RAI Volume 3, Chapter 2.2.1.3.6, First Set, Number 5, Supplemental Question 1:

> Explain how the magnitude and timing of seepage is related to percolation, net infiltration, and precipitation over the repository footprint. To support this explanation, provide a summary table consistent with TSPA-LA results that contains (i) precipitation, (ii) net infiltration (using weights from SNL, 2008), (iii) net infiltration (using GLUE-derived weights), (iv) percolation at repository horizon, and (v) seepage all averaged over the same domain (i.e., repository). The summary values for seepage also should include flux values for percolation subregion and seeping environment in the percolation subregion, and seepage fraction. Consider the nominal and seismic ground motion cases, and the glacial transition and post-10,000-yr climates (percolation and seepage only). This information is needed to verify compliance with 10 CFR 63.114(b).
>
> **Basis:** It is difficult to extract from the SAR a consistent set of values to use in a comparison of flux values on and through the mountain because of the different procedures used to develop summary values in SAR Sections 2.1, 2.3.1, 2.3.2, 2.3.3, and 2.4. The summary values are derived from (i) different modeling domains, (ii) infiltration uncertainty scenarios, (iii) unadjusted and adjusted net infiltration weights (for the latter, GLUE-derived weights), (iv) areas based on the entire repository or percolation region and seeping environment, (v) different rock types, and (vi) calculations from an example exercise.

1. RESPONSE

This response provides a summary of a consistent set of values to use in a comparison of precipitation and the resulting water flux through the mountain and the repository horizon. Table 1 summarizes precipitation, infiltration, percolation, and seepage values averaged over the repository footprint for each infiltration case (10th, 30th, 50th, and 90th percentiles) and climate state. Table 1 also includes mean values calculated using the generalized likelihood uncertainty estimation (GLUE) methodology weighting factors (SAR Section 2.3.2.4.1.2.4.5) for the percolation and seepage rates, as well as for the unsaturated zone flow model upper boundary net infiltration. The values in Table 1 for precipitation and net infiltration are consistent with the percolation flux values and the TSPA model seepage results. The seepage results in Table 1 are averaged over the repository footprint over both seeping and nonseeping waste package locations.

Sections 1.1 through 1.3 outline the relationship between precipitation, net infiltration, percolation, and seepage, including a discussion of the consistency between the values presented in Table 1 and those in the SAR for the different modeling domains and infiltration cases.

- Section 1.1 discusses the precipitation and net infiltration results from the Infiltration Model presented in SAR Section 2.3.1.

- Section 1.2 discusses the unsaturated zone flow model upper boundary net infiltration and percolation results at the base of the Upper Paintbrush nonwelded vitric (PTn) unit. These results are presented in SAR Section 2.3.2.

- Section 1.3 presents the average repository percolation and seepage results for the nominal and seismic ground motion cases, including the average seepage fractions, for each percolation subregion and for each climate state. Repository average results for the multiscale thermal-hydrologic model (MSTHM) percolation rates at the base of the PTn unit and TSPA seepage model results are presented in SAR Sections 2.1, 2.3.5, and 2.4.

Table 1. Precipitation, Net Infiltration, Percolation, and Seepage Averaged over the Repository Footprint

Infiltration Percentile[a]	Climate State	Precipitation (mm/yr)[b]	Unsaturated Zone Flow Model Upper Boundary Net Infiltration (mm/yr)[c]	MSTHM Percolation at the Base of PTn[d]		Seepage (m^3/yr per waste package)[e]	
			2007	mm/yr	m^3/yr per Waste Package	Nominal	Seismic
10th ***p*** **= 0.6191**	Present-Day	150.9	4.0	4.09	0.115	0.001	0.001
	Monsoon	216.2	7.7	7.82	0.219	0.005	0.006
	Glacial-Transition	284.4	11.8	12.14	0.341	0.016	0.020
	Post-10,000-year	—	21.29	21.50	0.603	0.042	0.241
30th ***p*** **= 0.1568**	Present-Day	168.2	10.1	10.23	0.287	0.008	0.008
	Monsoon	157.8	15.9	16.11	0.452	0.026	0.027
	Glacial-Transition	277.3	25.8	26.28	0.737	0.070	0.082
	Post-10,000-year	—	39.52	40.37	1.132	0.148	0.612
50th ***p*** **= 0.1645**	Present-Day	198.2	14.4	14.63	0.410	0.015	0.016
	Monsoon	252.1	19.3	19.53	0.548	0.037	0.037
	Glacial-Transition	233.6	35.3	36.17	1.015	0.109	0.123
	Post-10,000-year	—	51.05	51.78	1.452	0.195	0.804
90th ***p*** **= 0.0596**	Present-Day	222.7	33.7	34.08	0.956	0.072	0.074
	Monsoon	324.7	91.4	92.4	2.592	0.438	0.446
	Glacial-Transition	300.0	68.6	69.69	1.955	0.278	0.312
	Post-10,000-year	—	61.03	61.60	1.728	0.226	0.960
Unweighted Mean Results[f]	Present-Day	181.8	17.25	—	—	—	—
	Monsoon	288.1	37.93	—	—	—	—
	Glacial-Transition	296.7	38.69	—	—	—	—
	Post-10,000-year	—	—	—	—	—	—
Weighted Mean Results	Present-Day	—	8.44	8.57	0.24	0.01	0.01
	Monsoon	—	15.88	16.09	0.45	0.04	0.04
	Glacial-Transition	—	21.25	21.74	0.61	0.06	0.06
	Post-10,000-year	—	31.41	31.83	0.89	0.10	0.43

NOTE: Precipitation over repository footprint equals precipitation over infiltration domain multiplied by 1.047.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration cases: SAR Section 2.3.2.4.1.2.4.5.5. [b]SAR Tables 2.3.1-2, 2.3.1-3, and 2.3.1-4. [c]Unsaturated zone flow model results for the average upper boundary net infiltration over the 2007 repository footprint. Post-10,000-year values from SAR Table 2.3.2-15. [d]Data extracted from the MSTHM input to the TSPA model, SAR Section 2.3.5.4.1.3.2. The percolation flux (m^3/yr) was calculated using the cross-sectional area used in the calculation of seepage in the TSPA model (5.5m drift diameter x 5.1m waste package length). [e]The seepage values were extracted from the nominal and seismic ground motion modeling cases for 1,000,000 years. [f]SAR Tables 2.3.1-2, 2.3.1-3, and 2.3.1-4. Unweighted Mean net infiltration is based on unweighted probability of the infiltration percentiles (0.2, 0.2, 0.3, and 0.3) documented in SAR Section 2.3.2.4.1.2.4.5.1.

