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Scientific Notebook # 297: 3D Saturated Zone Numerical Modeling Work Site Scale Model

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

3D SATURATED ZONE NUMERICAL MODELING WORK...

SITE SCALE MODEL

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INITIAL ENTRIES

OBJECTIVE

The primary objective of this work is to develop a site-scale numerical model of the saturated zone in the vicinity of the proposed Yucca Mountain repository (see Figure 1). This site scale model has been abstracted from the regional saturated zone model. The details of the regional saturated zone model are discussed in "REGIONAL GROUNDWATER FLOW AND TRITIUM TRANSPORT MODELING AND RISK ASSESSMENT OF THE UNDERGROUND TEST AREA, NEVADA TEST SITE, NEVADA" ... dated October 1997. The goal of the site-scale model is to add more detail to the modeling effort than is practical in the regional model and so improve the model calibration. The improved model will improve transport flow path estimates and flow tube geometry. The extracted model/site-scale model will be calibrated against existing hydraulic head-data for the site. The software packages which will be used in the modeling process include, Groundwater Modeling System (GMS), MODFLOW and PEST (~~an~~ a model-independent parameter optimiser).

THE SITE SCALE MODEL

The geometry of the site scale model was designed by ~~Amit Armstrong~~ staff of CNWRA. ~~Figure 1~~ (D.AF. 11/16/98) The extraction from the regional model was peformed by one of the CNWRA consultants. On recieving the extracted model, CNWRA staff translated and rotated to model into an appropriate coordinate system. In this case the coordinate system used was the UTM system. A 5° rotation (measured clockwise from the north) was necessary to ~~allign~~ align the model with the regional model. The translation and rotation were all peformed in the GMS (Groundwater Modeling System) by CNWRA staff.

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FIGURE 1: DOMAIN OF SITE-SCALE MODEL

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Similar to the regional model the site-scale model is composed of 20 hydrostratigraphic layers. These hydrostratigraphic units are summarized in the following table (TABLE 1).

TABLE 1: HYDROSTRATIGRAPHIC UNITS / GEOLOGIC MODEL LAYERS USED IN REGIONAL AND SITE-SCALE MODELS

Consolidated Unit	Geologic Model Layer	Original Unit	Description
AA	20	AA	Alluvial Aquifer
TMA	19	TMAQ-7	Uppermost Welded Tuffs
TC	18	TPTC-6	Laterally Variable Tuffs and Lava Flows of Paintbrush Group Tuff Cone
		TPTC-5	Laterally Variable Tuffs and Lava Flows of Calico Hills
TCB	17	TCBCU-4	Non-Welded Tuffs
TBA	16	TBAQ-3	Welded Tuffs Above BCU-2
BCU	15	BCU-2	Non-Welded Tuffs
BAQ	14	BAQ-1	Welded Tuffs
VA	13	WTA	Welded Tuff Aquifer
		VTA	Vitric Tuff Aquifer
		TCU2	Zeolitized Tuff Confining Unit (Upper) Volcanic Tuff Aquifer
		TPTA	Topopah Springs Tuff Aquifer
		WLA	Wahmonie Lavas Aquifer
VCU	12	TCU1	Zeolitized Tuff Confining Unit (Lower)
		VCCU	Volcaniclastic Confining Unit (Volcanic Tuff Confining Unit)
VU	11	VU	Volcanics Undifferentiated
TSDVS	10	TS DVS	Tertiary Sediments Death Valley Section
LCA3	9	LCA3	Lower Carbonate Aquifer (Yucca Flat Upper Plate), Upper Carbonate Aquifer in NTS Area
UCCU	8	UCCU	Upper Clastic Confining Unit
LCA	7	LCA	Lower Carbonate Aquifer
LCCU	6	LCCU	Lower Clastic Confining Unit
LCA1	5	LCA1	Lower Carbonate Aquifer (Upper Plate)
LCCU1	4	LCCU1	Lower Clastic Confining Unit (Upper Plate)
LCA2	3	LCA2	Lower Carbonate Aquifer (Lower Plate)
LCCU2	2	LCCU2	Lower Clastic Confining Unit (Lower Plate)
I	1	I	Intrusives

Taken from "Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada" p. 4-9

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The tops and bottoms of the model layers are summarized in Table 2

TABLE 2: ELEVATIONS OF MODEL LAYERS USED IN BOTH THE REGIONAL AND SITE-SCALE MODELS

Model Layer	Elevation (m above amsl[a])
1	1,750 to 2,000
2	1,500 to 1,750
3	1,350 to 1,500
4	1,200 to 1,350
5	1,050 to 1,200
6	900 to 1,050
7	700 to 900
8	600 to 700
9	475 to 600
10	350 to 475
11	225 to 350
12	100 to 225
13	-50 to 100
14	-250 to -50
15	-500 to -250
16	-1,000 to -500
17	-1,500 to -1,000
18	-2,000 to -1,500
19	-3,000 to -2,000
20	-4,000 to -3,000

[a] amsl = Average mean sea level

Taken from "Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada" p. 7-10.

