DOC.20060808.0003

BSC	**Model** **Administrative Change Notice** *Complete only applicable items.*	QA: QA Page 1 of 4

1. Document Number:	MDL-NBS-HS-000004	**2. Revision:**	03	**3. ACN:**	02
4. Title:	Seepage Calibration Model and Seepage Testing Data				
5. No. of Pages Attached	9				

6. Approvals:

Preparer: Peter Persoff Peter Persoff — Print name and sign — 08/01/2006 Date

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Independent Technical Reviewer: Robert Howard — Print name and sign — 8/3/06 Date

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7. Affected Pages	**8. Description of Change:**
1-2	A citation and the DIRS report are updated to address the resolution of TBV-6034. This change is associated with CR 5345. Page 1-2, eighth paragraph, second sentence, "In addition, the discussions and results are used in the reports *Features, Events, and Processes in UZ Flow and Transport* (BSC 2004 [DIRS 170012], Section 6.1.24), and *Drift-Scale Coupled Processes (DST and TH Seepage) Models* (BSC 2004 [DIRS 170338])." is changed to read, "In addition, the discussions and results are used in the reports *Features, Events, and Processes in UZ Flow and Transport* (BSC **2005** [DIRS **174191**], Section **6.2**), and *Drift-Scale Coupled Processes (DST and TH Seepage) Models* (BSC 2004 [DIRS 170338])."
3-1	Sentence modified to address CR 5246. Page 3-1, first paragraph, third sentence, "They were used only within the range of validation; there are no limitations on outputs due to the selected software." is changed to read, "They were used only within the range of validation **and consistent with the intended use**; there are no limitations on outputs due to the selected software."

3-1

Table 3-1 is modified to address CR 5246.

Page 3-1, Table 3-1, columns “Platform” and “Operating System” are added; a note is added to the bottom of the table clarifying the different ways the SUN OS may be referenced.

Software Name	**Version**	**Software Tracking Number**	**Platform**	**Operating System**	**Reference**
iTOUGH2	4.0	10003-4.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 1999 [DIRS 139918]
			DEC	**OS v4.0**	
iTOUGH2	5.0	10003-5.0-00	**SUN**	**Sun OS 5.5.1**	LBNL 2002 [DIRS 160106]
			LINUX	**Red Hat v7.2**	
			DEC Alpha	**OSF1 v5.1**	
GSLIB Module SISIM	1.203	10001-1.0MSISIMV1.203-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 1999 [DIRS 134136]
			PC	**Windows 98**	
GSLIB Module SISIM	1.204	10397-1.0SISIMV1.204-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 153100]
GSLIB Module GAMV2	1.201	10087-1.0MGAMV2V1.201-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 1999 [DIRS 134139]
GSLIB Module GAMV3	1.201	10398-1.0GAMV3V1.201-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 153099]
EarthVision	4.0	10174-4.0-00	**SGI**	**IRIX 6.2**	Dynamic Graphics 2003 [DIRS 162369]
AddCoord	1.0	10355-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152814]
MoveMesh	1.0	10358-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152824]
AddBound	1.0	10357-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152823]
Perm2Mesh	1.0	10359-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152826]
CutNiche	1.2	10356-1.2-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152815]
CutNiche	1.3	10402-1.3-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152828]
CutDrift	1.0	10375-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152816]
AddBorehole	1.0	10373-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 2000 [DIRS 152822]
ECRB-XYZ	.03	30093-V.03-	**PC**	**Windows 95/98**	CRWMS M&O 1999 [DIRS 147402]
EXT	1.0	10047-1.0-00	**SUN**	**Sun O.S. 5.5.1**	LBNL 1999 [DIRS 134141]

Note: The SUN platform identified in this table corresponds to DOE Property Tag Number 6332537. The SUN Microsystem Vendor uses 3 synonymous reference identifiers for its Operating Systems. An example would be SUN Solaris 7, SUN Solaris 2.7 and SUN O.S. 5.7.

