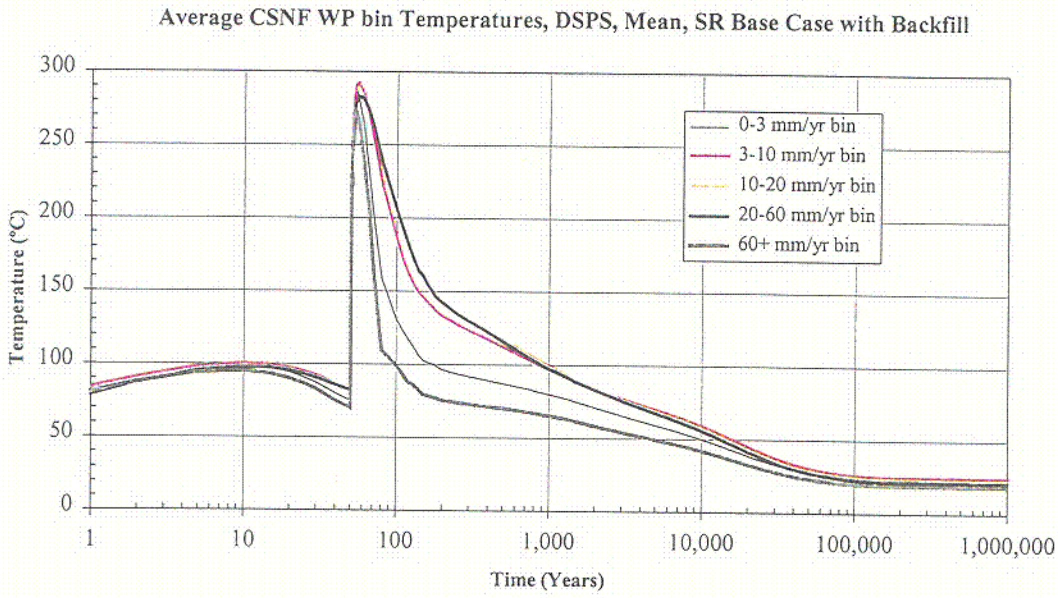
The five bin averaged waste package temperature time-histories for the mean infiltration flux case is presented in Figure 26. The maximum temperature for the bins were reached between 52 and 55 years and ranged from a low of 274°C for the 60+ mm/year bin to a high of 292°C for the 3-10 mm/year infiltration rate bin. The 0-3 and 60+ mm/year infiltration rate waste package bins cooled off the quickest as a result of the waste packages all being at the edges of the repository. The average temperatures returned to ambient conditions within 100,000 years.

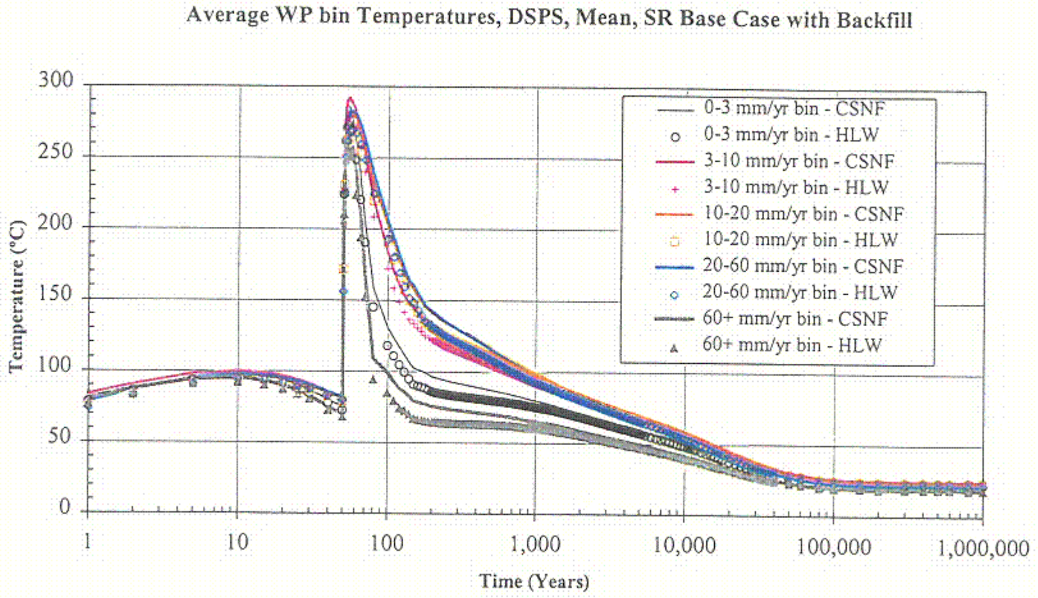


DTN: SN0001T0872799.006

Figure 26. The Average CSNF Waste Package Temperatures for the Mean Infiltration Rate Map Bins for the Base Case SR Design with Backfill

6.3.2 CSNF and HLW Waste Package Bin Temperature Comparison

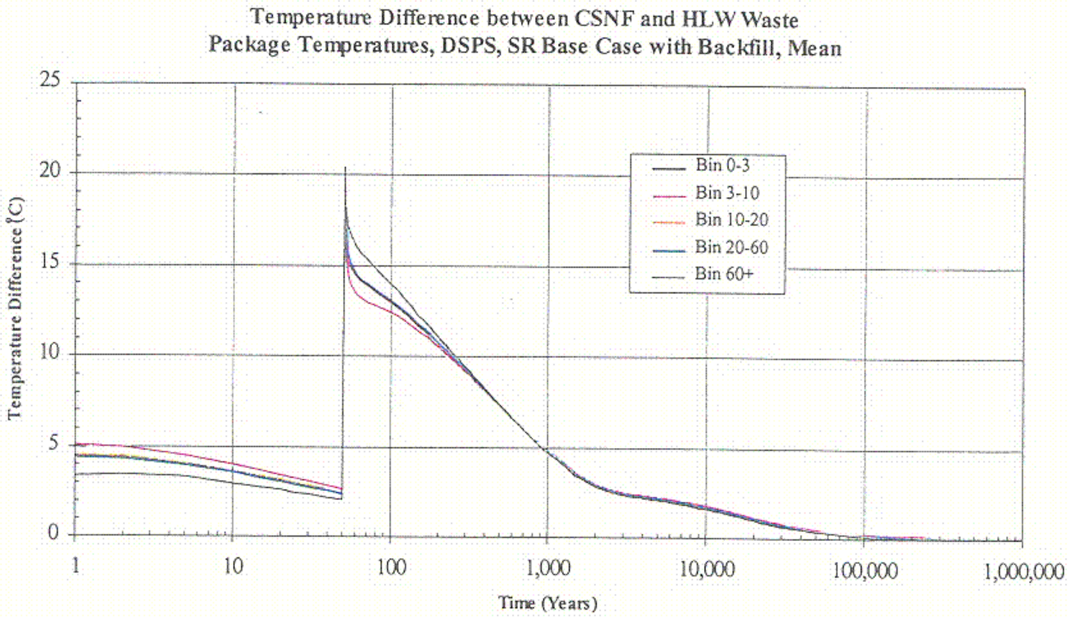
The average CSNF and HLW waste package bin temperatures for the mean infiltration rate are presented in Figure 27. There is a steep rise in temperatures at the time of repository closure (50 years) with peak maximum bin averaged temperatures of between 250 and 300°C. At 100 years after waste emplacement, there is much variability in the bin averaged temperatures from a low of 80°C (60+ mm/year HLW bin) to a high of 200°C (3-10 mm/year CSNF bin).



DTN: SN0001T0872799.006

Figure 27. The Average Waste Package Temperatures for Both the CSNF and HLW in Each of the Infiltration Bins for the Mean Infiltration Rate Map

Figure 28 contains the difference between the bin averaged CSNF and HLW waste package temperatures. The maximum difference between the CSNF and HLW packages is between 20 and 21°C for all three bins just after 50 years. After 100 years, the average CSNF waste package bin temperatures were 12 to 14°C higher than bin averaged HLW temperatures. This difference decreased to 10°C after 250 years, 5°C after 900 years and to 1°C after 22,000 years.



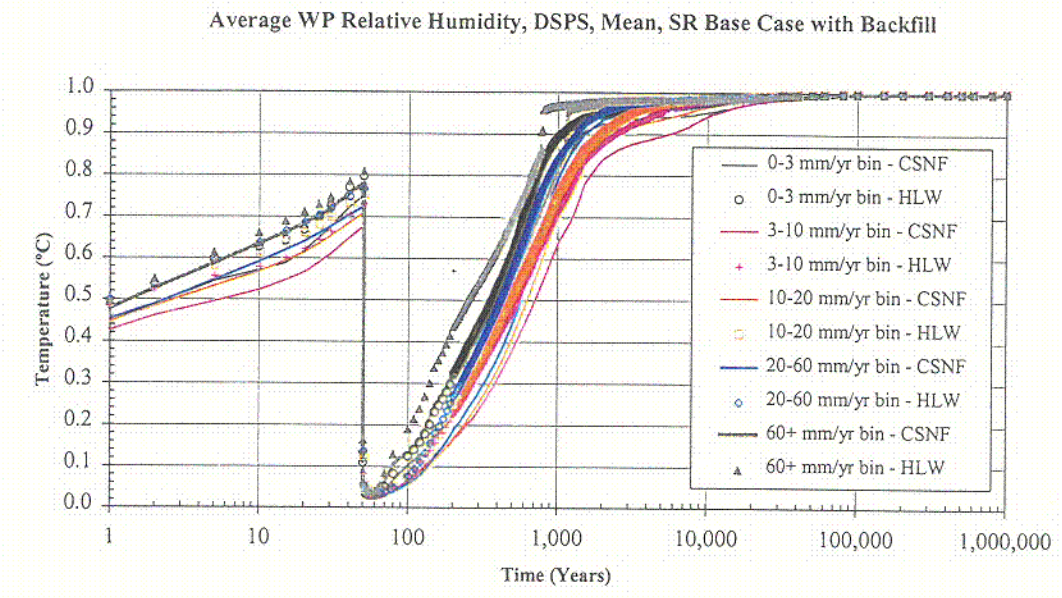
DTN: SN0001T0872799.006

Figure 28. The Temperature Difference Between the Average CSNF and HLW Waste Package Bin Temperatures for the Mean Infiltration Maps

6.3.3 CSNF and HLW Waste Package Bin Relative Humidity Comparison

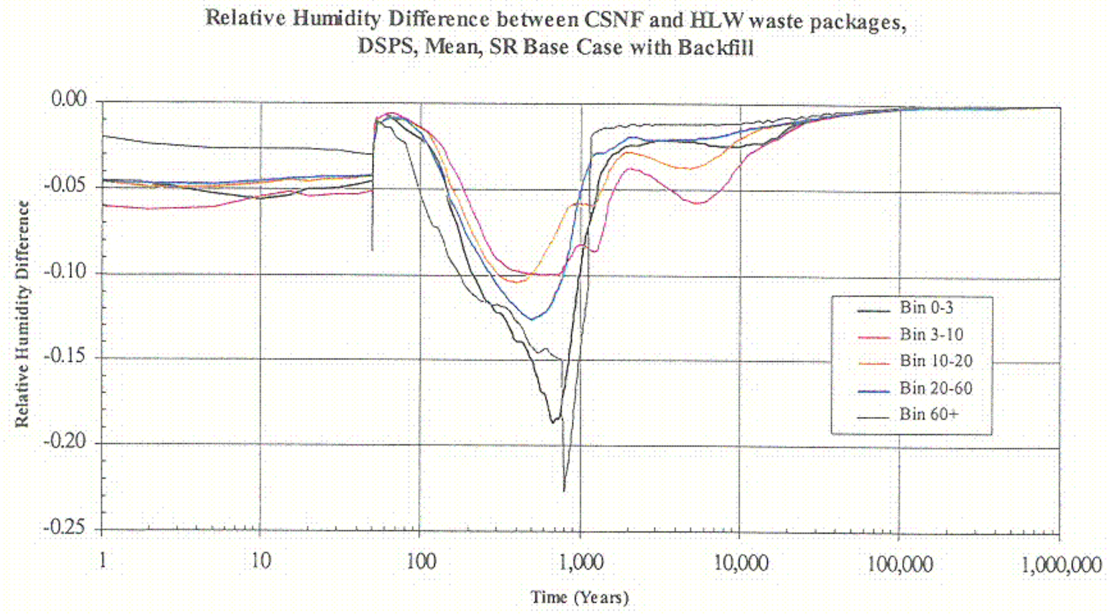
Figure 29 contains the relative humidity of the bin averaged CSNF and HLW waste packages for the mean infiltration flux map. The relative humidities reach a minimum right after closure between 50 and 70 years. The 0-3 mm/year and the 60+ mm/year bin relative humidities return to above 90% after between 780 and 1450 years. The last bin (3-10 mm/year CSNF bin) reaches 90% relative humidity after 6000 years.

Since the temperatures of the CSNF waste packages are always higher than those of the HLW waste packages, the relative humidity of the HLW waste packages is always higher than that for the corresponding CSNF waste package (see Figure 30). The difference between the HLW and the CSNF relative humidities is small at the time of closure when the absolute value of the relative humidities are at a minimum. The difference then increases reaching a maximum for different bins of 10% to 23% between 400 and 800 years. By 1200 years, the difference between all sets of curves dropped below 6%. At 10,000 years, the bin averaged RH differences varied between a high of 3.5% for the 3-10 mm/year bin to a low of 1.1% for the 60+ mm/year bin. After 100,000 years of simulation time, the differences had dropped below 0.23% in all five bins.



DTN: SN0001T0872799.006

Figure 29. The Average Waste Package Relative Humidity for Both the CSNF and HLW in Each of the Infiltration Bins for the Mean Infiltration Rate Map

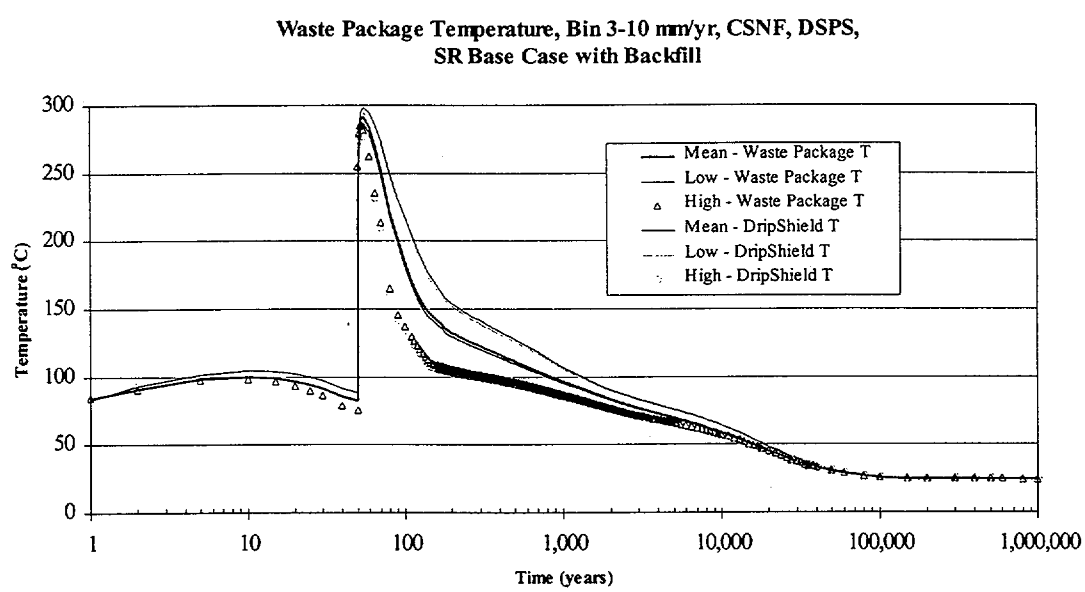


DTN: SN0001T0872799.006

Figure 30. The Difference in Relative Humidity Between the Average CSNF and HLW Waste Package Bin Temperatures for the Mean Infiltration Maps

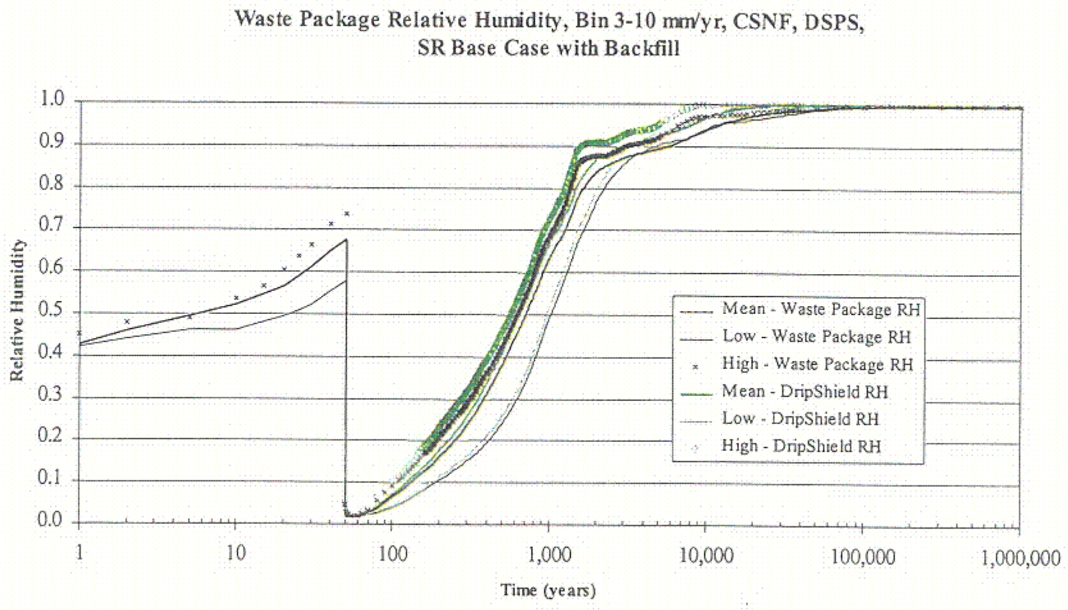
6.3.4 Comparison of Waste Package 3-10 mm/year Bin Averaged Temperatures and Relative Humidity for All Infiltration Flux Cases

The average waste package temperature and relative humidity time-histories for the 3-10 mm/year infiltration flux bin for all three infiltration cases are presented in Figure 31 and Figure 32. The 3-10 mm/year bin was the only infiltration flux bin that contained waste packages for each of the three infiltration flux cases.



DTN: SN0001T0872799.006

Figure 31. The 3-10 mm/year Infiltration Rate Bin Results for Waste Package and Drip Shield Temperatures for All Three Infiltration Flux Maps

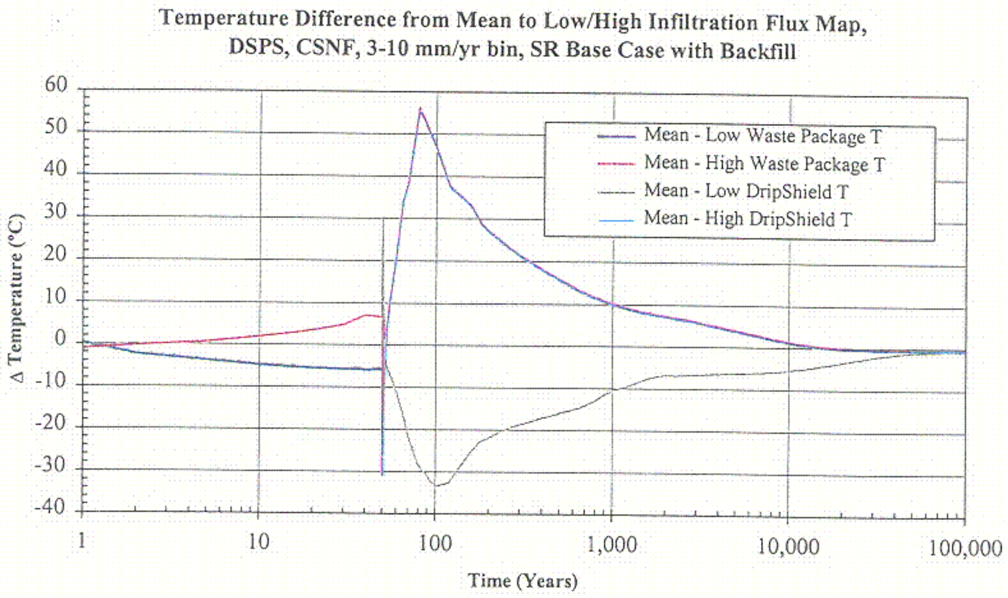


DTN: SN0001T0872799.006

Figure 32. The 3-10 mm/year Infiltration Rate Bin Results for Waste Package and Drip Shield Relative Humidities for All Three Infiltration Flux Maps

In Figure 31, the bin averaged waste package temperatures were higher for the drier infiltration flux cases. This result is caused by the spatial distribution of the waste packages in the three bins with the waste packages from the high infiltration flux case all concentrated next to the edge of the repository, the waste packages from the mean infiltration flux case having some in the center of the repository and others near the edge of the repository, and the waste packages from the low infiltration flux case having a large fraction of waste packages near the center and edge of the repository. The waste package relative humidity time histories for the 3-10 mm/year infiltration bins for all three infiltration maps are presented in Figure 32. The relative humidities bin averages all have minima between 1.74% to 1.96% at 55 to 60 years of simulation time. The bin averaged relative humidity curves are almost always are higher for the higher infiltration maps.