1.1 PRECIPITATION AND NET INFILTRATION SUMMARY RESULTS

Table 2 presents precipitation and net infiltration results for each pre-10,000-year climate state. These results are spatially averaged over the infiltration model domain and over the vertical projection of the 2002 repository footprint for each of the four infiltration percentile maps used in the TSPA model. The unweighted mean precipitation and net infiltration values in Table 2 are based on all 40 realizations of the infiltration model (SAR Section 2.3.1.3.3.1.2, p. 2.3.1-67). In addition, Table 2 presents the weighted mean net infiltration using GLUE methodology weighting factors (SAR Section 2.3.2.4.1.2.4.5). As discussed in SAR Section 2.3.2.4.1.2.4.5.1, the 10th, 30th, 50th, and 90th percentile infiltration maps from the infiltration model have prior weights of 0.2, 0.2, 0.3, and 0.3, respectively. The resulting weights after calibration, using the GLUE methodology, are 0.6191, 0.1568, 0.1645, and 0.0596, respectively. SAR Section 2.1 (p. 2.1-18) includes a discussion of the estimated average net infiltration ranges as a percentage of the precipitation, consistent with the data presented in SAR Section 2.3.1 and Table 2, averaged over the infiltration model domain. A significant reduction of precipitation is reflected in the ratio of net infiltration to precipitation included in Table 2 and also in the ratio of percolation to precipitation shown in Table 11.

It should be noted that the precipitation values in Tables 1 and 2 correspond to specific realizations of the infiltration model (Mass Accounting System for Soil Infiltration and Flow – MASSIF) selected as representative of the 10th, 30th, 50th, and 90th percentile net infiltration cases; they do not represent the respective percentiles of precipitation. The precipitation value presented for the realization selected for the 10th percentile net infiltration map for the monsoon climate state is larger than the precipitation value for the 30th percentile net infiltration map. The same is observed when comparing the precipitation presented for 10th, 30th, and 50th percentile net infiltration maps selected for the glacial-transition climate. This is due to differences in the sampled values uncertain parameters used in each of the 40 infiltration model realizations. Some of the parameters that were varied included stochastic parameters describing precipitation. It is also noteworthy that the maximum value of average annual precipitation for the monsoon climate is larger than that for the glacial-transition climate, because more extreme precipitation events are predicted for the monsoon than for glacial-transition climate.

The infiltration model provides four net infiltration maps to serve as the upper boundary condition flux for the site-scale unsaturated zone flow model, (SAR Section 2.3.2.4.1.2.4.5) for each of the three climate states in the pre-10,000-year period: present-day, monsoon, and glacial-transition. SAR Figure 2.3.1-2 portrays the information transfer within the TSPA model over the three modeled climate states. These maps represent the 10th, 30th, 50th, and 90th percentile infiltration conditions. Uncertainty in infiltration is incorporated through the selection of the net infiltration maps corresponding to one of the four infiltration conditions in each TSPA realization. The mean values for each infiltration percentile map presented in Table 2 represent the mean over the infiltration percentile for each of the three 10,000-year climate states used in the TSPA model. SAR Section 2.4.1 describes the implementation and integration of the infiltration model outputs into the TSPA model.

Table 2. Average Precipitation and Net Infiltration Rates over the pre-10,000-year Period

Infiltration Map Percentile[a]	Climate State	Infiltration Model Domain[b]			2002 Repository Footprint[b,c]		
		Precipitation (mm/yr)	Net Infiltration (mm/yr)	Ratio of Net Infiltration to Precipitation (%)	Precipitation (mm/yr)	Net Infiltration (mm/yr)	Ratio of Net Infiltration to Precipitation (%)
10th *p* = 0.6191	Present-Day	144.1	3.9	2.71	150.9	3.9	2.58
	Monsoon	206.5	6.3	3.05	216.2	6.2	2.87
	Glacial-Transition	271.7	13.2	4.86	284.4	8.5	2.99
30th *p* = 0.1568	Present-Day	160.6	7.3	4.55	168.2	6.5	3.86
	Monsoon	150.7	14.4	9.56	157.8	18.9	11.98
	Glacial-Transition	264.8	22.8	8.61	277.3	25.6	9.23
50th *p* = 0.1645	Present-Day	189.3	13	6.87	198.2	10.9	5.76
	Monsoon	240.8	22.9	9.51	252.1	28.8	11.42
	Glacial-Transition	223.1	28.6	12.82	233.6	40.5	17.34
90th *p* = 0.0596	Present-Day	212.7	26.7	12.55	222.7	34.4	16.17
	Monsoon	310.2	52.6	16.96	324.7	74.5	22.94
	Glacial-Transition	286.6	47	16.40	300	68.8	22.93
Unweighted Mean Results[d]							
	Present-Day	173.6	14.30	8.24	181.8	17.6	9.68
	Monsoon	275.2	25.50	9.27	288.1	32.9	11.42
	Glacial-Transition	283.4	30.00	10.59	296.7	38.7	13.04
GLUE-Weighted Mean Results[e]							
	Present-Day	—	7.29	—	—	7.28	—
	Monsoon	—	13.06	—	—	15.98	—
	Glacial-Transition	—	19.25	—	—	20.04	—

NOTE: Precipitation over repository footprint equals precipitation over infiltration domain multiplied by 1.047 (ratio that accounts for the mean elevation difference between the repository footprint cells and the entire infiltration modeling domain cells).

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration cases: SAR Section 2.3.2.4.1.2.4.5. [b] SAR Tables 2.3.1-2, 2.3.1-3, and 2.3.1-4.
[c]Repository Footprint Results extracted from the Infiltration Model results documented in SAR 2.3.1.3.3.1.2.
[d]SAR Tables 2.3.1-2, 2.3.1-3, and 2.3.1-4. Unweighted Mean values are averaged over all 40 realizations of the infiltration model.
[e]GLUE-weighted results calculated using the probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration cases.

1.2 UNSATURATED ZONE FLOW MODEL UPPER BOUNDARY NET INFILTRATION AND PERCOLATION SUMMARY RESULTS

For the pre-10,000-year period, the site-scale unsaturated zone flow model uses the 10th, 30th, 50th, and 90th percentile net infiltration maps for the present and two future climate states as input to produce steady-state percolation flow fields and distribution of percolation fluxes for use in the TSPA (SAR Section 2.3.2.4.1.2.4.2). For the post-10,000-year period, the site-scale unsaturated zone flow model provides four additional steady-state percolation flow fields for which the spatially averaged percolation at the repository horizon represents the distribution of deep percolation rates specified in 10 CFR 63.342(c)(2) (SAR Section 2.3.2.4.1.2.4.2). As described in SAR Section 2.3.2.4.1.2.4.2, a set of maps for the net infiltration boundary condition is developed to spatially distribute water flux while matching the specified average percolation rates. This is done using the infiltration maps for the pre-10,000-year period and scaling the net infiltration rates such that the average net infiltration rate over the 2007 repository footprint matches the target average percolation flux rates in the repository footprint selected to represent the log-uniform distribution. The post-10,000-year percolation results are based upon the proposed log-uniform (13-64 mm/yr) distribution, not the truncated log-normal (10-100 mm/yr) as revised in the final rule. The results presented in this response are consistent with the SAR and TSPA model results and therefore do not include the change in the distribution for the deep percolation rates.

