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MEMO/FY86/87/JP/86/02/14

MEMORANDUM FOR: Myron H. Fliegel, Section Leader
Hydrology Section, WMGT

FROM: Jeffrey A. Pohle, Project Officer
Hydrology Section, WMGT

SUBJECT: PROGRAM PLAN FOR HLW HYDROGEOLOGY EFFORTS IN FY86 AND FY87 DIRECTED TOWARD PREPARING FOR SITE CHARACTERIZATION PLAN REVIEWS

The amount of information being evaluated by section staff responsible for HLW hydrogeology has become so great, and detail so fine, that focusing disparate work efforts toward a common goal has become an increasingly difficult task. While our mission in the broad terms of licensing responsibility is clear, it has become necessary to establish a clear approach, or philosophy, as to just what our near term objectives are and how those objectives are to be accomplished. Therefore, the purpose of this memorandum is to delineate such a planned approach in order to integrate ongoing work efforts and ensure compatibility between near and long term objectives as we prepare to review DOE's site characterization plans. Objectives, products and potential problems are discussed herein.

Objectives

Over the long term our objectives include reviewing major DOE milestone reports, re-evaluating site issues, identifying technical concerns and, ultimately, tracking progress toward resolution of outstanding site issues. I believe that "issue tracking" is the most important long-term objective. However, before progress toward some targets can be assessed those targets need to be established. While in the long term the targets are the performance objectives of the regulations and related performance and site issues, near term targets are a potential myriad of detailed technical concerns. The problem confronting the technical staff in the near term is identifying these details in order to lay the foundation against which DOE's program can be evaluated and progress assessed.

Other than reviewing the Final Environmental Assessments, the next major milestone for the NRC is to review DOE's Site Characterization Plans. In order to lay the foundation for thorough and efficient review of the SCP's, there are four near term objectives, and potentially a fifth, which hydrology section staff may choose to accomplish prior to receipt of the SCP's. These objectives include:

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1. Indentify key conditions, assumptions or interpretations inherent in existing or alternative conceptual models.

   Accomplishing this objective will not be a trivial task even though time and resources require simplistic approaches be used. This is not an exercise in identifying "key parameters" which can be accomplished through inspection of the fundamental equations of flow and which has often been requested of us. The "key" terms here are "conditions, assumptions or interpretations".

2. Identify the type of data (information) necessary to verify key conditions, assumptions or interpretations in order to validate use of a conceptual model(s).

   "Data" has often been assumed to mean specific measurements or values for given parameters. In this case "data" may well include observations of steady-state or transient phenomena, without quantitative value, as verification of an assumed condition.

3. Identify gaps in needed data/information base.

   The objective here is not to evaluate each piece of information as to whether or not it is supportive of some key assumption but rather, having accomplished the first two objectives, reviewing the existing data base against data needs in order to identify gaps.

4. Develop GT Branch perspectives on technical considerations needing evaluation during site characterization.

   These perspectives provide a guideline against which to review both the objectives and planned accomplishments of DOE's testing strategies
   related to characterizing the present groundwater system. Completion of the first three objectives will provide the technical rationale supporting development of these Branch perspectives.

5. Develop staff positions on acceptable testing strategies.

   There is no consensus on the need for such positions at this time. However, past review plans developed within the Division usually require the staff not only to raise technical concerns but also to provide guidance and suggestions as to what is needed to resolve such concerns (SRP for EA Review 12/12/84). As we are informed about the details of DOE's testing programs, technical concerns may arise. It

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may be prudent to do some early work in this area in order to be in a position to develop STP's in a timely manner subsequent to SCP review. No commitment toward fulfilling this potential objective is being made at this time.

Products

Ongoing efforts by technical staff and contractors toward preparing for review of site characterization plans for each DOE HLW disposal site include: 1. Technical document reviews; 2. Inventory of existing data; 3. Evaluation of conceptual models and 4. Numerical or analytical analysis of various hydrogeologic conditions, assumptions or interpretations inherent in existing or alternative conceptual models. Although these work efforts can be itemized in linear fashion, in reality work is progressing concurrently.

As ideas and technical concerns are generated and proposals made to me for individual analyses I have begun to feel a need to provide a more integrated focus for these efforts. This is to avoid having the overall objectives lost in piecemeal fashion. To achieve this end a series of products which will integrate the results of ongoing work and accomplish identified objectives have been identified. These are:

1. Technical Evaluation Memoranda (TEM's) - These memoranda are undergoing their initial stage of development. The approach used here is a "top down" approach, starting with the regulations (performance objectives and favorable/potentially adverse conditions). Existing Issue-Oriented Site Technical Positions (Drafts) provide an analysis of the regulations which lead to development of site issues. The TEM's will follow-up on the site issues by working downward to summarize existing issues and aid in identifying new unresolved issues, technical concerns and gaps in DOE's program. Ultimately, I anticipate these memoranda will play the most important role in assessing progress of the overall program. In effect, these memoranda will provide the link between long and near term objectives of the staff. Clearly, the technical foundations (supporting rationales) for positions relative to the site issues are not completely developed yet. The number of "bottom line" conclusions which can be reached is limited. It is unlikely that these memoranda will mature fully, in a context important to technical staff, until late FY 87 or FY 88. These memoranda are not intended to be "one time shots" but are to be revised (updated) routinely, possibly annually.

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Table 1

NRC Hydrology Section Efforts in Preparing for DOE HLW SCP Reviews

Product	Section Lead	Contractor Lead	Peer Review	Tentative Schedule
1. Technical Evaluation Memoranda (Updated annually)				
A. NNWSI	Codell	N/A	TBD	4/86
B. BWIP	Weber	N/A	TBD	4/86
C. SALT (Palo Duro)	Ross	N/A	TBD	6/86
2. Data Needs Assessment				
A. NNWSI	Pohle	NWC/WWL	Codell/W&A	Draft 8/86
B. BWIP	Weber	NWC/TT	Coleman/W&A	Draft 8/86
C. SALT (Palo Duro)	Ross	NWC/DBS	Elzeftawy/W&A	Draft 11/86
Geotech Branch ~~Positions~~ Perspectives 3. GTBP - Site Characterization Objectives				
A. NNWSI	Pohle	W&A	Codell/NWC	Draft 11/86
B. BWIP	Weber	W&A	Coleman/NWC	Draft 11/86
C. SALT (Palo Duro)	Ross	W&A	Elzeftawy/NWC	Draft 3/87
4. STP - Testing Strategy (No commitments at this time)				
A. NNWSI	Pohle	W&A	Codell/NWC	TBD
B. BWIP (Revision)	Weber	W&A	Coleman/NWC	TBD
C. SALT (Palo Duro)	Ross	W&A	Elzeftawy/NWC	TBD

2. Data Needs Assessments - These reports will present the results of ongoing efforts related to review of existing data, conceptual model evaluations and supporting numerical/analytical analyses. Technical conclusions reached in these reports will be directed towards objectives 1, 2, and 3 discussed previously. These are intended to be objective, technical reports and will be prepared using site issues as guidance.

3. GT Branch Perspectives On Site Characterization Objectives - These perspectives will build upon the previous reports. Their focus will be on developing the technical considerations needing evaluation during site characterization, in effect, what DOE needs to accomplish. The primary focus will be on characterization of the present groundwater system (Site Issue 1.1 for all sites). These reports fulfill objective 4.

4. STP's On Testing Strategies - If the schedule allows and it is decided to pursue preparation of these positions, the focus will be on identifying acceptable testing strategies to accomplish site characterization objectives which, in effect, is guidance to DOE on how to accomplish. It may not be necessary to develop these positions unless serious concerns develop with DOE's planned testing strategies. These reports would fulfill objective 5.

Table 1 outlines the various reports, technical leads, review responsibility and tentative schedule.

Potential Problems

The complexity of the technical work together with time and resource constraints can impact schedules significantly. Some potential problem areas are identified and discussed.

1. Our approach to developing the data needs assessments will be as simple as can be justified. At this stage it is more important to be thorough and comprehensive than overly sophisticated. However, because all efforts and conclusions drawn must be related to overall performance of the repository in terms of the regulations, some transport analyses may be required. We may need to involve the geochemistry section and/or Sandia into the production or review process. This will impact schedules.

2. Table 1 indicates a more formalized internal review process. While we are fortunate to have considerable expertise available, I

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anticipate review of the Data Needs Assessments will require a number of iterations before acceptable drafts are available.

3. Review of final EA's will effectively halt progress in other areas until FEA reviews are complete.

4. Ongoing "routine" document reviews will interrupt production on a regular basis. Efforts at establishing bibliographic data bases have identified a considerable number of reports, for all sites, which could be reviewed formally. While the new review procedure does not apply "retroactively", priorities will have to be adjusted often by section staff when scheduling review of documents already on file. If we were to do a written review of every DOE report with any relevance to hydrology I estimate it would require 1 to 1.5 FTE's per site. Although familiarity with the document base is a necessity to produce major reports, individual written reviews will remain an independent production item.

5. Resources required for future efforts in preparing Technical Evaluation Memoranda need identification to be factored into schedules.

Fulfilling the objectives outlined prior to SCP reviews will require maximum utilization of resources. The tentative schedule still requires input from our contractors.

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Hydrology Section, WMGT

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R. Codell, WMGT
N. Coleman, WMGT
F. Ross, WMGT
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#4

MODEL A1a - RESATURATION BY VERTICAL POROUS MEDIA FLOW THROUGH UNFLAWED GEOLOGY

1.0 PURPOSE

This document presents analyses which, within the limits of the stated assumptions aid in assessment of the following questions regarding vertical porous media flow through unflawed geology:

- o What are the key parameters that control this process?
- o What level of knowledge of those parameters is necessary to adequately define the process?
- o Does this process appear to be a significant factor in determining whether performance of the repository will meet the requirements of 10CFR60?

2.0 OPERATIONAL APPROACH

In this analysis, it is assumed that vertical flow through the salt unit is the only mechanism for resaturation. The approach taken is to calculate the cumulative volumetric inflow to the repository as a function of time and to contrast this with the available repository volume.

The assumed physical flow system is illustrated in Figure A1a-1. Groundwater flow is towards the repository from aquifers above and below. The history of flow is as follows:

1. The repository is excavated. Initial flow is relatively high as the excess pressure in the nearby repository layer is dissipated.
2. For a significant period of time (on the order of 100 years) the repository is kept open and dry while emplacement occurs.
3. The repository is closed and resaturation begins.

