PRELIMINARY AIRBORNE ELECTROMAGNETIC (AEM) SURVEY RESULTS FOR THE ENWRA PROJECT AREA

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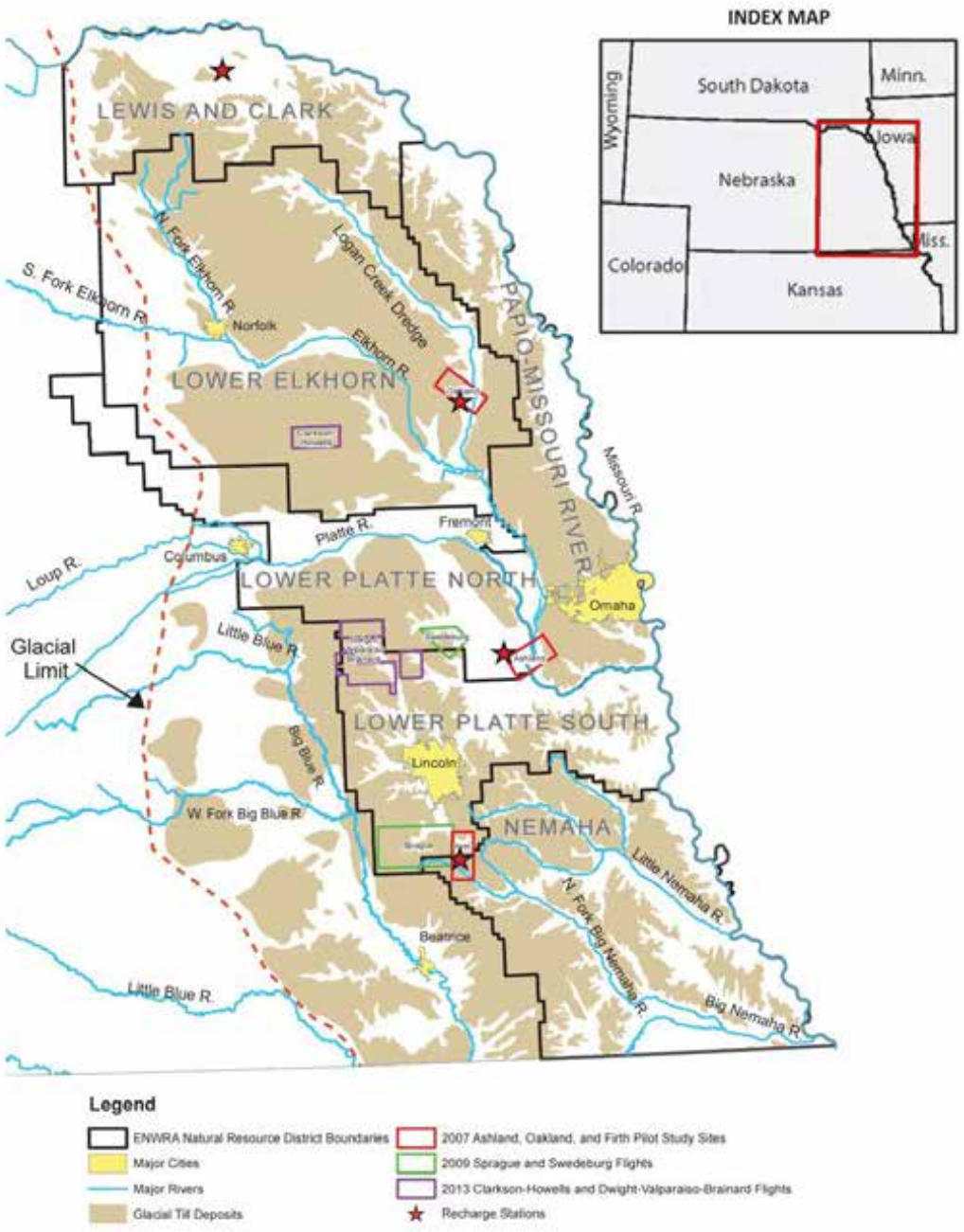
ENWRA STUDY SITES

