Database Design and Management for 3-D Hydrological Modeling at DSCP

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Hazlett-Kincaid, Inc.
Specialized Geological Modeling Services

Project Acknowledgements

- Dr. Todd Kincaid (Hydrogeology) and Dr. Timothy Hazlett, Ph.D (Hydrogeology) of Hazlett-Kincaid, Inc.
- Mr. Hasan Dogrul of the Defense Energy Support Center (DESC).

Abstract

Cleanup activities at the Defense Support Center Philadelphia (DSCP) facility in South Philadelphia involve a light non-aqueous phase liquid (LNAPL) plume covering an area over 60-acres. Characterizing the extent and volume of the plume has been problematic and involved the work of more than six environmental consultants over the past 7 years with an accurate plume volume estimate hindered by the complexity of the geology in the shallow subsurface.

In order to more accurately characterize the site hydrogeology, and design an effective remediation strategy, a relational database was used to archive the shallow subsurface geology and the LNAPL plume morphology information. An Enviro Data® database, based on Microsoft Access® was used to store the information. EarthVision® geologic modeling software was then used to develop 3-dimensional visualizations of the site conditions and calculate an estimate of the plume volume. The database also serves as the framework for dissolved-phase groundwater contaminant fate and transport modeling using FEFLOW® and the evaluation of LNAPL plume remediation strategies through other forms of multi-phase flow modeling. The combination of modeling efforts provides a superior method of characterizing geologic, hydraulic, and engineered subsurface complexities and then articulating those complexities in a flow-modeling environment. The result is significantly improved predictive capability and a more reliable decision-support tool.

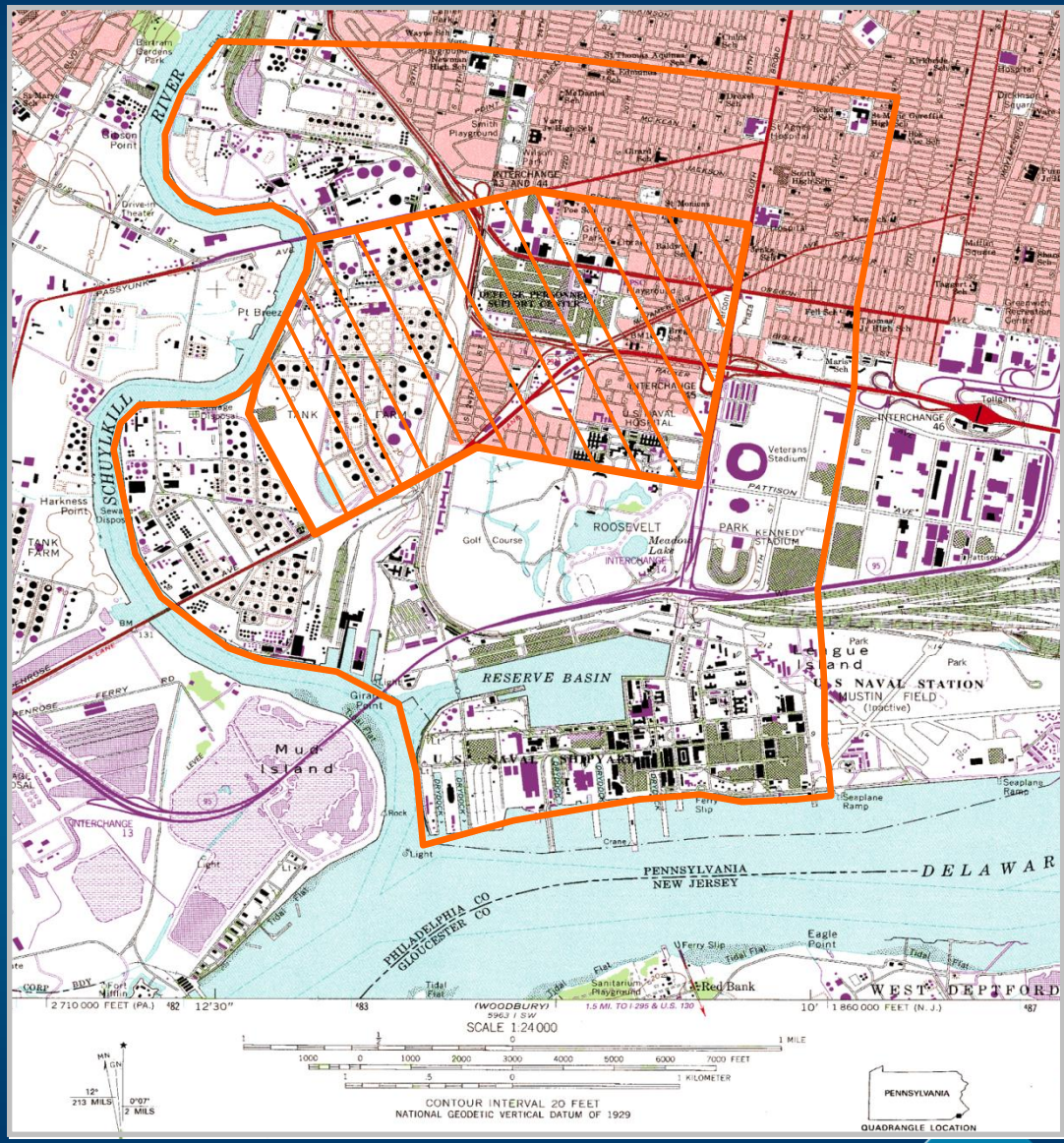
This paper will focus on the steps in the modeling process, including the exhaustive data compilation involving the boring logs, monitoring well construction logs, historical LNAPL thickness, groundwater and soil analyses, etc. dispersed among numerous hard copy reports and disorganized digital files. The paper will also discuss the advantages and disadvantages of using the EnviroData® database.

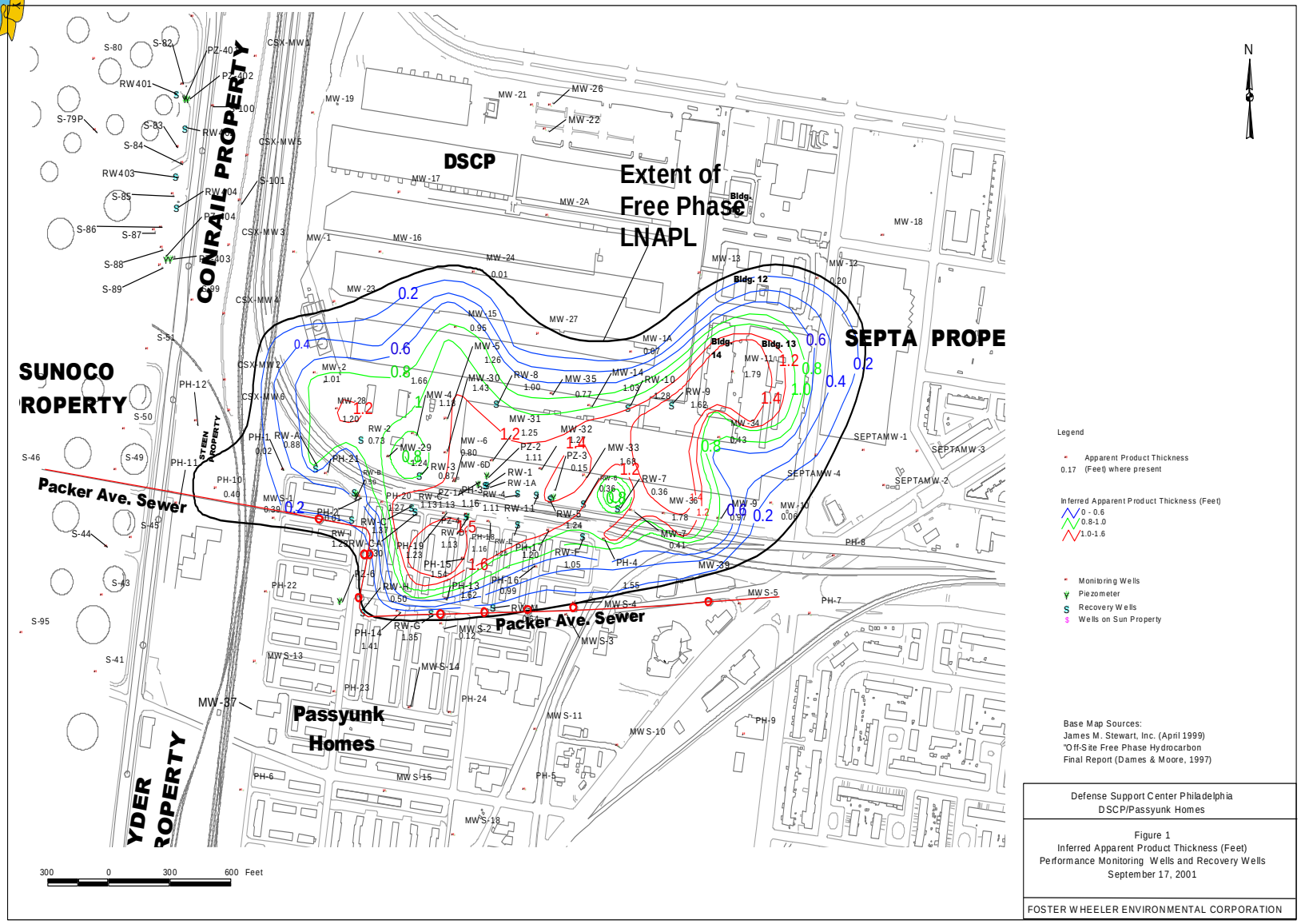
Defense Supply Center Philadelphia (DSCP) Background

