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ANALYSIS REPORT
TASK 2 OF AP-088
ESTIMATING BASE TRANSMISSIVITY FIELDS

(AP-088: Analysis Plan for Evaluation of the Effects of Head Changes on Calibration of Culebra Transmissivity Fields)

Task Number 1.3.5.3.1.2

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Table of Contents

1.0 Introduction

This analysis report describes the activities from Task 2 of AP-088, "Analysis Plan for Evaluation of the Effects of Head Changes on Calibration of Culebra Transmissivity Fields." The purpose of this task is to develop a geologically-based predictor of mean Culebra transmissivity using a standard linear-regression approach and use this predictor to generate 100 equally probable realizations of the Culebra mean transmissivity field. Realizations must show stochastic variability in the location of the high-transmissivity zones. This task is subdivided into six subtasks:

1) Conceptual Model Development – Formalize a conceptual model for geologic controls on Culebra Transmissivity.
2) Linear Regression Analysis – Regress geologic controls against Culebra transmissivity data to determine regression coefficients for geological controls on transmissivity.
3) Reduction of Geological Map Data – Import geological map data from Task 1 into a GIS environment and create data files of geological and "soft" data for the Culebra model domain.
4) Indicator Variography – Analyze variograms of an indicator function of high Culebra transmissivity to define a variogram model and variogram model parameters.
5) Conditional Indicator Simulation – Use variogram-model parameters for the high-transmissivity indicator to generate 100 conditional realizations of the spatial locations of high-transmissivity zones in the Culebra.
6) Construction of Transmissivity Fields – Use the regression coefficients, the 100 realizations of high-transmissivity indicators, and the other geologic data to generate 100 realizations of the mean transmissivity in the Culebra model domain.

The activities associated with each of these subtasks are described below.

2.0 Subtask 1 – Conceptual Model Development

The purpose of this subtask is to develop a conceptual model of geologic controls on Culebra transmissivity. Geologic controls on Culebra transmissivity are identified and a linear mathematical model relating these controls to transmissivity is constructed. Holt and Powers (1988), Powers and Holt (1990), Beauheim and Holt (1990), and Holt (1997) have described the geology and geologic history of the Culebra. The following conceptual model is developed from their work and is consistent with their interpretations. It is important to note that we follow Holt (1997) and assume that variability in Culebra transmissivity is due strictly to post-depositional processes. Throughout the following discussion the informal stratigraphic subdivisions of Holt and Powers (1988) are used to identify geologic units within the Rustler Formation (Figure 1).

We hypothesize that spatial distribution of Culebra transmissivity is a function of a series of deterministic geologic controls, including Culebra overburden thickness, dissolution of the upper Salado Formation, and the occurrence of halite in units above or below the Culebra. Each of these geologic controls can be determined at any location using geological map data. Because geologic data are not sufficiently resolved, high-transmissivity regions near the WIPP, however, cannot be predicted using deterministic geologic data and are treated as stochastic processes.

In the following, we define a fracture interconnectivity indicator. The specifics of each hypothesized control are then outlined. Finally a linear model relating these controls to Culebra transmissivity is presented.

2.1 Fracture Interconnection

Culebra transmissivity data show a bimodal distribution (Figure 2). As closely spaced wells show very different values, we hypothesize that higher transmissivity values reflect well-interconnected fractures at well locations. Lower transmissivities indicate regions where fracture interconnections are limited. We define a fracture interconnectivity indicator based on a cutoff of log(T) = -5.4 [log(m/s)], e.g.,

$$I_f = \begin{cases} 1 & \log(T) > -5.4 \text{ m/s} \\ 0 & \log(T) \leq -5.4 \text{ m/s} \end{cases} \tag{1}$$

Well-interconnected fractures occur in regions affected by Salado dissolution (e.g., Nash Draw) and in areas with complicated cement dissolution and precipitation histories (e.g., high-transmissivity zones near the WIPP site).

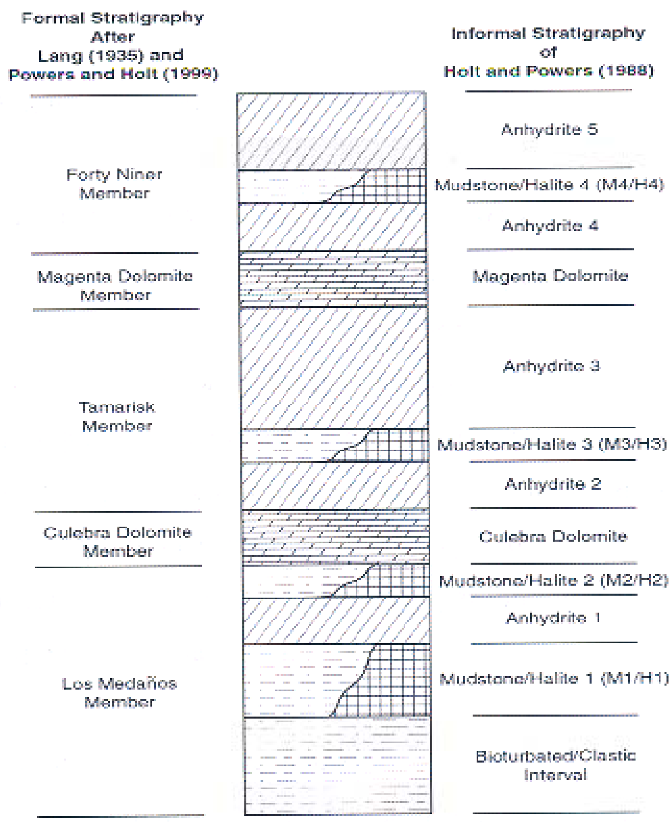

Figure 1. Stratigraphic subdivisions of the Rustler Formation

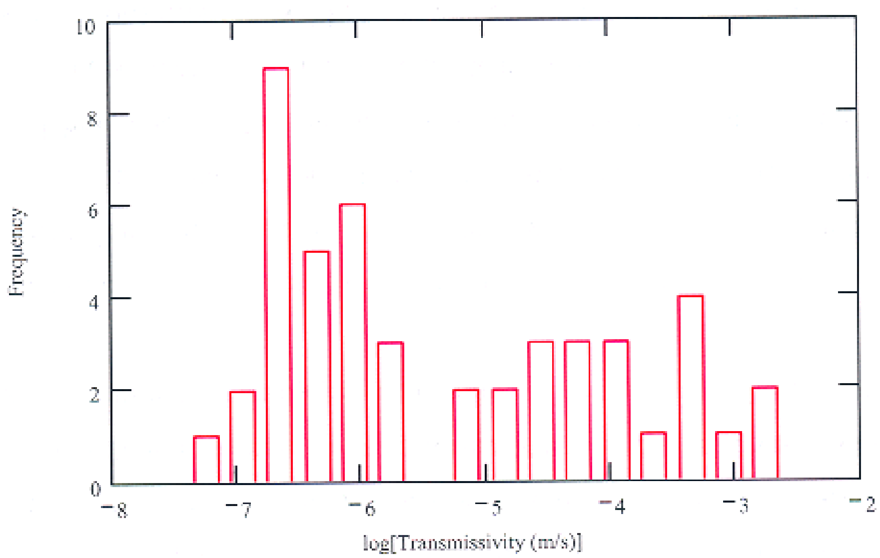

Figure 2. Histogram of log Culebra transmissivity. Data from DOE (1996), Beauheim and Ruskauff (1998), and Beauheim (2002).

2.2 Overburden Thickness

We hypothesize an inverse relationship between Culebra overburden thickness and transmissivity. Overburden thickness is a metric for two different controls on Culebra transmissivity. First, fracture apertures are limited by overburden thickness (e.g., Currie and Nwachukwu, 1974), which should lead to lower transmissivity where Culebra depths are great (Beauheim and Holt, 1990; Holt, 1997). Second, erosion of overburden leads to stress-relief fractures, and the amount of Culebra fracturing increases as the overburden thickness decreases (Holt, 1997).

2.3 Salado Dissolution

South and west of the WIPP site, Cenozoic dissolution has affected the upper Salado Formation (Figure 3). Where this dissolution has occurred, the rocks overlying the Salado, including the Culebra, are strained (leading to larger apertures in existing fractures), fractured, collapsed, and brecciated (e.g., Beauheim and Holt, 1990; Holt, 1997). All WIPP wells within dissolution zone fall within the high-transmissivity population, and we hypothesize that all regions affected by Salado dissolution have well-interconnected fractures and high transmissivity.

2.4 Halite Overlying or Underlying the Culebra

All wells (e.g., H-12) located where halite occurs in the Tamarisk (m3/h3 interval of Holt and Powers, 1988) and Los Medaños Members (m2/h2 interval of Holt and Powers, 1988) of the Rustler Formation (Figure 4) show low transmissivity. Transmissivity data are limited in this region, but it is unlikely that halite would survive in regions of high transmissivity because halite units are very close (several m) to the Culebra and would likely be dissolved by under-saturated Culebra waters. For example, the H-19 hydropad is located near the halite margin in the m3/h3 interval. H-19 shows high transmissivity, and cores from the Tamarisk show evidence of dissolution and collapse (Mercer et al., 1998). We therefore assume that high-transmissivity zones do not occur in regions where halite is present in the m2/h2 or m3/h3 intervals.

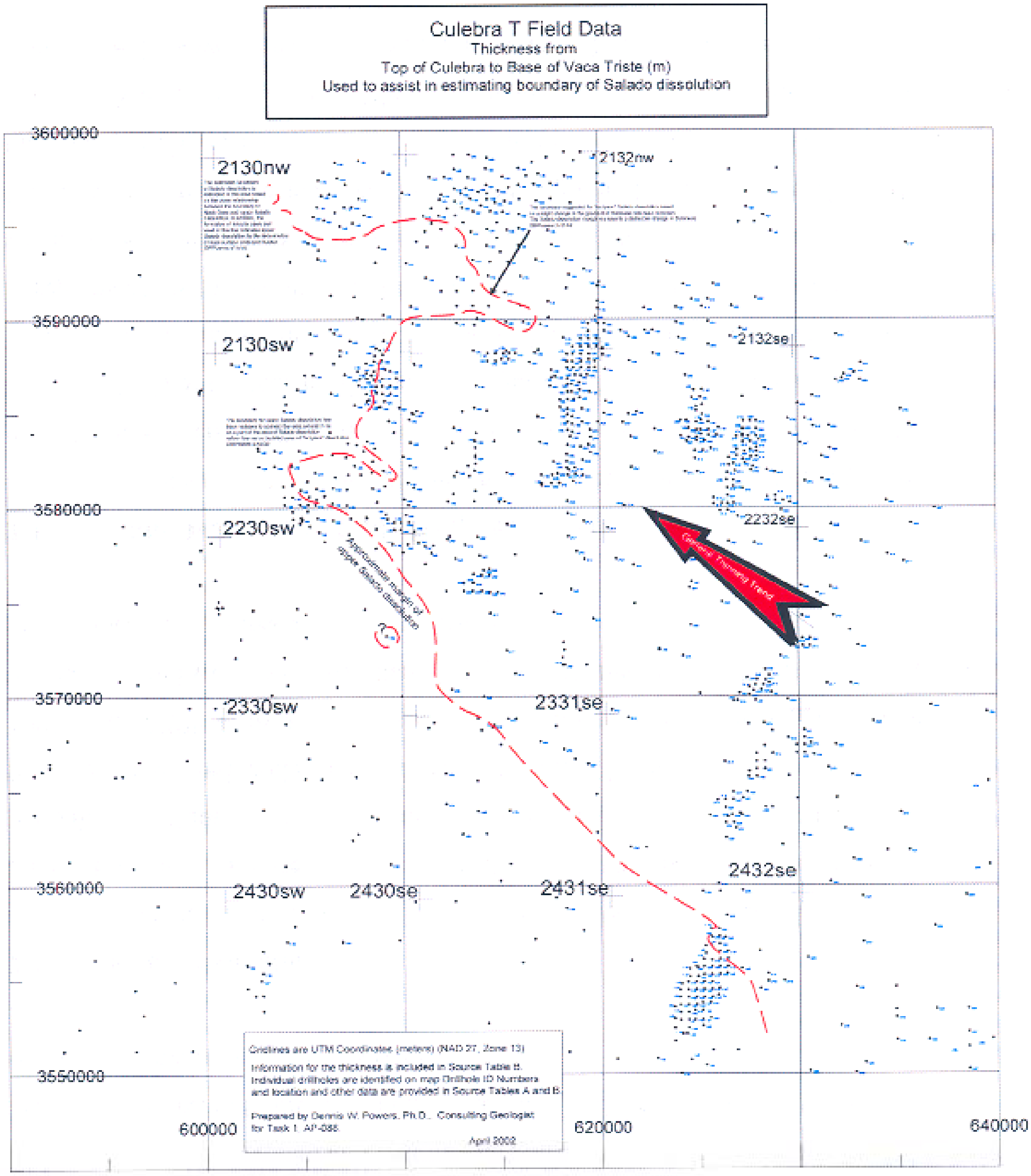

Figure 3. Salado dissolution margin from Powers (2002)