The flow process is illustrated in Figure A1a-2. Two cases are shown on the figure. Case A is for an aquitard with high storage capacity where essentially all the water needed for resaturation comes from storage in the aquitard, and Case B where essentially all the resaturation water comes from the adjacent aquifers. All other parameters, including the hydraulic conductivity of the aquitard material are the same for both cases.

3.0 TECHNICAL APPROACH

Consider the repository to be centered within an aquitard which is overlain and underlain by aquifers in which a constant and equal head is maintained. Construction of the repository is assumed to occur instantaneously and so, causes an instantaneous drawdown at the repository. This pressure reduction results in flow of water into the repository, at a rate that will

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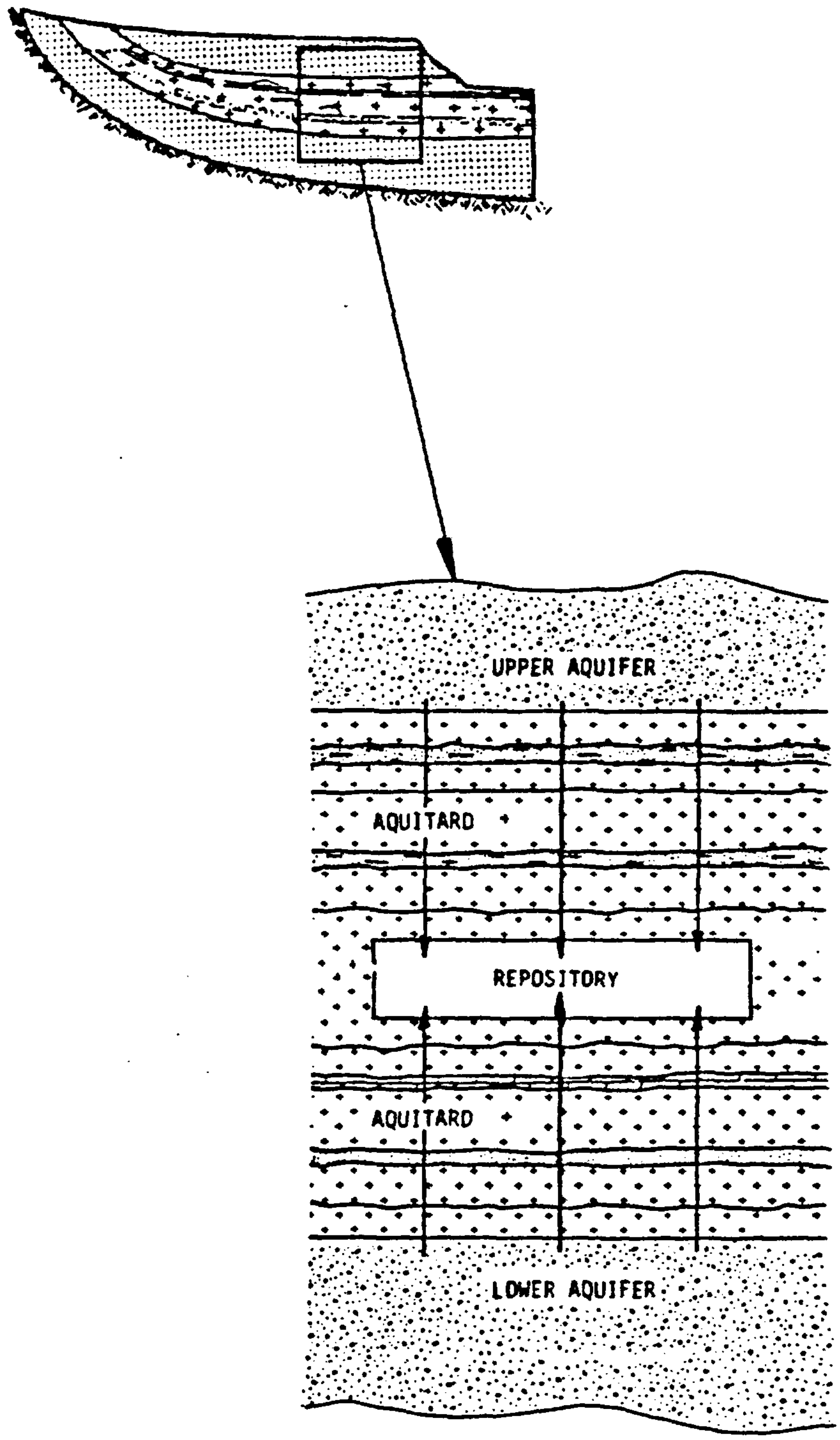
RESATURATION BY VERTICAL POROUS MEDIA FLOW

Figure A1a-1



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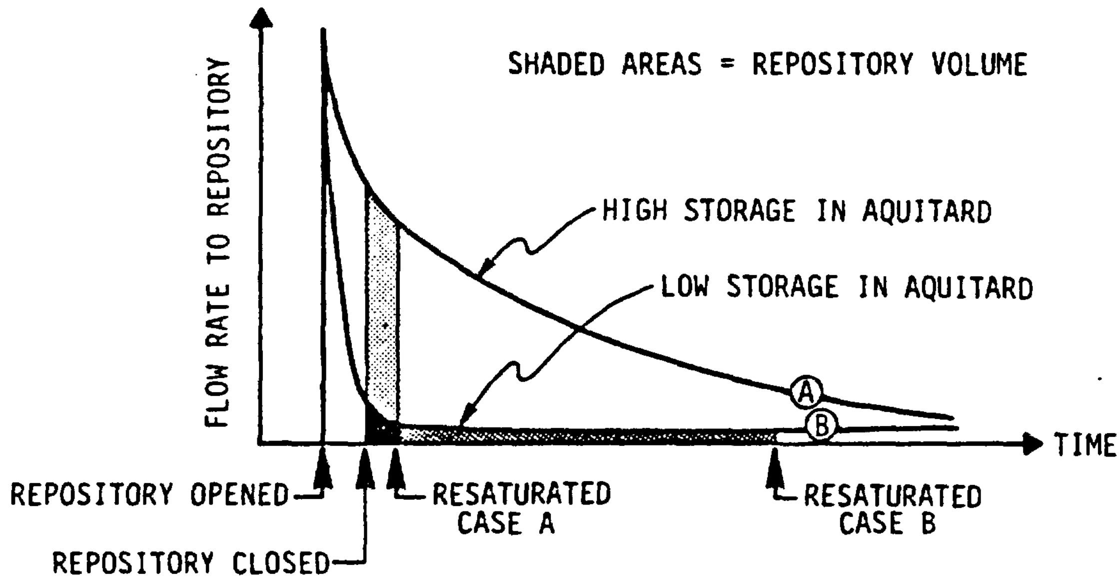
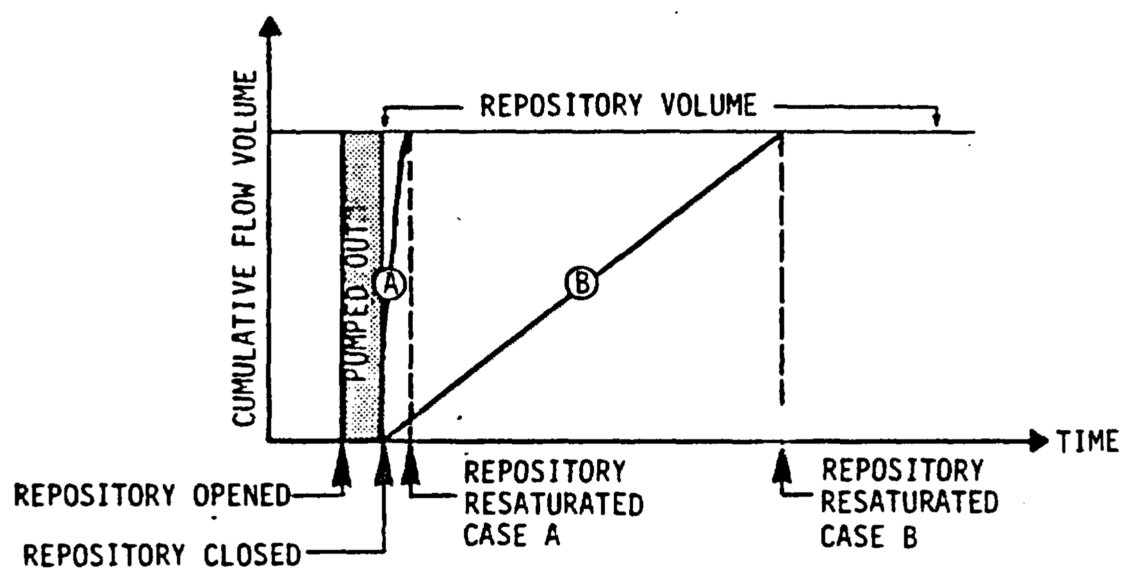
FLOW PROCESS

Figure A1a-2



a. Inflow History



b. Flow Volume Development

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progressively decrease until steady state conditions prevail.

3.1 Steady State Flow

The analysis of steady state flow to the repository and the resulting computation of saturation time is presented in Section 7. The resulting equation is:

$$t = \frac{n'L'E'L}{2\,K\,s} \qquad (3.1)$$

where:

- t = time after repository closure [T]
- n' = porosity of repository backfill [ ]
- L' = height of repository rooms [L]
- E' = extraction ratio of repository (mined area/perimeter area) [ ]
- L = thickness of aquitard above and below repository [L]
- K = vertical conductivity of aquitard [L/T]
- s = drawdown at repository due to opening [L]

Assumptions made in this analysis include:

- o One dimensional vertical flow.
- o No water released from the aquitard (i.e., steady state)
- o Constant head in the aquifers.
- o Repository void volume is constant.
- o All properties independent of time.

The first assumption is the subject of other analyses in this series. The second assumption, relating to water released from the aquitard can be checked and the required computations are treated later in this document. The change of volume due to salt creep and consolidation of the repository backfill is considered later in the analysis. The other assumptions are considered to be generally valid.