5-4	A citation and the DIRS report are updated to address the resolution of TBV-5958. This change is associated with CR 5345. Page 5-4, second paragraph, second sentence, "This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments [(BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure 6.2.1-7); ["Seepage into an Underground Opening Constructed in Unsaturated Fractured Rock under Evaporative Conditions." (Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9)]." is changed to read, "This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments (BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure **6-30**; Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9)."
6-14	A citation and the DIRS report are updated to address the resolution of TBV-5958. This change is associated with CR 5345. Page 6-14, last paragraph, fourth sentence, "This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments (BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure 6.2.1-7; Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9)." is changed to read, "This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments (BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure **6-30**; Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9)."
6-56	A citation and the DIRS report are updated to address the resolution of TBV-5958. This change is associated with CR 5345. Page 6-56, fourth paragraph, seventh sentence, "During the two-month testing period, the relative humidity in the drift varied between about 10 percent and 60 percent (BSC 2004 [DIRS 170004], Figure 6.11.2-11c)." is changed to read, "During the two-month testing period, the relative humidity in the drift varied between about 10 percent and 60 percent (BSC 2004 [DIRS 170004], Figure **6-140c**)."
6-56	A change in the approximate low value ("30 percent" is changed to "25 percent") cited from reference BSC 2004 [DIRS 170004], Figure 6-137, is made as a self-identified error. The change does not impact the product output of this model report. A citation and the DIRS report are updated to address the resolution of TBV-5958. This change is associated with CR 5345. Page 6-56, fifth paragraph, fourth sentence, "The relative humidity in the testing area (partly protected from air circulation by curtains installed at the two ends of the V-shaped seepage capture curtains) varied between approximately 30 percent and 90 percent (BSC 2004 [DIRS 170004], Figure 6.11.2-8)." is changed to read, "The relative humidity in the testing area (partly protected from air circulation by curtains installed at the two ends of the V-shaped seepage capture curtains) varied between approximately **25** percent and 90 percent (BSC 2004 [DIRS 170004], Figure **6-137**)."

9-2	A citation and the DIRS report are updated to address the resolution of TBV-6034. This change is associated with CR 5345. The following reference with DIRS number 170012 is deleted from the list of references: **BSC (Bechtel SAIC Company) 2004.** ***Features, Events, and Processes in UZ Flow and Transport.*** **ANL-NBS-MD-000001 REV 03. Las Vegas, Nevada: Bechtel SAIC Company.**
9-3	A citation and the DIRS report are updated to address the resolution of TBV-6034. This change is associated with CR 5345. The following reference with DIRS number **174191** is added to the list of references: **BSC (Bechtel SAIC Company) 2005.** ***Features, Events, and Processes in UZ Flow and Transport.*** **ANL-NBS-MD-000001 REV 04. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050809.0002.**

The primary caveats and limitations in the scope of this Model Report and the results from the SCM are as follows:

1. The seepage models are intended to provide estimates of the seepage flux averaged over a 5 m drift segment (the approximate length of a waste package). The seepage models are not expected to quantitatively predict individual seepage events or the precise spatial seepage distribution along the drift.
2. By definition, the derived parameters are related to the specific model structure used, i.e., these parameters are only applicable to a conceptual and numerical model similar to the SCM. (Note that the SCM and the SMPA are compatible in this sense.) The parameters are also process specific and scale dependent, i.e., while they can be considered optimal for seepage calculations on the drift scale, they are not necessarily applicable to other processes on different scales.
3. The effective parameters derived in this Model Report capture many processes and features leading to dripping of formation water into a large underground opening. However, this does not include water dripping as a result of condensate accumulation on the drift surface or other in-drift moisture redistribution processes.

More detailed discussions of the appropriateness of the modeling approach, the sufficiency of the data, and the inherent limitations and caveats can be found throughout this Model Report.

The technical scope, content, and management of this Model Report are described in the planning document *Technical Work Plan for: Unsaturated Zone Flow Model Report Integration* (BSC 2004 [DIRS 169654], Section 2). This document does not deviate from the TWP; no additional criteria were identified in the TWP.

Direct inputs to this Model Report are listed in Section 4.1. These source data include the air-permeability and liquid-release test data described in the report *In Situ Field Testing of Processes* (BSC 2004 [DIRS 170004], Sections 6.2 and 6.11), calculated percolation flow fields described in the report *UZ Flow Models and Submodels* (BSC 2001 [DIRS 158726]) and the related numerical grid described in the report *Development of Numerical Grids for UZ Flow and Transport Modeling* (BSC 2001 [DIRS 159356]), fracture property data described in the reports *Analysis of Hydrologic Properties Data* (BSC 2004 [DIRS 170038]) and *Calibrated Properties Model* (CRWMS M&O 2000 [DIRS 144426]).

