TERRA THERMA, INC.

WATER CONSULTANTS AND ENGINEERS

U.S NUCLEAR REGULATORY COMMISSION
DIVISION OF WASTE MANAGEMENT

Technical Report #14

SIGNIFICANCE OF LATERAL BOUNDARIES ON HYDRAULIC HEADS AT BWIP

Basalt Waste Isolation Project
Subtask 2.5
Numerical Evaluation of Conceptual Models

Prepared by

Terra Therma Inc.

for

Nuclear Waste Consultants

TECHNICAL ASSISTANCE IN HYDROGEOLOGY
PROJECT B - ANALYSIS
RS-NMS-85-009

MAY, 1987

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 GENERAL STATEMENT OF THE PROBLEM 1
1.2 RELEVAANCE TO NRC 2

2.0 OBJECTIVE 3

3.0 EVALUATION 3

4.0 ANALYSIS 5

5.0 CONCLUSIONS 6

6.0 DISCUSSION 7

LIST OF FIGURES

FIGURE 1. HEAD DIFFERENCES REQUIRED TO PRODUCE A SIGNIFICANT EFFECT (10^{-3}) ON GRADIENT AT THE RRL AS A FUNCTION OF DISTANCE FROM THE RRL 8

FIGURE 2. CONTOURS OF HEAD DIFFERENCE REQUIRED TO PRODUCE A 10^{-3} INCREMENTAL CHANGE IN GRADIENT THROUGH THE RRL 9

1.0 INTRODUCTION

1.1 GENERAL STATEMENT OF THE PROBLEM

Concern has been expressed about the potential for significant hydrologic effects at the RRL due to uncertainty in hydraulic head at relatively distant boundaries. Because the aquifer system at the BWIP site is relatively "stiff", characterized by a high ratio of transmissivity to storage coefficient, disturbances in head (whether real - i.e. due to human induced changes such as large-scale irrigation pumping or synthetic - i.e. due to uncertainty in the "true" value of hydraulic head) at a given location are transmitted through the system quite rapidly.

In order to absolutely characterize these effects it would be necessary to collect precise and accurate ground water level data from a large area surrounding the RRL, to locate and characterize all hydrologic boundaries for a considerable distance from the RRL, and to model all physically reasonable disturbances in the head system. However, more than rapid propagation of effects to the RRL is required to demonstrate that distant boundary conditions produce significant effects at the RRL.

For boundary conditions to be relevant to the NRC, a boundary condition must (1) impact a parameter that is of regulatory concern, and (2) produce a change

in that parameter value of sufficient magnitude and appropriate direction to affect the regulatory decision.

1.2 RELEVANCE TO NRC

Uncertainty in hydraulic head values at lateral boundaries will produce uncertainty in gradients between the boundary and the RRL and in gradients across the RRL. Boundary effects are manifested at the RRL in the head values that are measured. Regulatory concerns related to head are (1) pre-emplacement ground water travel time (GWTT) (10 CFR 60.113(B)(2)), (2) post-emplacement radionuclide flux (10 CFR 60.112), and (3) certain matters described in the Siting Criteria (10 CFR 60.122). In both performance objectives, gradient, rather than absolute head, directly affects the analysis. For the purposes of this initial analysis, TTI will use gradient as the performance measure, in large part due to the primary regulatory importance of the performance objectives, and the analysis will deal only with pre-emplacement gradients.

2.0 OBJECTIVE

The objective of this Technical Report is to determine the sensitivity of gradients across the RRL to uncertainty in hydraulic head at lateral boundaries as a function of distance from the RRL. This determination will be useful in assessing the level of precision and accuracy required for additional water level data from areas outside the RRL.

3.0 EVALUATION

A "worst-case" scenario for estimating effects of uncertainty in hydraulic head (at steady state) on gradients across the RRL is to assume that the differences due to the range of uncertainty in hydraulic head are permanent. Based on this scenario, the gradient across the RRL is linear, and the effect of head difference on that gradient is directly proportional to distance of the point at which head is measured from the center of the RRL; i.e. a one-meter head difference would change the gradient through the RRL by .001 if that head difference occured at a lateral distance of 1 km from the center of the RRL; if the distance instead were 10 km, the effect of a one-meter change in head on gradient would be only .0001. Thus, the analysis consists of

plotting head differences for "significant" changes in gradient through the RRL versus distance from the center of the RRL.