SAR Table 2.3.2-27 summarizes the net infiltration for all climate states averaged over the unsaturated zone flow model domain; these results are included in Table 3 for comparison with the repository footprint average net infiltration results. Table 3 presents results for both the older 2002 repository footprint used to calculate the average infiltration model results presented in Table 2, and the current repository footprint, used in 2007 for the License Application. Both repository footprint averages are presented in Table 3 for comparison with SAR Section 2.3.1 and to provide a consistent set of values over the same spatial domain. The infiltration results presented in Table 2 are calculated using a vertical projection of a 2002 version of the repository footprint, consistent with SAR Tables 2.3.1-2, 2.3.1-3, and 2.3.1-4, rather than the 2007 repository footprint used in the TSPA model. Since the 2002 repository footprint was used only for qualitative discussions of the infiltration model results and the difference between the average net infiltrations over the footprints is small (as presented in Table 3); the summary infiltration model results were not updated for the 2007 repository footprint in the supporting documentation or in SAR Section 2.3.1. The downstream models were unaffected since the net infiltration boundary flux was extracted from the net infiltration maps for the entire unsaturated zone model domain.

The unsaturated zone flow model provides percolation flux at the base of the PTn unit to the MSTHM, as well as providing the three-dimensional flow fields used by the unsaturated zone transport model component of the TSPA model (SAR Sections 2.3.5; SNL 2008, Section 6.3.2). The percolation rates over the repository footprint are spatially interpolated from the unsaturated zone model domain to the 3,624 MSTHM subdomain locations (SAR Sections 2.3.3.2.3.5 and 2.3.2). Table 3 provides a summary of the percolation rates over the repository footprint extracted from the unsaturated zone flow model and from the MSTHM. There are only minor differences in these average values as a result of the spatial interpolation between the unsaturated zone flow model domain and the MSTHM subdomain locations.

SAR Figure 2.3.2-1 shows the information flow diagram for development of the site-scale unsaturated zone flow model, and SAR Figure 2.3.2-2 shows the information transfer among the principal model components for the TSPA nominal modeling case. The unsaturated zone flow model provides the unsaturated zone flow fields used in the TSPA model unsaturated zone transport calculations. In addition, for each infiltration boundary condition and climate state, the site-scale unsaturated zone flow model provides the following outputs to the MSTHM (SAR Section 2.4.2.3.2.1): (1) the percolation flux at the base of the PTn unit above each subdomain location, (2) the three-dimensional numerical grid, and (3) associated unsaturated zone hydrologic properties. The percolation values used in the MSTHM are spatially interpolated from the 16 unsaturated zone flow fields and are passed from the MSTHM to the TSPA model to predict seepage into emplacement drifts under ambient and thermally perturbed conditions (SNL 2008, Section 6.3.3.1.2).

Table 3. Unsaturated Zone Flow Model Results

Unsaturated Zone Flow Model Domain			Repository Footprint			
Infiltration Map Percentile[a]	**Climate State**	**Net Infiltration (mm/yr)[b]**	**Unsaturated Zone Flow Model Upper Boundary Net Infiltration (mm/yr)**		**Unsaturated Zone Flow Model Percolation at Base of PTn (mm/yr)[e]**	**MSTHM Percolation at Base of PTn (mm/yr)[f]**
			2002[c]	**2007[d]**		
10th *p* = 0.6191	Present-Day	3.03	3.9	4.0	4.1	4.09
	Monsoon	6.74	6.2	7.7	7.8	7.82
	Glacial-Transition	11.03	8.5	11.8	12.2	12.14
	Post-10,000-year	16.89	—	21.29	21.58	21.50
30th *p* = 0.1568	Present-Day	7.96	6.5	10.1	10.2	10.23
	Monsoon	12.89	18.9	15.9	16.1	16.11
	Glacial-Transition	20.45	25.6	25.8	26.3	26.28
	Post-10,000-year	28.99	—	39.52	40.76	40.37
50th *p* = 0.1645	Present-Day	12.28	10.9	14.4	14.6	14.63
	Monsoon	15.37	28.8	19.3	19.5	19.53
	Glacial-Transition	25.99	40.5	35.3	36.2	36.17
	Post-10,000-year	34.67	—	51.05	52.07	51.78
90th *p* = 0.0596	Present-Day	26.78	34.4	33.7	34.1	34.08
	Monsoon	73.26	74.5	91.4	92.4	92.40
	Glacial-Transition	46.68	68.8	68.6	69.7	69.69
	Post-10,000-year	48.84	—	61.03	61.86	61.60
Mean Results						
	Present-Day	6.74	7.28	8.44	8.57	8.57
	Monsoon	13.09	15.98	15.88	16.07	16.09
	Glacial-Transition	17.09	20.04	21.25	21.79	21.74
	Post-10,000-year	23.62	—	31.41	32.00	31.83

NOTE: Mean results for the pre-10,000 year climates are GLUE weighted. Post-10,000 year Mean Results represent the sample mean of the percolation resulting from approximating the distribution of deep percolation by four discrete values. The GLUE weighting factors are used to select these four discrete values.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations SAR Section 2.3.2.4.1.2.4.5.5. [b]Average net infiltration over the unsaturated zone model domain, SAR Tables 2.3.2-27.[c]Infiltration model results over the repository footprint from Table 2 using a 2002 repository footprint, SAR Section 2.3.1.3.3.2. [d]Unsaturated Zone Flow Model Results for the Upper Boundary Net Infiltration over the 2007 Repository Footprint. Post-10,000-year values from SAR Table 2.3.2-15. [e]Unsaturated zone flow model results for the average percolation over the repository footprint and Table H-2 of SNL 2007. Post-10,000-year values from Fig. 6.1-6 (SNL 2007). [f] Data extracted from the MSTHM input to the TSPA model, SAR Section 2.3.5.4.1.3.

1.3 SEEPAGE SUMMARY RESULTS USED IN THE TSPA MODEL CALCULATIONS

As shown in SAR Figure 2.3.3-1, information needed for the implementation of the drift seepage submodel in the TSPA model is provided by two TSPA model components: (1) the Engineered Barrier System (EBS) thermal-hydrologic environment submodel (SNL 2008, Section 6.3.2), and (2) the seismic damage submodel (SNL 2008, Section 6.6). The EBS thermal-hydrologic environment submodel contains the MSTHM provided percolation flux values interpolated at various locations throughout the repository (SAR Section 2.3.3.2.3.5) from the flux distributions for current and future climate states calculated by the site-scale unsaturated zone flow model (SAR Section 2.3.2). The EBS thermal-hydrologic environment submodel also provides the evolution of drift-wall temperature at each repository location, which is required to evaluate whether thermal seepage is limited by a vaporization barrier (SAR Section 2.3.3.3.4). The TSPA submodel for the seismic damage abstraction provides cumulative rockfall volumes in response to single or multiple seismic events, which describe the degree of drift degradation and its impact on seepage (SAR Section 2.3.3.2.4.2.2).