3.2 Transient Analysis

The analysis of transient flow to the repository, and the resulting computation of resaturation time is also presented in Section 7. Resaturation time can be computed using the techniques outlined in the Appendix or can be approximated using the following equation:

$$T = \frac{n'L'E'L}{2\,K\,s} \qquad (\underline{t} > 1) \qquad (3.2)$$

$$T = \left[t'^{\frac{1}{2}} + \frac{n'L'E'}{4\,s} \left(\frac{P}{K\,S}\right)^{\frac{1}{2}} \right]^2 - t' \qquad (\underline{t} < 1) \qquad (3.3)$$

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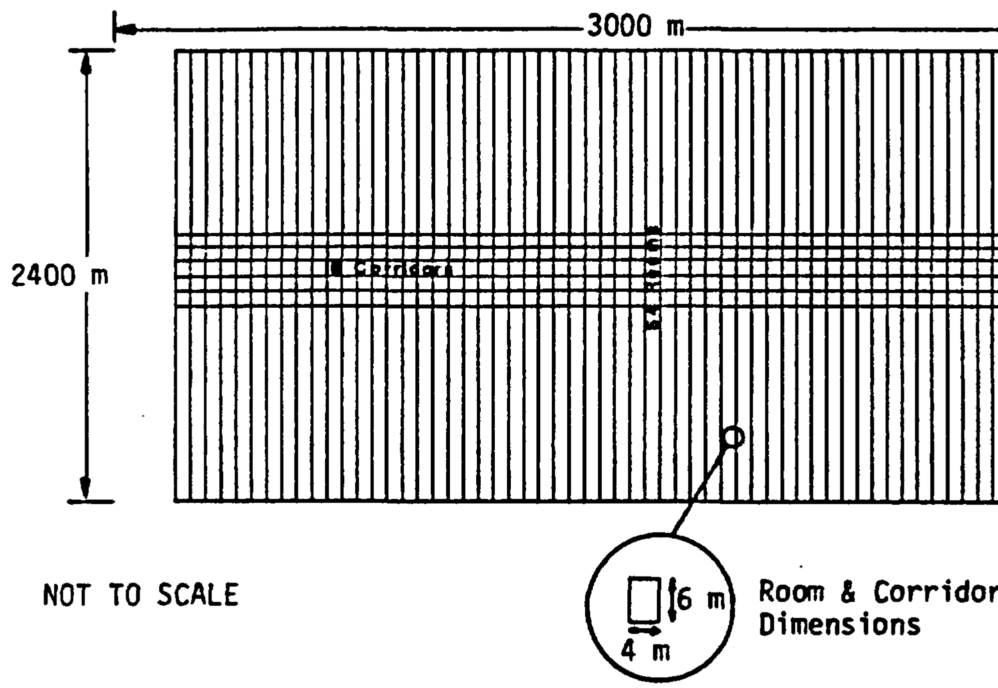
ASSUMED STANDARD BEDDED SALT REPOSITORY

Figure A1a-3

PLAN VIEW

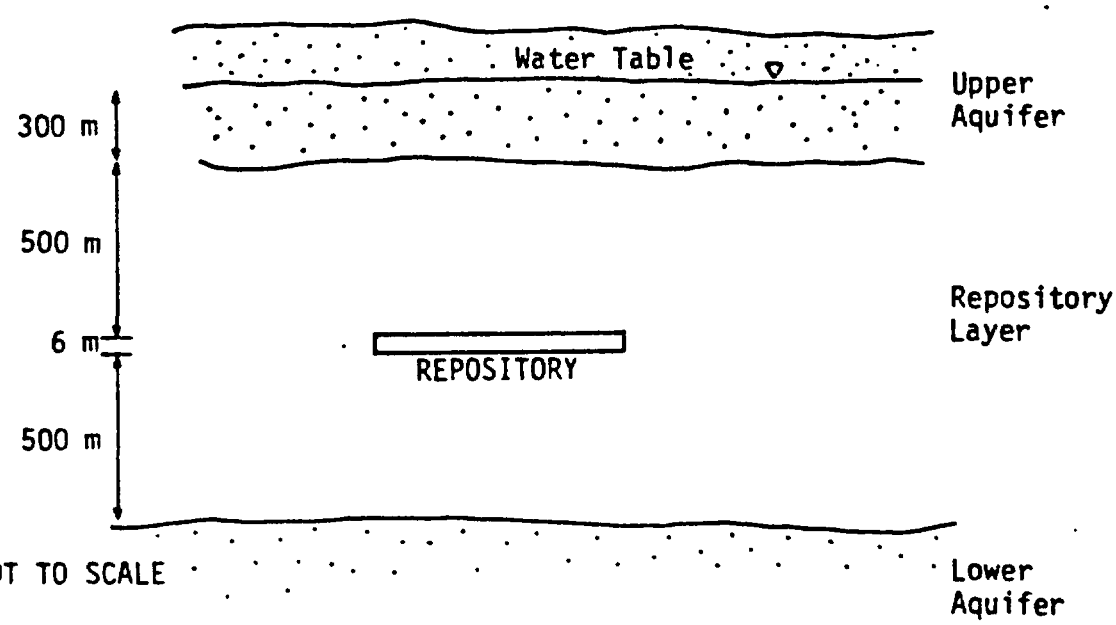


NOT TO SCALE

SECTION VIEW

Excavated Volume = 4.26 X 10^6 m

Excavation Ratio = 0.1



NOT TO SCALE

NOTE: Initial head assumed hydrostatic

where:

T = resaturation time (time since closure) [T]
t' = time that the repository is open and inflow is pumped out [T]
P = pi, approximately 3.142 [ ]
S = specific storage of the aquitard [1/L]
$\underline{t}$ = dimensionless time = $\frac{K}{S}\frac{(t' + T)}{L^2}$ [ ]

The assumptions associated with this analysis include the assumptions listed in section 3.1 with the exception that we now consider water released from the aquitard.

3.3 Consolidating Backfill

Finally, we must consider the assumption that the repository void volume is a constant. If a granular backfill is used, void volume will remain fairly constant after placement. However, it is likely crushed salt or a crushed salt/clay mix will be used as a backfill material and it will undergo considerable consolidation after placement.

The result of such consolidation is to reduce the void volume in the repository thus reducing the time required for resaturation relative to the time required to saturate a non-consolidating backfill.

4.0 ANALYSIS AND RESULTS

4.1 Key Parameters

Inspection of Equations 3.1 through 3.3 indicates that the following are key parameters in the determination of repository resaturation time by vertical porous media flow through unflawed geology.

1. n' - backfill porosity
2. L' - repository room height
3. E' - repository extraction ratio
4. L - aquitard thickness
5. s - drawdown at repository
6. K - vertical hydraulic conductivity of aquitard
7. S - specific storage of aquitard
8. t' - time that repository remains open

Of these, the first three determine repository void volume, the next four control flow to the repository, while the last controls when the inflow begins to contribute to resaturation.

4.2 Probable Parameter Values and Ranges

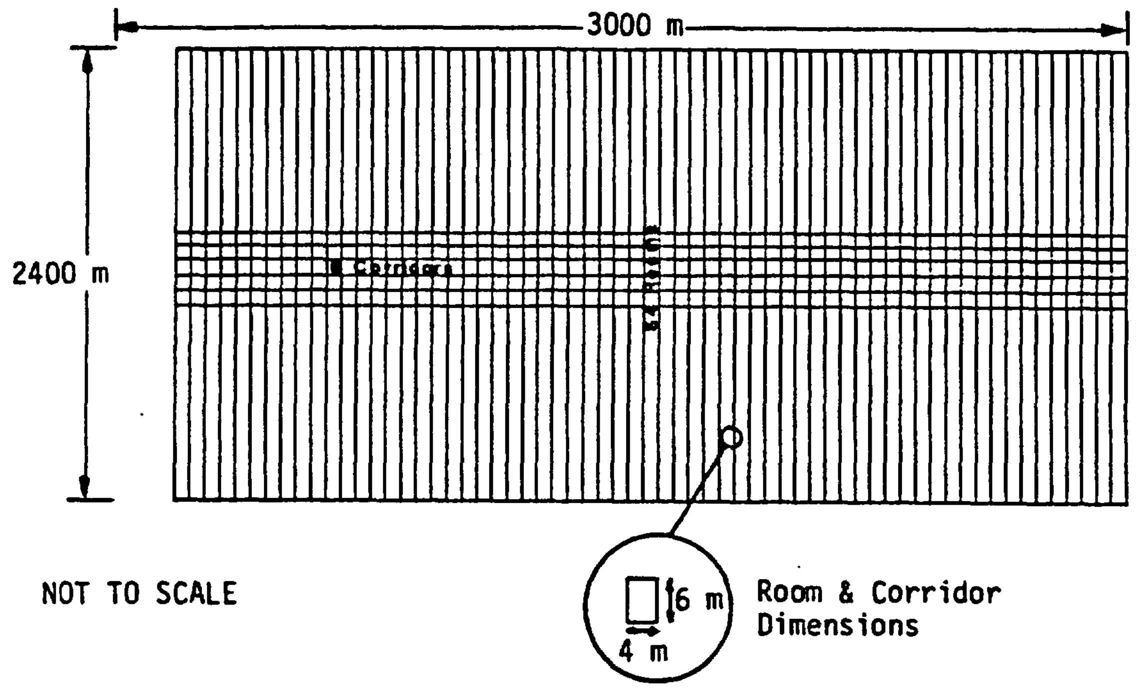
The situation analysed is indicated in Figure Ala-3. The geometric parameters, which are relatively invariant, are:

PRELIMINARY

ASSUMED STANDARD BEDDED SALT REPOSITORY

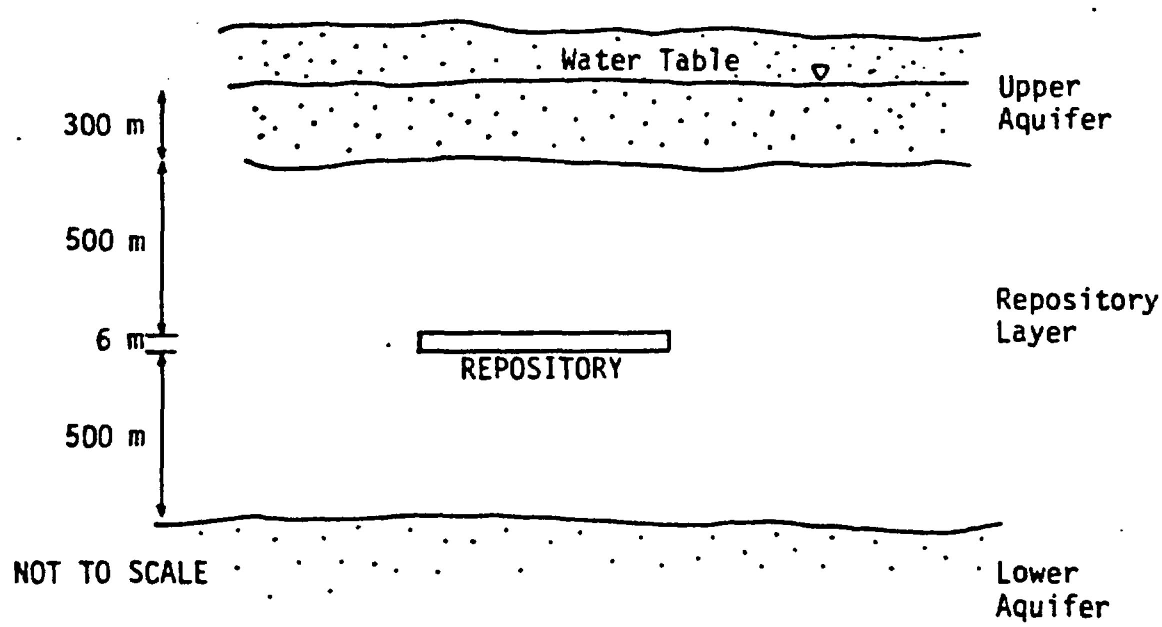
Figure A1a-3

PLAN VIEW



SECTION VIEW

Excavated Volume = 4.26 X 10^6 m
Excavation Ratio = 0.1



NOTE: Initial head assumed hydrostatic

$L' = 6$ meters
$E' = 0.1$
$L = 500$ meters
$s = 800$ meters

The vertical hydraulic conductivity of the aquitard is not well known. It may range from perhaps 1.0E-8 meters per second to as low as 1.0E-18 meters per second in pure salt (Tien et al, 1983).