Although this approach to establish the significance of head differences is quite simplistic, several conservative assumptions have been made. These assumptions include the following:

1. Steady-state conditions, which assumes any disturbance in heads due to boundary effects, such as surface recharge or equalizing of heads along a fracture will persist for an infinite period of time;

2. Distance from the center of the RRL is used, though the proper approach for a steady-state analysis would be to use two times the distance from the center; i.e. the "pivot point" should be considered to be an equal distance, in the opposite direction, from the source of head difference; and

3. "Significant" is defined as being of the same order of magnitude as the existing hydraulic gradient through the RRL, i.e. 10^{-3}. Existing gradients in the range of 10^{-3} to 10^{-4} have been measured; this range of values has been used in previous analyses of pre-emplacement ground water travel time (GWTT). Gradients through the RRL during and after project operation are expected to be significantly higher, due to physical disturbances and thermal effects. Therefore boundary effects will be proportionately less significant.

4.0 ANALYSIS

Results of this analysis are depicted graphically in Figures 1 and 2. Figure 1 is a plot of distance from the center of the RRL versus significant head difference, based on an existing gradient of 10^{-3}.

Head values from this graph may be interpreted as the level of accuracy required for head data as a function of distance from the center of the RRL. Thus, at a point 1.0 kilometer from the RRL, accuracy within 1.0 meter for head data would be adequate.

Figure 2 superimposes the information from Figure 1 on a regional map centered on the RRL. This map can be used to determine the required accuracy of head data for a given location.

5.0 CONCLUSIONS

The lower limit of significant head differences, relative to effect on gradients through the RRL, increases in direct proportion with distance from the center of the RRL. This lower limit of significant head difference also defines the appropriate level of accuracy of measured head data as a function of distance from the RRL.

6.0 DISCUSSION

An important result of this analysis is that it demonstrates that regulatory concerns relevant to head and gradient through the RRL can be answered without obtaining very detailed and accurate head data over a large area surrounding the RRL. At a distance of 10 km from the center of the RRL, for example, accuracy of measurements within a range of 10 meters is not only adequate, but appropriate, given that the accuracy of measured gradients within the RRL is on the order of 10^{-3}.

This suggests that for post-emplacement conditions, real head variations (e.g. due to long term climatic effects or human-induced perturbations) need to be known (predicted) only to the same level of accurracy as is needed to address uncertainty in pre-emplacement gradients across the RRL.

FIGURE 1. HEAD DIFFERENCES REQUIRED TO PRODUCE A SIGNIFICANT EFFECT(10^{-3}) ON GRADIENT AT THE RRL AS A FUNCTION OF DISTANCE FROM THE RRL

