Using 3D Geologic Models to Synthesize Large and Disparate Datasets for Site Characterization and Verification Purposes

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INTRODUCTION

3D geologic models can be excellent tools to illustrate key concepts and findings (especially to lay persons, such as stakeholders, customers, and other concerned parties). Here we present examples of 3D geologic modeling efforts using data collected during site characterization and verification activities at the WIPP (see Beauheim et al. 2008, this session). In addition, we present a 4D hydrogeologic model of the effects of a large-scale pumping test on pressure head. These modeling efforts are focused on refining our understanding of the WIPP site by integrating a variety of geologic data.

Figure 1. The WIPP is situated in the northern portion of the Delaware Basin, which underlies south-eastern New Mexico and portions of West Texas. The repository is excavated in bedded halite of the Salado Formation, approximately 655 m below ground surface.

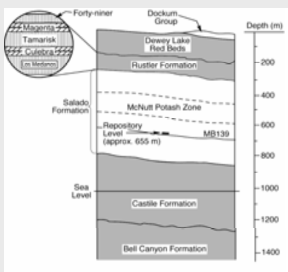


Figure 2. The Culebra is the primary focus of groundwater monitoring and modeling efforts as it is the most transmissive and continuously saturated hydrologic unit at the site and is considered the most plausible groundwater pathway for radionuclide release to the environment if the repository were ever to be breached.

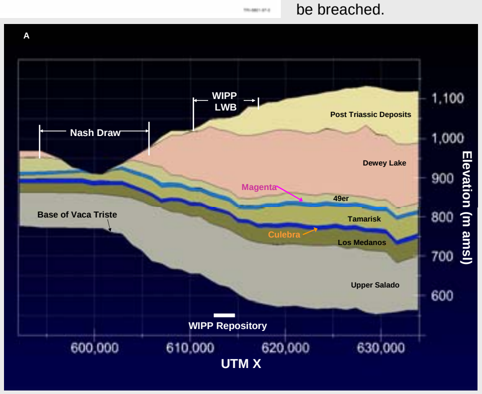


Figure 3. An east-west cross-section (A-A' in Fig. 4) of the WIPP area from land surface to the top of the Vaca Triste in the Upper Salado (40:1 vertical exaggeration).

2D Geologic Maps

Ground Surface Elevation

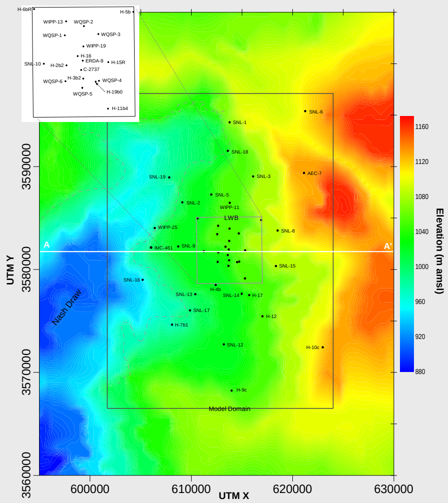


Figure 4. Map of ground surface elevation in the WIPP area, with the locations of the 50 Culebra monitoring network wells. LWB is the WIPP Land Withdrawal Act boundary.

Top of Culebra Elevation

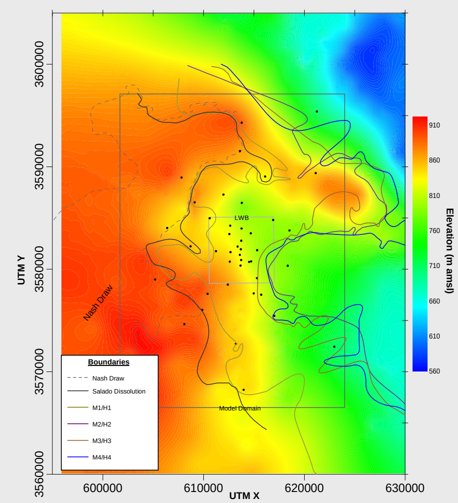


Figure 5. Map of Culebra structural elevation with Rustler depositional facies change boundaries. Facies changes are used in the Culebra conceptual model to predict transmissivity.