- The 86-acre Former DSCP Site is located in Philadelphia Pennsylvania.
- The facility was responsible for worldwide distribution of supplies for DOD.
- The site is located in a mixed industrial, commercial and residential area.
- A light non-aqueous phase liquid (LNAPL) plume is located under DSCP and a housing area to the south.

Problem Overview

- Extensive LNAPL in shallow unconfined aquifer
- Numerous consultants completed work at the site over a number of years.
- Geologic and hydrogeologic data in numerous reports and electronic files
- Inconsistencies in geological logging.
- No centralized database in which to manage all of the existing data.
- No accurate LNAPL estimate.



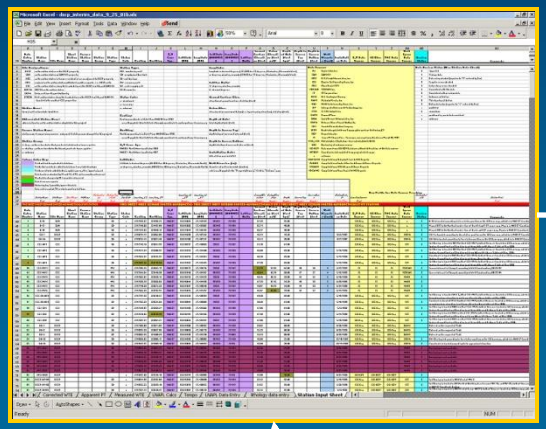

DSCP
Extent of
Free Phase
LNAPL
CONRAIL PROPERTY
SUNOCO
ROPERTY
SEPTA PROPE
Packer Ave. Sewer
Packer Ave. Sewer
Passyunk
Homes
YDER
ROPERTY
STEIN PROPERTY
Bldg. 12
Bldg. 13
Bldg. 14
N
300 0 300 600 Feet
Legend
Apparent Product Thickness
0.17 (Feet) where present
Inferred Apparent Product Thickness (Feet)
0 - 0.6
0.8-1.0
1.0-1.6
Monitoring Wells
Piezometer
Recovery Wells
Wells on Sun Property
Base Map Sources:
James M. Stewart, Inc. (April 1999)
"Off-Site Free Phase Hydrocarbon
Final Report (Dames & Moore, 1997)
Defense Support Center Philadelphia
DSCP/Passyunk Homes
Figure 1
Inferred Apparent Product Thickness (Feet)
Performance Monitoring Wells and Recovery Wells
September 17, 2001
FOSTER WHEELER ENVIRONMENTAL CORPORATION

Defense Supply Center Philadelphia Objectives

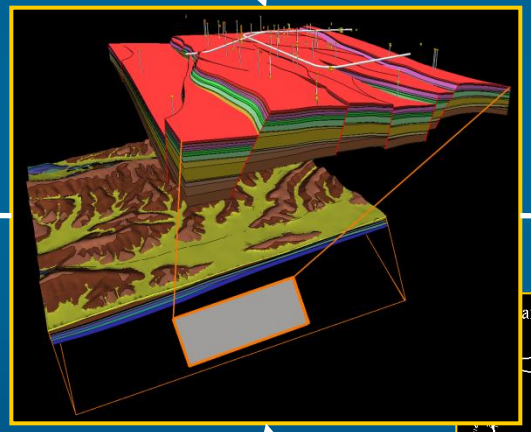
- Develop a comprehensive database.
- More accurately characterize site hydrogeology.
- Calculate an estimate of LNAPL plume volume.
- Establish a conceptual model basis for groundwater / fate & transport modeling
- Develop 3-dimensional visualizations of site complexities.

Database / Modeling Approach

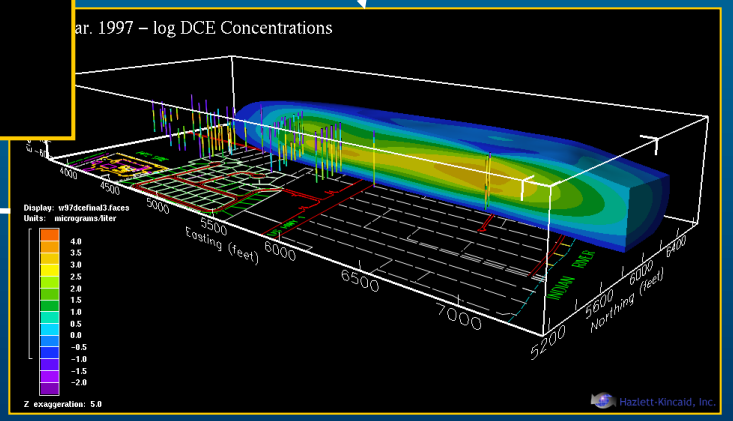
Data



GFM



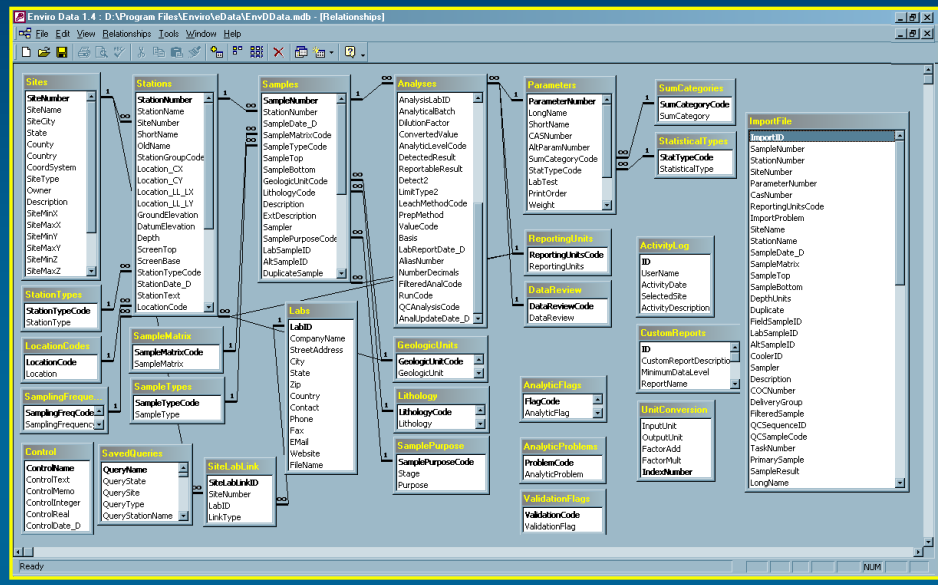
HSM



"Picture is worth 1000 words"