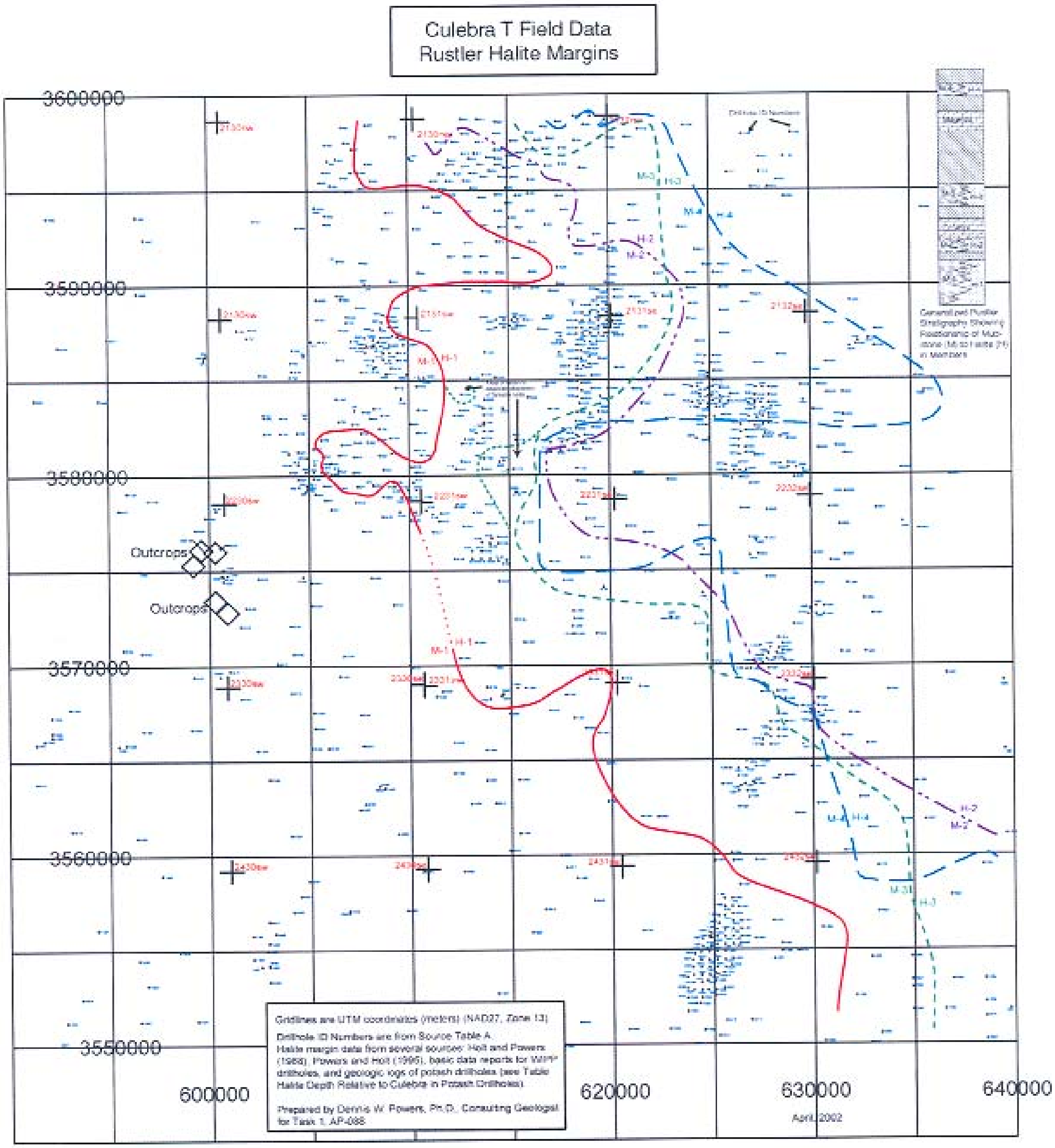

Figure 4. Rustler halite margins from Powers (2002)

2.5 Halite Bounding the Culebra

In regions where halite is present in both the m2/h2 and m3/h3 intervals, we have no reliable estimates of Culebra transmissivity (e.g., DOE, 1996, Beauheim and Ruskauff, 1998; and Beauheim, 2002). Based upon geologic observations of halite-bound units elsewhere within the WIPP area, Holt (1997) suggests that porosity within the Culebra may contain abundant halite cements in these areas. Beauheim and Holt (1990) and Holt (1997) indicate that Culebra porosity shows increasing amounts of pore-filling cement east of the WIPP site. We assume that the Culebra transmissivity is much lower in the region where halite occurs both above (m3/h3 interval) and below (m2/h2 interval) the Culebra.

2.6 High-Transmissivity Zones

High-transmissivity zones within the Culebra occur between areas affected by Salado dissolution and where halite is present in the m2/h2 and m3/h3 intervals. In these zones, fractures are well interconnected, and fracture interconnectivity is controlled by a complicated history of fracturing with several episodes of cement precipitation and dissolution (Beauheim and Holt, 1990; Holt, 1997). Unfortunately no geologic metric for fracture interconnectivity is identifiable in cores or from subsurface geophysical logs, and fracture interconnectivity can only be identified from *in situ* hydraulic test data. Unlike other geologic controls, we consider the spatial location of high-transmissivity zones to be a stochastic process that cannot be predicted using deterministic geologic data.

2.7 Linear Transmissivity Model

Using hypothesized geologic controls on Culebra transmissivity, we can construct the following linear model for $Y(\mathbf{x}) = \log(T(\mathbf{x}))$

$$Y(\mathbf{x}) = \beta_1 + \beta_2\, d(\mathbf{x}) + \beta_3\, I_f(\mathbf{x}) + \beta_4\, I_D(\mathbf{x}) \qquad (2)$$

where β_i are $i = 1,\ldots, 5$ regression coefficients, $\mathbf{x}$ is a two-dimensional location vector consisting of UTMX and UTMY coordinates, $d(\mathbf{x})$ is the overburden thickness, and $I_D(\mathbf{x})$ is a dissolution indicator function that assumes the value of 1 if Salado dissolution has occurred at point **x** and 0 otherwise. In this model, regression coefficient β_1 is the intercept value for the linear model. Coefficient β_2 is the slope of $Y(\mathbf{x})/d(\mathbf{x})$. Coefficients β_3 and β_4 represent adjustments to the intercept for the occurrence of interconnected fractures and Salado dissolution, respectively. Although other types of linear models could be developed, our model is consistent with our conceptual model relating transmissivity to geologic controls and can be tested using published WIPP geologic and transmissivity data. Note that the regression model does not explicitly contain terms relating Culebra transmissivity to zones where the Culebra is bounded by halite in the m2/h2 or m3/h3 intervals. Therefore it cannot be used to predict transmissivity in these zones.

3.0 Subtask 2 – Linear-Regression Analysis

The purpose of this subtask is to determine the regression coefficients for our linear model (2) using a standard linear regression analysis. A linear-regression model was written using the Windows based program Mathcad 7 professional. This model was written specifically for this application. The model contents and input files are presented in Appendix A. Data are read from data file "newdat4_7_02m2.prn" (Appendix A). Although other variables are input, this model requires only data on depth, log(T), and an estimate of the amount of dissolution that has affected the Culebra. The fracture interconnectivity indicator is defined from the log(T) data, and a Salado dissolution indicator is defined using the Salado dissolution data. These data are then used in a standard linear regression algorithm to determine the regression coefficients.

Regression coefficients are presented in Table 1. The regression has a multiple correlation coefficient (R^2) of 0.941 and a Regression ANOVA F statistic of 222. With m = 3 and n =42, the regression is significant above the 0.999 level. Residuals show no anomalous behavior (Appendix A). These statistics do not support rejection of this model (2).

The regression model does not predict transmissivity in the regions where the Culebra is both overlain by halite in the m3/h3 interval and underlain by halite in the m2/h2 interval. In these regions, we assume that the following modified version of the regression model (2) applies

$$Y(\mathbf{x}) = \beta_1 + \beta_2\, d(\mathbf{x}) + \beta_3\, I_f(\mathbf{x}) + \beta_4\, I_D(\mathbf{x}) + \beta_5\, I_H(\mathbf{x}) \qquad (3)$$

where $I_H(\mathbf{x})$ is a halite indicator function. This indicator is assigned a value of 1 in locations where halite occurs in both the m2/h2 and m3/h3 intervals and 0 otherwise. The coefficient β_5 is equal to –1 to assure that model (3) reduces the predicted transmissivity values by one order of magnitude where halite occurs in both the m2/h2 and m3/h3 intervals. With knowledge of the values of the geologic controls (e.g., Culebra depth, the interconnectivity indicator, dissolution indicator, and halite indicator), Culebra transmissivity values can be predicted at unobserved locations in the WIPP Culebra model domain (defined in Section 4.0) using equation (3).

β_1	β_2	β_3	β_4
-5.441	-4.636×10^{-3}	1.926	0.678

Table 1. Regression coefficients for equations (2) and (3).

4.0 Subtask 3 - Reduction of Geological Map Data

The purpose of this subtask is to reduce geologic map data to useable forms for conditional simulation of high-transmissivity zones and prediction of Culebra transmissivity using equation (3). Geologic maps (Figures 3 and 4) (Powers, 2002) are used to determine the values of geologic controls (e.g., Culebra depth, the interconnectivity indicator, dissolution indicator, and halite indicator) for a Culebra model domain defined by Rick Beauheim (Appendix C). To create useable data sets, we imported the geological maps into a GIS environment and digitized the maps (Appendix B). We then created a 50-meter grid for over the Culebra model domain (Appendix C). Using the Culebra Structure Contour map data (Appendix D) and surface elevation data (Appendix E), we created an isopach map of the Culebra overburden on the 50-meter model grid (Appendix F).

Using maps of the occurrence of halite in the units above and below the Culebra and well locations, we created soft data files (Appendix G) for conditional indicator simulations. We assume that transmissivity within 80 m of each well is from the same population (e.g., high or low transmissivity reflecting well-interconnected or poorly interconnected fractures, respectively) and that regions where the Culebra is overlain or underlain by halite (only m2/h2) are low-transmissivity regions.

Using maps of Salado dissolution and the occurrence of halite in the units above and below the Culebra, we created 50-meter indicator grids over the model domain. These indicator grids were created for regions affected by Salado dissolution, regions where the Culebra is both overlain or underlain by halite, and a middle zone where high-transmissivity zones occur stochastically (Appendix H).

5.0 Subtask 4 - Indicator Variography

The purpose of this task is to define the variogram model and variogram-model parameters for indicator functions of high Culebra transmissivity. Excluding data where Salado dissolution occurs, Culebra transmissivity data are indicator transformed (1 for log transmissivity > -5.4 [log m/s], 0 otherwise) (Appendix I). A high-transmissivity indicator variogram is then constructed for the indicator data in the region not affected by Salado dissolution using the GSLIB program gamv (Deutsch and Journel, 1998) (Appendix J). The lag spacing for this variogram is selected to maximize variogram resolution. The resulting indicator variogram is then fit with an isotropic spherical variogram model

$$\gamma(h) = \begin{cases} s[1.5(h/\lambda) - 0.5(h/\lambda)^3 & \text{if } h \le \lambda \\ s & \text{if } h \ge \lambda \end{cases} \quad (4)$$

where $\gamma(h)$ is the variogram as a function of lag spacing h, s is the sill value of the indicator variogram, and λ is the correlation length (Appendix K). This variogram model minimizes the mean squared error between the experimental and modeled variogram. The sill value is determined using $s = P[\log T > -5.4\,(\log \mathrm{m/s})] - \{P[\log T > -5.4\,(\log \mathrm{m/s})]\}^2$. For the Culebra data set, excluding wells where dissolution has occurred, $s = 0.201$. The correlation length λ is estimated to be 1790 m. No nugget effect is included in the variogram model. Variogram model parameters are then used in conditional indicator simulations of Culebra high-transmissivity zones (see Section 6.0).

6.0 Subtask 5 – Conditional Indicator Simulation

The purpose of this subtask is to use conditional indicator simulation to generate 100 conditional realizations of the spatial locations of high-transmissivity zones in the Culebra. 100 conditional indicator simulations are generated on the 50-meter model grid using the GSLIB program sisim (Deutsch and Journel, 1998) (Appendix L) with Culebra high-transmissivity indicator data, "soft" data for regions around wells and regions where halite underlies and overlies the Culebra, and the variogram parameters. Model grid coordinates are added to sisim output using the GSLIB program addcoord (Deutsch and Journel, 1998) (Appendix M). The resulting indicator simulations are used in the construction of mean transmissivity fields (see Section 7.0).

