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WM Project 10, 11, 16
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NUCLEAR WASTE CONSULTANTS INC.
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J Pohle

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'86 FEB 19 P12:17

February 13, 1986

009/PM/Meetings.002
RS-NMS-85-009
Communication No. 25

U.S. Nuclear Regulatory Commission
Division of Waste Management
Geotechnical Branch
MS 623-SS
Washington, DC 20555

Attention: **Mr. J. Pohle, Project Officer**
Technical Assistance in Hydrogeology - Project B (RS-NMS-85-009)

Re: **Trip Report, Meetings with Subcontractors in Socorro, Ft. Collins and Denver - Program Review and Planning - January 21-23 and 31, 1986**

Dear Mr. Pohle:

Please find attached Nuclear Waste Consultants, Inc.'s trip report for the meetings held in Socorro, NM (January 21-22), Ft. Collins, CO (January 23) and Denver, CO (January 31). The purpose of the meetings was for Nuclear Waste Consultants to conduct technical and managerial program reviews of our subcontractors (Daniel B. Stephens and Associates (DBS), Water, Waste and Land (WWL), and Terra Therma (TTI)) and to participate in their planning process for contractual activities under Subtasks N.2, N.4, N.5 and Task 5.

The trip report details the technical and administrative matters that were discussed with each of the subcontractors. However, several common matters emerged from the three days of meetings, and we consider that it is well to highlight these common items in this cover letter.

1. Both DBS and WWL expressed a strong concern about the importance of conducting a site vist in the very near future, certainly in advance of being called upon to conduct any major site reviews or reviews of DOE program documents. Preferrably in conjunction with the site visits, both teams are anxious to meet with other technical groups who are working on the sites (e.g., TBEG for DBS; DRI for WWL) and with the DOE contractors who are leading the hydrology studies at the sites. Ideally, representatives of all the principal parties might participate in a field trip together, though we realize that there are formidible procedural obstacles to this. Additionally, DBS and NWC consider that a site visit of the WIPP Project would be valuable to the Salt team at an early time. TTI participated in a site visit in conjunction with the December, 1985 workshop at Hanford, and several members of the BWIP team have visted the site on several occasions, so the need for such a visit is not pressing for the BWIP reviews.

2785

See D1021 2/13/86
TO J. Pohle 1796#-21
"Trip Report 1/21-23+31/86

2. All three teams are assembling basic geologic, geophysical, hydrologic and hydrochemical data in manners that can be easily retrieved and converted into graphical and planimetric forms for use in evaluating DOE data and in formulating aspects of conceptual models. Where the amount of data is such that there is a clear advantage to using computerized data bases for specific purposes (e.g., for quantitative evaluations of the relatively plentiful hydraulic test data at BWIP), this is being pursued. In all cases, computerized information is being referenced to both the original documentation and to physical files that contain copies of the critical information for easy retrieval and use and to provide adequate quality control on data that our teams are using.

3. All three of the teams are taking the approach that unguided assembly of hydrogeologic (and related earth-science) data is not particularly useful and certainly is not efficient. Because the focus of this contract is on analysis of the hydrogeology, we consider that the data that are needed for the purposes of this contract are, at least initially, the data that need to be integrated for the identification and evaluation of conceptual models. Therefore, our data inventory and management activities will revolve around ongoing analyses of the data that are needed to evaluate aspects of conceptual models of flow and transport systems for the sites in consideration.

If you have any questions about this matter, please contact me immediately.

Respectfully submitted,
NUCLEAR WASTE CONSULTANTS, INC.

Mark J. Logsdon

Mark J. Logsdon, Project Manager

Att: Trip Report - January 21-23 and 31, 1986

cc: US NRC - Director, NMSS (ATTN PSB)
DWM (ATTN Division Director)
Barry Bromberg, Contracting Officer
WMGT (ATTN Branch Chief)
Lyle Davis, WWL
M.Galloway, TTI
R. Knowlton, DBS

TRIP REPORT

PROGRAM REVIEW MEETINGS, JANUARY 21-23 AND 31, 1986

1.0 INTRODUCTION

Nuclear Waste Consultants, Inc. (NWC) met with its subcontractors (Daniel B. Stephens and Associates, Water, Waste and Land Inc., and Terra Therma Inc.) on January 21-23 and 31, 1986. The purpose of the meetings, each of which was held at the offices of the host subcontractor, was for NWC to conduct a technical and managerial review of the status of the three task projects and for the NWC staff to participate in interim planning for the near-term activities of the three groups. The following contractor and subcontractor managers participated in the three meetings:

Name	Position	Firm
Adrian Brown	Project Technical Director & BWIP Technical Director	Nuclear Waste Consultants
Mark Logsdon	Project Manager	Nuclear Waste Consultants
David McWhorter	NNWSI Technical Director	Water, Waste and Land
Lyle Davis	NNWSI Team Manager	Water, Waste and Land
Michael Galloway	BWIP Team Manager	Terra Therma
Daniel Stephens	Salt Technical Director	Daniel B. Stephens & Assoc.

Robert Knowlton	Salt Team Manager	Daniel B. Stephens & Assoc.

In addition, staff members of DBS, WWL and TTI participated in at least portions of the meetings at their offices.

The annotated agendas for the meetings with DBS and WWL meeting are attached (Attachments 1 and 2). The discussions with TTI addressed the same range of topics as those for the other two subcontractors. All agenda topics were addressed during the meetings. In the report that follows, discussion that more than acknowledges the various topics will be limited to those matters that require amplification.

2.0 DANIEL B. STEPHENS AND ASSOCIATES

NWC met with Daniel B. Stephens and Associates (DBS) from 7:30 a.m. to 4:30 p.m. on January 22, 1986, in Socorro, NM. In addition, Mssrs. Brown and Logsdon met separately with Dr. Stephens for dinner on the evening of January 22, 1986, before returning to Denver. DBS staff who participated in the meetings included Dan Stephens, Fred Phillips Bob Knowlton, Allison Barker, and Catherine Carlson. The annotated agenda for the meeting is attached (Attachment 1). The following comments will be organized around the contractual deliverables specified in the Statement of Work.

2.1 Site Familiarization (Subtask 3.1)

DBS has received essentially all of the documents requested from the NRC, and, in addition, have placed themselves on the direct mailing list for ONWI. The bibliographical data base has been computerized, and DBS is updating and maintaining that data base preparatory to the Subtask 3.1 letter report. The review of the literature has concentrated almost exclusively on the Palo Duro Basin, as directed by the NRC staff during the October 22-25, 1985 contract kickoff meeting and subsequent contacts with the NRC Salt Site Lead, Mr. Fred Ross. It is the intention of DBS to limit the Site Familiarization report to matters concerning the Palo Duro Basin. DBS and NWC propose that if the staff subsequently determines that substantive reviews of other salt sites should be conducted, then the NRC Project Officer should so direct NWC, and the NWC team will subsequently prepare a second site familiarization report that pertains to the additionally nominated salt site(s).

The DBS staff feels strongly that a "site" visit - that is, a field trip to the Palo Duro Basin for the purposes of observing the outcrop geology and hydrogeology of the basin - is an important activity at the earliest possible time. In outline, such a trip would begin, perhaps, at Clayton, NM for observation of those aspects of the geology that may be significant with respect to recharge relationships, procede toward the Amarillo area and the actual Deaf Smith County site, and finally continue to the Caprock Escarpment to the east of the proposed site. Such a trip would give a needed overview of the basin structure and its related lithostratigraphic relationships, particularly from a hydrogeologic viewpoint.

The most valuable way to organize and conduct such a field trip would be in conjunction with scientists who are familiar with the salient points of the geology and hydrology, for example staff members of the Texas Bureau of Economic Geology. Ideally, the field trip would begin with overviews presented by DOE (or their contractors) and by, say, TBEG, to the extent that there are alternative views of important matters that can be assessed, even partially, from surface geology. Then, the field trip, limited to a reasonable number of DOE/TBEG/DBS/NWC/NRC staff (say 12 people total), would be conducted, with ample opportunity for discussions at relevant outcrops. Finally, the trip could conclude with a session in which each of the groups presented and documented comments on the technical aspects of the trip.

Even if the field trip had to be conducted solely by DBS/NWC staff and without the benefit of any DOE/TBEG input, our team believes that such a field trip is very important to developing a balanced, objective professional opinion of the merit of contentions about the geology and hydrogeology of the Palo Duro Basin. NWC points out that such a field trip is a simple matter to organize and accomplish logistically for a group such as DBS, who are located in central New Mexico.