Assumptions inherent in the model as summarized as follows:

(i) movement of water ~~at the st~~ in (D.A.J. 11/16/98) fractures (at the site scale as at the regional scale) can be adequately described by a porous media model

(ii) variations in groundwater density due to changes in temperature or chemistry are negligible

(iii) the model is reflective of conditions prior to development; hence the system is at steady-state.

Other assumptions used in the modeling effort will be discussed later in this summary.

DOMAIN

The domain of the site scale model is shown in Figure 1. The domain is made up of 20 layers variably spaced. Within each layer the domain is discretized using a mesh spacing of $\Delta X = 300$ m and $\Delta Y = 300$ m. The length of the domain is approximately $Y =$ ~~6x~~ 60 km and width $X = 30$ km. The total thickness of the model is approximately 6000 m. Using these parameters the total number of elements in the system is ~~app.~~ 400,000 (D.A.J. 11/16/98).

BOUNDARY CONDITIONS

The boundary conditions used in the site-scale model were estimated largely from the regional scale model. Along the exterior of the domain constant head nodes are commonly applied. The values of these applied heads are determined based on the results of the regional flow model. Where the nodes of the regional model and site-scale model coincide, the ~~head~~ (D.A.J. 11/16/98) hydraulic head obtained on the regional model is applied to the site-scale model. Linear interpolation is used to estimate hydraulic heads at intermediate nodes on the ~~m~~ (D.A.J. 11/16/98) mesh of the site-scale

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model (Figure 2)

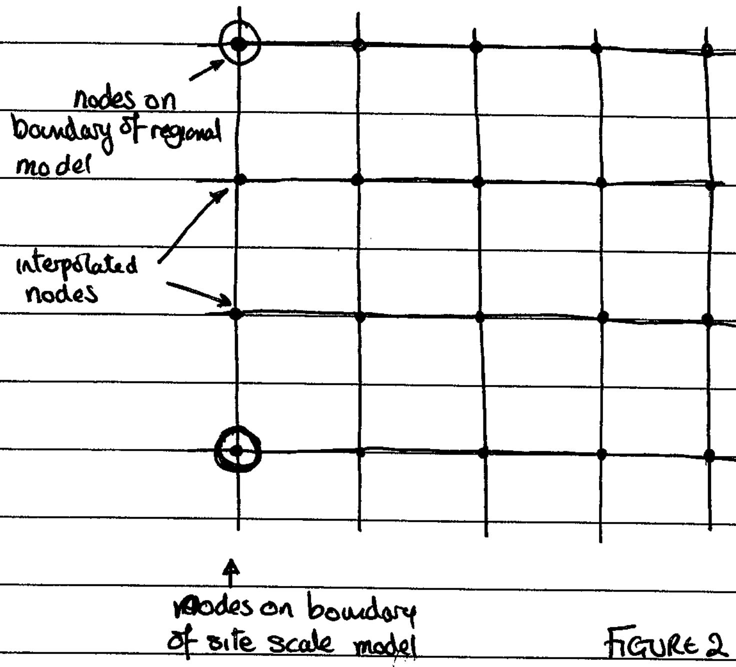
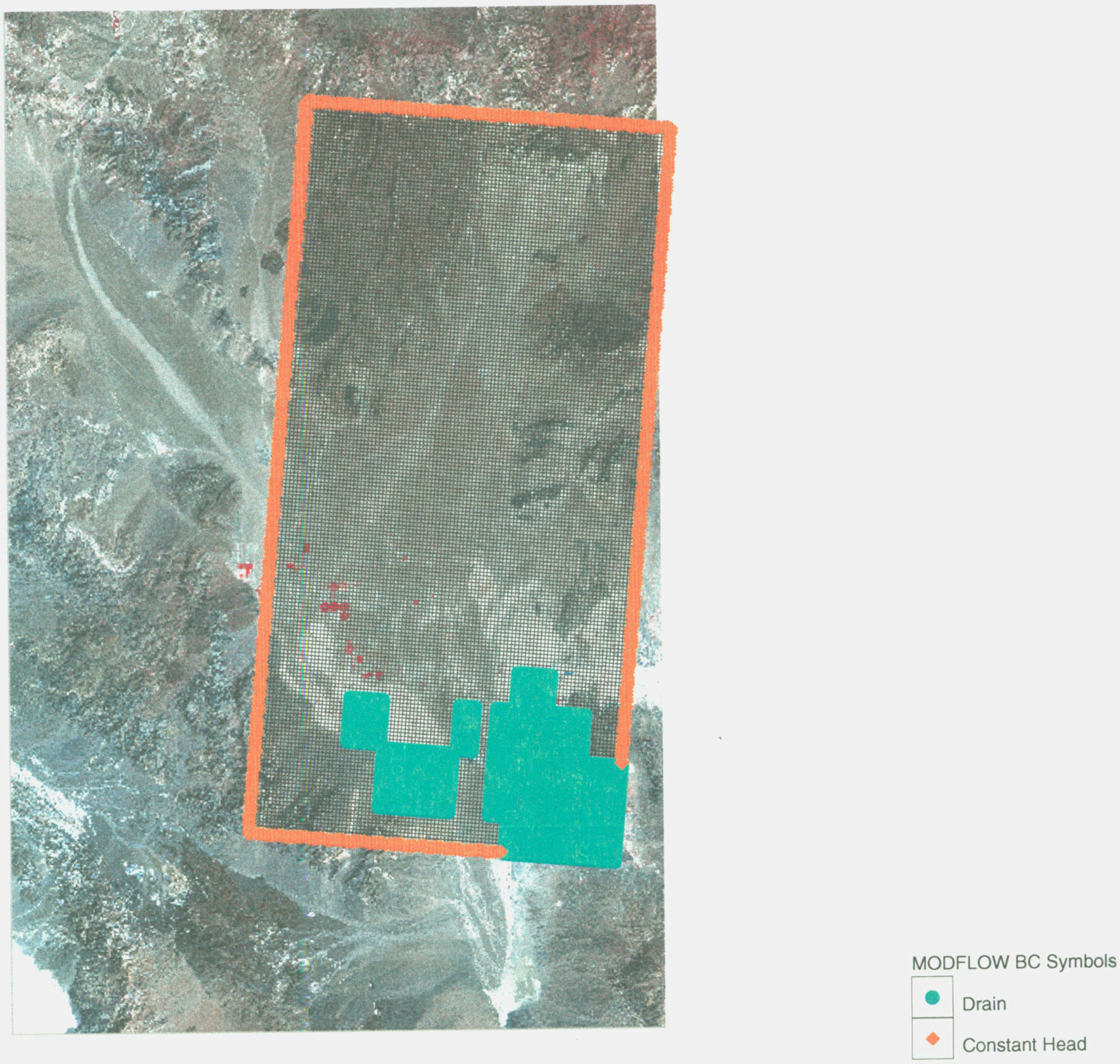