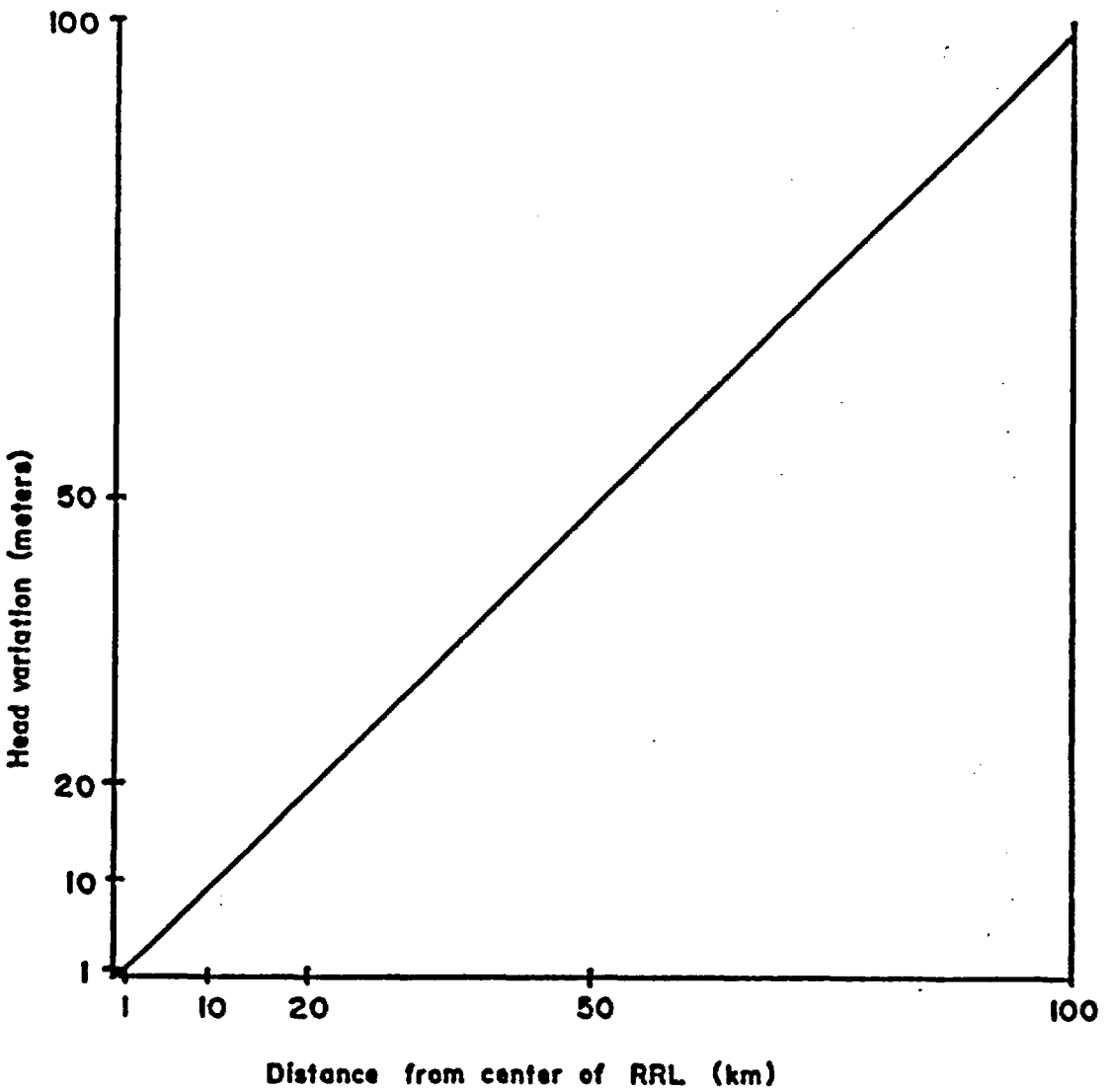
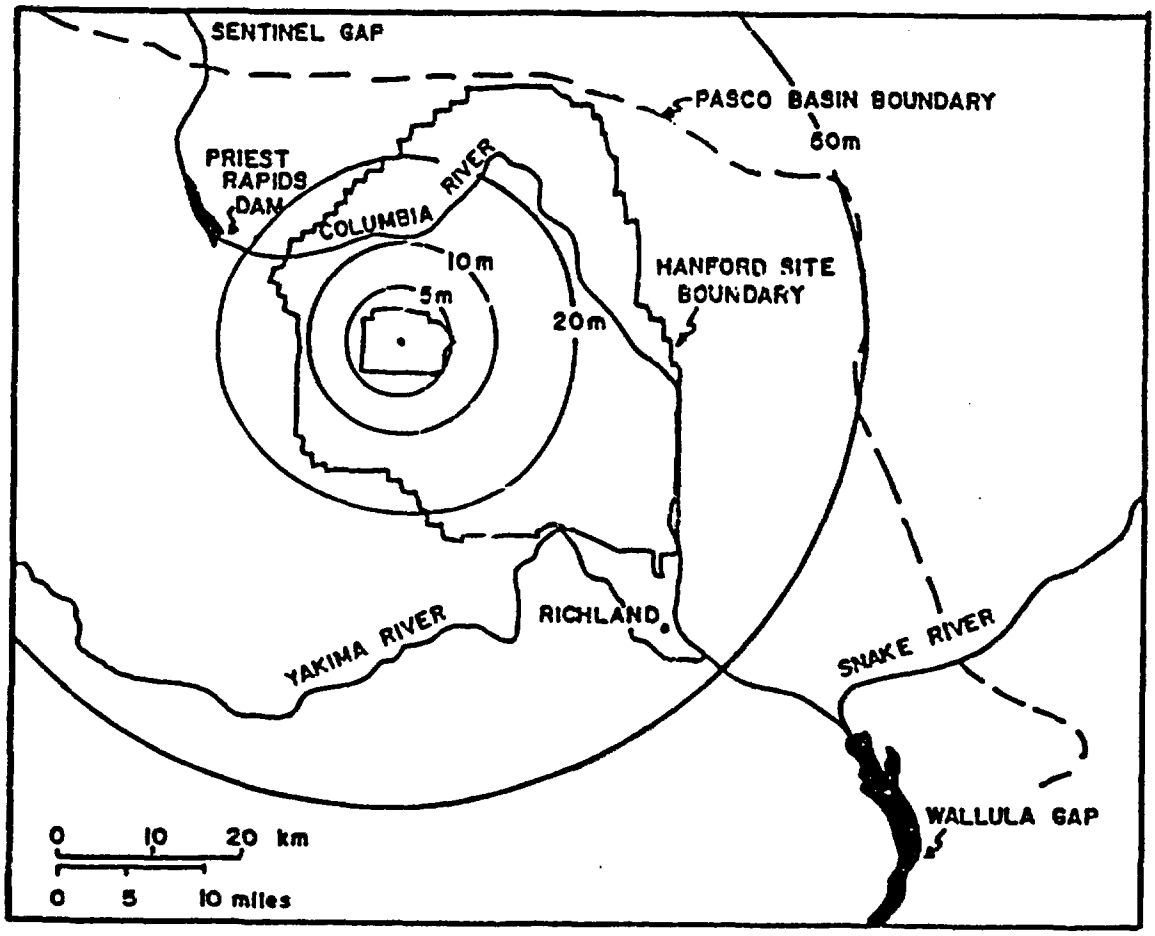