In addition to a site visit to the Palo Duro Basin, DBS and NWC consider that there would likely be great technical benefits to a visit by NRC staff and contractors to the WIPP site at Carlsbad, New Mexico. The site characterization, testing and construction projects at WIPP are so much farther advanced than at any of the potential OCRWM sites that we consider that there will be much to learn from such a visit. Again, the logistics of such a trip for the Stephens group are relatively simple.

2.2 Data Inventory and Management (Subtask 3.2)

After some discussion between the NWC and DBS staffs, it was agreed that it is appropriate to collect and document detailed information about the site in physical files which can be easily retrieved and integrated into analyses of the geologic and hydrogeologic framework of the Palo Duro Basin. In essence, this is part of the approach of the draft GeoTrans work on NNWSI that was transmitted to the NWC teams for review, consideration and comment.

In addition, the DBS staff will be assembling the hydrologic and hydrochemical data that have been and will be collected. In addition to having physical copies of the relevant data, DBS anticipates preparing computerized data bases of this quantitative information, primarily to permit efficient manipulation (both graphical and numerical) of the data. Because the BWIP task is two months ahead of the Salt task, NWC has undertaken to provide information on the analogous TTI/NWC systems to DBS for their early consideration as input to designing appropriate data bases for the specific purposes of the Salt program.

The information to be used in the DBS data bases will come directly from DOE documents, from DBS's independent analyses of data, from analyses performed by

Williams and Associates under Project A, and from selected, major outside sources, such as TBEG, USGS, etc.

2.4 Conceptual Model Evaluations (Subtask 3.4)

Because DBS is in the midst of the Site Familiarization subtask and at the beginning of organized efforts at data inventory and management, no formal work on evaluation of conceptual models has yet been done. However, DBS and NWC consider that since this is the primary focus of the current contract (even Subtasks N.5 refer to numerical evaluations of the conceptual models), the identification and at least initial evaluation of conceptual models and the data that are assembled to support them is the most logical way to organize the site familiarization and data inventory subtasks.

3.0 WATER, WASTE AND LAND

NWC met with Water, Waste and Land, Inc. (WWL) from 9:00 a.m. to 3:30 p.m., on January 23, 1986, in the WWL offices in Fort Collins, Colorado. WWL was represented by Dr. David McWhorter, Mr. Lyle Davis, and Mr. Tom Sniff, WWL staff engineer. The agenda for the meeting and notes prepared by WWL are presented as Attachment 2. As with the other subcontractors, the following discussion is based on the format of the Statement of Work.

3.1 Site Familiarization (Subtask 1.1)

WWL had already submitted its Site Familiarization report prior to the NWC/WWL meeting. The teams did spend some time reviewing the details of the Tucson workshop on flow and transport in the unsaturated zone, attended by Dr. McWhorter, as a sort of overview of important technical topics that are of concern to the technical community. Like DBS, WWL considers a site visit at the earliest possible time is critically important to their ability to evaluate DOE work and to formulate independent positions on the hydrogeologically important aspects of the Yucca Mountain site.

3.2 Data Inventory and Management (Subtask 1.2)

WWL reviewed their procedures for reviewing documents in their library, including all in-coming documents. The WWL bibliographic data base includes references to all NRC-related reviews which have been or are being conducted. A sample of the bibliographical data base format was submitted with the Site Familiarization report. All documents have an in-house, informal (but written) review, as NWC had directed its subcontractors to do. A sample of such an informal review is presented as Attachment 3. A primary objective of these informal staff reviews is to identify old and new documents to be reviewed in detail by senior WWL staff and to recommend to the NRC staff for formal document review.

Based on the site familiarization work and the informal document reviews conducted to date, WWL believes a computerized data base is not appropriate for the sparse data available at this time. Instead, WWL is preparing hard-copy sets of hole-by-hole records of hydrogeologic information. The information is prepared to the extent practicable in visual formats - borehole logs, test values by interval, etc. An example of such a compilation, for Test Well USW G-4, is presented as Attachment 4. The material is being compiled at the same scale for all holes, in order to facilitate comparisons and construction of maps and sections in the future. The selection of information for this "data base" is being guided by the team's needs for data to evaluate conceptual models of the site.

3.3 Conceptual Model Evaluations (Subtask 1.4)

WWL's evaluations to date of DOE conceptual models for the Yucca Mountain site have concentrated on conceptualizations of flow in the unsaturated, fractured tuff. WWL has decided to do this, in large part, because the uncertainties in the hydrology of the unsaturated zone are likely to have a much greater impact on the modelled performance of a repository located in the unsaturated zone than are uncertainties in the hydrology of the saturated zone, based on information available at this time. Because there are scant data and many fascinating and difficult technical questions that could be raised, the key concept in the WWL/NWC approach is to try to identify those aspects of the hydrogeology of the site that are demonstrably important to the performance of a repository. Based on WWL's Site Familiarization reviews and the matters discussed at the Tucson meeting, WWL proposes initially to analyze five aspects of existing conceptual models that preliminary calculations have already shown could have order-of-magnitude effects on the performance of a repository in unsaturated tuff:

1. The importance of a capillary barrier.

2. The relative importance of fracture and matrix flow.

3. The importance of two-phase (air-water) flow on fracture saturation and flow of water from fractures to matrix blocks.

4. The importance of air circulation through the unsaturated zone on the water balance of the system.

5. The importance of vapor-phase transport of radionuclides.

Attachment 2, the meeting agenda, includes brief write-ups by WWL concerning these topics. The basic approach will be to conduct scoping exercises, using available, simple models (analytical or numerical) and available or bounding data to determine the physical and chemical conditions under which these critical aspects of alternative conceptual models would be important. The objective will be to determine whether there are data needs with respect to these concerns, and if so, what level of detail and assurance with respect to the necessary data would be required to reach a significant decision on repository performance.

WWL and NWC consider these preliminary evaluations are within the scope of Subtask 1.4, which requires the Contractor to evaluate conceptual models for technical consistency and completeness in light of current data and directs the Contractor to identify additional data needs. In addition, these scoping calculations can serve as the basis for developing work plans for detailed numerical analyses of aspects of conceptual models, as required for Subtask 1.5. Based on our evaluations to date, we now consider that it is appropriate to conduct some of our analytical work in parallel with our data management and conceptual model evalautions, rather than leaving it until later.

4.0 TERRA THERMA

NWC met with Mike Galloway and Fred Marinelli of Terra Therma, Inc (TTI) from 7:00 a.m. to 12:00 noon on January 31, 1986. This meeting was shorter than the previous two because of Brown's and Logsdon's familiarity with the status of the BWIP activities, including the Subtask 2.1 Site Familiarization Report, which was completed on January 30, 1986. Consequently, essentially all of the discussion involved detailed planning for Subtasks 2.2 - 2.5 over the balance of Fiscal Year 1986. The goal of the meeting was to develop a detailed outline of how Task 2 activities will be conducted by TTI and NWC. The work plans for the subtasks are outlined below.

4.1 Data Inventory and Management (Subtask 2.2)

Fred Marinelli (TTI) will have the lead in developing the data management systems and will have primary responsibility for preparing the Subtask 2.2 letter report, which is due at the end of February, 1986. Marinelli will have responsibility for hydraulic data; Mike Galloway (TTI) will have responsibility for geologic and hydrogeologic data; and Mark Logsdon (NWC) will have responsibility for hydrogeochemical data.

It is proposed that the data management system will have two styles of subsystems. The first will be a set of physical files that contain copies of information that is relevant to the hydrogeology of the site. These files would include geologic, geophysical, hydrologic, and geochemical information (e.g., borehole logs; tables of test data) that can be used to efficiently construct descriptions and illustrations (e.g., various maps and sections that will be used in Subtask 2.4) or to refer to in the process of conducting detailed reviews of DOE documents (e.g., during EA or SCP reviews). It is anticipated that these files would be organized both by borehole and by specific technical topics (e.g., one file for hydraulic conductivity data; another file for data on dissolved gases in groundwaters). The material in the files would all be indexed with citations to the original literature (and hence tied into our existing bibliographic data base). The files would, in addition to DOE data, include any worksheets or calculations that were generated by the TTI/NWC staff in assessing the DOE data.

The second style of data management will be a set of computerized data bases, each designed to be used for a specific purpose. It is anticipated that there would be separate data bases for geologic, hydraulic, and geochemical information, since the specific types of information and also the use to which that information will likely be put are quite different in each case. These data bases will be designed specifically for quantitative information which the team has reason to believe will be manipulated (either graphically or numerically) during Subtask 2.4 and 2.5 activities. The data bases will include information on location, unit, interval, and type of test; evaluation of the quality of the data; and citations to both the original literature and to our hard-copy data files. TTI/NWC consider a key part of this two-tiered data management system is that by limiting the scope of the information which will be inventoried to that which has a direct connection with specific tasks that we are addressing, we can assure that the information will be both manageable and useful. In addition, this system will allow all of the data that we use to support analytical activities to be fully traceable, a key part of our quality assurance activities.