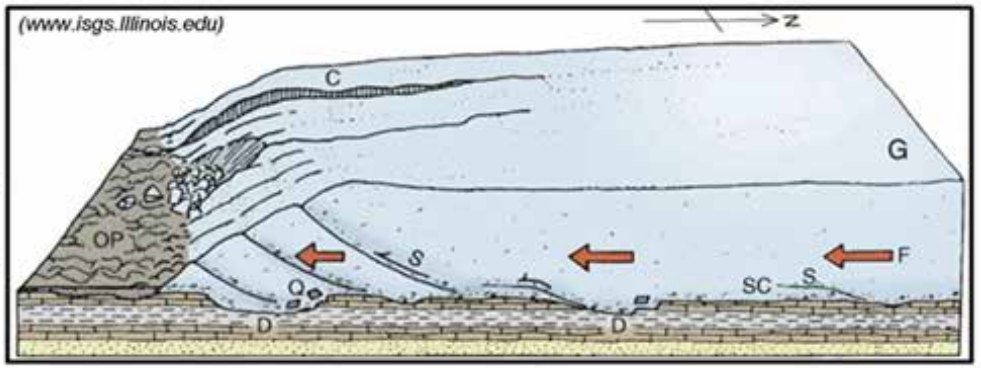


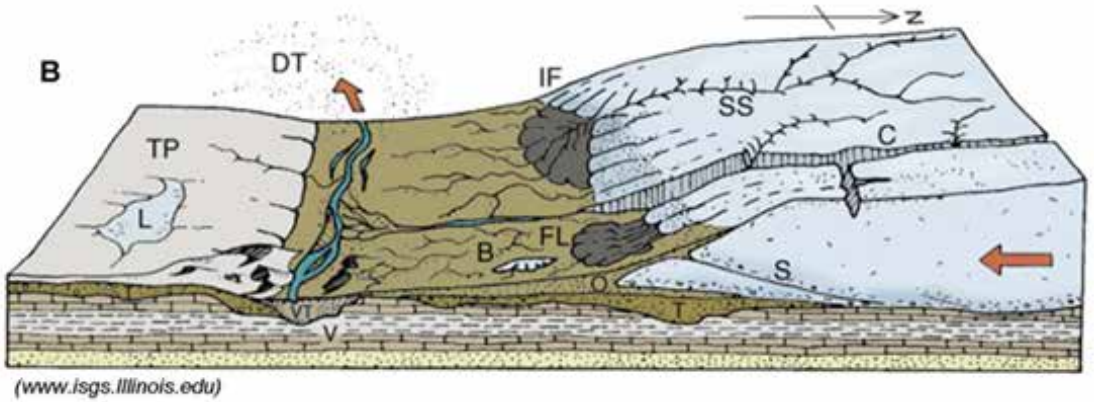
- 6 Eastern Nebraska NRDs
- Formed in 2006 to assess hydrogeologic framework of the glaciated area
- Agency partners: USGS, UNL CSD, NDNR, NDEQ
- 3 pilot study sites to test toolsets
- First used geophysical mapping by helicopter in 2007
- Application of the airborne survey technology evolved over time