Culebra Overburden Thickness

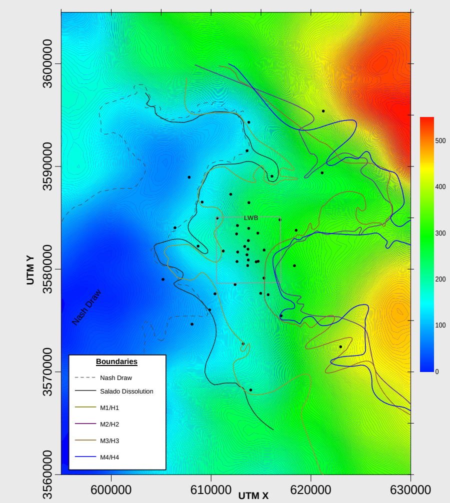


Figure 6. Culebra overburden thickness is a metric for the amount and degree of fracturing in the Culebra. Overburden thickness is another Culebra transmissivity predictor used in the conceptual model.

3D Geologic Structure

Culebra Structure

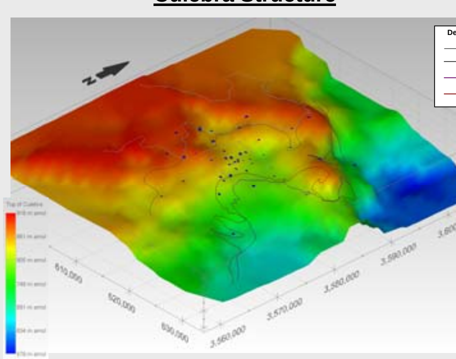


Figure 7. 3D image of Culebra structure colored for elevation, in m amsl (25:1 vertical exaggeration). Culebra structure is representative of the structure of the overall Rustler Formation.

Culebra Structure vs. Overburden

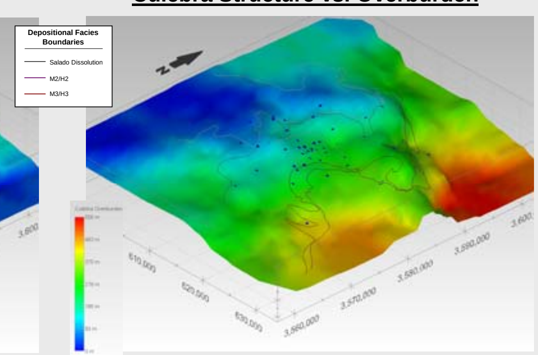


Figure 8. 3D image of Culebra structure colored for overburden thickness (25:1 vertical exaggeration). Facies boundaries are drawn (see also Fig. 7) and appear to follow both structural features of the Rustler and changes in overburden thickness.

Culebra Transmissivity vs. Structure

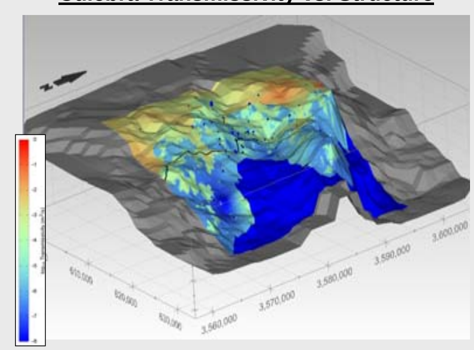


Figure 9. Image of a Culebra transmissivity (T) field overlain onto 3D map of Culebra structure (40:1 vertical exaggeration). Culebra T is linked to the amount and degree of fracturing and fracture fill, which are controlled, in part, by overburden thickness and Rustler Formation structure.

Pumping Tests

SNL has conducted a series of long-term pumping tests throughout the history of the WIPP hydrology program. Here we present contour maps of pumping tests at WIPP-11 (figures 10 and 11) and SNL-14 (figures 12 and 13) conducted Feb.1-20, 2005 and Aug. 4-26, 2005, respectively. Data are presented as change in pressure-head measured at the pumping and observation wells over the duration of each test (Hillesheim 2008). Data were kriged using GSLIB and contoured in Matlab 2008 (note: the color scales are different for each figure).