This Model Report mainly supports the reports that document the SMPA (BSC 2004 [DIRS 167652]) and seepage abstraction [*Abstraction of Drift Seepage* (BSC 2004 [DIRS 169131])]. In addition, the discussions and results are used in the reports *Features, Events, and Processes in UZ Flow and Transport* (BSC 2005 [DIRS 174191], Section 6.2), and *Drift-Scale Coupled Processes (DST and TH Seepage) Models* (BSC 2004 [DIRS 170338]).

This report also addresses the following issues: The development of a collection system in Niche 5 (also referred to as Niche 1620) for mass balance considerations (see Sections 6.5.3 and 6.8); monitoring and estimation of evaporation effects (see Sections 6.3.3.4, 6.5.4, 6.6.1.3, 6.6.1.4, 6.6.2.3, and 6.6.3.3); inclusion of film flow effects (see Sections 6.1.2, 6.3.3, 6.3.3.2, 6.3.4, and 6.6.3.1); inclusion of effects from small-scale irregularities at the drift surface (see

3. USE OF SOFTWARE

The software programs used in this study are listed in Table 3-1. These programs were selected because they are appropriate for the intended application. They were used only within the range of validation and consistent with the intended use; there are no limitations on outputs due to the selected software. The software programs were obtained from Software Configuration Management; their qualification and baseline status is given in the Document Input Reference System (DIRS).

Table 3-1. Qualified Software Used in this Report

Software Name	Version	Software Tracking Number	Platform	Operating System	Reference
iTOUGH2	4.0	10003-4.0-00	SUN	Sun O.S. 5.5.1	LBNL 1999 [DIRS 139918]
			DEC	OS v4.0	
iTOUGH2	5.0	10003-5.0-00	SUN	Sun OS 5.5.1	LBNL 2002 [DIRS 160106]
			LINUX	Red Hat v7.2	
			DEC Alpha	OSF1 v5.1	
GSLIB Module SISIM	1.203	10001-1.0MSISIMV1.203-00	SUN	Sun O.S. 5.5.1	LBNL 1999 [DIRS 134136]
			PC	Windows 98	
GSLIB Module SISIM	1.204	10397-1.0SISIMV1.204-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 153100]
GSLIB Module GAMV2	1.201	10087-1.0MGAMV2V1.201-00	SUN	Sun O.S. 5.5.1	LBNL 1999 [DIRS 134139]
GSLIB Module GAMV3	1.201	10398-1.0GAMV3V1.201-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 153099]
EarthVision	4.0	10174-4.0-00	SGI	IRIX 6.2	Dynamic Graphics 2003 [DIRS 162369]
AddCoord	1.0	10355-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152814]
MoveMesh	1.0	10358-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152824]
AddBound	1.0	10357-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152823]
Perm2Mesh	1.0	10359-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152826]
CutNiche	1.2	10356-1.2-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152815]
CutNiche	1.3	10402-1.3-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152828]
CutDrift	1.0	10375-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152816]
AddBorehole	1.0	10373-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 2000 [DIRS 152822]

Table 3-1. Qualified Software Used in this Report (Continued)

Software Name	Version	Software Tracking Number	Platform	Operating System	Reference
ECRB-XYZ	.03	30093-V.03	PC	Windows 95/98	CRWMS M&O 1999 [DIRS 147402]
EXT	1.0	10047-1.0-00	SUN	Sun O.S. 5.5.1	LBNL 1999 [DIRS 134141]

NOTE: The SUN platform identified in this table corresponds to the DOE Property Tag Number 6332537. The SUN Microsystems vendor uses three synonymous reference identifiers for its operating systems (O.S.). An example would be SUN Solaris 7, SUN Solaris 2.7 and SUN O.S. 5.5.7.

The use of the software programs identified in Table 3-1 is documented in Section 6 and in the supporting scientific notebooks (SNs). A summary description of the programs and their use is given below.