The specific storage of the repository layer is also unknown. The probable maximum value it may take is the connected salt volume divided by the absolute pressure (in meters of water) on the salt. For 1% brine content salt at atmospheric pressure this maximum value is:

$$S\ (max) = 0.01/800 = 1.3E\text{-}5 \text{ per meter.}$$

The minimum value which the specific storage may reasonably take is found by assuming the salt matrix is entirely rigid. For 1% brine content this is equivalent to (Freeze & Cherry, 1979):

$$S\ (min) = n p g B \qquad (4.1)$$

where:

n = porosity [ ]
p = density of water [M/L^3]
g = acceleration due to gravity [L/T^2]
B = compressibility of water [LT^2/M]

For 1% porosity:

$$S\ (min) = 4.3E\text{-}8 \text{ per meter}$$

Backfill porosity depends on the backfill type. For granular materials, the porosity is assumed to be 0.4 for a non-consolidating salt backfill. A ariation of porosity and hydraulic conductivity with time for crushed bedded salt backfill in a HLW repository is presented in Table a consolidating A1a-1.

TABLE A1a-1

Typical Properties of Crushed Bedded Salt Backfill in an HLW Repository as a Function of Time

Time From Placement (Years)	Porosity	Hydraulic Conductivity (m/sec)
0	0.40	1E-1
200	0.20	1E-3
250	0.14	3E-4
300	0.10	5E-5
340	0.05	5E-7
360	0.03	1E-8
380	0.006	1E-12

Data from Kelsall, et al 1982. (Values calculated for southeastern New Mexico bedded salts, other bedded salts exhibit similar values of "creep constant" and "stress component" which control the rate of consolidation.)

4.3 Resaturation Times

The resaturation times resulting from vertical porous media flow through unflawed geology are presented in Figure A1a-4 and A1a-5, for the non-consolidating and consolidating backfill cases respectively.

Inspection of the results indicates that the time required for repository resaturation as a result of porous media flow through unflawed geology is controlled primarily by vertical hydraulic conductivity of the repository layer and porosity of the repository backfill. Significant but less important parameters are the specific storage of the repository layer and the depth of the repository.

5.0 COMMENTS

Reviewers are requested to provide their opinions on the questions presented in Section 1.0 along with comments on the nature and content of this document. All opinions will be considered and incorporated into this comment section when the final version is submitted.

Golder Associates considers that for resaturation time to be significant with respect to repository performance, resaturation must require on the order of 1000 years or more. Figure A1a-6 shows the key parameter combination - needed for resaturation times of 1000 years for both consolidating and non-consolidating backfills. For the standard bedded salt scenarios, it is clear from Figure A1a-6 that for resaturation time to be significant to repository performance, the average vertical hydraulic conductivities of the aquitard must be lower than 1.0E-12 meters per second for a non-consolidating backfill and 1.0E-14 meters per second for a consolidating backfill.

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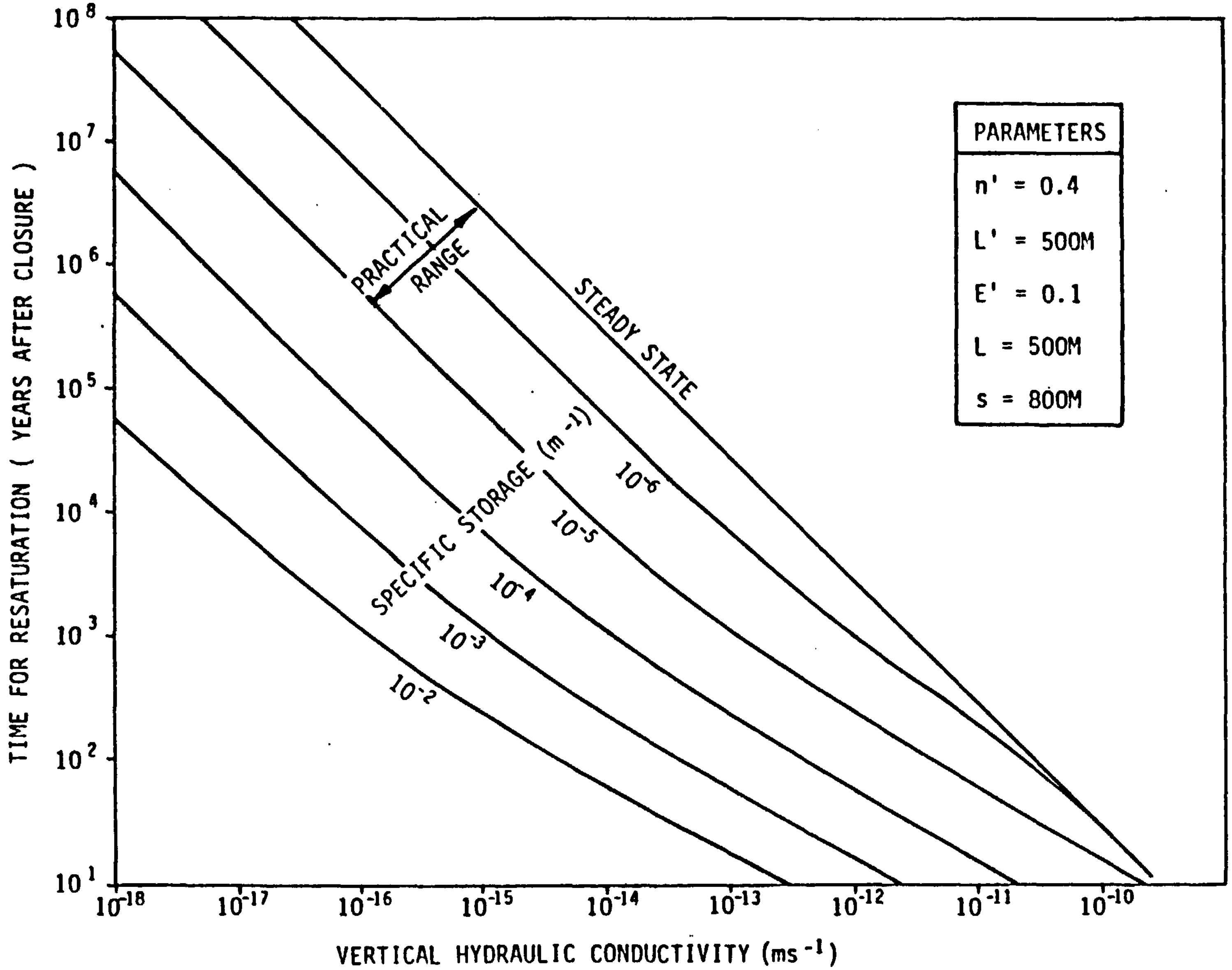

RESATURATION TIME - NON-CONSOLIDATING BACKFILL Figure A 1a-4

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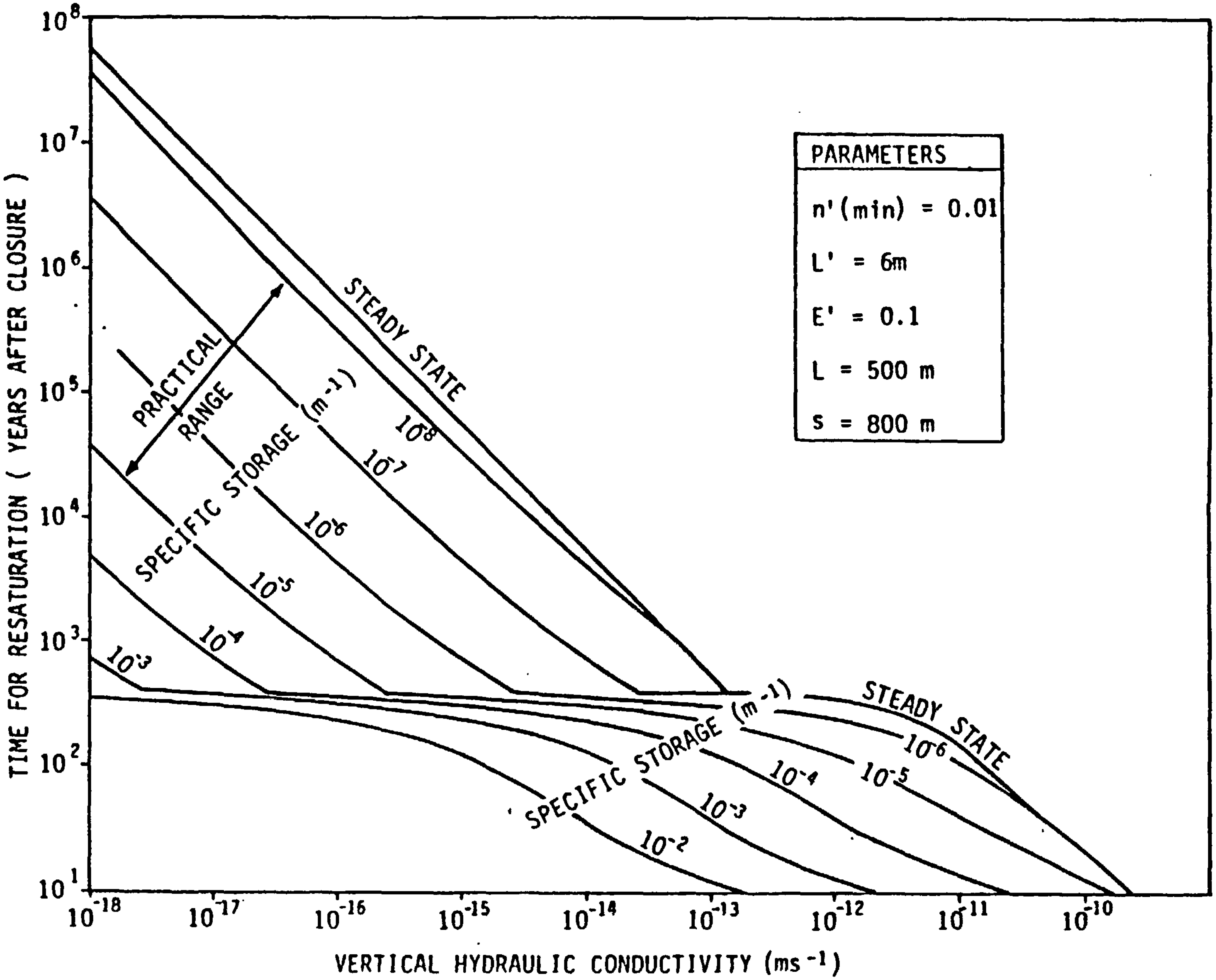

