WSE&I Subtask 2.1 CDS
Development - R. Brient P.I.

WSCEI Subtask 2.1 CDS Development
Key Technical Uncertainty Integration Activity.
20-5702.221

Personnel:
Principal Investigator: R. Brient LaB

Personnel from other elements participating in KTU Integration include:
C. Tschoepe - EBS
H. Karimi - RDCO
M. Nicholas - GS
D. Turner - GS
B. Baca - PA
R. Mantenfel - PA
R. Bagtzoglou - PA

Objectives: To evaluate KTUs for the purpose of identifying consistency, and to identify new KTUs. The results of these analyses could result in revision of the KTU, and likewise, revision of the parent CDS. The reviews are also to be conducted in light of the use of KTUs ~~as a tool~~ to identify Research and analysis methods development.

This task was originally intended to be a joint activity of the CNWRA and NRC. However, reorganization at NRC precluded the availability of NRC staff, so the CNWRA has been tasked to proceed alone.

After some integration activities began, NRC staff became concerned that CNWRA activities may not get NRC input, and their opinions may not be adequately voiced. To address this, the following NRC staff were included in KTU integration activities:

J. Trapp - GS
J. Park - PA
J. Pohle - Hydrology
D. Brooks - EBS

RDB
7/1/94

The plan for KTU integration is as follows:

PROPOSED CNWRA INITIATIVES FOR LARP DEVELOPMENT ACTIVITIES

revised 5/20/94

1. Compile and report on the results of the Type 3 Review Strategy Integration Review

The Type 3 Integration Review was a loosely structured review intended to identify obvious inconsistencies and additional integration needs. Each program element provided comments which may be compiled, and additional, more focused integration effort identified as necessary.

- o NRC will provide integration comments. by 5/30/94
- o CNWRA will compile comments, prepare a report of recommendations for additional integration for these strategies, and recommend revision to selected CDSs as necessary. (AD) 6/30/94

2. Compile Generic Interface Review Comments and Revise Tables

Generic Interface tables were drafted and reviewed by the various program elements.

- o NRC will provide interface review comments. by 5/30/94
- o CNWRA will compile comments and revise the interface tables for eventual inclusion as an appendix to LARP Revision 1. (AD) 6/30/94

3. Develop Type 2 Review plan for Generic Application

The majority of the Type 2 (General Information) review plans, located in Chapters 1 and 2 of the LARP, may lend themselves to similar review procedures and acceptance criteria. CNWRA will perform the following, with the results to be provided to NRC.

- o Identify those Type 2 Review Plans to which a generic example could apply.
- o Chose a topic for an example, and prepare the CDM. (IM) tbd
- o Revise the Type 2 CDSs as necessary to reflect the generic approach provided by a generic CDM. (IMs) tbd
- o Prepare the balance of the Type 2 CDMs. (IMs) tbd

4. Integration of Key Technical Uncertainties

KTU identification and rationales are probably the most inconsistent area of CDSs, and the most important to correct. Examination of KTUs is necessary to verify that uncertainties are accurately identified and that KTUs are presented to facilitate identification of user needs. Since KTUs may be addressed by DOE, by NRC, or by both DOE and NRC, their respective responsibilities in regard to uncertainty resolution should be clearly identified. The task consists of the following phases:

ROB 7/1/94

- o Review existing KTUs individually and as groups; (i) identify KTU topic, affected review plans and repository system/subsystem, uncertainty associated with compliance demonstration, uncertainty associated with compliance determination, and anticipated NRC resolution of determination uncertainty, (ii) prepare tables of KTUs organized by performance objective at risk and by subject, (iii) identify possible strategies for consolidating or splitting KTUs, and (iv) identify new KTU topics. A report on the results of this analysis will be prepared, as well as training to NRC and CNWRA for revising KTUs. (IM) 8/30/94
- o As necessary, the CDS procedure will be revised to reflect any changes in the presentation of KTUs. (IM) tbd
- o Revise CDSs as necessary to incorporate a revised KTU structure. This activity would be conducted by the original CDS development groups. (IM) 9/30/94
- o Prepare input to the revision of the User Needs Report. (IM) 12/30/94

CNWRA & NRC negotiated the proposal, communications were as follows:

] From: Robert Brient at CNWRA-OS2 5/20/94 9:45AM (1395 bytes: 17 ln)
: Larry McKague at CNWRA, A Bagtzoglou at CNWRA, Robert Brient, John Hageman,
Hengameh Karimi, Michael Miklas, Stephen Spector, E Tschoepe, David Turner
mailing list: #DIRS-MGRS
bject: CNWRA Initiatives for LARP Development
---------- Message Contents ----------

Pat Mackin and I spoke with Mike Lee about our proposed initiatives. The response was very positive, Mike (and Robert Johnson) placing the highest priority on KTU integration activities. Completing the Type 3 integration activities and the generic interface tables, both relatively short term, WSE&I activities were next in priority. Preparing Type 2 CDMs was lowest, and the integration review of Type 3 strategies was deleted from the list.

I will refine the plan for KTU integration based on Mike's comments. He and R. Johnson want very much to follow the LARP Development Plan schedule of having revised CDSs, including Type 4 and 5, by the end of the FY.

I want to get started on KTU work as soon as possible, beginning with a group meeting early next week. The revised initiatives will be forwarded to you when it is completed.

ROB 7/1/94

NRC accepted the Plan verbally, and activities began.

] From: Robert Brient at CNWRA-OS2 5/30/94 12:49PM (1067 bytes: 17 ln)
: Larry McKague at CNWRA, A Bagtzoglou at CNWRA, Robert Brient, John Hageman,
Hengameh Karimi, Michael Miklas, Stephen Spector, E Tschoepe, David Turner,
Randall Manteufel at CNWRA
mailing list: #DIRS-MGRS
bject: KTU Kick-off Meeting
---------- Message Contents ----------

I have scheduled a meeting to kick-off the KTU integration task for today, Monday 5/30/94, at 3:30 pm. I have tentatively scheduled Conference Room A137 (I'll let you know otherwise). This should be a brief (1/2 hour) meeting to review the task and discuss the approach that has been formulated.

Based on discussions with the EMs, membership of the KTU group is:

GS - M. Miklas, D. Turner
EBS - C. Tschoepe
RDCO - H. Karimi
PA - R. Bagtzoglou, R. Manteufel, B. Baca
WSE&I - B. Brient

Please plan to be there.

] From: Robert Brient at CNWRA-OS2 5/30/94 4:50PM (1201 bytes: 17 ln)
: A Bagtzoglou at CNWRA, Robert Brient, John Hageman, Hengameh Karimi,
Randall Manteufel at CNWRA, Michael Miklas, Stephen Spector, E Tschoepe,
David Turner, Patrick Mackin, Robert Baca
bject: KTU Kick-off Meeting
---------- Message Contents ----------

Important points of our meeting were:

1. All members of the group will review all of the KTUs, specifically to attempt to identify the uncertainities associated with (i) compliance demonstration, and (ii) compliance determination, and to identify the anticipated resolution by NRC of compliance determination uncertainties.

2. B. Brient will provide copies of KTUs to members on Tuesday morning 5/31/94. At the Thursday LARP Team Meeting, forms to document review comments will be provided.

3. At the LARP Team Meeting on Thursday we will also discuss how comments will be recorded.

4. Members are urged to keep their respective EMs informed of our activities.

7/1/94

2] From: Robert Brient at CNWRA-OS2 6/1/94 8:00AM (67003 bytes: 22 ln, 1 fl)
o: Robert Baca, A Bagtzoglou at CNWRA, Michael Miklas, David Turner,
Hengameh Karimi, Robert Brient, E Tschoepe
c: Patrick Mackin
ubject: Form for documenting KTU reviews
---------- Message Contents ----------

ext item 1:

Attached is a form for use in the KTU reviews. If you prefer working on a hard copy, you can print the attached, or I have a hard copy that can be Xeroxed.

I urge you to have the LARP available when reviewing these. Think about how the KTU fits in with the review plan topic and with the review strategy.

I have filled in much of the obvious material. For a couple of the KTUs, I couldn't tell from the strategy if they were Type 4 or Type 5. See if you can decipher better than I. It also seemed like some KTUs shared by several review plans were Type 4 in one review plan, and Type 5 in another. Keep an eye out for these and note these discrepancies on the form.

The form has no explicit space for other information or comments, but please add those whenever necessary. By all means let's get as much out of this as possible.

In our Thursday LARP Team meeting, we can discuss the timetable for these reviews.

Each of the 58 KTUs was formatted so that reviewers could provide their comments, a sample review sheet is included on page

7/1/94

Key Technical Uncertainty Topic: Poor resolution of critical exploration methods and uncertainty in interpretation and modeling techniques available to detect and investigate structural geologic features in the subsurface.

Poor resolution of available exploration techniques, and uncertainty in interpretation and modeling of acquired data is considered to require a Type 4 review because there is potentially a high risk of non-compliance with the performance objectives, particularly the post-closure requirements. The potentially high risk of non-compliance necessitates analyses above and beyond that required for a Type 3 safety review.

Review Type: 4

Performance Objective(s) at risk: 60.112, 60.113(a), 60.113(c)

Affected Review Plan(s): 3.2.1.5

Affected Repository System(s): Geologic

Uncertainty Associated with (DOE's) compliance demonstration:

Uncertainty associated with (NRC's) compliance determination:

Anticipated resolution of determination uncertainty by NRC:

7/1/94

7/1/94

Periodic meetings were held during the review period!

2] From: Robert Brient at CNWRA-OS2 6/2/94 4:37PM (2537 bytes: 37 ln)
>: Larry McKague at CNWRA, A Bagtzoglou at CNWRA, Robert Brient, John Hageman,
Hengameh Karimi, Randall Manteufel at CNWRA, Michael Miklas, Stephen Spector,
E Tschoepe, David Turner
> mailing list: #DIRS-MGRS
ibject: KTU and LARP Meeting
---------- Message Contents ----------

The group, including B. Baca, R. Manteufel, R. Bagtzoglou, C. Tschoepe, H. Karimi, M. Miklas (D. Turner was unable to attend), B. Brient, and P. Mackin discussed some of the early observations from the KTU reviews. We have noted some discrepancies between the rationales and the review typing listed in the strategy, some PAC and FAC KTUs may be better associated with Performance Objective Review Plans. We have also noticed that the rationales for choosing Type 4 vs. Type 5 are not clear nor are they consistent between KTUs. We seem to think that the results of this effort will provide suggestions for KTU topics considerably different than those presently.

Forms for documenting the KTU reviews are available on the G drive. The group agreed to try to complete the reviews by the end of June. During the meantime, we will keep each other informed of significant findings, and will meet periodically to discuss findings and results.

