WILLIAMS & ASSOCIATES, INC.

P.O. Box 48, Viola, Idaho 83872 (208) 883-0153 (208) 875-0147

Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

WM DOCKET CONTROL CENTER

'86 NOV 21 P3:10

November 20, 1986
Contract No. NRC-02-85-008
Fin No. D-1020
Communication No. 95

WM-RES
WM Record File D1020 WEA

WM Project 10, 11, 16
Docket No. ____
PDR ✓
LPDR ✓ (B, N, S)

Distribution:
Pohle
(Return to WM, 623-SS) Sac

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Jeff:

This letter conveys our draft outline for Topical Report #1 related to groundwater travel time estimation. We have used the title "Categories of Uncertainty" for this outline.

The purpose of this outline of Topical Report #1 is to list the sources of uncertainty inherent in the prediction of groundwater travel times. The sources of uncertainty are listed by category. The categories of uncertainty were selected to represent the various phases of effort required for predicting groundwater travel time.

The outline includes the uncertainties initiated from the start of data collection to the uncertainties inherent in the prediction of groundwater travel time. It includes consideration of both saturated and unsaturated flow of groundwater. The outline lists uncertainties because of the subjective nature of the professional judgement that is required during data evaluation, coefficient estimation and calculation of groundwater travel time distributions. The list contains the uncertainties that are associated with both the deterministic approach and the deterministic/stochastic approach of predicting groundwater travel times. The outline is limited to consideration of pre-emplacement groundwater travel times; uncertainty involved in evaluation of post-waste emplacement conditions are not listed in this outline.

This outline has passed Williams and Associates, Inc.'s standard review process. This process ensures that the product has passed Williams and Associates, Inc.'s quality assurance procedures.

Sincerely,

Gerry Winter

Gerry V. Winter

3497

CATEGORIES OF UNCERTAINTY

I. HYDROGEOLOGIC CONCEPTUAL MODEL(S)

A. Uncertainty about delineation of hydrogeologic framework (layers, zones, fold axes, faults).

B. Uncertainty about the distribution of hydrogeologic coefficients within the hydrogeologic framework or flow domain (layers, zones, anisotropy, heterogeneity, discontinuities as related to geology).

C. Uncertainty about the boundary conditions of the hydrogeologic framework.

1. Uncertainty about the definition of geologic boundaries (faults, facies changes, fold axes, collapse breccia structures, sedimentary features, groundwater divides).

2. Uncertainty about the location of the recharge areas.

3. Uncertainty about the location of the discharge areas.

4. Uncertainty about the recharge and discharge rates.

5. Uncertainty about whether the upgradient and downgradient boundaries can be assumed constant head or constant discharge boundaries.

6. Uncertainty about the initial conditions at boundaries.

7. Uncertainty about whether steady or unsteady flow conditions are operable.

D. Uncertainty in the conceptual model of flow processes (saturated flow, unsaturated liquid water flow, water vapor flow).

E. Uncertainty about the hydrochemical and isotopical characteristics of the ground water resource system.

1. Uncertainty about the hydrochemical and isotopical distinctness or lack of distinctness of the groundwater from different portions of the flow system.

2. Uncertainty about the hydrochemical and isotopical equilibration of the groundwater with the geologic environment.

3. Uncertainty about the hydrochemical and isotopical evolution of the groundwater.

4. Uncertainty about the correlation of groundwater flow paths and travel times with the hydrochemistry and isotopic characteristics.

II. UNCERTAINTY IN KNOWLEDGE ABOUT THE THREE-DIMENSIONAL DISTRIBUTION OF HEAD.

A. Uncertainty about sources of energy other than fluid potential energy.

B. Uncertainty in head measurements in saturated and unsaturated zones (uphole, downhole, tape, transducer, tensiometer, psychrometer, effect of borehole location and depth).

C. Uncertainty about direction of horizontal and vertical gradients.

III. UNCERTAINTY ABOUT THE EFFECT OF TRANSPORT OF DISSOLVED SOLIDS (NO EFFECT DUE TO PREEMPLACEMENT CONDITIONS; DISPERSION IS NOT PERTINENT).

IV. UNCERTAINTY IN CONVERSION OF HYDROGEOLOGIC CONCEPTUAL MODEL(S) TO DETERMINISTIC MATHEMATICAL MODEL(S) FOR PURPOSES OF TESTING.

A. Uncertainty about whether geologic conditions required for application of solutions to partial differential equations are met.

B. Uncertainty about whether the scale of the hydrogeologic conceptual model(s) is compatible with the scale of the deterministic mathematical model(s) used for testing.

C. Uncertainty due to data collection.

1. Measurement error (downhole, uphole, tape, transducer).

2. Errors in running test.

a. Maintaining constant pumping rate or measuring variable pumping rate.

b. Correcting for head changes as temperature changes during test.

c. Incompatible head patterns measured during tracer tests.