ENWRA.ORG

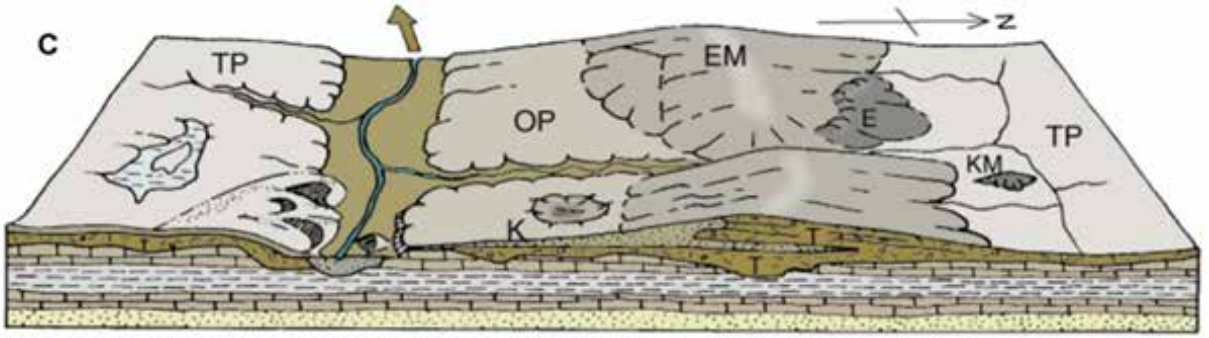
Glacial Processes

Schematic diagram showing the "plucking" process of bedrock material within the ice sheet that becomes part of the till deposits in the end and ground moraines.



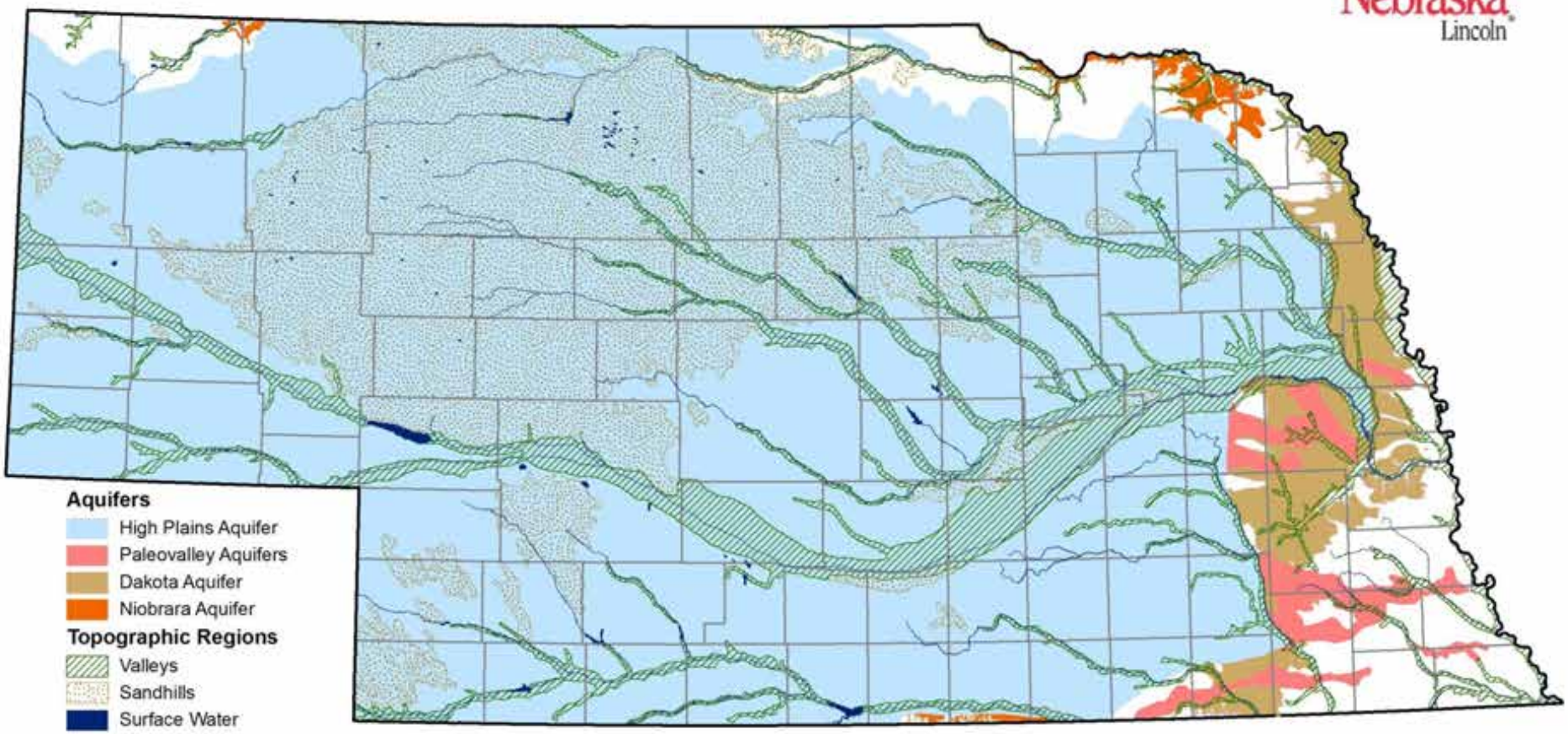


(www.isgs.Illinois.edu)