The LARP telecon involved the usual status reports, plus Mike Lee briefed NRC staff on CNWRA Larp Related Initiatives, particularly KTU integration. Mike has given us the go-ahead for this activity.

Also discussed were the alternatives proposed by the CDM 4.3 group for consolidating radiation protection reviews. P. Mackin expressed our support, but made it clear that this is really a policy matter for NRC to decide. Mike also indicated that proofs of LARP rev 0 will be ready in a few weeks. CNWRA elements may be tasked by their counterparts to check the proofs.

I'll be on travel next week, as will Pat Mackin. Sine PAt will be at White Flint, he will inform you of any LARP meeting next week, and if so, will participate from that end.

] From: Patrick Mackin at CNWRA-OS2 6/3/94 9:20AM (3051 bytes: 50 ln)
: Larry McKague at CNWRA
mailing list: #DIRS-MGRS
c: Robert Brient
bject: Progress of KTU Integration Group
---------- Message Contents ----------

Since the KTU integration effort is getting underway fairly aggressively, and since none of the WSE&I group will be available to discuss it at Monday's management meeting, I wanted to provide some observations to DIRS/EMS in support of those which Bob Brient E-mailed to you on 6/2.

- The response from the individuals which each of the EMs has assigned to this effort is supportive and enthusiastic.

- There seems to be some consensus that significant problems exist with the KTUs. Consequently, the recommendations which might result from the work of this group could include widespread changes to the KTUs. There are obvious implications for research user needs, and potentially, for research and technical assistance work.

- In our discussions with the group on 6/2, it was suggested that the group members keep their EMs informed on the nature of some of the comments which are evolving so that there is early awareness of the potential results of some of these comments.

- Bob Baca has been an active participant in the two meetings this group has had to date. I believe that to be extremely important, as the primary goal of the effort is technical integration, and KTUs, by definition, are performance-related issues. Bob's suggestions and insights are proving very valuable in forming the direction the group is taking. Similarly, other EMs may wish to be closely connected to this effort.

- As Bob Brient begins to collect results of the reviews by individual group members, he will start collating them. He will also begin to notify our staff about those consensus type comments which appear to present important issues related to KTUs.

- I think it will be important for us to develop a deliberate "marketing strategy" to help us inform the NRC of the results and recommendations of this review. I believe we will need to do this in steps in order to avoid the level of surprise which could accompany any recommendations for significant changes.

Please contact me or Bob Brient if you have any thoughts or suggestions for the continuation of this integration review of KTUs.

Pat Mackin also provided the following to inform NRC of the status of CNWRA activities (around 6/24/94)

INTEGRATION OF KEY TECHNICAL UNCERTAINTIES
A BASIC PLAN

PROCESS

1. Review and Comment on all KTUs (6/30/94)
   - Topic Statement
   - Identification of Affected Review Plans
   - Applicable Repository Systems/Subsystems
   - Description of the Compliance Demonstration Uncertainty (DOE's Role)
   - Description of the Compliance Determination Uncertainty, if any (NRC's Role)
   - Other Comments
2. Organize Results and Present to Management (Date TBD but preferably by 7/70/94)
   - Tables/Matrices
   - Consensus Comments
   - Issues
   - Recommendations for Proceeding
3. Present Final Results to Management (8/30/94)
   - Recommendations for consolidation, splitting, new KTUs, etc.
4. Revise CDS Procedure, if needed (8/30/94)
5. Revise CDSs/KTUs (Done by Development Groups) (9/30/94)
6. Input to LARP, Rev 1 (12/30/94)
7. Input to Revised User Needs (12/30/94)

PRELIMINARY RESULTS (UNSANCTIONED, FROM ONE REVIEWER)

1. Most KTUs Address Modeling Issues (Consolidate?)
2. DOE/NRC Roles are not Well Defined
3. There is Inadequate Justification for NRC Roles
4. There are Several Instances of Multiple KTUs for Very Similar Technical Issues
5. There may be Opportunities to Consolidate and Define Some "Global" KTUs
   - Model Validation
   - Conceptual/Mathematical Model Development
   - Future States
   - Extrapolation of Short Term Data
   - Expert Elicitation
   - Spatial Variability

If NRC provides guidance in these areas, they may cease to be KTUs

7/14/94 LKB A meeting of NRC & CNWRA KTU integration Team members was held to discuss preliminary review comments and results. The results are based on reviewers comments, but are those of R. Brient. The team was tasked to consider the review comments and preliminary results for discussion during the week of 7/25/94

7/14/94 LKB

NRC - CNWRA
KTU INTEGRATION MEETING

JULY 14, 1994

AGENDA

1. STATUS OF REVIEWS
   * NRC
   * CNWRA
2. REVIEW OF COMPILED STATISTICS AND SPREAD SHEET
3. PRELIMINARY REVIEW RESULTS
4. DISCUSSION OF NEXT ACTION TO BE TAKEN

KTU INTEGRATION REVIEW STATISTICS

1. PERFORMANCE OBJECTIVES AT RISK

60.111(a) Rad. Exposures and Releases -	2	(3%)
60.111(b) Retrievability	3	(5%)
60.112 Overall System Performance	43	(74%)
60.113(a)(1)(ii)(A) SCC	24	(41%)
60.113(a)(1)(ii)(B) Gradual Release	35	(71%)
60.113(a)(2) GWTT	12	(21%)
60.113(c) Unanticipated Processes & Events	5	(9%)
40 CFR 191.13	4	(7%)
40 CFR 191.15	1	(2%)

2. REPOSITORY SYSTEMS*

Geologic	15	(26%)
Hydrologic	20	(34%)
Geochemical	18	(31%)
GROA	9	(16%)
EBS	16	(28%)

* Four KTUs associated with the performance objective review plans were applicable to all repository systems.

3. KTU CATEGORY

Conceptual Models	22	(38%)
Mathematical Models	13	(22%)
Predictions of Future States	19	(33%)
Variability	2	(3%)
Model Validation	3	(5%)
Insufficient Data	6	(10%)

4. KTUs WITH SIMILAR TOPICS

A. 1 - Poor resolution of structural geologic methods
2 - Faulting in alluvium
16 - Low resolution to evaluate igneous features
17 - Can't sample igneous features

B. 3 - Conceptual tectonic models - structural deformation
15 - Tectonic models disagree with physical evidence
18 - Conceptual tectonic models - igneous activity

C. 4 - Conceptual models - groundwater flow
5 - Mathematical models- groundwater flow
20 - Groundwater flow models untested
21 - Conceptual models - groundwater flow in unsaturated fractured rock
22 - Characterization parameters
24 - Groundwater flow models - no experimental confirmation

D. 6 - Groundwater effects on waste package corrosion
7 - Groundwater effects on waste form
8 - Groundwater evolution near/within EBS
37 - Geochemical process that effect EBS
39 - Magnitude of effect of geochemical process on EBS

E. 11 - Earthquake prediction
13 - Earthquake prediction
14 - Prediction of seismicity

F. 19 - Large hydraulic gradient north of Yucca Mtn - effect on hydrologic models
27 - Large hydraulic gradient north of Yucca Mtn - tectonic disruption of fault related barriers

G. 29 - Alteration minerals & radionuclide migration
31 - Geochemical conditions - particulate and colloid formation
36 - Geochemical processes that reduce retardation
38 - Magnitude of effect of geochemical processes on retardation

H. 41 - Gas flow and gaseous radionuclide transport
51 - Predicting gaseous releases

I. 42 - Predicting long term performance of seals
45 - Predicting long term performance of seals for test boreholes

MATRIX OF KTU CATEGORIES vs. REPOSITORY SYSTEMS

KTU CATEGORY	GEOL.	HYDRO.	GEOCHEM.	GROA	EBS
CONCEPTUAL MODELS	X	X	X	*	X
MATHEMATICAL MODELS	X	X	X	*	X
PREDICTIONS	X	X	X	X	X
VARIABILITY	*	X	*	*	*
MODEL VALIDATION	*	X	*	*	*
INSUFFICIENT DATA	X	X	X	X	

X - Covered by specific KTUs

* - Covered by general KTUs in RPs 6.1, 6.2, 6.3

7/24/98

PRELIMINARY KTU INTEGRATION REVIEW RESULTS

1. STATEMENT OF UNCERTAINTY WITH DOE's ABILITY TO DEMONSTRATE COMPLIANCE: Generally the KTUs identified the uncertainty that DOE faces, but usually this was not explicitly stated.

2. STATEMENT OF UNCERTAINTY WITH NRC's ABILITY TO DETERMININE COMPLIANCE: The KTUs generally did not indicate any uncertainties that NRC should address. A number of KTUs did indicate that research is being conducted, is planned, or is needed, but these statements were usually not justified. NRCs role in adressing KTUs was generally not well defined.

3. REVIEW TYPE SELECTION: KTUs, particularly those calling for Type 5 reviews, in most cases did not justify why the higher level of analysis was necessary. However, a number of KTUs did indicate that resolution was unlikely. (This may signal that a scientific/engineering resolution cannot be had, so a legal i.e., NRC guidance, resolution may be necessary.)

4. KTU TOPICS: The majority of the KTUs are concentrated in tectonics, groundwater hydrology, groundwater chemistry, and geochemical effects on retardation.

5. KTU SUBJECTS: All of the KTUs could be logically fit into one or more of the following categories: conceptual and mathematical models and model validation, prediction of future states (also a modeling and validation issue), spatial and temporal variability, and data limitations.

5. KTU SCOPE: KTUs were inconsistent in their focus and scope, ranging from very specific to all encompassing. The very specific were concerned with a single phenomenum associated with one of the respository systems, e.g., "the source of the large hydraulic gradient north of Yucca Mountain", while the broad KTUs applied to all repository systems, e.g., "model validation." The extents of discussion in the KTUs were likewise highly variable.

6. ASSOCIATED REVIEW PLANS: 39 of the 58 current KTUs are assciated with Potentially Adverse Conditions and Favorable Conditions. These KTU should probably be associated with performance objective review plans rather than with PACs and FACs, for the following reasons:

- Virtually all of these KTUs appear to be concerned with the probability of occurrence and consequences of the presence of these conditions, not with determining the presence of the conditions.

- According to the PURL for 60.112/60.122, the impact on performance of the potentially adverse and favorable conditions, in combination, should be determined under the performance objective review plans for 60.112.

- PACS and FACs do not have performance objective regulatory requirements. One could argue that without a performance objective regulatory requirement, there could be no performance objective at risk, hence, no KTU associated with that specific (PAC or FAC) review plan.

The performance objective review plans (6.1, 6.2, and 6.3) have global KTUs covering conceptual modeling, mathematical modeling, variability, and model validation. The KTUs associated with the PACs and FACs are very likely to be covered under these broad scope KTUs.

