

COLORADO SOUTH PLATTE RIVER ALLUVIAL AQUIFER CHARACTERIZATION WITH AIRBORNE ELECTROMAGNETICS

SAGEEP 2019
Portland, Oregon
March 20, 2019

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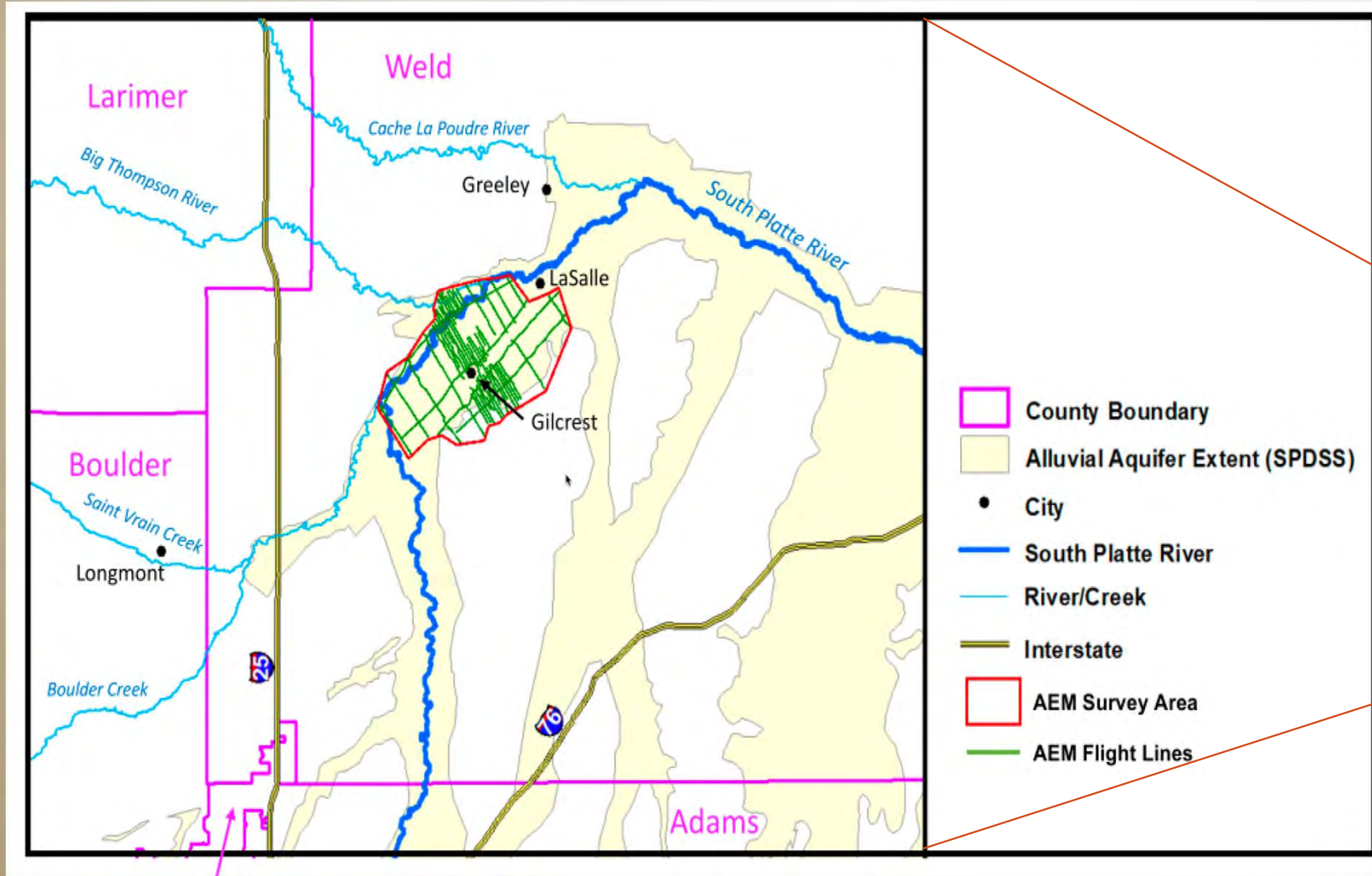


MISSION

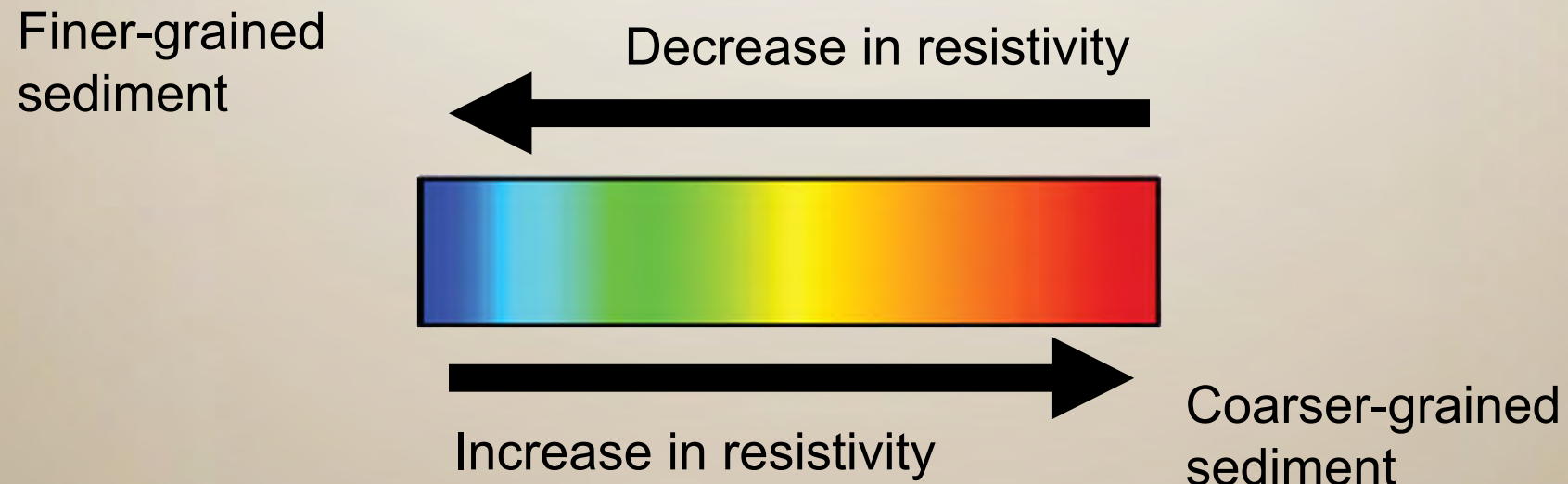


- The Central Colorado Water Conservancy District (CCWCD) desired a subsurface study to increase understanding of the South Platte River hydrogeology near Gilcrest and La Salle, Colorado. In particular, how the hydrostratigraphy in the near-surface which might be related to high groundwater levels. The high groundwater levels that caused extensive basement flooding occurred after State of Colorado mandated pumping restrictions in the area.
- An AEM mapping project was initiated to develop a 3D hydrogeologic framework of the Gilcrest project area including recommendations for future work to enhance groundwater management activities for managed aquifer recharge (MAR).