WIPP-11
19 days at 35 gpm

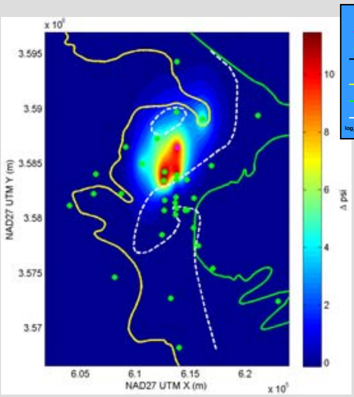
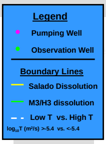


Figure 10. Extent of observed drawdown at the time the pump was shut off on day 19.



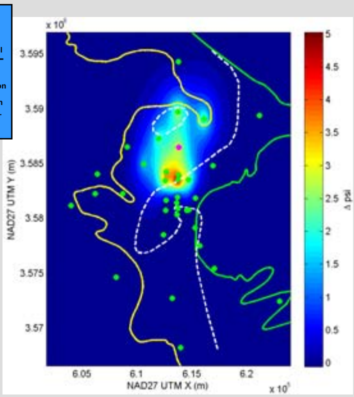


Figure 11. Extent of observed drawdown after 20 days of recovery.

SNL-14
22 days at 30 gpm

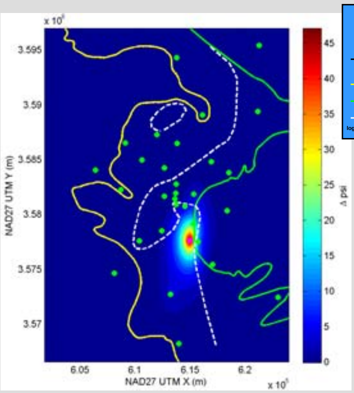
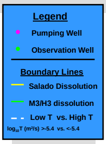


Figure 12. Extent of observed drawdown at the time the pump was shut off on day 22.



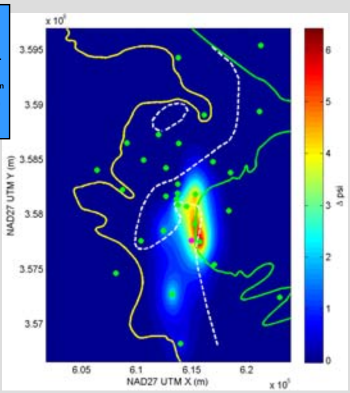


Figure 13. Extent of observed drawdown after 20 days of recovery.

4D Hydrologic Models

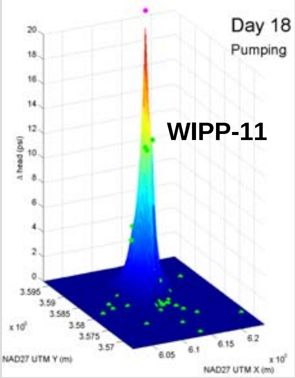
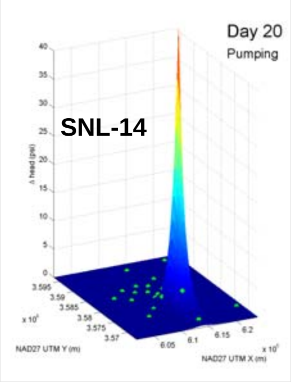


Figure 14. Extent of drawdown observed at WIPP-11 and SNL-14 near the end of their respective pumping periods (**note:** drawdown is inverted to better show changes in pressure head and that the scales are different between the two diagrams).

Note: 4D animations of both tests are displayed on laptop.



CONCLUSIONS

The modeling efforts described above have provided additional insights into the controls on transmissivity and flow in the WIPP vicinity. Ultimately, by combining these various types of data we have increased our understanding of the WIPP site's hydrogeologic system, a key aspect of continued certification.

References

Beauheim, R.L., P.S. Domski, R.M. Holt, and D.W. Powers, 2008, Integration of Thirty Years of Hydrogeological Investigations at the Waste Isolation Pilot Plant Site: Poster#H53E-1108, American Geophysical Union Fall Meeting. 15-19 December 2008, San Francisco, California USA.

Hillesheim, M.B., 2008, Change in Pressure-Head Calculations: Routine Calculations in Support of TP03-01, Testing of Wells at the WIPP Site: ERMS# 550521, Sandia National Laboratories, WIPP Records Center, Carlsbad, NM, 2 p.

Data presented here are preliminary and subject to change, do not cite.