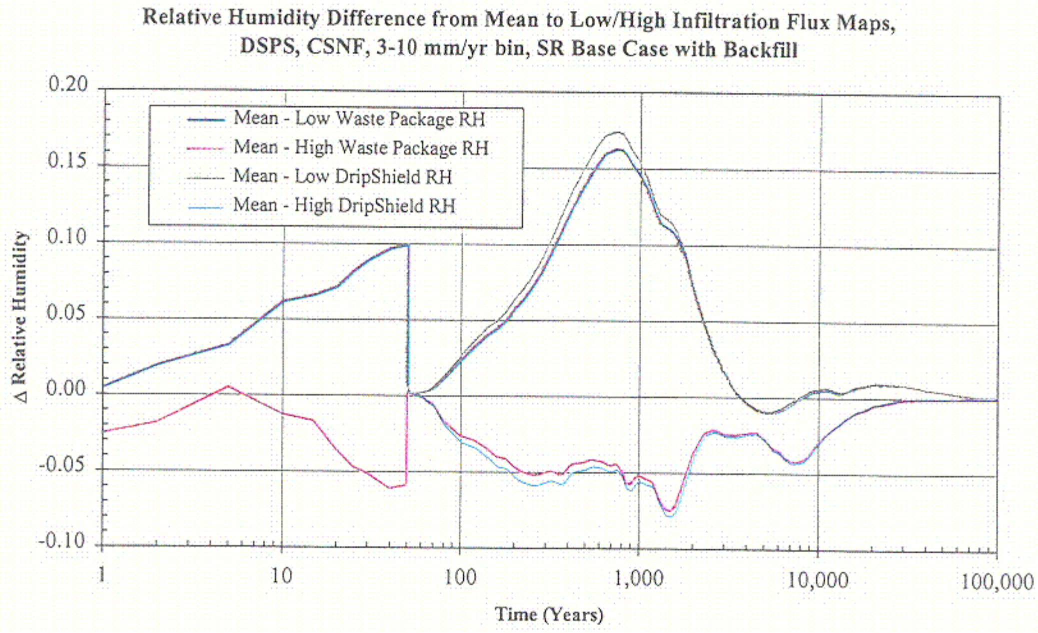
The difference between the bin averaged waste package and drip shield temperatures from the high and low to the mean infiltration maps are shown in Figure 33. The respective curves directly overlay each other (both curves for the mean-high overlay each other greater than zero, same for the mean-low less than zero). The maximum difference between the 3-10 mm/year bin averaged waste package temperatures from the mean and low and the mean and high infiltration maps was 55.9°C at 80 years and 33.5°C at 100 years, respectively. The difference between the high and low infiltration map temperatures drops to 20°C after 1000 years and to 10°C after 5000 years. These plots illustrate that there is considerable variability in the temperature time-histories within the same bin for different infiltration maps. The variability in temperature is a direct result of infiltration rate uncertainty (e.g., three infiltration flux cases).



DTN: SN0001T0872799.006

Figure 33. The Difference Between the Mean-Low and Mean-High Infiltration Flux Case Waste Package and Drip Shield Temperatures in the 3-10 mm/year Infiltration Rate Bin

The difference in relative humidity between the 0-3 mm/year bins is presented in Figure 34. The difference between the mean and the low bin averaged relative humidity curve was usually greater than the difference between the mean and the high bin averaged relative humidity curve. At repository closure with backfill (e.g., 50 years), the difference between the curves were within 0.2% of each other. The greatest bin averaged waste package relative humidity difference between the mean and the low curves was 16% at 750 years and the largest difference between the mean and high curves was 7.6% at 1500 years. The largest difference between the low and high curves was 21% at 850 years. The difference between the RH curves drops below 5% by 3000 years. These results show the variability between the same relative humidity infiltration bin for different infiltration rate maps. The variability in relative humidity is a direct result of infiltration rate uncertainty (e.g., three infiltration flux cases).

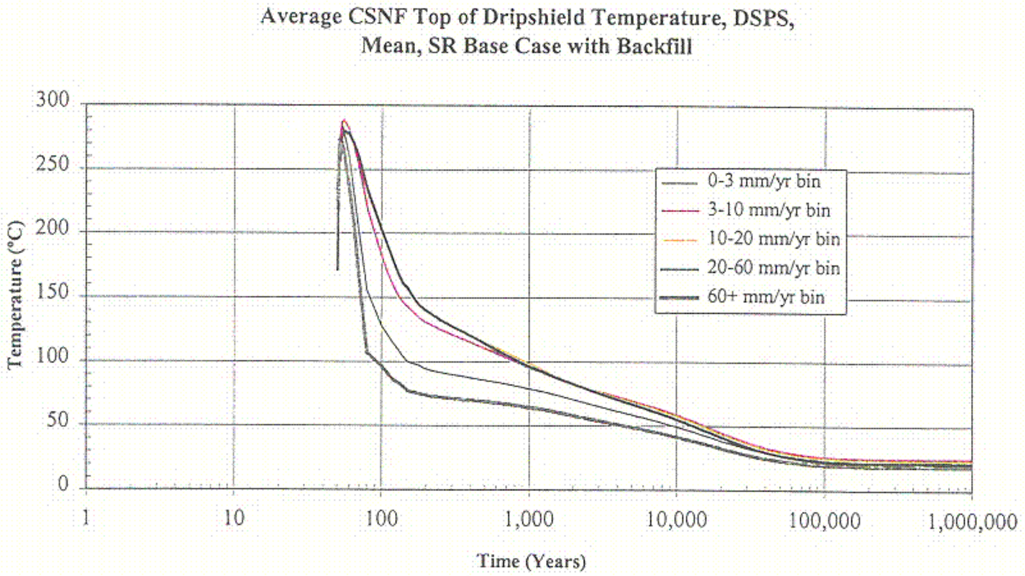


DTN: SN0001T0872799.006

Figure 34. The Difference Between the Mean-Low and Mean-High Infiltration Flux Waste Package and Drip Shield Relative Humidities in the 3-10 mm/year Infiltration Rate Bin

6.3.5 Temperature at the Top of the Drip Shield

The bin averaged temperature at the top of the CSNF drip shield for the mean infiltration flux case is presented in Figure 35. The temperature time-histories are similar to those for the CSNF waste packages only a few degrees cooler.

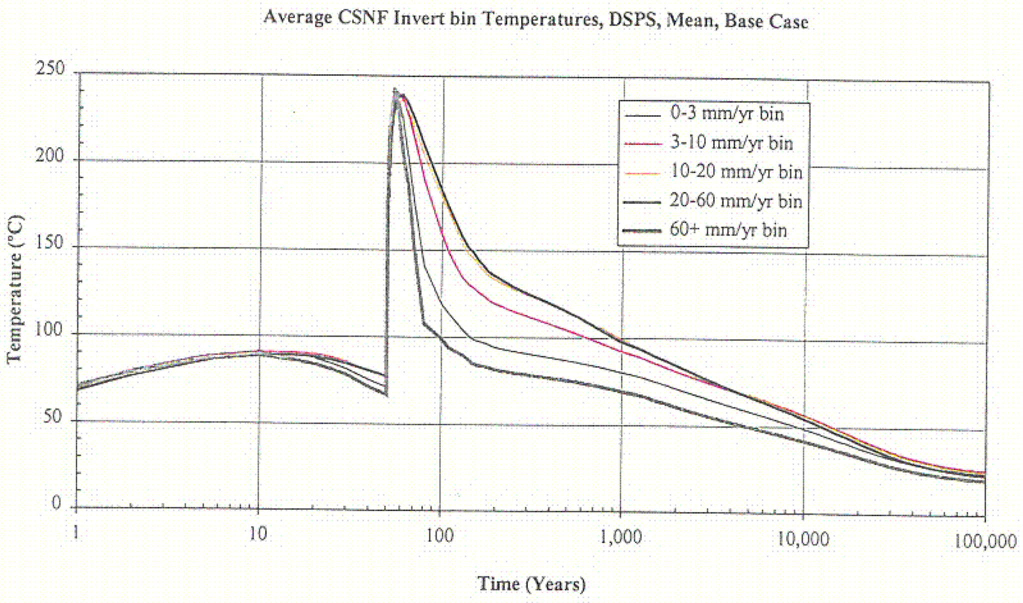


DTN: SN0001T0872799.006

Figure 35. The Bin Averaged Temperatures at the Top of the Drip Shield Near CSNF Waste Packages for the Mean Infiltration Rate Map and with the Backfill SR Design

6.3.6 Invert Thermodynamic Variables

The bin averaged CSNF invert temperatures for the mean infiltration flux case are presented in Figure 36. The invert temperature time-histories are cooler but contain the same trends that the waste package temperature curves. The peak temperatures for the five bins were between 236 and 243°C, which is approximately 40°C lower than those of the waste packages. The time that it takes for the invert to cool to 96°C range from 110 years for the 60+ mm/year infiltration bin to 1165 years for the 10-20 mm/year infiltration bin. The bin averaged CSNF invert relative humidity curves (Figure 37) also show the same trends as the waste package relative humidity curves. The bins all reach a minimum ranging from 0.026 and 0.031 between 55 and 60 years and all increase to 90% relative humidity within 1900 years. Since the invert temperatures are lower than the waste package temperatures, it expected that the relative humidity for the invert would recover to ambient values faster than the waste package values.



DTN: SN0001T0872799.006

Figure 36. The Bin Averaged Invert Temperatures Near CSNF Waste Packages for the Mean Infiltration Rate Map and with the Backfill SR Design

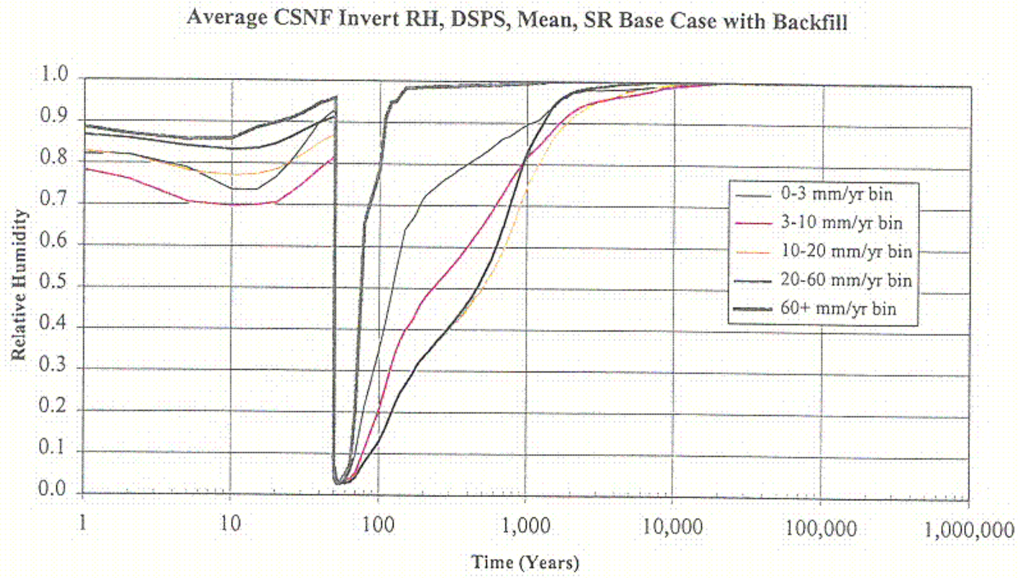


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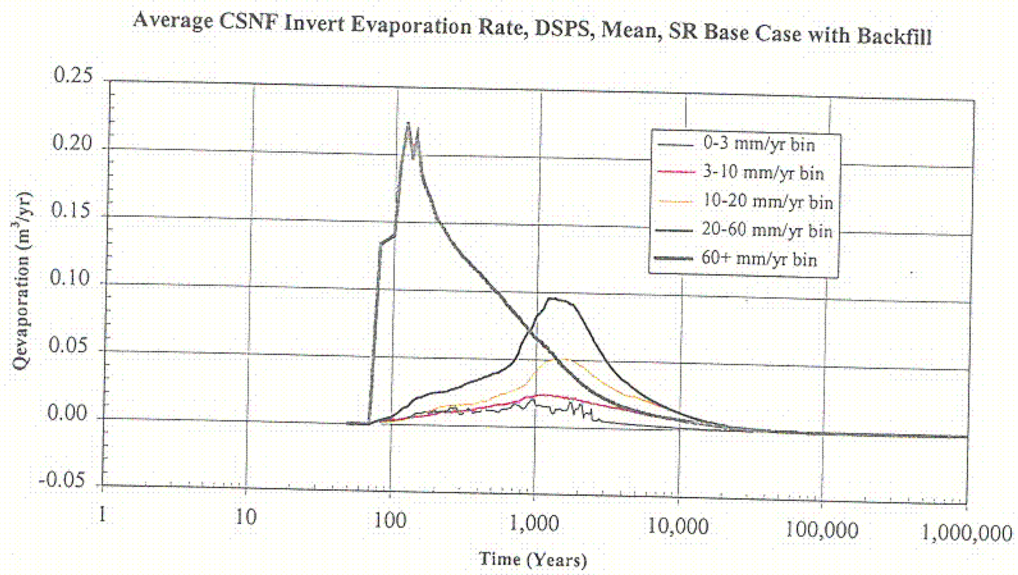
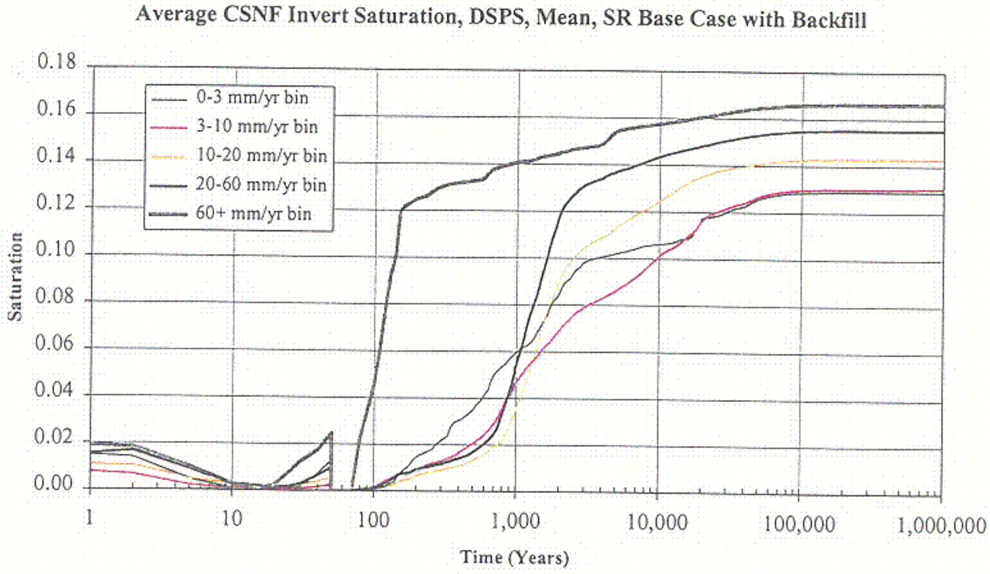
Figure 37. The Averaged CSNF Invert Relative Humidity for the Mean Infiltration Map for the SR Base Case Design with Backfill

The CSNF bin averaged invert evaporation rate and invert saturations for the mean infiltration case are presented in Figures 38 and 39. The invert evaporation rate immediately jumps when water is introduced into the invert (Figure 38). The evaporation rate for the 60+ mm/year infiltration rate bin peaks at 0.223 m^3/year/m-drift (610 ml/day/m-drift) at 120 years. The invert saturation drops during the first 20 years as a result of evaporation in the invert (Figure 39). The invert saturation time-histories recover just before 50 years but all drop to zero immediately following closure. The invert liquid saturation in all of the bins start to rise at 80 years although the 60+ mm/year bin liquid saturation rose to 4.5% at 100 years while the other four bins are all still below 0.2% after 100 years. The final invert saturations for the bins are different. This is a result of the higher percolation fluxes requiring higher saturations to allow the water to flow through the system. It takes the 60+ mm/year bin only 130 years to reach 50% of the final saturation, while it takes between 1290 and 1800 years for the other four bins to reach 50% of their final saturations. After 10,000 years, the evaporation rates have all dropped to below 0.013 m^3/year/m-drift (36 ml/day/m-drift).



DTN: SN0001T0872799.006

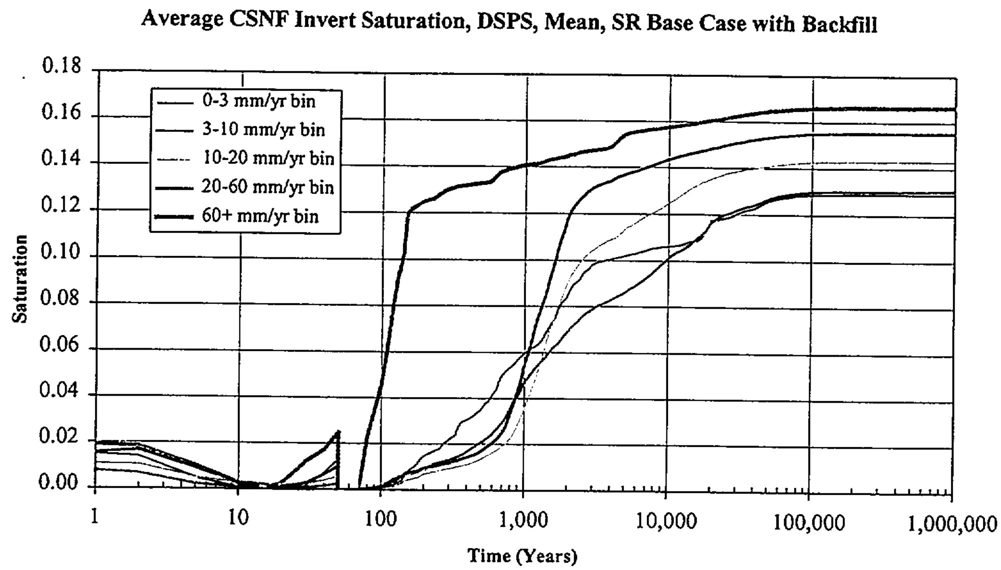
Figure 38. The Bin Averaged Evaporation Rate in the Invert Near a CSNF for the Mean Infiltration Map and Base Case SR Design with Backfill



DTN: SN0001T0872799.006

Figure 39. The Bin Averaged CSNF Invert Saturations for the Mean Infiltration Map for the SR Base Case Design with Backfill

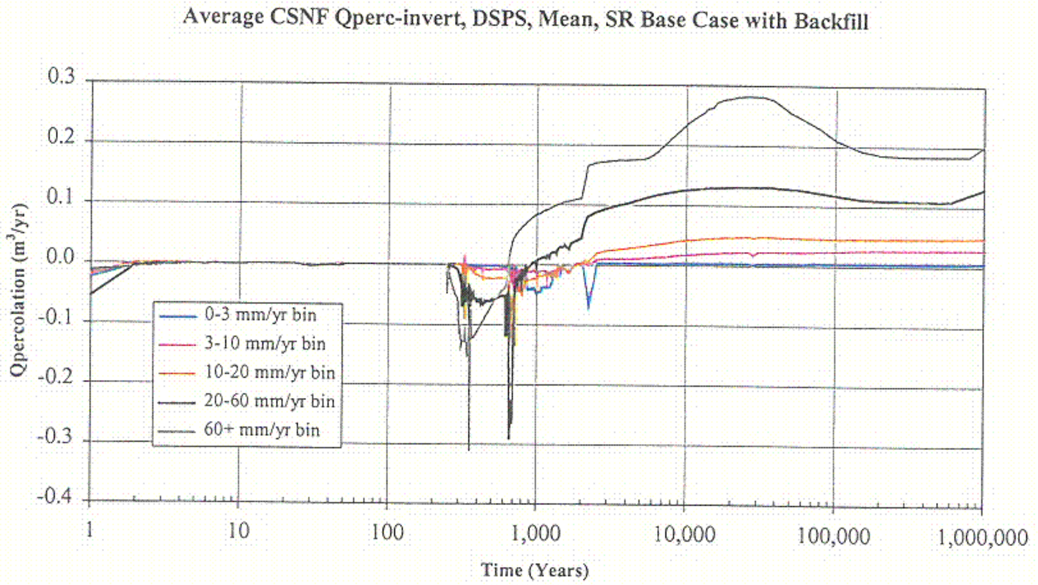
The bin averaged CSNF percolation flux in the invert is presented in Figure 40. The invert flux is small for the first 200 years after waste emplacement. The percolation flux is negative for the following several hundred years as water moves vertically upward to replace water that had evaporated in the invert. As the invert saturates, the percolation flux becomes positive as water begins to flow downward through the invert. The jump at 2000 years corresponds to the climate change from monsoonal climate to the higher infiltration rate glacial climate.



DTN: SN0001T0872799.006

Figure 39. The Bin Averaged CSNF Invert Saturations for the Mean Infiltration Map for the SR Base Case Design with Backfill

The bin averaged CSNF percolation flux in the invert is presented in Figure 40. The invert flux is small for the first 200 years after waste emplacement. The percolation flux is negative for the following several hundred years as water moves vertically upward to replace water that had evaporated in the invert. As the invert saturates, the percolation flux becomes positive as water begins to flow downward through the invert. The jump at 2000 years corresponds to the climate change from monsoonal climate to the higher infiltration rate glacial climate.