Table 4 contains average percolation fluxes used in the TSPA model to calculate the drift seepage for each infiltration case at each climate state, including an average percolation rate over the repository footprint as well as for each repository percolation subregion. The flux quantile values for each percolation subregion are also provided in the table. The weighted repository average percolation rate is shown on SAR Figure 2.1-5 and included in Table 4.

The TSPA drift seepage submodel calculates the seepage rate (average seepage per waste package in a seeping environment) as a function of time for each repository subregion for the nominal and seismic ground motion modeling cases (Section 6.3.3, SNL 2008). The probabilistic seepage calculation in the TSPA is a function of the local percolation and the ambient and thermal components of the drift seepage abstraction, as described in SAR Sections 2.3.3.2.4 and 2.3.3.3.4. Tables 5 through 10 contain TSPA model seepage results extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps to illustrate the temporal variation in seepage between the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. Seepage results for the nominal modeling case represents the average seepage rate over the epistemic uncertainties (conditional on one infiltration map) in the absence of disruptive events (e.g., igneous or seismic events). In addition, to demonstrate the impact of drift degradation, seepage results from the seismic ground motion modeling case are presented; these results are averaged over the epistemic uncertainties (conditional on one infiltration map) as well as the aleatory uncertainty in seismic events. Table 5 contains the TSPA nominal scenario modeling case seepage results in terms of flux per waste package for each infiltration case at each climate state, including an average over the repository footprint as well as an average for each repository subregion, including both seeping and non-seeping environments. The average seepage fractions (the fraction of waste packages in a percolation subregion experiencing seepage) are also presented in Table 5. Tables 6 and 7 provide the average seepage per waste package in a seeping environment for commercial spent nuclear fuel (SNF) and codisposal waste packages.

Table 8 contains the TSPA seismic ground motion modeling case seepage results. These seepage rates account for seismic-induced drift collapse, which increases the seepage rates over time until the drift is fully degraded, as demonstrated in SAR Figure 2.1-5. It should be noted in the seismic ground motion case results that the selection of seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps to demonstrate the temporal variation in seepage for each climate state, maximizes the effects of drift degradation on seepage for the glacial-transition and post-10,000-year climates by extracting the seepage values at the end of these climate states; at the 10,000- and 1,000,000-year time steps respectively. Tables 9 and 10 contain the commercial SNF and codisposal seismic seepage rate per waste package in a seeping environment. The seepage fractions are presented as calculated for the post-10,000-year climate, as used in the 1,000,000 year TSPA model. Since the seepage fractions are calculated at 1,000,000 years, the high fractions in the seismic ground motion modeling case reflect the increase in seepage due to seismic induced drift degradation. These seepage fractions are consistent with SAR Tables 2.1-6 to 2.1-9, which include the TSPA nominal and seismic ground motion modeling case seepage fractions for the glacial-transition climate and the post-10,000-year period. SAR Figure 2.3.3-47 presents the mean seepage rates as a function of time for the four infiltration scenarios consistent with the repository average results presented in Table 5. SAR Figure 2.1-5 plots the mean seepage over the repository, consistent with the weighted mean data presented in Tables 5 and 8 for the nominal and seismic ground motion modeling cases.

The tabulated TSPA model results show that higher infiltration scenarios result in more seepage in both the nominal and seismic ground motion modeling cases, as described in SAR Section 2.3.3.4.2 and shown in SAR Figures 2.3.3-47 to 2.3.3-49. As presented in Table 11, over all waste packages, the repository average amount of seeping water weighted by the relative probability for each infiltration case is approximately 0.01, 0.04, and 0.06 m^3/yr per waste package for the present-day, monsoon, and glacial-transition climate states, respectively. The corresponding ratio of seepage to percolation over the pre-10,000-year time period included on Table 11 is between approximately 4% and 10% for the repository average TSPA seepage over all infiltration maps. These results confirm that over the pre-10,000-year time period, about 90% to 96% of the percolation flux would be diverted around an intact drift, on average. For the post-10,000-year period over all waste packages, the repository average amount of seeping water weighted by the relative probability for each infiltration case is approximately 0.1 and 0.43 m^3/yr per waste package for the nominal and seismic ground motion modeling cases, respectively, at 1,000,000 years. The corresponding ratio of seepage to percolation over the post-10,000 year time period are approximately 11% and 49% for the nominal and seismic ground motion modeling cases respectively. On average, about 89% of the percolation flux would be diverted around a drift in the nominal modeling cases, whereas only 51% of the percolation flux would be diverted around a fully degraded drift at 1,000,000 years in the seismic ground motion modeling case. Drift degradation also results in a significant increase in the fraction of waste packages that encounter seeping conditions from 40% in the nominal case to 69% in the seismic ground motion modeling case based on the comparison of the seepage fraction shown in Tables 5 and 8 (SAR Section 2.4.2.2.1.2.2.1; SNL 2008, Tables 8.3-3[a] and 8.3-5[a]).

Table 4. Average Percolation Flux Used in the TSPA Calculations

Infiltration Map Percentile[a]	**Climate State**	**MSTHM Percolation at Base of PTn Subregion Rates**[b,c] **(mm/yr)**					**MSTHM Repository Average Percolation at Base of PTn**	
		1 (0.05)	**2 (0.25)**	**3 (0.4)**	**4 (0.25)**	**5 (0.05)**	**(mm/yr)**	**(m^3/yr per waste package)**
10th p = 0.6191	Present-Day	0.49	2.33	4.32	5.68	6.71	4.09	0.115
	Monsoon	1.23	5.38	8.31	10.00	11.72	7.82	0.219
	Glacial-Transition	0.68	3.72	11.06	20.93	30.46	12.14	0.341
	Post-10,000-year	2.56	15.06	23.32	26.94	30.90	21.50	0.603
30th p = 0.1568	Present-Day	1.58	6.50	10.84	13.59	15.81	10.23	0.287
	Monsoon	2.34	10.68	17.03	21.24	24.06	16.11	0.452
	Glacial-Transition	2.51	13.53	27.15	38.29	46.90	26.28	0.737
	Post-10,000-year	2.55	17.46	41.50	61.55	77.82	40.37	1.132
50th p = 0.1645	Present-Day	2.22	9.72	15.55	18.87	22.79	14.63	0.410
	Monsoon	2.29	11.22	20.38	26.62	36.14	19.53	0.548
	Glacial-Transition	2.45	15.71	37.17	55.09	69.65	36.17	1.015
	Post-10,000-year	4.29	29.85	55.67	70.47	84.28	51.78	1.452
90th p = 0.0596	Present-Day	4.942	24.08	36.87	42.53	48.59	34.08	0.956
	Monsoon	12.52	65.45	99.91	115.5	131.51	92.40	2.592
	Glacial-Transition	5.84	40.30	74.93	94.78	113.20	69.69	1.955
	Post-10,000-year	8.81	43.74	66.56	76.91	87.51	61.60	1.728
Mean Results								
	Present-Day	1.21	5.51	9.13	11.28	13.28	8.57	0.24
	Monsoon	2.25	10.76	17.12	20.79	24.81	16.09	0.45
	Glacial-Transition	1.57	9.41	21.69	33.67	44.41	21.74	0.61
	Post-10,000-year	3.22	19.58	34.07	42.51	50.41	31.83	0.89