FIGURE 2

Constant head boundary conditions are applied to the entire domain for layers 20 – 9. Along the south east corner of the domain for layer 8 (D.A.F. 11/16/98) drain boundary conditions are imposed. The ~~domain~~ boundary conditions for layer 8 are demonstrated in Figure 3. The drain boundary condition is used for surface discharging zones. The discharges shown along the southern portion of layer 8 represent the discharge zones around Ash Meadows. The drain conditions functions as follows. Drain elevations are specified. Discharge is zero when simulated heads (D.A.F. 11/16/98) ~~are below~~ at the location of the drain are below the elevation of the drain. When heads at the location of the drain exceed the elevation of the drain discharge occurs. The magnitude of the discharge is proportional to the difference between the elevation of the drain and the simulated hydraulic head. In the regional scale model the ~~drain~~ elevation of the drain ~~is~~ was initially set to an elevation approximately 5 m below the land surface to approximate the ET extinction depth (see "Regional Groundwater Flow and Tritium

Figure 3: Boundary Conditions for Layer 8



Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada; 3, p. 7-17). ~~In the regionals~~ where the land surface elevation used (D.A.J. 11/16/98) in the calculation was the lowest point in each model cell that fell within the discharge area.

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In the regional scale model the hydraulic conductance of the ~~area~~ interface (D.A.J. 11/16/98) between the aquifer and the drain ~~is~~ was calculated using the relationship

$$cond_{i,j,k} = \frac{A_{i,j,k}}{A_{D.A.}} \times \frac{FLUX_{D.A}}{(h_{i,j,k} - d_{i,j,k})}$$

where $A_{i,j,k} \equiv$ area of drain cell i,j,k

$A_{D.A.} \equiv$ total area of specified discharge area

$FLUX_{D.A} \equiv$ total estimated discharge flux from specified discharge area

$h_{i,j,k} \equiv$ hydraulic head in drain cell i,j,k

$d_{i,j,k} \equiv$ drain elevation in cell i,j,k

For the regional scale model ($h_{i,j,k} - d_{i,j,k} = 3.01$ m)

~~For layo~~ (D.A.J. 11/16/98)

~~Hydrostratigraphic units above layer 7 were not represented across the entire domain~~ D.A.J. (11/16/98)

The active flow regions in hydrostratigraphic units 7 to 1 did not fill the entire domain of the site-scale model (see eg, Figure 4a, 4b (D.A.J. 11/16/98) ~~Figure 4~~). The inactive flow region is specified ~~as~~ explicitly as a noflow zone through the specification of IBOUND = 0.

Fig. 4a : Inactive and active flow regions for layer 7

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Fig 4b: Active and inactive flow regions for layer 5

MODEL HYDRAULIC CONDUCTIVITIES/TRANSMISSIVITIES

This work was terminated incomplete after a staff change.

E. C. P[signature]
4/1/2003

I have reviewed this scientific notebook and find it in agreement with QAP-001. There is sufficient information regarding methods used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

E. C. P[signature]
4/1/2003