The data management activities will begin by concentrating on data that has been collected in units near the proposed repository location and will expand toward data that is stratigraphically and laterally more remote. While our initial compilations will emphasize information from the Wanapum and Grande Ronde Basalts in the Cold Creek Syncline, our goal will be to have all the existing hydrogeologic information which is relevant to the project entered into the data management system by the time of the first semi-annual update (August, 1986).

The Subtask 2.2 letter report will include:

a. Details on the formats and contents of the data management systems;

b. Examples of physical data files;

c. A listing of the updated computerized data bases;

d. Examples of useful manipulations of the data in the computerized data bases (e.g., histograms of log K vs. depth; graphical output of statistical manipulations such as linear regressions of K vs. depth)

e. Discussion of plans for the updating and use of the data management systems.

4.2 Conceptual Model Evaluations (Subtask 2.4)

Mike Galloway (TTI) will have lead responsibility for organizing the conceptual model subtask and for preparing the Subtask 2.4 letter report. He will be assisted in this by Mark Logsdon (NWC). It is anticipated that Adrian Brown (NWC), Fred Marinelli (TTI) and Catherine Kraeger-Rovey (TTI) will be involved in specific aspects of this subtask.

This subtask will involve three basic steps:

1. Identification and documentation of existing alternative conceptual models. The documentation will include the preparation of relevant descriptions, illustrations and hydrogeologic data bases.

2. Evaluation of the existing models against the available data base, including simple analyses of selected aspects of performance (e.g., the kind of analyses done in Appendix D of NUREG-0960 for groundwater travel time). The purposes of these evaluations will be to establish

the consistency of the models with present data and to identify areas of uncertainty or additional data needs, including those that pertain to anticipated future events. It is anticipated that most of the effort for this subtask will involve far-field scale conceptual models of flow and transport, but TTI/NWC also anticipates the need to address conceptual models at a local scale suitable for assessing specific issues related to the construction and operation of the Exploratory Shaft, test facilities and the proposed repository (e.g., evaluations of mine water inflow; resaturation of the repository; hydrologic aspects of source-term evaluations). Although the need for detailed evaluations of these small-scale conceptual models will depend on the performance allocations that DOE ultimately elects, we consider it appropriate for some initial work to be conducted at this scale in the near future, if for no other reason than to be prepared to support other NRC groups concerned with the ES program.

3. Preparation of detailed work plans for numerical evaluations of conceptual models. Based on the team's recommendations concerning data needs and areas of uncertainty, the TTI/NWC team will identify specific problems associated with evaluating conceptual models that need additional analysis. The work plans will identify and formally state the problem, identify the analytical approach that is proposed, indicate the data available to address the problem, and estimate the resources (staff, time and costs) needed to address the problem. We anticipate that we will prioritize the recommendations or analysis and propose a staged schedule for conducting the analyses.

The subtask 2.4 letter report will document all the foregoing activities, as prescribed in the Statement of Work for the contract.

4.3 Numerical Evaluations of Conceptual Models (Subtask 2.5)

As discussed at the October, 1985, contractor kick-off meeting, NWC considers that detailed discussions of the subtask for numerical evaluations are best left until Subtask 2.4 has been accomplished. TTI/NWC notes that the team has returned the INEL registration forms. We await further direction concerning the status of the NRC codes at the INEL computer facilities and of the status of documentation of these codes. We understand that Sandia National Laboratories is scheduled to present their tutorial on SWIFT II to the NRC staff this Spring, and we consider that it would be well for at least one of the TTI staff to attend this tutorial in preparation for using the code.

5.0 NWC OBSERVATIONS AND CONCLUSIONS

NWC considers that all three of the subcontractors have adequate facilities, including libraries and computers, and sufficiently well trained staff to perform the contractually required activities. All three of the teams are making normal progress on their subtasks and are planning for upcoming activities that will most effectively and efficiently implement the requirements of the Statement of Work. In summary, we consider that the subcontractors are performing up to the requirements of the spirit, as well as the letter, of the contract.

Based on the site familiarization work which has been conducted by the teams, including the reviews of the NRC staff and NNWSI issues documents, NWC considers the issues-oriented approach to preparing for licensing reviews is unlikely to lead to effective and efficient planning by DOE or preparation by the staff. This is particularly true with respect to preparing for reviews of the Site Characterization Plans. The basic concern is that the issues-oriented approach does not provide a mechanism for identifying, in a documented fashion, the information important to the potential performance of a geologic repository with respect to the performance objectives of 10 CFR Part 60, including the EPA Standard. NWC has presented this position at length in its review of the NNWSI Issues Hierarchy documentation (NWC Communication No. 22), and has documented the confusion that arises from trying to apply this approach in its review of the BWIP Exploratory Shaft Test Plan (NWC Communication No. 21).

As an alternative, NWC and its subcontractors propose to conduct data needs assessments through the vehicle of analyzing performance conceptual models of repository systems, or aspects of systems. An example of such a data needs assessment, prepared by Adrian Brown, Eileen Poeter and Fred Marinelli (who are all now members of the NWC team) is presented as Attachment 5. We consider this approach can be utilized to first identify and then focus NRC attention on those aspects of the hydrogeology of the site which must be understood before the staff is able to fulfill its review functions. The data needs assessments can provide quantitative support for NRC staff positions on the types, quantities, levels of detail and levels of certainty with respect to data collection and analysis that will be needed to support staff reviews and subsequent ASLB and Commission findings. We consider that if this approach is applied well in advance of the submission of the Site Characterization Plans, then the staff will be well prepared to document its positions with respect to the data collection and analysis plans that will be put forth by DOE. We are concerned that issues-oriented SCP reviews will not be sufficiently well guided or structured to provide a supportable basis for staff positions.

6.0 RECOMMENDATIONS

NWC recommends that the NRC hydrogeology staff direct NWC and its subcontractors to prepare a scope of work for quantitative assessments of hydrogeologic data needs for each of the sites currently under consideration by DOE for formal site characterization. We propose that the data needs assessments would be initiated during the performance of Subtasks N.2, N.3, N.4 and N.5, but that the final letter report documenting the work would be submitted after the Subtask N.5 letter reports that are specified in Contract No. RS-NMS-85-009.

ATTACHMENT 1

DANIEL B. STEPHENS AND ASSOCIATES
Consulting Ground-water Hydrologists
600 Neel Avenue
Socorro, New Mexico 87801
(505) 835-3162; 835-3828

NWC - Salt Team Meeting, January 22, 1986

Topics of Discussion

- Proposed ideas for Salt analyses to be performed while reviewing documents and evaluating conceptual models — ONA trip report
- Official disposition on which Salt sites need to be included in the Familiarization report — Palo Duro v. Dome
- Data management/inventory system and telephone mailbox service for communication a. Hard copies - à la brothers b. computerized for specific needs
- Where management/inventory data comes from (Williams and Associates?) DBS; Williams; other interested parties (e.g. TBEG)
- Numerical/Analytical codes that can be used - Status of ONEL (SNL) in-house codes
- Request Adrian Brown's analytical modeling results from Fred Ross — Requested by phone on 1/22
- Possible site visit and/or trip to TBEG — for trip report

5

ATTACHMENT 2

Logsdon

NRC Technical Assistance in Hydrogeology
Project B - Analysis
NRC Project Number: NMS-85-009
WWL Project Number: 4001
Nevada Nuclear Waste Storage Investigations (NNWSI)

NRC/WWL Meeting Agenda

1. Discussion of topics for detailed technical investigations.
   see follow on pages - iterative evaluation of information - this is the approach to evaluating alternative conceptual models

2. Preparation of data base.

   a. Documents   Format includes reference to all reviews
      All documents have in-house, informal (but written) reviews
      identify old & new documents to recommend for review

   b. Hydrologic Data   Hole-by-hole
      visual - logs, intervals, test values
      comments

3. Review of DOE Issue Hierarchy   motherhood statements
   even more general than NRC
   some gaps in detail   ← no 417 gaps - seem to cover the spectrum
   too generic to be helpful

4. Additional Discussion
   McWhorter - Tucson Trip

NRC Technical Assistance in Hydrogeology
Project B - Analysis
NRC Project Number: NMS-85-009
WWL Project Number: 4001
Nevada Nuclear Waste Storage Investigations (NNWSI)

Detailed Investigation Topics

1. Flow Modeling - use in house models to investigate some of the concepts reviewed during subtask 1.1. Two preliminary ideas:

   a. Capillary Barrier - the current conceptual model (Montazer and Wilson, 1984) relies on capillary barrier effects to explain some of the flow phenomena occurring at Yucca Mountain. We propose to use UNSAT2 to look at various configurations of sloping capillary barriers to determine their effect on lateral flow.

   b. Fracture vs. Matrix Flow - the model presented by Wang and Narasimhan (1985) provides a conceptual approach to modeling the flow system at Yucca Mountain. They modeled the system using the 3-D TRUST model and present a method in which the fractured, unsaturated tuff can be modeled using ordinary numerical methods. We propose to duplicate their work with UNSAT2 which is a 2-D model. Although they modeled the system in three dimensions, we feel that the symmetry of the system that they modeled will allow us to use the UNSAT2 model. The primary purpose of duplicating their work is to verify that UNSAT2 provides similar results. We could then apply the model to different configurations of fractures to investigate the effects of fracture orientation on results obtained.