NOTE: The percolation flux (m^3/yr) was calculated using the cross-sectional area used in the calculation of seepage in the TSPA model (5.5-m drift diameter × 5.1-m waste package length). Mean results for the pre-10,000 year climates are GLUE weighted. Post-10,000 year Mean Results represent the sample mean of the percolation resulting from approximating the distribution of deep percolation by four discrete values. The GLUE weighting factors are used to select these four discrete values.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]Data extracted from the MSTHM input to the TSPA model, SAR Section 2.3.5.4.1.3.2.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

Table 5. Nominal Modeling Case Average Seepage Rate and Fraction Summary

TSPA Average Seepage for the Nominal Modeling Case 1,000,000 Years – Repository Footprint							
Infiltration Map Percentile[a]	**Climate State**	**Average Flux over the Subregion[b,c] (m^3/yr per waste package)**					**Repository Average (m^3/yr per waste package)**
		1 (0.05)	**2 (0.25)**	**3 (0.4)**	**4 (0.25)**	**5 (0.05)**	
10th p = 0.6191	Present-Day	2.66×10^{-5}	4.81×10^{-4}	9.24×10^{-4}	1.20×10^{-3}	2.33×10^{-3}	0.001
	Monsoon	3.20×10^{-4}	3.53×10^{-3}	5.82×10^{-3}	6.40×10^{-3}	1.07×10^{-2}	0.005
	Glacial-Transition	7.97×10^{-5}	1.50×10^{-3}	1.14×10^{-2}	3.15×10^{-2}	6.92×10^{-2}	0.016
	Post-10,000-year	2.04×10^{-3}	2.79×10^{-2}	4.76×10^{-2}	4.97×10^{-2}	7.23×10^{-2}	0.042
	Seepage Fraction	*0.099*	*0.295*	*0.370*	*0.359*	*0.415*	*0.337*
30th p = 0.1568	Present-Day	4.24×10^{-4}	4.90×10^{-3}	8.16×10^{-3}	1.02×10^{-2}	1.68×10^{-2}	0.008
	Monsoon	1.52×10^{-3}	1.63×10^{-2}	2.81×10^{-2}	3.38×10^{-2}	4.75×10^{-2}	0.026
	Glacial-Transition	1.71×10^{-3}	2.51×10^{-2}	7.10×10^{-2}	1.09×10^{-1}	1.68×10^{-1}	0.070
	Post-10,000-year	1.57×10^{-3}	3.91×10^{-2}	1.46×10^{-1}	2.42×10^{-1}	3.84×10^{-1}	0.148
	Seepage Fraction	*0.135*	*0.356*	*0.517*	*0.553*	*0.622*	*0.472*
50th p = 0.1645	Present-Day	8.27×10^{-4}	1.05×10^{-2}	1.64×10^{-2}	1.81×10^{-2}	3.13×10^{-2}	0.015
	Monsoon	1.07×10^{-3}	1.66×10^{-2}	3.89×10^{-2}	4.92×10^{-2}	9.21×10^{-2}	0.037
	Glacial-Transition	1.17×10^{-3}	2.84×10^{-2}	1.07×10^{-1}	1.78×10^{-1}	2.89×10^{-1}	0.109
	Post-10,000-year	3.98×10^{-3}	9.08×10^{-2}	2.14×10^{-1}	2.69×10^{-1}	3.93×10^{-1}	0.195
	Seepage Fraction	*0.160*	*0.416*	*0.538*	*0.545*	*0.600*	*0.493*
90th p = 0.0596	Present-Day	4.71×10^{-3}	5.17×10^{-2}	8.06×10^{-2}	8.08×10^{-2}	1.24×10^{-1}	0.072
	Monsoon	3.11×10^{-2}	2.99×10^{-1}	4.90×10^{-1}	5.19×10^{-1}	7.09×10^{-1}	0.438
	Glacial-Transition	6.60×10^{-3}	1.30×10^{-1}	3.06×10^{-1}	3.77×10^{-1}	5.62×10^{-1}	0.278
	Post-10,000-year	1.61×10^{-2}	1.56×10^{-1}	2.54×10^{-1}	2.64×10^{-1}	3.72×10^{-1}	0.226
	Seepage Fraction	*0.269*	*0.555*	*0.646*	*0.638*	*0.687*	*0.605*
TSPA Mean Results	Present-Day	5.00×10^{-4}	5.88×10^{-3}	9.36×10^{-3}	1.02×10^{-2}	1.66×10^{-2}	0.009
	Monsoon	2.48×10^{-3}	2.54×10^{-2}	4.38×10^{-2}	4.84×10^{-2}	7.16×10^{-2}	0.040
	Glacial-Transition	9.06×10^{-4}	1.73×10^{-2}	5.40×10^{-2}	8.83×10^{-2}	1.50×10^{-1}	0.056
	Post-10,000-year	3.12×10^{-3}	4.76×10^{-2}	1.03×10^{-1}	1.28×10^{-1}	1.91×10^{-1}	0.095
	Seepage Fraction	*0.125*	*0.340*	*0.437*	*0.437*	*0.494*	*0.400*

NOTE: TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Nominal Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]The seepage values were extracted from the Nominal 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2

Table 6. Nominal Modeling Case Commercial SNF Waste Package Average Seepage Rates and Fractions in a Seeping Environment