KTU #	KTU Topic	Type	Related KTUs	PERFORMANCE OBJECTIVES: Rad.Exposures & Releases 111(a)	Retriev-ability (111(b)	Overall Sys.Perf. 112	SCC 113(a)(1)(ii)(A)	Gradual Release (B)	GWTT 113(a)(2)	Unanticipated Proc. 113(c)	40 CFR 191.13	40 CFR 191.15	REPOSITORY SYSTEM: Geologic	Hydrologic	Geochemical	GROA	EBS	KTU CATEGORY: Conceptual Model	Mathematical Model	Predictions	Variability	Model Validation	Insufficient Data	Associated Review Plans
1	Poor Resolution-struct.geo.methods	4	2,16,17			X	X	X		X			X					X	X		4			3.2.1.5 (PAC)
2	Faulting in alluvium	5	1,16,17			X	X	X		X			X					X						3.2.1.5 (PAC)
3	Conceptual Tectonic Models-Struct. deform	5	15,18			X	X	X		X			X					X						3.2.1.5 (PAC)
4	Conceptual Groundwater flowmodel	4	5,20,21,22,24						X					X				X						3.3,3.2.2.1,3.2.2.9 (GWTT/FAV/PAC)
5	Mathematical Groundwater flowmodel	4	4,20,21,22,24						X					X					X					3.3,3.2.2.1,3.2.2.9 (GWTT/FAV/PAC)
6	Groundwater effects on Waste Pkg. Corrosion	4	7,8,37,39				X								X		X	X						3.2.3.4 (PAC)
7	Groundwater effects on Waste Form	4	6,7,37,39			X		X							X		X	X						3.2.3.4 (PAC)
8	Groundwater evolution near/within EBS	5	6,7,37,39			X	X	X							X		X			X				3.2.3.4 (PAC)
9	Fastest Path of Radio-nuclide Travel	7							X					X				X			X			3.3 (GWTT)
10	Extent of Disturbed Zone	7							X					X				X						3.3 (GWTT)
11	Earthquake Prediction	4	13,14			X	X	X					X							X				3.2.1.7 (PAC)
12	Correlation of Earthquakes with Tectonic Features	5				X	X	X					X					X						3.2.1.7,3.2.1.8 (PACs)
13	Earthquake Prediction	4	11,14			X	X	X					X							X				3.2.1.8 (PAC)
14	Prediction of Seismicity	5	11,13			X	X	X					X							X				3.2.1.8 (PAC)
15	Tectonic Models disagree with Physical Evidence	5	3,18			X	X	X					X					X						3.2.1.8 (PAC)
16	Low Resolution to Evaluate Igneous Features	4	1,2,17			X							X										X	3.2.1.9 (PAC)
17	Can't Sample Igneous Features	5	1,2,16			X							X										X	3.2.1.9 (PAC)
18	Conceptual Tectonic Models for Igneous Activity	5	3,15			X							X					X						3.2.1.9 (PAC)
19	Large Hyd.Gradient N.of YM Hydrologic Models	4	27			X								X				X						3.2.2.1,3.2.2.9 (FAV/PAC)
20	Groundwater Flow Models untested(model valid?)	4	4,5,21,22,24			X		X	X					X					X			X		3.2.2.1,3.2.2.9,3.2.2.12 (FAV/PACs)
21	Conceptual Groundwaterflow unsat/fract.rock	4	4,5,20,22,24			X		X	X					X				X						3.2.2.1,3.2.2.9,3.2.2.12
22	Characterization Parameter Uncertainties	4	4,5,20,21,24			X		X	X					X					X					3.2.2.1,3.2.2.9,3.2.2.12
23	Predicting Precipitation	5				X								X						X				3.2.2.1,3.2.2.9,3.2.4.2
24	Groundwater flow models-no experimental confirm	5	4,5,20,21,22			X		X	X					X				X				X		3.2.2.1,3.2.2.9,3.2.2.12
25	Data Collection/Interpretation-Groundwater flowmodels	5				X		X	X					X					X				X	3.2.2.1,3.2.2.9,3.2.2.12
26	Perched Zone modeling-Thermally driven flow	5				X		X						X				X	X					3.2.2.1,3.2.2.9,3.2.2.12
27	Large Hyd.Gradient N.of YM-Tectonic Disruption of fault related barriers	4	19			X	X	X	X					X				X						3.2.2.8 (PAC)
28	Effect of Groundwater withdrawals on Groundwaterflow sys.	4				X								X				X						3.2.2.6,3.2.2.9 (PACs)
29	Alteration minerals & radio-nuclide migration	4	31,36,38			X								X					X					3.2.2.9,3.2.3.3. (PAC/FAV)
30	Prediction of Hydrologic Sys.Chgs	5				X		X						X						X				3.2.2.9 (PAC)
31	Geochem.conditions-particulate & colloid formation	4	29,36,38			X		X							X			X						3.2.3.2 (FAV)
32	Groundwater chemistry characterization processes	4				X		X							X								X	3.2.3.2 (FAV)
33	Effects of partial saturation on geochem. processes	4				X		X							X			X						3.2.3.2 (FAV)
34	Parametric representation of retardation processes	4				X		X							X				X					3.2.3.2 (FAV)
35	Alteration of minerals due to thermal loading	4				X									X			X						3.2.3.3 (FAV)
36	Geochemical processes that reduce retardation	4	29,31,38			X									X			X						3.2.3.5 (PAC)
37	Geochem.processes that affect EBS	4	6,7				X	X							X		X	X						3.2.3.5 (PAC)
38	Magnitude of effect of geochem. processes on retardation	5	29,31,36			X									X				X					3.2.3.5 (PAC)
39	Magnitude of effect of geochem. processes on EBS	3	6,7,37				X	X							X		X		X					3.2.3.5 (PAC)
40	Volatility and stability of radionuclides	4				X									X								X	3.2.3.7 (PAC)
41	Gasflow and gaseous radionuclide transport	4	51			X									X				X					3.2.3.7 (PAC)
42	Prediction of longterm performance of seals	4	45			X	X	X								X				X				4.3 (Design)
43	Prediction of THMC responses	4		X	X	X	X	X	X	X						X				X				4.3,4.4 (Design)
44	Retrievability of Waste	4			X											X				X			X	4.3,4.4,4.5.2 (Design,GROA Perf.
45	Predicting Longterm performance of seals-boreholes	4	42			X	X	X								X				X				4.4 (Design)
46	Predicting THMC on host rock around waste package	4		X	X	X	X	X	X	X						X				X				4.5.2 (GROA Perf)
47	Thermomechanical effects on Waste package and EBS	4					X	X									X			X				5.2,5.3,5.4 (EBS Perf)
48	Predicting Environmental effects of Waste package and EBS	4					X	X									X			X				5.2,5.3,5.4 (EBS Perf)
49	Predicting Criticality Events in Waste packages						X	X									X			X				5.2,5.4 (EBS Perf)
50	Predicting Release Path Parameters due to Thermomech., Environmental, Criticality effects	4					X	X									X			X				5.2,5.4 (EBS Perf)
51	Predicting Gaseous Releases	4	41				X	X									X			X				5.2,5.3,5.4 (EBS Perf)
52	Predicting Gaseous Releases	4					X	X									X			X				5.2,5.3,5.4 (EBS Perf)
53	Extrapolating short term results Waste package and EBS	5					X	X									X		X	X				5.2,5.3,5.4 (EBS Perf)
54	Conceptual Models	4				X					X		X	X	X	X	X	X						6.1,6.2 (Cum. Rel,Ind.Perf)
55	Variability in model parameters invoived	4				X					X		X	X	X	X	X				X			6.1,6.2
56	Mathematical Model assumptions and simplifications	4				X				X			X	X	X	X	X		X					6.1,6.2
57	Model Validations	5				X					X		X	X	X	X	X						X	6.1 (Cum. Release)
58	Prediction of Future Status	5				X					X									X				6.1 (Cum. Release)

8/12/94

[1] From: Robert Brient at CNWRA-OS2 8/12/94 7:40AM (1471 bytes: 20 ln)
To: Rawley Johnson at CNWRA, Larry McKague at CNWRA, A Bagtzoglou at CNWRA, Robert Brient, John Hageman, Hengameh Karimi, Randall Manteufel at CNWRA, Michael Miklas, Stephen Spector, E Tschoepe, David Turner
To mailing list: #DIRS-MGRS
Subject: KTU Meeting

---------- Message Contents ----------

We had a KTU Team Meeting Thursday afternoon, 8/11/94, and agreed on the review statistics to present to the NRC and CNWRA staff. Briefings will be held soon to inform the rest of the staffs involved in CDS and CDM development of the findings of the KTU Integration group.

I will be arranging with each EM to schedule the briefings, preferably early next week.

A fair amount of discussion concerned possible strategies for restructuring the KTUs. We set a meeting for next Thursday, 8/18/94, to review various proposals for KTU revision. So far, Baca, Manteufel, Brient, Tschoepe, and (Ibelieve) RDCO have come up with proposals. NRC KTU team members have plenty of ideas, and should be coming up with proposals as well.

KTU team members were requested to finalize their proposals by 8/17 for distribution to other members before the 8/19 meeting.

8/12/94

R

D

B

KTU INTEGRATION REVIEW STATISTICS
(Based on the current 58 KTUs)

1. PERFORMANCE OBJECTIVES AT RISK

60.111(a) Rad. Exposures and Releases -	2	(3%)
60.111(b) Retrievability	3	(5%)
60.112 Overall System Performance	43	(74%)
60.113(a)(1)(ii)(A) SCC	24	(41%)
60.113(a)(1)(ii)(B) Gradual Release	35	(71%)
60.113(a)(2) GWTT	12	(21%)
60.113(c) Unanticipated Processes & Events	5	(9%)
40 CFR 191.13	4	(7%)
40 CFR 191.15	1	(2%)

2. REPOSITORY SYSTEMS

Geologic	15	(26%)
Hydrologic	20	(34%)
Geochemical	18	(31%)
GROA	9	(16%)
EBS	16	(28%)

* Four KTUs associated with the performance objective review plans were applicable to all repository systems.

3. KTU CATEGORY

Conceptual Models	22	(38%)
Mathematical Models	13	(22%)
Predictions of Future States	19	(33%)
Variability	2	(3%)
Model Validation	3	(5%)
Insufficient Data	6	(10%)

The following are the finalized statistics & results for presentation to the NRC & CNWRA staff involved with CDS/CDM development.