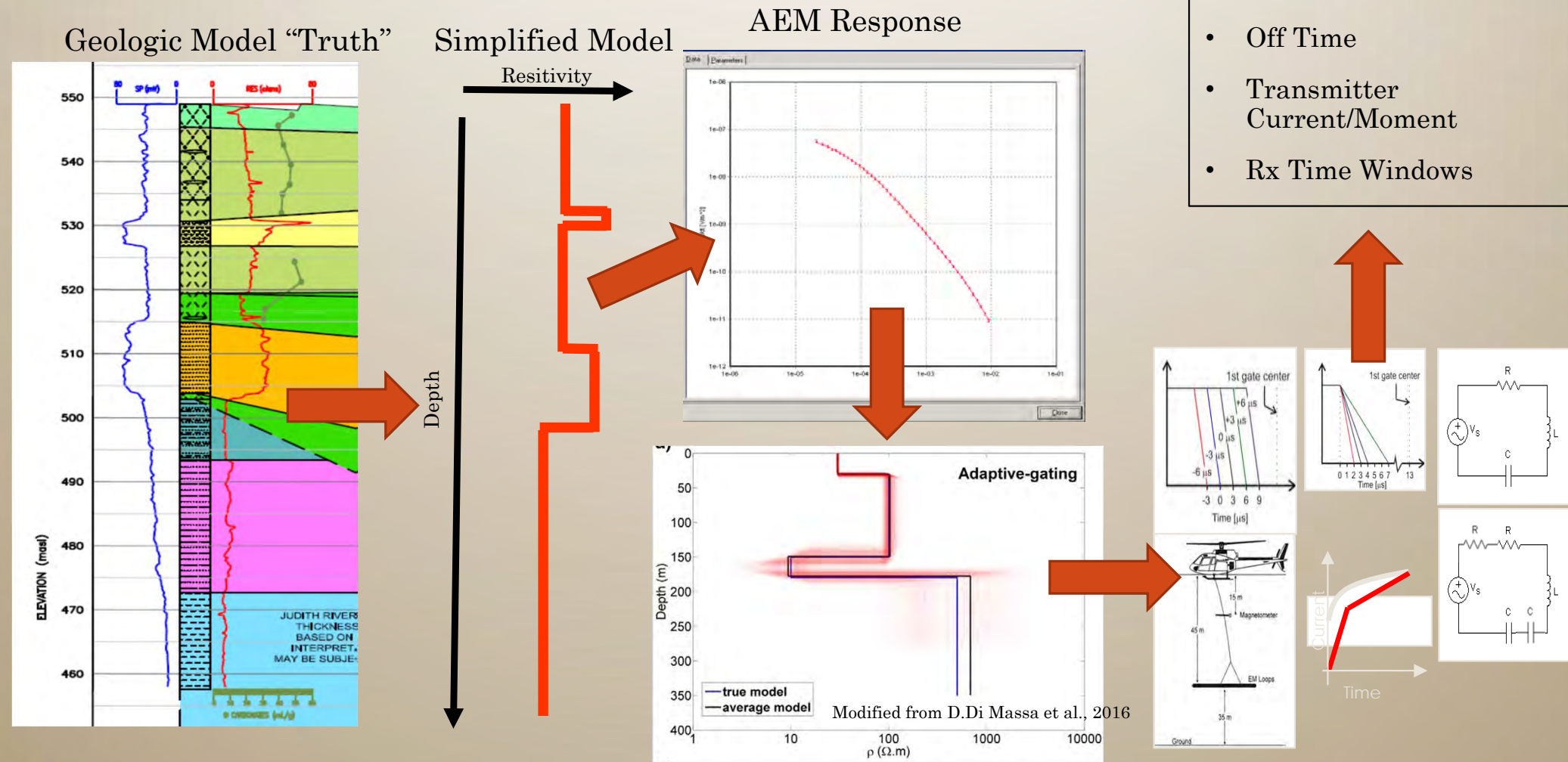
LOCATION



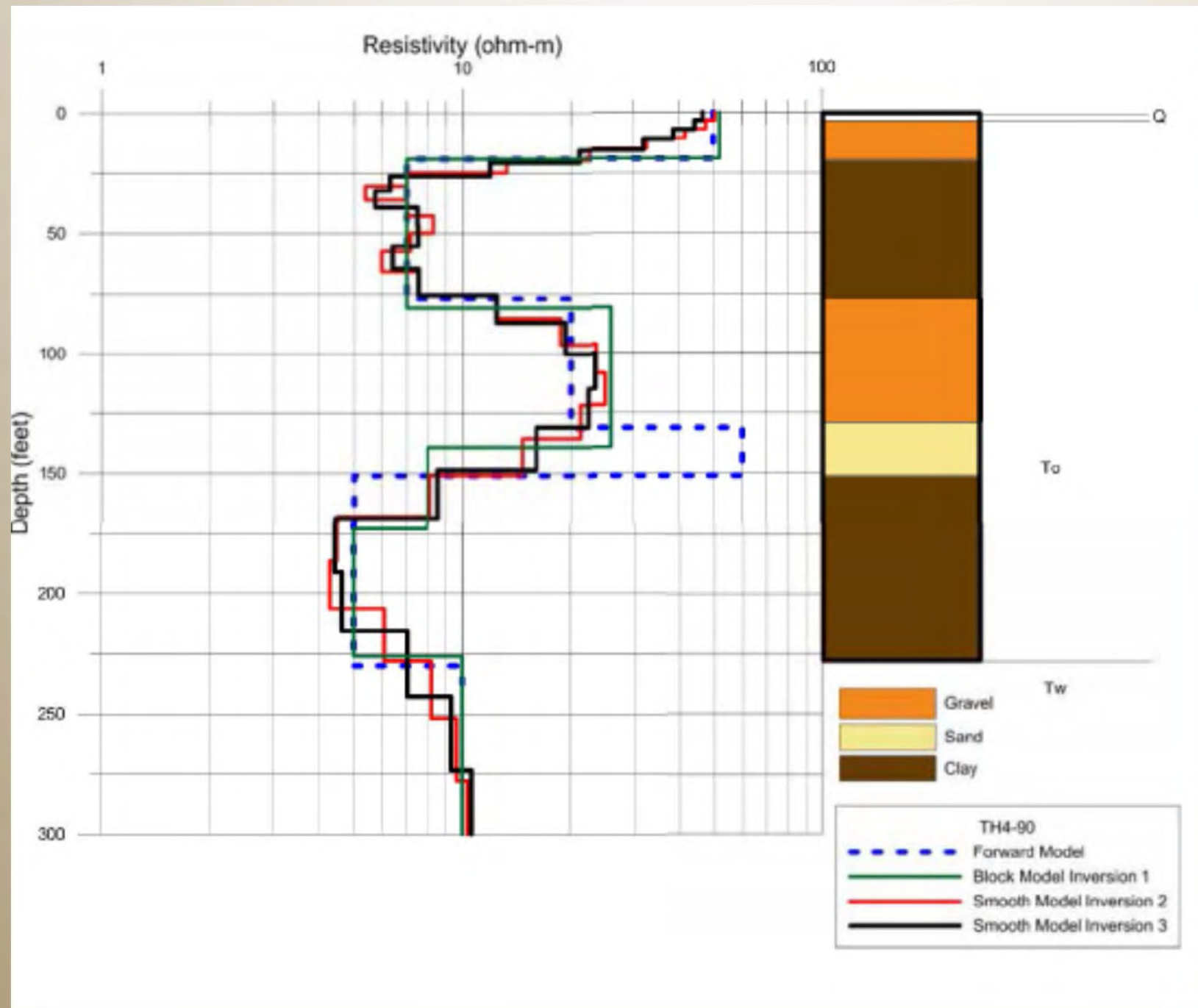
RESISTIVITY APPLIED TO SEDIMENTS



FORWARD MODELING



FORWARD MODELING TH 4-90 EXAMPLE

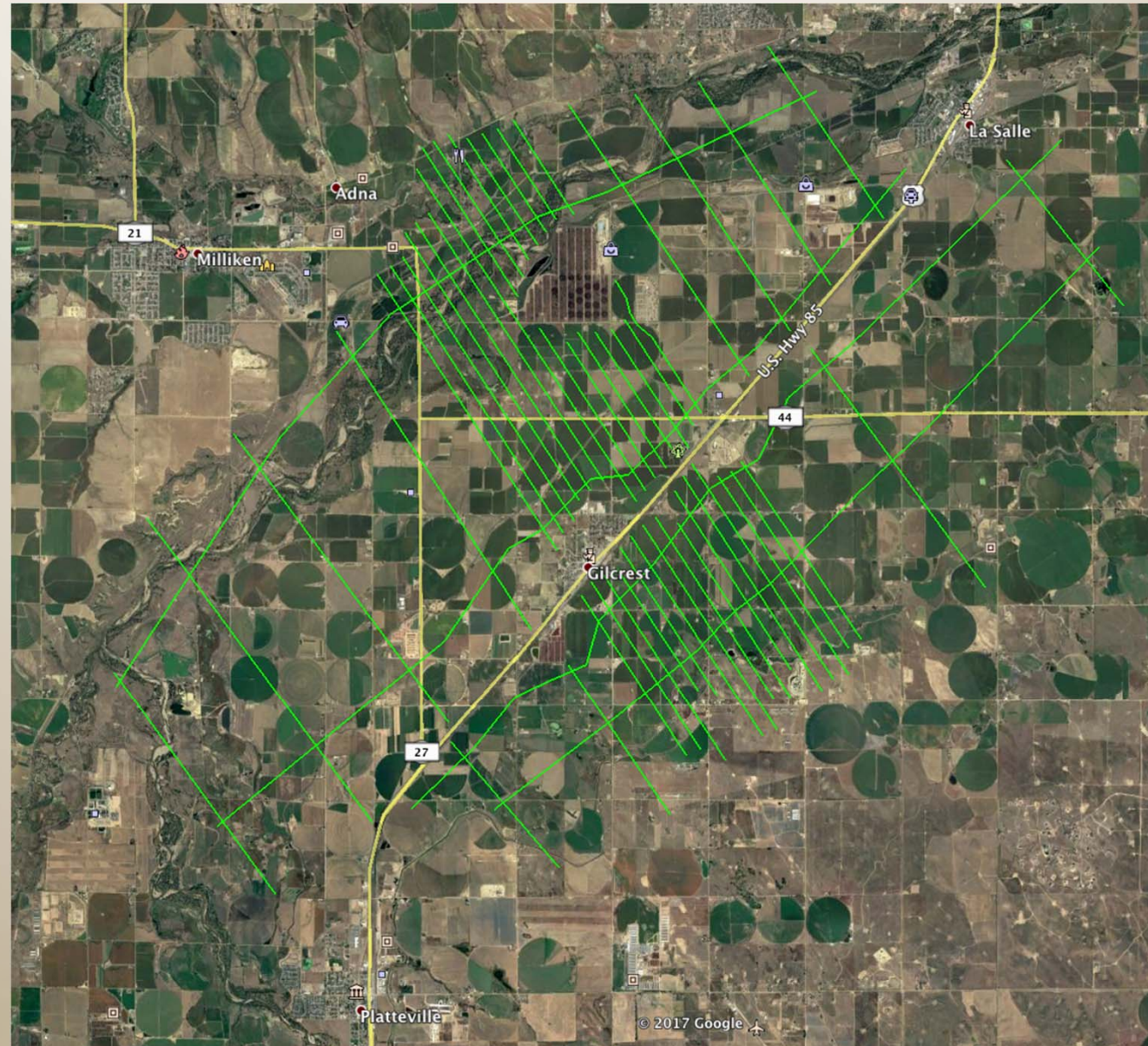


SPECIFICATIONS

- Acquisition
 - Bandwidth of system
 - Tx Waveforms
 - Tx Current
 - Time gates
 - Position
 - Speed
 - Height
 - Tilt
 - Data format
 - Deconvolution
 - Calibration
 - Drift
- Inversion
 - Algorithm
 - Errors/Noise
 - Processing
 - Filters
 - Tilt/height/topo
 - Constraints 2D, 3D
 - Deterministic/Stochastic
 - Additional Data
 - Borehole geophysics
 - Ground geophysics
 - Geological surfaces

SURVEY PLANNING

- Geological trends
- Infrastructure
- FAA rules/Safety
- Multiple Surveys
- Airport distance
- Weather



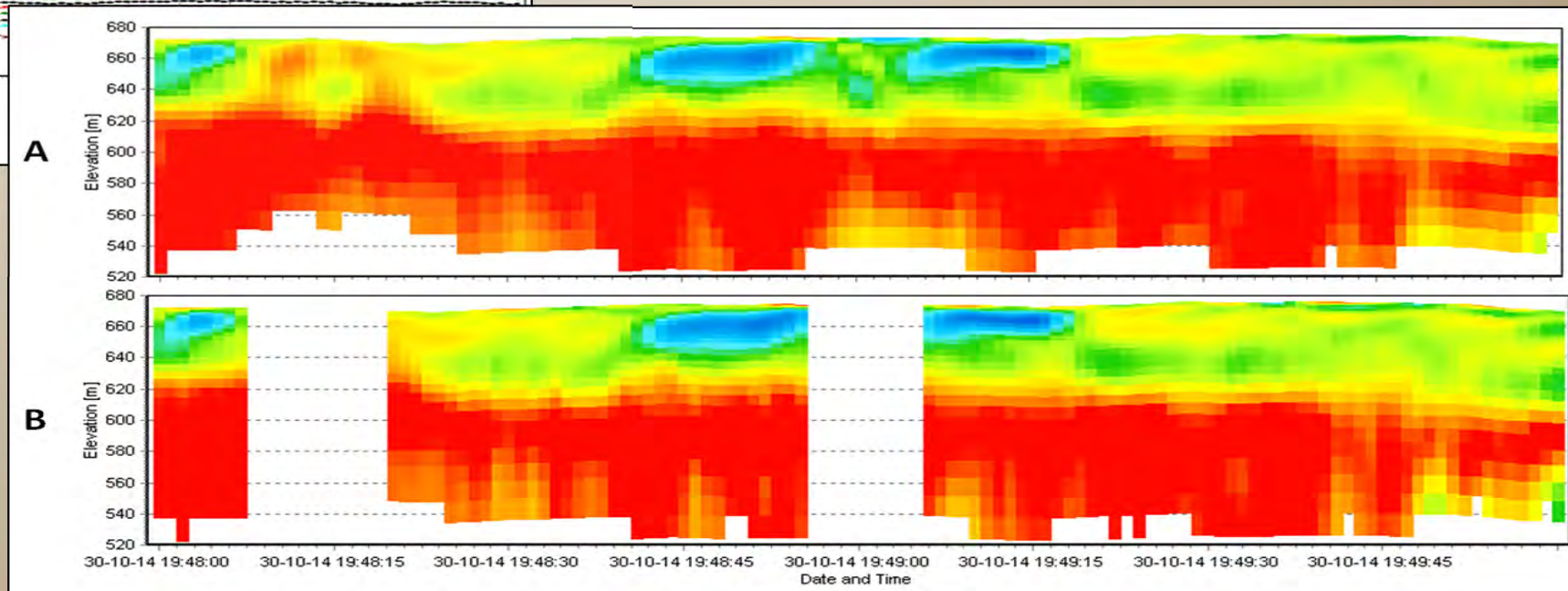
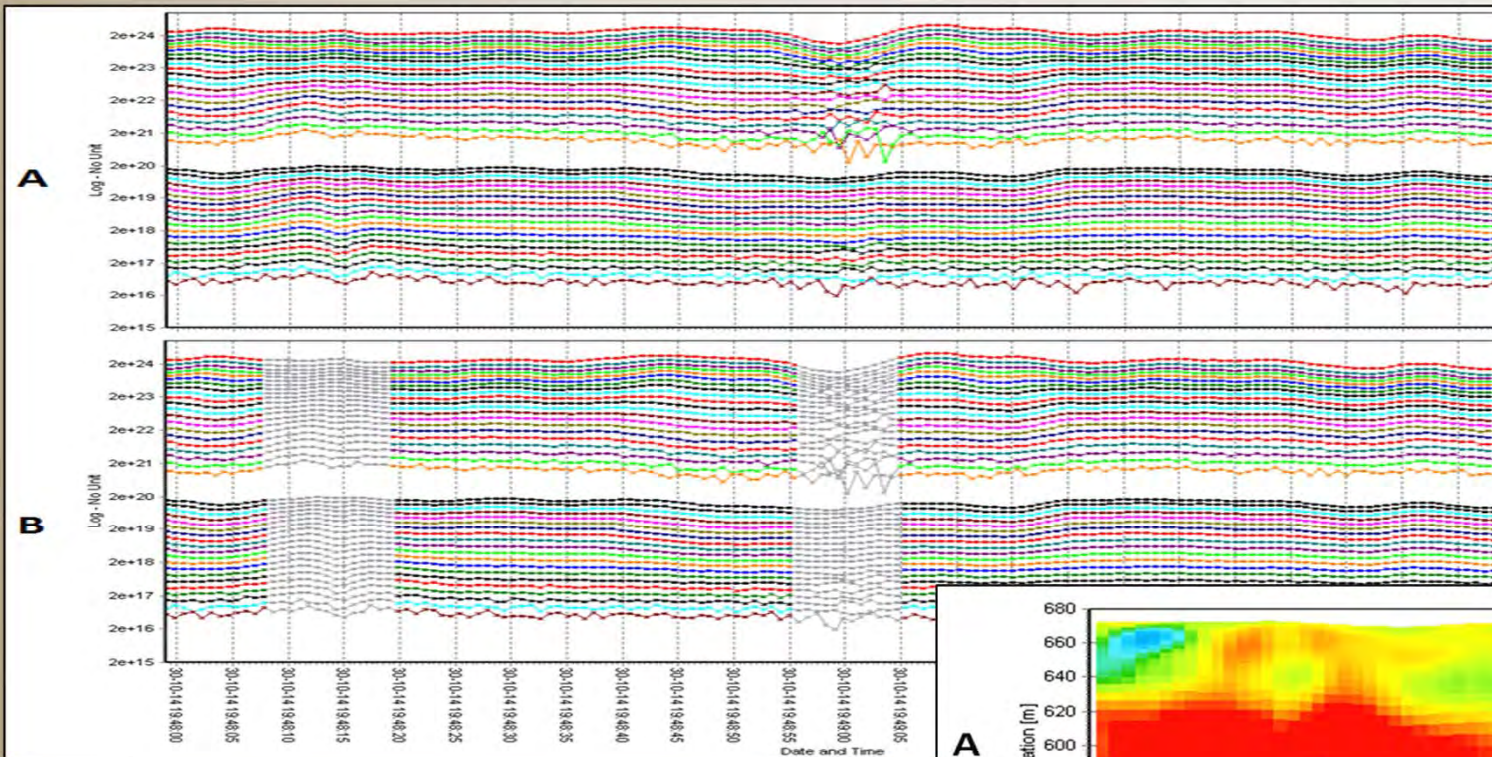
FLIGHTS OCCURRED JUNE 2017