RESATURATION TIME - CONSOLIDATING BACKFILL

Figure A1a-5

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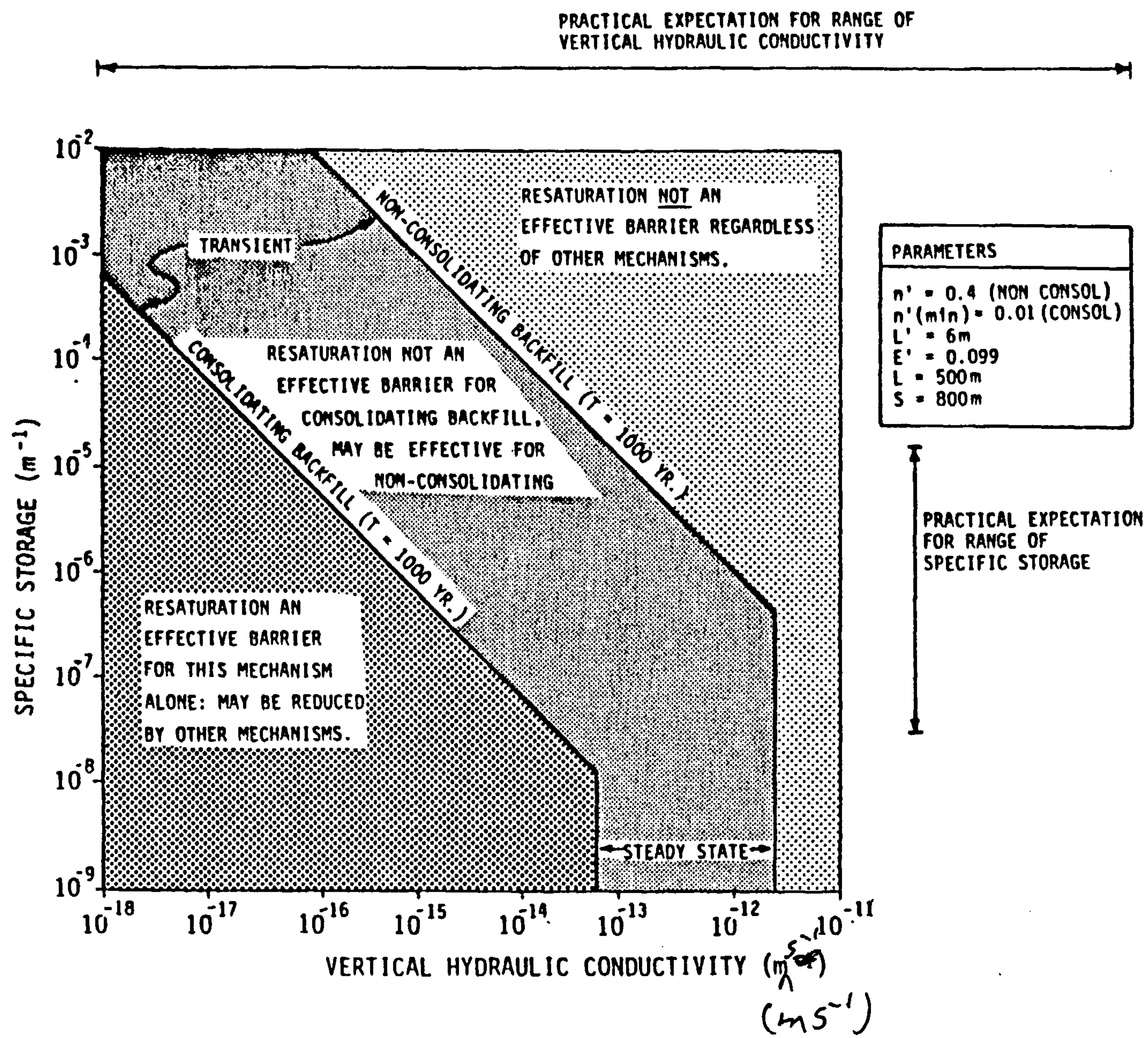


PARAMETER COMBINATIONS REQUIRED FOR POST-CLOSURE RESATURATION TIME OF 1000 YEARS BY VERTICAL POROUS MEDIA FLOW Figure A1a-6

PRELIMINARY

Tien, et al, 1983 give a possible range for vertical hydraulic conductivity of pure salt as 1.0E-18 to 1.0E-8 meters per second. For specific storage, a practical expected range is 4.0E-8 to 1.0E-5 as discussed earlier in this document.

The time required for resaturation of the repository is more sensitive to vertical hydraulic conductivity of the aquitard than to specific storage of the aquitard. The values of vertical hydraulic conductivity required for vertical porous media flow to provide a significant barrier to resaturation are within the expected range of conductivity values for a salt aquitard. The expected range spans at least ten orders of magnitude. Assessment of the vertical hydraulic conductivity of the salt aquitard should be undertaken at each potential repository site to reduce the expected range of values and to determine if vertical conductivity values are low enough to warrant further, more detailed evaluation.

6.0 REFERENCES

Bredehoft, J.D., and Pinder, G.F., 1970, Digital Analysis of Areal Flow in Multiaquifer Groundwater Systems: A Quasi Three-Dimensional Model, Water Resources Research, Vol. 6, No. 3. Available at Public Technical Libraries.

Carslaw, H.S. and Jaeger, J.C., 1959, Conduction of Heat in Solids. Oxford University Press, Oxford, England. Available at Public Technical Libraries.

Kelsall, P.C., et al, 1982, "Schematic Designs for Penetrating Seals for a Reference Repository in Bedded Salt", D'Appolonia Consulting Engineers Inc., ONWI-405. Available from Office of Nuclear Waste Isolation.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater, Prentice Hall. Available at Public Technical Libraries.

Tien et al, 1983, Repository Site Data and Information in Bedded Salt Palo Duro Basin, Texas, NUREG/CR-3129. Availble from NTIS.

7.0 APPENDIX TO MODEL A1a - RESATURATION BY VERTICAL POROUS MEDIA FLOW THROUGH UNFLAWED GEOLOGY

The mathematical analysis presented in this section is applicable to Figure A1a-3 of Section 4.2 and is illustrated in figure A1a-A of this section. The governing equation for transient flow is:

$$\frac{\partial^2 s}{\partial z^2} = \frac{K}{S}\frac{\partial s}{\partial t} \qquad (7.1)$$

With the initial condition of

$$s(z,0) = 0 \text{ for } 0 < z < L$$

And boundary conditions as

$$s(0,t) = 0$$
$$\text{for } t > 0$$
$$s(L,t) = s'$$

The drawdown a a function of vertical distance from the repository, and time was adapted from Carslaw and Jaeger, 1959, p. 310, and is given as:

$$s(z,t) = s' \, [\, \underline{s} \, (\underline{t}, \, z/L)] \qquad (7.2)$$

where:

- $s(z,t)$ = hydraulic drawdown at z at time t [L]
- s' = hydraulic drawdown at the repository, z = L [L]
- $\underline{s}$ = dimensionless drawdown [ ]
- $\underline{t}$ = dimensionless time [ ]
- z = vertical position measured from constant head aquifer towards repository [L]
- L = distance between repository and constant head aquifer [L]

and, $\underline{t}$ is defined as:

$$\underline{t} = \frac{K\,t}{S\,L2} \qquad (7.3)$$

where:

- K = vertical hydraulic conductivity of the aquitard [L/T]
- t = time since initial instantaneous drawdown (i.e., time since repository is opened) [T]
- S = specific storage [1/L]

Type curves (developed by Bredenhoft and Pinder, 1970) for $\underline{s}$ as a function of $\underline{t}$ and z/L are presented in figure A1a-B.

Flow rate into the repository at time t is given as:

$$Q = \frac{2KsA}{L} \quad [\underline{Q}(\underline{t})] \qquad (7.4)$$

where:

Q = inflow rate to repository at time t $[L^3/T]$
$\underline{Q}$ = dimensionless flow rate [ ]
A = plan area of the repository defined by its perimeter $[L^2]$

A type curve (Bredehoft and Pinder, 1970) for $\underline{Q}$ as a function of $\underline{t}$ is given in figure Ala-C.