Nominal Seepage - Commercial SNF Waste Packages in Seeping Environment							
Infiltration Map Percentile[a]	Climate State	Average Flux over the Subregion[b,c] (m^3/yr per waste package)					Repository Average (m^3/yr per waste package)
		1 (0.05)	2 (0.25)	3 (0.4)	4 (0.25)	5 (0.05)	
10th ***p* = 0.6191**	Present-Day	0.0002	0.0013	0.0020	0.0026	0.0050	0.0020
	Monsoon	0.0025	0.0108	0.0139	0.0151	0.0236	0.0134
	Glacial-Transition	0.0006	0.0043	0.0278	0.0820	0.1617	0.0408
	Post-10,000-year	0.0210	0.0956	0.1264	0.1321	0.1710	0.1171
	Seepage Fraction	*0.099*	*0.295*	*0.370*	*0.359*	*0.416*	*0.337*
30th ***p* = 0.1568**	Present-Day	0.0023	0.0118	0.0132	0.0146	0.0241	0.0132
	Monsoon	0.0107	0.0425	0.0480	0.0507	0.0692	0.0465
	Glacial-Transition	0.0116	0.0653	0.1241	0.1722	0.2496	0.1221
	Post-10,000-year	0.0096	0.1030	0.2616	0.3976	0.58442	0.2595
	Seepage Fraction	*0.134*	*0.356*	*0.516*	*0.553*	*0.621*	*0.472*
50th ***p* = 0.1645**	Present-Day	0.0038	0.0225	0.0264	0.0274	0.0463	0.0255
	Monsoon	0.0052	0.0365	0.0656	0.0784	0.1382	0.0622
	Glacial-Transition	0.0058	0.0618	0.1831	0.3002	0.4553	0.1868
	Post-10,000-year	0.0226	0.2107	0.3784	0.4618	0.6273	0.3520
	Seepage Fraction	*0.161*	*0.416*	*0.538*	*0.545*	*0.601*	*0.494*
90th ***p* = 0.0596**	Present-Day	0.0152	0.0858	0.1131	0.1145	0.1666	0.1044
	Monsoon	0.1142	0.5246	0.7362	0.7871	1.0094	0.6786
	Glacial-Transition	0.0224	0.2243	0.4551	0.5689	0.7970	0.4213
	Post-10,000-year	0.0568	0.2690	0.3777	0.3953	0.5225	0.3461
	Seepage Fraction	*0.270*	*0.556*	*0.647*	*0.638*	*0.689*	*0.605*
TSPA Mean Results	Present-Day	0.0020	0.0115	0.0144	0.0152	0.0244	0.0138
	Monsoon	0.0110	0.0508	0.0710	0.0773	0.1086	0.0664
	Glacial-Transition	0.0044	0.0364	0.0939	0.1610	0.2615	0.1002
	Post-10,000-year	0.0216	0.1260	0.2038	0.2433	0.3314	0.1915
	Seepage Fraction	*0.125*	*0.340*	*0.437*	*0.436*	*0.494*	*0.400*

NOTE: TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Nominal Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]The seepage values were extracted from the Nominal 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

Table 7. Nominal Modeling Case Codisposal Waste Package Average Seepage Rates and Fractions in a Seeping Environment

Nominal Seepage – Codisposal Waste Packages in Seeping Environment							
Infiltration Map Percentile[a]	**Climate State**	**Average Flux over the Subregion[b,c] (m^3/yr per waste package)**					**Repository Average (m^3/yr per waste package)**
		1 (0.05)	**2 (0.25)**	**3 (0.4)**	**4 (0.25)**	**5 (0.05)**	
10th ***p* = 0.6191**	Present-Day	0.0002	0.0015	0.0024	0.0033	0.0057	0.0025
	Monsoon	0.0030	0.0109	0.0148	0.0162	0.0243	0.0140
	Glacial-Transition	0.0006	0.0042	0.0280	0.0823	0.1598	0.0408
	Post-10,000-year	0.0221	0.0935	0.1268	0.1325	0.1688	0.1168
	Seepage Fraction	*0.100*	*0.295*	*0.371*	*0.359*	*0.414*	*0.337*
30th ***p* = 0.1568**	Present-Day	0.0027	0.0137	0.0155	0.0171	0.0259	0.0153
	Monsoon	0.0102	0.0442	0.0499	0.0527	0.0684	0.0481
	Glacial-Transition	0.0109	0.0663	0.1239	0.1718	0.2424	0.1218
	Post-10,000-year	0.0098	0.1043	0.2619	0.3975	0.5750	0.2594
	Seepage Fraction	*0.137*	*0.357*	*0.519*	*0.554*	*0.624*	*0.473*
50th ***p* = 0.1645**	Present-Day	0.0051	0.0241	0.0316	0.0328	0.0512	0.0297
	Monsoon	0.0054	0.0359	0.0664	0.0785	0.1379	0.0623
	Glacial-Transition	0.0061	0.0608	0.1830	0.2940	0.4448	0.1844
	Post-10,000-year	0.0226	0.2084	0.3788	0.4540	0.6116	0.3488
	Seepage Fraction	*0.158*	*0.414*	*0.539*	*0.546*	*0.600*	*0.493*
90th ***p* = 0.0596**	Present-Day	0.0156	0.0906	0.1241	0.1224	0.1764	0.1125
	Monsoon	0.1105	0.5293	0.7373	0.7877	1.0042	0.6799
	Glacial-Transition	0.0211	0.2234	0.4535	0.5648	0.7882	0.4189
	Post-10,000-year	0.0537	0.2699	0.3765	0.3918	0.5175	0.3446
	Seepage Fraction	*0.265*	*0.554*	*0.643*	*0.637*	*0.680*	*0.602*
TSPA Mean Results	Present-Day	0.0023	0.0124	0.0165	0.0174	0.0265	0.0155
	Monsoon	0.0110	0.0513	0.0721	0.0784	0.1085	0.0672
	Glacial-Transition	0.0043	0.0363	0.0938	0.1598	0.2570	0.0996
	Post-10,000-year	0.0221	0.1245	0.2041	0.2421	0.3257	0.1907
	Seepage Fraction	*0.125*	*0.339*	*0.438*	*0.436*	*0.493*	*0.400*

NOTE: Climate states: present-day; monsoon, glacial-transition, and post-10,000-year deep percolation rates. TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Nominal Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]The seepage values were extracted from the Nominal 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

Table 8. Seismic Ground Motion Modeling Case Average Seepage Rates and Fractions Summary

