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ADDENDUM 2 TO 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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Discussion

This addendum applies to 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. 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 in Holt and Yarbrough (2002; 2003). This addendum is necessary because Task 2 has been revised to reflect a change in the grid spacing of the mean transmissivity fields from 50 m to 100 m and the total number of realizations was increased from 100 to 500. Subtasks 1 (Conceptual Model Development), 2 (Linear Regression Analysis), and 4 (Indicator Variography) are unaffected by this change. Subtasks 3 (Reduction of Geological Map Data), 5

(Conditional Indicator Simulation), and 6 (Construction of Transmissivity Fields), however, were repeated.

Because the new grid spacing required minor changes in Subtasks 3, 5, and 6, this addendum contains supplements for Sections 4.0, 6.0, and 7.0 of Holt and Yarbrough (2002). In addition, supplements have been prepared for some of the appendices contained within Holt and Yarbrough (2002; 2003) that require modification. Appendix supplements include:

- Appendix C Supplement - Routine Calculation: Creation of 100-m grid for AP-088,
- Appendix D Supplement - Routine Calculation: Creation of Culebra Structure Surface for AP-088,
- Appendix E Supplement - Routine Calculation: Creating Surface Elevation Data for AP-088,
- Appendix F Supplement - Routine Calculation: Creating an Isopach of Culebra Overburden for AP-088,
- Appendix G Supplement - Routine Calculation: Creation of Soft Data Files for AP-088,
- Appendix H Supplement - Routine Calculation: Creation of the Indicator Grids for AP-088,
- Appendix L Supplement - Routine Calculation: Conditional Indicator Simulations for AP-088,
- Appendix M Supplement - Routine Calculation: Adding Coordinates to Conditional Indicator Simulations for AP-088,
- Appendix N Supplement - Routine Calculation: Calculation of Mean Transmissivity Fields for AP-088,
- Appendix O Supplement - Routine Calculation: Procedure for Calculating Mean Transmissivity Fields for AP-088,
- Appendix P Supplement – CD-ROM contents.

References Cited

Holt, R. M., and L. Yarbrough, 2002, Analysis Report Task 2 of AP-088 – Estimating base transmissivity fields, ERMS#523889.

Holt, R. M., and L. Yarbrough, 2003, Addendum to Analysis Report Task 2 of AP-088 – Estimating base transmissivity fields, ERMS#523889.

Report Section Supplements

Supplement for Section 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) of Holt and Yarbrough (2002). Geologic maps from 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 Supplement). To create useable data sets, we imported the geological maps into a GIS environment and digitized the maps (Appendix B of Holt and Yarbrough, 2003). We then created a 100-m grid for over the Culebra model domain (Appendix C Supplement). Using the Culebra Structure Contour map data (Appendix D Supplement) and surface elevation data (Appendix E Supplement), we created an isopach map of the Culebra overburden on the 100-m model grid (Appendix F Supplement).

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 Supplement) for conditional indicator simulations. We assume that transmissivity within 120 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 100-m 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 Supplement).

Supplement for Section 6.0 – Subtask 5 – Conditional Indicator Simulation

The purpose of this subtask is to use conditional indicator simulation to generate 500 conditional realizations of the spatial locations of high-transmissivity zones in the Culebra. 500 conditional indicator simulations are generated on the 100-m model grid using the GSLIB program sisim (Deutsch and Journel, 1998) (Appendix L Supplement) 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 Supplement). The resulting indicator simulations are used in the construction of mean transmissivity fields (see Section 7.0).

Supplement for Section 7.0 – Subtask 6 – Construction of Mean Transmissivity Fields

The purpose of this subtask is to use the linear predictor (3) to generate 500 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 500 realizations of high-transmissivity indicators (Subtask 5). Realizations were assembled using a simple Fortran code, "meantsim.for" (Appendix N Supplement).

The 500 simulations were created in 5 sets. Each set consists of 10 groups of 10 realizations. All calculations were performed on a single 1.8-GHz Pentium 4, Windows 2000 computer at The University of Mississippi. A DOS batch file was used to launch and control the processing of simulations (Appendix O Supplement). These calculations resulted in 500 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.

Section Supplement References:

Deutsch, C. V., and A. G. Journel, 1992, GSLIB: *Geostatistical Software Library and User's Guide*, 2nd ed., Oxford University Press, New York, NY, 369 p.

Holt, R. M., and L. Yarbrough, 2002, Analysis Report Task 2 of AP-088 – Estimating base transmissivity fields, ERMS#523889.

Holt, R. M., and L. Yarbrough, 2003, Addendum to Analysis Report Task 2 of AP-088 – Estimating base transmissivity fields, ERMS#523889.

Powers, D. W., 2002, Analysis Report for Task 1 of Ap-088 – Construction of geologic contour maps, ERMS#522086.

Appendix Supplements

Appendix C Supplement - Routine Calculation: Creation of 100-m grid for AP-088

Software Used:

ArcView

Description:

A newly revised 100-m block-centered grid was created in ArcView. Again, to be sure that grid-block centers lie along the model boundary, the created grid extends 50 m past the model domain. The following are the specifications of the domain grid:

- # of Columns 224
- # of Rows 307
- Lower Left UTMX 601650 edge, 601700 grid-block center
- Lower Left UTMY 3566450 edge, 3566500 grid-block center
- Cell Size 100 m × 100 m

The GRIDPOINT function in Arc/Info was used to generate a point spatial data set. The centers of each 100-m grid block increase in 100-m increments from 601700 in the X direction and 3566500 in the Y direction. This new 100-m grid provided the basis for all revised 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 68,768 data points. This resulting data file was exported into a TAB delimited text format.

Input:

N/A

Output:

- ArcView shapefile "100m_points.shp"
- TAB delimitated file "100m_points.txt"

Platform:

1.8-GHz Pentium 4 - Windows 2000

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

Software Used:

Arc/Info

Description:

Instead of resampling the previously created 50-m surfaces, the new 100-m grids would be created from the original vector data. Using the same contour data produced from Appendix B of Holt and Yarbrough (2003), a newly derived Culebra structure surface was created on the 100-m grid pattern. Again, a hydrologically correct surface was calculated using the TOPOGRID command in ESRI's Arc/Info software. The TOPOGRID command was executed using the new 100-m grid spacing based on the grid locations derived in Appendix C Supplement. 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:

Appendix B and Appendix C of Holt and Yarbrough (2003)

Platform:

1.8-GHz Pentium 4 - Windows 2000

References:

Holt, R. M., and L. Yarbrough, 2003, Addendum to Analysis Report Task 2 of AP-088 – Estimating base transmissivity fields, ERMS#523889.