"Fit the Model to the Data – not the Data to the Model"

Enviro Data® by Geotech Computer Systems

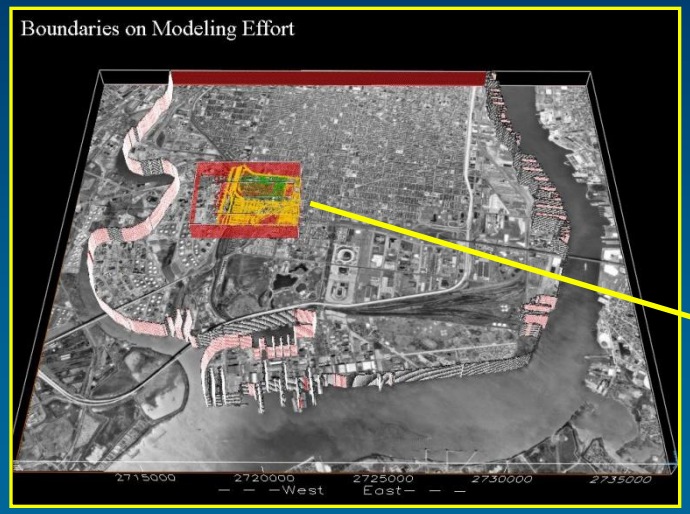


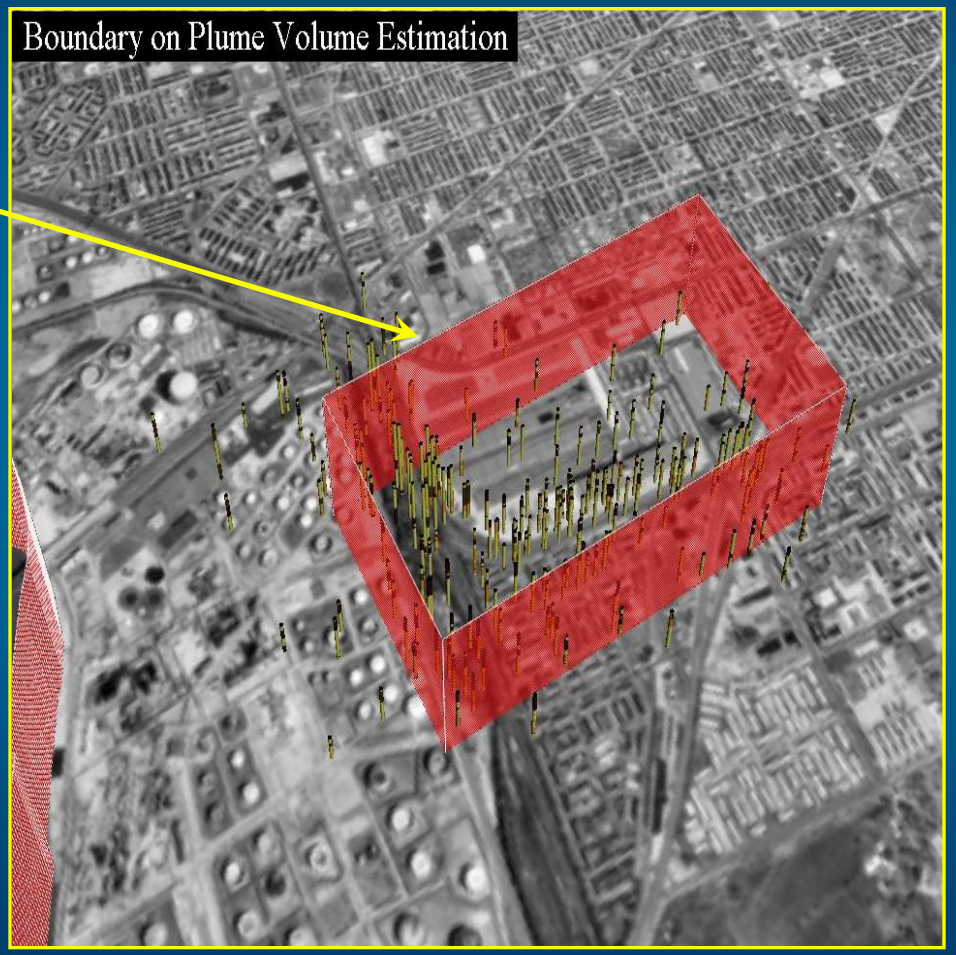
- Enviro Data® was used to manage and disseminate the large volumes of geological, hydrogeologic, and analytical data.
- Enviro Data® was chosen because:
  - It is well suited for geologic data;
  - Provides an easily adaptable data model structure to accommodate specific project goals;
  - It is relatively simple to learn & use.

Four Main Tables of Database Model

- Sites
  - Data sources: site data, regional data, etc.
  - Source contact information
- Stations
  - Well and borehole information: name, location, depth, screened interval, elevation data, etc.
  - Source of information.
- Samples
  - Unique measurements: lithologic units, depth to water, depth to product, geotechnical samples, etc.
  - Sample position information: depth to bottom, date, etc.
- Analysis
  - Result of all analysis performed on a sample.

Database Coverage to date

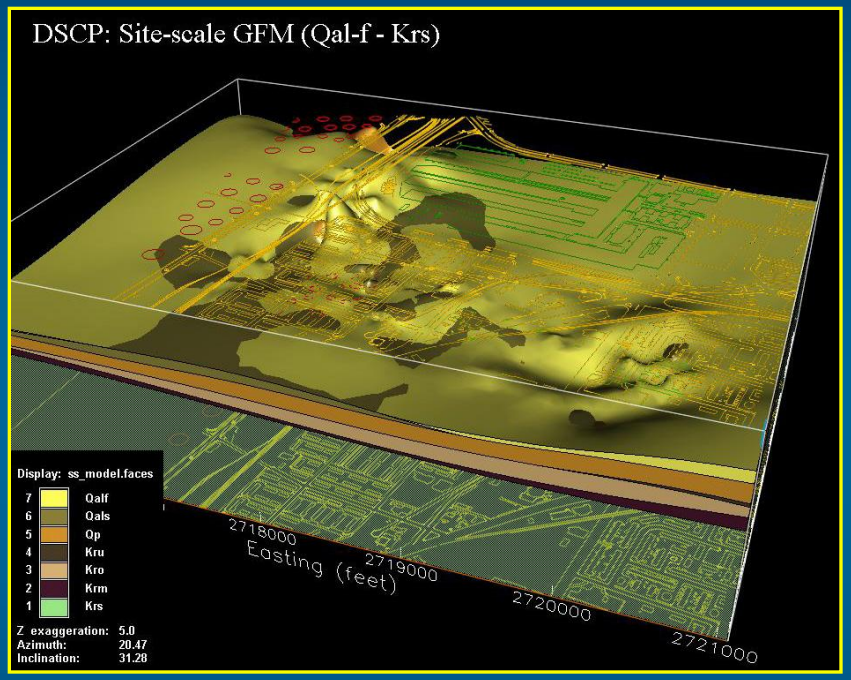




- Focused on Geologic and Groundwater Gauging data
  - > 400 wells and boreholes
  - > 10,000 individual samples
- Integrated database
- More complete 3-D picture of site than has ever been created

Geological Framework Model (GFM)

- Our GFM is a digital site conceptual model that synthesized all available data (geological, contam., and structural) into a centralized, visually and quantitatively query-able set of digital model files.