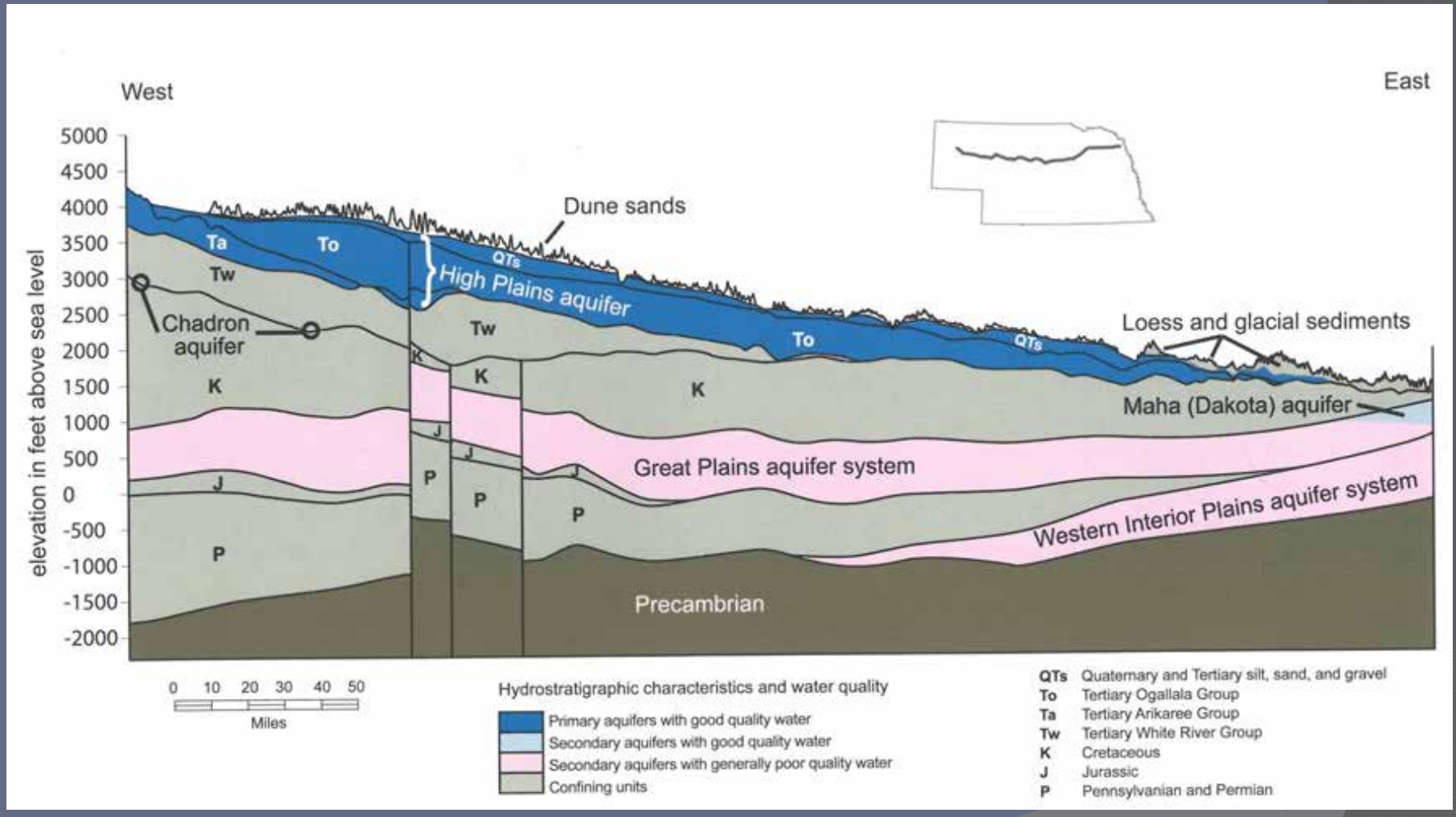
(www.isgs.Illinois.edu)