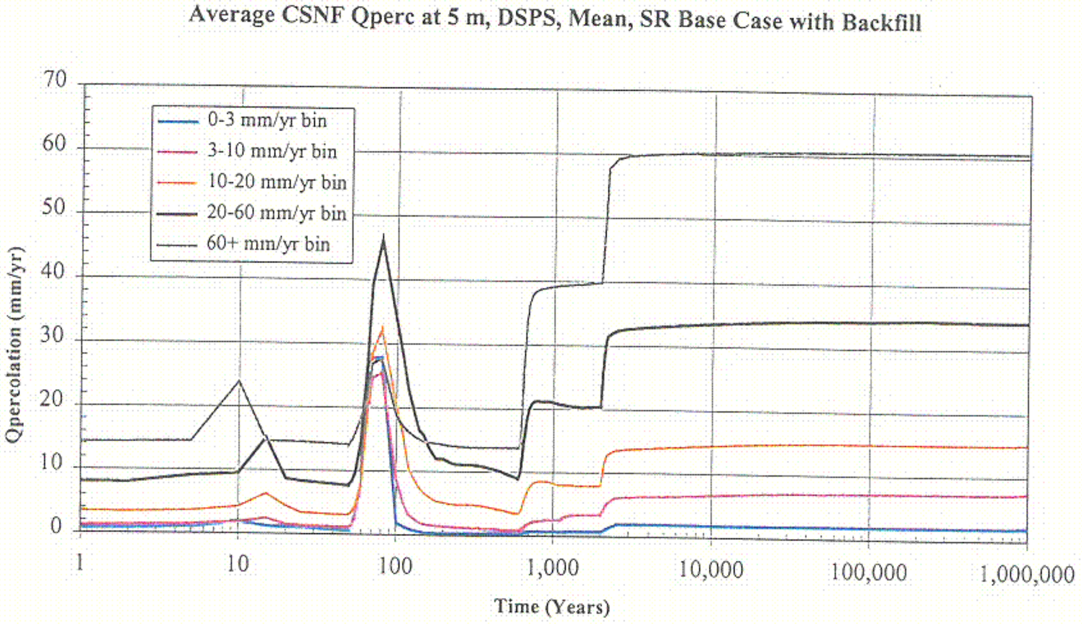


DTN: SN0001T0872799.006

Figure 40. Average Percolation Flux in the Invert for a CSNF Waste Package for the Mean Infiltration Map and the SR Base Case Design with Backfill

6.3.7 CSNF Percolation Flux 5 Meters Above Drift

The bin averaged CSNF percolation flux 5 m above the drift is presented in Figure 41. This variable is used to provide input into the seepage model in TSPA. The percolation flux has peaks both before and after closure and two jumps corresponding to the monsoonal climate change at 600 years and the glacial transition climate at 2000 years.

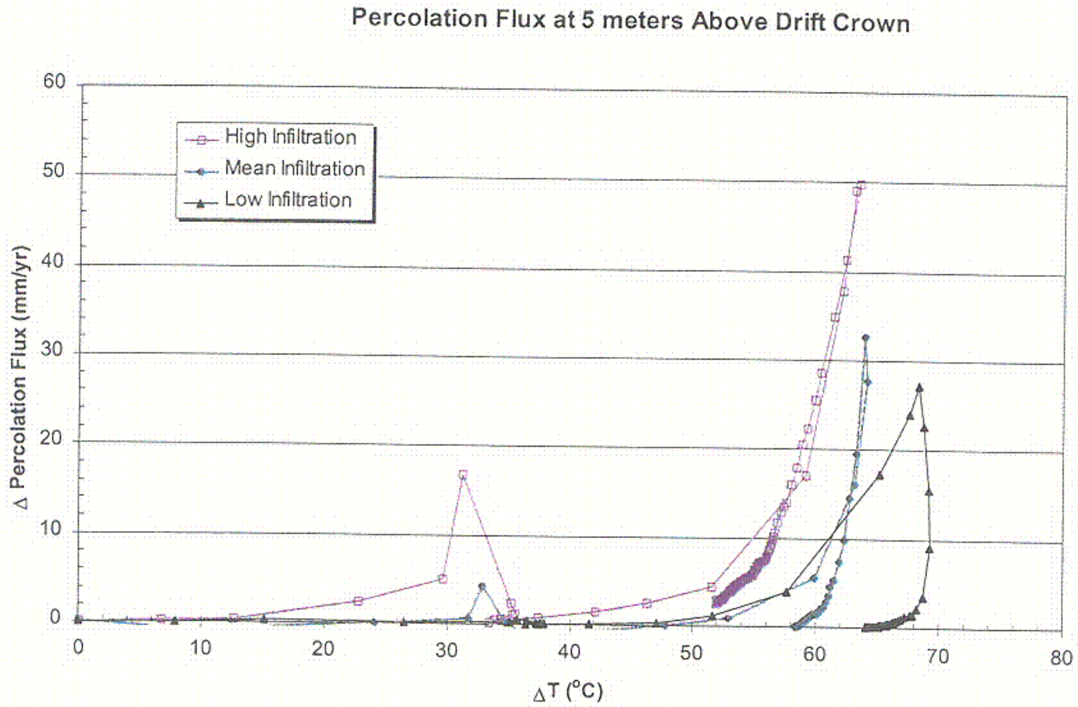


DTN: SN0001T0872799.006

Figure 41. The Bin Averaged CSNF Percolation Fluxes 5 m Above the Top of the Crown for the Mean Infiltration Map for the SR Base Case Design with Backfill

Since seepage onto the waste package is related to the percolation flux, it is important to understand how the thermal pulse from the waste packages affect the percolation flux. Figure 42 shows the change in percolation flux at 5 m versus the change in temperature at 5 m for each of the three infiltration flux cases (e.g., low, mean, and high). The change in percolation flux is defined as the percolation flux minus the ambient (present day) percolation flux and the change in temperature is defined as the temperature minus the ambient temperature. It is noted that this curve is representative of the present day climate only (the first 600 years after waste emplacement are plotted in the figure). This is primarily because the future climate states overwhelm the changes in percolation flux at about their onset. That is, heat driven processes are flooded by the increases in percolation flux due to climate change. The overall average result for each infiltration flux case (low, mean, and high) shown in the figure is based on each of the individual infiltration bins using the repository area fractions given in Table 5. Therefore, the variability associated with each of the curves in Figure 42 is described by a set of curves representative of the infiltration bins in a given infiltration rate case (e.g., the low infiltration rate case contains two curves that form the basis of the overall average curve given in the figure). A specific infiltration bin (e.g., 0-3 mm/yr curve in the low infiltration rate case) is representative of an average of a family of curves that reside at locations that have a glacial climate infiltration rate that places them in a specific bin (e.g., 368 total curves reside in the

0-3 mm/yr bin for the low infiltration rate case with one curve as the resulting average for the bin). Consequently, the range given in the figure is representative of the overall average uncertainty in the increase in percolation flux (at this location in the host rock) driven by heat addition due to the repository output.



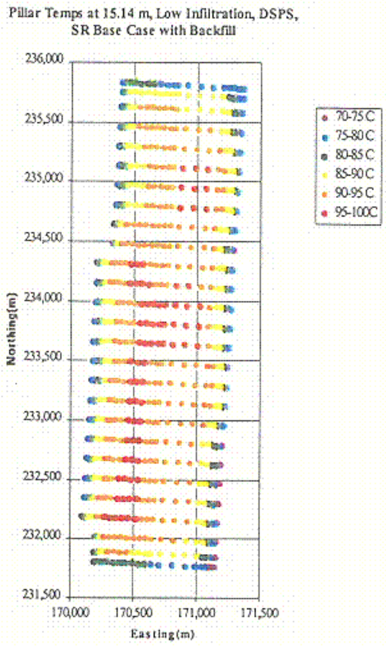
DTN: SN0001T0872799.006

Figure 42. Overall Change in Percolation Flux as a Function of Changes in Temperature at 5 m Above the Emplacement Drift Crown

This figure illustrates how much (more or less than ambient) water flows through this location as a result of heat addition to the host rock. (Only the changes in percolation flux greater than or equal to ambient are shown in the figure—the positive changes that indicate enhanced percolation flux driven only by the thermal perturbation.) This curve indicates two pulses of water through the system. The first occurs when the temperature difference is between 30 and 35°C, the second when the temperature difference is between 50 and 70°C above ambient. The first pulse of water occurs at 10 to 20 years at this location in the host rock and represents initial heating during the preclosure period. The second pulse occurs after backfill is emplaced and full power heating commences, between 50 and 200 years. After the first future climate change occurs at 600 years, the thermal perturbation maintains elevated temperatures in the host rock. The future climate change drives the percolation rate at 5 m above the crown of the emplacement drift up to ambient values approximately 200 years after the change in climate. It is this overall variability (and uncertainty from differing infiltration rate cases) shown in Figure 39 that is input directly into to the TSPA seepage model used to compute the seepage volume flow rate and the fraction contacted by seeps. Therefore, the enhanced seepage driven by heat input is included in the TSPA model calculation of seepage volume flow rate.

6.3.8 Pillar Temperatures in Repository

The pillar temperatures indicate how quickly the heat from the waste packages is able to diffuse into the rock. If the temperature of the rock goes above the local boiling temperature of 96°C, then water, either condensate or infiltrating, may not be able to drain through the superheated pillar as easy as it would in a subcooled pillar. Figures 43 and 44 show the maximum pillar temperature at the 623 waste package locations at two different pillar locations (15.14 and 22.64 meters from the center of the drift) for the low infiltration map. The low infiltration case map is shown here since the pillar temperatures are the highest for this case. The half-distance between drift centerlines is 40.5 meters so the two different pillar locations lie on each side of the quarter-pillar location.



DTN: LL000113904242.089

Figure 43. Maximum Temperatures at 15.14 Meters from the Drift Centerline for the Low Infiltration Flux Case

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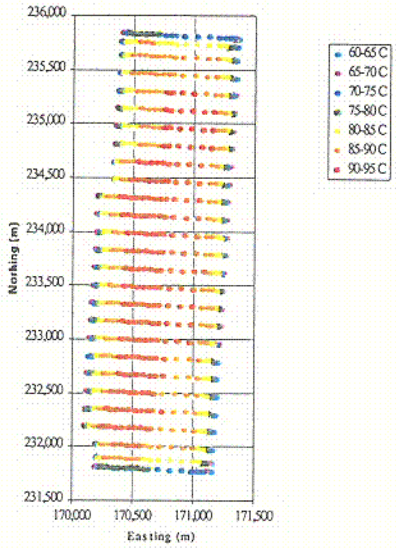

DTN: LL000113904242.089

Figure 44. Maximum Temperatures at 22.64 Meters from the Drift Centerline for the Low Infiltration Flux Case

At the 15.14 meter pillar location, the maximum pillar temperatures reach the highest values of 97°C in the center of the repository and with the lowest value of 72°C at the edge of the repository. The temperatures reach maximum values at the edge of the repository between 55 and 70 years while closer to the center of the repository, the maximum temperatures are reached at a much later time of between 400 and 700 years. At the 22.64 meter location, the maximum pillar temperatures range from 61 to 91°C. The maximum temperatures are lower for the 22.64 meter location because of a larger volume of rock being heated. The time to maximum temperatures are somewhat higher as a result of the longer distance that the waste package heat needs to diffuse. The time to maximum temperature ranges from 65 to 120 years at these locations. The 65 year maximum represents 15.14 meter pillar location, 120 year maximum represents the 22.64 meter location. Taken together, these plots show that less than half of every pillar is expected to ever exceed the local boiling temperature.

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6.4 ANALYSIS CONFIDENCE FOR INTENDED USE

The use of infiltration bin averaged TH values (see Table 4) as obtained from the TH abstraction routine described in Attachment I of this AMR are considered a valid abstraction method for the following reasons: (1) The infiltration bin averaged values preserve and highlight the overall variability and uncertainty in the variables used to describe the thermal-hydrologic performance of a geologic repository (refer to all figures in Section 6.3). (2) In the instances where the average value may overwhelm salient features of TH variable (e.g., the maximum waste package temperature), the process model results are also input directly into the TSPA model. For example, in addition to the average curve, the abstraction routine provides the maxmium peak and the minimum peak waste package temperature curves in each of the predefined infiltration bins. Subsequently, the waste package temperature variability within each of the infiltration bins is included. Since each infiltration flux case is also included in this abstraction, uncertainty defined in the UZ flow fields is identically maintained in the thermal hydrology. (3) The percolation flux at 5 m above the crown of the drift is input as repository footprint location dependent data. An average value is not used for the percolation flux so that complete variability (repository location, repository host unit, and proximity to repository edge) and uncertainty (infiltration flux cases: low, mean, and high) may be incorporated in the TSPA seepage model. (4) The TSPA corrosion model uses process model results directly as a model input, thus capturing in the abstraction the potential variability and uncertainty included in the process model. Direct location dependent inputs to the TSPA model are given in Table 3.

7. CONCLUSIONS

This AMR provides the abstraction of the process-level model that determines the in-drift thermodynamic environment and percolation flux at the crown of the drift. The in-drift environment (temperature, relative humidity, etc.) is an essential component for the waste package corrosion model, the in-drift geochemical environment, and the engineered barrier system transport model (all contained within the TSPA model). Additionally, the abstracted crown percolation flux (both ambient and thermally driven) provide input into the TSPA model that is used to calculate the seepage volume flow rate and fraction of waste packages (or drip shield) contacted by seeps. The TSPA model uses both location dependent TH data (Table 3) and infiltration rate averaged TH data (Table 4).

The abstraction results of this AMR provide an indication of the variability and uncertainty in the TH parameters that are used to describe the geologic system during a thermal perturbation. These TH parameters drive the eventual corrosion of the components of the EBS. The variability is obtained at 623 different locations within the repository footprint. It includes edge effects, infiltration rate variability (a boundary condition), host rock variability, and overburden thickness variability. TH uncertainty is captured in the infiltration flux cases considered by TSPA. Each infiltration flux case represents a potential ambient UZ flow solution of the geologic system. These infiltration flux cases form the basis for TH calculations using specified hydrologic property sets and infiltration rates. The range of possible outcomes in EBS temperature and NFE percolation flux span a broad range from low to high infiltration rate cases. All of the above can be described for a single repository design. They may also be used to describe a variety of different design options. This AMR focuses on 50 year preclosure ventilation case with 70% heat removal efficiency. It includes backfill and drip shield emplacement at repository closure at 50 years. In order to determine how corrosion may occur for waste packages at different repository locations, the footprint of the repository is subdivided into zones in which the abstraction analyses occur. The zones, defined by infiltration rate ranges, were selected so that each bin would represent the averaged waste package location TH characteristics based on the potential percolation fluxes at the emplacement drifts.

The infiltration bins result in average and waste package location dependent (represented by area fraction weight) TH data that can be used to characterize the impact of heat addition on a geologic system and the EBS. The bins inherently include the variability discussed above (e.g., the 623 different location dependent results and their averages). As is expected, the waste package surface temperatures are, on average, hotter for the low infiltration rate case and cooler for the high infiltration rate case. Since the waste package relative humidity is correlated to the temperature, higher temperatures result in lower relative humidities. At locations in the repository where EBS components remain hot for long periods of time that may also have a high relative humidity (e.g., regions near the repository center in which the percolation flux may be high), an environment most conducive to corrosion may be produced. The infiltration-binned averages preserve the influence of edge cooling on the average waste package temperature. In both the mean and the high infiltration rate cases, the lowest infiltration rate bin (0-3 mm/yr bin mean and the 3-10 mm/yr bin high) averaged temperatures peak at high temperatures (due to the low infiltration rate) yet drop sharply thereafter due to lateral heat loss to surrounding unheated rock masses. For the highest infiltration bin, 60+ mm/yr, in the mean infiltration rate case (all edge locations), the peak average temperature is low with a rapid drop-off in temperature thereafter. This is expected for an extreme edge location situated under a very high infiltration rate. Edge cooling plays an important part in the abstraction. At the repository edges, temperatures peak sooner and at much lower values. Cooling is rapid such that relative humidity is high for longer time periods and liquid saturations at edge locations are also higher (much less dryout). For the 60+ mm/yr bin in the high infiltration rate case, the average temperature peaks at the lowest of the four bin averaged results; however, the cooling trend is not so rapid as many of the entries in this bin for this uncertainty case are located near the center of the repository. The long-term relative humidity of these locations will be important in the corrosion model. For this bin in the high infiltration rate case, the temperature remains high for a long period while its relative humidity rapidly increases.

The TH results given in Tables 6 and 7 and in Figures 21 through 44 characterize the abstraction data included in DTN: SN0001T0872799.006. The abstraction data as presented in this AMR and contained in the DTN include variability in infiltration rate as it varies over the repository footprint, variability in repository host rock (3 host units included in the results), variability in overburden thickness, and variability due to proximity to repository edges. Uncertainty included in the abstraction of TH data is specified by UZ flow and transport and is for infiltration rate and hydrologic property uncertainty (3 infiltration flux cases and property sets: low, mean, and high). Uncertainties in thermal properties are neglected since their measured uncertainties are much smaller than the estimates of hydrologic property and infiltration rate uncertainties. For example, laboratory measurements of rock thermal conductivity are far more precisely measured than the uncertainty range can be characterized for the fracture van Genuchten alpha parameter. The abstracted data for the infiltration rate bin averages of drift wall temperature and relative humidity are contained in DTN: SN0002T0872799.008. These data also characterize the same variability and uncertainty as described above.

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8. INPUTS AND REFERENCES

8.1 REFERENCES CITED

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NRC (U.S. Nuclear Regulatory Commission) 1998. *Issue Resolution Status Report Key Technical Issue: Total System Performance Assessment and Integration*. Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.19990105.0083.

8.2 DATA INPUT, LISTED BY DATA TRACKING NUMBER

LL000113904242.089. TSPA-SR Lower Calculations. Submittal date: 01/28/2000.

LL000114004242.090. TSPA-SR Mean Calculations. Submittal date: 01/28/2000.

LL000114104242.091. TSPA-SR Upper Calculations. Submittal date: 01/28/2000.

8.3 DATA OUTPUT, LISTED BY DATA TRACKING NUMBER

SN0001T0872799.006. In-Drift Thermodynamic Environment and Percolation Flux. Submittal date: 01/27/2000.

SN0002T0872799.008. Infiltration Bin Averaged Drift Wall Temperature And Relative Humidity. Submittal date: 02/01/2000.

SN9912T0511599.002. Revised Seepage Abstraction Results For TSPA-SR (Total System Performance Assessment-Site Recommendation). Submittal date: 12/15/1999.

8.4 SOFTWARE ROUTINES

TH-msmabs_ver_1. Version 1.0. (Included with DTN: SN0001T0872799.006).

maxtwp. Versions 1.00, 1.01, 1.02. (Included with DTN: SN0001T0872799.006).

pillart. Version 1.00. (Included with DTN: SN0001T0872799.006).

8.5 PROCEDURES

AP-3.10Q, Rev. 2, ICN 0. *Analysis and Models*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000217.0246.

AP-SI.1Q, Rev. 2, ICN 4. *Software Management*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000223.0508.

QAP-2-0, Rev. 5, ICN 0. *Conduct of Activities*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980826.0209.

QAP-2-3, Rev. 10. *Classification of Permanent Items*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990316.0006.

NLP-2-0, Rev. 5. *Determination of Importance Evaluations*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981116.0120.