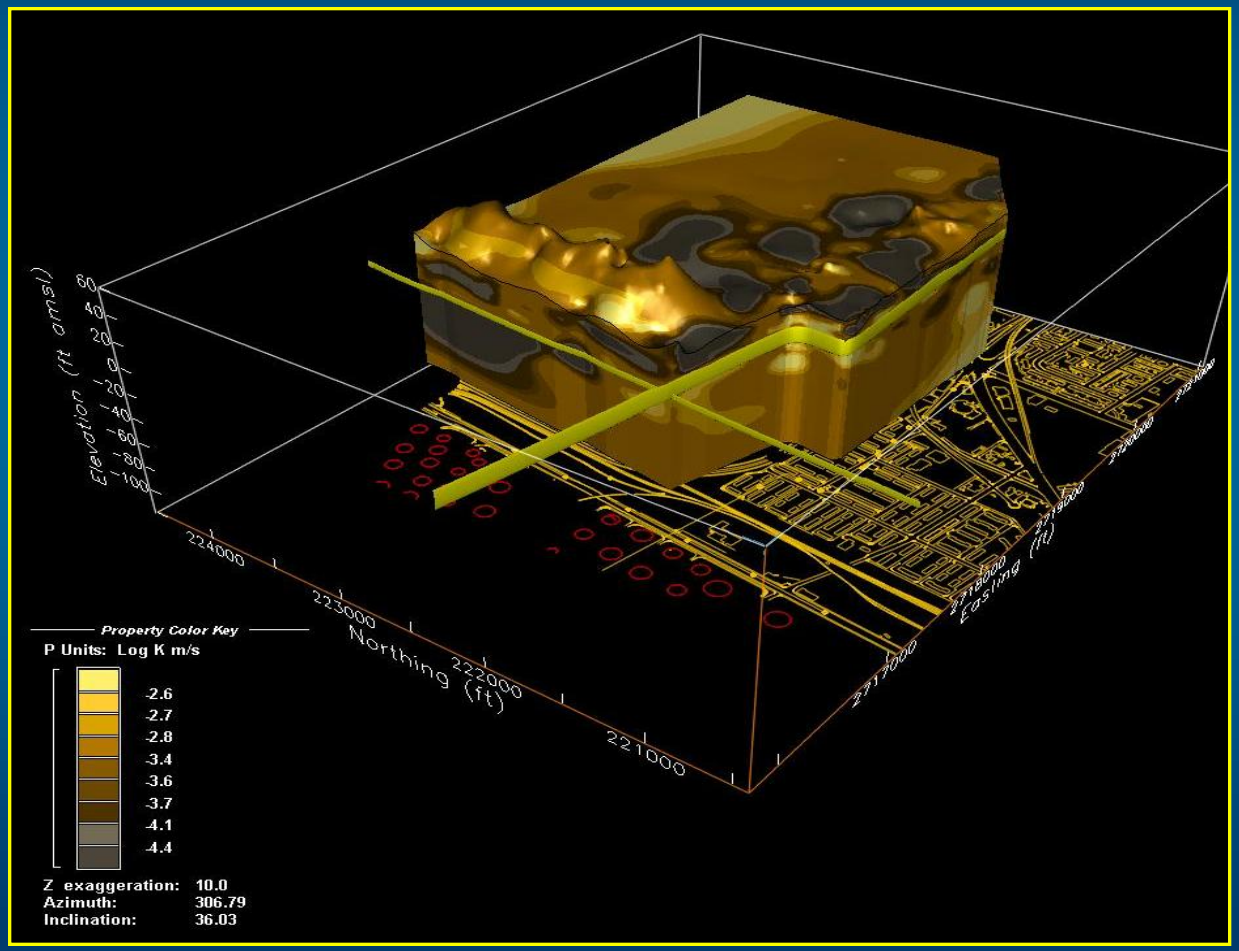
- The GFM becomes the working database containing all data and interpretations.

Earth Vision® Software Used to Develop Geological Framework Model

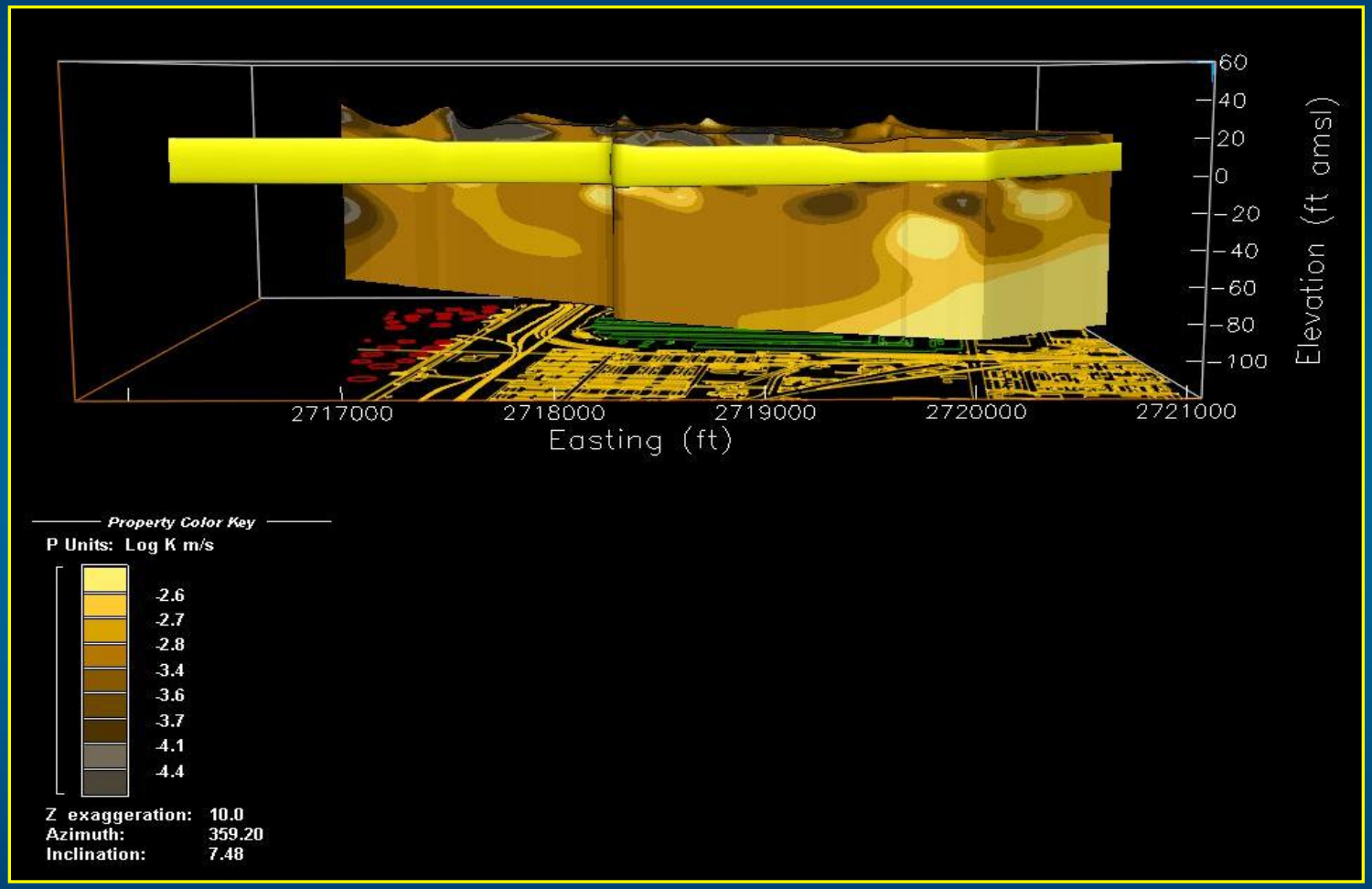
- EarthVision® solids and parameter modeling software was developed by Dynamic Graphics, Inc.
- Integrates diverse types of two- and three-dimensional data into grid files.
- Grid files can be quantitatively manipulated and visually evaluated.