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4. KTUs WITH SIMILAR TOPICS

A. 1 - Poor resolution of structural geologic methods
2 - Faulting in alluvium
16 - Low resolution to evaluate igneous features
17 - Can't sample igneous features

B. 3 - Conceptual tectonic models - structural deformation
15 - Tectonic models disagree with physical evidence
18 - Conceptual tectonic models - igneous activity

C. 4 - Conceptual models - groundwater flow
20 - Groundwater flow models untested
21 - Conceptual models - groundwater flow in unsaturated fractured rock
22 - Characterization parameters
24 - Groundwater flow models - no experimental confirmation

D. 6 - Groundwater effects on waste package corrosion
7 - Groundwater effects on waste form
8 - Groundwater evolution near/within EBS
37 - Geochemical process that effect EBS
39 - Magnitude of effect of geochemical process on EBS

E. 11 - Earthquake prediction
13 - Earthquake prediction
14 - Prediction of seismicity

F. 19 - Large hydraulic gradient north of Yucca Mtn - effect on hydrologic models
27 - Large hydraulic gradient north of Yucca Mtn - tectonic disruption of fault related barriers

G. 29 - Alteration minerals & radionuclide migration
31 - Geochemical conditions - particulate and colloid formation
36 - Geochemical processes that reduce retardation
38 - Magnitude of effect of geochemical processes on retardation

H. 41 - Gas flow and gaseous radionuclide transport
51 - Predicting gaseous releases

I. 42 - Predicting long term performance of seals
45 - Predicting long term performance of seals for test boreholes

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MATRIX OF KTU CATEGORIES vs. REPOSITORY SYSTEMS

KTU CATEGORY	GEOL.	HYDRO.	GEOCHEM.	GROA	EBS
CONCEPTUAL MODELS	X	X	X	*	X
MATHEMATICAL MODELS	X	X	X	*	X
PREDICTIONS	X	X	X	X	X
VARIABILITY	*	X	*	*	*
MODEL VALIDATION	*	X	*	*	*
INSUFFICIENT DATA	X	X	X	X	

X - Covered by specific KTUs

* - Covered by general KTUs in RPs 6.1, 6.2, 6.3

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KTU INTEGRATION REVIEW RESULTS

1. STATEMENT OF UNCERTAINTY WITH DOE's ABILITY TO DEMONSTRATE COMPLIANCE: Generally, the KTUs identified the uncertainty that DOE faces, but this was usually not explicitly stated.

2. STATEMENT OF UNCERTAINTY WITH NRC's ABILITY TO DETERMINE COMPLIANCE: The KTUs generally did not indicate any uncertainties that NRC should address. A number of KTUs did indicate that research is being conducted, planned, or needed, these statements were usually not supported by rationale. NRC's role in addressing KTUs was generally not well defined.

3. REVIEW TYPE SELECTION: KTUs, particularly for Type 5 reviews, in most cases did not defend why the higher level of review was necessary. However, a number of KTUs indicated that resolution of the uncertainty was unlikely.

4. KTU TOPICS: The majority of the KTUs are concentrated in tectonics, groundwater hydrology, groundwater chemistry, and geochemical effects on retardation.

5. KTU SUBJECTS: All of the KTUs could logically fit into one or more of the following categories: conceptual models, mathematical models, model validation, prediction of future states, spacial and temporal variability, and data limitations.

6. KTU SCOPE: KTUs were inconsistent in their focus and scope, ranging from very specific to all encompassing. The very specific were concerned with a single phenomenon associated with a single repository system, e.g., "the source of the large hydraulic gradient north of Yucca Mountain", while the broad KTUs applied to all repository systems, e.g., "model validation." The extent of discussion in the KTUs was likewise highly variable.

7. ASSOCIATED REVIEW PLANS: 39 of the 58 KTUs are associated with Potentially Adverse Conditions and Favorable Conditions.

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TYPE 5 KTU ANALYSIS

RELATED TYPE 5 KTUs	RELATED TYPE 4 KTUs	KTU CATEGORY	REPOSITORY SYSTEM
2-Faulting in alluvium 17-Can't sample Igneous Features	1-Poor res. struct. geo. methods 16-Low resol. to eval. Igneous features	Conceptual Models	Geologic
3-Concept. Tectonic models-Struct. deform 15-Tectonic models disagree w/Physical Evidence 18-Conceptual Tectonic models-Igneous Activity		Conceptual Models	Geologic
8-Grndwater evolution near/w/in EBS 39-Magnitude of effect of geochemical processes on EBS	6-Grndwater effects on Waste Pkg Corrosion 7-Grndwater effects on Waste form 37-Geochem. process that effect EBS	Conceptual Models	Geochemical/EBS
12-Correlation of Earthquake w/ Tectonic features		Conceptual Models	Geologic
14-Prediction of Seismicity	11,13-Earthquake Prediction	Predictions	Geologic
23-Predicting Precipitation		Predictions	Hydrologic
5-Mathematical Grndwater Flow models 24-No exp.confirm. of Grndwater flow models 25-Data collection/interpretation-Grndwater flow models 26-Perched zone modeling-thermally driven flow 30-Prediction of Hydrologic System changes	4-Conceptual Grndwater flow models 20-Grndwater Flow models untested 21-Concept models-Grndwater flow in unsaturated fractured rock	Model Validation, Conceptual, Math. Models, Predictions	Hydrologic

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[illegible]

38-Magnitude of effect of geochem processes on retardation	29-Alteration minerals & radionuclide migration 31-Geochem. conditions-particulate and colloid formation 36-Geochem process that reduce retardation	Geochemical	Mathematical models
53-Extrapolating short term results - Waste Pkg and EBS		EBS	Predictions
57-Model validation (General) One other type 5	11 other type 4s	All	Model validation
58-Prediction of Future states Five other Type 5s	13 other Type 4s	All	Predictions

[illegible] 9/27/94

more plans were discussed with NRC for CNWRA to take over most of the LARP development tasks. A compromise was also proposed for KTI integration: for CNWRA to take the lead, but moreover, for the KTI revision to go ahead without a massive restructuring plan. Basically, we would convene the technical working groups and try to consolidate & integrate in discipline based groups. The following document the steps.

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

M E M O R A N D U M

September 2, 1994

TO: Robert Johsnon
M. Lee

FROM: P. Mackin

SUBJECT: Action Plan for Continuing LARP/KTU Development

This is in response to our discussion on 8/31/94 in which you asked that I prepare a plan of action to support the Center's recommendation on the next step to take in KTU integration. You also asked that I include in the plan those items which were not completed in the FY 94 LARP Development Plan and also a proposed schedule for completion of LARP, Revision 1. This memo forwards all that information. Although I have discussed it briefly with Center management and the LARP/KTU Development Team, it has not been thoroughly reviewed. W. Patrick and B. Sagar have both reviewed it in detail, however, and concur in it.

To summarize the attached memo, the Center is proposing that we focus our efforts related to KTUs on providing a clear statement of the action NRC should be taking. These statements could be used to define or revise research user needs and technical assistance requirements. In the process of preparing these statements, it may be possible to consolidate, refine, or coordinate activities among KTUs or elements.

Status and Plan of Action for LARP Development Activities

The update provided below contains the Center's understanding of the status of each activity, and suggested actions and schedules for completion where appropriate. The numbering and identification of activities match those in the FY 94 LARP Development Plan.

I. Revise CDSs

1. Conduct Integration/Consistency Review of CDSs

A. Conduct Integration/Consistency Review of Existing KTUs

A group composed of NRC/CNWRA technical staff has reviewed, commented upon, and proposed action related to KTUs. While a number of processes could be followed and a number of categorization schemes could be used, there is general consensus that the most useful thing which could be done to integrate KTUs at this point would be to delineate NRC's role related to each KTU. A proposed schedule for this activity is outlined below.

1. CDS development groups at the CNWRA, with participation by NRC team members if they are available, prepare an "NRC plan of action," as appropriate, which delineates what NRC would need to do to fulfil its licensing role relative to each KTU. These plans, where useful, should attempt to accommodate plans for any similar KTUs and consider consolidation where appropriate - complete by 9/30/94.

2. CNWRA management conduct a review of the action plans, ensuring that they have been combined, cross-referenced, or deconflicted when appropriate - complete by 10/18/94.

3. CNWRA briefs NRC staff/management on the action plans on 11/29/94.

4. NRC staff and management consider the CNWRA proposals discussed above as input to research user needs and technical assistance requirements - complete by 12/30/94

5. After incorporation of NRC review comments, the CNWRA incorporates the action plans into the rationale portions of the appropriate CDSs - complete by 3/30/95.

6. As a supporting item, CNWRA WSE&I staff will update the CDS procedure to require the incorporation of these action plans which clarify NRC's role related to each KTU.

B. Identify New "ology" KTUs for Each Performance Objective CDS

This activity has not started and is the source of significant debate. Some feel that, by definition, KTUs relate only to performance objectives, and that PAC/FC review plans should focus only on presence or absence rather than evaluation of issues related to performance. The CNWRA thinks that this contentious issue has the potential to hold up progress on LARP development and to consume valuable time. As an alternative, the Center proposes that the action plans discussed in item I.1.A. above can serve as the vehicle to present any required NRC actions related to "ology" KTUs. A general consensus from the KTU review is that the KTUs are usually stated broadly enough to allow the technical staff to pursue the most important issues. Therefore, the Center thinks that this activity will be adequately completed by carrying out the action proposed in item I.1.A. above.

C1. Conduct Integration/Consistency Review of CDSs

For CDS types 1 through 3, this review was done, and results were incorporated into the CDSs prior to completion of LARP, Rev 0. For CDS types, 4 and 5, the review has been completed, and the activity proposed in item I.1.A. above would complete the necessary action.

C2. Update Existing CDSs Based on New Sources of Information (as appropriate)

For CDS types 1 through 3, the necessary updates were included in LARP, Rev 0. For CDS types 4 and 5, the activity proposed in item I.1.A. above would be completed by the CNWRA on 3/30/95.

D. Conduct OGC and Editorial Reviews of Revised CDSs

For CDS types 1 through 3, this activity was completed in support of the development of LARP, Rev 0. For CDS types 4 and 5, this activity could commence once the CNWRA submits the CDSs with the updated KTU rationales on 3/30/95.

II. Develop CDMs

1. Define CDM Interfaces

A. Define Interfaces for Individual Review Plans

This activity is essentially complete, although in execution, the intent has evolved somewhat. NRC and CNWRA staff completed work on a matrix defining interfaces among review plans. That matrix has been used to refine interfaces as individual CDMs are written. The process of writing CDMs has improved upon the matrix.

The RPD has not been loaded with the matrix since the interfaces will be incorporated into the RPD as the individual CDMs are loaded. If there is still a need to load the matrix separately, the associated interrelationships and functions to be derived from the matrix can become a specific task under RPD Maintenance and Operation in FY95.