Important Aquifers and Topographic Regions of Nebraska



- Groundwater resources are more limited in eastern Nebraska
- Much of the groundwater supply in eastern Nebraska is from aquifers that are within & below glacial deposits
- They can be laterally discontinuous, have highly variable geometry, and are heterogeneous making them very complex to map
- Delineation of these aquifers is critical for management purposes
  - The quantity of water may be limited due to the spatially confined nature of the aquifers
  - Natural water quality varies in different aquifers, human introduced contaminants on the surface (example nitrates) may infiltrate to these aquifers and degrade their water quality

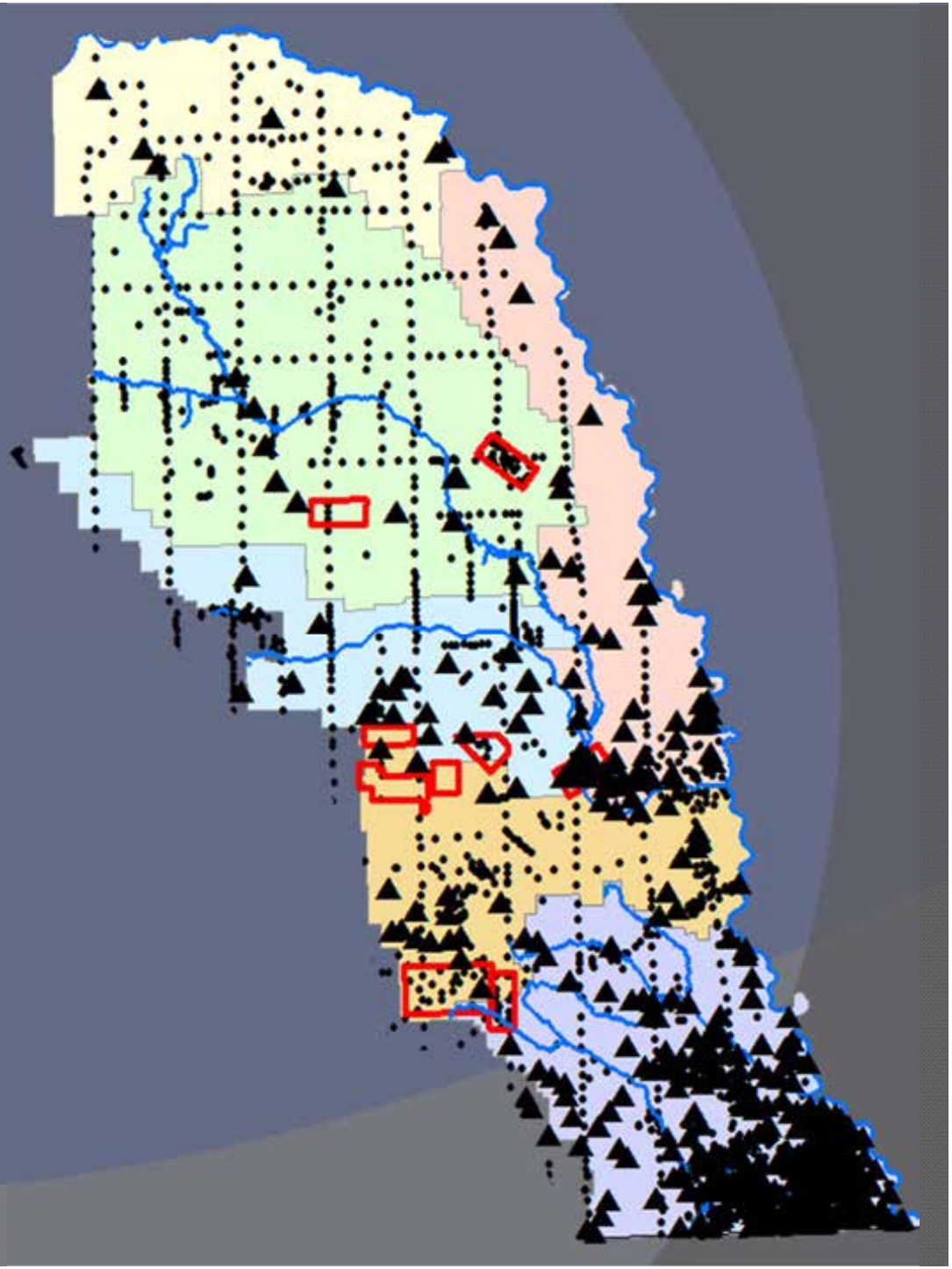
Cross Section Across Nebraska



The Groundwater Atlas of Nebraska Resource Atlas No. 4b/2013 Third (revised) Edition Conservation and Survey Division School of Natural Resources Institute of Agriculture and Natural Resources University of Nebraska - Lincoln

Existing Data

- Test holes logged by state geologists since 1940
- Deep oil and gas well cores
- Study sites
- Geologic cross-sections, maps, and reports
- Registered well logs



Existing Data Georeferenced

INTERIM REPORT ON AIRBORNE ELECTROMAGNETIC GEOPHYSICAL SURVEYS AND HYDROGEOLOGIC FRAMEWORK DEVELOPMENT FOR SELECTED SITES IN THE EASTERN NEBRASKA WATER RESOURCES ASSESSMENT