Examples of Query-able Output

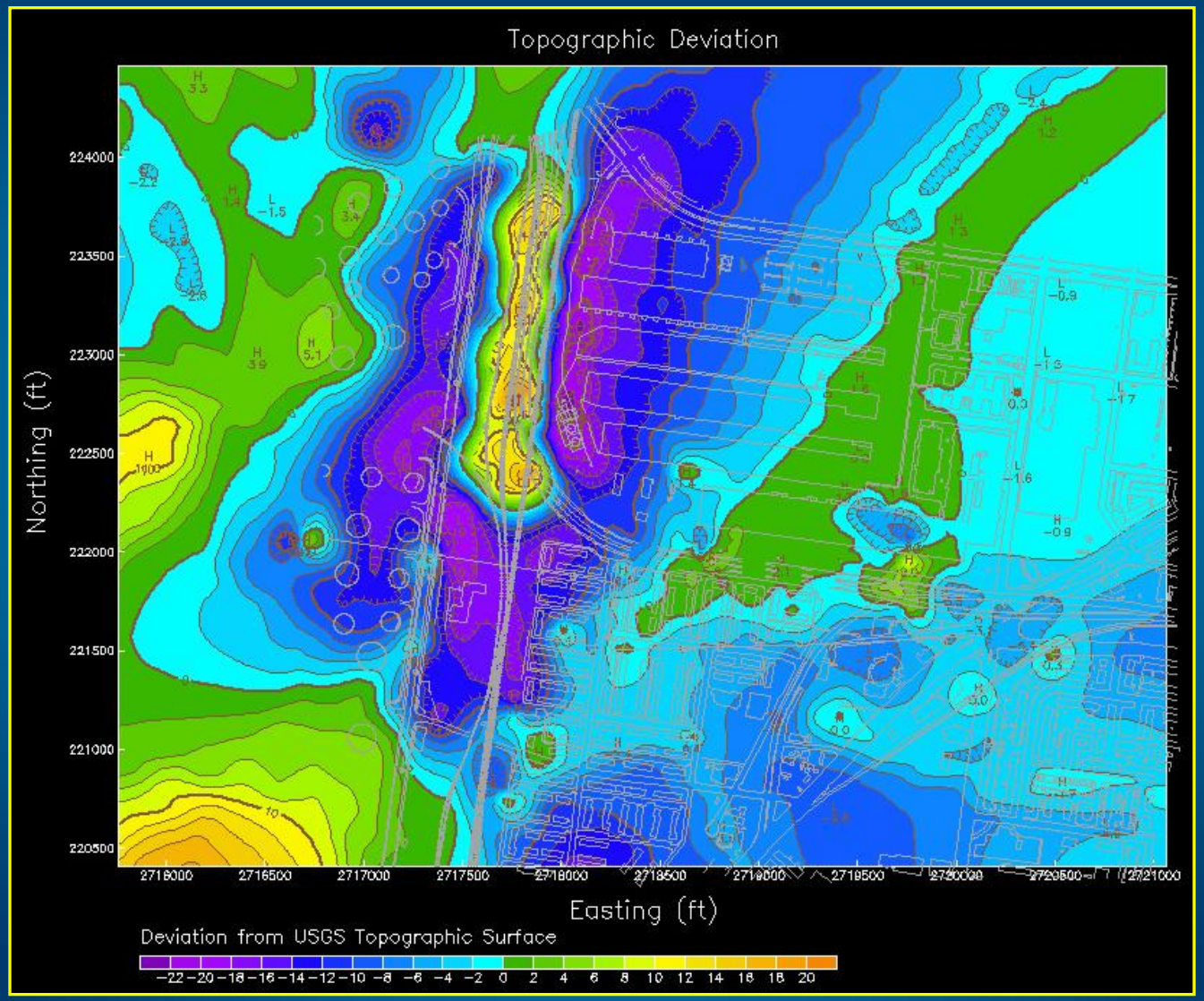
Hydraulic Conductivity along Sewers



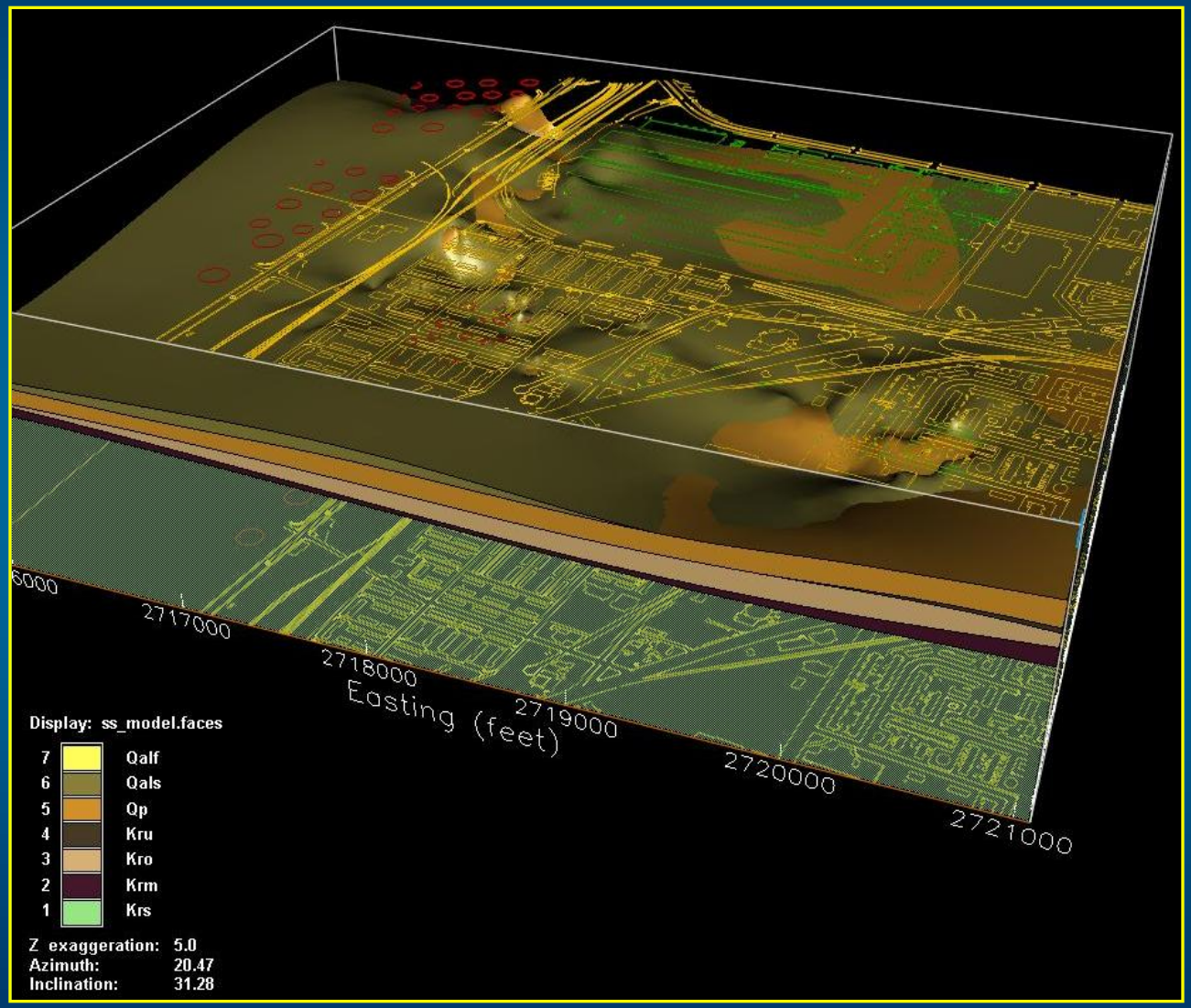
Hydraulic Conductivity - Packer Avenue Sewer