The software program iTOUGH2 V4.0 (LBNL 1999 [DIRS 139918]) provides forward and inverse modeling capabilities for unsaturated and multiphase flow in fractured porous media. The iTOUGH2 V5.0 (LBNL 2002 [DIRS 160106]) program has—among other features—the extended capability of efficiently simulating evaporation effects [*Requirements Document (RD) for iTOUGH2 V5.0-00* (BSC 2002 [DIRS 161067], Section 1.2)]. Both programs are used in this Model Report for simulating liquid-release experiments and predicting seepage rates. Moreover, they solve the inverse problem by automatically calibrating the model against measured data, and calculate prediction uncertainties for model validation.

The GSLIB modules GAMV2 V1.201 and GAMV3 V1.201 (LBNL 1999 [DIRS 134139]; LBNL 2000 [DIRS 153099]) analyze spatial correlation of, respectively, two-dimensional (2-D) and three-dimensional (3-D), irregularly spaced datasets. These programs are used for the geostatistical analysis of air-permeability data.

5.6 EVAPORATION IN OPEN DRIFT

Assumption: Evaporation from the drift surface is assumed to be governed by one-dimensional vapor diffusion across an evaporative boundary layer, the thickness of which can be estimated from measurements of relative humidity and evaporation rate from a free water surface.

Rationale: As water injected during a liquid-release test reaches the opening, it spreads along the surface on account of capillarity within the rough surface. As a result, water potentially seeping into the opening may not only form droplets or lines along fracture traces with a small surface area, but may spread across the drift surface over a relatively large area. This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments (BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure 6-30; Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9). The geometry of the wet spot does not have a clear correlation with the visible fractures traces. Even though water first appears along fracture traces (Trautz and Wang (2002 [DIRS 160335], Figure 10), the wet spot grows in an areal fashion. The short arrival time and the average speed at which the leading edge of the plume moves across the ceiling makes it obvious that the water is not transmitted through the matrix, but spreads along the ceiling as a surface film, possibly supported by flow through microfractures. Evaporation from such wet areas is similar to evaporation from a free water surface, where the evaporation rate is governed by one-dimensional vapor diffusion across a relatively thin boundary layer of linearly decreasing vapor concentration. A detailed description of the corresponding conceptual and mathematical model and the estimation of the evaporation boundary-layer thickness is given in Sections 6.6.1.3 and 6.6.1.4.

No further confirmation is required for this assumption, which is used in Sections 6.6.3 and 7.2.2.1.

5.7 LITHOPHYSAL CAVITIES

Assumption: The impact of lithophysal cavities on seepage is assumed to be appropriately captured in the estimation of an effective capillary-strength parameter.

Rationale: The impact of lithophysal cavities on flow and seepage is twofold: (1) lithophysal cavities are essentially obstacles to water flow because they act as capillary barriers, focusing the water that flows around them; (2) lithophysal cavities intersected by the drift lead to a rough drift wall, potentially creating seepage points at local topographic lows. Both effects tend to promote seepage.

The assumption states that the effect of lithophysal cavities on seepage can be captured through the estimation of an effective capillary-strength parameter, making the explicit inclusion of lithophysal cavities into the process model unnecessary. This approach is considered appropriate for the following reasons: (1) omitting lithophysal cavities in the process model used for inverse modeling yields lower estimates of the capillary-strength parameter and is thus conservative; (2) consistency between the calibration model (the SCM) and the prediction model (the SMPA) removes the impact of a potential estimation bias; (3) the approach followed allows for the

Consequently, the effective capillary-strength parameter estimated by inverse modeling depends on the chosen discretization; it contains a geometric component related to the length of the nodal distance between the formation and the drift. The estimate is thus model-related, and the discretization between the calibration model and the prediction model must be consistent.

In summary, the geometric factors affecting seepage are accounted for through (1) explicit discretization of the opening (which includes the overall shape as well as medium-scale roughness from break-outs lithophysal cavities), (2) by preventing flow diversion in a 0.05 m thick layer around the drift (mimicking small-scale surface roughness with a 0.05 m amplitude of the irregularities), and (3) the estimation of an effective capillary-strength parameter. The inclusion of small-scale surface roughness (exceeding an amplitude of 0.05 meters) and discrete effects from small fractures into an effective capillary-strength parameter is appropriate because their impact on seepage rates is directly related to capillarity.