B. Define Organizational Responsibilities for Review Plans

This activity has been completed. Results are being reviewed and refined as necessary as each individual CDM is completed.

C. Prepare Top-Level Findings for LARP

This activity remains to be completed. Since there is a regulatory structure which has been defined by OGC, and since this regulatory structure is being used effectively in completion of CDMs, the Center recommends no further work on this item.

2. Develop CDMs

We have met our goal (prepare 8 to 15 CDMs). Not all CDMs submitted by the Center have received final approval from the NRC; however, no significant policy or technical issues have been identified. A status follows.

CDM 1.4	Certification of Safeguards. Primary authorship was assigned to DFCSS. A draft is complete and is being reviewed by NRC/CNWRA staff. However, this CDM may not be completed by the end of FY94 and may have to be moved to the end of October 1994.
CDM 1.5	Physical Security Plan. Primary authorship was assigned to DFCSS. A draft is complete and is being reviewed by NRC/CNWRA staff. However, this CDM may not be completed by the end of FY94 and may have to be moved to the end of October 1994.

CDM 2.7	Nuclear Material Control. A draft is being reviewed. This CDM may not be completed by the end of TY94 and may have to be moved to the end of October 1994.
CDM 10	Quality Assurance. Done.
CDM 3.1.1	Geologic System Description. Done.
CDM 3.1.2	Hydrologic System Description. Done.
CDM 3.1.3	Geochemical System Description. Done.
CDM 3.1.4	Climatology and Meteorology System Description. Done.
CDM 4.1.1	GROA Surface Facilities Description. Done.
CDM 4.1.2	GROA Shafts and Ramps Description. Done.
CDM 5.1	EBS Description. Expected to be completed by the end of FY94.
CDM 3.2.1.1	Nature and Rates of Physical Processes. NRC has resolved a policy issue related to this CDM, and the CDS is now being prepared. The CDM will be developed later.
CDM 3.2.4.1	Potential Evapotranspiration. May be completed by the end of FY94.
CDM 3.2.1.9	Evidence of Igneous Activity. Done.
CDM 3.2.1.10	Extreme Erosion. Done.
CDM 3.2.2.5	Flooding. May be completed by the end of FY94.
CDM 4.2	Assessment of Compliance with Design Criteria for the GROA Surface Facilities Design. To be completed in FY96.
CDM 4.3	Assessment of Compliance with Design Criteria for Shafts and Ramps. Done.

Ten CDMs have been completed in FY94, meeting the goal established.

Plan for the Development of LARP, Rev 1

This plan is dependent upon the schedules for completion of any new CDMs in FY95, the need to revise any existing CDS/CDMs, and the completion of the action plans for the KTUs.

A basic approach would be as follows:

1. CNWRA submits KTU action plans on 10/18/94.

2. NRC completes review/approval of action plans by 12/30/94.

3. CNWRA incorporates comments, updates CDSs, and submits them for NRC concurrence by 3/30/95.

4. FY95 CDM completion and any CDS update is scheduled to be completed by 7/30/95.

5. RPD is updated and LARP file is provided to the NRC by 8/30/94.

6. NRC completes internal action required to publish LARP, Rev 1 by 11/15/95.

If you concur in this plan, we will have to factor it into the development of the CNWRA Operations Plans for FY95 after incorporation of your comments. Although not all of the CNWRA management have reviewed this plan in detail, there is no disagreement on its basic approach.

RDB 9/2/1994

RDB 9/2/1994 NRC subsequently concurred with this plan, and activities were started to do a first-group of KTU integration, targeting Geochemical Effects on Retardation.

RDB 9/2/1994

GUIDANCE FOR KTU REVISION

1. PREPARATORY ACTIVITIES

- Performed by WSE&I.
- Preliminary grouping of KTUs according to subject, associated 10 CFR 60 requirement, and by likely NRC action.

2. REVISING KTUs AND ASSOCIATED CDSs

- Identify and convene working group based on KTU subject and affected repository system(s).
- WSE&I acts as working group facilitator.
- Evaluate related groups of KTUs for consolidation based on:
  - Similar or same subject.
  - Same or related Regulatory Requirement(s).
  - Similar action to address the uncertainty.
- Revise KTUs
  - Identify the uncertainty associated with NRC's ability to determine compliance.
  - Describe the anticipated NRC action needed to address each KTU for inclusion in the affected CDS(s).
  - For PACs and FACs, distinguish between uncertainties associated with the presence and extent and uncertainties with probabilities of occurrence and consequences.
  - For consolidated KTUs, identify a lead review plan (most central to the KTU subject). KTUs will only be spelled out once, other affected CDSs will refer to the lead review plan.
  - Propose new text for other CDSs associated with a KTU to refer to the lead review plan.
  - Propose new text for the other portions of the CDSs as necessary for agreement with the revised KTU and the revised KTU structure.
  - Submit line-in/line-out recommendations for revisions to CDSs/KTUs to NRC.
- Identify Inputs to and Outputs from Performance Assessment.

RDB 9/26/94

KDS 9/22/94 These groups were identified as the Preparatory activities on the parallel log.

GROUP A - STRUCTURAL GEOLOGY

#1
Key Technical Uncertainty Topic: Poor resolution of critical exploration methods and uncertainty in interpretation and modeling techniques available to detect and investigate structural geologic features in the subsurface.

Poor resolution of available exploration techniques, and uncertainty in interpretation and modeling of acquired data is considered to require a Type 4 review because there is potentially a high risk of non-compliance with the performance objectives, particularly the post-closure requirements. The potentially high risk of non-compliance necessitates analyses above and beyond that required for a Type 3 safety review.

KDS 9/22/94

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a), 60.113(c)

Affected Review Plan(s): 3.2.1.5 Affected Regulatory Requirement: 60.122(c)(11)

Affected Repository System(s): Geologic

#2
Key Technical Uncertainty Topic: Evaluation of faulting mechanisms in alluvium.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a), 60.113(c)

Affected Review Plan(s): 3.2.1.5 Affected Regulatory Requirement: 60.122(c)(11)

Affected Repository System(s): Geologic

#3
Key Technical Uncertainty Topic: Development and use of conceptual Tectonic Models as related to structural deformation.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a), 60.113(c)

Affected Review Plan(s): 3.2.1.5 Affected Regulatory Requirement: 60.122(c)(11)

Affected Repository System(s): Geologic

#15
Key Technical Uncertainty Topic: Many fault plane solutions from the historical seismic record do not agree with the fault movement indicated by striae (slickensides) on exposed fault planes, therefore fault movement, earthquake strong motions and their radiation patterns, which will be used in tectonic models, are uncertain.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)

KDS 9/22/94

Affected Review Plan(s): 3.2.1.8 Affected Regulatory Requirements: 60.122(c)(14)

Affected Repository System(s): Geologic

#16
Key Technical Uncertainty Topic: Low Resolution of Exploration Techniques to Detect and Evaluate Igneous Features.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.1.9 Affected Regulatory Requirements: 60.122(c)(15)

Affected Repository System(s): Geologic

#17
Key Technical Uncertainty Topic: Inability to Sample Igneous Features

Review Type: 5 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.1.9 Affected Regulatory Requirements: 60.122(c)(15)

Affected Repository System(s): Geologic

#18
Key Technical Uncertainty Topic: Development and Use of Conceptual Tectonic Models as Related to Igneous Activity.

Review Type: 5 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.1.9 Affected Regulatory Requirements: 60.122(c)(15)

Affected Repository System(s): Geologic

GROUP B - GROUNDWATER FLOW MODELS

#4
Key Technical Uncertainty Topic: Developing a conceptual groundwater flow model that is representative of the Yucca Mountain site groundwater flow system.

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(2)

Affected Review Plan(s): 3.3, 3.2.2.1, 3.2.2.9 Affected Regulatory Requirement: 60.122(b)(1), 60.113(a)(2), 60.122(c)(5)

Affected Repository System(s): Hydrologic

#5
Key Technical Uncertainty Topic: Developing a mathematical groundwater flow model that is representative of the Yucca Mountain site groundwater flow system.

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(2)

Affected Review Plan(s): 3.3, 3.2.2.1, 3.2.2.9 Affected Regulatory Requirements: 60.122(b)(1), 60.113(a)(2), 60.122(c)(5)

Affected Repository System(s): Hydrologic

#9
Key Technical Uncertainty Topic: Determining the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment.

Review Type: ? Performance Objective(s) at risk: 60.113(a)(2)

Affected Review Plan(s): 3.3 Affected Regulatory Requirement: 60.113(a)(2)

Affected Repository System(s): Hydrologic

#19
Key Technical Uncertainty Topic: The nature of the large hydraulic gradient located north of Yucca Mountain.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.2.1, 3.2.2.9 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5)

Affected Repository System(s): Hydrologic

#20
Key Technical Uncertainty Topic: Uncertainty in modeling groundwater flow through unsaturated fractured rock caused by the lack of codes tested against field and laboratory data.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#21
Key Technical Uncertainty Topic: Uncertainty in identifying which conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at Yucca Mountain.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#22
Key Technical Uncertainty Topic: Uncertainties associated with determining characterization parameters.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#24
Key Technical Uncertainty Topic: Experimental confirmation of the basic physical concepts of groundwater flow through unsaturated fractured rock is needed.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#25
Key Technical Uncertainty Topic: The development of new data collection and interpretation techniques

are required for codes which model groundwater flow through unsaturated fractured rock.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#26
Key Technical Uncertainty Topic: Uncertainty in modeling the formation of perched zones by thermally driven flow.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.2.12 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(23)

Affected Repository System(s): Hydrologic

#27
Key Technical Uncertainty Topic: The cause of the large hydraulic gradient located north of Yucca Mountain, and potential for tectonic disruption of fault-related barriers.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1), 60.113(a)(2)

Affected Review Plan(s): 3.2.2.8 Affected Regulatory Requirements: 60.122(c)(4)

Affected Repository System(s): Hydrologic

#28
Key Technical Uncertainty Topic: Adverse effects of future groundwater withdrawals on the groundwater flow system.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.2.6, 3.2.2.9 Affected Regulatory Requirements: 60.122(c)(2), 60.122(c)(5)

Affected Repository System(s): Hydrologic

#30
Key Technical Uncertainty Topic: Prediction of future changes to the hydrologic system resulting from a combination of climatic and tectonic changes and human activities (including heat effects from waste emplacement).