7.0 Subtask 6 – Construction of Mean Transmissivity Fields

The purpose of this subtask is to use the linear predictor (3) to generate 100 equally probable realizations of the mean transmissivity in the Culebra model domain. This calculation requires the regression coefficients determined in Subtask 2, Culebra depth data (Subtask 3), a Salado dissolution indicator function (Subtask 3), an indicator for where halite occurs in m2/h2 (Subtask 3), and 100 realizations of high-transmissivity indicators (Subtask 5). Calculations were done using a simple Fortran code, "meantsim.for" (Appendix N).

100 simulations were created in 10 groups of 10 on 10 different 750 MHz Pentium III, Windows NT 4.0 computers contained in The University of Mississippi Geoinfomatics Laboratory. Separate DOS batch files were used to launch and control the processing of simulations (Appendix O). These calculations resulted in 100 ASCII files containing UTM coordinates, an estimate of Culebra log-transmissivity, and a prediction of the mean Culebra transmissivity for each grid point in the Culebra model domain.

8.0 Summary

We have completed the activities from Task 2 of AP-088, "Analysis Plan for Evaluation of the Effects of Head Changes on Calibration of Culebra Transmissivity Fields." In this task we developed a geologically based predictor of mean Culebra transmissivity using a standard linear-regression approach. We then used this predictor to generate 100 equally probable realizations of the Culebra mean transmissivity field. These realizations show stochastic variability in the location of the high-transmissivity zones. This closes out Task 2 of AP-088 and allows Sean McKenna to proceed with Task 3.

References Cited

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Powers, D. W., and R. M. Holt, 1990, Sedimentology of the Rustler Formation Near the Waste Isolation Pilot Plant (WIPP) Site, in Geological and Hydrological Studies of Evaporites in the Northern Delaware Basin for the Waste Isolation Pilot Plant (WIPP), D. W. Powers, R. M. Holt, R. L. Beauheim, and N. Rempe, eds., *Geological Society of America Fieldtrip Guidebook 14*, pp. 79-106.

Appendices

Appendix A - Routine Calculation: Linear Regression Calculation for AP-088

Software Used:

Mathcad 7 Professional

Description:

A linear regression model was written specifically for this task. Data are read from data file "newdat4_7_02m2.prn". Although other variables are input, this program requires only data on depth, log(T), and an estimate of the amount of dissolution that has affected the Culebra. The fracture interconnectivity indicator is defined from the log(T) data, and a Salado dissolution indicator is defined using the Salado dissolution data. These data are then used in a standard linear regression algorithm to determine the regression coefficients.

Input:

- File: newdat4_7_02m2.prn (Attached)

Output:

- Regression coefficients (Displayed in attached program listing)
- File: residuals.prn (Attached)

Data Sources:

- DOE (U.S. Department of Energy), 1996, Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant, Vol. XVIII, Appendix TFIELD, *DOE/CAO-1996-2184*, US DOE Waste Isolation Pilot Plant, Carlsbad Area Office, Carlsbad, NM. (UTM coordinates and center of Culebra elevation data from Table TFIELD-1; log transmissivity values come from Table TFIELD-2; Exceptions noted below)
- Gonzales, M.M, 1989, Compilation and Comparison of Test-Hole Location Surveys in the Vicinity of the Waste Isolation Pilot Plant Site, *SAND88-1065*, Sandia National Laboratories, Albuquerque, NM. (Ground surface elevation data; Exceptions noted below)

- Beauheim, R. L, 2002, Analysis Package for Interpretation of 1984 H-3 Pumping Tests, ERMS 522203. (H-3 Transmissivity value)
- Beauheim, R. L., and G. J. Ruskauff, 1998, Analysis of Hydraulic Tests of the Culebra and Magenta Dolomites and Dewey Lake Redbeds Conducted at the Waste Isolation Pilot Plant Site, *SAND98-0049*, Sandia National Laboratories, Albuquerque, NM. (H-19 transmissivity value; Ground surface elevation and center of Culebra elevation data for H-19 and WQSP wells)
- Powers, D. W., 2002, Analysis Report for Task 1 of Ap-088 – Construction of geologic contour maps, ERMS#522086 (Wells showing dissolution; Dissolution values shown in data file not used)

Platform:

750 MHz Pentium III, Windows 2000

Program Listing for

Regress Model 3.mcd

WIPP Regression - Model 3 - 4/7/02 Data Set (note: T data log10)

Model 3:

$Y2 = \beta_1 + \beta_2 \cdot depth + \beta_3 \cdot Indicator + \beta_4 \cdot DissInd$

Data Input:

Read in data matrix, define the number of observations, define the sequential variable i.

$Data := READPRN("newdat4\_7\_02m2.prn")$ $n := rows(Data)$ $i := 1, 2 .. n$

From the matrix Data, define vectors of the variables of interest:

$XX_i := Data_{i,1}$ $UTMX_i := Data_{i,1} - min(XX)$

$YY_i := Data_{i,2}$ $UTMY_i := Data_{i,2} - min(YY)$

$depth_i := Data_{i,7}$

$lnT_i := Data_{i,5}$

$Diss_i := Data_{i,6}$

$Elev_i := Data_{i,4}$

Define an indicator for high T based on the value of cutoff

$cutoff := -5.4$ $Ind_i := if(lnT_i > cutoff, 1, 0)$

Define a dissolution indicator:

$Dind_i := if(Diss_i > 0, 1, 0)$

Define a vector of ones for intercept values

$Ones_i := 1$

Regression Models

$Y := \ln T$

Define the model:

$Y2 = \beta_1 + \beta_2 \cdot depth + \beta_3 \cdot Indicator + \beta_4 \cdot DissInd$

$X2_{i,1} := Ones_i$ $X2_{i,2} := depth_i$ $X2_{i,3} := Ind_i$ $X2_{i,4} := Dind_i$ $p2 := 4$

Define the S matricies:

$S2 := X2^T \cdot X2$

Calculate the β's

$\beta 2 := S2^{-1} \cdot X2^T \cdot Y$

$$\beta 2 = \begin{bmatrix} -5.441 \\ -4.636 \cdot 10^{-3} \\ 1.926 \\ 0.678 \end{bmatrix}$$

Calculate Residuals

$\varepsilon 2 := Y - X2 \cdot \beta 2$

The sum of squares about the regression can be defined as

$SSRes2 := \left| \varepsilon 2^T \cdot \varepsilon 2 \right|$

The residuals are also the sum of squares about the regression. We can also define the total sum of squares.

$SST := \left| (Y - mean(Y))^T \cdot (Y - mean(Y)) \right|$

Then we can determine R^2 using 1-SSR/SST

$R2 := \left(1 - \frac{SSRes2}{SST}\right)^{\frac{1}{2}}$ $R2^2 = 0.941$

Determine the sum of squares about the regression

$SSreg2 := \left| (X2 \cdot \beta 2 - mean(Y))^T \cdot (X2 \cdot \beta 2 - mean(Y)) \right|$

Determine the mean squares:

$MSreg2 := \frac{SSreg2}{p2 - 1}$ $MSres2 := \frac{SSRes2}{n - p2}$ $F2 := \frac{MSreg2}{MSres2}$ $F2 = 222.26$

$SST = 82.639$ $SSreg2 = 77.7424$ $SSRes2 = 4.897$

Set up ANOVA table

$k := 1..4 \qquad kk := 1..4$

$A_1 :=$ "Source" $\quad A_2 :=$ "Full Model" $\quad A_3 :=$ "Full SSResiduals" $\quad A_4 :=$ "SST"

$B_1 :=$ "SS" $\quad C_1 :=$ "dF" $\quad D_1 :=$ "MS" $\quad F_1 :=$ "F Test"

$B_2 := SSreg2 \quad B_3 := SSRes2 \quad B_4 := SST$

$C_2 := p2 - 1 \quad C_3 := n - p2 \quad C_4 := n - 1$

$D_2 := \frac{B_2}{C_2} \quad D_3 := \frac{B_3}{C_3} \quad D_4 :=$ "-"

$F_2 := \frac{D_2}{D_3} \quad F_3 :=$ "-" $\quad F_4 :=$ "-" $\qquad S := F$

$$P(F, m, n) := \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\cdot\Gamma\left(\frac{n}{2}\right)} \cdot m^{\frac{m}{2}} \cdot n^{\frac{n}{2}} \cdot x^{\frac{m-2}{2}} \cdot (n + m \cdot x)^{-\frac{m+n}{2}}\, dx$$

$S_1 :=$ "Signif. level" $\quad S_2 := 1 - pF(F_2, C_2, C_3)$

$ANOVA_{k,1} := A_k \quad ANOVA_{k,2} := B_k \quad ANOVA_{k,3} := C_k \quad ANOVA_{k,4} := D_k \quad ANOVA_{k,5} := F_k$

$ANOVA_{k,6} := S_k$

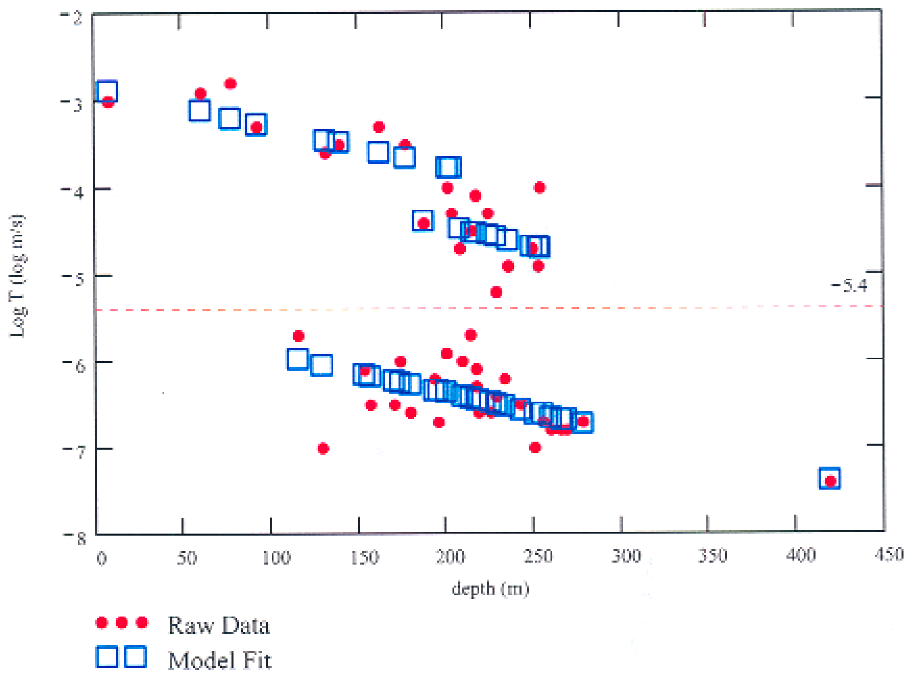
ANOVA =

"Source"	"SS"	"dF"	"MS"	"F Test"	"Signif. level"
"Full Model"	77.7424	3	25.9141	222.2598	0
"Full SSResiduals"	4.8969	42	0.1166	"−"	"−"
"SST"	82.6393	45	"−"	"−"	"−"