Note that the nominal diameter of a repository drift is 5.5 m, which is slightly larger than that of the ECRB Cross-Drift (5.0 m). This difference is of no significance, because the seepage-related parameters are determined using a model with the correct diameter (5.0 m) to be used for the analysis of liquid-release tests in the ECRB Cross-Drift. These parameters are then applied in the prediction model, which simulates seepage into an opening with a 5.5 m diameter. The impact of drift-shape changes as a result of drift degradation is discussed in *Seepage Model for PA Including Drift Collapse* (BSC 2004 [DIRS 167652]).

6.3.3.4 Evaporation Conditions

General Description

Reduced relative humidity in the underground opening leads to evaporation of water at the drift surface and the development of a dry-out zone in the vicinity of the cavity. Part or all of the water reaching the ceiling of the opening during a liquid-release test may evaporate, depending on the evaporation potential in the drift and the wet area exposed to evaporation. The evaporation potential depends on the relative humidity in the opening and the thickness of a diffusive boundary layer at the drift surface, which in turn is governed by the air velocity in the ventilated drift.

The size of the wet spot developing at the drift ceiling as a result of liquid release above the drift depends on the formation properties, the spreading mechanism along the drift surface, and evaporation itself. As water injected during a liquid-release test reaches the opening, it spreads along the surface on account of capillary tension within the rough drift wall. As a result, water potentially seeping into the opening may not only form droplets or lines of water along fracture traces with a small surface area, but may spread across the drift surface over a relatively large area. This phenomenon is qualitatively confirmed by the geometry of the wet spot observed at the niche ceiling during seepage experiments (BSC 2004 [DIRS 170004], Section 6.2.1.3.4, Figure 6-30; Trautz and Wang 2002 [DIRS 160335], Figures 7 and 9). The geometry of the wet spot does not have a clear correlation with the visible fracture traces. Even though water first appears along fracture traces (Trautz and Wang 2002 [DIRS 160335], Figure 10), the wet spot grows in an areal fashion. It is obvious from the short arrival time and the average speed at which the leading edge of the plume moves across the ceiling that the water is not transmitted stochastic model of the inversion). Instead, the model follows the smooth, deterministic component of the seepage-rate data, which is non-negative.

Seepage rates are used instead of cumulative seepage data because an error in the prediction of the early-time seepage behavior leads to a shift in the cumulative seepage curve. Such a shift induces a bias in the estimated parameters, even if only late-time data were used in the inversion. In general, early-time seepage data are relatively strongly affected by storage effects. Moreover, they reflect the properties of only a few fractures that connect the injection interval with the point at the drift surface where seepage is initiated. These fractures may not be representative of the drift-scale properties of the fracture network engaged in the seepage process under near-steady-state conditions. These few fractures are likely to be conceptually different from the larger-scale network providing connectivity for flow diversion around the drift. Consequently, matching early-time data potentially leads to an unwanted bias in the estimated parameters. Late-time, near-steady data are less affected by storage effects, allowing for a more representative estimation of $\log(1/\alpha)$.

The following paragraphs discuss the data sets used for calibration (see also Table 6-5).

Borehole SYBT-ECRB-LA#1, Lower Lithophysal Zone
DTN: LB0110ECRBLIQR.002 [DIRS 156879]

Only one borehole interval (zone 2) was available for liquid-release testing in borehole SYBT-ECRB-LA#1 (BSC 2004 [DIRS 170004], Sections 6.11.2.5 and 6.11.2.6). Starting on February 28, 2001, water was released for a period of almost a month at an average rate of approximately 17 ml/min. No seepage was induced. In the following month, four tests with approximate release rates between 41 ml/min and 45 ml/min were performed, interrupted by phases of inactivity that lasted from a few hours to approximately 6 days. These higher-rate tests led to seepage. Seepage-rate data from all five tests (Events 65–69 of Table 6-5) are used for calibration. During the two-month testing period, the relative humidity in the drift varied between about 10 percent and 60 percent (BSC 2004 [DIRS 170004], Figure 6-140c). Data preparation is described in Appendix F and Wang (2003 [DIRS 161456], SN-LBNL-SCI-228-V1, pp. 15–17).