FIGURE 2. CONTOURS OF HEAD DIFFERENCE REQUIRED TO PRODUCE A 10^{-3} INCREMENTAL CHANGE IN GRADIENT THROUGH THE RRL

(VALUES IN METERS)



PDR-(1)
LPDR wm-10 (a)
wm-11 (a)
wm-16 (a)

wm-RES
Docket File
D1021

10/11/16

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x Pohle

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June 12, 1987

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Communication No. 165

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

Lee Pohle for enclosures

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

Re: Semi-Annual Update of BWIP Numerical Evaluation Report

Dear Mr. Pohle:

This cover letter transmits to the NRC staff Terra Therma Inc.'s (TTI) semi-annual update of the Numerical Evaluation Report for BWIP (Subtask 2.5). The report has received management and technical reviews by M. Logsdon and A. Brown of Nuclear Waste Consultants. The reports have been completed under TTI's quality assurance procedures in compliance with NWC's project-specific QA Plan.

This update report includes three reports for Staff review and comment:

Technical Report	Title	Author
11	Evaluation of a Large-Scale Tracer Test Conducted in Grande Ronde Basalt	Galloway/ Marinelli
13	Effects of Repository Heat on Groundwater Flux: One-Dimensional Analysis	Marinelli
14	Significance of Lateral Boundaries on Hydraulic Heads at BWIP	Kraeger-Rovey

Additional reports currently in progress and which should be completed during the next two months include:

Technical Report	Subject	Author
10	Effect of Variable Density on Heads	Marinelli
12	Lumped Parameters in Evaluating GWTT	Brown
15	Effects of Vertical Boundaries on Hydraulic Heads at BWIP	Kraeger-Rovey

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PKg dupe

16	Stabilization of Gradients at BWIP	Galloway
17	Hydraulic Continuity Across the RRL	Basse

Submission of this update report completes the contract deliverable for Subtask 2.5 at this time. Please note that this is the final required deliverable for Subtask 2.5 under the current contract. However, TTI will continue to pursue the Technical Report series over the remaining months of the current contract, as part of the data needs assessment effort in preparation for the BWIP SCP. The results of these efforts will be forwarded to the Staff as they are completed as deliverables under Subtask 2.5, and the results will be available for submission as Subtask updates on a semi-annual basis if the Staff does in fact extend the current contract.

If you have any questions concerning this letter or the attached report, please contact me immediately.

Respectfully submitted,
NUCLEAR WASTE CONSULTANTS, INC.

Mark J. Logsdon, Project Manager

Att: BWIP Numerical Evaluations - Semi-Annual Update Report (Subtask 2.5)

cc: US NRC - Director, NMSS (ATTN: PSB)
HLWM (ATTN: Division Director) - 2
Mary Little, Contract Administrator
HLWM/TRB (ATTN: Branch Chief)
J. Minier, DBS
L. Davis, WWL

bc: M. Galloway, TTI

TERRA THERMA, INC.
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June 8, 1987

Nuclear Waste Consultants
8341 S. Sangre de Cristo Road
Littleton, Colorado 80127

Att: Mark Logsdon, Project Manager

Re: Subtask 2.5 Update

Dear Mr. Logsdon:

This letter and the attached documents constitute the Subtask 2.5 Update, as required by the NRC-NWC scope of work and contract for the Technical Assistance Program.

Terra Therma personnel are presently engaged in the analysis and completion of numerous Technical Reports under the 2.5 Subtask heading. At this time, three of the reports have been completed and are listed.

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12	Lumped Parameters	Brown
15	Effect of Boundaries on Vertical Heads/Gradients	Rovey
16	Stabilization of Gradients at BWIP	Galloway
17	Hydraulic Continuity Across the RRL	Basse

If we can provide any additional information or clarification, please do not hesitate to call us.

Sincerely,
TERRA THERMA, INC.

Michael Galloway

Michael Galloway
Project Manager

ATT

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June 8, 1987

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Sincerely,
TERRA THERMA, INC.

Michael Galloway

Michael Galloway
Project Manager

ATT