NRC Technical Assistance in Hydrogeology
Project B - Analysis
NRC Project Number: NMS-85-009
WWL Project Number: 4001
Nevada Nuclear Waste Storage Investigations (NNWSI)

Detailed Investigation Topics

2. Two-Phase Flow - it appears that the relationship between the permeability to air and saturation of the matrix blocks has not been investigated. It appears to us that the resistance to air flow at the relatively high saturations that exist in the matrix blocks may retard seepage into the matrix and, therefore, result in sustained seepage in the fractures. Most of the models considered to date indicate that flow from the fracture to the matrix desaturates the fracture relatively rapidly resulting in low vertical fluxes and therefore long travel times. If the resistance to air flow prevents fluid inflow to the matrix, the vertical seepage rates may be larger than calculated and travel times may also be reduced. We propose to do some simple analytical modeling to evaluate the effects of air-water flow on fracture saturations and flow of water from the fracture to the matrix blocks. We believe that we can develop analytical solutions that neglect the air phase (fuurrow advance problem) as well as relatively simple two phase solutions for the same boundary conditions. Comparing the two solutions may provide insight into the imporatance of two-phase flow..

NRC Technical Assistance in Hydrogeology
Project B - Analysis
NRC Project Number: NMS-85-009
WWL Project Number: 4001
Nevada Nuclear Waste Storage Investigations (NNWSI)

Detailed Investigation Topics

3f. Air Circulation - while the literature does indicate that air circulation will occur because of a repository located in the unsaturated zone, it does not appear that the effects of such circulation on inflow to the overall system have been considered. We propose to use methods presented by McWhorter and Brown (1985) to develop an initial understanding of the relative importance of air circulation of net recharge to the system..

4. Vapor Phase Transport

ATTACHMENT 3

WWL Document Number: 3

Document Title: CONCEPTUAL HYDROLOGIC MODEL OF FLOW IN THE UNSATURATED ZONE, YUCCA MOUNTAIN, NEVADA

Document Author(s): PARVIZ MONTAZER, WILLIAM E WILSON

Document Number: U.S.G.S. 84-4345 Publication Date: 1984

Document Request From: NRC Request Date: NOV, 85

Document Received From: NRC Receipt Date: NOV, 85

Document Rating (1=poor to 10=excellent) 9

Document Description (general, specific, etc.) General

Document Read By (initials): TLS

Key Words: HYDROLOGIC MODEL, FRACTURE FLOW, UNSATURATED FLOW, CAPILLARY BARrier hysteresis, VAPOR TRANSPORT

Key Data: Hydrologic properties of Hydrogeologic UNITS

General Comments:

WWL Document Number: ________________

Document Title: ________________

SUMMARY: A conceptual model describing the flow of fluids through the unsaturated zone at Yucca Mountain is proposed. The proposed model considers the following flow phenomena in the unsaturated region: flow through fractured rock, capillary barriers, infiltration into fractured rock, lateral movement, and capillary fringe. The proposed model gives a representation of the flow in the hydrogeologic units and structural pathways at Yucca Mountain. Areas needing further investigation are identified.

ATTACHMENT 4

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

"TEST WELL USW 6-4"

WITHIN THIS PACKAGE

D-1

ATTACHMENT 5

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

WM DOCKET CONTROL CENTER

'84 MAY 31 A11:41

May 30, 1984

U.S. Nuclear Regulatory Commission
Division of Waste Management
7915 Easter Avenue M/S 623-SS
Silver Spring, MD 20910

Our ref: G/84/202
833-1099C

✓ Attn: Barbara Cooke, Project Officer

WM Record File B-7390
WM Project 16
Docket No.
PDR ✓
LPDR 5

Distribution: B. Cooke
(Return to WM, 623-SS) 13

Re: Contract No. NRC-02-83-034
FIN No. B-7390
Salt Hydrogeology
Data Needs Assessment Document Ala
Letter # 25

Gentlemen:

As discussed in our letter #18 of May 2, 1984, we are preparing Data Needs Assessment Documents for the following items on the attached hydrogeologic process list:

Ala, Alb, A2, A3
Bla, Blb, B2, B3, B4
Cl, C3
D2a, D2b, D2c
Summary discussions of Dl, D2 and D3

The first of these, Ala is enclosed. The rest should be arriving shortly. Those that have not been submitted by June 8, 1984, will not be submitted until sometime in July because the entire project staff has other commitments for the end of June.

Yours truly,

GOLDER ASSOCIATES

Eileen Poeter

Eileen Poeter
833-1099C

cc: Office of the Director, NMSS
Division of Waste Management - Division Director
Contracting Officer
Geotechnical Branch
Adrian Brown

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. Ground-water 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.