9. ATTACHMENTS

Table 8. List of Attachments

ATTACHMENT	TITLE	NUMBER OF PAGES
I	TH Abstraction Routine (TH-msmabs_ver_1)	39
II	TH Abstraction Routine (pillart)	4
III	TH Abstraction Routine (maxtwp)	7

Attachment I
TH Abstraction Routine
(TH-msmabs_ver_1)

The following is the listing of the software routine TH-msmabs_ver_1 which is used to abstract the multiscale TH data. The routine can be found in DTN: SN0001T0872799.006 in the compressed file source_routine.ZIP. This routine needs the following input files to run properly: inputs_for_routines.ZIP. For example, the mean infiltration flux case requires the file names csnfmean and THabstraction.fil to run. Note the ZIP file contains the file name THabstraction.fil-csnfmean to denote it from the other cases. The variable name (-csnfmean) should be removed before running the routine. The routine produces the output files contained in the ZIP files submitted to the TDMS: csnf_low-RIP.ZIP, csnf_mean-RIP.ZIP, csnf_high-RIP.ZIP, hlw_low-RIP.ZIP, hlw_mean-RIP.ZIP, hlw_high-RIP.ZIP, abs_qliq_inv.ZIP, and T_rh-dw.zip.

```
c2345678901234567890123456789012345678901234567890123456789012345678901

c....This computes averages directly from the multiscale model results
c    for TSPA-SR.  This will place resultant files into appropriate
c    infiltration bins as specified by the TCT.
c    raw values given by LLNL
c    ndf 4/3/98-original file for TSPA-VA, LADS
c....ndf 10/12/99-modified for TSPA-SR
c....ndf 10/99-12/99 various changes for RIP including time stepping
c     control based on rates of changes on T and q.liquid 5m
c    change top dripshield and invert q.liquid to volume flow rate
c
c
c
c     Input the number of time points in the LLNL file so that
c     the correct number of data points within the file can be
c     processed.
C
C.....The required input is a value for $npts$.  This value must be
C     input before compilation of the source code
C
c.....The required input is a value for $ninf$.  This value specifies
c     the number of infiltration bins and it must be input before
c     complilation of the source code.  An example: is for ninf =2.
c     in this case the bins may look like 0 - 25 mm/yr for the bin 1
c     and > 25 mm/yr for bin 2
c
c
        parameter(npts=442, ninf=5, nbinm=650)
C
      implicit double precision (a-h,l,o-z)
      character*4 name
      character*10 label
      character*80 infile1
      character*80 infile2
      character*80 infile3
      character*80 infile4
      character*80 outfile(ninf)
      character*80 resultsbinfile(ninf)
      character*80 resultsbinfile2(ninf)
      character*80 resultsbinfile2p(ninf)
      character*80 resultsbinfile3(ninf)
      character*80 resultsbinfile3a(ninf)
      character*80 resultsbinfile3b(ninf)
      character*80 resultsbinfile4(ninf)
      character*80 resultsbinfile5(ninf)
      character*80 resultsbinfile6(ninf)
      character*80 resultsbinfile7(ninf)
      character*80 resultsbinfile8(ninf)
```

```
      character*80 resultsbinfile9(ninf)
      character*80 resultsbinfile10(ninf)
      character*80 resultsbinfile11(ninf)


      character*12 nmeinf
      character*80 xinfillabel
      character*80 ch
c
c.....infile1 opens the large file containing waste packages of the same type
c     infile2 file names contained within an infiltration bin for bin averages
c     infile3 file names contained within the large file
c     infile4 file names contained within an infiltration bin for bin area weight
c     outfile file names sorted into appropriate infiltration bins
c     resultsbinfile name of the resulting file for average quantities
c     resultsbinfile2 name of the resulting file for raw values for RIP
c     resultsbinfile3 name of the resulting file for average values for RIP
c
c
c
c.....The format of value X(i,j) is the following:
c     i = the number of entries in an infiltration bin
c     j = the number of time entries within an input file inside the
c         the infiltration bin
c
c23456789012345678901234567890123456789012345678901234567890123456789012
        dimension timeyr(npts), PAwpT(nbinm,npts), PAwpRH(nbinm,npts),
     @ PAdsT(nbinm,npts), PAdsRH(nbinm,npts),PAwpT1a(npts),
     @ PAwpRH2a(npts),
     @ PAdsT3a(npts), PAdsRH4a(npts), T_wp(nbinm,npts),
     @ T_5m(nbinm,npts),
     @ T_bfpk(nbinm,npts), T_ds(nbinm,npts), T_dw(nbinm,npts),
     @ T_inv(nbinm,npts), T_dwlow(nbinm,npts), RH_dw(nbinm,npts),
     @ RH_bfp(nbinm,npts), RH_ds(nbinm,npts), RH_wp(nbinm,npts),
     @ RH_inv(nbinm,npts), Sl_dw(nbinm,npts), Sl_ds(nbinm,npts),
     @ Sl_inv(nbinm,npts), ql_5m(nbinm,npts), ql_3m(nbinm,npts),
     @ ql_dw(nbinm,npts), ql_dsT(nbinm,npts), ql_dsS(nbinm,npts),
     @ ql_inv(nbinm,npts), xa_ds(nbinm,npts), P_ds(nbinm,npts),
     @ Pc_ds(nbinm,npts), Pc_inv(nbinm,npts), PcM_dw(nbinm,npts),
     @ PcF_dw(nbinm,npts), qw_dw(nbinm,npts), qa_dw(nbinm,npts),
     @ qvpdsT(nbinm,npts), qvpdsP(nbinm,npts), qvpbfp(nbinm,npts),
     @ qvpinv(nbinm,npts), T_wp1a(npts), T_5m2a(npts), T_bfpk3a(npts),
     @ T_ds4a(npts), T_dw5a(npts), T_inv6a(npts), T_dwlow7a(npts),
     @ RH_dw1a(npts), RH_bfp2a(npts), RH_ds3a(npts), RH_wp4a(npts),
     @ RH_inv5a(npts), Sl_dw1a(npts), Sl_ds2a(npts), Sl_inv3a(npts),
     @ ql_5m1a(npts), ql_3m2a(npts), ql_dw3a(npts), ql_dsT4a(npts),
     @ ql_dsS5a(npts), ql_inv6a(npts), xa_ds1a(npts), P_ds1a(npts),
     @ Pc_ds1a(npts), Pc_inv2a(npts), PcM_dw3a(npts), PcF_dw4a(npts),
     @ qw_dw1a(npts), qa_dw2a(npts),qvpdsT1a(npts), qvpdsP2a(npts),
     @ qvpbfp3a(npts), qvpinv4a(npts), qinf0(ninf), facttb(ninf),
     @ factbin(ninf,nbinm), PAwpTf(nbinm,npts), PAwpRHf(nbinm,npts),
     @ PAdsTf(nbinm,npts), PAdsRHf(nbinm,npts), T_wpf(nbinm,npts),
     @ T_5mf(nbinm,npts),
     @ T_bfpkf(nbinm,npts), T_dsf(nbinm,npts), T_dwf(nbinm,npts),
     @ T_invf(nbinm,npts), T_dwlowf(nbinm,npts), RH_dwf(nbinm,npts),
     @ RH_bfpf(nbinm,npts), RH_dsf(nbinm,npts), RH_wpf(nbinm,npts),
     @ RH_invf(nbinm,npts), Sl_dwf(nbinm,npts), Sl_dsf(nbinm,npts),
     @ Sl_invf(nbinm,npts), ql_5mf(nbinm,npts), ql_3mf(nbinm,npts),
     @ ql_dwf(nbinm,npts), ql_dsTf(nbinm,npts), ql_dsSf(nbinm,npts),
     @ ql_invf(nbinm,npts), xa_dsf(nbinm,npts), P_dsf(nbinm,npts),
     @ Pc_dsf(nbinm,npts), Pc_invf(nbinm,npts), PcM_dwf(nbinm,npts),
     @ PcF_dwf(nbinm,npts), qw_dwf(nbinm,npts), qa_dwf(nbinm,npts),
     @ qvpdsTf(nbinm,npts), qvpdsPf(nbinm,npts), qvpbfpf(nbinm,npts),
     @ qvpinvf(nbinm,npts), TavgRIP(ninf,npts), S_lavgRIP(ninf,npts),
     @ ql_5mavgRIP(ninf,npts), noent(ninf), Tdstop(nbinm,npts),
     @ Tdstopf(nbinm,npts), Tdstop8a(npts), ql_dsTagf(nbinm,npts),
     @ ql_dsTag(nbinm,npts), ql_dsTag7a(npts),Tpl299f(nbinm,npts),
     @ Tpl299(nbinm,npts), Tpl369f(nbinm,npts), Tpl369(nbinm,npts),
     @ Tpl489f(nbinm,npts), Tpl489(nbinm,npts),
     @ Tpl689f(nbinm,npts), Tpl689(nbinm,npts), Tpl1014f(nbinm,npts),
     @ Tpl1014(nbinm,npts), Tpl1514f(nbinm,npts), Tpl1514(nbinm,npts),
     @ Tpl2264f(nbinm,npts), Tpl2264(nbinm,npts), Tpl3382f(nbinm,npts),
     @  Tpl3382(nbinm,npts), Tpl2991a(npts), Tpl3692a(npts),
     @ Tpl4893a(npts), Tpl6894a(npts), Tpl10145a(npts), Tpl15146a(npts),
     @ Tpl22647a(npts), Tpl33828a(npts), coord1(ninf,nbinm),
```

```
     @ coord2(ninf,nbinm), Tmaxrip(ninf,npts), RHavgRIPin(ninf,npts),
     @ TavgRIPinv(ninf,npts), qvpavgRIPinv(ninf,npts), Tmax_min(nbinm),
     @ Tminrip(ninf,npts), TavgRIPdstop(ninf,npts)
     @ ,T_dwtopf(nbinm,npts), T_dwtop(nbinm,npts),
     @ T_dwtop9a(npts), ql_invavgRIP(ninf,npts),ql_invavgabs(ninf,npts)


        integer iinf(ninf)
        real *8 xinf, finf(ninf,nbinm)
c.....density of water
c     drip shield top flow area
c     invert flow area

        rho=1000.
        a_dsT=0.57
        a_inv=0.92

c.....This counter will specify the number of entries in each
c     of the infiltration bins--note: for k=ninf is the high infiltration
c     bin while for k=1 iinf is the low infiltration bin
c
        do k = 1,ninf
        iinf(k)=0
        end do

        write(*,*)
        write(*,*) '*********************************************'
        write(*,*) '***The TH abstraction routine for TSPA-SR***'
        write(*,*) '*****Performance Assessments Operations*****'
        write(*,*) '*********************************************'
        write(*,*)
        write(*,*)
        write(*,*) '*****************************************************'
        write(*,*) 'This version of the code will require an input deck'
        write(*,*) 'for the names of the i/o files.'
        write(*,*) 'Input Deck Filename is required: THabstraction.fil'
        write(*,*)
        write(*,*) 'The total required file names is a function of ninf'
        write(*,*) '** ninf is the number of infiltration bins **'
        write(*,*)
        write(*,*) '*****************************************************'
        write(*,*) '*****************************************************'
        write(*,*)
        write(*,*)
        write(*,*) 'The input deck is a name list in a single column:'
        write(*,*)
        write(*,*) 'bin1'
        write(*,*) 'bin2'
        write(*,*) '...'
        write(*,*) 'ninf'
        write(*,*) 'File name containing WP type file names from LLNL'
        write(*,*) 'bin1 results-average file'
        write(*,*) 'bin1 results-RIP raw values file'
        write(*,*) 'bin1 results-RIP Qperc-only values file'
        write(*,*) 'bin2 results-average file'
        write(*,*) 'bin2 results-RIP raw values file'
        write(*,*) 'bin2 results-RIP Qperc-only values file'
        write(*,*) '...'
        write(*,*) 'ninf results-average file'
        write(*,*) 'ninf results-RIP raw values file'
        write(*,*) 'ninf results-RIP Qperc-only values file'
        write(*,*) 'bin1RIP-Tavg file'
        write(*,*) 'bin1RIP-S_L avg file'
        write(*,*) 'bin1RIP-Q_perc avg file'
        write(*,*) 'bin1RIP-Tmax file'
        write(*,*) 'bin1RIP-Tmin file'
        write(*,*) 'bin1RIP-Tinvavg file'
        write(*,*) 'bin1RIP-RHinvavg file'
        write(*,*) 'bin1RIP-Qevap_invavg file'
        write(*,*) 'bin1RIP-Top DS file'
        write(*,*) 'bin1RIP-qperc_invavg file'
        write(*,*) '...'
        write(*,*) 'ninfRIP-Tavg file'
        write(*,*) 'ninfRIP-S_L avg file'
```

```
      write(*,*) 'ninfRIP-Q_perc avg file'
      write(*,*) 'ninfRIP-Tmax file'
      write(*,*) 'ninfRIP-Tmin file'
      write(*,*) 'ninfRIP-Tinvavg file'
      write(*,*) 'ninfRIP-RHinvavg file'
      write(*,*) 'ninfRIP-Qevap_invavg file'
      write(*,*) 'ninfRIP-Top DS file'
      write(*,*) 'ninfRIP-qperc_invavg file'
      write(*,*) 'bin1 ABS qprec inv avg'
      write(*,*) '...'
      write(*,*) 'ninf ABS qprec inv avg'

      write(*,*)
      write(*,*) 'So, as an example for ninf = '
      write(*,*) ninf
       ifiles = ninf+1+3*ninf+11*ninf
      write(*,*) 'There are a total of file names required:'
      write(*,*) ifiles
      write(*,*)

      write(*,*)
      write(*,*) 'Enter the rate of change factor'
      read(*,*) prntfac
      write(*,*)


      open(3,file='THabstraction.fil', status='old')

c.....Begin to read in the ranges of infiltration bins
        do k = 1, ninf
        write(*,*) 'Enter bin ranges starting from lowest mm/yr'
        read(*,*) qinf0(k)
        end do
      do k = 1,ninf
      read(3,'(a)') outfile(k)
      end do
c.....open the resulting infiltration bin files for later processing
c     write the appropriate file names that belong in the bin
c
      do k = 1,ninf
      open (106-k, file=outfile(k),status='new')
         if (k .eq. ninf) then
         write(106-k,1) qinf0(k)
 1        format('qinf >', 1x,f5.1,1x, 'mm/yr  ')
         else

         write(106-k,11) qinf0(k+1), qinf0(k)
 11       format(f5.1, 1x,'> qinf >', 1x,f5.1, 1x,'mm/yr  ')
         end if
       end do

c
c     Read in the large files (2 total) that contain all of the results for
c     a single run.  An example is each waste package location
c     for a specific type (e.g., csnf) from the mean infiltration
c     case multiscale model run
c.....Note: The input file must contain a label as the first line
c     an example may be csnf, hlw and the last line should be end
c
c      write(*,*)'What is the name of the large input file?'
      read(3,'(a)') infile1
      open(51,file=infile1,status='old')
       read(51,'(a)') label
       write(*,*)
       write(*,*) '****************************************'
       write(*,*) 'now reading input file for LLNL files:'
       write(*,*) label
       write(*,*) '****************************************'
       write(*,*)
       write(*,*)

 55      read(51,'(a)') infile3
          if (infile3 .eq. 'end') goto 44
         open(999,file=infile3,status='old')
 4            read (999,45) nmeinf
```

```
45            format(a12)
        if (nmeinf .ne. 'Infiltration') goto 4
        read (999, '(a)') ch
        read (ch(26:),*) xinf
        close(999)

c.....check each infiltration rate in each file to determine the
c     appropriate infiltration rate bin placement
c

        do k = 1,ninf
        j=ninf+1-k
        if (xinf .ge. qinf0(j) ) goto 33
        end do

c.....write each file name to the appropriate infiltration bin
c     file name for later processing on an infiltration rate bin
c     basis
c

 33      open (106-j, file=outfile(j),status='old')
        write (106-j,31) infile3
 31     format(a70)
        iinf(j) = iinf(j)+1
        goto 55

c.....keep track of the number of entries in each infiltration
c     bin for later processing
c

 44     open (555, file='binmembers.dat', status='new')
         write(555,*) 'The entries in infiltration bin:from lo to hi'
        do k =1,ninf
         write(555,*) iinf(k)
        end do
        close(555)

        do k = 1,ninf
        close(106-k)
        enddo

        close(51)

c.....end the portion of the rountine that builds the infiltration bins
c.....The infiltration bins have now been assembled.  The remainder of
c     rountine will build the average quantities and reformat the data
c
c
c.....This section will build the average quantities for each infiltration
c     bin as specified by the above portion of this routine
c
c     Each sub-section in the multiscale model results will
c     be handled as an averaging process----
c
c
c.....Nomenclature for this processor
c       timeyr--time in years as taken from the multiscale results
c       T_wp--the waste package temperature
c        T_5m--the temperature at 5 meters into host rock
c        T_bfpk--the temperature at the backfill spoil peak
c        T_ds--the temperature at the dripshield
c        T_dw--the temperature at the drift wall
c        T_inv--the invert temperature
c        T_dwlow--the drift wall lower temperature
c        RH_dw--the relative humidity of the drift wall
c        RH_bfp--the relative humidity of the backfill spoil peak
c        RH_ds--the relative humidity of the dripshield
c        RH_wp--the relative humidity of the waste package
c        RH_inv--the relative humidity of the invert
c        Sl_dw--the liquid saturation of the drift wall
c        Sl_ds--the liquid saturation of the dripshield
c        Sl_inv--the liquid saturation of the invert
c        ql_5m--the liquid flow in fracture 5m into host rock
c        ql_3m--the liquid flow in fracture 3m into host rock
c        ql_dw--the liquid flow in fracture at drift wall
```

```
c       ql_dsT--the liquid flow at the top of the dripshield
c       ql_dsS--the liquid flow at the side of the dripshield
c       ql_inv--the liquid flow in the invert
c       xa_ds--the air mass fraction at the dripshield
c       P_ds--gas pressure at the dripshield
c       Pc_ds--the capillary pressure at dripshield
c       Pc_inv--the capillary pressure at invert
c       PcM_dw--matrix capillary pressure at drift wall
c       PcF_dw--fracture capillary pressure at drift wall
c       qw_dw--the water flux in the gas phase at the drift wall
c       qa_dw--the air flux in the gas phase at the drift wall
c       qvpdsT--the evaporation rate at the top of the drip shield
c       qvpdsP--the evaporation rate at the perimeter of the drip shield
c       qvpbfp--the evaporation rate at backfill spoil peak
c       qvpinv--the evaporation rate at the invert
c       PAwpT--waste package temperature
c       PAwpRH--waste package relative humidity
c       PAdsT--dripshield temperature
c       PAdsRH--driphield relative humidity
c
c
c
c

           do k1=1,ninf
            facttb(k1) = 0.
           enddo

           do ii=1,ninf
             noent(ii)=0
           enddo

c
c
c
c.....open the results files for the average values within a bin
c     this information will require the number of infiltration bins
c

        do k = 1,ninf


        Tmaxo = 0.

c.....compute the infiltration rate bin factor so that a bin
c     averaged value can be computed
c
         open(106-k,file=outfile(k),status='old')
         read(106-k,'(a)') xinfillabel

           do m = 1,iinf(k)
         read(106-k,'(a)') infile4
          open(666,file=infile4,status='old')
 21       read(666,6) name
 6      format(a4)
        if(name .ne. 'frac') goto 21
        read(666,10) factbin(k,m)
 10     format(29x,f8.6)
        facttb(k) = factbin(k,m)+facttb(k)
           end do
         close (106-k)

c......re-open the files to obtain the coordinate locations
c
         open(106-k,file=outfile(k),status='old')
         read(106-k,'(a)') xinfillabel


           do m = 1,iinf(k)
         read(106-k,'(a)') infile4
          open(667,file=infile4,status='old')
 81       read(667,6) name
```

```
      if(name .ne. 'Loca') goto 81
      read(667,41) coord1(k,m)
      read(667,41) coord2(k,m)
41    format(23x,f9.2)
         end do
       close (106-k)

       open(106-k,file=outfile(k),status='old')
       read(106-k,'(a)') xinfillabel


         do m = 1,iinf(k)
       read(106-k,'(a)') infile4
        open(668,file=infile4,status='old')
82      read(668,6) name
      if(name .ne. 'Infi') goto 82
       read (668, '(a)') ch
       read (ch(26:),*) finf(k,m)
         end do
       close (106-k)


c
c
c......Name and open the output files
c
c


      write (*,*) 'Computing all averages for E0130'
c
      write (*,*) k

      read(3,'(a)') resultsbinfile(k)

       open(206-k,file=resultsbinfile(k),status='new')

       open(106-k,file=outfile(k),status='old')
       read(106-k,'(a)') xinfillabel
       write(206-k,*) 'Infiltration Bin:'
       write(206-k,*) xinfillabel
       write(206-k,*) resultsbinfile(k)
         if(iinf(k) .eq. 0) then
         write(206-k,*) 'No Entries in this Bin'
         end if

       write (*,*) 'Computing the RIP raw values'
c     @ --this is the raw value file for RIP'
c
      write (*,*) k

      read(3,'(a)') resultsbinfile2(k)

       open(306-k,file=resultsbinfile2(k),status='new')

       write(306-k, *) 'Infiltration Bin:'

       write(306-k,*) xinfillabel


       write(306-k,*) resultsbinfile2(k)
c23456789012345678901234567890123456789012345678901234567890123456789012

       write(306-k,*)'Time (yr), Waste Pack Temp.(C), Drip shield temp.
     @ (C), Drift wall temp.(C), Invert temp. (C), Waste pack RH, Drip
     @ shield RH, Drift wall RH, Backfill RH, Invert RH, Liquid Satr. @
     @ Drip Shield, Liquid Satr.@Invert, Air mass Frac, Water Vapor flux
     @ at Dwall (kg/yr/m of drift), Air flux at Dwall(kg/yr/m of drift),
     @ A Drip Shield Evapo. rate (m3/yr), Backfill Evapo. Rate (m3/yr),
     @ Invert Evapo. Rate (m3/yr), Percolation Flux at 5 m (mm/yr), Vol
     @ume flow at top dripshield (m3/yr), volume flow at invert (m3/yr),
     @ Top of the dripshield Temp (C)'

          if(iinf(k) .eq. 0) then
          write(306-k,*) 'No Entries in this Bin'
```

```
          end if


        write (*,*) 'Computing the RIP raw Qperc-only values'
c      @ --this is the raw value file for RIP'
c
       write (*,*) k

       read(3,'(a)') resultsbinfile2p(k)

        open(306+k,file=resultsbinfile2p(k),status='new')

        write(306+k, *) 'Infiltration Bin:'

        write(306+k,*) xinfillabel


        write(306+k,*) resultsbinfile2p(k)
c234567890123456789012345678901234567890123456789012345678901234567890123456789012

        write(306+k,*) ' Time (yr),   Percolation Flux at 5 m (mm/yr),
     @Percolation Flux at 3 m (mm/yr)'

          if(iinf(k) .eq. 0) then
          write(306+k,*) 'No Entries in this Bin'
          end if



c

c.....read each entry within an infiltration bin (e.g., ninf=1)
c     which may be the low infiltration bin as the following
c     (0-5 mm/yr)
c

          do i=1,iinf(k)

          Tmxmno = 0.

        read(106-k,'(a)') infile2
         open(777,file=infile2,status='old')
        write(206-k,*) infile2


 2       read(777,6) name
        if(name .ne. 'frac') goto 2
        read(777,10) fact
        fact=fact/facttb(k)