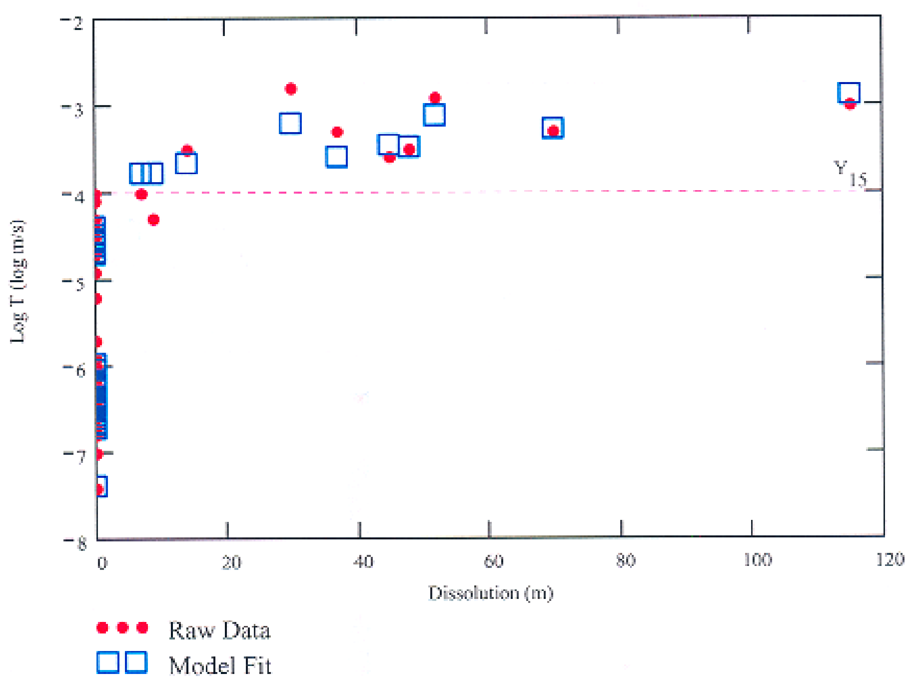
Model Appears Significant

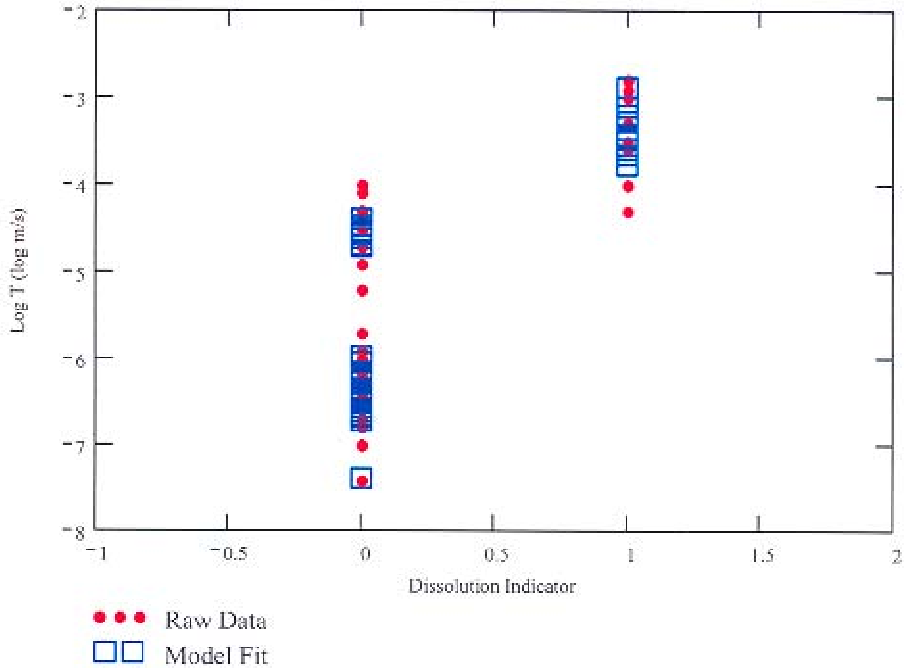
$Y2 := X2 \cdot \beta 2$

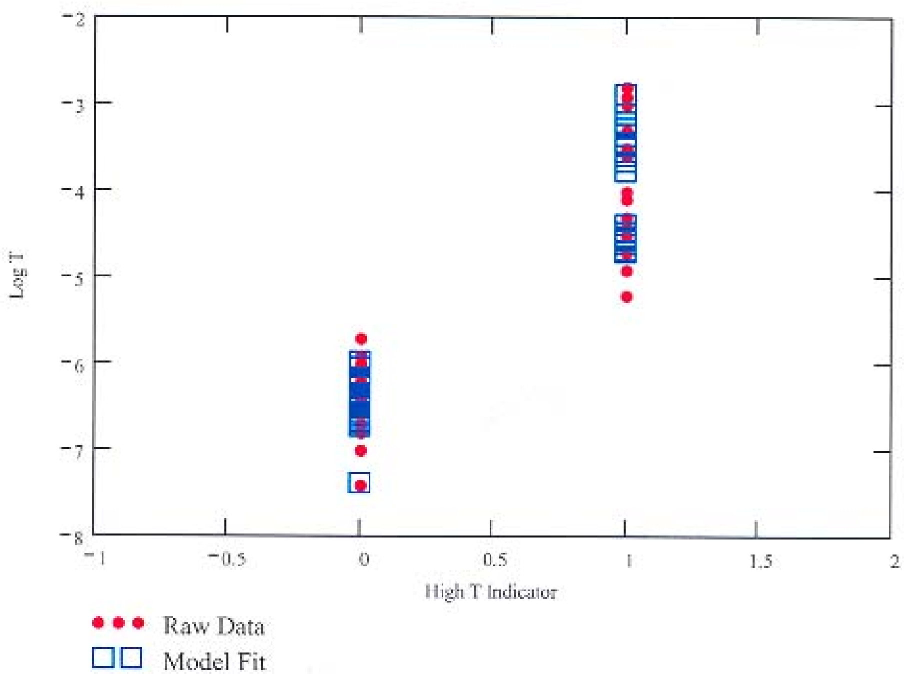
Let's look at the fits



$Ind_{15} = 1$




Log T (log m/s)
Dissolution Indicator
-2
-3
-4
-5
-6
-7
-8
-1
-0.5
0
0.5
1
1.5
2
Raw Data
Model Fit


Log T
High T Indicator
-2
-3
-4
-5
-6
-7
-8
-1
-0.5
0
0.5
1
1.5
2
Raw Data
Model Fit

Input File: "newdat4_7_02m2.prn"

Column 1 – Well Identifier, Column 2 – UTMX, Column 3 – UTMY, Column 4 – Elevation of Well, Column 5 – Elevation of Middle of Culebra, Column 6 – Log Transmissivity [Log (m/s)], Column 7 – Amount of Salado Dissolution (m), Column 8 – Culebra Depth.

"AEC-7"	621126	3589381	1114.73	845.59	-6.8	0	269.14
"CB-1"	613191	3578049	1014.15	856.88	-6.5	0	157.27
"D-268"	608702	3578877	999.3	883.32	-5.7	0	115.98
"DOE-1"	615203	3580333	1056.16	802.72	-4.9	0	253.44
"DOE-2"	613683	3585294	1041.89	787.38	-4	0	254.51
"Engle"	614953	3567454	1042	837.78	-4.3	9	204.22
"ERDA-9"	613696	3581958	1039	820.92	-6.3	0	218.08
"H-1"	613423	3581684	1035.68	826.13	-6	0	209.55
"H-2c"	612666	3581668	1029.52	836.58	-6.2	0	192.94
"H-3b1"	613729	3580895	1033.04	825.17	-4.7	0	207.87
"H-4c"	612406	3578499	1016.04	862.73	-6.1	0	153.31
"H-5c"	616903	3584802	1068.56	790.74	-6.7	0	277.82
"H-6c"	610610	3584983	1020.45	832.84	-4.4	0	187.61
"H-7c"	608095	3574640	964.21	886.33	-2.8	30	77.88
"H-9c"	613974	3568234	1038.31	836.53	-4	7	201.78
"H-10b"	622975	3572473	1124.32	705.07	-7.4	0	419.25
"H-11b4"	615301	3579131	1039.37	815.44	-4.3	0	223.93
"H-12"	617023	3575452	1044.24	789.27	-6.7	0	254.97
"H-14"	612341	3580354	1019.7	849.47	-6.5	0	170.23
"H-15"	615315	3581859	1060.77	794.98	-6.8	0	265.79
"H-16"	613369	3582212	1039.25	821.79	-6.1	0	217.46
"H-17"	615718	3577513	1031.45	812.42	-6.6	0	219.03
"H-18"	612264	3583166	1040.39	826.82	-5.7	0	213.57
"H-19b0"	614514	3580716	1041.5	812.3	-5.2	0	229.2
"P-14"	609084	3581976	1024.05	846.05	-3.5	14	178
"P-15"	610624	3578747	1008.82	879.58	-7	0	129.24
"P-17"	613926	3577466	1016.74	842.85	-6	0	173.89
"USGS-1"	606462	3569459	1044.1	881.66	-3.3	37	162.44
"WIPP-12"	613710	3583524	1058.05	807.35	-7	0	250.7
"WIPP-13"	612644	3584247	1037.96	820.79	-4.1	0	217.17
"WIPP-18"	613735	3583179	1053.51	810.43	-6.5	0	243.08
"WIPP-19"	613739	3582782	1046.4	812.47	-6.2	0	233.93
"WIPP-21"	613743	3582319	1041.53	815.68	-6.6	0	225.85
"WIPP-22"	613739	3582653	1044.18	814.67	-6.4	0	229.51
"WIPP-25"	606385	3584028	979.16	839.1	-3.5	48	140.06
"WIPP-26"	604014	3581162	960.65	900.45	-2.9	52	60.2
"WIPP-27"	604426	3593079	968.4	875.43	-3.3	70	92.97
"WIPP-28"	611266	3594680	1020.05	888.07	-3.6	45	131.98
"WIPP-29"	596981	3578694	907.37	899.14	-3	115	8.23
"WIPP-30"	613721	3589701	1044.7	849.01	-6.7	0	195.69
"WQSP-1"	612561	3583427	1041.4	825.61	-4.5	0	215.79
"WQSP-2"	613776	3583973	1055	805.28	-4.7	0	249.72
"WQSP-3"	614686	3583518	1059.9	799.52	-6.8	0	260.38
"WQSP-4"	614728	3580766	1045.6	809.18	-4.9	0	236.42
"WQSP-5"	613668	3580353	1030.7	830.03	-5.9	0	200.67
"WQSP-6"	612605	3580736	1024.7	844.39	-6.6	0	180.31

Both Rick Beauheim and Dennis Powers checked this data file (see below).

newdat4_7_02-mod.prn.txt

"AEC-7"	621126	3589381	1114.73	845.59	-6.8	0	2	69.14
"CB-1"	613191	3578049	1014.15	856.88	-6.5	0	1	57.27
"D-268"	608702	3578877	999.3	883.32	-5.7	0	1	15.98
"DOE-1"	615203	3580333	1056.16	802.72	-4.9	0	2	53.44
"DOE-2"	613683	3585294	1041.89	787.38	-4	0	2	54.51
"Engle"	614953	3567454	1042	837.78	-4.3	9	2	04.22
"ERDA-9"	613696	3581958	1039	820.92	-6.3	0	2	18.08
"H-1"	613423	3581684	1035.68	826.13	-6	0	2	09.55
"H-2c"	612666	3581668	1029.52	836.58	-6.2	0	1	92.94
"H-3b1"	613729	3580895	1033.04	825.17	-4.7	0	2	07.87
"H-4c"	612406	3578499	1016.04	862.73	-6.1	0	1	53.31
"H-5c"	616903	3584802	1068.56	790.74	-6.7	0	2	77.82
"H-6c"	610610	3584983	1020.45	832.84	-4.4	0	1	87.61
"H-7c"	608095	3574640	964.21	886.33	-2.8	30		77.88
"H-8b"	608683	3563556	1046.34	863.16	-5.1	0	1	83.18
"H-9c"	613974	3568234	1038.31	836.53	-4	7	2	01.78
"H-10b"	622975	3572473	1124.32	705.07	-7.4	0	4	19.25
"H-11b4"	615301	3579131	1039.37	815.44	-4.3	0	2	23.93
"H-12"	617023	3575452	1044.24	789.27	-6.7	0	2	54.97
"H-14"	612341	3580354	1019.7	849.47	-6.5	0	1	70.23
"H-15"	615315	3581859	1060.77	794.98	-6.8	0	2	65.79
"H-16"	613369	3582212	1039.25	821.79	-6.1	0	2	17.46
"H-17"	615718	3577513	1031.45	812.42	-6.6	0	2	19.03
"H-18"	612264	3583166	1040.39	826.82	-5.7	0	2	13.57

Output File: "residuals.prn"

621126	3589381	-6.8	-0.1107778784
613191	3578049	-6.5	-0.3294288234
608702	3578877	-5.7	0.2791427551
615203	3580333	-4.9	-0.2100431344
613683	3585294	-4	0.6949175924
614953	3567454	-4.3	-0.5163184524
613696	3581958	-6.3	0.1524980915
613423	3581684	-6	0.4129513626
612666	3581668	-6.2	0.1359441918
613729	3580895	-4.7	-0.2213144633
612406	3578499	-6.1	0.05221185114
616903	3584802	-6.7	0.02946427951
610610	3584983	-4.4	-0.01524373968
608095	3574640	-2.8	0.3979448855
613974	3568234	-4	-0.2276307641
622975	3572473	-7.4	-0.0148389014
615301	3579131	-4.3	0.2531428011
617023	3575452	-6.7	-0.0764727375
612341	3580354	-6.5	-0.2693437581
615315	3581859	-6.8	-0.1263091259
613369	3582212	-6.1	0.3496236516
615718	3577513	-6.6	-0.1430975249
612264	3583166	-5.7	0.7315888597
614514	3580716	-5.2	-0.6224244601
609084	3581976	-3.5	0.1621205591
610624	3578747	-7	-0.9593813217
613926	3577466	-6	0.2476247093
606462	3569459	-3.3	0.2899813913
613710	3583524	-7	-0.3962692829
612644	3584247	-4.1	0.4218021344
613735	3583179	-6.5	0.0684029241
613739	3582782	-6.2	0.3259817554
613743	3582319	-6.6	-0.1114786865
613739	3582653	-6.4	0.105489781
606385	3584028	-3.5	-0.01377661484
604014	3581162	-2.9	0.2159769878
604426	3593079	-3.3	-0.03209495755
611266	3594680	-3.6	-0.1512370567
596981	3578694	-3	-0.1249659782
613721	3589701	-6.7	-0.3513062766
612561	3583427	-4.5	0.01540418764
613776	3583973	-4.7	-0.02728977353
614686	3583518	-6.8	-0.1513909317
614728	3580766	-4.9	-0.2889511445
613668	3580353	-5.9	0.471781966
612605	3580736	-6.6	-0.3226109296

Appendix B - Routine Calculation: Adobe Acrobat File Import for AP-088

Software Used:

ERDAS Imagine

ArcView

Description:

Four geologic maps were imported into a GIS format. These maps were Adobe Acrobat portable document files (PDFs). Each of these PDFs was converted to a high-resolution (600dpi) Tagged Image Format File (TIFF). Using ERDAS Imagine, the image files were then georectified (assigned coordinates) to the coordinate system supplied on the maps. In each case, the Universe Transverse Mercator (UTM) Projection, Zone 13 North was used. All maps were assigned the North American Datum 1927 (NAD27). These rectified images were then opened in ESRI ArcView to begin heads-up digitizing (HUD). HUD is an interpretive procedure that allows the analyst to trace on-screen features from a rectified image. The HUD resulted in the following spatial arc data.