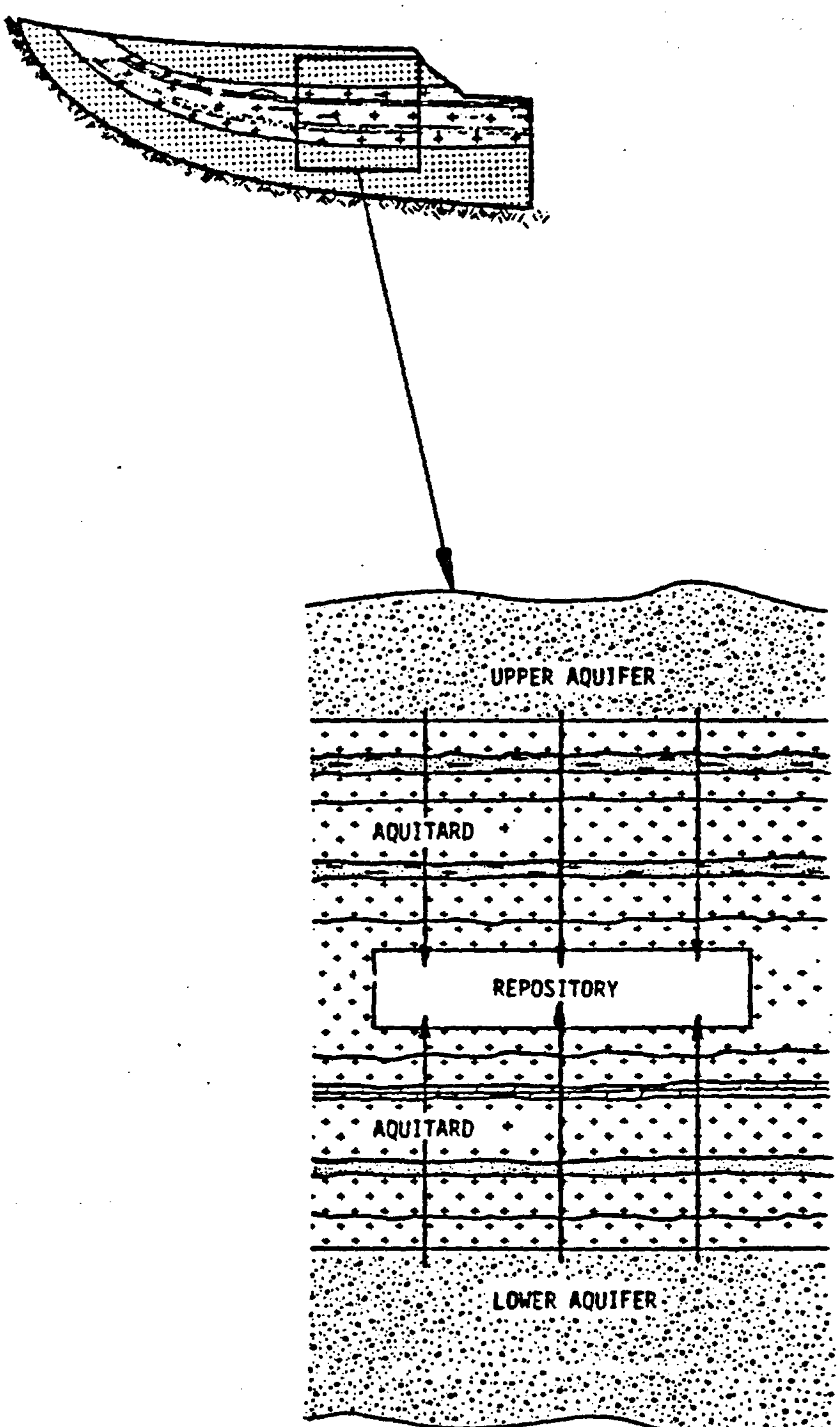
3.0 TECHNICAL APPROACH

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

PRELIMINARY

RESATURATION BY VERTICAL POROUS MEDIA FLOW

Figure A1a-1



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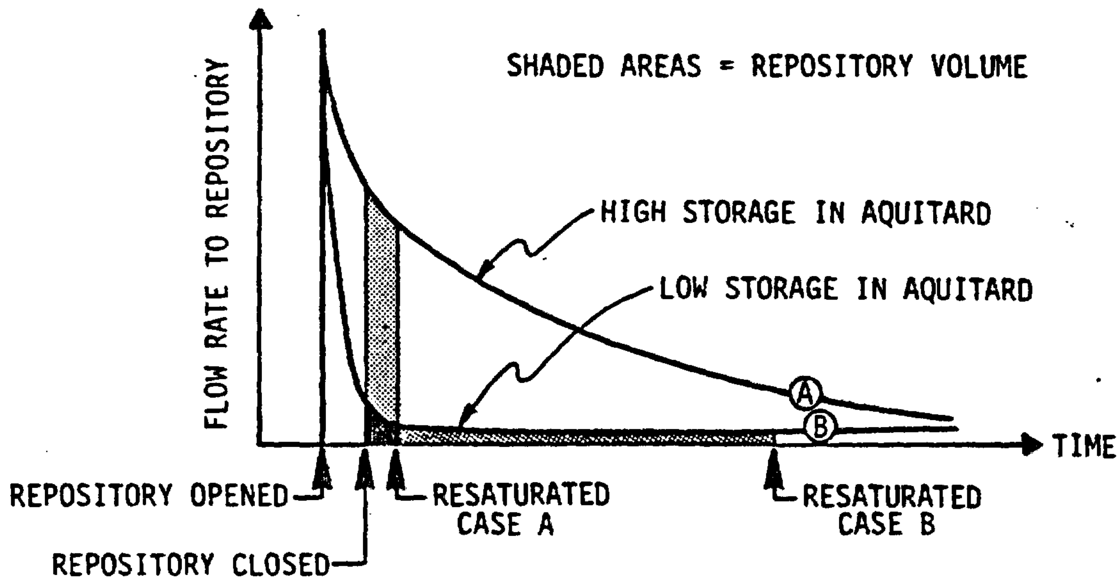
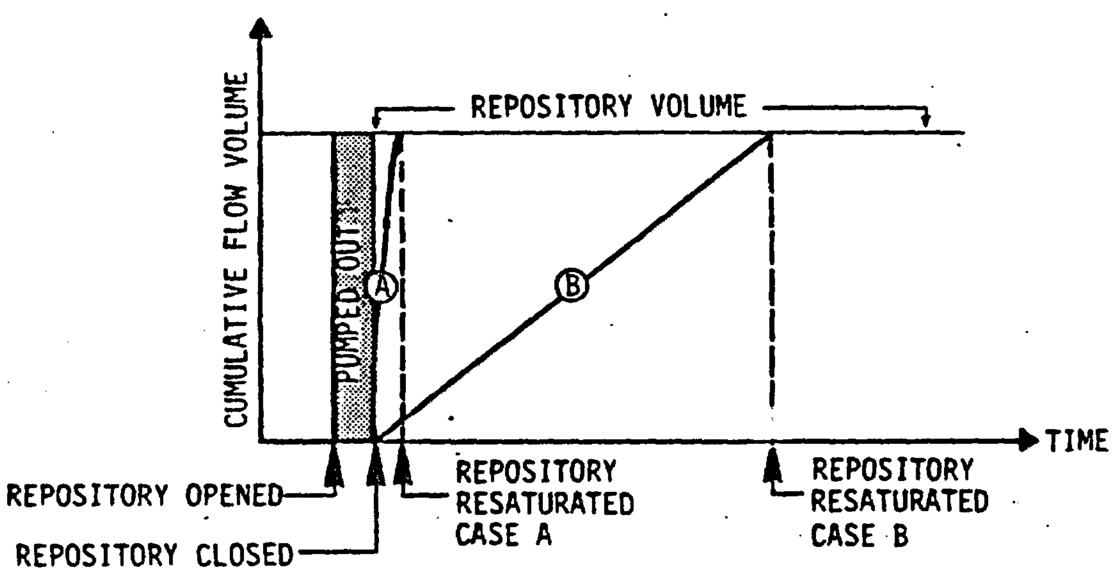
PRELIMINARY

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:

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

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

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

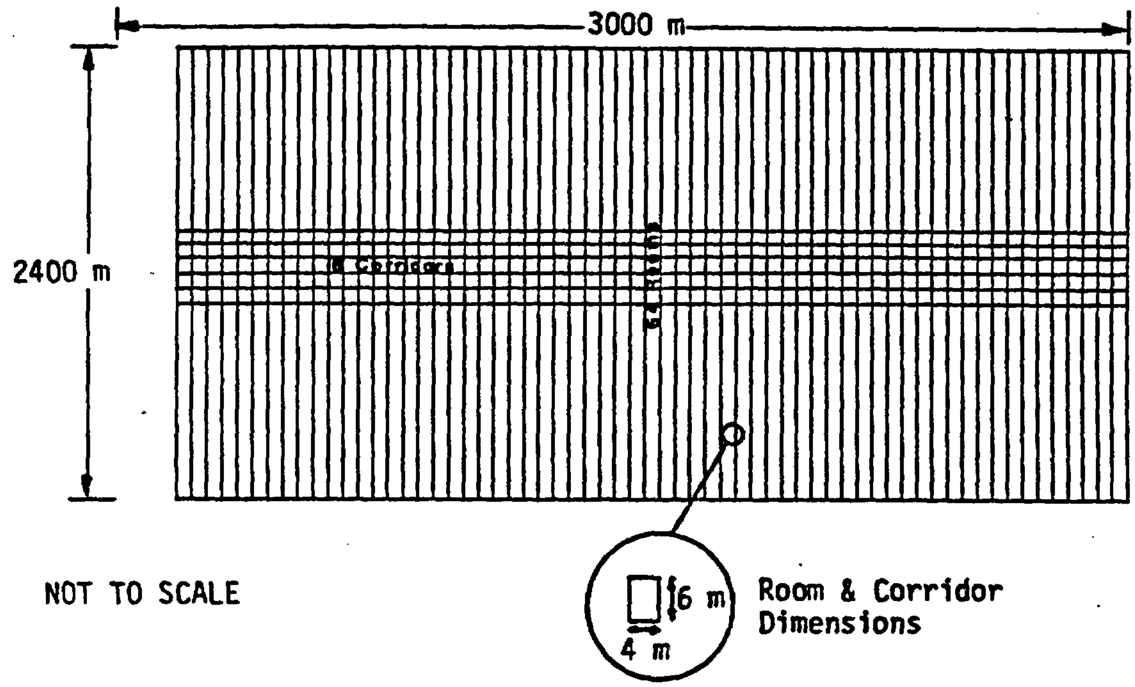
The situation analysed is indicated in Figure Ala-3. The geometric parameters, which are relatively invariant, are:

PRELIMINARY

ASSUMED STANDARD BEDDED SALT REPOSITORY

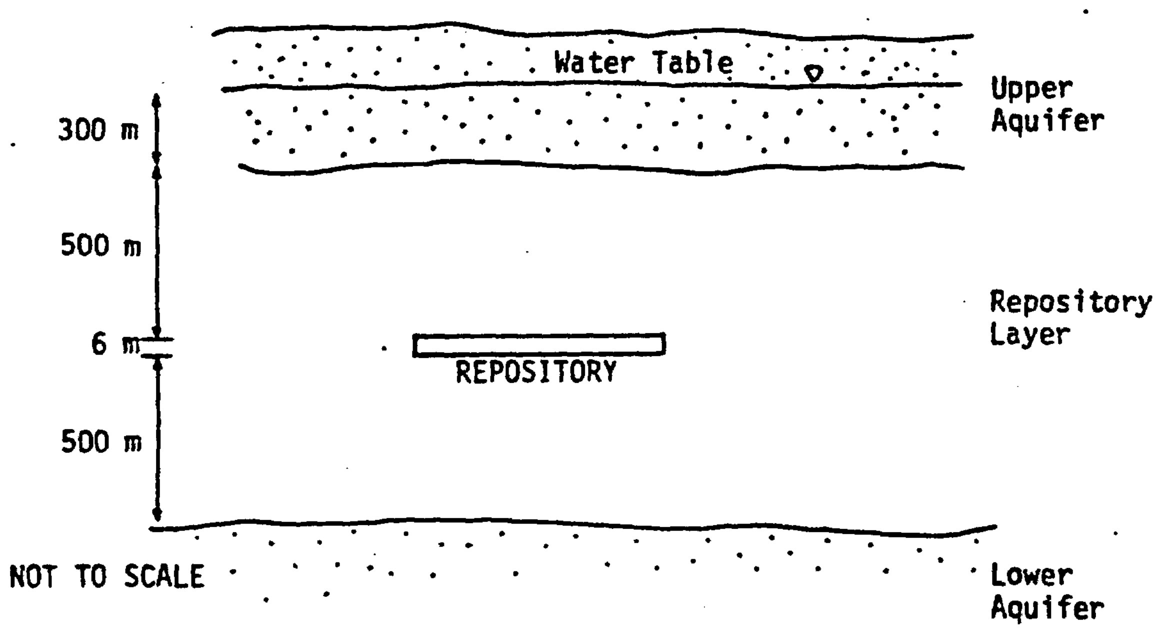
Figure A1a-3

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):

$$S\ (min) = n\rho g\beta \qquad (4.1)$$

where:

n = porosity [ ]
ρ = density of water [M/L^3]
g = acceleration due to gravity [L/T^2]
β = 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.

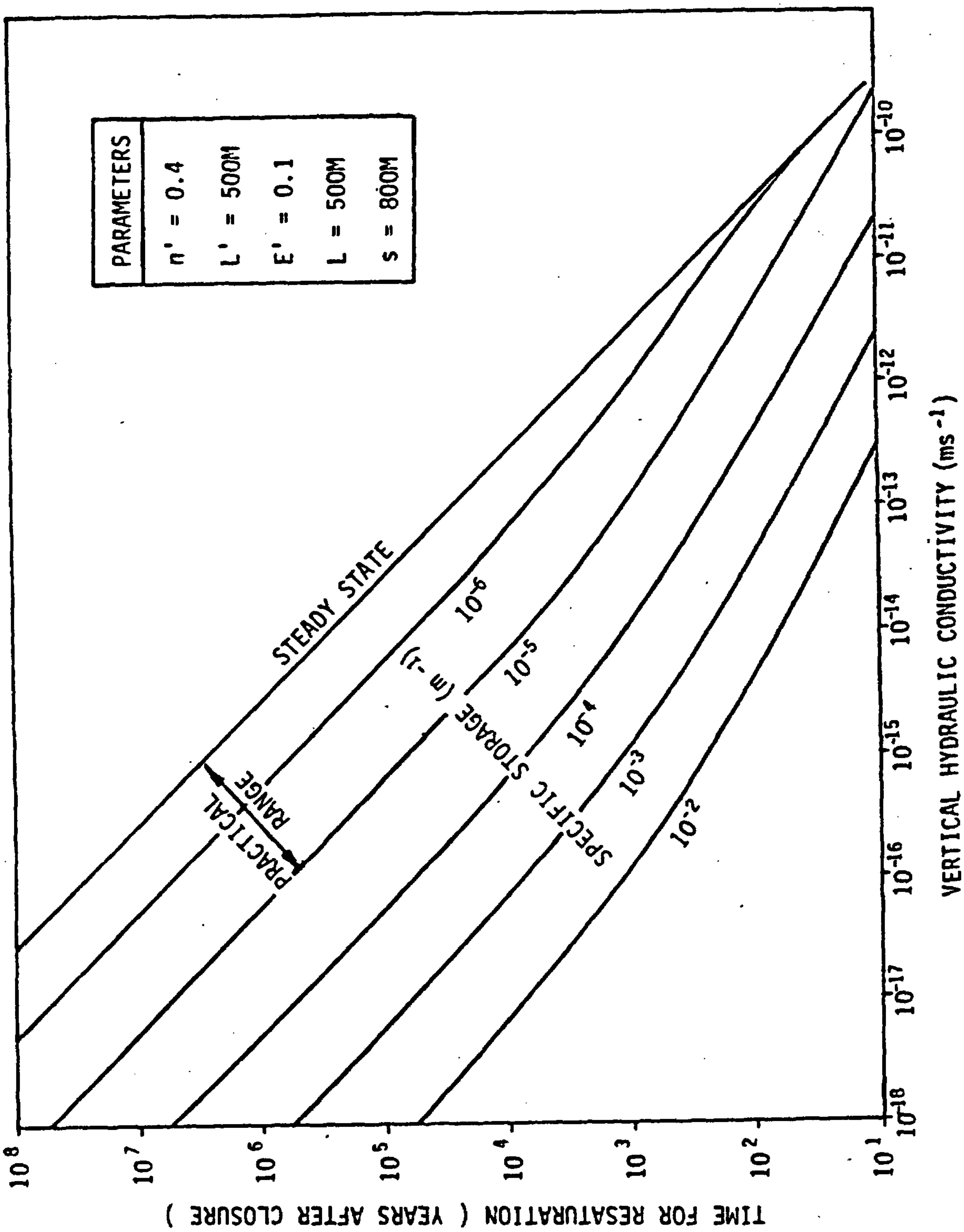
5.0 COMMENTS

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.

PRELIMINARY

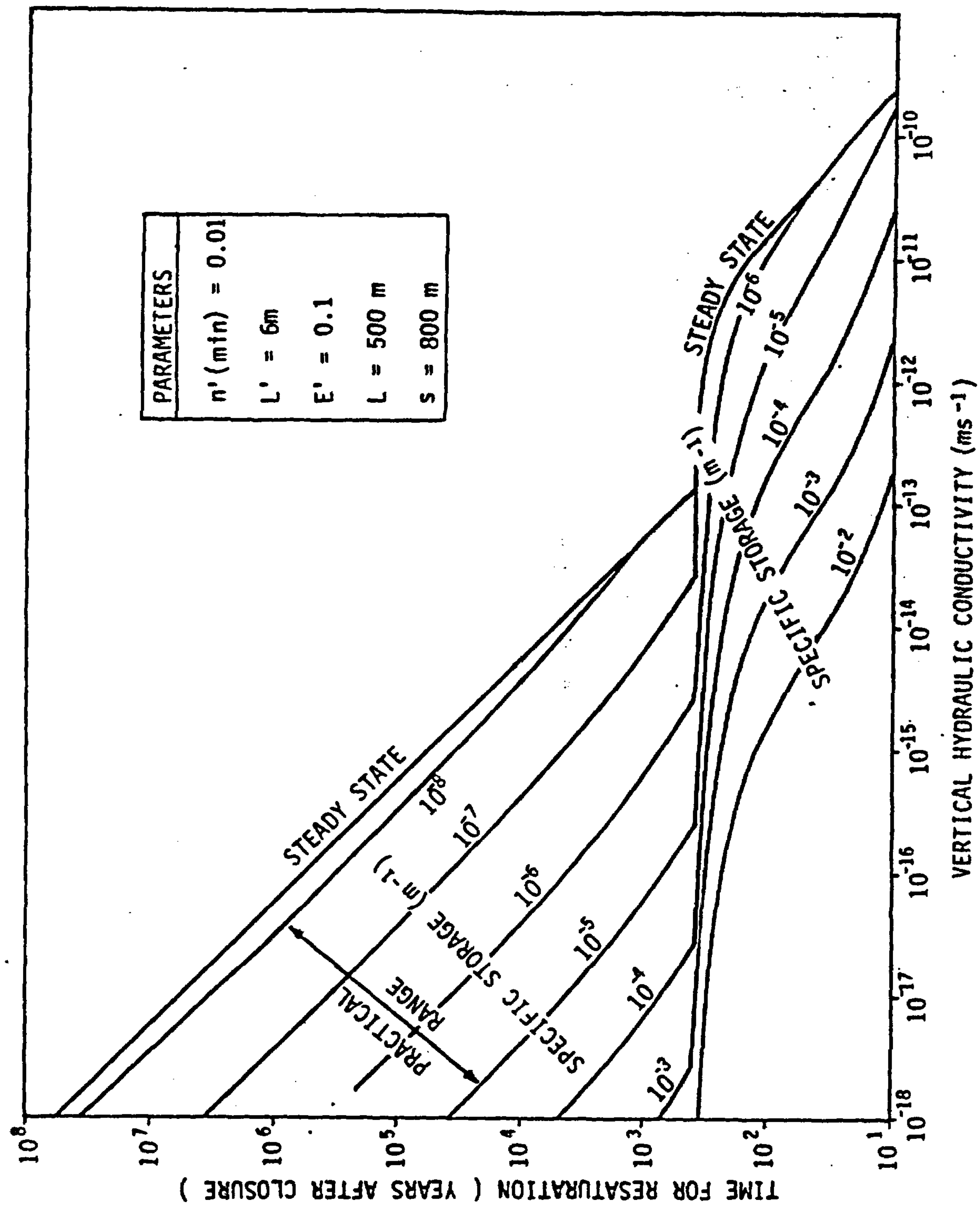
RESATURATION TIME – NON-CONSOLIDATING BACKFILL Figure A1a-4