153 line-miles (250 line-km)
SkyTEM 304

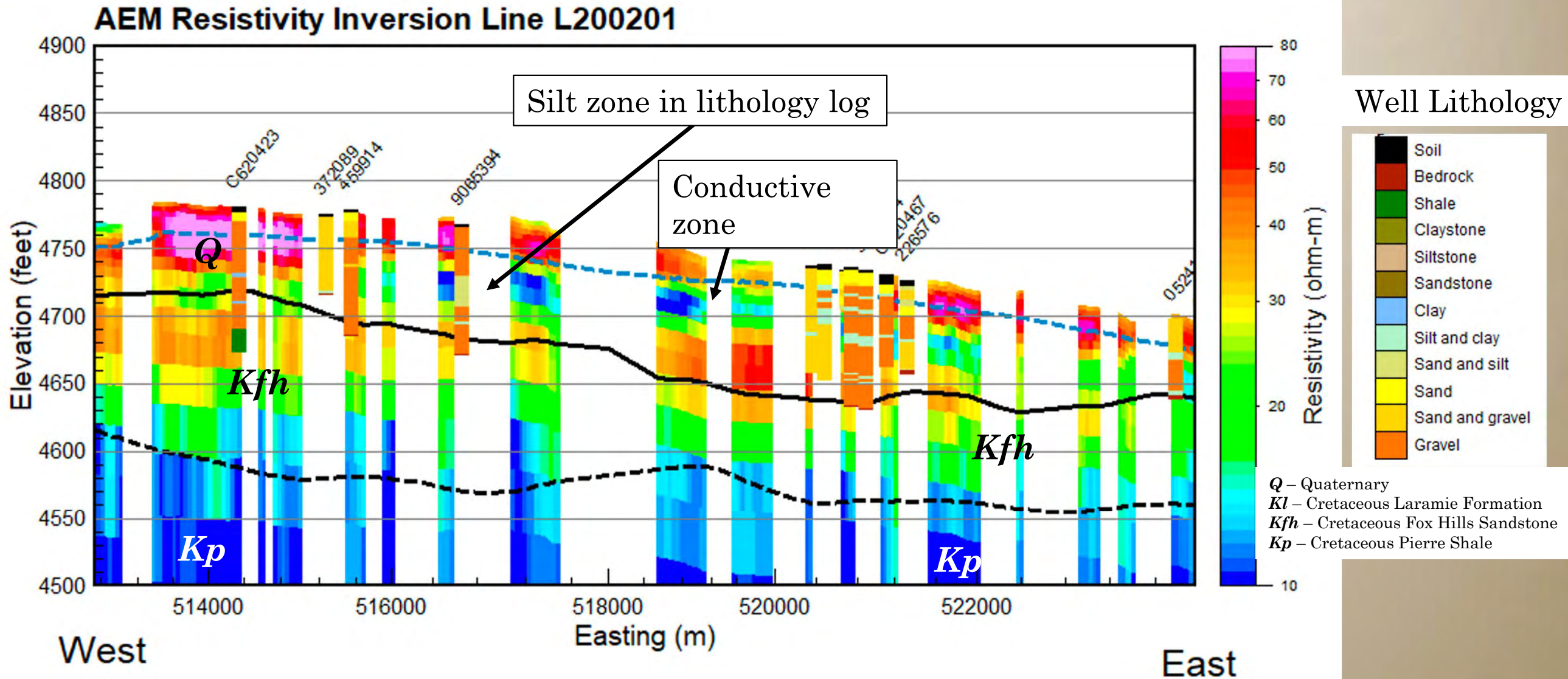
IN FIELD QA/QC AND INVERSION

- Within 24 hours we invert

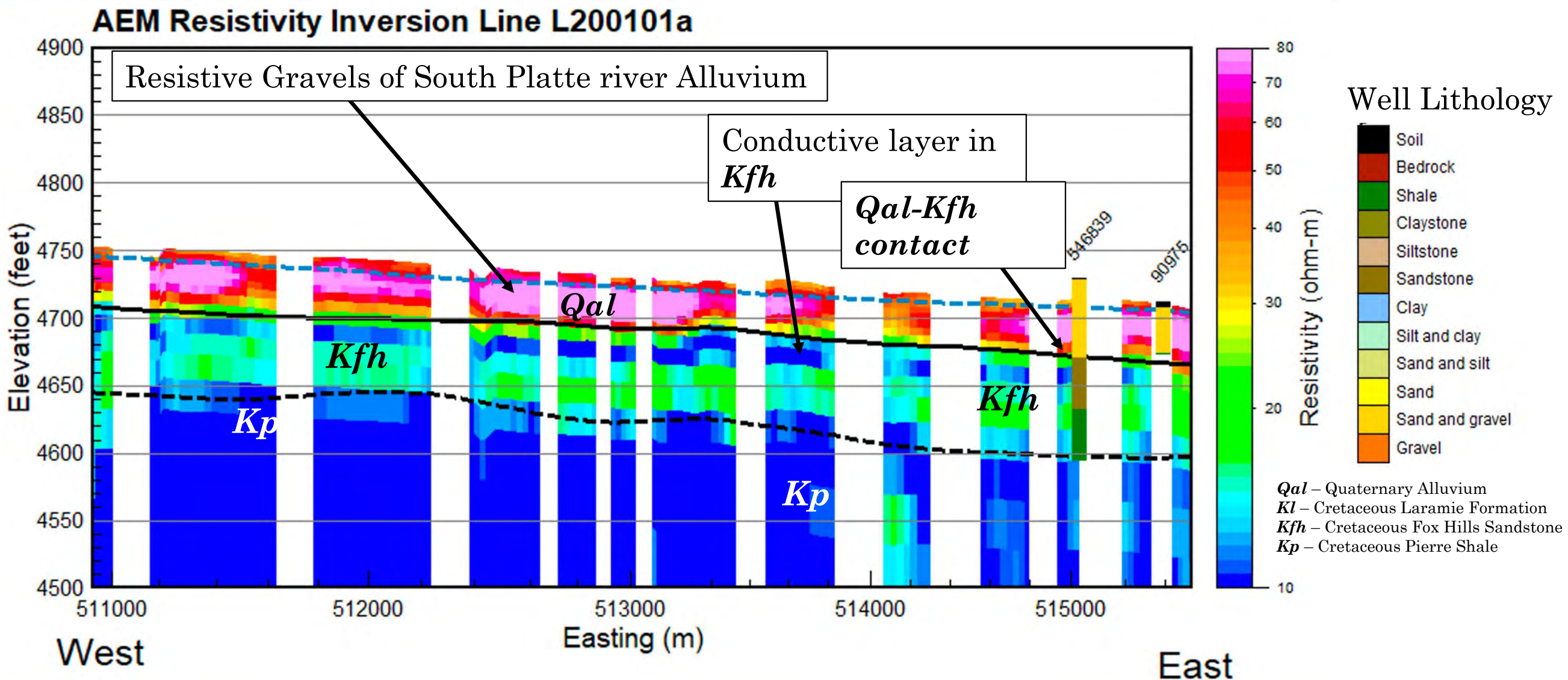


Aarhus Workbench
30 Layer smooth
Early-time gate deconvolution

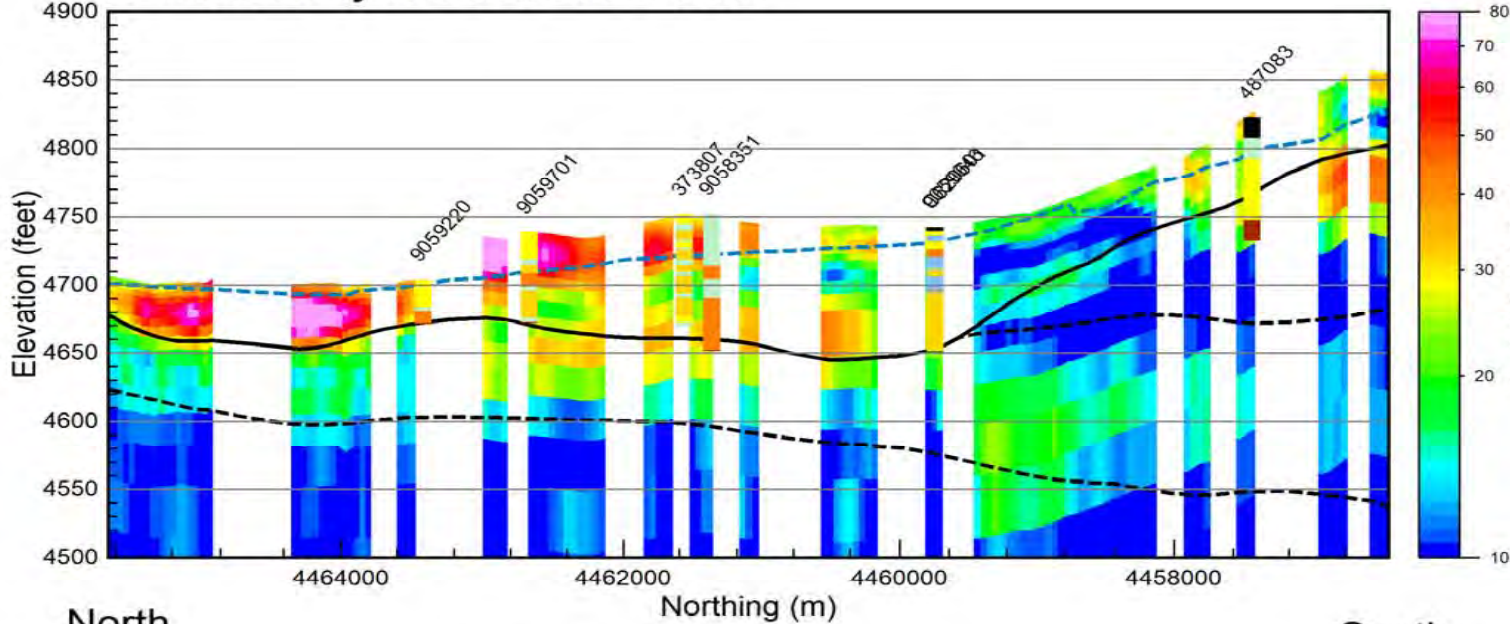
INTERPRETATION OF THE AEM PROFILES



INTERPRETATION OF THE AEM PROFILES



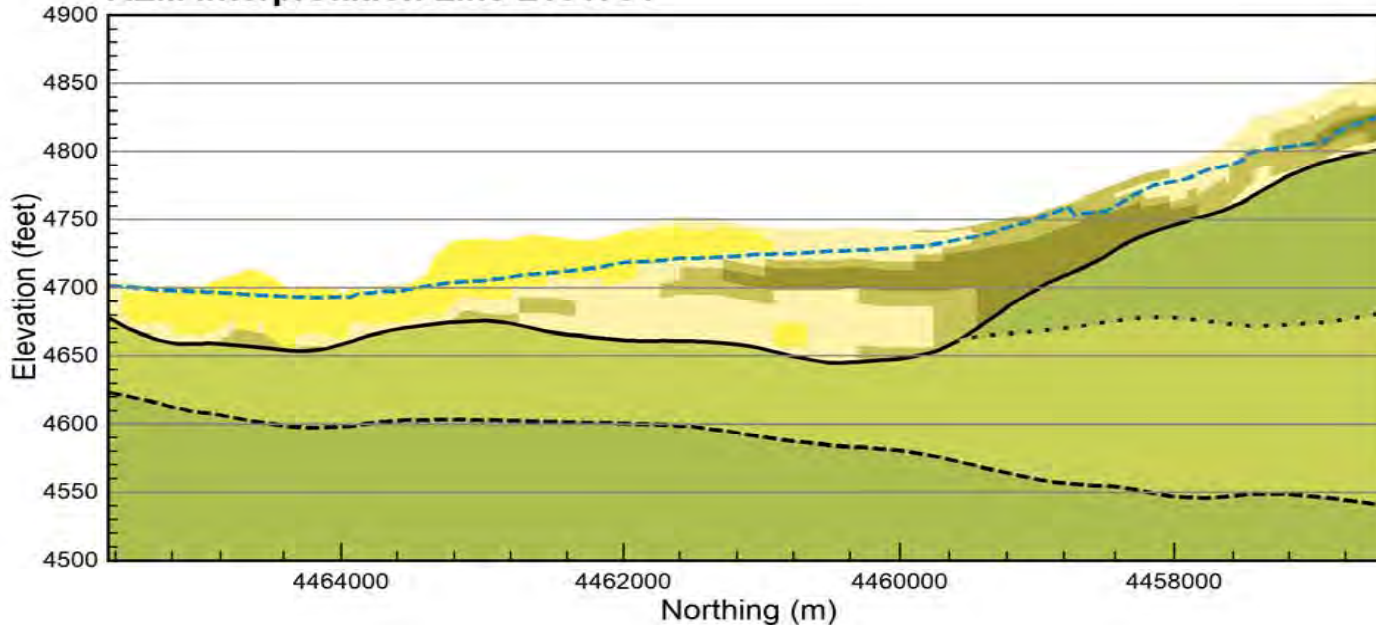
AEM Resistivity Inversion Line L101701



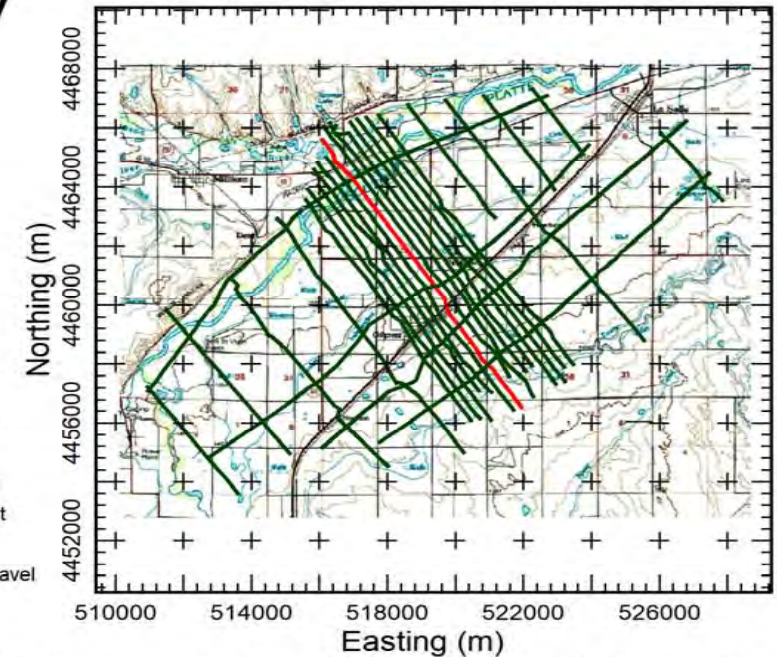
North

South

AEM Interpretation Line L101701



AEM Flight Area



Results of the final inversion of Airborne Electromagnetic (AEM) data collected along flight lines within the Gilcrest, Colorado area on June 2-3, 2017. The inversions shown are Spatially-Constrained using the Aarhus Geo Software Workbench version 5.4.0.0. Prepared for the Central Colorado Water Conservancy District (CCWCD) by Aqua Geo Frameworks, LLC.

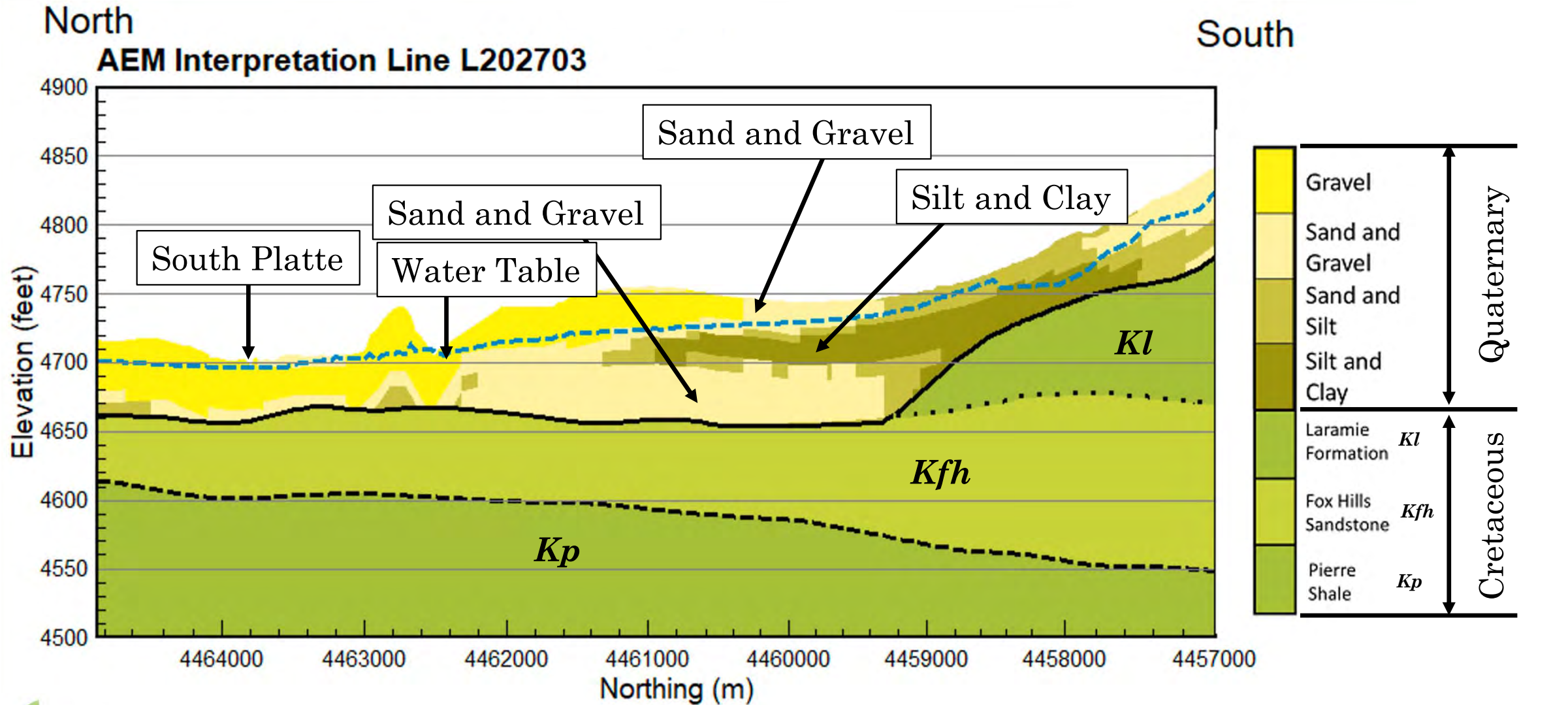
On the AEM flight map the background is of the USGS 100K Topography Map with the flight lines shown in dark green. The current displayed profile is indicated by red.

The AEM Resistivity Inversion Profile shows the results of the inversion as electrical resistivity. Gaps in the resistivity profile are a result of editing areas of EM-coupling out of the data or of areas that were not over flown due to infrastructure. Located on the profile are lithology (see legend) from the Colorado DWR Registered Wells that are within 100 meters of the flight line. The dashed blue line is the estimated water table of the area. The black solid and dashed lines indicated interpreted contacts of the Cretaceous Laramie Formation, Cretaceous Fox Hills Sandstone, and the Cretaceous Pierre Shale.