c
 801      read(777,6) name
        if(name .ne. 'time') goto 801

c
c.....This will read the first block of data in the raw files
c     resulting from the multiscale model--TSPA data
c
              do j = 1,npts
        read(777,*) timeyr(j), PAwpT(i,j), PAwpRH(i,j),
     @   PAdsT(i,j),PAdsRH(i,j)

        PAwpTf(i,j) = PAwpT(i,j)*fact
        PAwpRHf(i,j) = PAwpRH(i,j)*fact
        PAdsTf(i,j) = PAdsT(i,j)*fact
        PAdsRHf(i,j) = PAdsRH(i,j)*fact
              end do


c
c......continue reading the raw file for other variables
c       read the second block--temperature data
c
```

```
802      read(777,6) name
      if(name .ne. 'time') goto 802


          do j = 1,npts
      read(777,*) timeyr(j), T_dw(i,j), T_5m(i,j), T_bfpk(i,j),
     @   T_ds(i,j), Tdstop(i,j), T_wp(i,j), T_inv(i,j), T_dwlow(i,j)
     @   , T_dwtop(i,j)

      T_wpf(i,j) = T_wp(i,j)*fact
      T_5mf(i,j) = T_5m(i,j)*fact
      T_bfpkf(i,j) = T_bfpk(i,j)*fact
      T_dsf(i,j) = T_ds(i,j)*fact
      T_dwf(i,j) = T_dw(i,j)*fact
      T_invf(i,j) = T_inv(i,j)*fact
      T_dwlowf(i,j) = T_dwlow(i,j)*fact
      Tdstopf(i,j) = Tdstop(i,j)*fact
      T_dwtopf(i,j) = T_dwtop(i,j)*fact

      Tmaxn = DMAX1(T_wp(i,j), Tmaxo)
              if (Tmaxn .gt. Tmaxo) then
               mark=i
               Tmaxo=Tmaxn
              endif
      Tmax_min(i) = DMAX1(T_wp(i,j), Tmxmno)
              Tmxmno = Tmax_min(i)

           end do


c
c.....continue reading the raw file for other variables
c       read the third block--Relative Humidity data
c

 803      read(777,6) name
      if(name .ne. 'time') goto 803


          do j = 1,npts
      read(777,*) timeyr(j), RH_dw(i,j), RH_bfp(i,j),
     @   RH_ds(i,j), RH_wp(i,j), RH_inv(i,j)

      RH_dwf(i,j) = RH_dw(i,j)*fact
      RH_bfpf(i,j) = RH_bfp(i,j)*fact
      RH_dsf(i,j) = RH_ds(i,j)*fact
      RH_wpf(i,j) = RH_wp(i,j)*fact
      RH_invf(i,j) = RH_inv(i,j)*fact
           end do

c
c.....continue reading the raw file for other variables
c       read the fourth block--Liquid Saturation data
c

 804      read(777,6) name
      if(name .ne. 'time') goto 804


          do j = 1,npts
      read(777,*) timeyr(j), Sl_dw(i,j), Sl_ds(i,j), Sl_inv(i,j)

      Sl_dwf(i,j) = Sl_dw(i,j)*fact
      Sl_dsf(i,j) = Sl_ds(i,j)*fact
      Sl_invf(i,j) = Sl_inv(i,j)*fact
           end do

c
c.....continue reading the raw file for other variables
c       read the fifth block--liquid flux data
c

 805      read(777,6) name
```

```
      if(name .ne. 'time') goto 805

           dc j = 1,npts
      read(777,*) timeyr(j), ql_5m(i,j), ql_3m(i,j),
     @   ql_dw(i,j), ql_dsT(i,j), ql_dsTag(i,j), ql_dsS(i,j),
     @   ql_inv(i,j)

      ql_5mf(i,j) = ql_5m(i,j)*fact
      ql_3mf(i,j) = ql_3m(i,j)*fact
      ql_dwf(i,j) = ql_dw(i,j)*fact
      ql_dsTf(i,j) = ql_dsT(i,j)*fact
      ql_dsSf(i,j) = ql_dsS(i,j)*fact
      ql_invf(i,j) = ql_inv(i,j)*fact
      ql_dsTagf(i,j) = ql_dsTag(i,j)*fact
           end do

c
c......continue reading the raw file for other variables
c       read the sixth block--air mass fraction data
c

 806       read(777,6) name
      if(name .ne. 'time') goto 806

           do j = 1,npts
      read(777,*) timeyr(j), xa_ds(i,j)

      xa_dsf(i,j) = xa_ds(i,j)*fact
           end do

c
c......continue reading the raw file for other variables
c       read the seventh block--Gas-phase pressure data
c

 807       read(777,6) name
      if(name .ne. 'time') goto 807

           do j = 1,npts
      read(777,*) timeyr(j), P_ds(i,j)

      P_dsf(i,j) = P_ds(i,j)*fact
           end do


c
c......continue reading the raw file for other variables
c       read the eighth block--Capillary pressure data
c

 808       read(777,6) name
      if(name .ne. 'time') goto 808

           do j = 1,npts
      read(777,*) timeyr(j), Pc_ds(i,j), Pc_inv(i,j),
     @   PcM_dw(i,j), PcF_dw(i,j)

      Pc_dsf(i,j) = Pc_ds(i,j)*fact
      Pc_invf(i,j) = Pc_inv(i,j)*fact
      PcM_dwf(i,j) = PcM_dw(i,j)*fact
      PcF_dwf(i,j) = PcF_dw(i,j)*fact
           end do

c
c......continue reading the raw file for other variables
c       read the ninth block--gas flux data
c

 809       read(777,6) name
      if(name .ne. 'time') goto 809
```

```
            do j = 1,npts
       read(777,*) timeyr(j), qw_dw(i,j), qa_dw(i,j)

       qw_dwf(i,j) = qw_dw(i,j)*fact
       qa_dwf(i,j) = qa_dw(i,j)*fact
            end do

c
c......continue reading the raw file for other variables
c       read the tenth block--evaporation rate data
c

 810      read(777,6) name
       if(name .ne. 'time') goto 810


            do j = 1,npts
       read(777,*) timeyr(j), qvpdsT(i,j), qvpdsP(i,j),
     @   qvpbfp(i,j), qvpinv(i,j)

       qvpdsTf(i,j) = qvpdsT(i,j)*fact
       qvpdsPf(i,j) = qvpdsP(i,j)*fact
       qvpbfpf(i,j) = qvpbfp(i,j)*fact
       qvpinvf(i,j) = qvpinv(i,j)*fact
            end do

c
c......continue reading the raw file for other variables
c       read the eleventh block--pillar temperature data
c


811      read(777,6) name
       if(name .ne. 'time') goto 811


            do j = 1,npts
       read(777,*) timeyr(j), Tpl299(i,j), Tpl369(i,j),
     @   Tpl489(i,j), Tpl689(i,j), Tpl1014(i,j), Tpl1514(i,j),
     @   Tpl2264(i,j), Tpl3382(i,j)

       Tpl299f(i,j) = Tpl299(i,j)*fact
       Tpl369f(i,j) = Tpl369(i,j)*fact
       Tpl489f(i,j) = Tpl489(i,j)*fact
       Tpl689f(i,j) = Tpl689(i,j)*fact
       Tpl1014f(i,j) = Tpl1014(i,j)*fact
       Tpl1514f(i,j) = Tpl1514(i,j)*fact
       Tpl2264f(i,j) = Tpl2264(i,j)*fact
       Tpl3382f(i,j) = Tpl3382(i,j)*fact
            end do

c......the raw data has been processed for an infiltration bin
c      **close the i loop**
c


         end do



c......Now-Assemble the max & min WP temperature data for the bin
c

         if(iinf(k) .ne. 0) then
           do j = 1, npts
            Tmaxrip(k,j) = T_wp(mark,j)
           enddo

            Tmino = 1.E+10
           do i = 1,iinf(k)
             Tminn= DMIN1(Tmax_min(i), Tmino)
             if(Tminn .lt. Tmino) then
```

```
              imin = i
              Tmino=Tminn
             endif
           enddo

           do j = 1, npts
            Tminrip(k,j) = T_wp(imin,j)
           enddo
         endif

c.....Indicate that the bin has no entries
c


        if(iinf(k) .eq. 0) then
        noent(k)=1
        goto 998
        end if


c
c.....compute the infiltration bin averages of the PA variables
c       for WP T, RH and  DS T, RH
c       This is for a particular infiltration bin
c


        do j = 1,npts

        s1PAwpT = 0.
        s2PAwpRH = 0.
        s3PAdsT = 0.
        s4PAdsRH = 0.

         do i = 1,iinf(k)
          s1PAwpT= s1PAwpT + PAwpTf(i,j)
          s2PAwpRH=s2PAwpRH + PAwpRHf(i,j)
          s3PAdsT=s3PAdsT + PAdsTf(i,j)
          s4PAdsRH = s4PAdsRH + PAdsRHf(i,j)
         end do

          PAwpT1a(j) = s1PAwpT
          PAwpRH2a(j) = s2PAwpRH
          PAdsT3a(j)= s3PAdsT
          PAdsRH4a(j) = s4PAdsRH
        end do


c
c
c.....compute the averages of the temperature data
c
        do j = 1,npts

        s1T_wp = 0.
        s2T_5m = 0.
        s3T_bfpk = 0.
        s4T_ds = 0.
        s5T_dw = 0.
        s6T_inv = 0.
        s7T_dwlow = 0.
        s8Tdstop = 0.
        s9T_dwtop = 0.

         do i = 1,iinf(k)
          s1T_wp = s1T_wp + T_wpf(i,j)
          s2T_5m = s2T_5m + T_5mf(i,j)
          s3T_bfpk = s3T_bfpk + T_bfpkf(i,j)
          s4T_ds = s4T_ds + T_dsf(i,j)
          s5T_dw=s5T_dw+T_dwf(i,j)
          s6T_inv=s6T_inv+T_invf(i,j)
          s7T_dwlow=s7T_dwlow+T_dwlowf(i,j)
          s8Tdstop= s8Tdstop+Tdstopf(i,j)
          s9T_dwtop = s9T_dwtop + T_dwtopf(i,j)
         end do
```

```
          T_wp1a(j) = s1T_wp
          TavgRIP(k,j)=s1T_wp
          T_5m2a(j) = s2T_5m
          T_bfpk3a(j)= s3T_bfpk
          T_ds4a(j) = s4T_ds
          T_dw5a(j) = s5T_dw
          T_inv6a(j) = s6T_inv
          TavgRIPinv(k,j)=s6T_inv
          T_dwlow7a(j) = s7T_dwlow
          Tdstop8a(j) = s8Tdstop
          T_dwtop9a(j) = s9T_dwtop
          TavgRIPdstop(k,j) = s8Tdstop
        end do


c
c
c......compute the averages of the relative humidity data
c
        do j = 1,npts

        s1RH_dw = 0.
        s2RH_bfp = 0.
        s3RH_ds = 0.
        s4RH_wp = 0.
        s5RH_inv = 0.

         do i = 1,iinf(k)
          s1RH_dw = s1RH_dw + RH_dwf(i,j)
          s2RH_bfp = s2RH_bfp + RH_bfpf(i,j)
          s3RH_ds = s3RH_ds + RH_dsf(i,j)
          s4RH_wp = s4RH_wp + RH_wpf(i,j)
          s5RH_inv=s5RH_inv + RH_invf(i,j)
         end do

          RH_dw1a(j) = s1RH_dw
          RH_bfp2a(j) = s2RH_bfp
          RH_ds3a(j)= s3RH_ds
          RH_wp4a(j) = s4RH_wp
          RH_inv5a(j) = s5RH_inv
          RHavgRIPin(k,j)=s5RH_inv
        end do


c
c
c......compute the averages of the liquid saturation data
c
        do j = 1,npts

        s1Sl_dw = 0.
        s2Sl_ds = 0.
        s3Sl_inv = 0.

         do i = 1,iinf(k)
          s1Sl_dw = s1Sl_dw + Sl_dwf(i,j)
          s2Sl_ds = s2Sl_ds + Sl_dsf(i,j)
          s3Sl_inv = s3Sl_inv + Sl_invf(i,j)
         end do

           S_lavgRIP(k,j) = s3Sl_inv
          Sl_dw1a(j) = s1Sl_dw
          Sl_ds2a(j) = s2Sl_ds
          Sl_inv3a(j)= s3Sl_inv
        end do

c
c
c......compute the averages of the liquid flux data
c
        do j = 1,npts

        s1ql_5m = 0.
        s2ql_3m = 0.
```

```
        s3ql_dw = 0.
        s4ql_dsT = 0.
        s5ql_dsS = 0.
        s6ql_inv = 0.
        s7ql_dsTag = 0.
        s66ql_inv = 0.

         do i = 1,iinf(k)
          s1ql_5m = s1ql_5m + ql_5mf(i,j)
          s2ql_3m = s2ql_3m + ql_3mf(i,j)
          s3ql_dw = s3ql_dw + ql_dwf(i,j)
          s4ql_dsT = s4ql_dsT + ql_dsTf(i,j)
          s5ql_dsS = s5ql_dsS+ql_dsSf(i,j)
          s6ql_inv=s6ql_inv+ql_invf(i,j)
          s7ql_dsTag = s7ql_dsTag + ql_dsTagf(i,j)
          s66ql_inv = s66ql_inv + abs( ql_invf(i,j) )
         end do

          ql_5m1a(j) = s1ql_5m
          ql_5mavgRIP(k, j)=s1ql_5m
          ql_3m2a(j) = s2ql_3m
          ql_dw3a(j)= s3ql_dw
          ql_dsT4a(j) = s4ql_dsT
          ql_dsS5a(j) = s5ql_dsS
          ql_inv6a(j) = s6ql_inv
          ql_invavgRIP(k,j)=s6ql_inv
          ql_invavgabs(k,j)=s66ql_inv
          ql_dsTag7a(j) = s7ql_dsTag
        end do

c
c
c......compute the averages of the air mass fraction data
c
        do j = 1,npts

        s1xa_ds = 0.

         do i = 1,iinf(k)
          s1xa_ds = s1xa_ds + xa_dsf(i,j)
         end do

          xa_ds1a(j) = s1xa_ds
        end do

c
c
c......compute the averages of the gas pressure data
c
        do j = 1,npts

        s1P_ds = 0.

         do i = 1,iinf(k)
          s1P_ds = s1P_ds + P_dsf(i,j)
         end do

          P_ds1a(j) = s1P_ds
        end do

c
c
c......compute the averages of the capillary pressure data
c
        do j = 1,npts

        s1Pc_ds = 0.
        s2Pc_inv = 0.
        s3PcM_dw = 0.
        s4PcF_dw = 0.

         do i = 1,iinf(k)
          s1Pc_ds = s1Pc_ds + Pc_dsf(i,j)
          s2Pc_inv = s2Pc_inv + Pc_invf(i,j)
```

```
          s3PcM_dw = s3PcM_dw + PcM_dwf(i,j)
          s4PcF_dw = s4PcF_dw + PcF_dwf(i,j)
         end do

          Pc_ds1a(j) = s1Pc_ds
          Pc_inv2a(j) = s2Pc_inv
          PcM_dw3a(j)= s3PcM_dw
          PcF_dw4a(j) = s4PcF_dw
        end do


c
c
c......compute the averages of the gas flux data
c
        do j = 1,npts

        s1qw_dw = 0.
        s2qa_dw = 0.

         do i = 1,iinf(k)
          s1qw_dw = s1qw_dw + qw_dwf(i,j)
          s2qa_dw = s2qa_dw + qa_dwf(i,j)
         end do

          qw_dw1a(j) = s1qw_dw
          qa_dw2a(j) = s2qa_dw
        end do


c
c
c......compute the averages of the evaporation rate data
c
        do j = 1,npts

        s1qvpdsT = 0.
        s2qvpdsP = 0.
        s3qvpbfp = 0.
        s4qvpinv = 0.

         do i = 1,iinf(k)
          s1qvpdsT = s1qvpdsT + qvpdsTf(i,j)
          s2qvpdsP = s2qvpdsP + qvpdsPf(i,j)
          s3qvpbfp = s3qvpbfp + qvpbfpf(i,j)
          s4qvpinv = s4qvpinv + qvpinvf(i,j)
         end do

          qvpdsT1a(j) = s1qvpdsT
          qvpdsP2a(j) = s2qvpdsP
          qvpbfp3a(j)= s3qvpbfp
          qvpinv4a(j) = s4qvpinv
          qvpavgRIPinv(k,j)=s4qvpinv
        end do


c
c
c....compute the average pillar temperatures
c

        do j = 1,npts

        s1Tpl299 = 0.
        s2Tpl369 = 0.
        s3Tpl489 = 0.
        s4Tpl689 = 0.
        s5Tpl1014 = 0.
        s6Tpl1514 = 0.
        s7Tpl2264 = 0.
        s8Tpl3382 = 0.

         do i = 1,iinf(k)
          s1Tpl299 = s1Tpl299 + Tpl299f(i,j)
          s2Tpl369 = s2Tpl369 + Tpl369f(i,j)
```

```
         s3Tpl489 = s3Tpl489 + Tpl489f(i,j)
         s4Tpl689 = s4Tpl689 + Tpl689f(i,j)
         s5Tpl1014 = s5Tpl1014 + Tpl1014f(i,j)
         s6Tpl1514 = s6Tpl1514 + Tpl1514f(i,j)
         s7Tpl2264 = s7Tpl2264 + Tpl2264f(i,j)
         s8Tpl3382 = s8Tpl3382 + Tpl3382f(i,j)
        end do

         Tpl2991a(j) = s1Tpl299
         Tpl3692a(j) =s2Tpl369
         Tpl4893a(j) = s3Tpl489
         Tpl6894a(j)= s4Tpl689
         Tpl10145a(j) = s5Tpl1014
         Tpl15146a(j) = s6Tpl1514
         Tpl22647a(j) = s7Tpl2264
         Tpl33828a(j) = s8Tpl3382
       end do


c
c.....write the infiltration bin raw information for RIP
c.....control the number of time prints
c

       do i=1,iinf(k)
        jcount=0
        do j = 1,npts

        if (j .eq. 1) then

         jcount = jcount + 1
         jtag = j
        else if (j .eq. npts) then

         jcount = jcount + 1
        else

            if (ql_5m(i,j) .eq. 0.) then
             jcount = jcount + 1
             imark0 = j
            else

             ch1 =  ql_5m(i,jtag)
               if(ch1 .eq. 0.) then
                jcount = jcount + 1
                jtag = j
                go to 89
               endif

          crate = (( ql_5m(i,j) - ql_5m(i,jtag) )/ ql_5m(i,jtag) )*100.
          crate1 = (( T_wp(i,j) - T_wp(i,jtag) )/ T_wp(i,jtag) )*100.

             if (abs(crate) .ge. prntfac .or. j-1 .eq. imark0 .or.
     @              abs(crate1) .ge. prntfac) then
              jcount = jcount+1
              jtag = j
             end if
 89         endif

         endif


         end do


          write(306-k,925) jcount
 925      format('The number of Rows = ', i3)
          write(306-k,926) factbin (k,i)
 926      format('The fraction of this history=',f8.6)

          write(306-k,*) 'Coordinate Location:'
```

```
      write(306-k,128) coord1(k,i)
128   format('The easting coordinate = ', f9.2, ' m')

      write(306-k,129) coord2(k,i)
129   format('The northing coordinate = ', f9.2, ' m')
      write(306-k,*) 'Infiltration rate:'
      write(306-k,130) finf(k,i)
130   format('qinf = ', f9.5, ' mm/yr')
927   format(f10.2, 21(2x, E13.6))
c23456789012345678901234567890123456789012345678901234567890123456789012

      do j = 1,npts

      if (j .eq. 1) then

           if (qvpdsT(i,j) .eq. -99.9 .or. qvpbfp(i,j)
     @          .eq. -99.9 ) then

      write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @ T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @ RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @ qa_dw(i,j), qvpdsT(i,j), qvpbfp(i,j),
     @ qvpinv(i,j),  ql_5m(i,j), ql_dsT(i,j), ql_inv(i,j)*
     @ (a_inv/1000.),Tdstop(i,j)
        jtag = j

           else

      write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @ T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @ RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @ qa_dw(i,j), qvpdsT(i,j)/rho, qvpbfp(i,j)/rho,
     @ qvpinv(i,j)/rho,  ql_5m(i,j), ql_dsT(i,j)*(a_dsT/1000.)
     @ ,ql_inv(i,j)*(a_inv/1000.), Tdstop(i,j)
        jtag = j

           end if


      else if (j .eq. npts) then

      write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @ T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @ RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @ qa_dw(i,j), qvpdsT(i,j)/rho, qvpbfp(i,j)/rho,
     @ qvpinv(i,j)/rho,  ql_5m(i,j), ql_dsT(i,j)*(a_dsT/1000.),
     @ ql_inv(i,j)*(a_inv/1000.), Tdstop(i,j)

      else

         if(ql_5m(i,j) .eq. 0.) then

             if (qvpdsT(i,j) .eq. -99.9 .or. qvpbfp(i,j)
     @          .eq. -99.9 ) then

      write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @ T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @ RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @ qa_dw(i,j), qvpdsT(i,j), qvpbfp(i,j),
     @ qvpinv(i,j),  ql_5m(i,j), ql_dsT(i,j),ql_inv(i,j)
     @ *(a_inv/1000.), Tdstop(i,j)
           imark0 = j


             else
```

```
        write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @  T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @  RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @  qa_dw(i,j), qvpdsT(i,j)/rho, qvpbfp(i,j)/rho,
     @  qvpinv(i,j)/rho,  ql_5m(i,j), ql_dsT(i,j)*(a_dsT/1000.),
     @  ql_inv(i,j)*(a_inv/1000.), Tdstop(i,j)
             imark0 = j
             end if

           else


             ch1 = ql_5m(i,jtag)
             if(ch1 .eq. 0.) then

               if (qvpdsT(i,j) .eq. -99.9 .or. qvpbfp(i,j)
     @           .eq. -99.9 ) then


c2345678901234567890123456789012345678901234567890123456789012345678901234
          write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @  T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @  RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @  qa_dw(i,j), qvpdsT(i,j), qvpbfp(i,j),
     @  qvpinv(i,j), ql_5m(i,j), ql_dsT(i,j),ql_inv(i,j)*(a_inv/1000.)
     @ , Tdstop(i,j)
               jtag=j
               goto 71

               else


c2345678901234567890123456789012345678901234567890123456789012345678901234
          write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @  T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @  RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @  qa_dw(i,j), qvpdsT(i,j)/rho, qvpbfp(i,j)/rho,
     @  qvpinv(i,j)/rho,  ql_5m(i,j), ql_dsT(i,j)*(a_dsT/1000.),
     @  ql_inv(i,j)*(a_invT/1000.), Tdstop(i,j)
               jtag=j
               goto 71

               end if


             endif

c2345678901234567890123456789012345678901234567890123456789012345678901234

         crate = (( ql_5m(i,j) - ql_5m(i,jtag) )/ ql_5m(i,jtag) )*100.
         crate1 = (( T_wp(i,j) - T_wp(i,jtag) )/ T_wp(i,jtag) )*100.

           if (abs(crate) .ge. prntfac .or. j-1 .eq. imark0 .or.
     @          abs(crate1) .ge. prntfac) then


             if (qvpdsT(i,j) .eq. -99.9 .or. qvpbfp(i,j)
     @           .eq. -99.9 ) then


         write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @  T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @  RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @  qa_dw(i,j), qvpdsT(i,j), qvpbfp(i,j),
     @  qvpinv(i,j), ql_5m(i,j), ql_dsT(i,j),ql_inv(i,j)*(a_inv/1000.)
     @ , Tdstop(i,j)
           jtag = j

             else
```

```
       write(306-k,927) timeyr(j), T_wp(i,j), T_ds(i,j), T_dw(i,j),
     @ T_inv(i,j), RH_wp(i,j), RH_ds(i,j), RH_dw(i,j), RH_bfp(i,j),
     @ RH_inv(i,j), Sl_ds(i,j), Sl_inv(i,j), xa_ds(i,j), qw_dw(i,j),
     @ qa_dw(i,j), qvpdsT(i,j)/rho, qvpbfp(i,j)/rho,
     @ qvpinv(i,j)/rho,  ql_5m(i,j), ql_dsT(i,j)*(a_dsT/1000.),
     @ ql_inv(i,j)*(a_inv/1000.), Tdstop(i,j)
        jtag = j

            endif


          end if
 71     endif


       endif


       end do

c.....write the percolation flux specific files.  This does not use
c      a predetermined set of time prints for use in the seepage
c      model--prints eacg point to extreme variability in q.liquid
c



        write(306+k,925) npts
        write(306+k,926) factbin (k,i)

        write(306+k,*) 'Coordinate Location:'

        write(306+k,128) coord1(k,i)

        write(306+k,129) coord2(k,i)

        write(306+k,*) 'Infiltration rate:'
        write(306+k,130) finf(k,i)
 939    format(f10.2, 2x, E13.6, 2x, E13.6)
c234567890123456789012345678901234567890123456789012345678901234567890


       do j = 1, npts
         write(306+k,939) timeyr(j), ql_5m(i,j),ql_3m(i,j)
       enddo

c.....close the i loop for writing RIP raw values
c


       end do

c
c
c
c.....write the infiltration bin **averages** for each quantity
c     including time
c


       write(206-k,*) 'infiltration bin file:'
       write(206-k,*) outfile(k)
       write(206-k,*) 'average value outputs:'
       write(206-k,*) resultsbinfile(k)
       write(206-k,*)
       write(206-k,*)
       write(206-k,*) 'The average TSPA Variables'
       write(206-k,*)'Time (yr), WP-T (C), WP-RH, DS-T(C), DS-RH'

       do j = 1,npts
       write(206-k,901) timeyr(j),PAwpT1a(j), PAwpRH2a(j),
     @    PAdsT3a(j), PAdsRH4a(j)
```

```
901     format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6)
        enddo

        write(206-k,*)
        write(206-k,*)
        write(206-k,*) 'The average Temperature Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