Borehole SYBT-ECRB-LA#2, Lower Lithophysal Zone
DTN: LB00090012213U.002 [DIRS 153154], DTN: LB0110SYST0015.001 [DIRS 160409]

Borehole SYBT-ECRB-LA#2 was tested twice, in May/June 2000 and October/November 2000. Humidity in the drift was not controlled or monitored during the earlier tests; these tests will therefore not be used for calibration, but for validation with an assumed relative humidity. During the second test period starting October 23, 2000, long-term liquid-release tests were conducted in zones 2 and 3 (Events 61–64 of Table 6-5) with approximate release rates ranging between 33 ml/min and 41 ml/min. The relative humidity in the testing area (partly protected from air circulation by curtains installed at the two ends of the V-shaped seepage capture curtains) varied between approximately 25 percent and 90 percent (BSC 2004 [DIRS 170004], Figure 6-137). Data preparation is described in Finsterle (2002 [DIRS 161043], p. 133) and Wang (2003 [DIRS 161456], SN-LBNL-SCI-228-V1, pp. 18–21).

BSC (Bechtel SAIC Company) 2003. *Errata for Risk Information to Support Prioritization of Performance Assessment Models.* TDR-WIS-PA-000009 REV 01 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021017.0045; DOC.20031014.0003.	168796
BSC (Bechtel SAIC Company) 2003. *Total System Performance Assessment-License Application Methods and Approach.* TDR-WIS-PA-000006 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20031215.0001.	166296
BSC (Bechtel SAIC Company) 2004. *Abstraction of Drift Seepage.* MDL-NBS-HS-000019 REV 01. Las Vegas, Nevada: Bechtel SAIC Company.	169131
BSC (Bechtel SAIC Company) 2004. *Analysis of Hydrologic Properties Data.* ANL-NBS-HS-000042, Rev. 00. Las Vegas, Nevada: Bechtel SAIC Company.	170038
BSC (Bechtel SAIC Company) 2004. *Drift-Scale Coupled Processes (DST and TH Seepage) Models.* MDL-NBS-HS-000015. Rev. 01. Las Vegas, Nevada: Bechtel SAIC Company.	170338
BSC (Bechtel SAIC Company) 2004. *Errata 002 for Drift-Scale Coupled Processes (DST and THC Seepage) Models.* MDL-NBS-HS-000001 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20030804.0004; DOC.20040219.0002; DOC.20040405.0005.	168848
BSC (Bechtel SAIC Company) 2004. *Errata for Technical Work Plan for: Performance Assessment Unsaturated Zone.* TWP-NBS-HS-000003 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20030102.0108; DOC.20040121.0001.	167969
BSC (Bechtel SAIC Company) 2004. *In Situ Field Testing of Processes.* ANL-NBS-HS-000005 REV 03. Las Vegas, Nevada: Bechtel SAIC Company.	170004
BSC (Bechtel SAIC Company) 2004. *Natural Analogue Synthesis Report.* TDR-NBS-GS-000027 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040524.0008.	169218
BSC (Bechtel SAIC Company) 2004. *Q-List.* 000-30R-MGR0-00500-000-000 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040721.0007.	168361
BSC (Bechtel SAIC Company) 2004. *Seepage Model for PA Including Drift Collapse.* MDL-NBS-HS-000002 REV 03. Las Vegas, Nevada: Bechtel SAIC Company.	167652

BSC (Bechtel SAIC Company) 2004. *Technical Work Plan for: Regulatory Integration Evaluation of Analysis and Model Reports Supporting the TSPA-LA.* TWP-MGR-PA-000014 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040603.0001. 169653

BSC (Bechtel SAIC Company) 2004. *Technical Work Plan for: Unsaturated Zone Flow Analysis and Model Report Integration*. TWP-MGR-HS-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040701.0005. 169654

BSC (Bechtel SAIC Company) 2005. *Features, Events, and Processes in UZ Flow and Transport.* ANL-NBS-MD-000001 REV 04. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050809.0002. 174191

Campbell, G.S. and Norman, J.M. 1998. *An Introduction to Environmental Biophysics.* 2nd Edition. New York, New York: Springer-Verlag. TIC: 243951. 150929

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