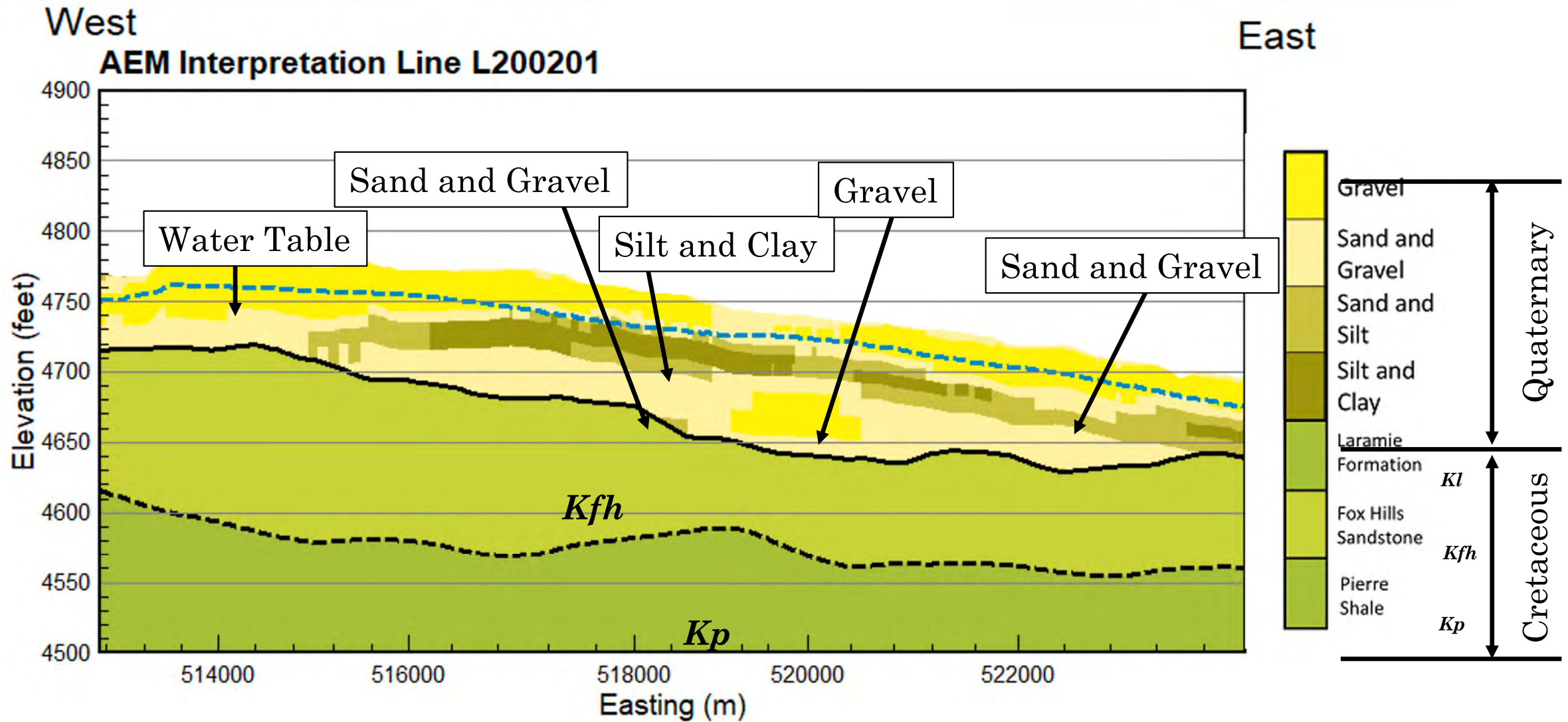
The AEM Interpretation Profile indicates the interpreted lithology (see legend) of the Quaternary materials overlying the Cretaceous bedrock. The dashed blue line is the estimated water table of the area. The black solid line indicates the top of the bedrock consisting of both the Cretaceous Laramie Formation and the Cretaceous Fox Hills Sandstone. The dotted black line indicates the top of the Cretaceous Fox Hills Sandstone under the Cretaceous Laramie Formation. The dashed black line indicates interpreted contact of the Cretaceous Fox Hills Sandstone and the Cretaceous Pierre Shale.

Map projections is NAD83 UTM Zone 13 North (meters), vertical datum is NAVD88 (feet).