        write(206-k,*)'Time (yr), WP temp (C), temp at 5m (C), temp at
     @ backfill peak(C), dripshield temp(C), drift wall temp (C), invert
     @ temp(C), lower drift wall (C), dripshield top temp (C), drift wal
     @l top temp (C)'


        do j = 1,npts
        write(206-k,902) timeyr(j), T_wp1a(j), T_5m2a(j),
     @   T_bfpk3a(j), T_ds4a(j), T_dw5a(j), T_inv6a(j),
     @   T_dwlow7a(j), Tdstop8a(j)
     @, T_dwtop9a(j)

902     format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6,
     @    5x, E13.6, 5x, E13.6, 5x, E13.6, 5x, E13.6, 5x, E13.6)
        enddo


        write(206-k,*)
        write(206-k,*)
        write(206-k,*) 'The average Relative Humidity Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
        write(206-k,*)'Time (yr), drift wall RH, backfill RH, dripshield
     @ RH, waste package RH, invert RH'


        do j = 1,npts
        write(206-k,903) timeyr(j), RH_dw1a(j), RH_bfp2a(j),
     @   RH_ds3a(j), RH_wp4a(j), RH_inv5a(j)

903     format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6,
     @    5x, E13.6)
        enddo


        write(206-k,*)
        write(206-k,*)
        write(206-k,*) 'The average Liquid Saturation Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
        write(206-k,*)'Time (yr), drift wall liq sat, dripshield liq sat
     @, invert liq sat'


        do j = 1,npts
        write(206-k,904) timeyr(j), Sl_dw1a(j), Sl_ds2a(j),
     @   Sl_inv3a(j)

904     format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6)
        enddo


        write(206-k,*)
        write(206-k,*)
        write(206-k,*) 'The average liquid flux Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
        write(206-k,*)'Time (yr), liquid flux 5m (mm/yr), liquid flux 3m
     @ (mm/yr), liquid flux drift W (mm/yr),  liquid flux top Dshield
     @ (mm/yr), liquid flux side Dshield (mm/yr),  liquid flux invert
     @ (mm/yr), liquid flux top DS average (mm/yr)'


        do j = 1,npts
        write(206-k,905) timeyr(j), ql_5m1a(j), ql_3m2a(j),
     @   ql_dw3a(j), ql_dsT4a(j), ql_dsS5a(j), ql_inv6a(j),
     @   ql_dsTag7a(j)

905     format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6,
     @    5x, E13.6, 5x, E13.6, 5x, E13.6)
```

```
      enddo

      write(206-k,*)
      write(206-k,*)
      write(206-k,*) 'The average air mass fraction Variables'
      write(206-k,*) 'Time (yr), air mass fraction Dshield'

      do j = 1,npts
      write(206-k,906) timeyr(j), xa_ds1a(j)

906   format(f10.2,5x,E13.6)
      enddo

      write(206-k,*)
      write(206-k,*)
      write(206-k,*) 'The average gas-phase pressure Variables'
      write(206-k,*) 'Time (yr), gas pressure (Pa)'

      do j = 1,npts
      write(206-k,907) timeyr(j), P_ds1a(j)

907   format(f10.2,5x,E13.6)
      enddo

      write(206-k,*)
      write(206-k,*)
      write(206-k,*) 'The average capillary pressure Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
      write(206-k,*) 'Time (yr), Cap pressure Dshield (Pa),  Cap press
     @ure @ invert (Pa), Cap pressure Dwall-Matrix (Pa),   Cap pressure
     @Dwall-fracture (Pa)'

      do j = 1,npts
      write(206-k,908) timeyr(j), Pc_ds1a(j), Pc_inv2a(j),
     @  PcM_dw3a(j), PcF_dw4a(j)

908   format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6)
      enddo

      write(206-k,*)
      write(206-k,*)
      write(206-k,*) 'The average gas flux Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
      write(206-k,*) 'Time (yr), water vapor flux(kg/yr/m of drift),
     @air flux (kg/yr/m of drift)'

      do j = 1,npts
      write(206-k,909) timeyr(j), qw_dw1a(j), qa_dw2a(j)

909   format(f10.2,5x,E13.6,5x,E13.6)
      enddo

      write(206-k,*)
      write(206-k,*)
      write(206-k,*) 'The average evaporation rate Variables'
c23456789012345678901234567890123456789012345678901234567890123456789012
      write(206-k,*) 'Time (yr), Evaporation rate Dshield top (m3/yr),
     @Evaporation rate Dshield top perimeter (m3/yr), Evaporation rate
     @backfill pk (m3/yr), Evaporation rate invert (m3/yr)'

910   format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6)

      do j = 1,npts
```

```
        write(206-k,910) timeyr(j), qvpdsT1a(j)/rho,
     @  qvpdsP2a(j)/rho, qvpbfp3a(j)/rho,
     @  qvpinv4a(j)/rho

       enddo


       write(206-k,*)
       write(206-k,*)
       write(206-k,*) 'The average Pillar Temperatures'
c23456789012345678901234567890123456789012345678901234567890123456789012
       write(206-k,*) 'Time (yr), Tx=2.99m (C), Tx=3.69m (C), Tx=4.89m
     @(C), Tx=6.89 m (C), Tx=10.14m (C), Tx=15.14m (C), Tx=22.64 (C),
     @Tx=33.82m (C)'


       do j = 1,npts
       write(206-k,911) timeyr(j),Tpl2991a(j), Tpl3692a(j),
     @  Tpl4893a(j), Tpl6894a(j), Tpl10145a(j), Tpl15146a(j),
     @  Tpl22647a(j), Tpl33828a(j)


 911    format(f10.2,5x,E13.6,5x,E13.6,5x,E13.6,5x,E13.6,
     @     5x, E13.6, 5x, E13.6, 5x, E13.6, 5x, E13.6)
       enddo




 998   close(206-k)
       close(306-k)

c
c.....read the next infiltration bin and start process over--
c.....The portion of the routine from this point on up to the beginning
c     of the routine is completely general for any number of infiltration
c     bins specified in the parameter statement listed near the top of the
c     routine
c       **end the k loop**

       end do


c......Now--write the average results to individual files for RIP
c
c
c
c23456789012345678901234567890123456789012345678901234567890123456789012
 7     format(';', a70)
 8     format(';', 'The Average Waste Package Surface Temp (C)')
 9     format(';', 'The Average Invert Liquid Saturation')
 12    format(';', 'The Average Liquid Flux at 5 m (mm/yr)')
 27    format(';', 'The Maximum Waste Package Surface Temp (C)')
 74    format(';', 'The Minimum Waste Package Surface Temp (C)')
 75    format(';', 'The Average Invert Temp (C)')
 76    format(';', 'The Average Invert Rel. Humidity')
 77    format(';', 'The Average Invert Evaporation rate (m3/yr)')
 13    format(';', 'Time(yr)',',', ' Bin Weight= ', E13.6)
 14    format(';', a80)
 80    format(';', 'The Average Top Dripshield Temp (C)')
 91    format(';', 'The Average Invert Percolation Flux (m3/yr)')
 92    format(';', 'The Absolute Average Invert Percolation Flux
     @  (m3/yr)')
 928    format(f10.2, ',', E13.6)


c.....Begin building the RIP column files for averages, maximum, minimum Ts
c     invert, etc

        do  k = 1, ninf

c
c.....Average Temperature
```

```
      write (*,*) 'Writing T average value file for RIP'
      read(3,'(a)') resultsbinfile3(k)
      open(406-k,file=resultsbinfile3(k),status='new')
      write(406-k,8)
      write(406-k,7) resultsbinfile3(k)
      write(406-k,13) facttb(k)
      write(406-k,14) outfile(k)


       if (noent(k) .ne. 0) then
             write(406-k,*) 'No Entries for this Bin'
       else

        do j = 1,npts
       if ( j .eq. 1 ) then
        write(406-k,928) timeyr(j), TavgRIP(k,j)
        jtag = j
       else if (j .eq. npts) then
        write(406-k,928) timeyr(j), TavgRIP(k,j)
       else
        crate= ( (TavgRIP(k,j)-TavgRIP(k,jtag))/TavgRIP(k,jtag) )
     @  *100.

              if(abs(crate) .ge. prntfac) then
                write(406-k,928) timeyr(j), TavgRIP(k,j)
                jtag = j
               end if

       end if

         end do
        end if

      close(406-k)


c.....Average Liquid Saturation

       write (*,*) 'Writing S_L average value file for RIP'
       read(3,'(a)') resultsbinfile3a(k)
       open(406+k,file=resultsbinfile3a(k),status='new')
       write(406+k,9)
      write(406+k,7) resultsbinfile3a(k)
      write(406+k,13) facttb(k)
      write(406+k,14) outfile(k)


       if (noent(k) .ne. 0) then
             write(406+k,*) 'No Entries for this Bin'
       else

        do j = 1,npts
       if ( j .eq. 1 ) then
        write(406+k,928) timeyr(j), S_lavgRIP(k,j)
        jtag = j
       else if (j .eq. npts) then
        write(406+k,928) timeyr(j), S_lavgRIP(k,j)
       else

          if (S_lavgRIP(k,j) .eq. 0.) then
             write(406+k,928) timeyr(j), S_lavgRIP(k,j)
             imark0=j
          else

             chl = S_lavgRIP(k,jtag)
              if(chl .eq. 0.) then
               write(406+k,928) timeyr(j), S_lavgRIP(k,j)
               jtag=j
               goto 88
              endif
       crate= ( (S_lavgRIP(k,j)-S_lavgRIP(k,jtag))/S_lavgRIP(k,jtag)
     @     ) *100.
```

```
            if(abs(crate) .ge. prntfac .or.
     @           j-1 .eq. imark0) then
             write(406+k,928) timeyr(j), S_lavgRIP(k,j)
             jtag = j
            end if
88         endif
       end if

         end do
       end if
      close(406+k)

c2345678901234567890123456789012345678901234567890123456789012345678901

c.....Average liquid flux at 5 m

       write (*,*) 'Writing Q_perc average value file for RIP'

      read(3,'(a)') resultsbinfile3b(k)

      open(506-k,file=resultsbinfile3b(k),status='new')


      write(506-k,12)
      write(506-k,7) resultsbinfile3b(k)
      write(506-k,13) facttb(k)
      write(506-k,14) outfile(k)


       if (noent(k) .ne. 0) then
             write(506-k,*) 'No Entries for this Bin'
       else

        do j = 1,npts
       if ( j .eq. 1 ) then
        write(506-k,928) timeyr(j), ql_5mavgRIP(k,j)
        jtag = j
       else if (j .eq. npts) then
        write(506-k,928) timeyr(j), ql_5mavgRIP(k,j)
       else

          if (ql_5mavgRIP(k,j) .eq. 0.) then
             write(506-k,928) timeyr(j), ql_5mavgRIP(k,j)
             imark0 = j
          else

             ch1 = ql_5mavgRIP(k,jtag)
              if(ch1 .eq. 0.) then
               write(506-k,928) timeyr(j), ql_5mavgRIP(k,j)
               jtag=j
               goto 87
              endif


        crate= ( (ql_5mavgRIP(k,j)-ql_5mavgRIP(k,jtag))
     @  /ql_5mavgRIP(k,jtag) ) *100.


            if(abs(crate) .ge. prntfac .or. j-1 .eq.
     @           imark0) then
             write(506-k,928) timeyr(j), ql_5mavgRIP(k,j)
             jtag = j
            end if
87         endif
       end if

         end do
       end if

      close(506-k)

c.....Maximum Temperature
```

```
        write (*,*) 'Writing Tmax value file for RIP'

       read(3,'(a)') resultsbinfile4(k)

        open(506+k,file=resultsbinfile4(k),status='new')

        write(506+k,27)
        write(506+k,7) resultsbinfile4(k)
        write(506+k,13) facttb(k)
        write(506+k,14) outfile(k)

         if (noent(k) .ne. 0) then
               write(506+k,*) 'No Entries for this Bin'
         else

          do j = 1,npts
         if ( j .eq. 1 ) then
          write(506+k,928) timeyr(j), Tmaxrip(k,j)
          jtag = j
         else if (j .eq. npts) then
          write(506+k,928) timeyr(j), Tmaxrip(k,j)
         else
          crate= ( (Tmaxrip(k,j)-Tmaxrip(k,jtag))
     @    /Tmaxrip(k,jtag) ) *100.

                if(abs(crate) .ge. prntfac) then
                  write(506+k,928) timeyr(j), Tmaxrip(k,j)
                  jtag = j
                 end if

         end if

           end do
          end if
         close(506+k)

c.....Minimum Temperature

         write (*,*) 'Writing Tmin value file for RIP'

        read(3,'(a)') resultsbinfile5(k)

         open(606-k,file=resultsbinfile5(k),status='new')

         write(606-k,74)
         write(606-k,7) resultsbinfile5(k)
         write(606-k,13) facttb(k)
         write(606-k,14) outfile(k)


          if (noent(k) .ne. 0) then
                write(606-k,*) 'No Entries for this Bin'
          else

           do j = 1,npts
          if ( j .eq. 1 ) then
           write(606-k,928) timeyr(j), Tminrip(k,j)
           jtag = j
          else if (j .eq. npts) then
           write(606-k,928) timeyr(j), Tminrip(k,j)
          else
           crate= ( (Tminrip(k,j)-Tminrip(k,jtag))
     @     /Tminrip(k,jtag) ) *100.

                 if(abs(crate) .ge. prntfac) then
                   write(606-k,928) timeyr(j), Tminrip(k,j)
                   jtag = j
                  end if
```

```
      end if

        end do
       end if
      close(606-k)


c.....Average Invert T

       write (*,*) 'Writing Tinvert value file for RIP'

      read(3,'(a)') resultsbinfile6(k)

      open(606+k,file=resultsbinfile6(k),status='new')

      write(606+k,75)
      write(606+k,7) resultsbinfile6(k)
      write(606+k,13) facttb(k)
      write(606+k,14) outfile(k)


       if (noent(k) .ne. 0) then
             write(606+k,*) 'No Entries for this Bin'
       else

        do j = 1,npts
       if ( j .eq. 1 ) then
        write(606+k,928) timeyr(j), TavgRIPinv(k,j)
        jtag = j
       else if (j .eq. npts) then
        write(606+k,928) timeyr(j), TavgRIPinv(k,j)
       else
        crate= ( (TavgRIPinv(k,j)-TavgRIPinv(k,jtag))
     @    /TavgRIPinv(k,jtag) ) *100.

              if(abs(crate) .ge. prntfac) then
                write(606+k,928) timeyr(j), TavgRIPinv(k,j)
                jtag = j
               end if

       end if

         end do
        end if
       close(606+k)

c.....Average Invert RH

       write (*,*) 'Writing RHinvert value file for RIP'

      read(3,'(a)') resultsbinfile7(k)

      open(706-k,file=resultsbinfile7(k),status='new')

      write(706-k,76)
      write(706-k,7) resultsbinfile7(k)
      write(706-k,13) facttb(k)
      write(706-k,14) outfile(k)



       if (noent(k) .ne. 0) then
             write(706-k,*) 'No Entries for this Bin'
       else

        do j = 1,npts
       if ( j .eq. 1 ) then
        write(706-k,928) timeyr(j), RHavgRIPin(k,j)
        jtag = j
       else if (j .eq. npts) then
```

```
          write(706-k,928) timeyr(j), RHavgRIPin(k,j)
         else
          crate= ( (RHavgRIPin(k,j)-RHavgRIPin(k,jtag))
     @    /RHavgRIPin(k,jtag) ) *100.

               if(abs(crate) .ge. prntfac) then
                 write(706-k,928) timeyr(j), RHavgRIPin(k,j)
                 jtag = j
                end if

         end if

           end do
          end if
        close(706-k)


c.....Average Invert evaporation rate

         write (*,*) 'Writing Q_evapinvert value file for RIP'

        read(3,'(a)') resultsbinfile8(k)

        open(706+k,file=resultsbinfile8(k),status='new')

        write(706+k,77)
        write(706+k,7) resultsbinfile8(k)
        write(706+k,13) facttb(k)
        write(706+k,14) outfile(k)


         if (noent(k) .ne. 0) then
                write(706+k,*) 'No Entries for this Bin'
         else

          do j = 1,npts
         if ( j .eq. 1 ) then

            qvpavgRIPinv(k,j)=-99.9

          write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)
          jtag = j


         else if (j .eq. npts) then
          write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)/rho
         else

            if (qvpavgRIPinv(k,j)/rho .eq. 0.) then

                if ( qvpavgRIPinv(k,j)  .eq. -99.9) then

              write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)
              imark0 = j

                 else


              write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)/rho
              imark0 = j

                 endif


            else

              ch1 = (qvpavgRIPinv(k,jtag)/rho)
                if(ch1 .eq. 0.) then

                  if ( qvpavgRIPinv(k,j)  .eq. -99.9) then

                 write(706+k,928) timeyr(j),qvpavgRIPinv(k,j)
                 jtag=j
```

```
              goto 83

               else

              write(706+k,928) timeyr(j),qvpavgRIPinv(k,j)/rho
              jtag=j
              goto 83

               endif

             endif


       crate= ( (qvpavgRIPinv(k,j)/rho-qvpavgRIPinv(k,jtag)/rho)
     @    /(qvpavgRIPinv(k,jtag)/rho) ) *100.


             if(abs(crate) .ge. prntfac .or. j-1 .eq.
     @            imark0) then

               if ( qvpavgRIPinv(k,j)  .eq. -99.9) then

              write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)
              jtag = j

               else

              write(706+k,928) timeyr(j), qvpavgRIPinv(k,j)/rho
              jtag = j

               endif

              end if
 83         endif
       end if

         end do
        end if

       close(706+k)


c
c.....Average DS Temperature

       write (*,*) 'Writing T DS average value file for RIP'
       read(3,'(a)') resultsbinfile9(k)
       open(750-k,file=resultsbinfile9(k),status='new')
       write(750-k,80)
       write(750-k,7) resultsbinfile9(k)
       write(750-k,13) facttb(k)
       write(750-k,14) outfile(k)


        if (noent(k) .ne. 0) then
              write(750-k,*) 'No Entries for this Bin'
        else

         do j = 1,npts
        if ( j .eq. 1 ) then
         write(750-k,928) timeyr(j), TavgRIPdstop(k,j)
         jtag = j
        else if (j .eq. npts) then
         write(750-k,928) timeyr(j), TavgRIPdstop(k,j)
        else
         crate= ( (TavgRIPdstop(k,j)-TavgRIPdstop(k,jtag))
     @ /TavgRIPdstop(k,jtag) )*100.


              if(abs(crate) .ge. prntfac) then
                write(750-k,928) timeyr(j), TavgRIPdstop(k,j)
                jtag = j
               end if
```

```
        end if

         end do
        end if

       close(750-k)

c2345678901234567890123456789012345678901234567890123456789012345678901 2

c.....Average Qperc.liq in the invert

        write (*,*) 'Writing Qperc_inv average value file for RIP'
        read(3,'(a)') resultsbinfile10(k)
        open(750+k,file=resultsbinfile10(k),status='new')
        write(750+k,91)
       write(750+k,7) resultsbinfile10(k)
       write(750+k,13) facttb(k)
       write(750+k,14) outfile(k)


        if (noent(k) .ne. 0) then
              write(750+k,*) 'No Entries for this Bin'
        else

         do j = 1,npts
        if ( j .eq. 1 ) then
         write(750+k,928) timeyr(j), ql_invavgRIP(k,j)*(a_inv/1000.)
         jtag = j
        else if (j .eq. npts) then
         write(750+k,928) timeyr(j), ql_invavgRIP(k,j)*(a_inv/1000.)
        else

           if (ql_invavgRIP(k,j) .eq. 0.) then
              write(750+k,928) timeyr(j), ql_invavgRIP(k,j)
     @        *(a_inv/1000.)
              imark0=j
           else

              ch1 = ql_invavgRIP(k,jtag)
               if(ch1 .eq. 0.) then
                write(750+k,928) timeyr(j), ql_invavgRIP(k,j)
     @        *(a_inv/1000.)
                jtag=j
                goto 66
               endif
c2345678901234567890123456789012345678901234567890123456789012345678901 2
        crate= ( (ql_invavgRIP(k,j)-ql_invavgRIP(k,jtag))/
     @ ql_invavgRIP(k,jtag) ) *100.


              if(abs(crate) .ge. prntfac .or.
     @             j-1 .eq. imark0) then
                write(750+k,928) timeyr(j), ql_invavgRIP(k,j)
     @        *(a_inv/1000.)
                jtag = j
               end if
66           endif
        end if

         end do
        end if
       close(750+k)


        end do
c
c
c....All averages have been computed for RIP
c
c
c     This is an averaged value that disregardes the directionality
c     given in the raw data for the invert flux.  It has been requested
c     by the THC TSPA model
```

```
c

       do  k = 1, ninf
c23456789012345678901234567890123456789012345678901234567890123456789012
c.....Average ABS(Qperc.liq) in the invert

        write (*,*) 'Writing ABS(Qperc_inv) average value file for RIP'
        read(3,'(a)') resultsbinfile11(k)
        open(850-k,file=resultsbinfile11(k),status='new')
        write(850-k,92)
       write(850-k,7) resultsbinfile11(k)
       write(850-k,13) facttb(k)
       write(850-k,14) outfile(k)


        if (noent(k) .ne. 0) then
              write(850-k,*) 'No Entries for this Bin'
        else

         do j = 1,npts
        if ( j .eq. 1 ) then
         write(850-k,928) timeyr(j), ql_invavgabs(k,j)*(a_inv/1000.)
         jtag = j
        else if (j .eq. npts) then
         write(850-k,928) timeyr(j), ql_invavgabs(k,j)*(a_inv/1000.)
        else


           if (ql_invavgabs(k,j) .eq. 0.) then
              write(850-k,928) timeyr(j), ql_invavgabs(k,j)
     @        *(a_inv/1000.)
              imark0=j
           else

              ch1 = ql_invavgabs(k,jtag)
               if(ch1 .eq. 0.) then
                write(850-k,928) timeyr(j), ql_invavgabs(k,j)
     @        *(a_inv/1000.)
                jtag=j
                goto 67
               endif
c23456789012345678901234567890123456789012345678901234567890123456789012
        crate= ( (ql_invavgabs(k,j)-ql_invavgabs(k,jtag))/
     @ ql_invavgabs(k,jtag) ) *100.


               if(abs(crate) .ge. prntfac .or.
     @              j-1 .eq. imark0) then
                 write(850-k,928) timeyr(j), ql_invavgabs(k,j)
     @        *(a_inv/1000.)
                 jtag = j
                end if
 67         endif
        end if

          end do
         end if
        close(850-k)

      enddo


        close(3)


        stop
        end
```