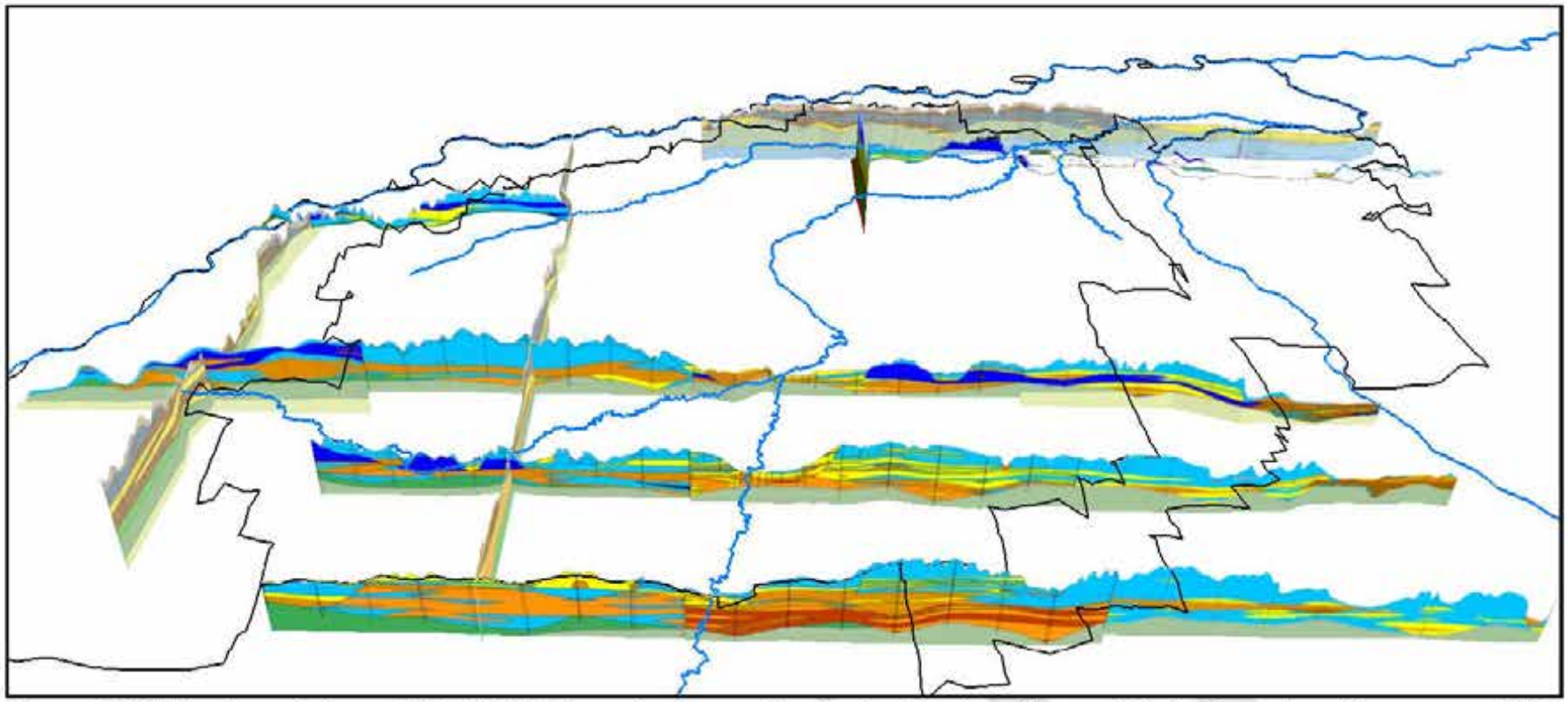