Integrating equation 7.4 with respect to time, we obtain the cumulative volume of inflow over time which can be expressed as:

$$V = 2ASLs \ [\underline{V}(\underline{t})] \qquad (7.5)$$

where:

V = cumulative inflow volume at time t $[L3]$
$\underline{V}$ = dimensionless volume [ ]

A type curve is given for $\underline{V}$ as a function of $\underline{t}$ in Figure Ala-D. Scrutiny of Figure Ala-D indicates that, to a good degree of approximation, the relationship between $\underline{V}$ and $\underline{t}$ is:

$$\underline{V} = \underline{t} + 1/3\ \underline{t} \qquad \underline{t} > 1$$
$$\underline{V} = 2\sqrt{\underline{t}/P} \qquad \underline{t} < 1 \qquad (7.6)$$

where:

P = pi, approximately 3.142

The repository is resaturated when:

$$V = n'L'E'A \qquad (7.7)$$

where:

n' = backfill porosity
L' = room corridor height
E' = extraction ratio

Then, combining equations 7.5, 7.6 and 7.7 and rearranging, gives approximate expressions for the resaturation time since repository closure, T:

$$T = t - t' \cong \frac{n'L'E'L}{2\ K\ s} \qquad \text{for } (\underline{t} > 1)$$

$$T = t - t' \cong \left[(t')^{\frac{1}{2}} + \frac{n'L'E'}{4\ s} \left(\frac{P}{K\ S} \right)^{\frac{1}{2}} \right]^2 - t' \qquad \text{for } (\underline{t} < 1) \qquad (7.8)$$

where:

T = time since repository closure
t = time since repository opened
t' = time that repository is opened and inflow is pumped out

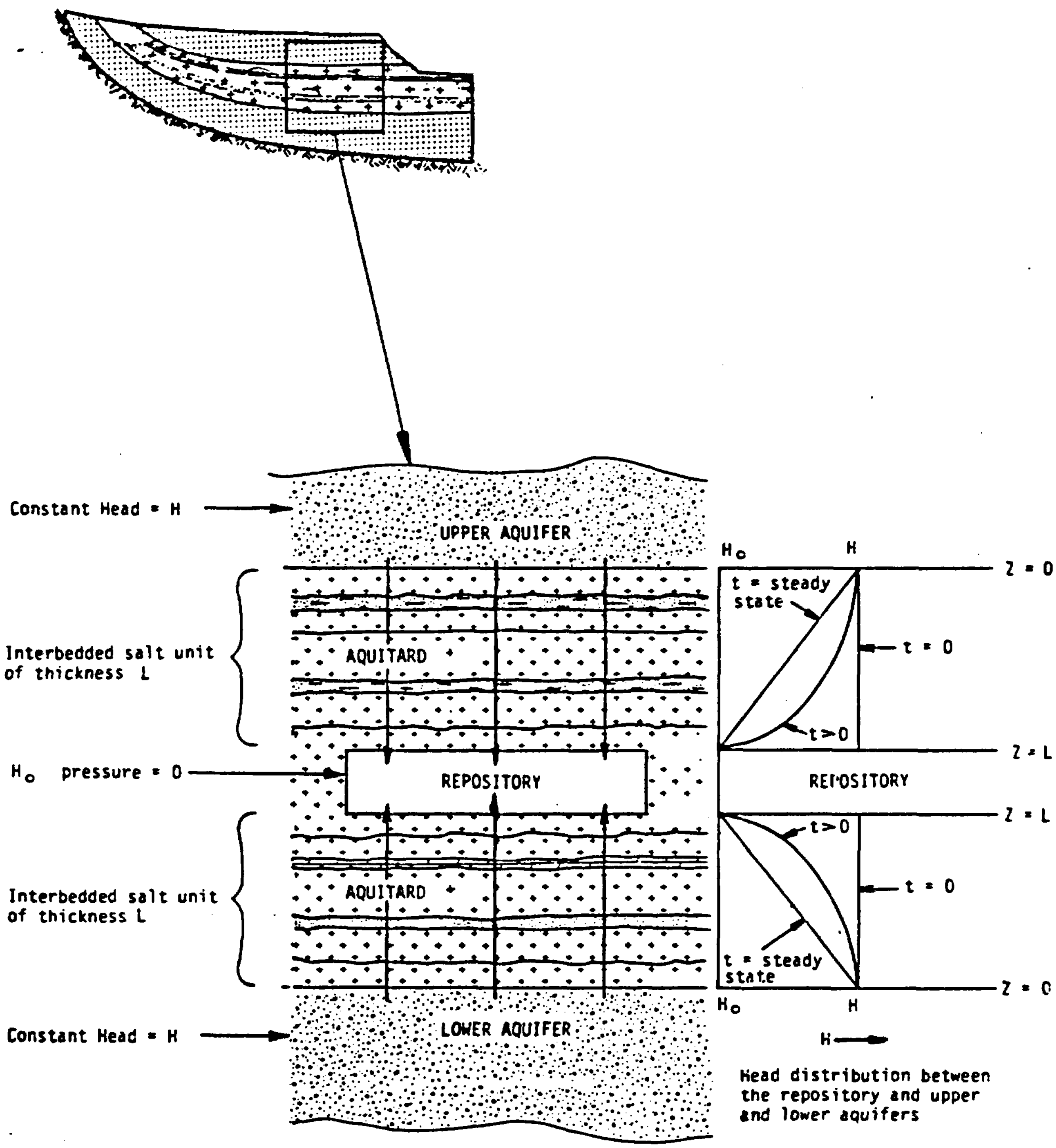
The first expression is for steady state conditions (independent of S) while the second is for transient conditions.

833-1099B
D/305E

PRELIMINARY

RESATURATION BY VERTICAL POROUS MEDIA FLOW

Figure A 1a-A

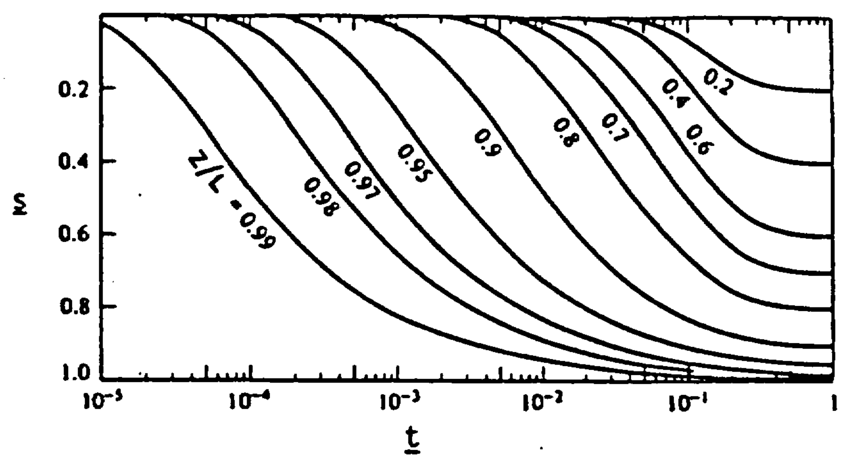


Rev. Dwg. No. 843-1006 Date 6-84 Eng. S.C.

TYPE CURVE FOR s̲ VS. t̲ AND Z/L

Figure A 1a-B

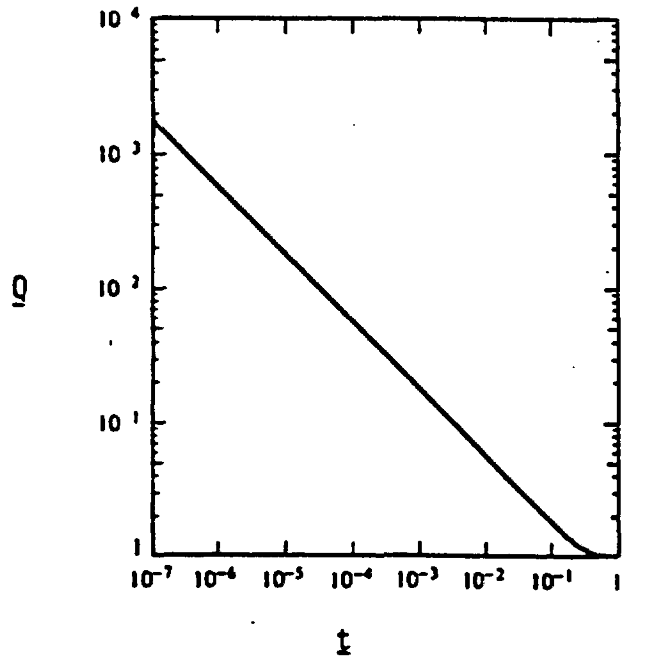
TYPE CURVE OF DIMENSIONLESS DRAWDOWN (s̲) VERSUS DIMENSIONLESS TIME (t̲) AND DIMENSIONLESS DISTANCE FROM THE REPOSITORY (Z/L).



After Bredehoft and Pinder, 1970

PRELIMINARY

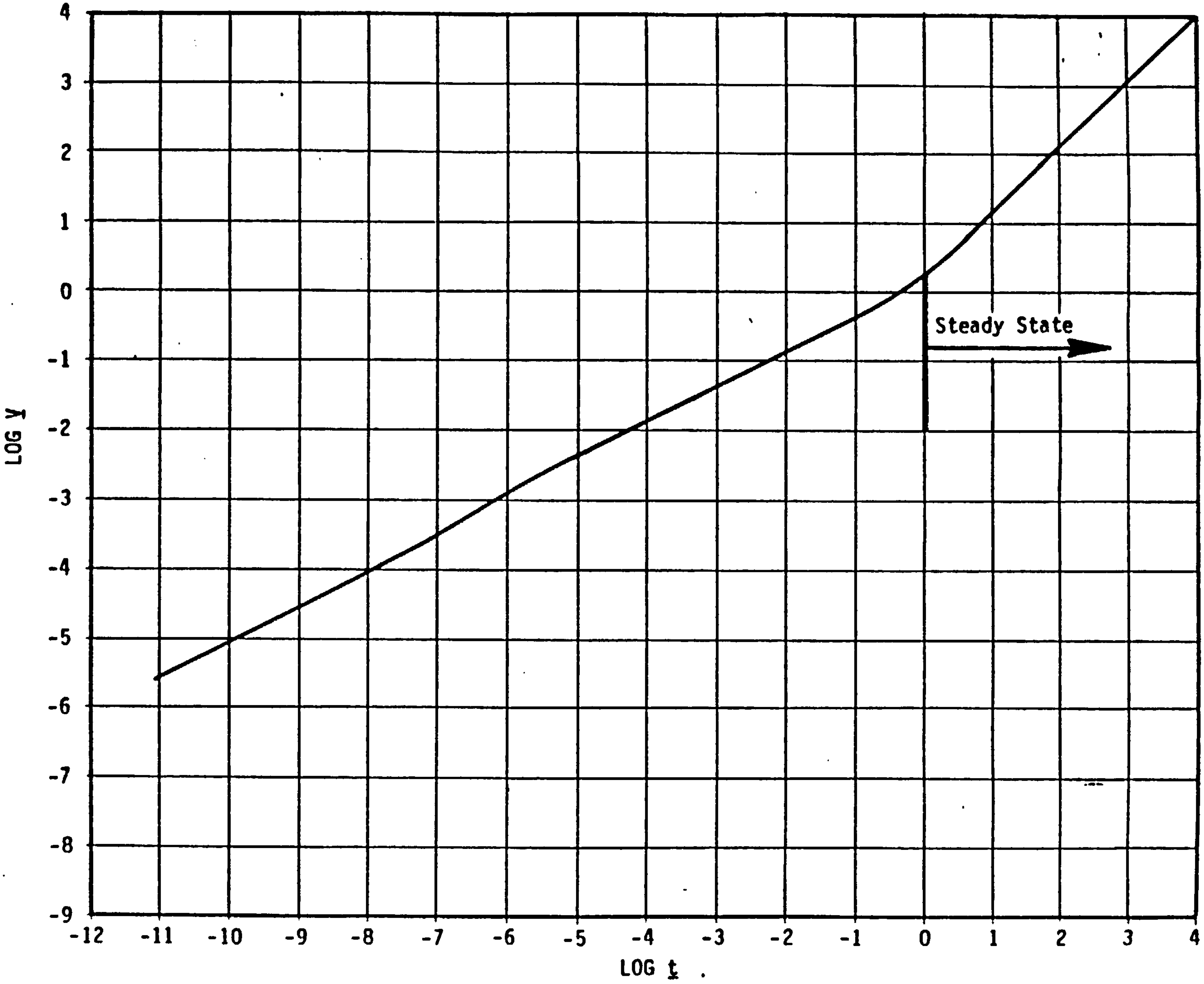
TYPE CURVE OF DIMENSIONLESS DISCHARGE (Q) VERSUS DIMENSIONLESS TIME (t) FOR CONSTANT DRAWDOWN IN THE REPOSITORY



(After Bredehoft and Pinder, 1970)

Rev. Dwg. No. A833-1099C Date 5/89 Eng. G.P.