Input:

- "Culebra_Structure.pdf" from ERMS# 522086
- "Drillhole_ID_Numbers.pdf" from ERMS# 522086
- "Rustler_Halite_Margins.pdf" from ERMS# 522086
- "Salado_Dissolution_and CulVT_Thickness.pdf" from ERMS# 522086

Output:

- ArcView Shapefiles:
    - "salado_dissolution_new.shp"
    - "salt_margin_m1_h1shp.shp"
    - "salt_margin_m2_h2.shp"
    - "salt_margin_m3_h3.shp"
    - "salt_margin_m4_h4.shp"
    - "top_culebra.shp"

Data Sources:

Spatial data digitized from geologic maps prepared by Dennis Powers for Task 1 of AP-088. ERMS# 522086.

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix C - Routine Calculation: Creation of 50-meter grid for AP-088

Software Used:

ArcView

Microsoft EXCEL

Description:

A 50-meter block-centered grid was created in ArcView. Because block centers lie along the model boundary, the created grid extends 25 meters past the model domain. The following are the specifications of the domain grid:

- # of Columns 447
- # of Rows 613
- Lower Left UTMX 601675
- Lower Left UTMY 3566475
- Cell Size in meters 50

The GRIDPOINT function in Arc/Info was used to generate a point spatial data set. Each point was the center of a 50-meter grid block. Again, points would lie along model domain boundaries. Therefore, the center of the lower left grid space would be 25 meter north and 25 meter east of the listed UTM coordinates. This would be UTMX = 601700 and UTMY = 3566500, or the lower left coordinate of the model domain. This grid provided the basis for all spatial calculations and other data set creation.

After the point spatial data set was created, the ADDXY command was used in Arc/Info to assign the xy coordinates to the 274,011 data points. This resulting data file was exported into a TAB delimited text format. The file was checked using a differencing formula in EXCEL to assure the xy coordinates were in 50-meter increments. The following is an example of the data file:

LCX	LCY
601700	3597100
601750	3597100
601800	3597100

601850 3597100

601900 3597100

601950 3597100

Input:

N/A

Output:

- ArcView shapefile "final_points.shp"
- TAB delimitated file "final_points.txt"
- EXCEL format file "final_points_qa.xls"

Data Sources:

Model domain boundaries specified by Rick Beauheim in the following emails:

```
From:    Beauheim, Richard L [SMTP:rlbeauh@sandia.gov]
Sent:    Tuesday, April 23, 2002 12:13 PM
To:      'rmholt@olemiss.edu'
Subject:         domain

Bob,
I've been looking at the last domain Marsh used that was oriented N-S.  He
used it in SAND89-7068/1.  The corners were at:

NW: 3,597,100 m N  602,700 m E
NE: 3,597,100 m N  624,000 m E
SW: 3,566,500 m N  602,700 m E
SE: 3,566,500 m N  624,000 m E

It seems to me to capture everything we need, although we might be able to
shift the eastern boundary slightly to the west.  As is, it would give Sean
about 261K elements, which is more than the 100K he mentioned earlier, but
if that solver is really faster, he should be able to handle this.

Take a look, and I'll talk to you sometime this afternoon.

Rick
```

From: Beauheim, Richard L [SMTP:rlbeauh@sandia.gov]
Sent: Wednesday, May 01, 2002 10:58 AM
To: 'Lance Yarbrough'; 'rmholt@olemiss.edu'; 'dwpowers@htg.net'
Subject: modeling domain extension

All,
Let's extend the modeling domain an additional 1000 m to the west, which will put the western boundary at 601,700 m E. This will run the boundary across Laguna Uno. Sean is pretty confident now that he can handle the number of cells this will give us in the model (273K).

Rick

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix D - Routine Calculation: Creation of Culebra Structure Surface for AP-088

Software Used:

Arc/Info

Description:

Prior to constructing a spatial data map of the Culebra overburden thickness, a structure surface had to be created. Using the "top_culebra.shp" spatial data created from the HUD (Appendix B), a hydrologically correct surface was calculated. The surface was created using the TOPOGRID command in ESRI's Arc/Info software. The TOPOGRID command is an interpolation method specifically designed for the creation of hydrologically correct digital elevation models (DEMs) from elevation points and contours (isolines). It is based upon the ANUDEM program developed by Michael Hutchinson (1988, 1989). The TOPOGRID command was executed using a 50-meter grid spacing based on the grid locations derived in Appendix C. The resulting structure surface was saved as an Arc/Info GRID format.

Input:

- Arc/Info coverage format "top_culebra.shp" from Appendix B.

Output:

- Arc/Info GRID format directory file named "culebra"

Data Sources:

Spatial data digitized from geologic maps prepared by Dennis Powers for Task 1 of AP-088. ERMS# 522086. (see Input listed in Appendix B)

Platform:

1.8-GHz Pentium 4 - Windows 2000

References:

Hutchinson, M. F, 1988, "Calculation of hydrologically sound digital elevation models," Third International Symposium on Spatial Data Handling, Sydney, Columbus, Ohio, International Geographical Union.

Hutchinson, M. F, 1989, "A new procedure for gridding elevation and stream line data with automatic removal of spurious pits," *Journal of Hydrology*, Vol. 106, p. 211-232.

Appendix E - Routine Calculation: Creating Surface Elevation Data for AP-088

Software Used:

ArcView

Description:

Prior to constructing a spatial data map of the Culebra overburden thickness, surface elevation data on our 50-meter grid had to be created. The surface elevation of the model domain was obtained from the USGS National Elevation Dataset (NED) (http://edcnts12.cr.usgs.gov/ned/). The NED has been developed by merging the highest-resolution, best-quality elevation data available across the United States into a seamless raster format (surface). The NED has a 30-meter horizontal resolution. For this task, the grid was resampled in ArcView to a 50-meter grid based on the boundaries of the model domain. The reported elevation value for each of the 50-meter node points represents an average of elevation for the surface area contained within the grid block.

Input:

- Arc/Info GRID format file of the USGS National Elevation Dataset (NED)

Output:

- Arc/Info GRID format directory file named "dem"

Data Sources:

USGS National Elevation Dataset (NED) (http://edcnts12.cr.usgs.gov/ned/)

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix F - Routine Calculation: Creating an Isopach of Culebra Overburden for AP-088

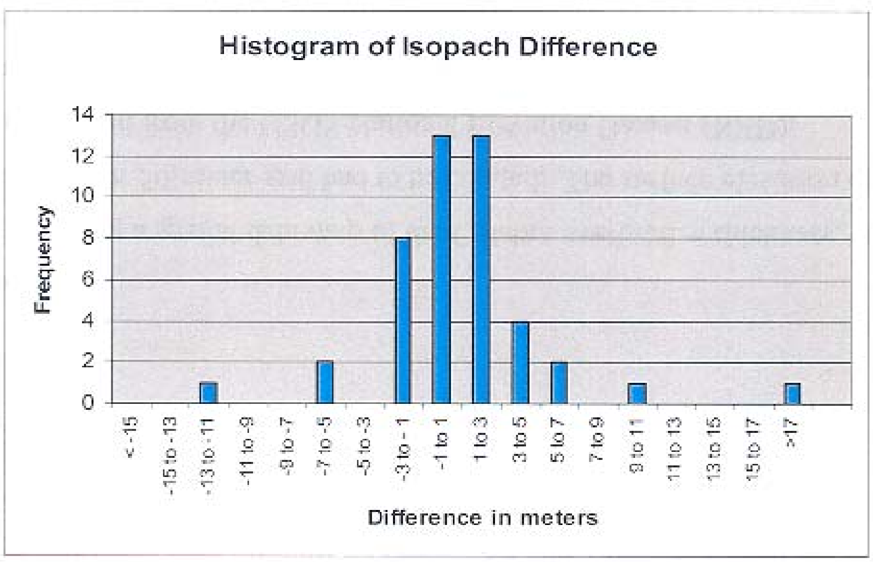
Software Used:

ArcView

Description:

Using the digital elevation data from the NED and the Culebra structure surface, an isopach grid was created. The isopach was created in ArcView using the map calculator function. The Culebra structure data were subtracted from the elevation data. The resulting grid is an isopach of Culebra overburden on 50-meter spacing.

The GRIDPOINT function in Arc/Info was used to generate a point spatial data set. Each point was the center of a 50-meter grid block. This resulting isopach data file was exported into a TAB delimited text format. To assure that the overburden value contained in the file was represented in the isopach spatial data set, we compared the two values at each well location where the overburden thickness was known. This provides forty five locations where the accuracy of the spatial model can be checked with an average error of 0.91 m and a standard deviation of 4.52 m. A histogram of the well values in provided in the figure below.



Input:

- Arc/Info GRID format directory file named "culebra" from Appendix D
- Arc/Info GRID format directory file named "dem" from Appendix E

Output:

- Arc/Info GRID format directory file named "isopach"
- EXCEL format file "qa_isopach.xls"
- TAB delimitated file "isopach.txt"

Data Sources:

Geologic maps prepared by Dennis Powers for Task 1 of AP-088. ERMS# 522086. (see Input listed in Appendix B)

USGS National Elevation Dataset (NED) (http://edcnts12.cr.usgs.gov/ned/)

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix G - Routine Calculation: Creation of Soft Data Files for AP-088

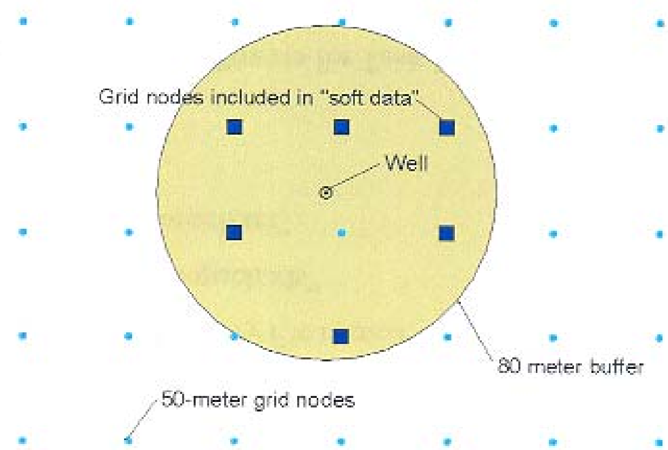
Software Used:

ArcView

Description:

For conditional indicator simulations, we created "soft data" based on the salt margin m2/h2 and salt margin m3/h3 spatial data. A 500-meter grid was created to the east of the combined m2/h2 and m3/h3 lines. This 500-meter grid used the original 50-meter grid excluding every nine points and saving the tenth. This was to assure the 500-meter "soft data" grid spatially overlay the 50-meter grid. The combined line was also represented by points spaced approximately 500-800 meters apart.

Additional "soft data" were created near well locations using an 80-meter buffer (see figure below). All 50-meter grid nodes (Appendix C) lying within the 80-m buffer were selected and assigned the transmissivity attribute of the closest well.



Because all the nodes within 80 meters of the well and the well itself were selected as "soft data", there was duplication in the input files. Only one "soft data" point can occupy a 50-meter grid space during a realization. Therefore the node closest to the well was eliminated from the "soft data" file. The "soft data" points were then exported into a TAB delimited text format.