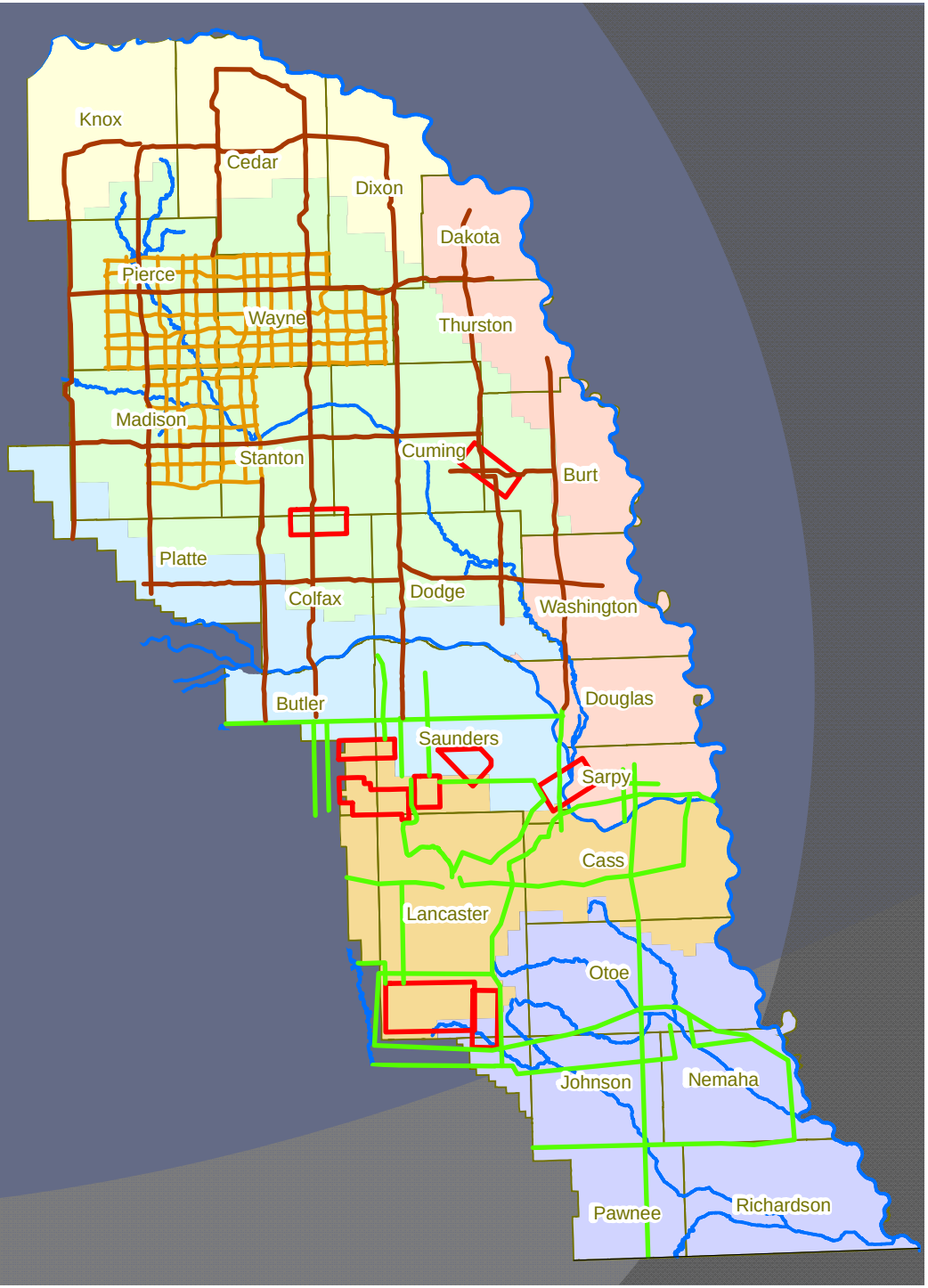