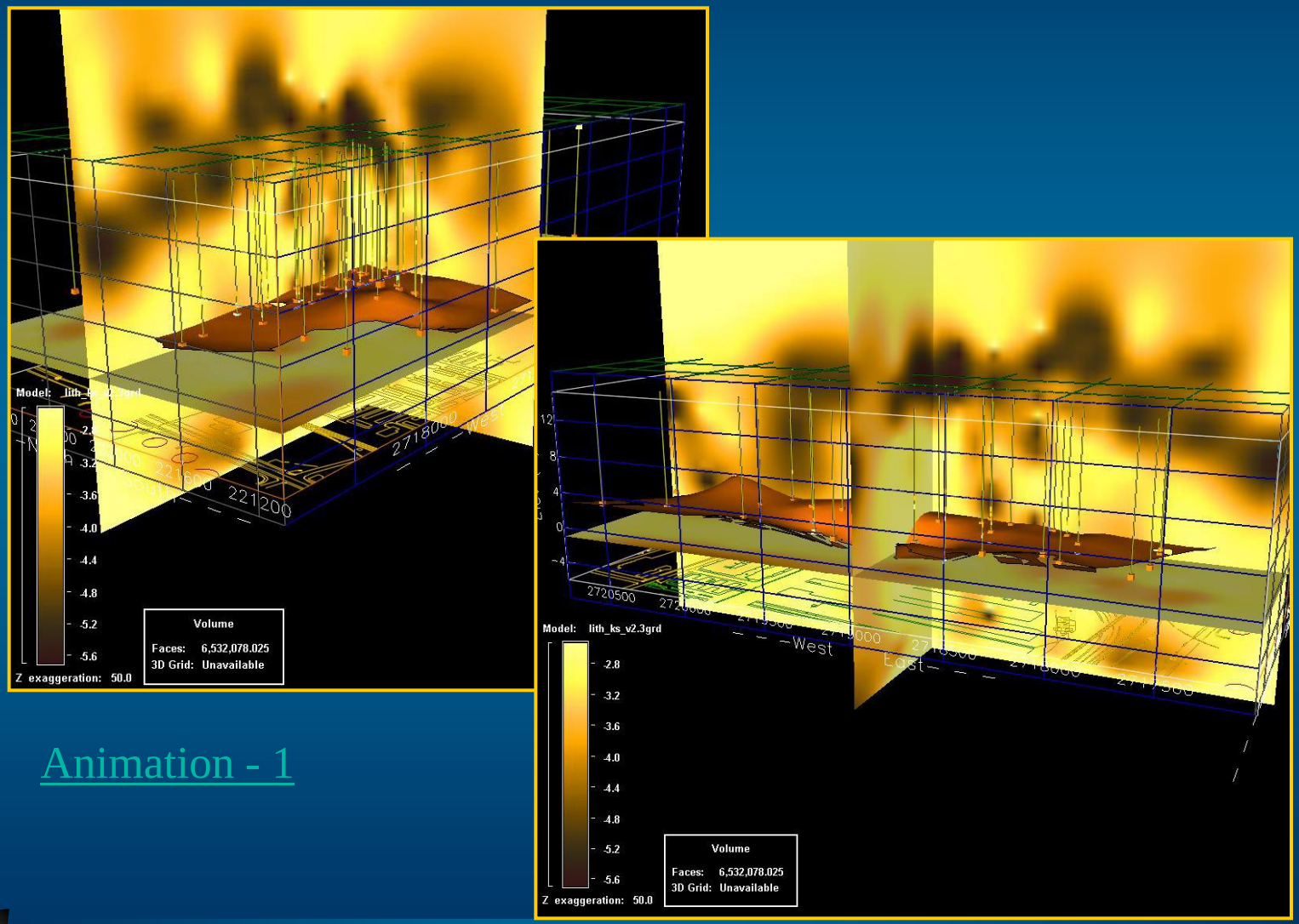
Evaluating Changes in Land Surface Elevation



Distribution of Upper Silt Layer (Qal-s)