PRELIMINARY

RESATURATION TIME - CONSOLIDATING BACKFILL

Figure A1a-5



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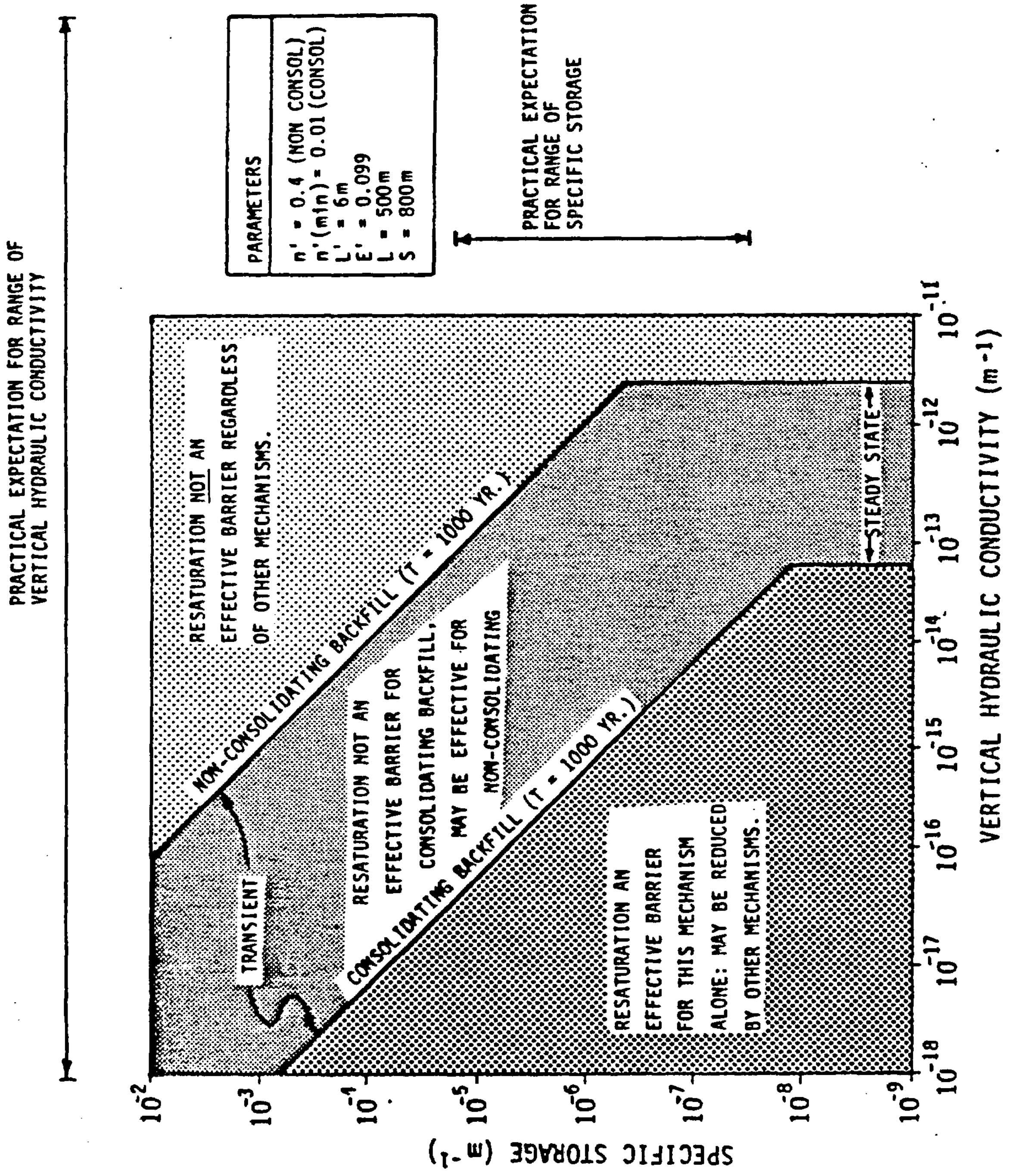
PRELIMINARY

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

Figure A1a-6



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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

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

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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

$$\left.\begin{aligned} s(0,t) &= 0 \\ s(L,t) &= s' \end{aligned}\right\} \text{ for } t > 0$$

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:

$$\underline{t} = \frac{K\,t}{S\,L^2} \qquad (7.3)$$

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 A1a-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 [L^3]
$\underline{V}$ = dimensionless volume [ ]

A type curve is given for $\underline{V}$ as a function of $\underline{t}$ in Figure A1a-D. Scrutiny of Figure A1a-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:

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

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

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.

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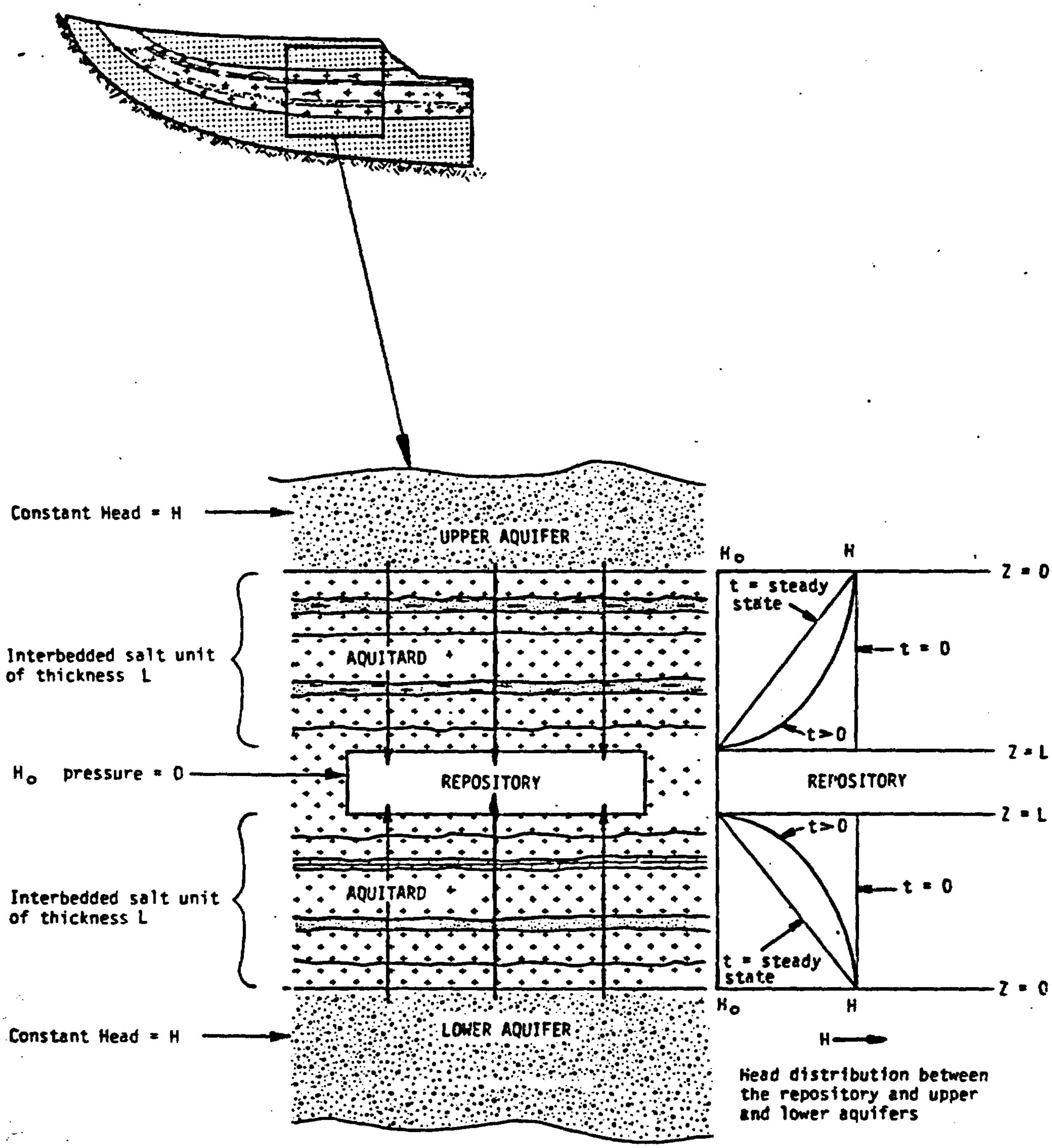
PRELIMINARY