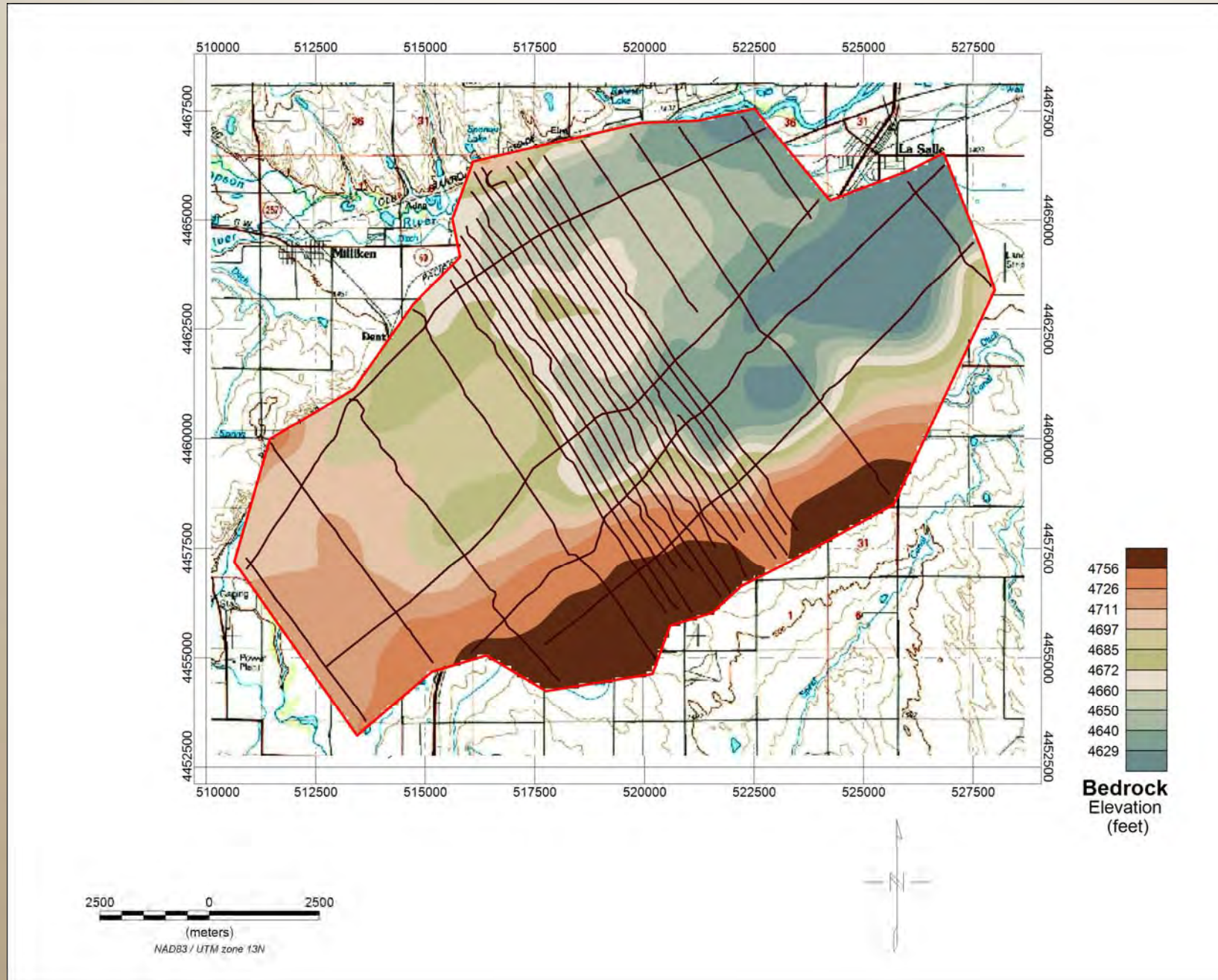
INTERPRETED PROFILES



INTERPRETED PROFILES



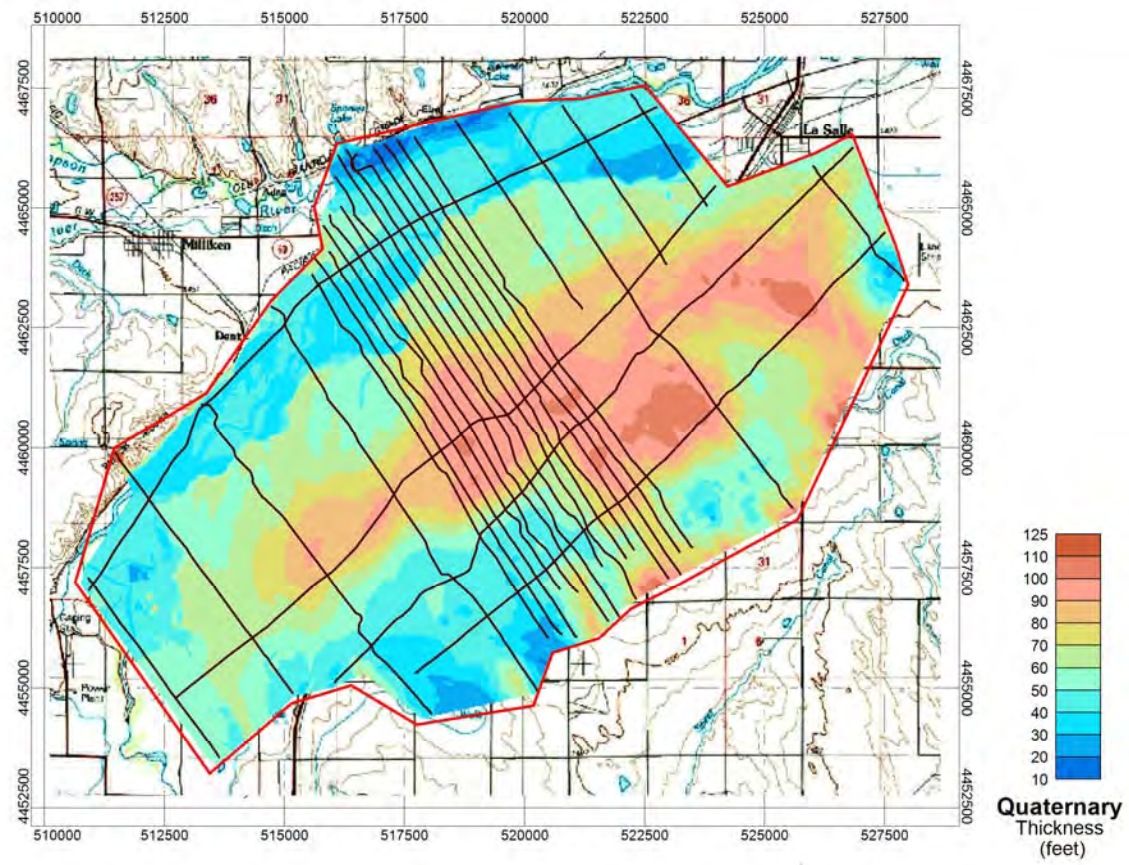
GILCREST BEDROCK ELEVATION



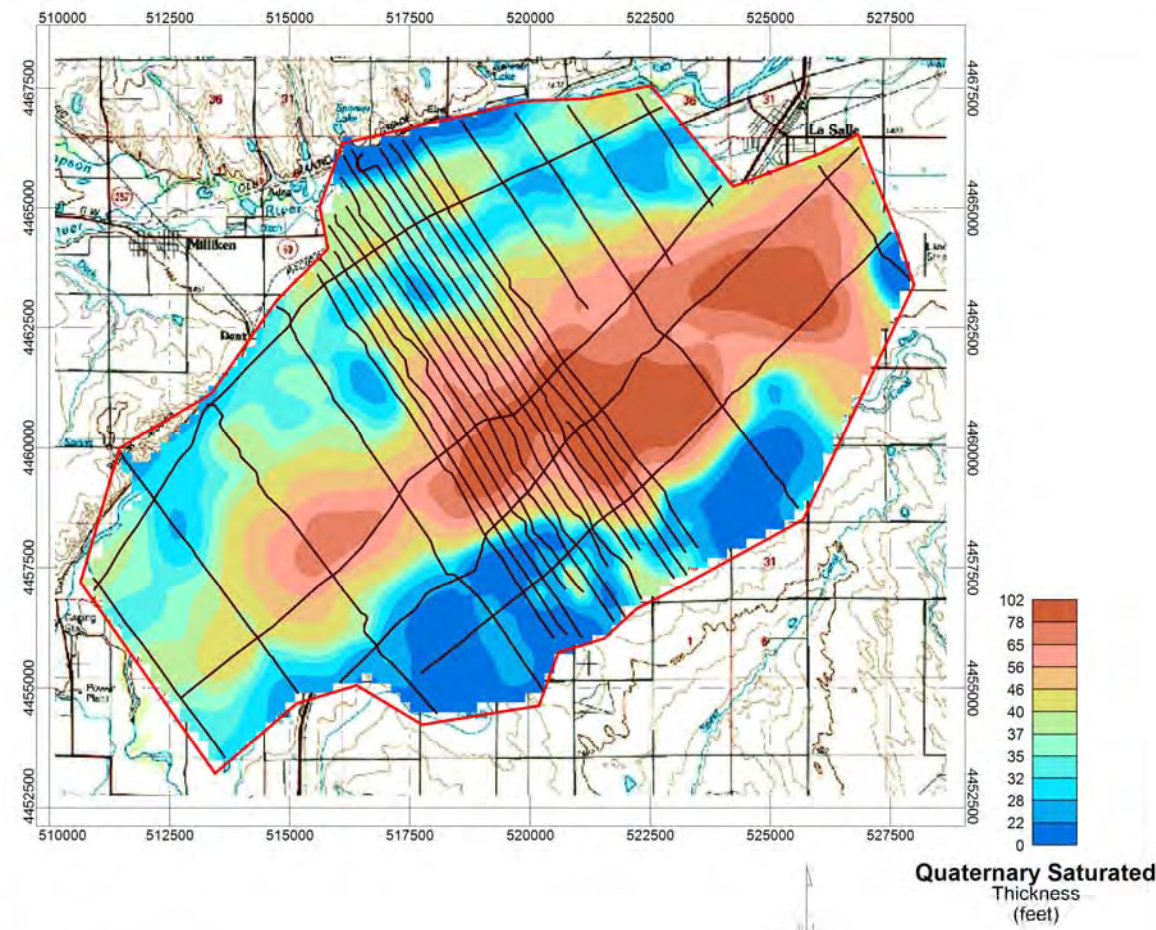
Abraham et al., 2018

QUATERNARY

Quaternary Thickness

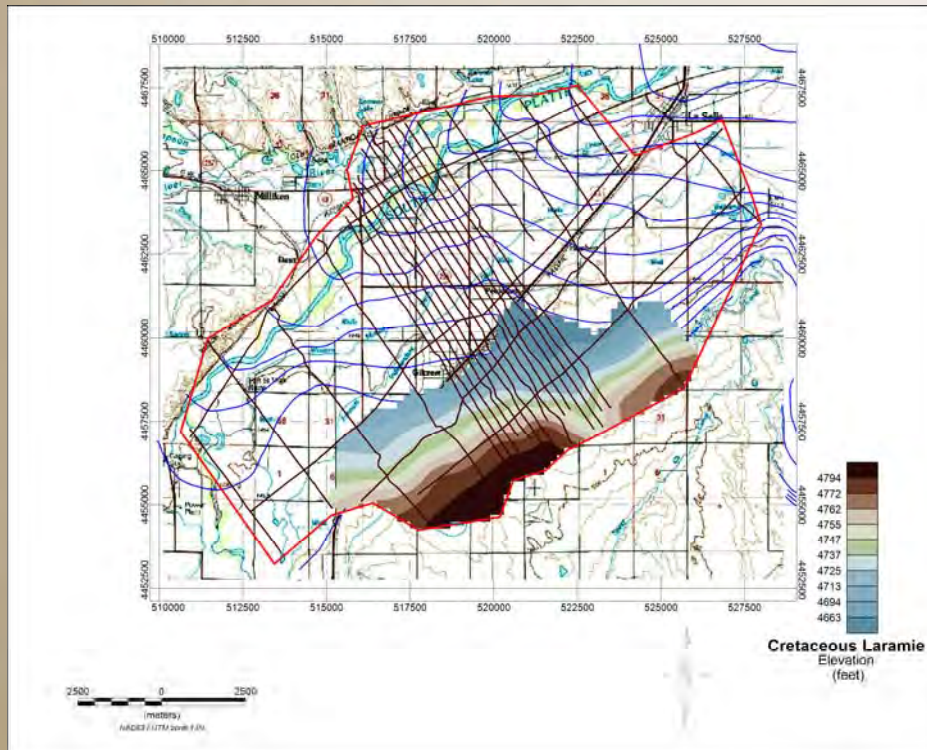


Quaternary Saturated Thickness

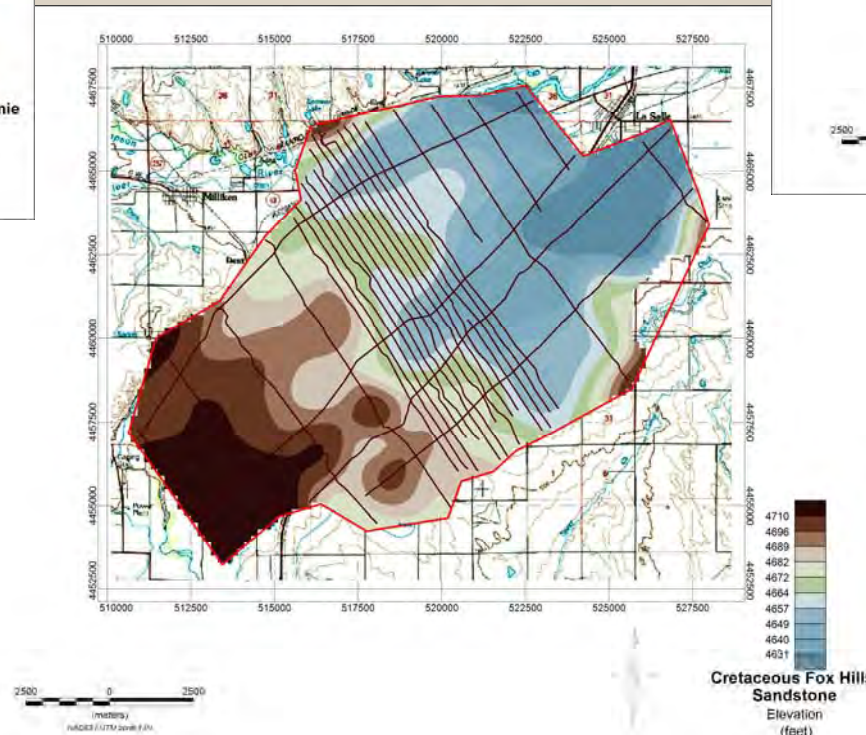


ELEVATION OF CRETACEOUS UNITS

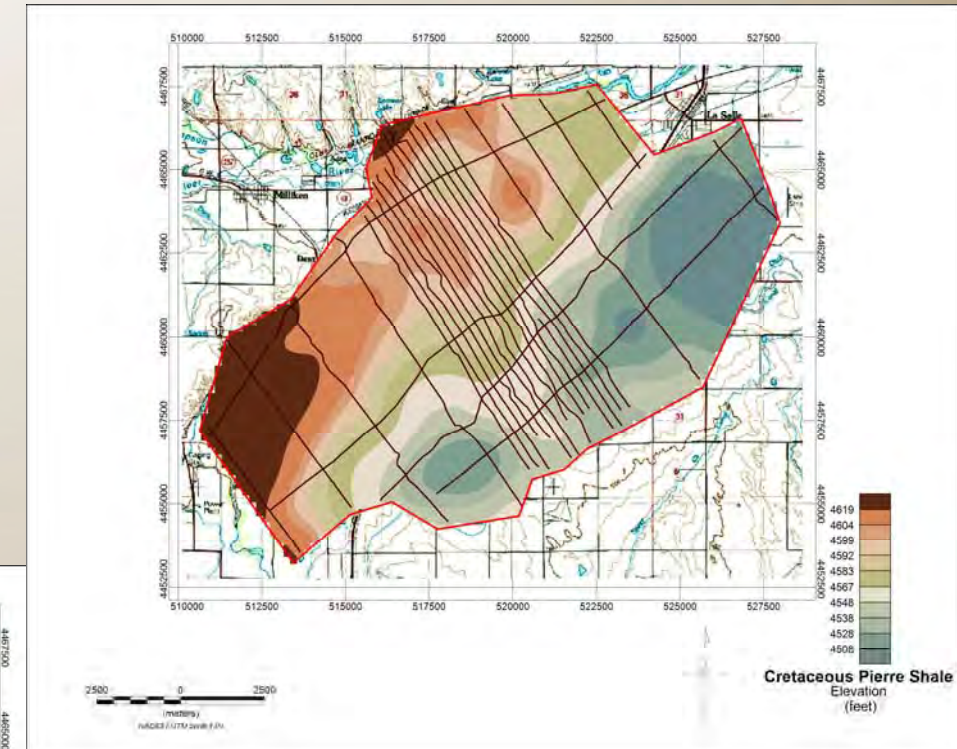
Laramie (*Kl*) Formation



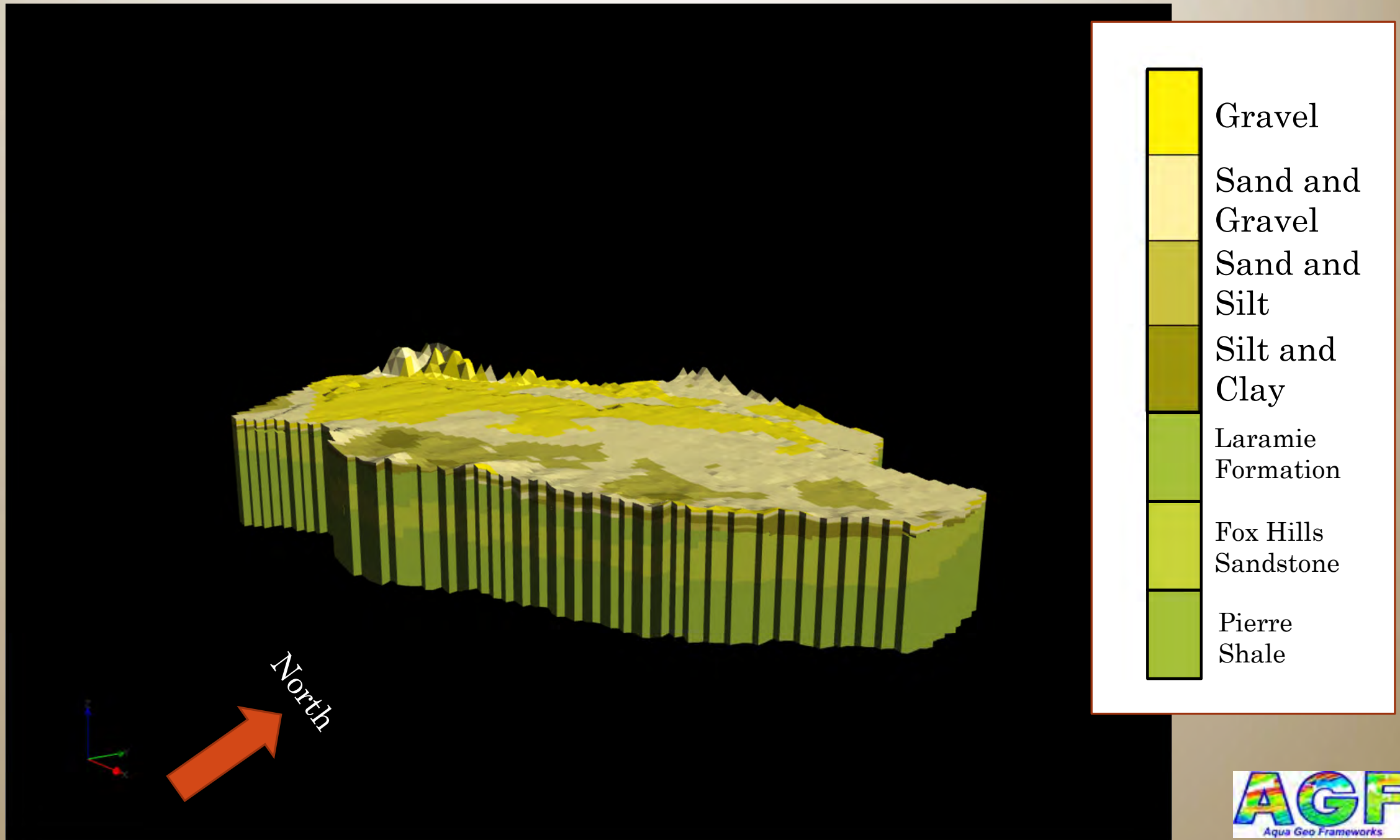
Fox Hills Sandstone (*Kfh*)



Pierre Shale (*Kp*)

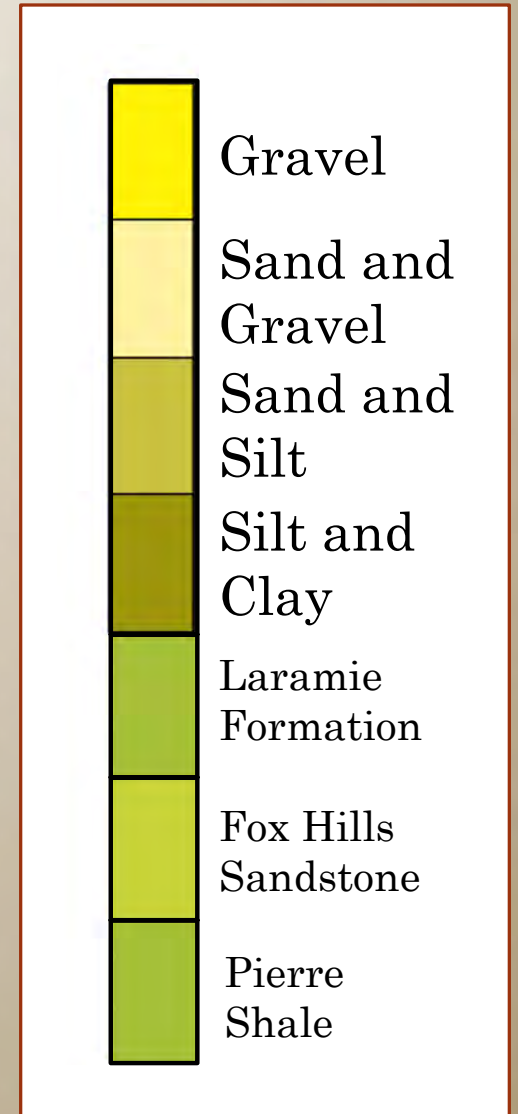
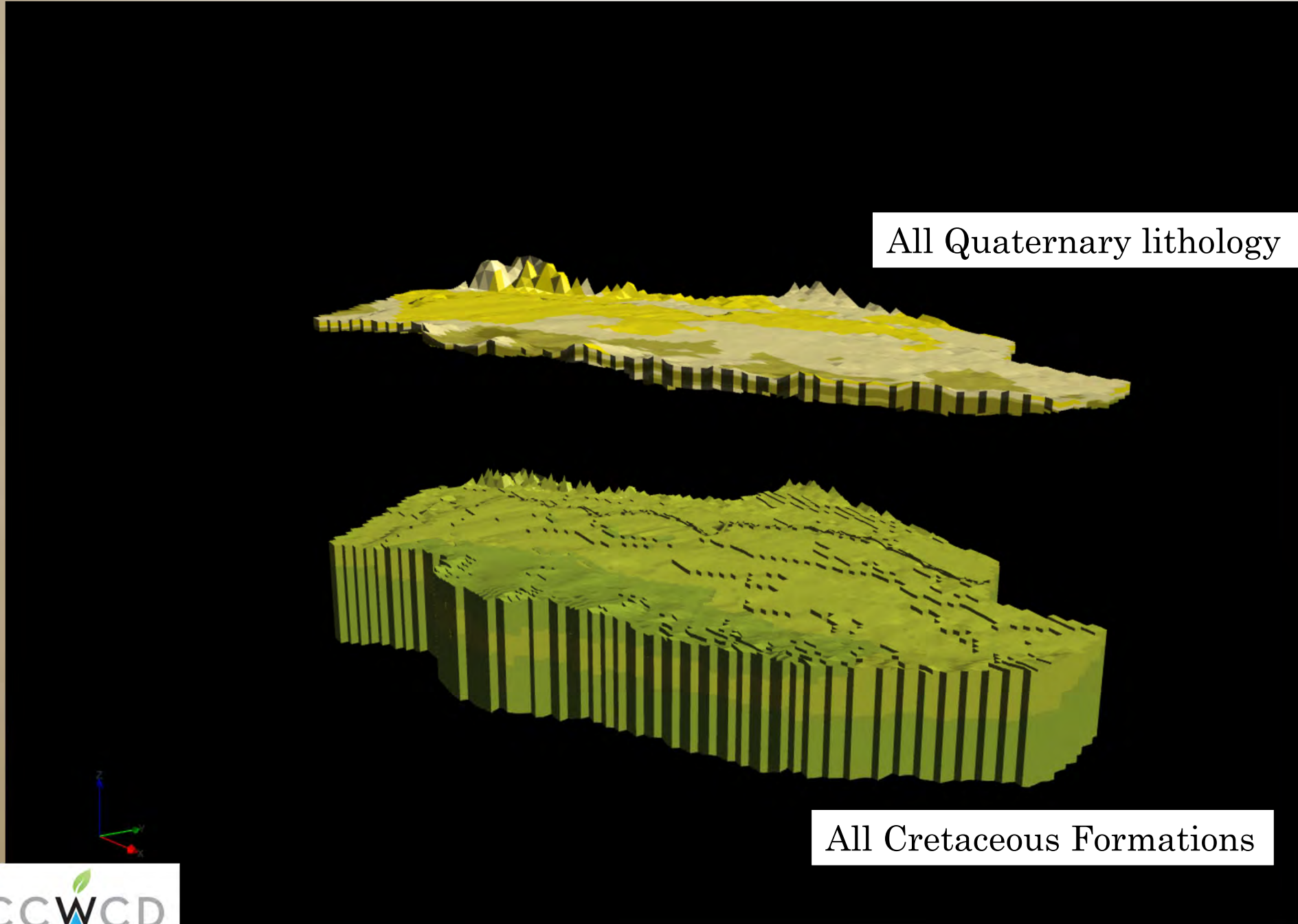