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.2.9 Affected Regulatory Requirements: 60.122(c)(5)

Affected Repository System(s): Hydrologic

GROUP C - GEOCHEMICAL EFFECTS ON THE EBS

#6
Key Technical Uncertainty Topic: Understanding the Effect of Groundwater Conditions on Mode and Rate of Waste Package Corrosion

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)(ii)(A)

Affected Review Plan(s): 3.2.3.4 Affected Regulatory Requirement: 60.122(c)(7)

Affected Repository System(s): Geochemical, EBS

#7
Key Technical Uncertainty Topic: Understanding/Predicting the effect of Groundwater Conditions on Dissolution of Waste Form

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.4 Affected Regulatory Requirement: 60.122(c)(7)

Affected Repository System(s): Geochemical, EBS

#8
Key Technical Uncertainty Topic: Prediction of the Evolution of Groundwater Conditions near and within the Engineered Barrier System

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)(1)

Affected Review Plan(s): 3.2.3.4 Affected Regulatory Requirement: 60.122(c)(7)

Affected Repository System(s): Geochemical, EBS

#37
Key Technical Uncertainty Topic: Uncertainty in identifying geochemical processes that adversely affect the EBS.

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

Affected Repository System(s): Geochemical, EBS

#39
Key Technical Uncertainty Topic: Uncertainty in determining the magnitude of the effect of the geochemical processes that adversely affect the EBS.

Review Type: 5 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

Affected Repository System(s): Geochemical, EBS

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GROUP D - GEOCHEMICAL EFFECTS ON RETARDATION

#29
Key Technical Uncertainty Topic: Equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.2.9, 3.2.3.3 Affected Regulatory Requirements: 60.122(c)(5), 60.122(b)(4)

Affected Repository System(s): Geochemical, Hydrologic

#31
Key Technical Uncertainty Topic: Uncertainty in identifying geochemical conditions that would inhibit particulate and colloid formation.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

Affected Repository System(s): Geochemical

#32
Key Technical Uncertainty Topic: Uncertainty in characterizing the chemistry of the groundwater in the partially-saturated hydrologic zone of Yucca Mountain, Nevada.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

Affected Repository System(s): Geochemical

#33
Key Technical Uncertainty Topic: Understanding the effects of degree of saturation on geochemical processes such as radionuclide sorption and precipitation and formation of particulates and colloids, and on the transport of radionuclides by particulates, colloids and complexes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

Affected Repository System(s): Geochemical

#34

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Key Technical Uncertainty Topic: Parametric representation of retardation processes involving radionuclide-bearing particulates, colloids, and complexes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

Affected Repository System(s): Geochemical

#35
Key Technical Uncertainty Topic: Determining the alteration of mineral assemblages due to thermal loading.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.3 Affected Regulatory Requirements: 60.122(b)(4)

Affected Repository System(s): Geochemical

#36
Key Technical Uncertainty Topic: Uncertainty in identifying geochemical processes that reduce radionuclide "retardation."

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

Affected Repository System(s): Geochemical

#38
Key Technical Uncertainty Topic: Uncertainty in determining the magnitude of the effect of the geochemical processes that reduce radionuclide "retardation."

Review Type: 5 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

Affected Repository System(s): Geochemical

#40
Key Technical Uncertainty Topic: Volatility and stability of chemical species of radionuclides

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.7 Affected Regulatory Requirements: 60.122(c)(24)

Affected Repository System(s): Geochemical

#41
Key Technical Uncertainty Topic: Gas flow and gaseous radionuclide transport

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.7 Affected Regulatory Requirements: 60.122(c)(24)

Affected Repository System(s): Geochemical

GROUP E - THMC

#43
Key Technical Uncertainty Topic: Prediction of the thermal-mechanical-hydrological-chemical responses of the host rock, surrounding strata, and groundwater system to thermal loads.

Review Type: 4 Performance Objective(s) at risk: 60.111, 60.112, 60.113

Affected Review Plan(s): 4.3, 4.4 Affected Regulatory Requirements: 60.111(b)(1), 60.133(c), 60.133(i), 60.134

Affected Repository System(s): GROA

#46
Key Technical Uncertainty Topic: Prediction of the thermal, mechanical, and hydrological impact on the host rock surrounding the waste package.

Review Type: 4 Performance Objective(s) at risk: 60.111, 60.112, 60.113

Affected Review Plan(s): 4.5.2 Affected Regulatory Requirements: 60.111(b)(1), 60.133(c), 60.133(i), 60.134

Affected Repository System(s): GROA

#47
Key Technical Uncertainty Topic: Prediction of Thermomechanical Effects on the Performance of Waste Packages and the Engineered Barrier System (EBS)

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.3, 5.4 Affected Regulatory Requirements: 60.135, 60.133(i), 60.113(a,b)

Affected Repository System(s): EBS

GROUP F - EBS RELEASE

#48
Key Technical Uncertainty Topic: Prediction of Environmental Effects on the Performance of Waste Packages and the Engineered Barrier System (EBS)

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.3(?), 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

#49
Key Technical Uncertainty Topic: Prediction of Criticality Events in Waste Packages

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

#50
Key Technical Uncertainty Topic: Prediction of Release Path Parameters (such as the Size, Shape, and Distribution of Penetrations of Waste Packages) due to Thermomechanical, Environmental, or Criticality Effects

Review Type: 4 Performance Objective(s) at risk: 6.113(a)(1)

Affected Review Plan(s): 5.2, 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

#51
Key Technical Uncertainty Topic: Prediction of the Releases of Gaseous Radionuclides from Waste Packages during the Containment Period and from the Engineered Barrier System during the Post-Containment Period.

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.3(?), 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

#52
Key Technical Uncertainty Topic: Prediction of the Releases of Non-Gaseous Radionuclides from Waste Packages during the Containment Period and from the Engineered Barrier System during the Post-Containment Period.

Review Type: 4 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.3(?), 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

#53
Key Technical Uncertainty Topic: Extrapolation of Short-Term Laboratory and Prototype Test Results to Predict Long-Term Performance of Waste packages and Engineered Barrier Systems

Review Type: 5 Performance Objective(s) at risk: 60.113(a)(1)

Affected Review Plan(s): 5.2, 5.3(?), 5.4 Affected Regulatory Requirements: 60.135, 60.113(a,b)

Affected Repository System(s): EBS

GROUP G - SEAL PERFORMANCE

#42
Key Technical Uncertainty Topic: Predicting the long term performance of seals for shafts, ramps, and boreholes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)

Affected Review Plan(s): 4.3 Affected Regulatory Requirements: 60.111(a,b), 60.112, 60.134

Affected Repository System(s): GROA

#45
Key Technical Uncertainty Topic: Predicting the long term performance of seals for the underground test boreholes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)

Affected Review Plan(s): 4.4 Affected Regulatory Requirements: 60.111(a,b), 60.112, 60.134

Affected Repository System(s): GROA

GROUP H - PERFORMANCE ASSESSMENT

#54
Key Technical Uncertainty Topic: Conceptual model representations of the natural and engineered systems

Review Type: 4 Performance Objective(s) at risk: 60.112, 40 CFR 191.13

Affected Review Plan(s): 6.1, 6.2 Affected Regulatory Requirements: 60.112

Affected Repository System(s): All

#55
Key Technical Uncertainty Topic: Variability (temporal, spatial, etc.) in model parametric values

Review Type: 4 Performance Objective(s) at risk: 60.112, 40 CFR 191.13

Affected Review Plan(s): 6.1, 6.2 Affected Regulatory Requirements: 60.112

Affected Repository System(s): All

#56
Key Technical Uncertainty Topic: Appropriateness of assumptions and simplification in mathematical models

Review Type: 4 Performance Objective(s) at risk: 60.112, 40 CFR 191.15

Affected Review Plan(s): 6.1. 6.2 Affected Regulatory Requirements: 60.112

Affected Repository System(s): All

#57
Key Technical Uncertainty Topic: Validation of mathematical models

Review Type: 5 Performance Objective(s) at risk: 60.112, 40 CFR 191.13

Affected Review Plan(s): 6.1 Affected Regulatory Requirements: 60.112

Affected Repository System(s): All

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#58
Key Technical Uncertainty Topic: Prediction of future system states (i.e., disruptive scenarios)

Review Type: 5 Performance Objective(s) at risk: 60.112, 40 CFR 191.13

Affected Review Plan(s): 6.1 Affected Regulatory Requirements: 60.112

Affected Repository System(s): All

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GROUP I - EARTHQUAKES AND TECTONICS

#11
Key Technical Uncertainty Topic: The inability to predict the likelihood of earthquake occurrence during the next 10,000 years.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)

Affected Review Plan(s): 3.2.1.7 Affected Regulatory Requirement: 60.122(c)(13)

Affected Repository System(s): Geologic

#12
Key Technical Uncertainty Topic: Correlation of earthquakes with tectonic features.

Review Type: 5 Performance Objective(s) at risk: 60.112, 60.113(a)

Affected Review Plan(s): 3.2.1.7, 3.2.1.8 Affected Regulatory Requirements: 60.122(c)(13), 60.122(c)(14)

#13
Key Technical Uncertainty Topic: The inability to predict the likelihood of earthquake occurrence over the next 10,000 years.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)

Affected Review Plan(s): 3.2.1.8 Affected Regulatory Requirements: 60.122(c)(14)

Affected Repository System(s): Geologic

#14
Key Technical Uncertainty Topic: Paleofaulting data indicates that seismic activity has migrated randomly from one major range front fault system to another in the Basin and Range tectonic province. Therefore there is considerable uncertainty that the relatively low seismicity at Yucca Mountain will continue over a 10,000 year period.

Review Type: 5 Performance Objective(s) at risk: 60.112. 60.113(a)(1), 60.113(b)

Affected Review Plan(s): 3.2.1.8 Affected Regulatory Requirements: 60.122(c)(14)

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INDEPENDENT KTUs

#10
Key Technical Uncertainty Topic: Determining the extent of the disturbed zone.

Review Type: ? Performance Objective(s) at risk: 60.113(a)(2)

Affected Review Plan(s): 3.3 Affected Regulatory Requirement: 60.113(a)(2)

#23
Key Technical Uncertainty Topic: The uncertainty associated with predicting precipitation and temperature (climate) at the Yucca Mountain site for 10,000 years into the future.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.2.1, 3.2.2.9, 3.2.4.2 Affected Regulatory Requirements: 60.122(b)(1), 60.122(c)(5), 60.122(c)(6)

Affected Repository System(s): Hydrologic

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

MEMORANDUM October 21, 1994

KWS 10/21/94

TO: W. Patrick
Directors
Element Managers
R. Johnson, HLUR
M. Lee, HLUR

FROM: Bob Brient BB

SUBJECT: KTU Integration - Geochemical Effects on Retardation

For the first attempt at integrating KTUs, a group of 10 closely related KTUs were identified, associated with geochemical effects on retardation. This group of KTUs currently reside in 4 of the siting criteria CDSs; PACs 3.2.3.5 and 3.2.3.7, and in FACs 3.2.3.2 and 3.2.3.3. The four regulatory requirements of 60.122 are affected, and the overall performance objective is at risk (60.112). Note that several of the KTUs identify the gradual release performance objective (60.113(a)(ii)(B) as at risk, but this is not correct since retardation affects performance after release from the EBS.