RESATURATION BY VERTICAL POROUS MEDIA FLOW

Figure A 1a - A



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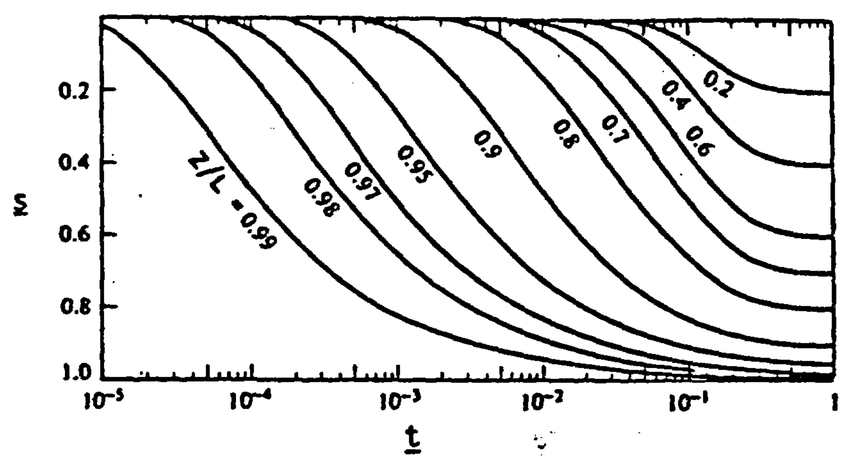
PRELIMINARY

TYPE CURVE FOR s VS. t AND Z/L

Figure A 1a-B

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



After Bredehoft and Pinder, 1970

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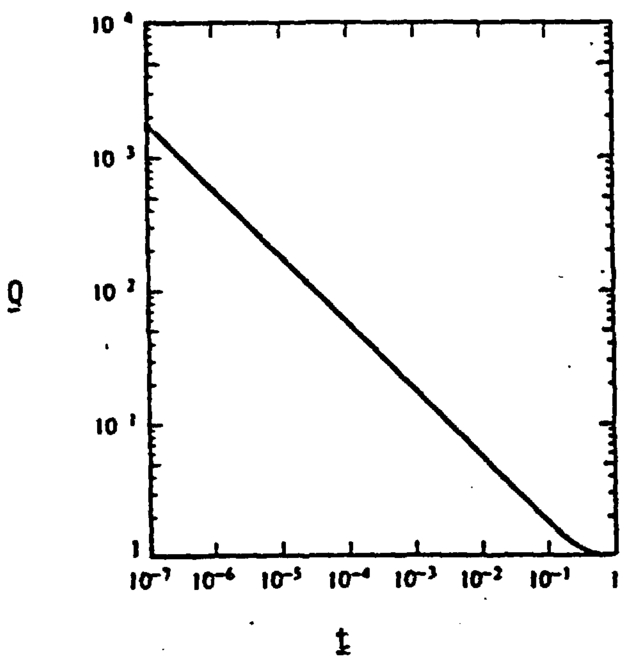
TYPE CURVE FOR Q VS. t

PRELIMINARY

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



(After Bredehoft and Pinder, 1970)

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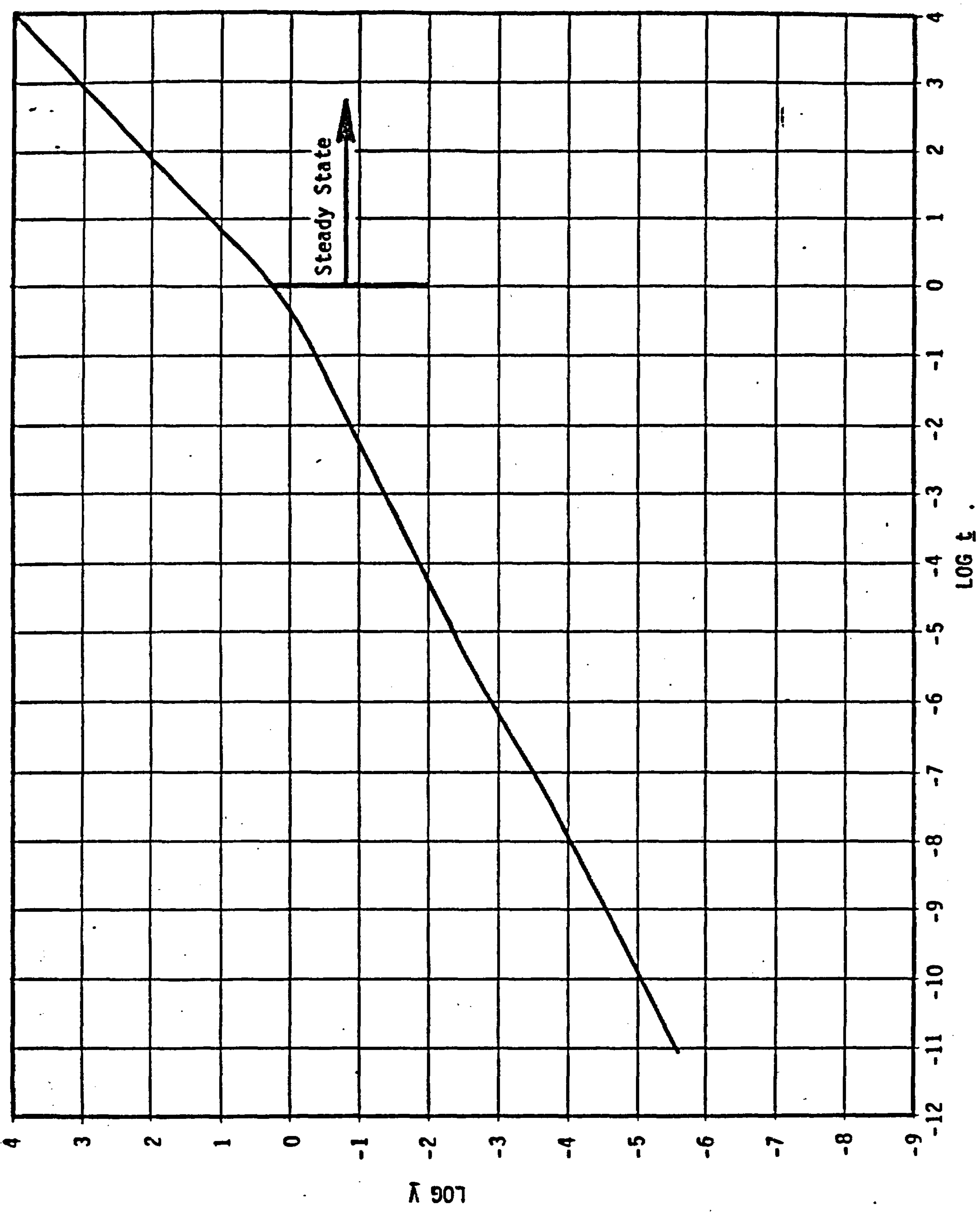
Golder Associates

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

Figure A1a-D



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ATTACHMENT A

DOCUMENTS REQUESTED

, RHO-BWI-C-39

, RHO-C-11

, SD-BWI-62

, SD-BWI-63

, SD-BWI-64

, SD-BWI-TI-187

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ATTACHMENT B

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BWIP LIBRARY INVENTORY
JANUARY 30, 1986

, , PARTS - TABLES, FIGURES, MAPS FROM DOC. - A.B. FILE 823-2106 (82/11)
RHO-BWI-ST-14 NWC #: 1037

, , ISSUES FOR SIA DEVELOPMENT RE: GROUNDWATER FLOW, A.B. FILE - 823-2106 (82/11)
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, , THIRD QUARTERLY PROGRESS REPORT, PROJECT FIN NO. B8956, STOCHASTIC ANALYSIS OF SOLUTE TRANSPORT IN UNSATURATED SOILS (84/07)
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