Input:

- ArcView shapefile “final_points.shp” from Appendix C
- ArcView shapefile “salt_margin_m2_h2.shp” from Appendix B
- ArcView shapefile “salt_margin_m3_h3.shp” from Appendix B

Output:

- TAB delimited file “halite.txt”

Data Sources:

Spatial data digitized from geologic maps prepared by Dennis Powers for Task 1 of AP-088. ERMS# 522086. (see Input listed in Appendix B)

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix H - Routine Calculation: Creation of the Indicator Grids for AP-088

Software Used:

Arc/Info

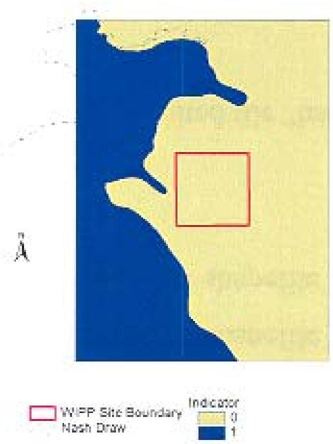
Description:

Indicator grids consisting of 0's or 1's were created using the Salado dissolution line, halite margin m2/h2, and halite margin m3/h3 spatial data. Using Arc/Info ArcEdit functions, polygons were created to represent areas of Salado dissolution, where halite occurs in the m2/h2 interval, and a middle zone defined by the region where Salado dissolution has not occurred and where halite does not occur above and below the Culebra. These polygons attributes were then populated with the appropriate indicator in the database, as follows:

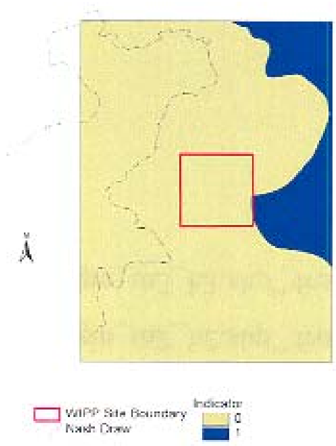
- Halite Indicator – (1 where halite occurs in the m2/h2 interval, 0 elsewhere)
- Middle Zone Indicator – (0 where dissolution occurs and m2/h2 overlies and underlies the Culebra, 1 elsewhere)
- Salado Dissolution Indicator – (1 where Salado dissolution has occurred, 0 elsewhere)

The figures below show the indicator polygons within the model domain.

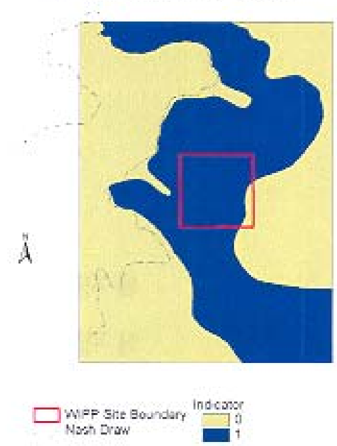
Dissolution Indicator



M2/H2 Indicator



Middlezone Indicator



Next the 50-meter points created in a previous subtask (Appendix C) were overlain on each of the indicator polygons. The attributes of the polygons were then spatially joined to the points, thereby creating a new attribute in the point data representing the associated indicator value. Three indicator point data files were created using this technique:

- Halite Indicator Grid
- Middle Zone Indicator Grid
- Salado Dissolution Indicator Grid

A visual check was preformed to assure proper indicator value assignment to each point. Large scale PDFs were produced for each grid file. The indicator was color coded and plotted with the spatial data used to create the indicator girds. Each indicator grid was then exported into a TAB delimited text format.

Input:

- Shapefile "final_points.shp" from Appendix C
- Shapefile "salado_dissolution_new.shp" from Appendix B
- Shapefile "salt_margin_m2_h2.shp" from Appendix B
- Shapefile "salt_margin_m3_h3.shp" from Appendix B

Output:

- TAB delimited file: p_halite.txt
- TAB delimited file: p_middlezone.txt
- TAB delimited file: p_dissolution.txt
- PDF file: "halite_qa.PDF"
- PDF file: "middlezone_qa.PDF"
- PDF file: "salado_dissolution_qa.PDF"

Data Sources:

Spatial data digitized from geologic maps prepared by Dennis Powers for Task 1 of AP-088. ERMS# 522086. (see Input listed in Appendix B)

Platform:

1.8-GHz Pentium 4 - Windows 2000

Appendix I - Routine Calculation: Indicator Transformation of Culebra Transmissivity Data for AP-088

Software Used:

Mathcad 7 Professional; Excel

Description:

A short Mathcad file was written specifically for this task. Data are read from data file "newdat4_7_02m2.prn." This program reads input data, calculates a high-transmissivity zone indicator ($HTind_i$), calculates a fracture interconnectivity indicator (Ind_i), and a dissolution indicator function ($Dind_i$) for each Culebra well. The indicator data are then output with UTMX, UTMY, and log(T) data to an ASCII file "inddat.dat." This file was then read into Excel and sorted based on the dissolution indicator column. Wells where Salado dissolution has occurred were removed from the file. Columns containing the interconnectivity indicator and the dissolution indicator were removed. A column for a low transmissivity indicator was added (1 – the high transmissivity indicator), and the file was formatted for use with GSLIB programs. The data file was saved as "ndlogTe.dat."

Input:

- File: newdat4_7_02m2.prn (Attached in Appendix A)

Output:

- File: inddat.dat (Attached)
- File: ndlogTe.dat (Attached)

Data Sources:

See Appendix A.

Platform:

750 MHz Pentium III, Windows 2000

Program Listing for

High T indicator 2.mcd

WIPP Regression - Calculation of High T indicator for input to GSlib - using new data

Data Input:

Read in data matrix, define the number of observations, define the sequential variable i.

Data := READPRN("newdat4_7_02m2.prn") n := rows(Data) i := 1, 2.. n

From the matrix Data, define vectors of the variables of interest:

$XX_i := Data_{i,1}$ $UTMX_i := Data_{i,1}$

$YY_i := Data_{i,2}$ $UTMY_i := Data_{i,2}$

$depth_i := Data_{i,7}$

$lnT_i := Data_{i,5}$

$Diss_i := Data_{i,6}$

$Elev_i := Data_{i,4}$

Define an indicator for high T based on the value of cutoff

$cutoff := -5.4$ $Ind_i := if(lnT_i > cutoff, 1, 0)$

Define a dissolution indicator:

$Dind_i := if(Diss_i > 0, 1, 0)$

Define the high T indicator

$HTind_i := Ind_i - Dind_i$

Output data

$D_{i,1} := UTMX_i$ $D_{i,2} := UTMY_i$ $D_{i,3} := lnT_i$ $D_{i,4} := Ind_i$ $D_{i,5} := HTind_i$ $D_{i,6} := Dind_i$

WRITEPRN("inddat.dat") := D

Output File: "inddat.dat"

Column 1 –UTMX, Column 2 – UTMY, Column 3 – Log Transmissivity [Log (m/s)], Column 4 – Fracture Interconnectivity Indicator, Column 5 – High T Zone Indicator, Column 6 –Salado Dissolution Indicator.

621126	3589381	-6.8	0	0	0
613191	3578049	-6.5	0	0	0
608702	3578877	-5.7	0	0	0
615203	3580333	-4.9	1	1	0
613683	3585294	-4	1	1	0
614953	3567454	-4.3	1	0	1
613696	3581958	-6.3	0	0	0
613423	3581684	-6	0	0	0
612666	3581668	-6.2	0	0	0
613729	3580895	-4.7	1	1	0
612406	3578499	-6.1	0	0	0
616903	3584802	-6.7	0	0	0
610610	3584983	-4.4	1	1	0
608095	3574640	-2.8	1	0	1
613974	3568234	-4	1	0	1
622975	3572473	-7.4	0	0	0
615301	3579131	-4.3	1	1	0
617023	3575452	-6.7	0	0	0
612341	3580354	-6.5	0	0	0
615315	3581859	-6.8	0	0	0
613369	3582212	-6.1	0	0	0
615718	3577513	-6.6	0	0	0
612264	3583166	-5.7	0	0	0
614514	3580716	-5.2	1	1	0
609084	3581976	-3.5	1	0	1
610624	3578747	-7	0	0	0
613926	3577466	-6	0	0	0
606462	3569459	-3.3	1	0	1
613710	3583524	-7	0	0	0
612644	3584247	-4.1	1	1	0
613735	3583179	-6.5	0	0	0
613739	3582782	-6.2	0	0	0
613743	3582319	-6.6	0	0	0
613739	3582653	-6.4	0	0	0
606385	3584028	-3.5	1	0	1
604014	3581162	-2.9	1	0	1
604426	3593079	-3.3	1	0	1
611266	3594680	-3.6	1	0	1
596981	3578694	-3	1	0	1
613721	3589701	-6.7	0	0	0
612561	3583427	-4.5	1	1	0
613776	3583973	-4.7	1	1	0
614686	3583518	-6.8	0	0	0
614728	3580766	-4.9	1	1	0
613668	3580353	-5.9	0	0	0
612605	3580736	-6.6	0	0	0

Output File: "ndlogTe.dat"

Column 1 –UTMX, Column 2 – UTMY, Column 3 – Dummy Z Variable, Column 4 – High T Zone Indicator, Column 5 – Log Transmissivity [Log (m/s)], Column 6 – Low Transmissivity Indicator.

```
Culebra log T data and indicators
6
UTMX
UTMY
ZDUM
HTI
logT
LTI
621126     3589381     1     0     -6.8   1
613191     3578049     1     0     -6.5   1
608702     3578877     1     0     -5.7   1
615203     3580333     1     1     -4.9   0
613683     3585294     1     1     -4     0
613696     3581958     1     0     -6.3   1
613423     3581684     1     0     -6     1
612666     3581668     1     0     -6.2   1
613729     3580895     1     1     -4.7   0
612406     3578499     1     0     -6.1   1
616903     3584802     1     0     -6.7   1
610610     3584983     1     1     -4.4   0
622975     3572473     1     0     -7.4   1
615301     3579131     1     1     -4.3   0
617023     3575452     1     0     -6.7   1
612341     3580354     1     0     -6.5   1
615315     3581859     1     0     -6.8   1
613369     3582212     1     0     -6.1   1
615718     3577513     1     0     -6.6   1
612264     3583166     1     0     -5.7   1
614514     3580716     1     1     -5.2   0
610624     3578747     1     0     -7     1
613926     3577466     1     0     -6     1
613710     3583524     1     0     -7     1
612644     3584247     1     1     -4.1   0
613735     3583179     1     0     -6.5   1
613739     3582782     1     0     -6.2   1
613743     3582319     1     0     -6.6   1
613739     3582653     1     0     -6.4   1
613721     3589701     1     0     -6.7   1
612561     3583427     1     1     -4.5   0
613776     3583973     1     1     -4.7   0
614686     3583518     1     0     -6.8   1
614728     3580766     1     1     -4.9   0
613668     3580353     1     0     -5.9   1
612605     3580736     1     0     -6.6   1
```

Appendix J - Routine Calculation: Calculation of Culebra High-Transmissivity Indicator Variogram for AP-088

Software Used:

GSLIB program: GAMV.FOR

GSLIB subroutine: CHKNAM.FOR

GSLIB include file: GAMV.INC

Compiler: Fortran Powerstation 4.0

Description:

An indicator variogram for Culebra high-transmissivity zones was calculated using the GSLIB routine "gamv.for". One line of source code (line 940 of the GSLIB routine "gamv.for") was commented to facilitate the use of gamv output with Mathcad. This line read: write(lout,'(a74)') title(1:74). Removal of this line prevented the writing of a header at the top of the output file. The Fortran executable was compiled and linked using Fortran Powerstation 4.0. An input parameter file entitled "gamv.par" controlled the program options. Data were read from file "ndlogTe.dat." The code then calculated an omnidirectional variogram with 22 lags at a lag spacing of 450 m and output the results to file "gamv450.prn."

Input:

- File: gamv.par (Attached)
- File: ndlogTe.dat (Attached in Appendix I)

Output:

- File: gamv450.prn (Attached)

Data Sources:

See Appendix I.