TSPA Average Seepage for the Seismic GM Modeling Case 1,000,000 Years – Repository Footprint							
Infiltration Map Percentile[a]	**Climate State**	**Average Flux over the Subregion[b,c] (m^3/yr per waste package)**					**Repository Average (m^3/yr per waste package)**
		1	**2**	**3**	**4**	**5**	
		0.05	**0.25**	**0.4**	**0.25**	**0.05**	
10th *p* = 0.6191	Present-Day	4.19×10^{-5}	5.27×10^{-4}	9.87×10^{-4}	1.25×10^{-3}	2.42×10^{-3}	0.001
	Monsoon	3.77×10^{-4}	3.70×10^{-3}	6.02×10^{-3}	6.53×10^{-3}	1.10×10^{-2}	0.006
	Glacial-Transition	5.31×10^{-4}	2.92×10^{-3}	1.52×10^{-2}	3.68×10^{-2}	8.02×10^{-2}	0.020
	Post-10,000-year	3.61×10^{-2}	1.86×10^{-1}	2.74×10^{-1}	2.61×10^{-1}	3.65×10^{-1}	0.241
	Seepage Fraction	*0.441*	*0.608*	*0.667*	*0.640*	*0.695*	*0.636*
30th *p* = 0.1568	Present-Day	4.53×10^{-4}	4.99×10^{-3}	8.30×10^{-3}	1.03×10^{-2}	1.70×10^{-2}	0.008
	Monsoon	1.57×10^{-3}	1.65×10^{-2}	2.85×10^{-2}	3.42×10^{-2}	4.80×10^{-2}	0.027
	Glacial-Transition	3.66×10^{-3}	3.21×10^{-2}	8.35×10^{-2}	1.23×10^{-1}	1.89×10^{-1}	0.082
	Post-10,000-year	3.38×10^{-2}	2.23×10^{-1}	6.27×10^{-1}	9.40×10^{-1}	1.39	0.612
	Seepage Fraction	*0.488*	*0.682*	*0.789*	*0.804*	*0.844*	*0.753*
50th *p* = 0.1645	Present-Day	9.34×10^{-4}	1.08×10^{-2}	1.67×10^{-2}	1.83×10^{-2}	3.16×10^{-2}	0.016
	Monsoon	1.19×10^{-3}	1.70×10^{-2}	3.94×10^{-2}	4.95×10^{-2}	9.27×10^{-2}	0.037
	Glacial-Transition	2.63×10^{-3}	3.45×10^{-2}	1.22×10^{-1}	1.97×10^{-1}	3.18×10^{-1}	0.123
	Post-10,000-year	6.06×10^{-2}	4.37×10^{-1}	8.81×10^{-1}	1.06	1.46	0.804
	Seepage Fraction	*0.503*	*0.717*	*0.799*	*0.797*	*0.831*	*0.765*
90th *p* = 0.0596	Present-Day	5.08×10^{-3}	5.34×10^{-2}	8.32×10^{-2}	8.35×10^{-2}	1.28×10^{-1}	0.074
	Monsoon	3.22×10^{-2}	3.05×10^{-1}	4.99×10^{-1}	5.29×10^{-1}	7.21×10^{-1}	0.446
	Glacial-Transition	1.10×10^{-2}	1.52×10^{-1}	3.44×10^{-1}	4.18×10^{-1}	6.19×10^{-1}	0.312
	Post-10,000-year	1.30×10^{-1}	6.93×10^{-1}	1.07×10^{-1}	1.13	1.46	0.960
	Seepage Fraction	*0.583*	*0.800*	*0.864*	*0.860*	*0.885*	*0.834*
TSPA Mean Results	Present-Day	5.54×10^{-4}	6.07×10^{-3}	9.63×10^{-3}	1.04×10^{-2}	1.70×10^{-2}	0.009
	Monsoon	2.61×10^{-3}	2.60×10^{-2}	4.46×10^{-2}	4.93×10^{-2}	7.27×10^{-2}	0.040
	Glacial-Transition	1.99×10^{-3}	2.16×10^{-2}	6.30×10^{-2}	9.93×10^{-2}	1.68×10^{-1}	0.064
	Post-10,000-year	4.54×10^{-2}	2.63×10^{-1}	4.76×10^{-1}	5.50×10^{-1}	7.69×10^{-1}	0.434
	Seepage Fraction	*0.467*	*0.649*	*0.719*	*0.705*	*0.752*	*0.687*

NOTE: TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Seismic Ground Motion Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b] The seepage values were extracted from the Seismic Ground Motion 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

Table 9. Seismic Ground Motion Modeling Case Commercial SNF Waste Package Average Seepage Rates and Fractions in a Seeping Environment

Seismic Seepage - Commercial SNF Waste Packages in Seeping Environment							
Infiltration Map Percentile[a]	**Climate State**	**Average Flux over the Subregion[b,c] (m^3/yr per waste package)**					**Repository Average (m^3/yr per waste package)**
		1	**2**	**3**	**4**	**5**	
		0.05	**0.25**	**0.4**	**0.25**	**0.05**	
10th *p* = 0.6191	Present-Day	0.0001	0.0007	0.0012	0.0015	0.0030	0.001
	Monsoon	0.0008	0.0055	0.0079	0.0085	0.0141	0.007
	Glacial-Transition	0.0012	0.0047	0.0213	0.0519	0.1084	0.028
	Post-10,000-year	0.0845	0.3178	0.4195	0.4090	0.5319	0.380
	Fraction	*0.442*	*0.608*	*0.667*	*0.639*	*0.694*	*0.635*
30th *p* = 0.1568	Present-Day	0.0008	0.0064	0.0091	0.0108	0.0183	0.0089
	Monsoon	0.0030	0.0221	0.0325	0.0373	0.0527	0.0306
	Glacial-Transition	0.0074	0.0438	0.0979	0.1386	0.2114	0.0957
	Post-10,000-year	0.072514	0.32587	0.78036	1.1307	1.6117	0.760
	Fraction	*0.487*	*0.682*	*0.788*	*0.803*	*0.844*	*0.753*
50th *p* = 0.1645	Present-Day	0.0016	0.0136	0.0184	0.0195	0.0342	0.0174
	Monsoon	0.0022	0.0219	0.0454	0.0557	0.1031	0.0428
	Glacial-Transition	0.0053	0.0450	0.1424	0.2289	0.3636	0.1439
	Post-10,000-year	0.12621	0.6131	1.0961	1.3128	1.7399	1.013
	Fraction	*0.503*	*0.718*	*0.799*	*0.797*	*0.833*	*0.765*
90th *p* = 0.0596	Present-Day	0.0081	0.0628	0.0899	0.0904	0.1363	0.0815
	Monsoon	0.0533	0.3680	0.5602	0.5932	0.7938	0.5067
	Glacial-Transition	0.0189	0.1845	0.3884	0.4718	0.6853	0.3547
	Post-10,000-year	0.2318	0.8696	1.2261	1.2932	1.6312	1.1243
	Fraction	*0.584*	*0.800*	*0.864*	*0.861*	*0.886*	*0.834*
TSPA Mean Results	Present-Day	0.0009	0.0075	0.0106	0.0112	0.0185	0.0099
	Monsoon	0.0045	0.0325	0.0511	0.0558	0.0815	0.0468
	Glacial-Transition	0.0039	0.0282	0.0751	0.1196	0.2008	0.0772
	Post-10,000-year	0.0983	0.4004	0.6349	0.7228	0.9643	0.5879
	Fraction	*0.467*	*0.649*	*0.719*	*0.704*	*0.752*	*0.687*

NOTE: TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Seismic Ground Motion Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]The seepage values were extracted from the Seismic Ground Motion 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

Table 10. Seismic Ground Motion Modeling Case Codisposal Waste Package Average Seepage Rates and Fractions in a Seeping Environment