To integrate these KTUs, CNWRA staff involved with the development of the CDSs (D. Turner, E. Pearcy, B. Pabalan, B. Murphy, and D. Pickett) were assembled into a working group. B. Brient participated for WSE&I. After familiarization of the working group with the current KTUs and initial integration comments, the working group restructured the KTUs as follows:

KTUs 29, 31, 33, 34, 34, 35, 36, and 38 were sufficiently similar, so were consolidated into a single KTU, which was done primarily through "cutting and pasting" text from the parent KTUs. CDS 3.2.3.5, Geochemical Conditions, was identified as the most appropriate location for this KTU. This new KTU is considered a Type 5 by the working group, because research is necessary by NRC to prepare for LA review.

KTU 32, concerning partially saturated zone geochemistry, was sufficiently different from the other group so that it will remain as an independent KTU, but also associated with CDS 3.2.3.5. It was originally associated with the Favorable Condition: Geochemical Conditions, which is the corollary to the PAC: Geochemical Conditions (3.2.3.5). The consensus of the working group was that this KTU should be upgraded to a Type 5 considering its importance and difficulty in resolving.

KTU 40, concerning volatility and stability of radionuclides, was determined by the original author, B. Murphy, not to constitute a technical uncertainty, so will be deleted.

KTU 41, concerning gas flow and gaseous radionuclide transport, was determined by the working group not to be associated with geochemical conditions, and should be grouped with other hydrological type KTUs as appropriate.

The consolidated KTU and KTU 32 now include additional clarification of the uncertainty facing NRC's ability to determine compliance (in the description of the uncertainty) and the role which NRC should be expected to take in preparation for performing the detailed safety reviews associated with these KTUs. This new information, particularly that in the "Description of Resolution Difficulty," should provide the basis for developing user needs. The rationales for review strategy for these KTUs are provided in Attachments B and C.

Additional efforts to be accomplished are to (i) provide input for user needs, (ii) revise the detailed safety review strategies for CDS 3.2.3.5, (iii) and to delete KTUs (rationales and strategies) from the other CDSs which included the original 10 KTUs, and in these CDSs, identify Review Plan 3.2.3.5 as an input interface, providing results of the detailed safety reviews conducted under that review plan. Review Plan 3.2.3.5 will identify these other affected review plans as output interfaces.

Please review this process and the products, and provide comments as soon as possible. If concurrence is given, additional integration groups for the balance of the KTUs will be convened during this month.

ATTACHMENT A

CURRENT KTUs ASSOCIATED WITH GEOCHEMICAL EFFECTS ON RETARDATION

#29
Key Technical Uncertainty Topic: Equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.2.9, 3.2.3.3 Affected Regulatory Requirements: 60.122(c)(5), 60.122(b)(4)

#31
Key Technical Uncertainty Topic: Uncertainty in identifying geochemical conditions that would inhibit particulate and colloid formation.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

#32
Key Technical Uncertainty Topic: Uncertainty in characterizing the chemistry of the groundwater in the partially-saturated hydrologic zone of Yucca Mountain, Nevada.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

#33
Key Technical Uncertainty Topic: Understanding the effects of degree of saturation on geochemical processes such as radionuclide sorption and precipitation and formation of particulates and colloids, and on the transport of radionuclides by particulates, colloids and complexes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

#34
Key Technical Uncertainty Topic: Parametric representation of retardation processes involving radionuclide-bearing particulates, colloids, and complexes.

Review Type: 4 Performance Objective(s) at risk: 60.112, 60.113(a)(1)(i)(B), 60.113(a)(1)(ii)(B)

Affected Review Plan(s): 3.2.3.2 Affected Regulatory Requirements: 60.122(b)(3)(i-iii)

#35
Key Technical Uncertainty Topic: Determining the alteration of mineral assemblages due to thermal loading.

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.3 Affected Regulatory Requirements: 60.122(b)(4)

#36
Key Technical Uncertainty Topic: Uncertainty in identifying geochemical processes that reduce radionuclide "retardation."

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

#38
Key Technical Uncertainty Topic: Uncertainty in determining the magnitude of the effect of the geochemical processes that reduce radionuclide "retardation."

Review Type: 5 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.5 Affected Regulatory Requirements: 60.122(c)(8)

#40
Key Technical Uncertainty Topic: Volatility and stability of chemical species of radionuclides

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.7 Affected Regulatory Requirements: 60.122(c)(24)

#41
Key Technical Uncertainty Topic: Gas flow and gaseous radionuclide transport

Review Type: 4 Performance Objective(s) at risk: 60.112

Affected Review Plan(s): 3.2.3.7 Affected Regulatory Requirements: 60.122(c)(24)

ATTACHMENT B

Key Technical Uncertainty Topic. Uncertainty in identifying geochemical processes and conditions that affect radionuclide retardation and determining and predicting the magnitude of the effects at Yucca Mountain.

Description of Uncertainty. Migration of radionuclides can occur by advective movement of fluids containing dissolved or suspended radionuclides and by diffusive transport in fluids or along surfaces. The rate of migration (velocity) of radionuclide transport may be significantly smaller than the rate of fluid flow or the rate of diffusion in a pure liquid because of various mechanisms, including sorption on immobile solids, precipitation, filtration of particulates, and matrix diffusion of radionuclides from flowing fluids to areas where flow velocities are smaller. Reduction of the rate of radionuclide migration relative to advective velocities or pure diffusive velocities is referred to as retardation.

Radionuclide retardation depends on many factors, including concentrations of chemical components, activity coefficients, rate constants, temperatures, pressures, microbial effects, and flow rates. For large, heterogeneous natural systems, such as Yucca Mountain, there is a lack of certitude about methods for obtaining information relevant to these factors. An example of the large number of parameters necessary for characterizing processes is the triple layer model for surface complexation (sorption), where seven adjustable parameters are required (Turner, 1991).

Further, radionuclide retardation is a function of numerous conditions and inter-related processes that must be interpreted over large spatial scales (e.g., 10^5 m) and long time periods (e.g., 10^4 yr). These conditions and processes, their couplings, and their temporal variation, are not well understood. For example, performance assessment calculations typically use a single retardation factor (R_f) to represent the attenuation of radionuclide transport. Although using R_f simplifies transport calculations, it is empirical in nature and has no theoretical basis for extrapolation beyond the particular conditions of the initial experiments. It is well-known that sorption of radionuclides on rock and mineral substrates is influenced by the physical and chemical characteristics of the groundwater (e.g., pH, composition, temperature) and of the substrate (e.g., mineralogy, surface area, surface properties). R_f (K_d) tends to be assigned as a "property" of the medium. This does not accurately reflect the role of systematic chemical variations in determining the extent of retardation of radionuclide migration. This factor is frequently based on an experimentally measured sorption coefficient (K_d), which is assumed to represent equilibrium sorption/desorption processes alone. However, other processes may contribute to retardation, including diffusion, dispersion, and precipitation. Therefore, it is not clear how quantitative representation of retardation processes can be undertaken using the R_f approach.

Radionuclide retardation is also related to the availability of particulates and colloids which may serve as platforms for radionuclide transport. A variety of processes could potentially contribute to the formation of particulates and colloids (e.g., precipitation, condensation, weathering, dispersion). Particulates and colloids can be originally composed of radionuclides as, for example, particles from the spallation of waste form or Pu(IV) colloid. Given the various processes that could contribute to the formation of particulates and colloids, it is uncertain what geochemical conditions at Yucca Mountain would affect their formation.

It is uncertain how the partial hydrologic saturation at Yucca Mountain will affect sorption, precipitation, colloid formation, and transport of radionuclides by particulates, colloids, and complexes. All batch sorption experiments and most column sorption studies are conducted under conditions where the sorbing medium is fully saturated with water. It is not known if radionuclide sorption coefficients determined using fully-saturated experiments can be extrapolated to conditions of variable saturation.

In addition, radionuclide transport may occur through the matrix or fractures. Water chemistry and host rock mineralogy, and therefore retardation, may differ between these domains. An additional complexity is introduced in the unsaturated zone, where fracture transport may not occur until relatively high moisture contents are reached. Mineralization in fractures may serve as a sorptive substrate, but it is possible that fracture coatings formed by poorly sorptive minerals such as quartz and calcite will inhibit retardation and limit diffusion from the fracture into the matrix. Such an effect will limit the contribution of diffusive processes to radionuclide retardation.

Heat produced by radioactive decay may also affect radionuclide retardation mechanisms. Although various data and analyses indicate that mineral assemblages are likely to be altered due to thermal loading, the type and extent of alteration and the properties of the minerals in the alteration assemblage are uncertain. There is significant technical uncertainty associated with the determination of whether or not mineral assemblages so altered will have an equal, decreased, or increased capacity to inhibit radionuclide migration. In addition, experimental data on temperature effects on sorption processes are virtually nonexistent.

Performance Objective at Risk: 10CFR Part 60.112

Explanation of Nature of Risk. Modeling radionuclide retardation will require evaluating the effect of numerous processes and interactions between many chemical components under various conditions expected at Yucca Mountain over large spatial and temporal scales. There exist many possible combinations of processes and conditions that could affect radionuclide retardation such that the overall system performance objective is not met.

Failure by DOE to consider all relevant processes and conditions may make it difficult for DOE to demonstrate compliance with the overall system performance objective. Lack of certitude about methods for obtaining necessary data, methods for modelling relevant processes, and uncertainties regarding understanding and interpretation of conditions and processes may limit NRC's ability to effectively determine whether the overall system performance objective will be met.

Description of Resolution Difficulty. Resolution of this KTU is difficult because there is a lack of understanding about conditions and processes relevant to retardation. Radionuclide retardation is a function of numerous geochemical conditions and inter-related processes that must be interpreted over large spatial scales and long time periods. These conditions and processes, their couplings, and their spatial and temporal variations, are not well understood.

Retardation processes involve both radioactive and nonradioactive constituents of the repository and vicinity. The number of chemical components present at Yucca Mountain to be considered in this analysis will include key radionuclides and components introduced in the construction and characterization of the repository, corrosion products from the EBS, and components indigenous to the system. Geochemical modeling which will be used to demonstrate compliance with this regulatory requirement topic involves the simultaneous solution of linear and nonlinear equations representing mass balance and mass action, respectively, of the chemical components. The large number of components, processes, and conditions expected at the site limits quantitative characterization of all possible (and expected) combinations of these parameters.