Platform:

750 MHz Pentium III, Windows 2000

Input File: "gamv.par"

```
Parameters for GAMV
                    ******************

START OF PARAMETERS:
ndlogTe.dat
1   2   3                                 \   columns for X, Y, Z coordinates
1   4                                     \   number of varables,column numbers
-1.0e21      1.0e21                       \   trimming limits
gamv450.prn                                  \file for variogram output
22                                        \number of lags
450.0                                       \lag separation distance
450.                                       \lag tolerance
1                                         \number of directions
0.0  90.0 5000000.0   0.0  90.0  50.0  \azm,atol,bandh,dip,dtol,bandv
0                                         \standardize sills? (0=no, 1=yes)
1                                         \number of variograms
1   1   1                                 \tail var., head var., variogram type
```

Output File: "gamv450.prn"

1	.000	.00000	72	.27778	.27778
2	337.500	.05000	20	.15000	.15000
3	583.374	.07813	64	.23438	.23438
4	977.646	.15517	116	.31034	.31034
5	1402.954	.20115	174	.30460	.30460
6	1812.919	.23585	212	.29245	.29245
7	2226.525	.26316	190	.30526	.30526
8	2697.784	.29221	154	.35714	.35714
9	3173.759	.28161	174	.38506	.38506
10	3549.204	.25904	166	.35542	.35542
11	4065.109	.22308	130	.30000	.30000
12	4524.179	.18750	128	.28125	.28125
13	4906.392	.16667	108	.29630	.29630
14	5417.965	.15686	102	.27451	.27451
15	5829.011	.19444	108	.25000	.25000
16	6291.266	.22340	94	.28723	.28723
17	6691.583	.21212	66	.27273	.27273
18	7232.571	.14000	50	.18000	.18000
19	7617.592	.12000	50	.16000	.16000
20	8021.575	.14706	34	.14706	.14706
21	8578.190	.19231	26	.19231	.19231
22	8952.749	.25000	28	.25000	.25000

Appendix K - Routine Calculation: Indicator Variogram Fitting for AP-088

Software Used:

Mathcad 7 Professional

Description:

A short Mathcad file was written specifically for this task. Data are read from data file "gamv450.prn". This program reads and plots variogram data. A spherical variogram model (4) is interactively fit to the variogram data and a MSE is calculated. The variogram correlation length is adjusted until the MSE reaches a minimum.

Input:

- File: gamv450.prn (Attached in Appendix J)

Output:

- Estimate of Correlation Length in Mathcad File

Data Sources:

See Appendix J.

Platform:

750 MHz Pentium III, Windows 2000

Program Listing for

varioview450.mcd

$D := READPRN("gamv450.prn")$ $\quad I := rows(D)$ $\quad i := 1..I$

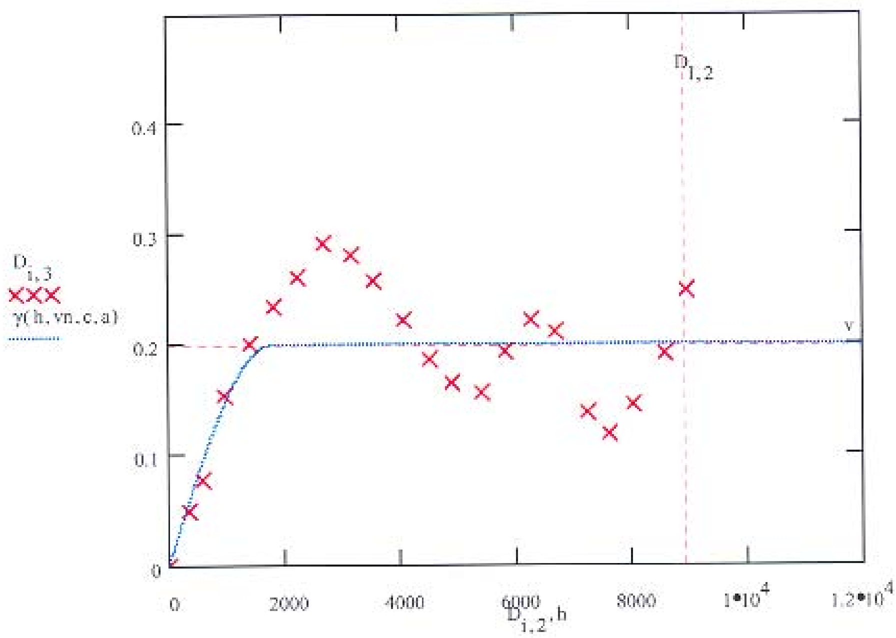
$h := 0, 10..12000$ $\quad v := 0.201$

$$\gamma(h, vn, c, a) := vn + c \cdot if\left[h < a, \left[1.5 \cdot \frac{h}{a} - 0.5 \cdot \left(\frac{h}{a}\right)^3\right], 1\right]$$

$a := 1790$ $\quad vn := 0.0$ $\quad c := v$ $\quad v = 0.201$

$$MSE := \frac{1}{I-1} \cdot \sum_{i=2}^{I} \left(D_{i,3} - \gamma\left(D_{i,2}, vn, c, a\right)\right)^2$$

$MSE \cdot 100 = 0.209215$



Appendix L - Routine Calculation: Conditional Indicator Simulations for AP-088

Software Used:

GSLIB program, subroutines, and include files: ACORNI.FOR, BEYOND.FOR, CHKNAM.FOR, COVA3.FOR, GETINDX.FOR, KSOL.FOR, LOCATE.FOR, ORDREL.FOR, PICKSUPR.FOR, POWINT.FOR, SETROT.FOR, SETSUPR.FOR, SISIM.F, SORTEM.FOR, SQDIST.FOR, SRCHSUPR.FOR, sisim.inc

Compiler: Fortran Powerstation 4.0

Description:

Conditional indicator simulations of Culebra high transmissivity zones were generated using the GSLIB routine "SISIM.f." A small section of the source code (lines 83-101 of the GSLIB routine "SISIM.f") was modified to facilitate the use DOS batch files. The following lines were modified:

```
c
c Get the name of the parameter file - try the default name if no input:
c
      write(*,*) 'Which parameter file do you want to use?'
      read (*,'(a40)') str
      if(str(1:1).eq.' ')str='sisim.par                           '
      inquire(file=str,exist=testfl)
      if(.not.testfl) then
            write(*,*) 'ERROR - the parameter file does not exist,'
            write(*,*) '        check for the file and try again  '
            write(*,*)
            if(str(1:20).eq.'sisim.par           ') then
                  write(*,*) '        creating a blank parameter file'
                  call makepar
                  write(*,*)
            end if
            stop
      endif
      open(lin,file=str,status='OLD')
```

to read:

```
c
c Get the name of the parameter file - try the default name if no input:
c

c          COMMENTED OUT BY RMHOLT 5/15/02
c
c     write(*,*) 'Which parameter file do you want to use?'
c     read (*,'(a40)') str
```

```
c     if(str(1:1).eq.' ')str='sisim.par
c     inquire(file=str,exist=testfl)
c     if(.not.testfl) then
c          write(*,*) 'ERROR - the parameter file does not exist,'
c          write(*,*) '       check for the file and try again  '
c          write(*,*)
c          if(str(1:20).eq.'sisim.par           ') then
c               write(*,*) '       creating a blank parameter file'
c               call makepar
c               write(*,*)
c          end if
c          stop
c     endif
      open(lin,file='sisim.par',status='OLD')
```

A Fortran executable (sisim.exe) was created using Fortran Powerstation 4.0. An input parameter file (sisim.par) controlled the program options. An example parameter file with explanation of parameters is shown below.

```
                  Parameters for SISIM
                  ********************

START OF PARAMETERS:
0                          \1=continuous(cdf), 0=categorical (pdf) – We simulated a categorical random variable
2                          \number thresholds/categories – We used 2 Categories (0=high T, 1=low T)
0 1                        \thresholds / categories – Category labels (0=high T, 1=low T)
0.278 0.722                \global cdf / pdf – Fraction of each category in the data
ndlogTe.dat                \file with data - Containing categorical data for each well with (0=high T, 1=low T)
1  2  3   6                \columns for X,Y,Z, and variable – Indicates that Categorical data is contained in column 6
haliteg.dat                \file with soft indicator input – Soft data around wells and in the halite region
1  2  3   4 5              \columns for X,Y,Z, and indicators – Indicators for high T in column 4, Indicators for Low T in column 5
                           Note that the total of both columns must sum to 1
0                          \Markov-Bayes simulation (0=no,1=yes)
0        0                 \ calibration B(z) values
-.0001   2.0               \trimming limits
0.0      1.0               \minimum and maximum data value – 0 and 1 for categorical variables
1    0.0                   \lower tail option and parameter – Not used - dummy values
1    1.0                   \middle option and parameter – Not used - dummy values
1    1.0                   \upper tail option and parameter – Not used - dummy values
haliteg.dat                \file with tabulated values – Not used - is a dummy file name
6  3                       \columns for variable, weight – Not used - dummy values
2                          \debugging level: 0,1,2,3
sisim.dbg                  \file for debugging output
sisim.out                  \file for simulation output
10                         \number of realizations – We chose to run 10 simulations at a time
447   601700.0    50.0  \nx,xmn,xsiz – Number of x nodes, minimum x value, delta x
613   3566500.0   50.0  \ny,ymn,ysiz – Number of y nodes, minimum y value, delta y
1   1.0   1.0              \nz,zmn,zsiz – Number of z nodes, minimum z value, delta z – the simulation is 2D
8589637                    \random number seed - Varied between 10 different runs to generate 100 different simulations
8                          \maximum original data  for each kriging – Selected to yield simulations consistent with conceptual model
3                          \maximum previous nodes for each kriging– Selected to yield simulations consistent with conceptual model
8                          \maximum soft indicator nodes for kriging– Selected to yield simulations consistent with conceptual model
1                          \assign data to nodes? (0=no,1=yes) – Selected to yield simulations consistent with conceptual model
0    3                     \multiple grid search? (0=no,1=yes),num – No multiple grid search, dummy variable
0                          \maximum per octant    (0=not used)
200000.0  200000.0  200000.0    \maximum search radii – Set large to insure that data are used
 0.0  0.0   0.0                 \angles for search ellipsoid – Indicating isotropic search
0 0.5                      \0=full IK, 1=median approx. (cutoff) – Full indicator kriging
0                          \0=SK, 1=OK – Simple kriging required by theory
1   0.0                    \One   nst, nugget effect – Variogram for high T, nugget effect = 0
1   0.201 0.0   0.0   0.0\it,cc,ang1,ang2,ang3 –Variogram type = spherical, sill value, rotation angles =0 because isotropic
       1790. 1790. 1.            \a_hmax, a_hmin, a_vert – Correlation lengths x=y 2D  isotropic
```

```
1   0.0                           \One   nst, nugget effect – Variogram for low T, nugget effect = 0
1   0.201 0.0   0.0   0.0\it,cc,ang1,ang2,ang3 – Variogram type = spherical, sill value, rotation angles =0 because isotropic
     1790. 1790. 1.               \a_hmax, a_hmin, a_vert – Correlation lengths x=y 2D  isotropic
```

Conditioning data are read from file "ndlogTe.dat." Soft data for conditioning are read from "haliteg.dat." All 10 conditional indicator simulations are output to "sisim.out" as a single vector of 1's or 0's.

Input:

- File: sisim.par (shown above)
- File: ndlogTe.dat (Attached in Appendix I)
- File: haliteg.dat (File halite.txt of Appendix G)

Output:

- File: sisim.out (Attached)

Data Sources:

Appendix I and Appendix G

Platform:

750 MHz Pentium III, Windows NT 4.0

This parameter file directs output containing indicator values with x, y, and z coordinates to file "r01cord.out." For each of the ten realizations, this code is re-run with a new parameter file (e.g., R02.par for realization 2) and a different output file (e.g., r02coord.out for realization 2). The second and third characters in both the *.par and *coord.out files are varied to reflect the realization.

Input:

- File: R**.par (Shown above)
- File: sisim.out (Described in Appendix L)

Output:

- File: r**coord.prn (Attached)

Data Sources:

See Appendix L.