Seismic Seepage – Codisposal Waste Packages in Seeping Environment							
Infiltration Map Percentile[a]	Climate State	Average Flux over the Subregion[b,c] (m^3/yr per waste package)					Repository Average (m^3/yr per waste package)
		1	2	3	4	5	
		0.05	0.25	0.4	0.25	0.05	
10th ***p* = 0.6191**	Present-Day	0.0001	0.0008	0.0015	0.0019	0.0035	0.0015
	Monsoon	0.0009	0.0055	0.0084	0.0091	0.0145	0.0078
	Glacial-Transition	0.0012	0.0047	0.0213	0.0522	0.1069	0.0281
	Post-10,000-year	0.0849	0.3164	0.4199	0.4098	0.5278	0.3802
	Seepage Fraction	*0.440*	*0.608*	*0.667*	*0.641*	*0.697*	*0.636*
30th ***p* = 0.1568**	Present-Day	0.0010	0.0073	0.0108	0.0127	0.0200	0.0104
	Monsoon	0.0029	0.0228	0.0340	0.0389	0.0527	0.0318
	Glacial-Transition	0.0073	0.0440	0.0984	0.1383	0.2072	0.0957
	Post-10,000-year	0.0723	0.3288	0.7862	1.1312	1.6058	0.7634
	Seepage Fraction	*0.489*	*0.681*	*0.789*	*0.804*	*0.845*	*0.753*
50th ***p* = 0.1645**	Present-Day	0.0020	0.0146	0.0219	0.0235	0.0384	0.0203
	Monsoon	0.0022	0.0214	0.0459	0.0560	0.1033	0.0430
	Glacial-Transition	0.0052	0.0442	0.1421	0.2249	0.3569	0.1422
	Post-10,000-year	0.1262	0.6129	1.0992	1.3027	1.7298	1.0114
	Seepage Fraction	*0.504*	*0.715*	*0.800*	*0.798*	*0.828*	*0.765*
90th ***p* = 0.0596**	Present-Day	0.0084	0.0657	0.0974	0.0960	0.1441	0.0870
	Monsoon	0.0523	0.3686	0.5595	0.5942	0.7903	0.5066
	Glacial-Transition	0.0182	0.1826	0.3863	0.4695	0.6805	0.3525
	Post-10,000-year	0.2323	0.8628	1.2257	1.2925	1.6400	1.1227
	Seepage Fraction	*0.582*	*0.800*	*0.863*	*0.859*	*0.881*	*0.833*
TSPA Mean Results	Present-Day	0.0010	0.0080	0.0120	0.0128	0.0202	0.0111
	Monsoon	0.0045	0.0326	0.0516	0.0565	0.0815	0.0472
	Glacial-Transition	0.0038	0.0280	0.0750	0.1189	0.1979	0.0768
	Post-10,000-year	0.0985	0.3995	0.6366	0.7216	0.9597	0.5878
	Seepage Fraction	*0.467*	*0.648*	*0.720*	*0.705*	*0.753*	*0.687*

NOTE: TSPA seepage data extracted at 500-, 750-, 10,000-, and 1,000,000-year time steps for the present-day, monsoon, glacial-transition, and post-10,000-year climate states, respectively. The data was extracted from the TSPA Seismic Ground Motion Modeling Case for 1,000,000 years and is averaged over the epistemic uncertainties.

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations: SAR Section 2.3.2.4.1.2.4.5.5.
[b]The seepage values were extracted from the Seismic Ground Motion 1,000,000-year modeling case.
[c]Percolation subregions and quantile ranges SAR Section 2.4.2.3.2.1.2.

1.4 SUMMARY

The results presented in Tables 1 to 11 include the TSPA model percolation and seepage output for the nominal and seismic ground motion modeling cases and are consistent with the summary results presented in SAR Section 2.3.3 for the seepage model and SAR Sections 2.1 (Demonstration of Multiple Barriers) and 2.4 (Demonstration of Compliance with Postclosure Public Health and Environmental Standards). In addition, the TSPA model summary data is consistent with the input from the precipitation and infiltration model results, as documented in SAR Section 2.3.1, and with the site-scale unsaturated zone flow model results, as documented in SAR Section 2.3.2.

Table 11. Summary Values Spatially Averaged over the Repository Footprint

Infiltration Percentile[a]	Climate State	Precipitation (mm/yr)	Unsaturated Zone Flow Model Percolation at the base of PTn (mm/yr)	Ratio of Percolation to Precipitation (%)	MSTHM Percolation at base of PTn (m^3/yr per waste package)	Seepage (m^3/yr per waste package)		Ratio of Seepage to Percolation (%)	
						Nominal	Seismic	Nominal	Seismic
10th *p* = 0.6191	Present-Day	150.9	4.1	2.7	0.115	0.001	0.001	0.8	0.8
	Monsoon	216.2	7.8	3.6	0.219	0.005	0.006	2.4	2.5
	Glacial-Transition	284.4	12.2	4.3	0.341	0.016	0.020	4.8	5.9
	Post-10,000-year	—	21.58	—	0.603	0.042	0.241	7.0	40.0
30th *p* = 0.1568	Present-Day	168.2	10.2	6.1	0.287	0.008	0.008	2.8	2.8
	Monsoon	157.8	16.1	10.2	0.452	0.026	0.027	5.8	5.9
	Glacial-Transition	277.3	26.3	9.5	0.737	0.070	0.082	9.5	11.1
	Post-10,000-year	—	40.76	—	1.132	0.148	0.612	13.1	54.1
50th *p* = 0.1645	Present-Day	198.2	14.6	7.4	0.410	0.015	0.016	3.7	3.8
	Monsoon	252.1	19.5	7.7	0.548	0.037	0.037	6.7	6.7
	Glacial-Transition	233.6	36.2	15.5	1.015	0.109	0.123	10.7	12.1
	Post-10,000-year	—	52.07	—	1.452	0.195	0.804	13.4	55.3
90th *p* = 0.0596	Present-Day	222.7	34.1	15.3	0.956	0.072	0.074	7.5	7.8
	Monsoon	324.7	92.4	28.5	2.592	0.438	0.446	16.9	17.2
	Glacial-Transition	300.0	69.7	23.2	1.955	0.278	0.312	14.2	15.9
	Post-10,000-year	—	61.86	—	1.728	0.226	0.960	13.1	55.6
Weighted Mean Results	Present-Day	—	8.57	**TSPA Mean Results**	0.24	0.01	0.01	4.0	4.0
	Monsoon	—	16.07		0.45	0.04	0.04	9.0	9.0
	Glacial-Transition	—	21.79		0.61	0.06	0.06	10.0	10.0
	Post-10,000-year	—	32.00		0.89	0.1	0.43	11.0	49.0

Source: [a]GLUE probability weighting factors for the 10th, 30th, 50th, and 90th percentile infiltration realizations SAR Section 2.3.2.4.1.2.4.5.5.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

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