Rev. ____
Dwg. No. A018-1099C Date 5/84 Eng. C.P



Golder Associates

DIMENSIONLESS VOLUME VS. DIMENSIONLESS TIME FOR CONSTANT DRAWDOWN IN THE REPOSITORY

PRELIMINARY

Figure A1a-D

NWC 4/15

MAJOR UNRESOLVED HYDROLOGIC ISSUES
OF THE
BASALT WASTE ISOLATION PROJECT

1. Siting Criteria

1.1 Would the nature and rates of hydrogeologic processes operating in the Quaternary Period, when projected, not affect or favorably affect the ability of a geologic repository to isolate HLW? (§60.122(b)(1) - Lead)

1.2 Is the repository setting characterized by the following three characteristics: (1) host rock has a low horizontal and vertical permeability, (2) downward or dominantly horizontal hydraulic gradients in the host rock and adjacent hydrogeologic units, and (3) low vertical permeability and hydraulic gradient between the host rock and surrounding hydrogeologic units? (§60.122(b)(2) - Lead)

1.3 Does the pre-waste emplacement groundwater travel time substantially exceeds 1,000 years along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment? (§60.122(b)(7) - Lead)

1.4 Would potential flooding of the underground facility be caused by modification of floodplains or failure of existing or planned surface impoundments? (§60.122(c)(1) - Lead)

1.5 Would foreseeable human activities adversely affect the groundwater flow system? (§60.122(c)(2) - Lead)

1.6 Are natural phenomena that would create large-scale surface impoundments resulting in changes to the regional groundwater flow system likely to occur? (§60.122(c)(3) - Input)

1.7 Would structural deformation adversely affect the regional groundwater flow system? (§60.122(c)(4) - Lead)

1.8 Are changes in hydrologic conditions that would affect migration of radionuclides to the accessible environment likely to occur? (§60.122(c)(5) - Lead)

1.9 Would foreseeable changes in climate change hydrologic conditions? (§60.122(c)(6) - Lead)

1.10 Is groundwater or surface present, whether identified or undiscovered, in such form that either economic extraction is currently feasible or potentially feasible during the foreseeable future, or the water resource has a greater gross value or net value than the average for other areas of similar size representative of the geologic setting? (§60.122(c)(17) - Input)

1.11 Is there any evidence of drilling on the site? (§60.122(c)(19) - Input)

1.12 Would groundwater conditions require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes? (§60.122(c)(20) - Input)

2. Performance Objectives

2.1 Is the pre-waste emplacement groundwater travel time greater than 1,000 years, or other time limit approved by the Commission, along the fastest likely path of radionuclide travel from the disturbed zone to the accessible environment? (§60.113(a)(2) - Lead)

2.2 Do cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal have a greater than 90% probability of being less than the Table 1 limits and a greater than 99.9% probability of being less than 10 times these limits? (§60.112(a) - Input)

2.3 Will annual dose equivalents for 1,000 years after closure to any member of the public consuming water from a significant source of groundwater in the accessible environment exceed 25 millirems to the whole body or 75 millirems to any critical organ? (§60.112(b) - Lead)

2.4 Will releases from the emplaced waste during the first 1,000 years cause radionulcide concentrations averaged over any one year withdrawn from special sources of groundwater to exceed 5 picocuries per liter of combined Ra-226 and Ra-228, 15 picocuries per liter of alpha-emitting radionuclides (excluding radon), or combined concentrations of beta- or gamma-emitting radionuclides that would produce annual dose equivalents to the total body or any internal organ greater than 4 millirems per year? (§60.112(c) - Lead)

2.5 If background concentrations exceed the concentrations limits listed in 2.4, will releases from the emplaced waste cause radionuclide concentrations to exceed the sum of background concentrations and the limits? (§60.112(c) - Lead)

3. Operational Requirements

3.1 Are structures, systems, and components important to safety designed so that anticipated natural phenomena and environmental conditions will not interfere with necessary safety functions? (§60.131(b)(1) - Input)

3.2 Are structures, systems, and components designed to withstand dynamic effects that could result in loss of their safety function? (§60.131(b)(2) - Input)

3.3 Are structure, systems, and components designed to maintain control of radioactive waste and effluents, and permit prompt termination of operations and evacuation of personnel during an emergency? (§60.131(b)(4) - Input)

3.4 Are surface facilities designed to control release of radioactive materials in effluents during normal operations to comply with 10 CFR Part 20 and 40 CFR Part 190 (including releases from other components of the nuclear fuel cycle? (§60.132(c)(1) - Input)

3.5 Are effluent monitoring systems designed to measure the amount and concentration of radionuclides with sufficient precision to determine whether releases conform to the design requirements for effluent control? (§60.132(c)(2) - Input)

3.6 Are radioactive waste treatment facilities designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable for safe disposal or transportation? (§60.132(d) - Input)

3.7 Is the underground facility designed so that effects of credible disruptive events during the period of operations will not spread through the facility? (§60.133(a)(2) - Input)

3.8 Does the design of the underground facility provide for control of water or gas intrusion? (§60.133(d) - Input)

3.9 Are shaft and borehole seals designed so that they do not become pathways that compromise repository performance after closure? (§60.134(a) - Input)

3.10 Have seal materials and placement methods been selected to reduce, to the extent practicable, preferential pathways for groundwater contact of waste packages and for radionuclide migration through existing pathways? (§60.134(b) - Lead)

4. Performance Confirmation

4.1 Does the performance confirmation program provide data that indicate, where practicable, whether actual subsurface hydrologic conditions are within the limits assumed in the licensing review? (§60.140(a)(1) - Lead)

4.2 Does the performance confirmation program provide data that indicate, where practicable, whether the hydrologic system is functioning as anticipated in the licensing review? (§60.140(a)(2) - Lead)

4.3 Does the performance confirmation program adversely affect the ability of the natural system of the geologic repository to meet the performance objectives? (§60.140(d)(1) - Input)

4.4 Does the performance confirmation program provide baseline information and analyses of hydrologic parameters and processes that may be changed by site characterization, construction, and operational activities? (§60.140(d)(2) - Lead)

4.5 Does the performance confirmation program monitor and analyze changes from baseline condition of hydrologic parameters that could affect repository performance? (§60.140(d)(3) - Lead)

WM Record File 101.2

WM Project 10

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Office of Civilian Radioactive Waste Management Program