There are many physical and chemical parameters that affect retardation processes, many of which have synergistic effects. The use of simple empirical representations of sorption and retardation, such as K_d and R_f, are uncertain when extrapolated to conditions other than those of the initial experiment. More robust models, such as surface-complexation models, require more parameters and additional types of experimental data. The latter represents state-of-the-art modeling, but model parameters are available

for only a few radionuclides and a few sorbents. Surface-complexation approaches are also not currently applied to modeling transport of particulates and colloids.

Current geochemical modeling codes do not have the capability to simulate the formation of particulates and colloids. The science of surface interactions and characterizations is still in its infancy. Lacking thermodynamic and kinetic data on these phases, the geochemist is hard pressed to predict their effect on performance of the repository. Existing codes will have to be modified to take into account the effect of surface tension on the stability of small particles. It may be possible to include surface complexation models to describe the surface charge of colloids and particulates. Surface charge helps stabilize the small particles, keeping them dispersed through electrostatic repulsion. Furthermore, different size particles settle at different rates. If coupled flow and transport modeling is attempted, consideration of particle size on diffusivity and rate of gravitational settling at various flow rates would be required.

It is not clear whether partially-saturated experiments will allow differentiation of the effects of retardation processes from the effects of medium heterogeneities and complex fluid flow systematics (Turner, 1991). For reactive solutes (e.g., uranium, plutonium and neptunium), aqueous chemistries are complex due to hydrolysis and complexation reactions and oxidation state changes, which in turn strongly affect sorption, precipitation, and colloid formation. It is not known how synergistic effects of different parameters, as well as complications due to kinetic effects, can be resolved by partially-saturated experiments.

Interpretation of the present and future mineralogy of the repository system is uncertain. Mineralogy of the repository system is difficult to characterize because of wide compositional variations in minerals, common nonstoichiometry and variable crystallinity, spatial heterogeneity of mineral assemblages, and metastability of a variety of polymorphs and phases of differing hydration state. Additional difficulty stems from the transience of the thermal loading resulting from radioactive decay. Rates of alteration reactions are unlikely to be sufficient to achieve or maintain equilibrium, limiting the utility of thermodynamic theory to provide predictions of alterations. Uncertainty associated with the variably saturated conditions creates difficulties in resolving the properties of the altered assemblages because water plays a critical role in mineral alteration. Few experimental studies have focused on mineral alteration in hydrologically unsaturated conditions at elevated temperatures.

Altered mineral assemblages could have an equal, enhanced, or diminished capacity to inhibit radionuclide migration through a variety of complex processes. For example, alteration minerals could have a greater surface area, potential for surface sorption, or ion exchange potential. Alteration mineral assemblages could control water chemistry in a pH range that results in increased (or decreased) sorption. Alteration during periods of either increasing or decreasing temperature could lead to precipitation of minerals in which radionuclides may be coprecipitated. Thermally-induced precipitation of mineral cements such as calcite could alter fluid flow paths, sealing fluid pathways increasing tortuosity, or filtering of radionuclide-bearing colloids or particulates, processes which could lead to an increased capacity of the altered assemblage to inhibit radionuclide migration. Thermal expansion of minerals could increase groundwater travel times (Manteufel et al., 1993; Daily et al., 1987), and therefore affect radionuclide migration.

DOE is addressing these various difficulties through an ongoing program involving laboratory and field experiments (e.g., sorption, thermal loading effects, precipitation, and fracture-matrix interactions), modeling (e.g., sorption, precipitation, aqueous speciation, and thermal loading effects), natural analog studies (e.g., mineral solubilities, aqueous speciation, waste package alteration), and site characterization (e.g., colloidal transport, mineralogy, and fracture and matrix flow).

From the NRC's perspective, uncertainties about conditions and processes relevant to retardation preclude satisfactory evaluation of the approaches being taken by the DOE and adequate interpretation of DOE results. It is necessary, therefore, for the NRC to develop an independent understanding of conditions and processes relevant to retardation so that DOE work may be evaluated. Alternatives to DOE concepts and models must be independently developed by the NRC to assess the conservatism of DOE models and bounding conditions.

NRC staff and CNWRA personnel are independently addressing radionuclide retardation through geochemical modeling (e.g., IPA). This modeling is being used to evaluate needs for specific research. Current research efforts focus on developing models of sorption processes and the geochemical aspects of unsaturated mass transport. Additional efforts include laboratory investigations of sorption, ion exchange, and precipitation/dissolution kinetics, as well as large-scale studies of long-term migration through both fractures and matrix at natural analog sites. Although there is ongoing work with regard to *in-situ* mineral assemblages, additional work will be needed to characterize mineral assemblages that may result from thermal alteration of near-field materials and from the interactions of near-field and natural materials. To develop the required independent understanding of conditions and processes relevant to retardation, continued geochemical modeling is likely to be required for mineral alteration, sorption, colloidal transport, thermal loading effects, aqueous speciation, and fracture-matrix interactions. This modeling will be supported by thermodynamic and kinetic data and extensive analysis of site characterization data, data from natural analog sites, and laboratory analyses under variably saturated conditions.

ATTACHMENT C

Key Technical Uncertainty Topic. Characterizing the Chemistry of the Groundwater in the Partially-Saturated Hydrologic Zone of Yucca Mountain, Nevada. (RRT 3.2.3.2)

Description of Uncertainty. Little information is available on the groundwater chemistry for the hydrologically partially-saturated zone of Yucca Mountain, Nevada. Although some efforts to extract aqueous solutions by triaxial compression ('high pressure') of rock samples taken from the partially-saturated zone of Yucca Mountain are underway (e.g., Yang et al., 1988; Peters et al., 1992), there are large variabilities in the chemical compositions of solutions derived using this technique. Aqueous samples have also been extracted from partially-saturated soils and sands by ultracentrifugation techniques (e.g., Edmunds et al., 1992; Puchelt and Bergfeldt, 1992). It is uncertain whether compositions of water extracted from rock pores by ultracentrifugation or by high-pressure 'squeezing' techniques accurately represent the compositions of in-situ water. The compositions of in-situ water extracted in these manners are likely to be different due to several possible processes (Peters et al., 1992): (1) dilution of pore solutions by water desorbed from hydrated minerals like zeolites and clays; (2) dissolution reactions due to increased mineral solubility and/or higher carbon dioxide concentration at higher pressures; (3) membrane filtration by clays and zeolites; and (4) ion exchange with the zeolites and clays. In addition, colloids which may be present in pore waters are likely to be altered, destabilized, or filtered out of solution during the extraction process. No method is currently known to give unambiguous, accurate data on the chemistry of pore waters in partially-saturated crystalline rock.

Performance Objective at Risk: 10 CFR 60.112

Explanation of Nature of Risk. Geochemical processes such as radionuclide precipitation, sorption, and complexation, as well as formation of colloids, are strongly influenced by groundwater chemistry (e.g., pH, ionic strength, solute composition and concentration). For example, experimental data for various types of sorbents indicate that uranium sorption is strongly dependent on pH (Tripathi, 1984; Payne et al., 1992; Pabalan et al., 1993). The presence of complex-forming species reduces the amount of radionuclide sorbed on mineral surfaces; this represents an unfavorable geochemical condition. The presence of colloids, which may enhance transport of radionuclides, is also a potentially unfavorable condition. Therefore, without knowledge of the groundwater chemistry in the partially-saturated zone, including the presence and characteristics of colloids and particulates, it is not possible to determine whether geochemical conditions present at the proposed repository are favorable or unfavorable to inhibition of radionuclide migration.

Description of Resolution Difficulty. No technique is known that provides unambiguous, accurate measurements of the chemistry of pore waters in partially-saturated media. The methods of extracting pore waters by high-pressure compression and by ultracentrifugation most likely impose some change in solution composition and are susceptible to contamination problems. *In situ* methods, such as low-vacuum electron microscopy and X-ray analysis, do not yet have the resolution to quantitatively measure solute concentrations in relatively dilute groundwater and remain to be tested for analyzing pore water chemistry in unsaturated media. Moreover, solution pH, which is a key parameter that controls radionuclide precipitation, sorption and complexation, cannot be determined by *in situ* methods, and the pH of extracted pore water is likely different from that of *in situ* pore water. The chemistry of the groundwaters in the partially-saturated zone of Yucca Mountain are therefore extremely uncertain. One way of testing techniques of extracting and analyzing pore water chemistry from partially saturated rock is to apply these techniques to rocks containing minerals and groundwater whose equilibrium interactions can be modelled using existing codes. For example, a rock containing the zeolite used in the ion exchange experiments by Pabalan (1991) could be partially saturated with a water of known composition, allowed to equilibrate,

and then treated in the extraction and analytical methods proposed by DOE. The results of the analysis could then be compared with the calculated composition. This possible method of resolution would require a collaborative effort between CNWRA personnel and investigators from the USGS.

2/27/95 Individual KTU integration groups worked on their KTUs, combining, deleting, and adding new KTUs based on the guidance. The deliverable date was revised to 4/24/95 and later to 5/31/95. The format of the report was reviewed with NRC. A schedule for final preparation of the report was made as follows:

Week ending 3/3/95 - Formal reports on each KTU.
Week ending 3/10/95 - Complete technical reviews.
Assemble individual reports into one - 3/13-3/15.
~~week ending 3/17/95~~ 3/16-3/22 - Programmatic reviews.
Final report 3/27/95.

9/8/95 CORRELATION OF KTIs, KTUs, and TECHNICAL SUPPORT Needs

On 8/25/95, special tasking was received from S. Wastler to establish a new milestone for this task under WSEI Subtask 2.1.

Robert Johnson of NRC provided the technical direction:

1) TAKE the lists of associated KTUs from the draft Vertical Slice Implementation Plans (later revised to KTI Implementation Plans). This correlates KTIs to KTUs. Then, take the corresponding Technical Support Need from the KTU Integration Report to form the final correlation. One difficulty was the correction of "old" KTUs to "integrated" KTUs to get the Technical Support Needs.

CNWRA Technical Staff reviewed the correlation to edit & weed out those that obviously didn't fit.

Another step was assigning responsibility to each KTI, KTU, & T.S. Need. This proved another hurdle.

The technical review as to all CNWRA. They checked the edit (the technical staff) & altered assignments

Because we started with the draft implementation plans, the correlation were rough & bulky. We wanted to avoid making any judgements on the draft plans, but let this correlation speak for itself. Obviously, the correlation will be revised to reflect changes in the implementation plans. RJS

2/2/96 Revised Operations Plans for FY96 do not include funding for WSEI activities. No further entries are expected since no activities are planned. RJS