3D VOXEL MODEL OF GEOLOGY

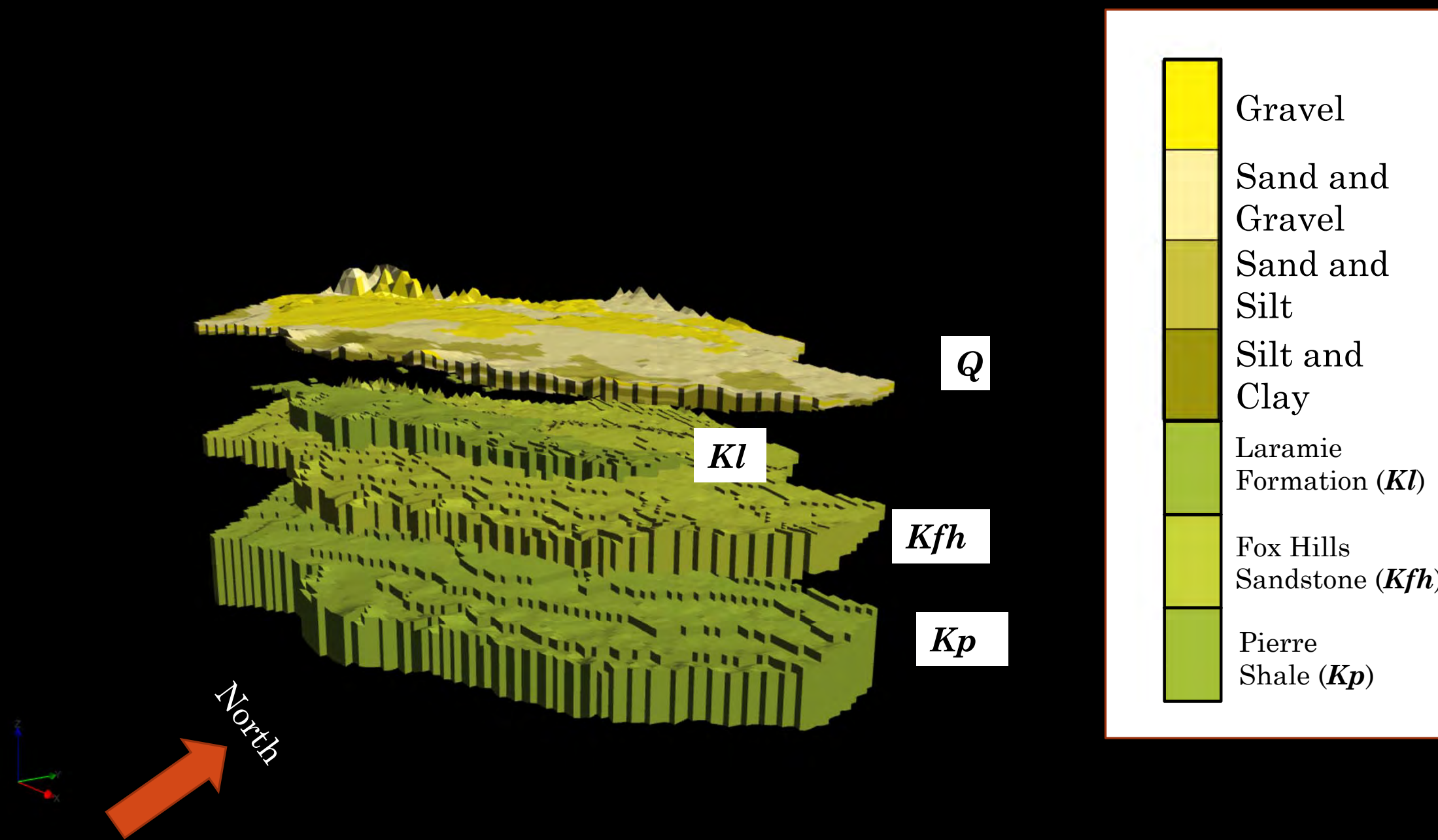


Abraham et al., 2018

QUATERNARY SEPARATED FROM CRETACEOUS



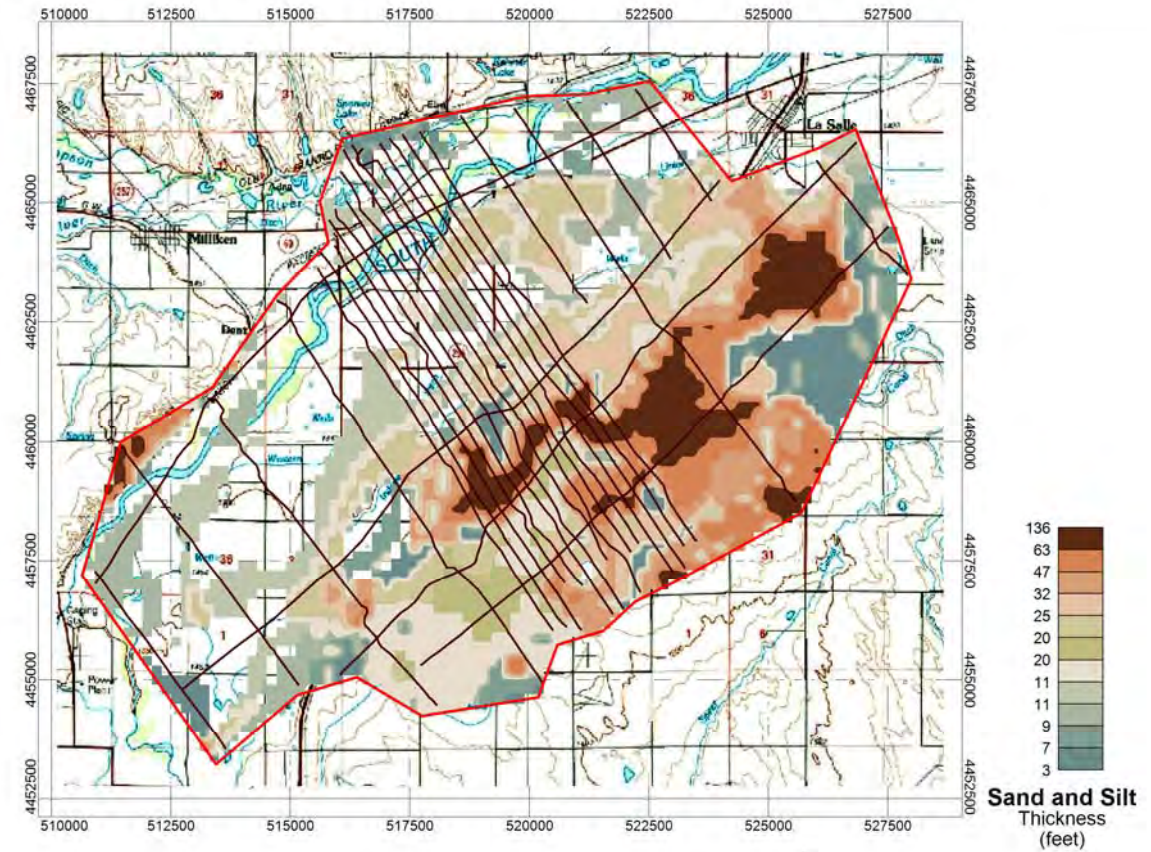
SEPARATED CRETACEOUS UNITS



GILCREST QUATERNARY LITHOLOGY THICKNESS

Clay and Silt

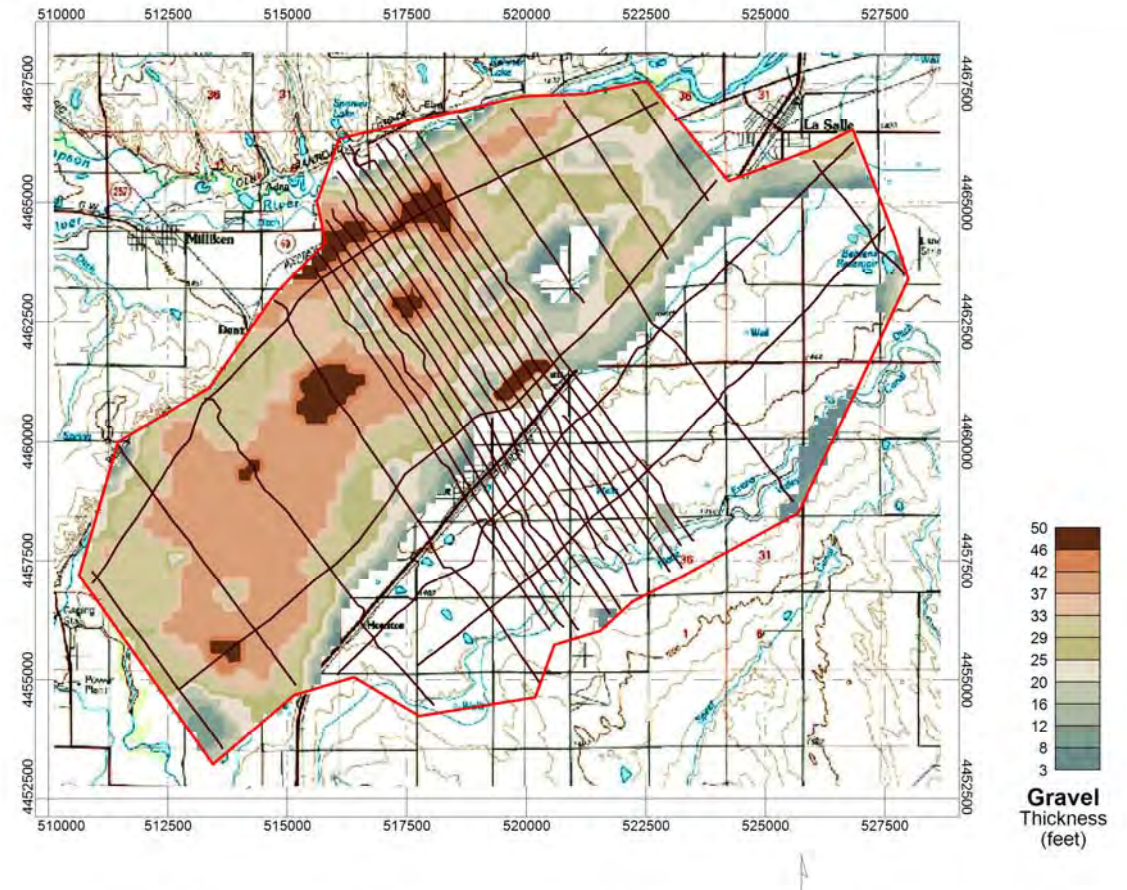
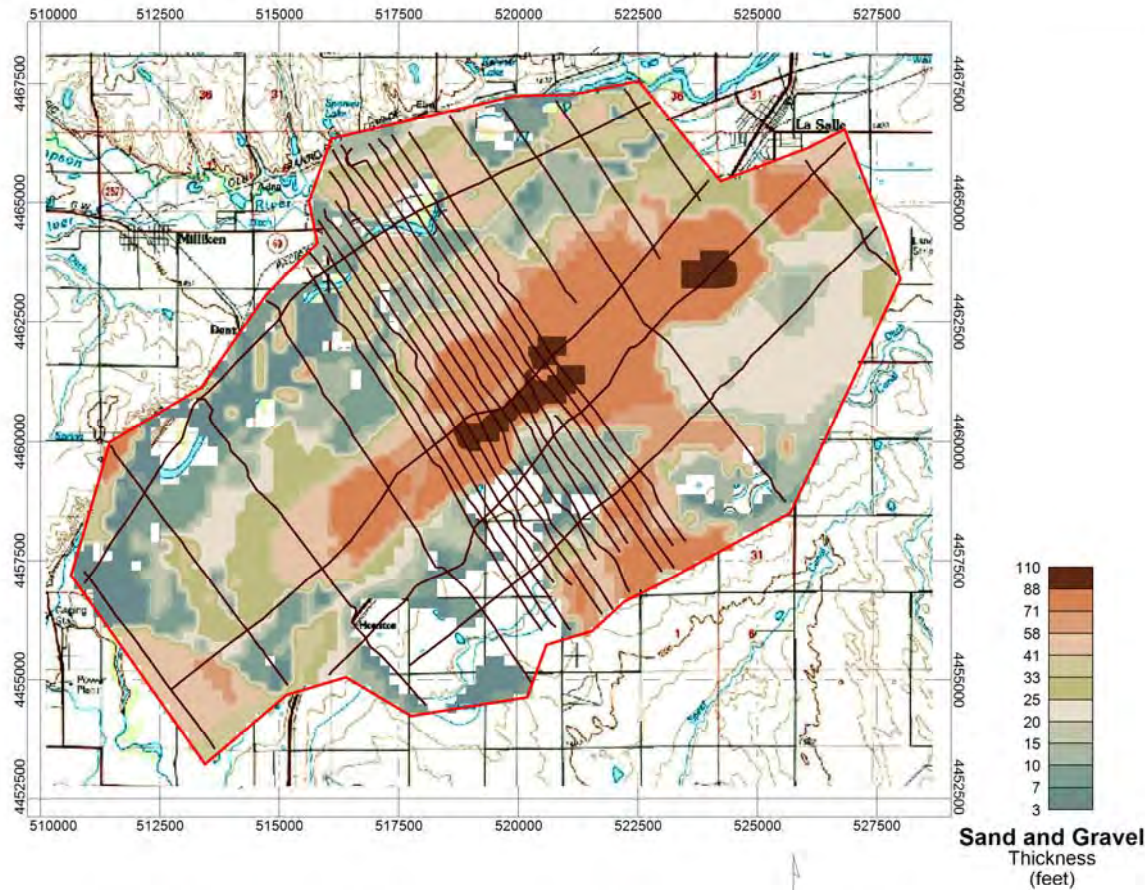
Sand and Silt