Test Case

The test case for this routine is described as the following. Using an older set of process-level multiscale TH model results, a test case was specified using a subset of the location dependent results. The test case for **TH-msmabs_ver_1** utilized a small subset of the process-level location dependent results with enough infiltration rate variability to fill a number of predefined infiltration rate bins. The five infiltration rate bins defined for this test case were arbitrarily set to be:

- 0-5 mm/yr
- 5-20 mm/yr
- 20-50 mm/yr
- 50-100 mm/yr
- > 100 mm/yr

The 19 testing raw file names are the following:

csnf_x11_y23_data
csnf_x10_y10_data
csnf_x10_y25_data
csnf_x11_y13_data
csnf_x11_y3_data
csnf_x11_y31_data
csnf_x12_y13_data
csnf_x14_y21_data
csnf_x14_y25_data
csnf_x16_y12_data
csnf_x23_y14_data
csnf_x23_y24_data
csnf_x23_y25_data
csnf_x24_y24_data
csnf_x25_y13_data
csnf_x25_y25_data
csnf_x6_y22_data
csnf_x8_y18_data
csnf_x9_y25_data

These files names provide the raw data for the TH abstraction routine. Note that the infiltration rate given in the files correspond to the infiltration rate for the glacial infiltration flux map. These 19 files as well as the limits of the infiltration bins were selected so that one bin (>100) would be empty and the others would contain several waste package locations. Excerpts of the header information from each one are the following:

file: **csnf_x10_y10_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwrl

Location:
easting (NV central): 170794.14
northing (NV central): 232027.50

Area:
fraction of repository area
represented by cell 10,10 = 0.002370

Infiltration:
cell 10,10 infiltration: 38.281521 (mm/yr)

file: **csnf_x10_y25_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwrl

Location:
easting (NV central): 173259.67
northing (NV central): 232158.33

Area:
fraction of repository area
represented by cell 10,25 = 0.002370

Infiltration:
cell 10,25 infiltration: 58.710880 (mm/yr)

file: **csnf_x11_y13_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwrl

Location:
easting (NV central): 171284.59
northing (NV central): 232103.59

Area:
fraction of repository area
represented by cell 11,13 = 0.001471

Infiltration:
cell 11,13 infiltration: 45.176048 (mm/yr)

file: **csnf_x11_y23_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwr1

Location:
easting (NV central): 172928.28
northing (NV central): 232190.81

Area:
fraction of repository area
represented by cell 11,23 = 0.001471

Infiltration:
cell 11,23 infiltration: 58.402111 (mm/yr)

file: csnf_x11_y3_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwr1

Location:
easting (NV central): 170074.80
northing (NV central): 232039.39

Area:
fraction of repository area
represented by cell 11,3 = 0.000736

Infiltration:
cell 11, 3 infiltration: 10.243590 (mm/yr)

file: csnf_x11_y31_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwr1

Location:
easting (NV central): 174094.34
northing (NV central): 232252.69

Area:
fraction of repository area
represented by cell 11,31 = 0.000736

Infiltration:
cell 11,31 infiltration: 23.503290 (mm/yr)

file: csnf_x12_y13_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 171281.95
northing (NV central): 232153.52

Area:
fraction of repository area
represented by cell 12,13 = 0.002370

Infiltration:

cell 12,13 infiltration: 43.338348 (mm/yr)

file: **csnf_x14_y21_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwrl

Location:
easting (NV central): 172591.59
northing (NV central): 232323.16

Area:
fraction of repository area
represented by cell 14,21 = 0.002370

Infiltration:
cell 14,21 infiltration: 18.467110 (mm/yr)

file: **csnf_x14_y25_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwrl

Location:
easting (NV central): 173249.08
northing (NV central): 232358.05

Area:
fraction of repository area
represented by cell 14,25 = 0.002370

Infiltration:
cell 14,25 infiltration: 55.427521 (mm/yr)

file: **csnf_x16_y12_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwrl

Location:
easting (NV central): 171106.98
northing (NV central): 232344.52

Area:
fraction of repository area
represented by cell 16,12 = 0.001802

Infiltration:
cell 16,12 infiltration: 26.987841 (mm/yr)

file: **csnf_x23_y14_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwrl

Location:
easting (NV central): 171410.23
northing (NV central): 232842.34

Area:
fraction of repository area
represented by cell 23,14 = 0.001153

Infiltration:
cell 23,14 infiltration: 5.818380 (mm/yr)

file: **csnf_x23_y24_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 173053.92
northing (NV central): 232929.56

Area:
fraction of repository area
represented by cell 23,24 = 0.001153

Infiltration:
cell 23,24 infiltration: 4.026520 (mm/yr)

file: **csnf_x23_y25_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 173218.28
northing (NV central): 232938.28

Area:
fraction of repository area
represented by cell 23,25 = 0.001153

Infiltration:
cell 23,25 infiltration: 4.168559 (mm/yr)

file: **csnf_x24_y24_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 173052.33
northing (NV central): 232959.52

Area:
fraction of repository area
represented by cell 24,24 = 0.000960

Infiltration:
cell 24,24 infiltration: 3.302886 (mm/yr)

file: **csnf_x25_y13_data**

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 171242.81
northing (NV central): 232891.03

Area:
fraction of repository area
represented by cell 25,13 = 0.000576

Infiltration:
cell 25,13 infiltration: 4.223064 (mm/yr)

file: csnf_x25_y25_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 173215.23
northing (NV central): 232995.70

Area:
fraction of repository area
represented by cell 25,25 = 0.000576

Infiltration:
cell 25,25 infiltration: 3.046576 (mm/yr)

file: csnf_x6_y22_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: bwr1

Location:
easting (NV central): 172771.86
northing (NV central): 232032.30

Area:
fraction of repository area
represented by cell 6,22 = 0.000576

Infiltration:
cell 6,22 infiltration: 59.383259 (mm/yr)

file: csnf_x8_y18_data

data file creation date: Fri Nov 12 03:15:23 1999
MSTHM version: MSTHM_rev_6.0
base EXTfile creation date: Fri Nov 12 02:30:06 1999

Type:
average WP type: pwr1

Location:
easting (NV central): 172112.00
northing (NV central): 232042.34

```
Area:
fraction of repository area
represented by cell 8,18 =            0.000960

Infiltration:
cell  8,18 infiltration:              30.672880      (mm/yr)
```

file: **csnf_x9_y25_data**

```
data file creation date:              Fri Nov 12 03:15:23 1999
MSTHM version:          MSTHM_rev_6.0
base EXTfile creation date:           Fri Nov 12 02:30:06 1999

Type:
average WP type:              bwrl

Location:
easting (NV central):         173261.34
northing (NV central):        232126.72

Area:
fraction of repository area
represented by cell 9,25 =            0.001471

Infiltration:
cell  9,25 infiltration:              58.489750      (mm/yr)
```

The infiltration bin constituents resulted in the following and can be easily verified by referring to the header information for each of the file names given above.

```
5.0 > qinf >   0.0 mm/yr
csnf_x23_y24_data
csnf_x23_y25_data
csnf_x24_y24_data
csnf_x25_y13_data
csnf_x25_y25_data

20.0 > qinf >   5.0 mm/yr
csnf_x11_y3_data
csnf_x14_y21_data
csnf_x23_y14_data

50.0 > qinf >  20.0 mm/yr
csnf_x10_y10_data
csnf_x11_y13_data
csnf_x11_y31_data
csnf_x12_y13_data
csnf_x16_y12_data
csnf_x8_y18_data

100.0 > qinf >  50.0 mm/yr
csnf_x10_y25_data
csnf_x11_y23_data
csnf_x14_y25_data
csnf_x6_y22_data
csnf_x9_y25_data

qinf > 100.0 mm/yr
no entries
```

Reference to the above header information excerpts indicates that the routine performed a correct infiltration bin sort. To verify that the routine was averaging the files correctly, the contents of the 5-20 mm/yr bin were analyzed since it contained only three entries.

The maximum and minimum peak waste package temperatures for an infiltration bin have been computed by the abstraction routine. The raw file excerpts (csnf_x11_y3_data, csnf_x14_y21_data, and csnf_x23_y14_data) are the following where the waste package temperature is the seventh entry on each line of data.

From: csnf_x11_y3_data

```
time     T_dw     T_5m     T_bfpeak        T_ds     T_ds_top        T_wp     T_invert        T_dw_lower

5.020000e+01    1.079079e+02    5.946280e+01    9.495312e+01    1.933456e+02    2.100566e+02
        1.990075e+02    1.865332e+02    1.305814e+02
5.100000e+01    1.265991e+02    6.663611e+01    1.076963e+02    2.263057e+02    2.508282e+02
        2.309583e+02    2.247124e+02    1.656196e+02
5.200000e+01    1.374631e+02    7.230843e+01    1.144087e+02    2.375682e+02    2.604502e+02
        2.419210e+02    2.363690e+02    1.792419e+02
5.300000e+01    1.429321e+02    7.630112e+01    1.180446e+02    2.422036e+02    2.630546e+02
        2.463977e+02    2.403818e+02    1.851753e+02
5.500000e+01    1.481243e+02    8.066521e+01    1.214946e+02    2.450592e+02    2.642318e+02
        2.490645e+02    2.430757e+02    1.901798e+02
6.000000e+01    1.473233e+02    8.753497e+01    1.275821e+02    2.383133e+02    2.361833e+02
        2.420897e+02    2.198097e+02    1.792415e+02
6.500000e+01    1.362480e+02    8.510767e+01    1.199244e+02    2.216802e+02    2.106310e+02
        2.253286e+02    1.968262e+02    1.628184e+02
7.000000e+01    1.231383e+02    8.088477e+01    1.095362e+02    2.036236e+02    1.850576e+02
        2.071774e+02    1.735592e+02
```

From: csnf_x14_y21_data

```
time     T_dw     T_5m     T_bfpeak        T_ds     T_ds_top        T_wp     T_invert        T_dw_lower

5.020000e+01    8.434234e+01    5.893561e+01    7.837916e+01    1.858008e+02    1.535886e+02
        1.927077e+02    1.344603e+02    9.657288e+01
5.100000e+01    1.079077e+02    6.157022e+01    9.625459e+01    2.218336e+02    2.160703e+02
        2.275257e+02    1.903096e+02    1.333903e+02
5.200000e+01    1.227583e+02    6.590492e+01    1.054143e+02    2.365033e+02    2.444548e+02
        2.418567e+02    2.180495e+02    1.587123e+02
5.300000e+01    1.313680e+02    6.975902e+01    1.106904e+02    2.439642e+02    2.562992e+02
        2.491412e+02    2.306773e+02    1.718645e+02
5.500000e+01    1.413509e+02    7.548883e+01    1.169717e+02    2.512053e+02    2.643777e+02
        2.561747e+02    2.408007e+02    1.840303e+02
6.000000e+01    1.521632e+02    8.360072e+01    1.255995e+02    2.554626e+02    2.680487e+02
        2.601839e+02    2.470273e+02    1.943517e+02
6.500000e+01    1.568559e+02    8.838988e+01    1.322779e+02    2.541520e+02    2.648200e+02
        2.587371e+02    2.452089e+02    1.961259e+02
7.000000e+01    1.586102e+02    9.053515e+01    1.345224e+02    2.506727e+02    2.599013e+02
        2.551649e+02    2.413101e+02    1.948222e+02
```

From: csnf_x23_y14_data

```
time     T_dw     T_5m     T_bfpeak        T_ds     T_ds_top        T_wp     T_invert        T_dw_lower

5.020000e+01    1.115959e+02    6.142118e+01    9.766385e+01    2.130544e+02    2.225866e+02
        2.199612e+02    1.958969e+02    1.386458e+02
5.100000e+01    1.247149e+02    6.767982e+01    1.061320e+02    2.386408e+02    2.460411e+02
        2.443329e+02    2.181769e+02    1.609650e+02
5.200000e+01    1.342640e+02    7.332985e+01    1.125285e+02    2.480090e+02    2.538714e+02
        2.533624e+02    2.282049e+02    1.734821e+02
5.300000e+01    1.392271e+02    7.740089e+01    1.162857e+02    2.518232e+02    2.551589e+02
        2.570002e+02    2.309404e+02    1.783068e+02
5.500000e+01    1.448649e+02    8.281490e+01    1.210741e+02    2.547192e+02    2.545706e+02
        2.596887e+02    2.323590e+02    1.829909e+02
6.000000e+01    1.460401e+02    8.458882e+01    1.224996e+02    2.493394e+02    2.527710e+02
        2.540608e+02    2.312749e+02    1.833191e+02
```

```
6.500000e+01    1.410488e+02    9.031780e+01    1.239312e+02    2.383449e+02    2.209467e+02
        2.429300e+02    2.046711e+02    1.686650e+02
7.000000e+01    1.343912e+02    9.113138e+01    1.204031e+02    2.264538e+02    2.007162e+02
        2.309459e+02    1.871023e+02    1.571478e+02
```

The numbers in regular bold above are checked against excerpts from the routine generated data from max and min waste package surface temperature in bold below:

The bin max file:

```
50.20, 0.192708E+03
51.00, 0.227526E+03
52.00, 0.241857E+03
53.00, 0.249141E+03
55.00, 0.256175E+03
60.00, 0.260184E+03
65.00, 0.258737E+03
70.00, 0.255165E+03
```

The bin min file:

```
50.20, 0.199007E+03
51.00, 0.230958E+03
52.00, 0.241921E+03
53.00, 0.246398E+03
55.00, 0.249065E+03
60.00, 0.242090E+03
65.00, 0.225329E+03
70.00, 0.207177E+03
```

The routine is making the correct evaluation of the maximum and minimum peak waste package surface temperature. The averaging process is also checked for each of the variables passed to the TSPA model. For convenience (refer to values in bold italics above), the average calculated value of the waste package surface temperature at 70 years was checked. The fraction of repository area corresponding to each waste package location file can be found in the header of the data file given above. The average is calculated as (refer to equation 2):

$$Tavg = \frac{0.000736}{0.004259}(207.1774) + \frac{0.00237}{0.004259}(255.1649) + \frac{0.001153}{0.004259}(230.9459) = 240.316$$

It is compared to the routine average value for the temperature of the waste package:

```
50.20, 0.201174E+03
51.00, 0.232669E+03
52.00, 0.244983E+03
53.00, 0.250795E+03
55.00, 0.255897E+03
60.00, 0.255399E+03
65.00, 0.248684E+03
70.00, 0.240316E+03
```

Again, the TH abstraction routine correctly performs its task. Although not shown here, each of the remaining TSPA averaged values given in Table 4 (in Section 6.1) have been spot checked at different times for this arbitrary infiltration bin. All of the average have been calculated correctly by the TH abstraction routine. Additionally, the raw value files used in the TSPA model have also been spot checked at different times for every variable passed (see Table 3 in Section 6.1) and have been found to be completely correct.

Attachment II
TH Abstraction Routine
(pillart)

This attachment contains documentation of the hand-check to demonstrate that the Subroutine **pillart** version 1.00 works correctly. This routine was written in Fortran 77 and reads in the 623 files whose names are in the file "csnflow" and searches for the peak pillar temperature at two locations that are closest to the quarter pillar locations. Quarter-pillar temperatures that are lower than the local boiling temperature implies that over half of the pillar remains sub-boiling and therefore will always allow, if available, liquid to drain through fractures in the pillars. The output file contains the following variables: the waste package name, the easting (m) location, the northing (m) location, the time for peak temperature at 15.14 m (years), the peak pillar temperature (°C) at X = 15.14 m, the time for peak temperature at 22.64 m (years), and the peak pillar temperature (°C) at X = 22.64 m.

For this subroutine to function correctly, the routine must have a file named "csnflow" that contains the locations of all of the 623 waste package files. The name of the output file is "output."