LNAPL Morphology & Relationship to K

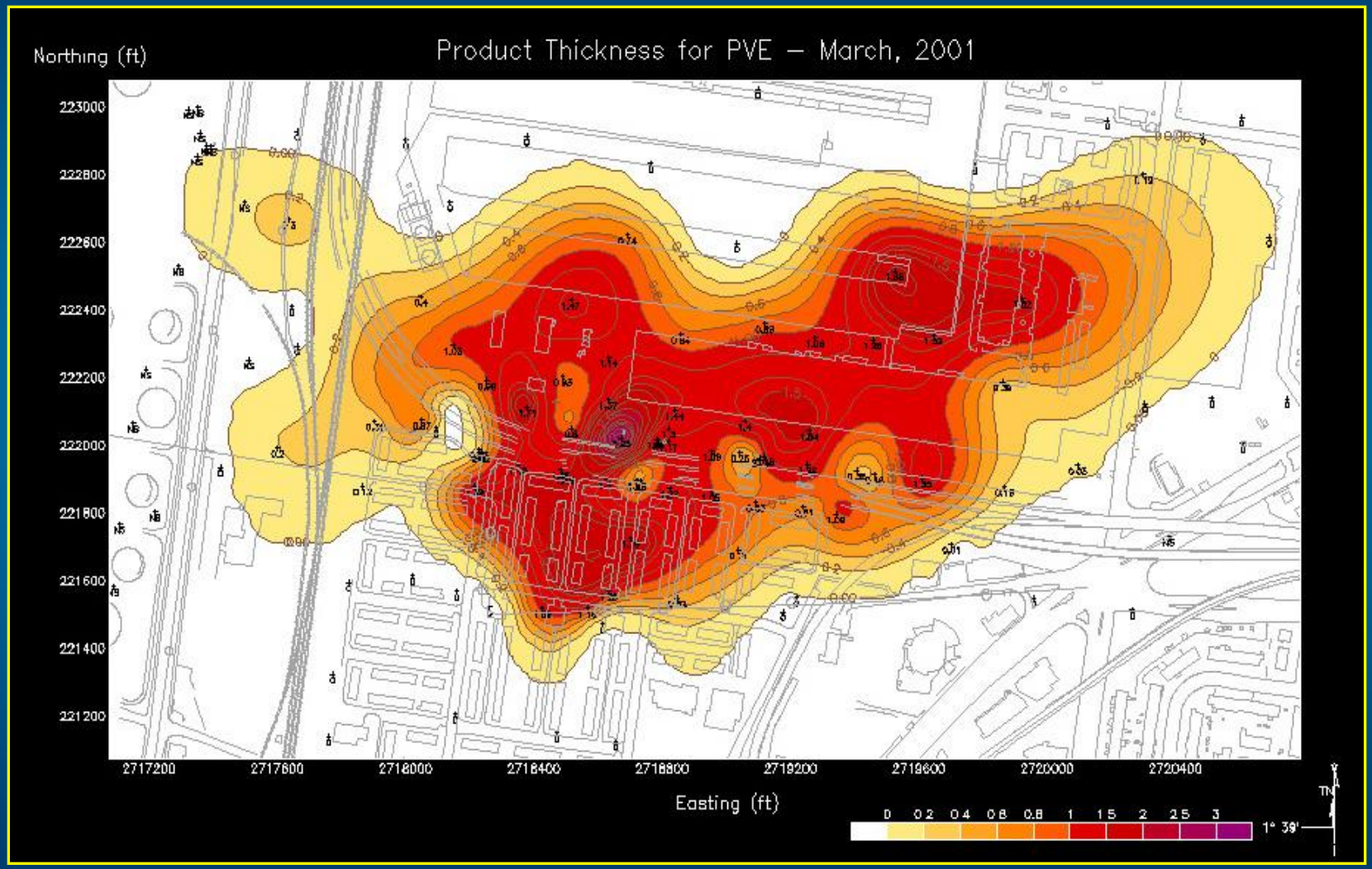


Animation - 1

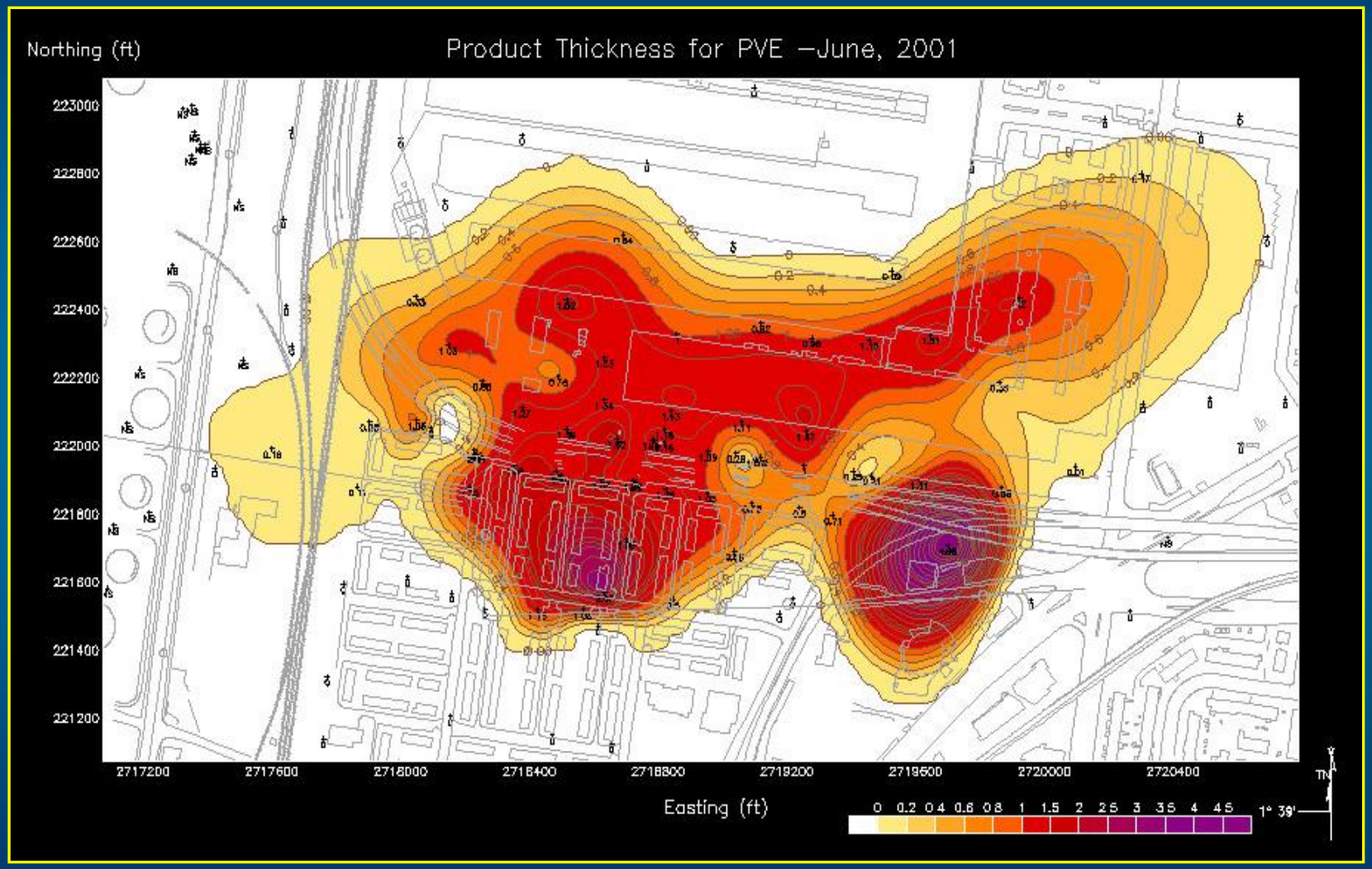
Plume Volume Estimation

- Volumetric model parameter estimates based on previous work using:
  - Soil types
  - Soil particle size distribution
  - Porosity
  - Bulk density
- Modified VanGenucthen Method using gridded parameter and product thickness information extracted from the GFM
- Estimated that approximately 1.5 million gallons of LNAPL remain at the site.