3. Uncertainty created by the collection and selection of "representative" core samples for laboratory analysis.

4. Uncertainty introduced by selection of depths and locations of boreholes.

   a. Uncertainty about whether locations of boreholes are appropriate with respect to lithologic and structural features.

   b. Uncertainty introduced by non-random procedure used for selecting borehole sites.

   c. Uncertainty introduced by vertical and horizontal distances between boreholes that are inappropriate for analytical methods.

   d. Uncertainty introduced by construction of piezometers.

   e. Uncertainty introduced by existing open boreholes that cause interunit flow of groundwater.

D. Uncertainty about whether the numerical or analytical deterministic model(s) selected for coefficient calculation reflect field conditions.

1. Uncertainty in the degree to which assumed conditions as required by the selected analytical or numerical deterministic model(s) are present in the hydrogeologic framework being tested.

2. Uncertainty in the compatibility of scale of test(s) with scale of model selected.

3. Uncertainty in applying equivalent porous media deterministic models to fractured rocks.

4. Uncertainty introduced by combining results of different types and scales of tests.

E. Uncertainty in the professional subjective judgement required for the calculation of distributions or ranges of values of hydrogeologic coefficients.

1. Uncertainty introduced by treatment of externally produced perturbations.

2. Uncertainty in emphasis placed on selected portions of the data base.

3. Uncertainty introduced by deviations of data from analytical or numerical deterministic model expectations (poor curve matches).

4. Uncertainty in interpretation of boundaries from the results of the tests (as opposed to mapped geologic features).

F. Utilization of calculated coefficients.

1. Uncertainty in the selection of the size of area to which calculated values of coefficients are applied.

2. Uncertainty in the definition of the hydrostratigraphic unit to which the data are applied.

3. Uncertainty in selecting distributions or ranges of values of hydraulic conductivity from values of transmissivity.

4. Uncertainty in calculating distributions or ranges of effective thickness from borehole flow logs, borehole geophysical logs and tracer test results.

5. Uncertainty caused by different sample sizes among different hydrogeologic coefficients. Size of sample influences distribution and range of resulting data (effective porosity versus hydraulic conductivity).

G. Uncertainty in deciding how much testing is sufficient.

H. Uncertainty in interpreting the relationship between hydrochemical and isotopic data and the groundwater flow system that is interpreted based on field determined hydrogeologic coefficients.

V. UNCERTAINTY IN MODEL PREDICTIONS OF GWTT.

A. Uncertainty resulting from utilizing deterministic model(s) for predicting GWTT.

1. All the uncertainties under items I, II, and IV carry through.

2. Uncertainty due to mathematical approximations and numerical instabilities.

3. Uncertainty caused by the lumping of the coefficients in the hydrogeologic conceptual model(s).

4. Uncertainty about whether boundaries in the hydrogeologic conceptual model can be portrayed mathematically in the deterministic mathematical model.

5. Uncertainty in the designation of initial conditions.

6. Uncertainty introduced by the subjective selection of the model element geometry used in the deterministic analysis.

7. Uncertainty introduced by the designation of coefficients for input into the deterministic model(s).

8. Uncertainty in the subjective selection of the acceptable range of deterministic model outputs of GWTT.

B. Uncertainty resulting from utilizing deterministic model(s) with stochastic analyses (deterministic/stochastic model(s)) for predicting GWTT.

1. Uncertainties listed in items I, II, and IV carry through.

2. Uncertainties due to mathematical approximations and numerical instabilities.

3. Uncertainty introduced by the differences between the geometry and scale of the deterministic model(s) adopted for testing and the geometry and scale of the deterministic model to which stochastic analysis is applied.

4. Uncertainty introduced by the subjective selection of the model element geometry used in the deterministic/stochastic analysis.

5. Uncertainty in the decision of which coefficients and the number of coefficients that are to be treated stochastically in the deterministic model framework.

6. Uncertainty introduced by the stochastic analysis itself.

7. Uncertainty due to technical limitations on defining and applying correlation structure(s) within and among hydrogeologic coefficients for the stochastic portion of the model(s).

8. Uncertainty about the validity of data point values that are considered to be fixed during kriging and conditional simulation.

9. Uncertainty caused by different sample sizes of hydrogeologic coefficients.

10. Uncertainty in the professional judgement used in the identification of the portion of the GWTT output from the stochastic procedure which is defensible in a hydrogeologic context.

11. Uncertainty in determining whether the output of a deterministic/stochastic modeling procedure for GWTT is a true probability distribution or simply a cumulative frequency distribution.

C. Purely stochastic GWTT model(s) are not possible because values of GWTT are only available via application of wholly or partial deterministic model(s).