A copy of this routine can be found in DTN: SN0001T0872799.006 in the Zip file called source_routines.ZIP. The output file for the CSNF low infiltration flux case can be found in the same DTN in the file called: wptemp_pillert_out.ZIP.

```
c23456789012345678901234567890123456789012345678901234567890123456789012
c....This routine pulls the maximum temperature from the pillars
c    from the output files.
c
c    MT Itamura 1/10/00
c
c    pillart version 1.00 for low infiltration rate files
c
c.....Nomenclature for this processor
c       timeyr --time in years as taken from the multiscale results
c        temp(8)--eight pillar 3emps going from 2.99m, 3.69m, 4.89m,
c                 6.89 m, 10.14m, 15.14m, 22.64, 33.82m.
c        time15 --time in years for the max temp at 15.14 meters
c        time23 --time in years for the max temp at 22.14 meters
c
      implicit double precision (a-h,l,o-z)
      character*4 name
      character*10 text10
      character*80 infile1
c
c23456789012345678901234567890123456789012345678901234567890123456789012
c
        real *8 temp(8)
c
c...... open the file containing the THMSM file names and the
c       output files
c
        open(3,file='csnflow', status='old')
        read(3,*)
        open(4,file='output',status='new')
c
c...... start main loop
c
 50     read(3,'(a)') infile1
        if (infile1 .eq. 'end') goto 100
        open(5,file=infile1,status='old')
```

```
 40     read(5,10) name
c
c...... isolate coordinate locations
c
 10     format (a4)
        if(name .ne. 'Loca') goto 40
        read(5,20) coord1
        read(5,20) coord2
 20     format(23x,f9.2)
c
c...... Search files for Pillar Temps
c
 60      read(5,30) text10
         if(text10 .ne. 'T_pillar_x') goto 60
 30      format(5x,A10)
c
c...... Loop to find the maximum pillar temps.
c
         tmax15 = 0.
         tmax23 = 0.
         do I = 1,442
           read(5,*) timeyr,(temp(J),J=1,8)
           if (temp(6) .ge. tmax15) then
             tmax15 =  temp(6)
             time15 = timeyr
           endif
           if (temp(7).ge. tmax23) then
             tmax23 = temp(7)
             time23 = timeyr
           endif
         end do
         close (5)
c
c...... print out the name/location of WP and Pill Temps
c
        if(infile1(11:12) .eq. '_d') infile1(11:12)='  '
        if(infile1(12:12) .eq. '_') infile1(12:12)=' '
        write (4,80) infile1(6:12),coord1,coord2,time15,
     &    tmax15,time23,tmax23
 80     format(A7,3x,6F12.3)
        goto 50
100     continue
        close (4)
        stop
        end
```

To verify that the **pillart** v 1.00 was working properly, the maximum temperature in several files were checked against the contents of the output files. Due to the length of the thermal hydrology multi-scale files, only a few lines out of a one output file will be presented here. The routine works by first searching for the section that contains the pillar temperatures by searching for the data header line that contains the string "T_pillar_x." The routine then loops through the data to find the maximum values at the pillar locations X = 15.14 and 22.64 meters for all of the waste packages.

The following five entries were taken from the pillar section of the file csnf_x1_y20_data using the mean infiltration flux map. The first entry is the time in years and the next eight entries correspond to pillar temperatures at eight different locations. The sixth and seventh temperatures correspond to the locations X = 15.14 and 22.64 meters and the maximum temperatures are highlighted in bold type.

5.300000e+01	1.423711e+02	1.351577e+02	1.232342e+02	1.067540e+02	9.005058e+01	7.398631e+01	5.757977e+01	5.576180e+01
5.500000e+01	1.439366e+02	1.372549e+02	1.261465e+02	1.105013e+02	9.341956e+01	7.862854e+01	6.248182e+01	6.050611e+01
6.000000e+01	1.360688e+02	1.308228e+02	1.220843e+02	1.096992e+02	9.490884e+01	**8.151456e+01**	6.825842e+01	6.646258e+01
6.500000e+01	1.269969e+02	1.226202e+02	1.153304e+02	1.049925e+02	9.254220e+01	8.063892e+01	**6.947131e+01**	6.795477e+01
7.000000e+01	1.083797e+02	1.053895e+02	1.004097e+02	9.335429e+01	8.481591e+01	7.618452e+01	6.836872e+01	6.734280e+01
8.000000e+01	9.532781e+01	9.326108e+01	8.982748e+01	8.497298e+01	7.909160e+01	7.300096e+01	6.749231e+01	6.681044e+01
9.000000e+01	9.172752e+01	8.993189e+01	8.694819e+01	8.272629e+01	7.760643e+01	7.227520e+01	6.741820e+01	6.682641e+01

An excerpt from routine of output file for the waste package location are presented here to check if the routine is working properly.

x1_y20	170208.780	234316.700	60.000	**81.515**	65.000	**69.471**

Both the time printouts and the maximum pillar temperatures match. Another excerpt from the output file from csnf_x13_y31 show that maximum pillar temperatures at 15.14 and 22.64 meters occur at 70 and 120 years, respectively.

5.200000e+01	1.213061e+02	1.144523e+02	1.039011e+02	9.307321e+01	7.870619e+01	6.307616e+01	4.973679e+01	4.849637e+01
5.300000e+01	1.272037e+02	1.200079e+02	1.085175e+02	9.624622e+01	8.339574e+01	6.748940e+01	5.299600e+01	5.153705e+01
5.500000e+01	1.321354e+02	1.252082e+02	1.137900e+02	9.939754e+01	8.809335e+01	7.267431e+01	5.774720e+01	5.609202e+01
6.000000e+01	1.331451e+02	1.272544e+02	1.174956e+02	1.039785e+02	9.123426e+01	7.812762e+01	6.472215e+01	6.309930e+01
6.500000e+01	1.255228e+02	1.208164e+02	1.130022e+02	1.020672e+02	9.063167e+01	7.980171e+01	6.899314e+01	6.766010e+01
7.000000e+01	1.151501e+02	1.115701e+02	1.056237e+02	9.730519e+01	8.832446e+01	**7.981609e+01**	7.160784e+01	7.060218e+01
8.000000e+01	1.005094e+02	9.831336e+01	9.467903e+01	8.972212e+01	8.427147e+01	7.889580e+01	7.391724e+01	7.332684e+01
9.000000e+01	9.728370e+01	9.541467e+01	9.233379e+01	8.818055e+01	8.357285e+01	7.895582e+01	7.468965e+01	7.418692e+01
1.000000e+02	9.559982e+01	9.389543e+01	9.109969e+01	8.734933e+01	8.315911e+01	7.892779e+01	7.501669e+01	7.455741e+01

```
1.200000e+02   8.990249e+01   8.873103e+01   8.682445e+01   8.425212e+01   8.126514e+01
        7.820049e+01   7.535120e+01   7.502020e+01
1.400000e+02   8.769317e+01   8.669902e+01   8.506699e+01   8.286695e+01   8.027061e+01
        7.759660e+01   7.510276e+01   7.481392e+01
1.500000e+02   8.534691e+01   8.455280e+01   8.324000e+01   8.138216e+01   7.913449e+01
        7.681091e+01   7.463757e+01   7.438668e+01
1.600000e+02   8.475370e+01   8.397767e+01   8.269715e+01   8.091068e+01   7.876307e+01
        7.654623e+01   7.447131e+01   7.423197e+01
```

The entry in the output file reflects that both the time and the temperature are being correctly identified by the software routine.

```
x13_y31     170700.530  235815.300     70.000     79.816     120.000     75.351
```

The number of time entries in the output fine was checked to verify that there was one entry for each of the 623 waste packages in the output file..

Attachment III
TH Abstraction Routine
(maxtwp)

This attachment contains documentation of the hand-check to demonstrate that the Subroutine **maxtwp** works correctly. This routine was written in Fortran 77 and reads in the 623 files whose names are in the file "csnflow," "csnfmean," or "csnfhigh" and searches for and prints out the peak waste package temperature from each of the individual files. Once the subroutine has looped through all of the temperatures, then the waste package name, location, time (at peak temperature), and peak temperature are printed out. The name of the output file is "output."

There are three versions of the routine **maxtwp** used in this AMR. A version of this subroutine was created for each of the three infiltration flux cases; version 1.00 for the mean case, version 1.01 for the high case, and version 1.02 for the low case **(Note: a comment line in the source code below for maxtwp version 1.01 incorrectly indicates that it applies to the low case, a comment line in the source code below for maxtwp version 1.02 incorrectly indicates that it applies to the high case)**. The only code change in the routine was changing the name of the input file and changing the number of entries in one of the loops since the number of time entries for the three different cases were not the same. All three subroutines are presented on this and the next five pages.

A copy of this routine can be found in DTN: SN0001T0872799.006 in the Zip file called source_routines.ZIP. The output file for the CSNF low infiltration flux case can be found in the same DTN in the file called: wptemp_pillert_out.ZIP.

```
maxtwp version 1.00

c2345678901234567890123456789012345678901234567890123456789012
c....This routine pulls the maximum waste package temperatures
c    from the output files.
c
c    MT Itamura 1/12/00
c
c   maxtwp v 1.00 software routine.   Written to extract max temps
c      from mean infiltration files of the MSTH model
c
c.....Nomenclature for this processor
c       timeyr --time in years as taken from the multiscale results
c        tempwp --wastepackage temperature
c        tmaxwp --maximum waste package temperature
c
      implicit double precision (a-h,l,o-z)
      character*4 name
      character*10 text10
      character*80 infile1
c
c2345678901234567890123456789012345678901234567890123456789012
c
c...... open the file containing the THMSM file names and the
c        output files
c
        open(3,file='csnfmean', status='old')
        read(3,*)
        open(4,file='output',status='new')
```

```
c
c...... start main loop
c
 50     read(3,'(a)') infile1
        if (infile1 .eq. 'end') goto 100
        open(5,file=infile1,status='old')
 40     read(5,10) name
c
c...... isolate coordinate locations
c
 10     format (a4)
        if(name .ne. 'Loca') goto 40
        read(5,20) coord1
        read(5,20) coord2
 20     format(23x,f9.2)
c
c...... Search files for Pillar Temps
c
 60       read(5,30) text10
          if(text10 .ne. 'TSPA data ') goto 60
 30       format(3x,A10)
          read(5,*)
c
c...... Loop to find the maximum pillar temps.
c
          tmaxwp = 0.
          do I = 1,352
            read(5,*) timeyr,tempwp
            if (tempwp .ge. tmaxwp) then
              tmaxwp =  tempwp
              time = timeyr
            endif
          end do
          close (5)
c
c...... print out the name/location of WP Temps
c
        if(infile1(11:12) .eq. '_d') infile1(11:12)='  '
        if(infile1(12:12) .eq. '_') infile1(12:12)=' '
        write (4,80) infile1(6:12),coord1,coord2,time,
     &    tmaxwp
 80     format(A7,3x,4F12.3)
        goto 50
100     continue
        close (4)
        stop
        end
```

maxtwp version 1.01

```
c2345678901234567890123456789012345678901234567890123456789012345678901 2
c....This routine pulls the maximum waste package temperatures
c    from the output files.
c
c    MT Itamura 1/12/00
c
c   maxtwp v 1.01 software routine.   Written to extract max temps
c      from low infiltration files of the MSTH model
c
c.....Nomenclature for this processor
c       timeyr --time in years as taken from the multiscale results
c       tempwp --wastepackage temperature
c       tmaxwp --maximum waste package temperature
c
      implicit double precision (a-h,l,o-z)
      character*4 name
      character*10 text10
      character*80 infile1
c
c234567890123456789012345678901234567890123456789012345678901234567890 12
c
c...... open the file containing the THMSM file names and the
c       output files
c
        open(3,file='csnflow', status='old')
        read(3,*)
        open(4,file='output',status='new')
c
c...... start main loop
c
 50     read(3,'(a)') infile1
        if (infile1 .eq. 'end') goto 100
        open(5,file=infile1,status='old')
 40     read(5,10) name
c
c...... isolate coordinate locations
c
 10     format (a4)
        if(name .ne. 'Loca') goto 40
        read(5,20) coord1
        read(5,20) coord2
 20     format(23x,f9.2)
c
c...... Search files for Pillar Temps
c
 60      read(5,30) text10
         if(text10 .ne. 'TSPA data ') goto 60
 30      format(3x,A10)
         read(5,*)
c
c...... Loop to find the maximum pillar temps.
c
         tmaxwp = 0.
         do I = 1,442
           read(5,*) timeyr,tempwp
           if (tempwp .ge. tmaxwp) then
             tmaxwp =  tempwp
             time = timeyr
           endif
         end do
         close (5)
c
c...... print out the name/location of WP Temps
c
        if(infile1(11:12) .eq. '_d') infile1(11:12)='  '
```

```
        if(infile1(12:12) .eq. '_') infile1(12:12)=' '
        write (4,80) infile1(6:12),coord1,coord2,time,
     &   tmaxwp
 80     format(A7,3x,4F12.3)
        goto 50
100     continue
        close (4)
        stop
        end
```

maxtwp version 1.02

```
c2345678901234567890123456789012345678901234567890123456789012345678901
c....This routine pulls the maximum waste package temperatures
c    from the output files.
c
c    MT Itamura 1/12/00
c
c   maxtwp v 1.02 software routine.   Written to extract max temps
c     from high infiltration files of the MSTH model
c
c.....Nomenclature for this processor
c      timeyr --time in years as taken from the multiscale results
c       tempwp --wastepackage temperature
c       tmaxwp --maximum waste package temperature
c
      implicit double precision (a-h,l,o-z)
      character*4 name
      character*10 text10
      character*80 infile1
c
c2345678901234567890123456789012345678901234567890123456789012345678901
c
c...... open the file containing the THMSM file names and the
c       output files
c
        open(3,file='csnfhigh', status='old')
        read(3,*)
        open(4,file='output',status='new')
c
c...... start main loop
c
 50     read(3,'(a)') infile1
        if (infile1 .eq. 'end') goto 100
        open(5,file=infile1,status='old')
 40     read(5,10) name
c
c...... isolate coordinate locations
c
 10     format (a4)
        if(name .ne. 'Loca') goto 40
        read(5,20) coord1
        read(5,20) coord2
 20     format(23x,f9.2)
c
c...... Search files for Pillar Temps
c
 60      read(5,30) text10
         if(text10 .ne. 'TSPA data ') goto 60
 30      format(3x,A10)
         read(5,*)
c
c...... Loop to find the maximum pillar temps.
c
         tmaxwp = 0.
```

```
         do I = 1,365
           read(5,*) timeyr,tempwp
           if (tempwp .ge. tmaxwp) then
             tmaxwp =  tempwp
             time = timeyr
           endif
         end do
         close (5)
c
c...... print out the name/location of WP Temps
c
        if(infile1(11:12) .eq. '_d') infile1(11:12)='  '
        if(infile1(12:12) .eq. '_') infile1(12:12)=' '
        write (4,80) infile1(6:12),coord1,coord2,time,
     &   tmaxwp
 80     format(A7,3x,4F12.3)
        goto 50
100     continue
        close (4)
        stop
        end
```

To verify that the subroutines were working correctly, a spot check was performed on several of the entries of the files to verify that the peak waste package temperatures were being captured in the output files. Each output file contained an entry for each of the 623 waste package. A section of two individual CSNF data files (locations X1_Y20 and X15_Y17) at each infiltration flux case is shown below at times near when the temperature peaks. The peak waste package temperature in the file is in bold type.

Mean infiltration case flux subroutine. (maxtwp V 1.00)

Excerpt from file: `csnf_x1_y20_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	6.657310e+01	7.845000e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	2.361726e+02	7.589400e-02	2.305107e+02	8.407500e-02
5.100000e+01	2.706794e+02	3.432300e-02	2.660268e+02	3.693000e-02
5.200000e+01	**2.738024e+02**	2.706200e-02	2.694496e+02	2.895800e-02
5.300000e+01	2.710059e+02	2.792200e-02	2.668118e+02	2.982200e-02
5.500000e+01	2.614215e+02	2.887500e-02	2.574163e+02	3.082100e-02
6.000000e+01	2.250090e+02	3.281900e-02	2.212326e+02	3.524200e-02

Excerpt from mean infiltration flux case output file for X1_Y20:

WP loc	Easting	Northing	Time	Peak WP Temp
x1_y20	170208.780	234316.700	52.000	**273.802**

Excerpt from file: `csnf_x15_y17_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	8.220609e+01	7.438060e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	1.023986e+02	1.013430e-01	9.673669e+01	1.241350e-01
5.100000e+01	2.159479e+02	4.863900e-02	2.112953e+02	5.330500e-02
5.200000e+01	2.432497e+02	4.314800e-02	2.388969e+02	4.656700e-02
5.300000e+01	2.600193e+02	4.427400e-02	2.558252e+02	4.742200e-02
5.500000e+01	2.705654e+02	3.941300e-02	2.665602e+02	4.197600e-02
6.000000e+01	**2.752484e+02**	3.443700e-02	2.714719e+02	3.650600e-02
6.500000e+01	2.736104e+02	3.438400e-02	2.699619e+02	3.639000e-02
7.000000e+01	2.694624e+02	3.332400e-02	2.659086e+02	3.524600e-02

Excerpt from mean infiltration flux case output file for X15_Y17:

WP loc	Easting	Northing	Time	Peak WP Temp
x15_y17	170693.530	233796.500	60.000	**275.248**

The peak waste package temperature and the time of the peak was found correctly and printed out in the output file for both cases.

High infiltration flux case subroutine (maxtwp V 1.01)

Excerpt from file: `csnf_x1_y20_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	6.429750e+01	7.811210e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	2.264506e+02	7.729200e-02	2.207887e+02	8.599500e-02
5.100000e+01	2.634177e+02	3.746500e-02	2.587651e+02	4.039500e-02
5.200000e+01	**2.665676e+02**	3.259000e-02	2.622148e+02	3.493700e-02
5.300000e+01	2.638432e+02	2.877200e-02	2.596491e+02	3.078700e-02
5.500000e+01	2.540628e+02	2.983800e-02	2.500575e+02	3.190900e-02
6.000000e+01	2.168745e+02	3.696700e-02	2.130981e+02	3.980100e-02

Excerpt from high infiltration flux case output file for X1_Y20:

WP loc	Easting	Northing	Time	Peak WP Temp
x1_y20	170208.780	234316.700	52.000	**266.568**

Excerpt from file: `csnf_x15_y17_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	8.052612e+01	7.350380e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	1.007864e+02	9.816500e-02	9.512450e+01	1.204720e-01
5.100000e+01	2.122181e+02	4.862700e-02	2.075655e+02	5.337000e-02
5.200000e+01	2.372458e+02	4.452500e-02	2.328930e+02	4.814400e-02
5.300000e+01	2.538464e+02	4.134100e-02	2.496523e+02	4.435600e-02
5.500000e+01	2.655702e+02	3.957000e-02	2.615650e+02	4.219400e-02
6.000000e+01	**2.704116e+02**	3.421800e-02	2.666352e+02	3.631400e-02
6.500000e+01	2.684012e+02	3.347300e-02	2.647528e+02	3.546700e-02
7.000000e+01	2.634180e+02	3.503300e-02	2.598641e+02	3.710100e-02

Excerpt from high infiltration flux case output file for X15_Y17:

WP loc	Easting	Northing	Time	Peak WP Temp
x15_y17	170693.530	233796.500	60.000	**270.412**

The peak waste package temperature and the time of the peak was found correctly and printed out in the output file for both cases.

Low infiltration flux case subroutine (maxtwp V 1.02)

Excerpt from file: `csnf_x1_y20_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	7.780746e+01	4.952560e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	2.924384e+02	2.008300e-02	2.870254e+02	2.173300e-02
5.100000e+01	**3.101013e+02**	1.104700e-02	3.057005e+02	1.173500e-02
5.200000e+01	3.100339e+02	9.012000e-03	3.059125e+02	9.536000e-03

5.300000e+01	3.059053e+02	1.132700e-02	3.019289e+02	1.197100e-02
5.500000e+01	2.952192e+02	1.202500e-02	2.914128e+02	1.270200e-02
6.000000e+01	2.569320e+02	1.466900e-02	2.533272e+02	1.557100e-02

Excerpt from low infiltration flux case output file for X1_Y20:

WP loc	Easting	Northing	Time	Peak WP Temp
x1_y20	170208.780	234316.700	51.000	**310.101**

Excerpt from file: `csnf_x15_y17_data`

Time	WP Temp	WP Rel Hmdty	DS Temp	DS Rel Hmdty
5.000000e+01	9.154845e+01	5.416440e-01	-9.990000e+01	-9.990000e+01
5.020000e+01	1.335545e+02	3.723800e-02	1.266476e+02	4.578500e-02
5.100000e+01	2.597624e+02	2.530800e-02	2.540703e+02	2.779100e-02
5.200000e+01	2.868616e+02	2.498800e-02	2.815082e+02	2.705700e-02
5.300000e+01	2.952561e+02	2.219700e-02	2.900791e+02	2.391900e-02
5.500000e+01	3.012744e+02	1.982600e-02	2.963049e+02	2.126900e-02
6.000000e+01	**3.033349e+02**	1.773800e-02	2.986136e+02	1.895300e-02
6.500000e+01	3.003757e+02	1.698700e-02	2.957907e+02	1.812800e-02
7.000000e+01	2.952851e+02	1.761200e-02	2.907930e+02	1.879100e-02

Excerpt from low infiltration flux case output file for X15_Y17:

WP loc	Easting	Northing	Time	Peak WP Temp
x15_y17	170693.530	233796.500	60.000	**303.335**

The peak waste package temperature and the time of the peak was found correctly and printed out in the output file for both cases.