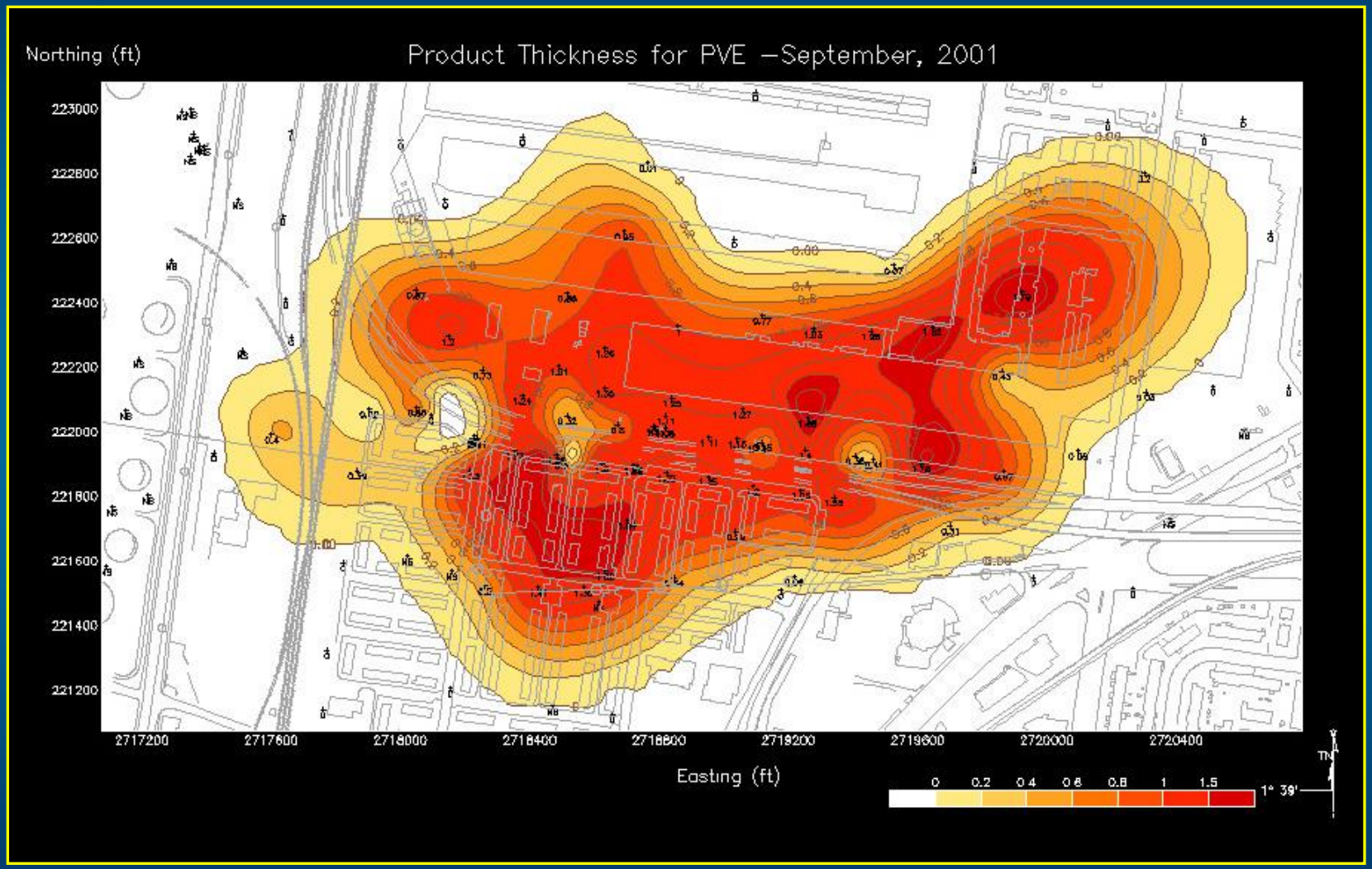
Product Thickness Modeling
March - 2001



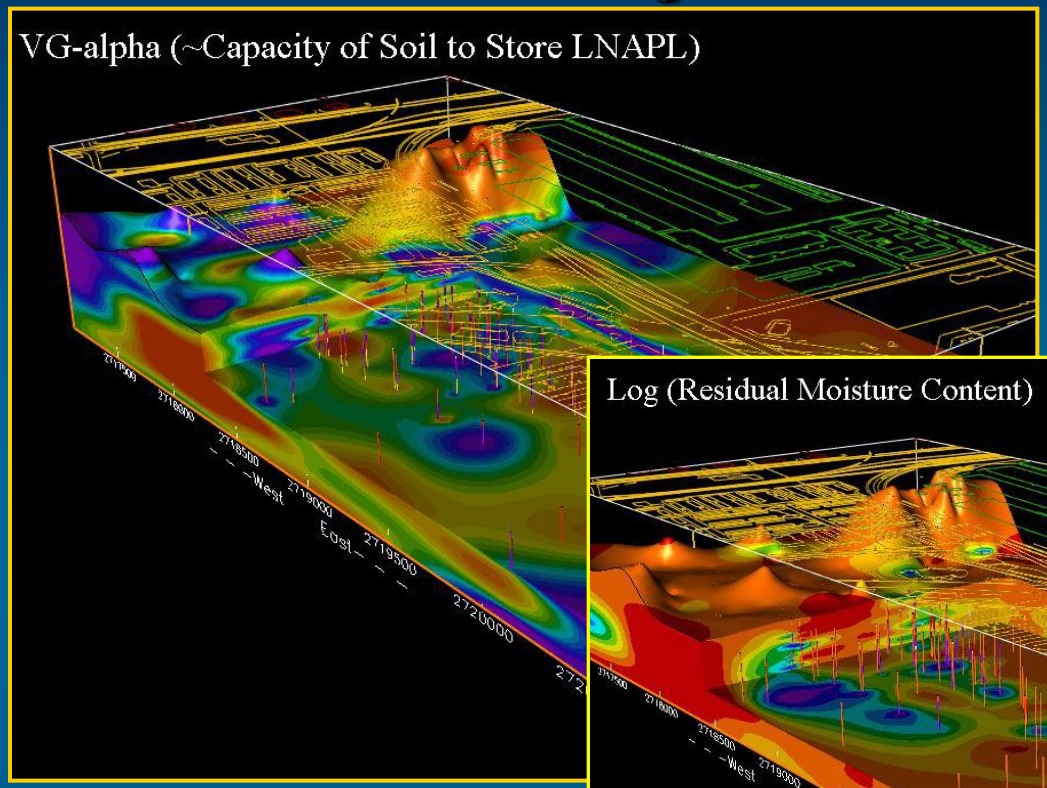
Product Thickness Modeling
June - 2001

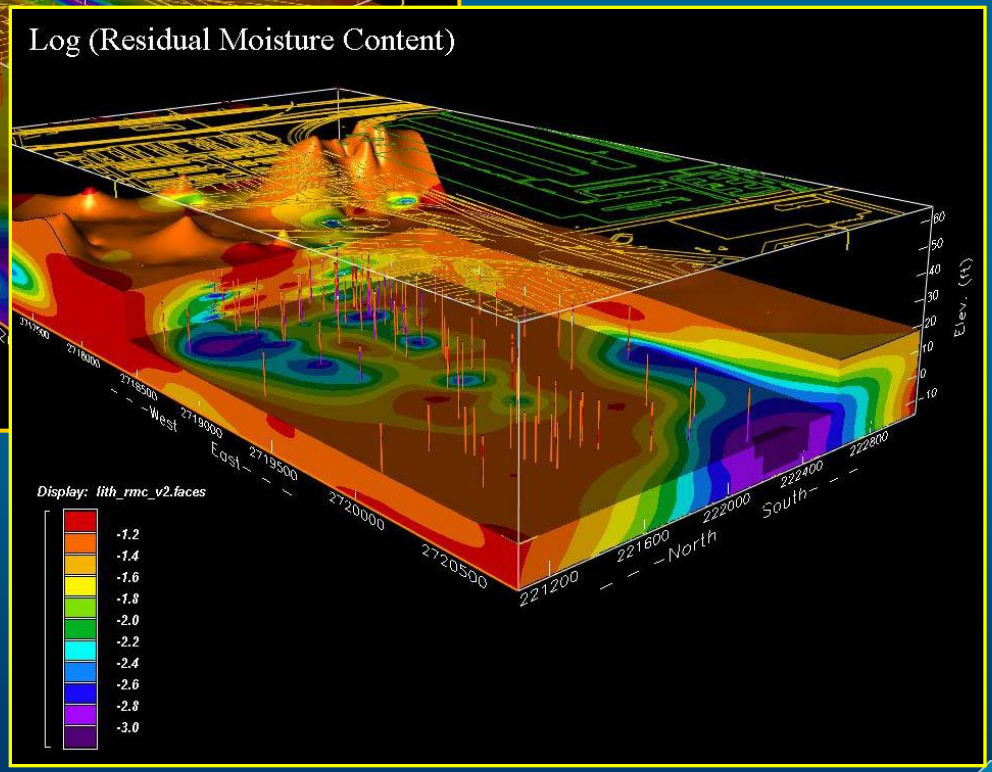


Product Thickness Modeling
September - 2001



Parameter Modeling



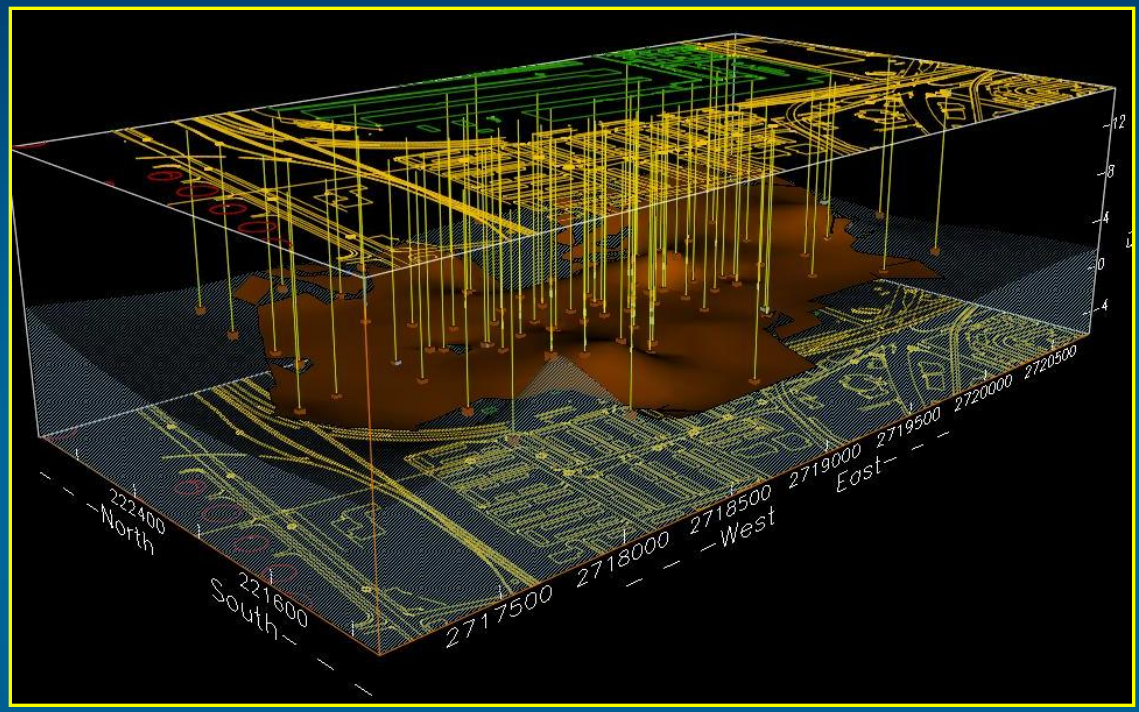


Grid Spacing
50x50x1 feet

- **VG-α**
- **VG – N**
- **Ks**
- **n**
- **RMC, etc.**

Plume Volume Estimation

- gridded data exported to ASCII format
  - oil/water interface
  - oil/air interface
  - land surface
  - parameter dist.
- interface program used to perform VG calcs.
- VG volume estimation rendered for quarterly data sets
- Result
  - Volume Estimate ~1.5 million gallons
  - Overall decreasing trend in plume volume since start of skimmer remediation system



Conclusions

- Although data entry was tedious, the benefits of this effort are long lasting and will result in significant project savings over time.
- Additional data can be entered into the database over the life of the project as well as enable specific information to be queried for future modeling efforts.
- The visualization capabilities of the model enable the demonstration of site features to the public.