Platform:

750 MHz Pentium III, Windows NT 4.0

Appendix M - Routine Calculation: Adding Coordinates to Conditional Indicator Simulations for AP-088

Software Used:

GSLIB program: ADDCOORD.FOR

GSLIB subroutines: CHKNAM.FOR, STRLEN.FOR

Compiler: Fortran Powerstation 4.0

Description:

Output from the conditional indicator simulator does not contain coordinates and all 10 of the simulations are contained within a single output file. The GSLIB program "ADDCOORD.FOR" separates the individual simulations and adds coordinates to the indicator output. To facilitate use of this program with DOS batch files, the following lines of source code in "ADDCOORD.FOR" were commented out.

```
c          COMMENTED OUT BY RMHOLT 5/15/02
c     write(*,*) 'Which parameter file do you want to use?'
c     read (*,'(a20)') str(1:20)
c     if(str(1:1).eq.' ') str(1:20) = 'addcoord.par        '
c     inquire(file=str(1:20),exist=testfl)
c     if(.not.testfl) then
c           write(*,*) 'ERROR - the parameter file does not exist,'
c           write(*,*) '        check for the file and try again  '
c           write(*,*)
c           if(str(1:20).eq.'addcoord.par        ') then
c                 write(*,*) '        creating a blank parameter file'
c                 call makepar
c                 write(*,*)
c           end if
c           stop
c     endif
c     open(lin,file=str(1:20),status='OLD')
c
c Find Start of Parameters:
c
c 1   read(lin,'(a4)',end=98) str(1:4)
c     if(str(1:4).ne.'STAR') go to 1
c          END COMMENTED OUT
```

A parameter file controls this program. An example parameter file (R01.par) is shown below.

```
sisim.out                    \file with data
r01cord.out                  \file for output
1                            \realization number
447   601700.0    50.0       \nx,xmn,xsiz
613   3566500.0    50.0      \ny,ymn,ysiz
1   1.0   1.0                \nz,zmn,zsiz
```

Appendix N - Routine Calculation: Calculation of Mean Transmissivity Fields for AP-088

Software Used:

program: meantsim.for (written by R. M. Holt)

Compiler: Fortran Powerstation 4.0

Description:

A simple Fortran routine was developed to apply the equation (3) to the Culebra model domain (program listing below). Program "meantsim.for" requires a simple parameter file that contains a three character realization name (see below). This program reads in a series of data files that contain either depth or indicator data at each grid point in the Culebra model domain. File "depths.dat" contains the depth of the Culebra at each grid point. File "dinds.dat" contains an indicator function that is 1 when the grid point location falls in the region where Salado dissolution has occurred and 0 otherwise. File "middlezones.dat" contains an indicator function that is 1 when the grid point location falls between the zone of Salado dissolution and the region where halite is present in either m2/h2 or m3/h3 and 0 otherwise. File "h2ind.dat" contains an indicator function that is 1 when halite is present in the m2/h2 interval at the grid point location and 0 otherwise. File "r**coord.out" contains an indicator function that is 0 when the grid point falls in a high transmissivity zone and 1 otherwise. Note there are 100 different "r**coord.out" files that have stochastically varying locations of Culebra high-transmissivity zones. Each of these files has a unique name with the realization number occupying the "**" portion of the file name. The program also opens three output files. File "r**T.out" contains the UTMX, UTMY, log[transmissivity (m/s)], and transmissivity (m/s). File "r**T.txt" is a comma-delimited file containing a grid point counter and log[transmissivity (m/s)]. File "r**cntr.txt" which is comma delimited file containing a grid point counter, the UTMX coordinate of the grid point, and the UTMY coordinate of the grid point. The last two files are used for visualization of the transmissivity field using GIS software.

The program opens all files and then loops over all grid points. It reads the depth and indicator values from input files, estimates the log transmissivity using equation (3), and writes the results to the output files.

Input:

- File: r**T.par (See below)
- File: depths.dat (File isopach.txt from Appendix F)
- File: dinds.dat (File p_dissolution.txt from Appendix H)
- File: middlezones.dat (File p_middlezone.txt from Appendix H)
- File: h2ind.dat (File p_halite.txt from Appendix H)
- File: r**coord.dat (See Appendix M)

Note: '**' corresponds to realization number

Output:

- File: r**T.out
- File: r**T.txt
- File: r**cntr.txt

Note: '**' corresponds to realization number

Data Sources:

See Appendix F, Appendix H, and Appendix M

Platform:

750 MHz Pentium III, Windows NT 4.0

Program Listing for "meantsim.for"

```
      program meantsim
c     This program reads in required data for regression estimation of
c     the mean of Culebra logT.

      parameter (NX = 447)
      parameter (NY = 613)
      parameter (b1 = -5.441)
      parameter (b2 = -4.636e-3)
```

```
          parameter (b3 = 1.926)
          parameter (b4 = 0.678)
          parameter (b5 = -1.0)

          real X,Y,Z,h2,mz,di,dpth,ht,logT,T
          character str*3

          read(21,'(a3)') str

   open(22,file='h2inds.dat',status='old')
   open(23,file='middlezones.dat',status='old')
   open(24,file='dinds.dat',status='old')
   open(25,file='depths.dat',status='old')
   open(26,file=str // 'cord.out',status='old')
   open(41,file=str // 'T.out',status='unknown')
   open(42,file=str // 'T.txt',status='unknown')
   open(43,file=str // 'cntr.txt',status='unknown')

          do i=1,7
            read(26,*)
          end do

          icntr=0
          do j=1,NY
            do i=1,NX
              icntr=1+icntr
              read(22,*) X,Y,h2
              read(23,*) X,Y,mz
              read(24,*) X,Y,di
              read(25,*) X,Y,dpth
              read(26,*) X,Y,Z,ht
                     logT=b1+b2*dpth+b3*mz*(1.-ht)+(b3+b4)*di+b5*h2
              T=10**(logT)
c         Output for flow models
              write(41,10) int(X),int(Y),logT,T
c         Output for visuallization
              write(42,*) icntr,',',logT
              write(43,*) icntr,',',int(X),',',int(Y)
            end do
          end do

 10  format(2(1x,i14),1x,2(1x,e14.5))
          end
```

Example parameter file for "meantsim.for"

File "R01T.par

r01

Appendix O - Routine Calculation: Procedure for Calculating Mean Transmissivity Fields for AP-088

Software Used:

DOS

Description:

100 realizations of Culebra transmissivity were generated in 10 groups of 10 on 10 different 750 MHz Pentium III, Windows NT 4.0 computers contained in The University of Mississippi Geoinfomatics Laboratory. Computations were performed simultaneously and independently on multiple computer platforms to reduce the time of computation. Separate DOS batch files were used on each computer to launch and control the processing of simulations. All batch files were the same (see below). The batch file first launches the program "sisim.exe" which then generates 10 equally probable indicator realizations of Culebra high-transmissivity zones (see Appendix L). It then adds coordinates to each of the indicator realizations using addcoord.exe (see Appendix M). Finally it calculates a mean Culebra transmissivity field for each realization using "meantsim.exe" (see Appendix N).

This batch file was executed on each of the 10 computers used. Input, Fortran executable, and batch files were first copied onto each computer. All files were identical except for the files "sisim.par" which contained different random number seeds. The batch files were then launched manually. The resulting directories were copied off of the machines and archived.

Input:

N/A

Output:

N/A

Data Sources:

N/A

Platform:

750 MHz Pentium III, Windows NT 4.0

Contents of Tfield.bat

```
sisim
addcoord r01.par
addcoord r02.par
addcoord r03.par
addcoord r04.par
addcoord r05.par
addcoord r06.par
addcoord r07.par
addcoord r08.par
addcoord r09.par
addcoord r10.par
meantsim r01t.par
meantsim r02t.par
meantsim r03t.par
meantsim r04t.par
meantsim r05t.par
meantsim r06t.par
meantsim r07t.par
meantsim r08t.par
meantsim r09t.par
meantsim r10t.par
```

Appendix P – CD ROM Contents

All of the files created in Task 2 of AP-088 are contained within two CD ROMs. The directory structure for these CDs is shown below.

Appendix File Structure and File Name List

AP_088 Task 2

CD #1

- Appendix A
  - Input
    - newdat4_7_02m2.prn
  - Mathcad
    - Regress Model 3.mcd
  - Output
    - residuals.dat
- Appendix B
  - Input
    - culebra_structure.pdf
    - drillhole_ID_numbers.pdf
    - rustler_halite_margins.pdf
    - salado_dissolution_and_culvt_thickness.pdf
  - Output
    - salado_dissolution_new.shp
    - salt_margin_m1_h1.shp
    - salt_margin_m2_h2.shp
    - salt_margin_m3_h3.shp
    - salt_margin_m4_h4.shp
    - top_culebra.shp
- Appendix C
  - Output
    - final_points.shx
    - final_points.txt
    - qa_final_pints.xls
- Appendix D
  - Input
    - top_culebra (Arc/Info Coverage)
  - Output
    - culebra (Arc/Info Grid)
- Appendix E
  - Input
    -
  - Output
    - dem (Arc/Info Grid)
- Appendix F
  - Input
    - culebra (Arc/Info Grid)
    - dem (Arc/Info Grid)

  - Output
    - isopach
    - isopach.txt
    - qa_isopach.xls
- Appendix G
  - Input
    - final_points.shx
    - salt_margin_m2_h2.shp
    - salt_margin_m3_h3.shp
  - Output
    - halite.txt
- Appendix H
  - Input
    - final_points.shp
    - final_points.txt
    - salado_dissolution_new.shp
    - salt_margin_m2_h2.shp
    - salt_margin_m3_h3.shp
  - Output
    - salado_dissolution_qa.pdf
    - middlezone_qa.pdf
    - halite_qa.pdf
    - p_middlezone.txt
    - p_halite.txt
    - p_dissolution.txt
- Appendix I
  - Input
    - newdat4_7_02m2.prn
  - Mathcad
    - High T indicator 2.mcd
  - Output
    - inddat.dat
    - ndlogTe.dat
- Appendix J
  - Executable
    - gamv.exe
  - Input
    - GAMV.PAR
    - ndlogTe.dat
  - Output
    - gamv450.prn
  - Source_Code
    - CHKNAM.F
    - CHKNAM.FOR
    - GAMV.FOR
    - GAMV.INC
- Appendix K
  - Input
    - gamv450.prn
  - Mathcad
    - varioview450.mcd
- Appendix L
  - Input
    - haliteg.dat
    - ndlogTe.dat

        - SISIM.PAR
    - Source_code
        - ACORNI.FOR
        - BEYOND.FOR
        - CHKNAM.FOR
        - COVA3.FOR
        - GETINDX.FOR
        - KSOL.FOR
        - LOCATE.FOR
        - ORDREL.FOR
        - PICKSUPR.FOR
        - POWINT.FOR
        - SETROT.FOR
        - SETSUPR.FOR
        - SISIM.F
        - SISIM.INC
        - SORTEM.FOR
        - SQDIST.FOR
        - SRCHSUPR.FOR
- Appendix M
    - Input
        - R01.PAR
    - Source_code
        - ADDCOORD.FOR
        - CHKNAM.FOR
        - STRLEN.FOR
- Appendix N
    - Input
        - R01t.PAR
    - Source_code
        - meantsim.for

CD #2 – Note that all realization directories are essentially the same. File names vary as described in Appendix N.

- Appendix O
    - newb10r.zip
    - newb09r.zip
    - newb08r.zip
    - newb07r.zip
    - newb06r.zip
    - newb05r.zip
    - newb04r.zip
    - newb03r.zip
    - newb02r.zip
    - newb01r.zip

Example Listing of a Realization Directory

addcoord.exe	Application
meantsim.exe	Application
sisim.exe	Application
depths.dat	Data File
dinds.dat	Data File
h2inds.dat	Data File

haliteg.dat	Data File
middlezones.dat	Data File
ndlogTe.dat	Data File
sisim.dbg	Data File
Tfield.bat	Batch File
r01cord.out	Out File
r01T.out	Out File
r02cord.out	Out File
r02T.out	Out File
r031cord.out	Out File
r03T.out	Out File
r04cord.out	Out File
r04T.out	Out File
r05cord.out	Out File
r05T.out	Out File
r06cord.out	Out File
r06T.out	Out File
r07cord.out	Out File
r07T.out	Out File
r08cord.out	Out File
r08T.out	Out File
r09cord.out	Out File
r09T.out	Out File
r10cord.out	Out File
r10T.out	Out File
sisim.out	Out File
R01.PAR	Parameter File
R01t.PAR	Parameter File
R02.PAR	Parameter File
R02t.PAR	Parameter File
R03.PAR	Parameter File
R03t.PAR	Parameter File
R04.PAR	Parameter File
R04t.PAR	Parameter File
R05.PAR	Parameter File
R05t.PAR	Parameter File
R06.PAR	Parameter File
R06t.PAR	Parameter File
R07.PAR	Parameter File
R07t.PAR	Parameter File
R08.PAR	Parameter File
R08t.PAR	Parameter File
R09.PAR	Parameter File
R09t.PAR	Parameter File
R10.PAR	Parameter File
R10t.PAR	Parameter File
SISIM.PAR	Parameter File
r01cntr.txt	Text file of node ID and UTM coordinates
r01T.txt	Text file of node ID and transmissivity
r02cntr.txt	Text file of node ID and UTM coordinates
r02T.txt	Text file of node ID and transmissivity
r03cntr.txt	Text file of node ID and UTM coordinates
r03T.txt	Text file of node ID and transmissivity
r04cntr.txt	Text file of node ID and UTM coordinates
r04T.txt	Text file of node ID and transmissivity
r05cntr.txt	Text file of node ID and UTM coordinates

r05T.txt	Text file of node ID and transmissivity
r06cntr.txt	Text file of node ID and UTM coordinates
r06T.txt	Text file of node ID and transmissivity
r07cntr.txt	Text file of node ID and UTM coordinates
r07T.txt	Text file of node ID and transmissivity
r08cntr.txt	Text file of node ID and UTM coordinates
r08T.txt	Text file of node ID and transmissivity
r09cntr.txt	Text file of node ID and UTM coordinates
r09T.txt	Text file of node ID and transmissivity
r10cntr.txt	Text file of node ID and UTM coordinates
r10T.txt	Text file of node ID and transmissivity