Presentation
of the

Basalt Waste Isolation Project

to the

**Joint Interim Committee on Hazardous Materials
Oregon State Legislature**

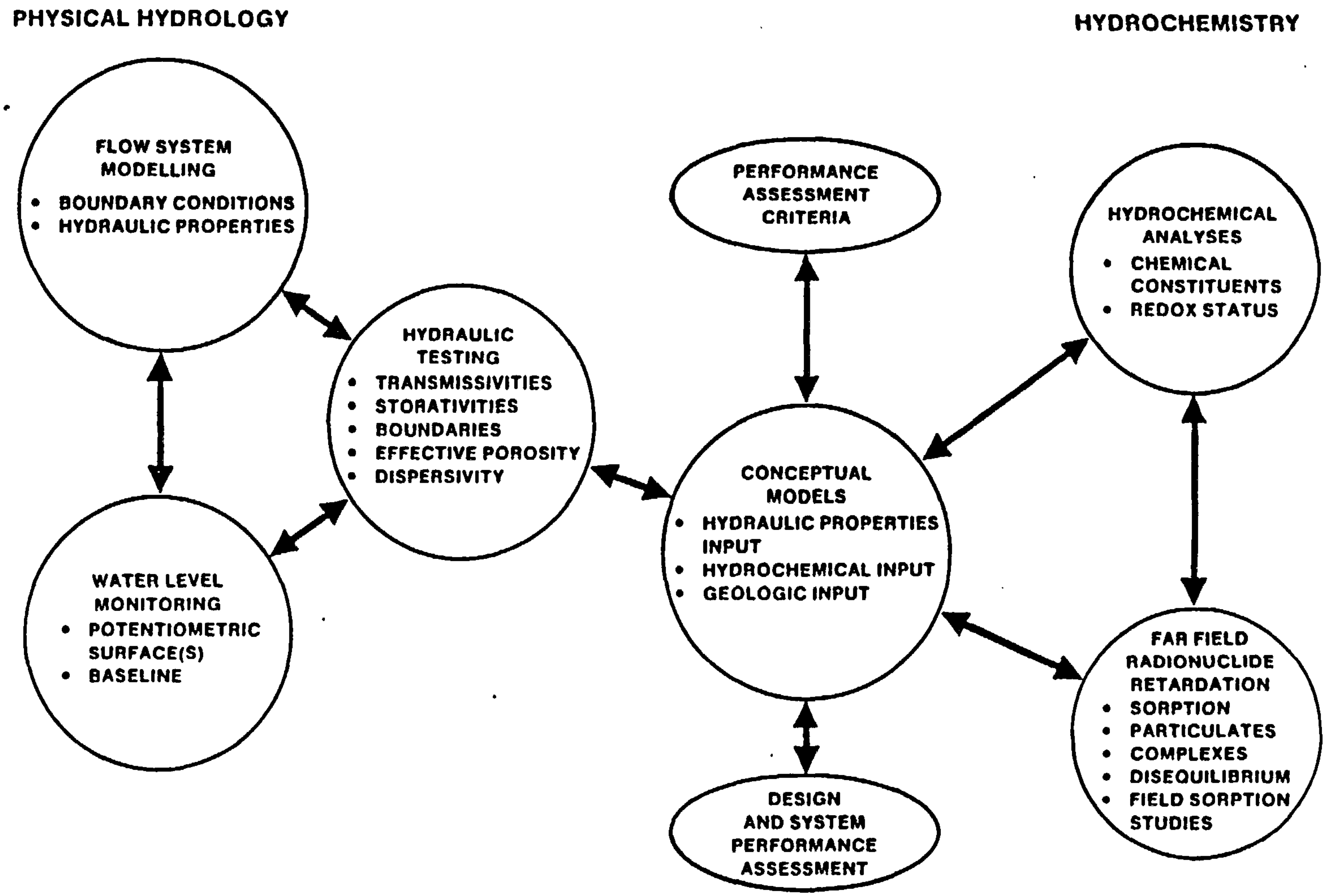
at

Salem, Oregon
March 14, 1986

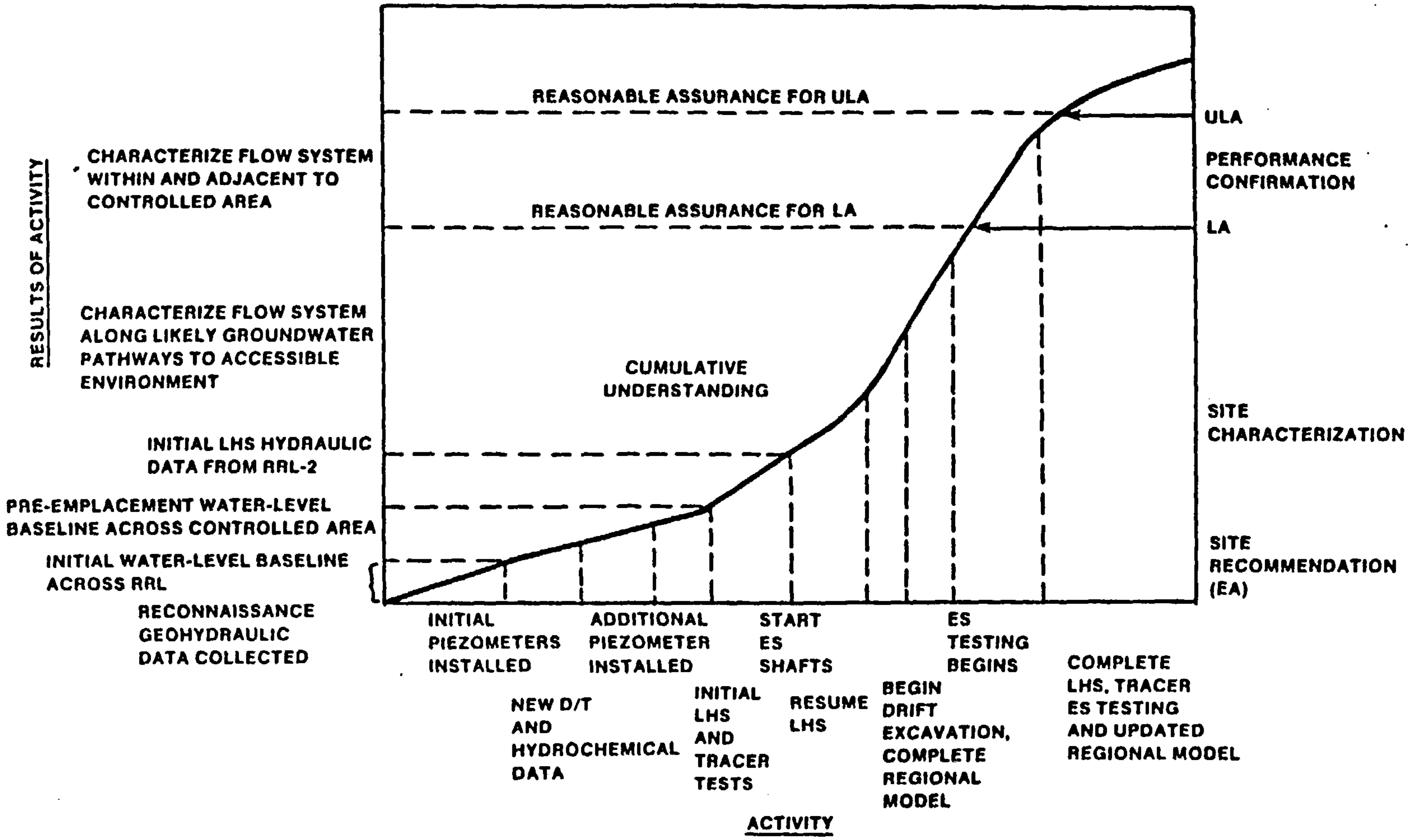
by

Dr. D.H. Dahlem, Chief
Geoscience & Technology Branch
Basalt Waste Isolation Division
Richland, Washington

ROLE OF PERFORMANCE EVALUATION
HYDROLOGIC CHARACTERIZATION PLAN



STRATEGY SEQUENCE FOR DEVELOPING AN UNDERSTANDING OF THE CONTROLLED AREA HYDROLOGY



LEGEND:

LA = LICENSE APPLICATION
ULA = UPDATED LICENSE APPLICATIONS
D/T = DRILL AND TEST
LHS = LARGE SCALE HYDRAULIC STRESS TEST
ES = EXPLORATORY SHAFT
RRL = REFERENCE REPOSITORY LOCATION
EA = ENVIRONMENTAL ASSESSMENT

HYDROLOGY ISSUES

- THE CONCEPTUAL HYDROLOGIC MODEL OF THE HANFORD SITE IS NEEDED; INCLUDING THE NATURE OF WATER MOVEMENT AND VELOCITY AND CHEMISTRY
- THE PREDICTABILITY OF THE LOCAL AND REGIONAL HYDROLOGY SURROUNDING A POTENTIAL REPOSITORY SITE NEEDS ASSESSMENT
- AFFECT OF GEOLOGIC DISCONTINUITIES ON THE HYDROLOGY
- EFFECT OF SITE CHARACTERIZATION ACTIVITIES ON GROUNDWATER CIRCULATION AND MONITORING
- THE GEOCHEMICAL DISPERSION IN THE GROUNDWATER SYSTEMS, CHEMICAL MIXING, AND AGE OF THE GROUNDWATER

MAJOR ISSUES DRIVING RECOMMENDED HYDROLOGIC CHARACTERIZATION PLAN

BWIP KEY ISSUE 1

WILL THE GEOLOGIC REPOSITORY AT THE REFERENCE REPOSITORY LOCATION, INCLUDING MULTIPLE NATURAL AND ENGINEERED BARRIERS, ISOLATE THE RADIOACTIVE WASTE FROM THE ACCESSIBLE ENVIRONMENT AFTER CLOSURE IN ACCORDANCE WITH THE REQUIREMENTS SET FORTH IN 10 CFR PART 60 AND 40 CFR PART 191?

ISSUE	INFORMATION REQUIRED	METHODS TO OBTAIN INFORMATION
BWIP CHARACTERIZATION ISSUE 1.1 WHAT ARE THE PRESENT AND EXPECTED CHARACTERISTICS OF THE GEO-HYDROLOGICAL SETTING THAT MUST BE KNOWN TO DETERMINE COMPATIBILITY WITH CONTAINMENT AND ISOLATION?	UNDERSTANDING OF PRESENT AND FUTURE GROUNDWATER FLOW SYSTEM	• GEOMETRY FROM GEOLOGIC STUDIES • HYDRAULIC PROPERTIES OF CONTROLLED ZONE FROM HYDROLOGIC TESTS • BOUNDARY CONDITIONS FOR CONTROLLED ZONE FROM REGIONAL MODELING • GRADIENT AND DIRECTION OF GROUNDWATER MOVEMENT IN CONTROLLED ZONE FROM PIEZOMETRY • POTENTIAL CHANGE FROM CLIMATIC MODELING, TECTONIC MODELING, AND WATER USE SCENARIOS.
BWIP CHARACTERIZATION ISSUE 1.2 WHAT ARE PRESENT AND EXPECTED GEOCHEMICAL CHARACTERISTICS THAT MUST BE KNOWN TO DETERMINE COMPATIBILITY WITH CONTAINMENT AND ISOLATION?	BASALT FLOW INTERIOR CHEMISTRY, FLOW TOP CHEMISTRY, WATER CHEMISTRY, CHEMICAL REACTIONS	• CORE ANALYSES • GROUNDWATER SAMPLES • GEOCHEMICAL MODELING

MAJOR ISSUES DRIVING RECOMMENDED HYDROLOGIC CHARACTERIZATION PLAN (CONT.)

ISSUE	INFORMATION REQUIRED	METHODS TO OBTAIN INFORMATION
BWIP CHARACTERIZATION ISSUE 1.4 WHAT ARE THE FUTURE CLIMATIC CONDITIONS THAT MUST BE KNOWN TO DETERMINE IF RADIONUCLIDE RELEASES WILL BE GREATER THAN THOSE ALLOWED BY REGULATIONS?	RANGE OF POSSIBLE GROUNDWATER RECHARGE OVER THE NEXT 100,000 YEARS	• CLIMATIC MODELING • MODEL CALIBRATED TO PALEOCLIMATE DATA
BWIP CHARACTERIZATION ISSUE 1.8 WHAT ARE THE NATURAL RESOURCES AT OR NEAR THE SITE THAT COULD CAUSE HUMAN INTERFERENCE ACTIVITIES THAT COULD LEAD TO RADIONUCLIDE RELEASES GREATER THAN THOSE ALLOWED BY REGULATIONS?	POSSIBLE CHANGES IN BOUNDARY CONDITIONS FOR CONTROLLED ZONE DUE TO GROUNDWATER USE	• REGIONAL MODEL TO DETERMINE OCCURRENCE OF GROUNDWATER • WATER QUALITY DATA • WATER USE SCENARIOS • SIMULATE SCENARIOS WITH REGIONAL MODEL
BWIP PERFORMANCE ISSUE 1.15 IS THE PRE-WASTE-EMPLACEMENT GROUNDWATER TRAVEL TIME AT LEAST 1,000 YEARS ALONG THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT?	LIKELY FLOW PATHS AND WATER PARTICLE VELOCITY ALONG THE FLOW PATHS	• HYDRAULIC PROPERTIES OF CONTROLLED ZONE FROM HYDRAULIC TESTS • GRADIENT AND DIRECTION OF GROUND-WATER MOVEMENT IN CONTROLLED ZONE FROM PIEZOMETRY • GROUNDWATER AGE DATA ALONG A FLOW PATH

HAND INTERPRETED GRANDE RONDE POTENTIAL SURFACE