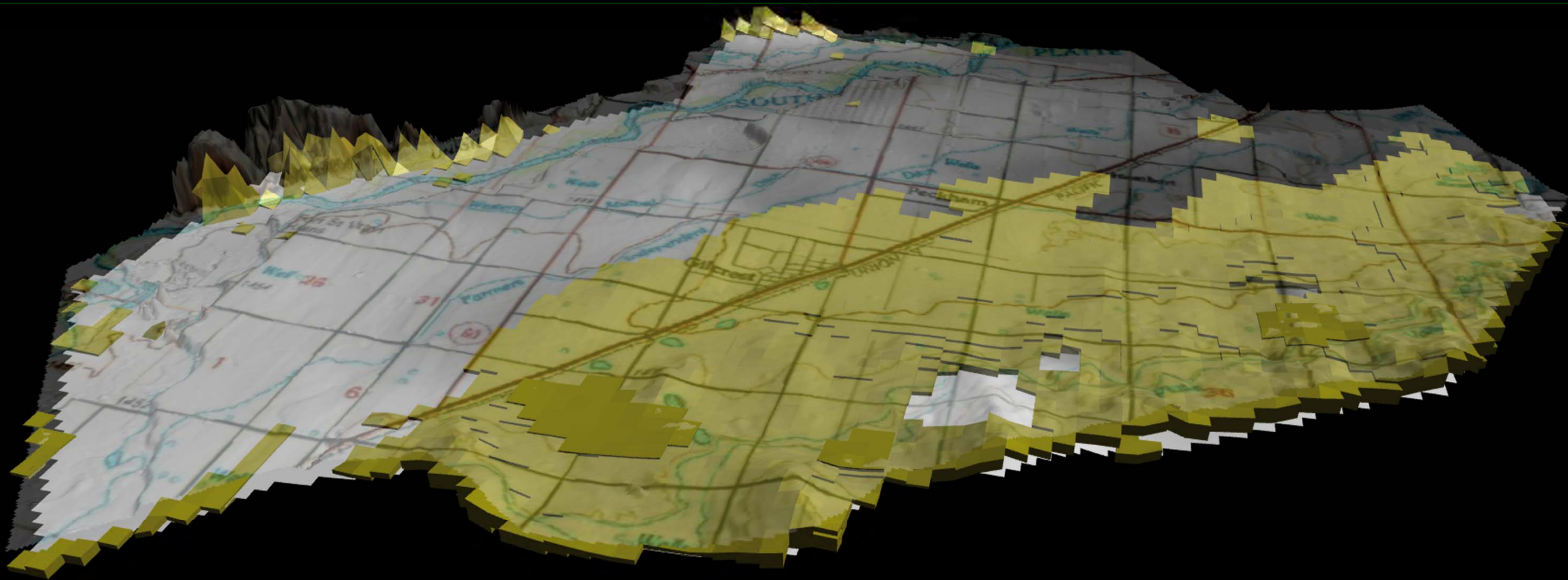
GILCREST QUATERNARY LITHOLOGY THICKNESS

Sand and Gravel

Gravel



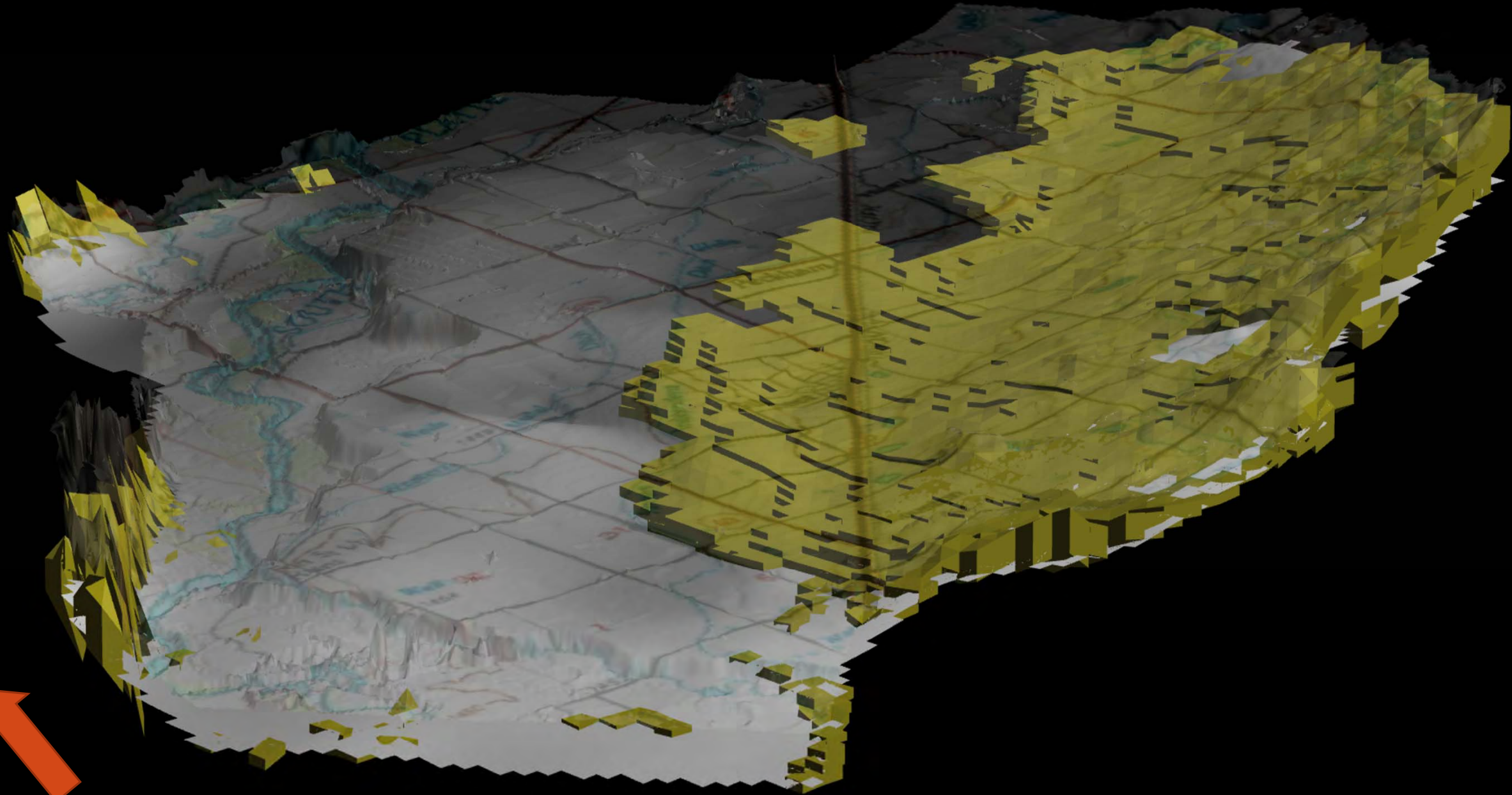
SILT AND CLAY ZONE



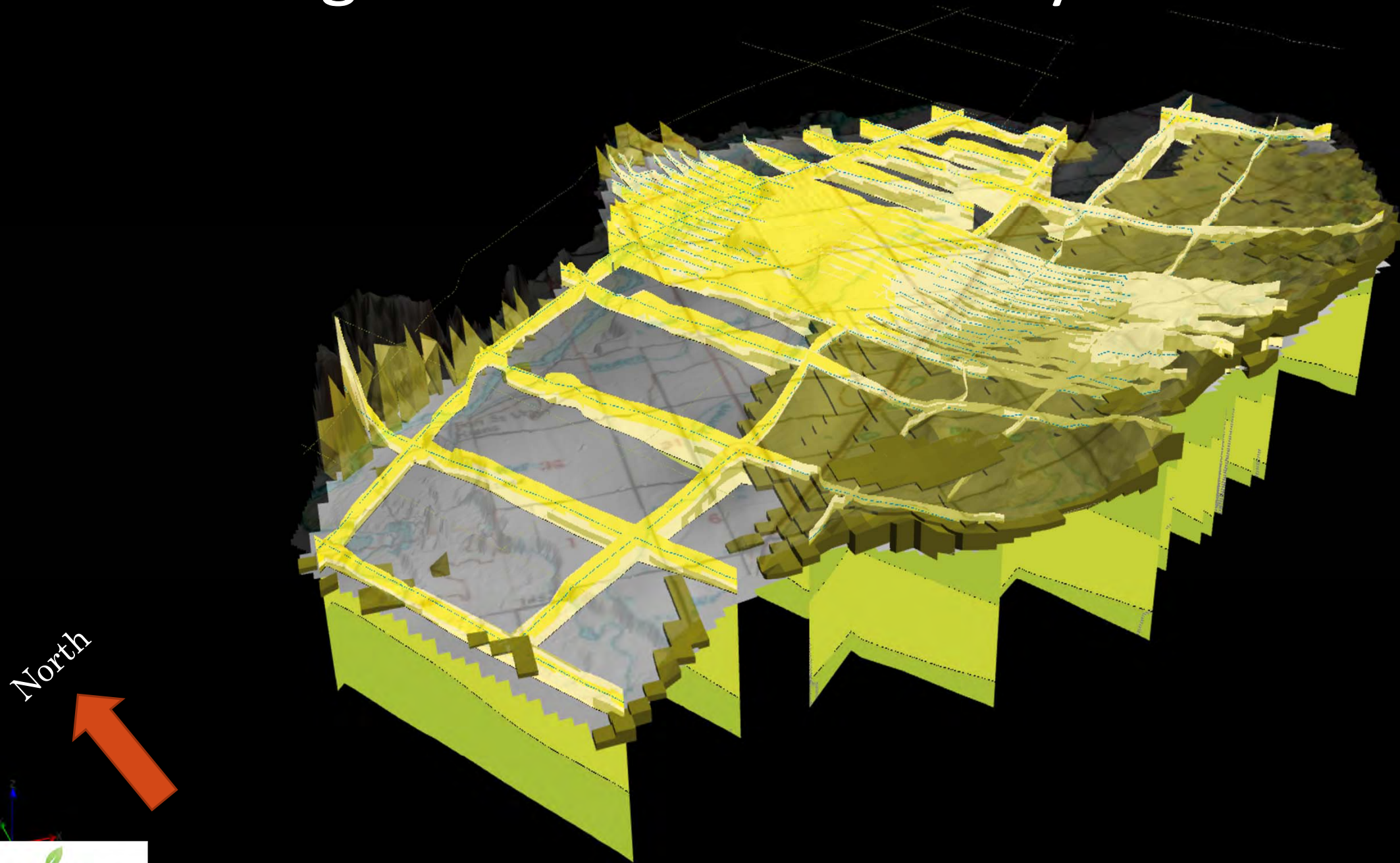
North



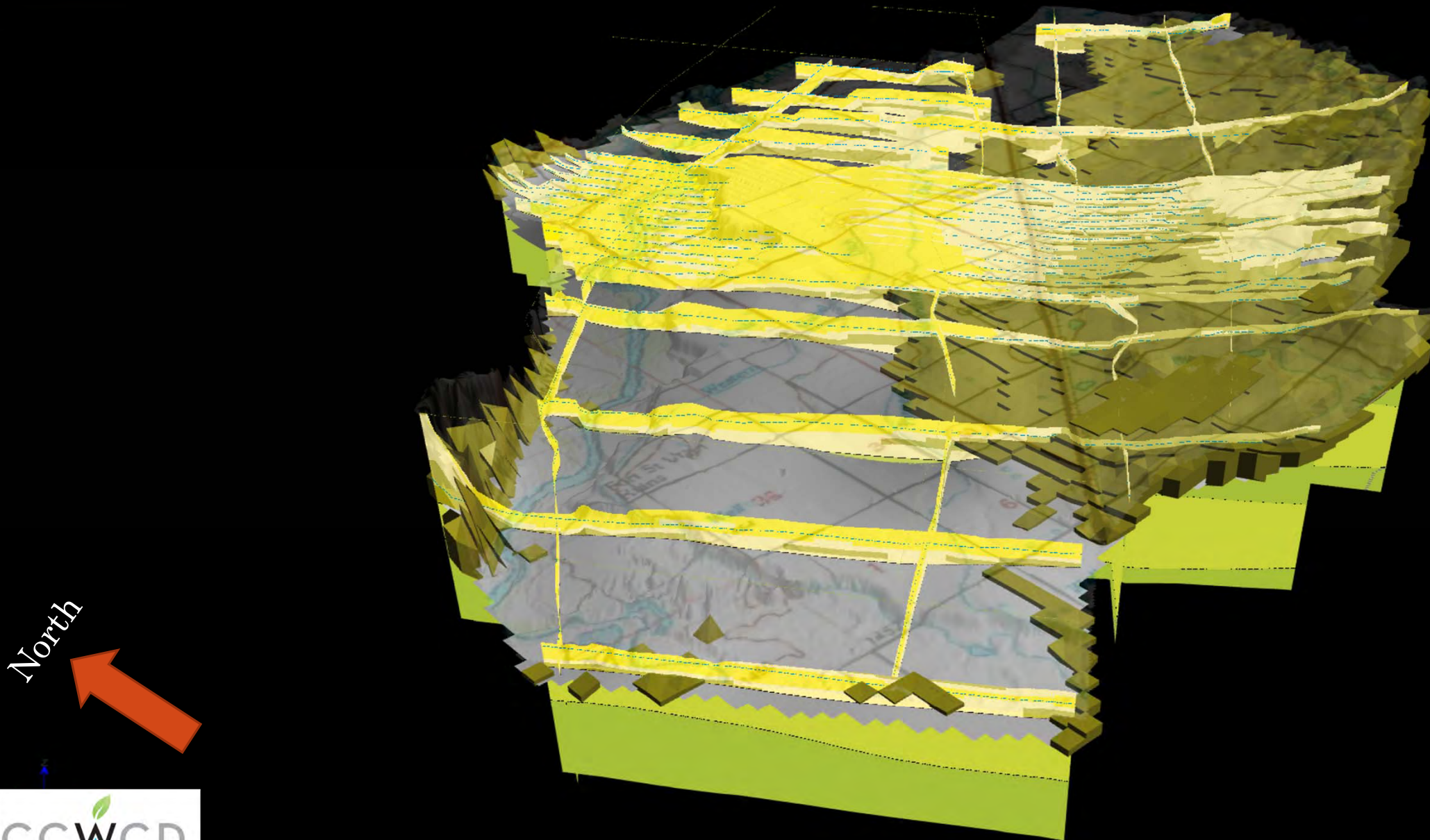
Silt and Clay Zone



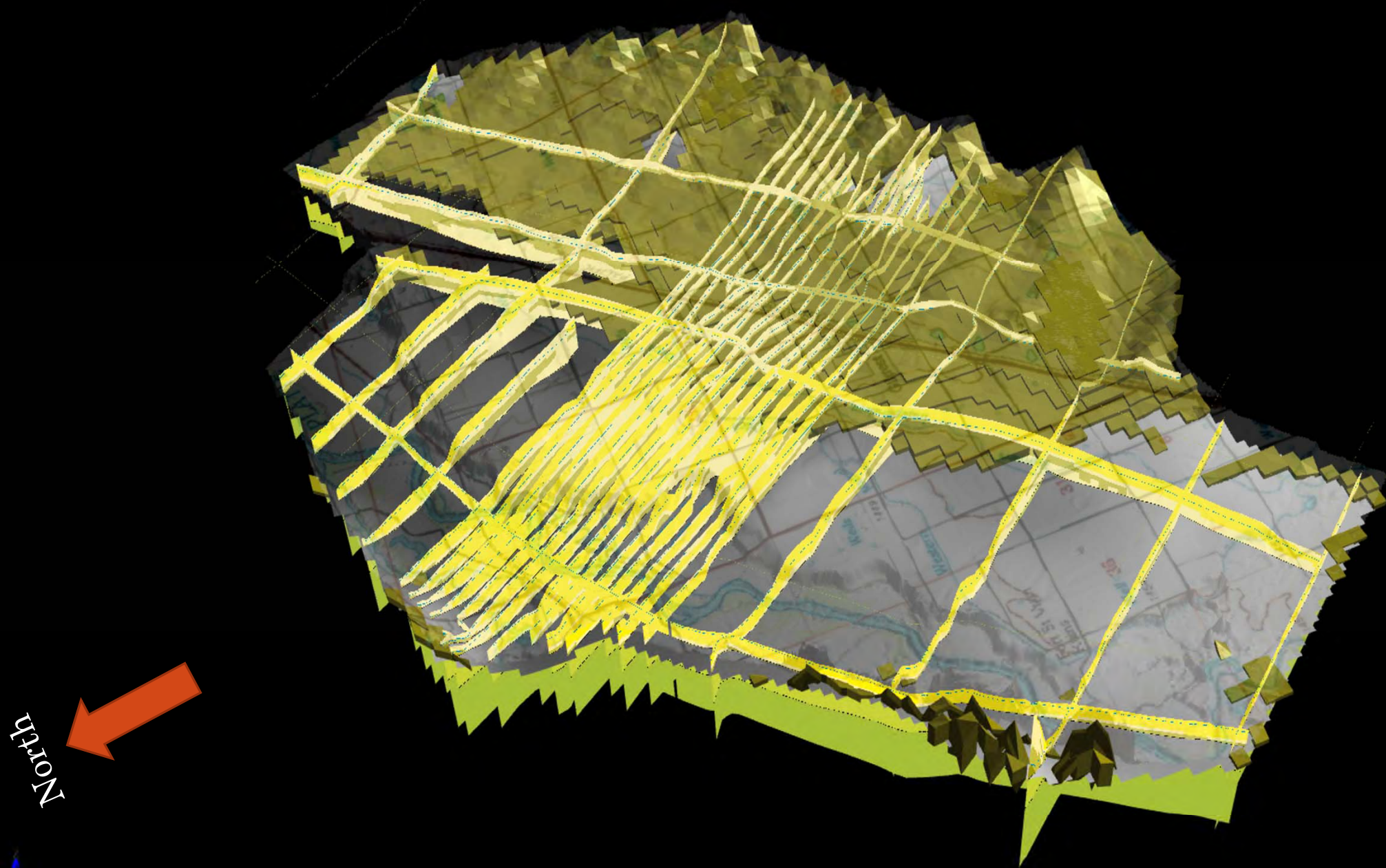
Fence Diagrams and Silt and Clay Zone



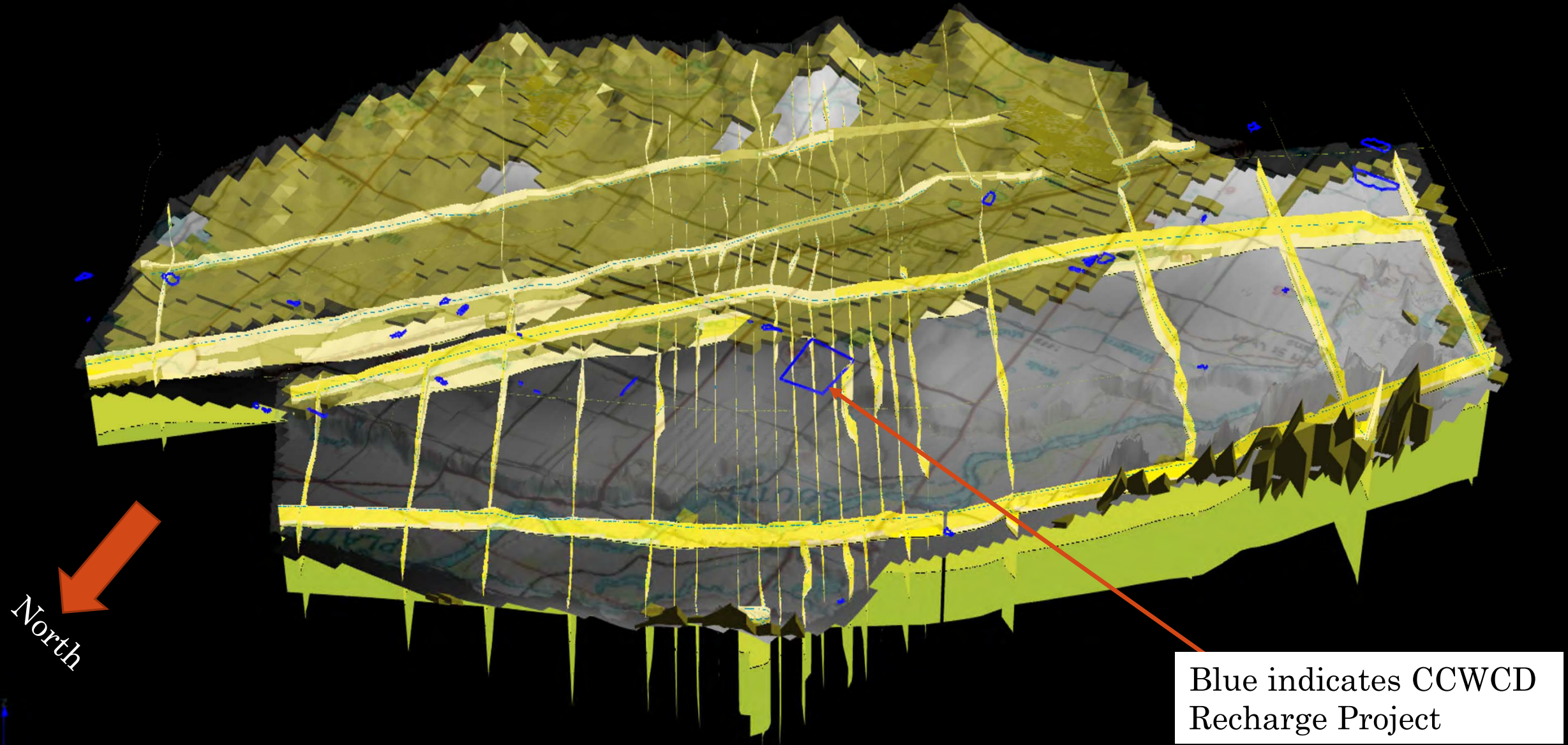
Fence Diagrams and Silt and Clay Zone



Fence Diagrams and Silt and Clay Zone

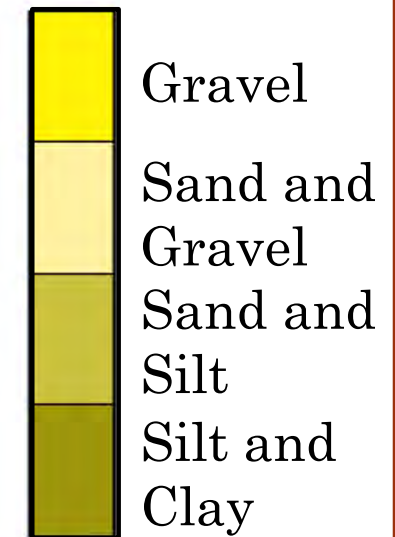
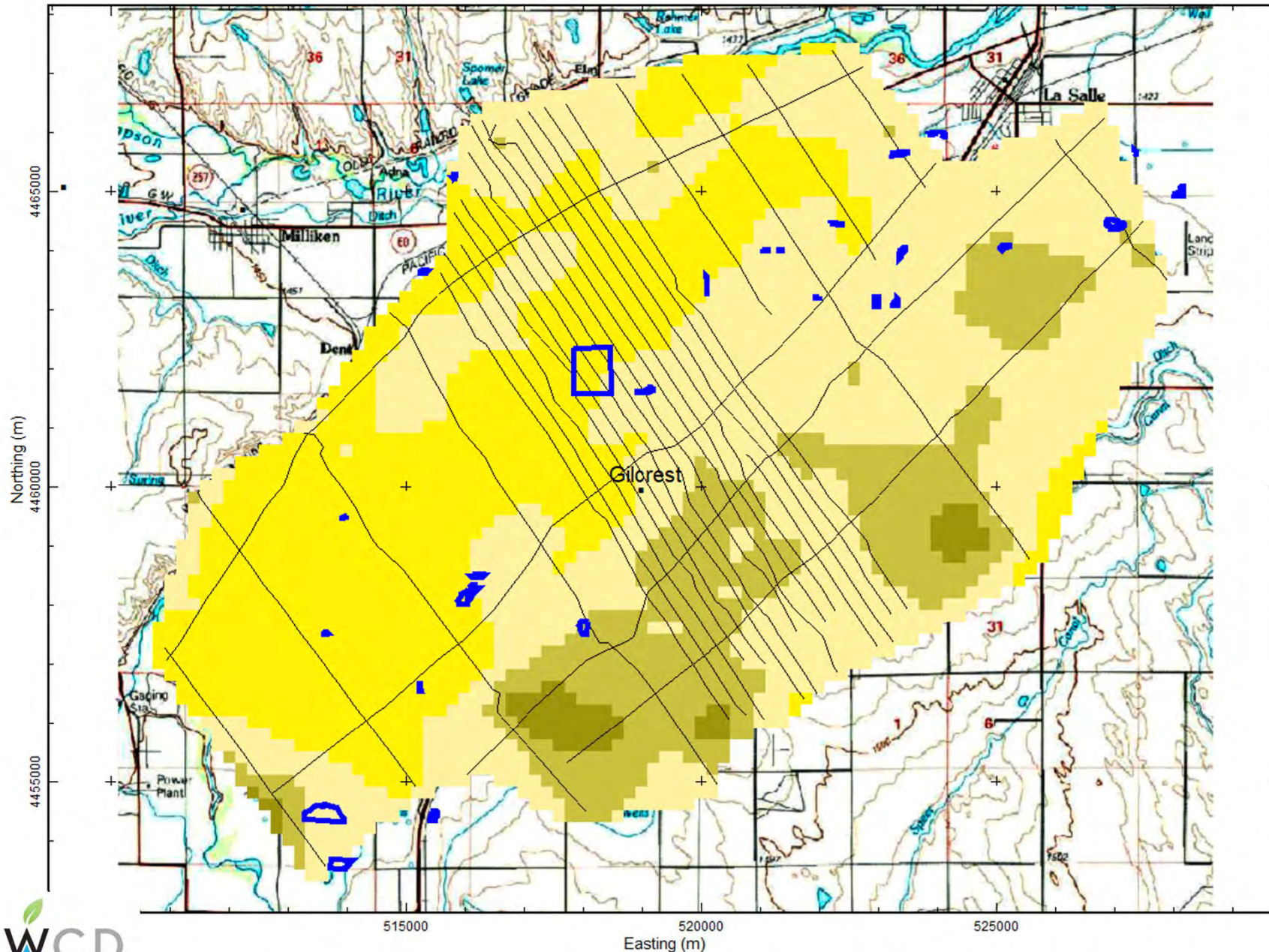


Fence Diagrams and Silt and Clay Zone and Recharge Projects

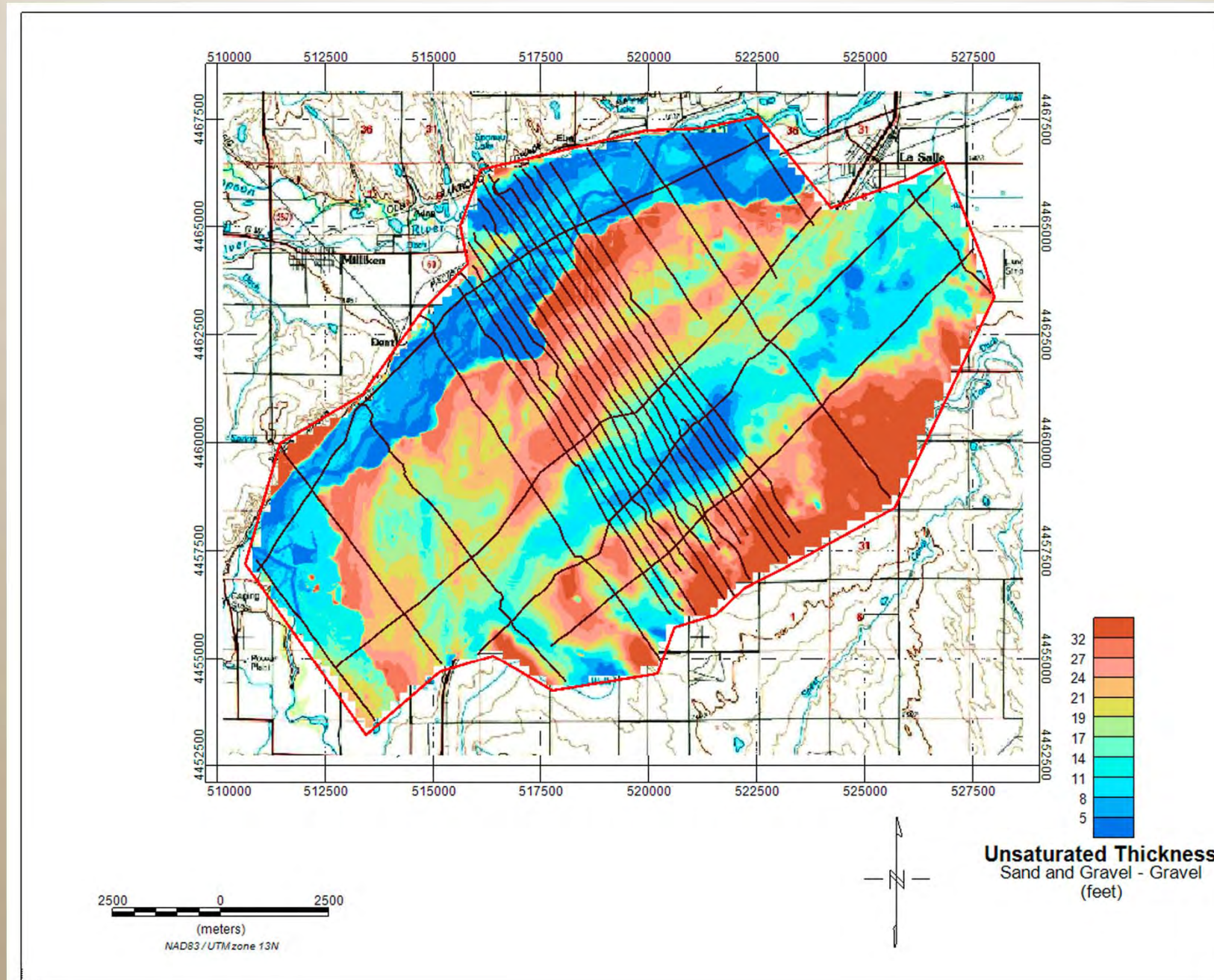


North

LAYER 1 (~0-3) FEET DEPTH LITHOLOGY MODEL



UNSATURATED GRAVEL/SAND AND GRAVEL



Abraham et al., 2018

CONCLUSIONS



In addition to mapping the geometry of the clay layer in the area, MAR sites were identified for recharge optimization.

These MAR sites would be in areas without fine grained material in the near surface and away from the clay layers that may contribute to increased groundwater levels.

Using the enhanced hydrogeological framework, the CCWCD has improved their understanding of the groundwater system and optimized their management of the resource.



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