Figure 5-16: Eastward view of the ENWRA project area displaying the locations of historic and contemporary CSD geologic cross sections. The color scale is shown in Figure 5-3.

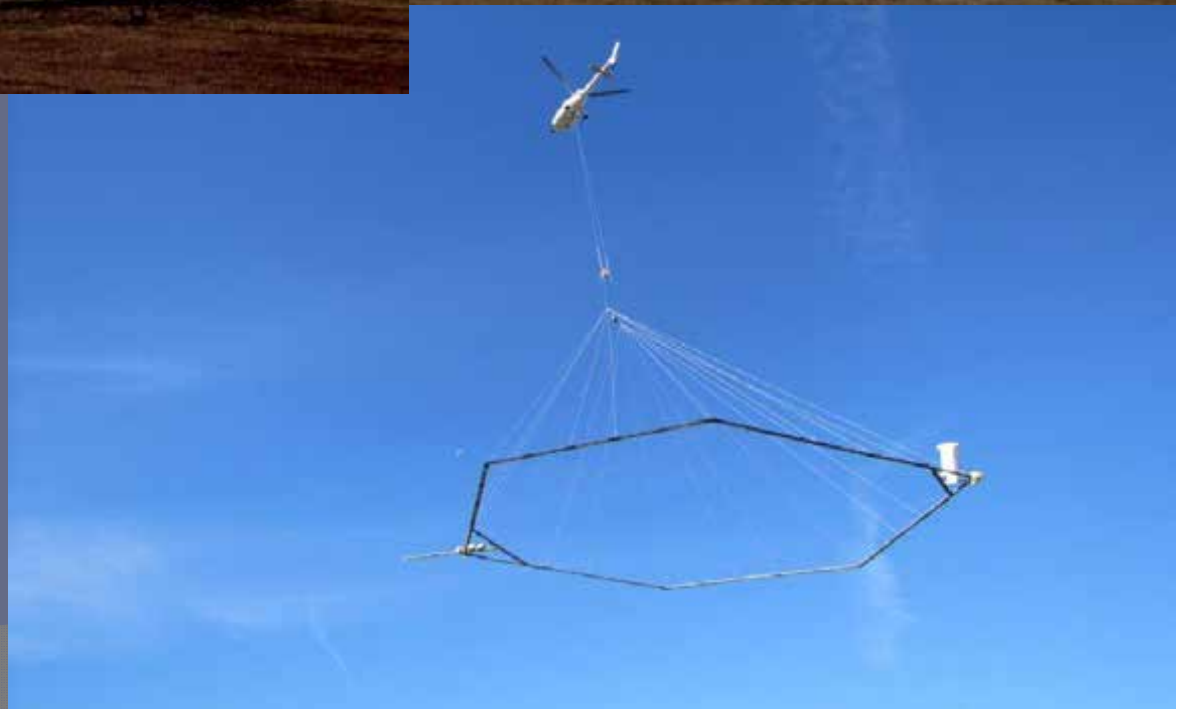
Recon Flights

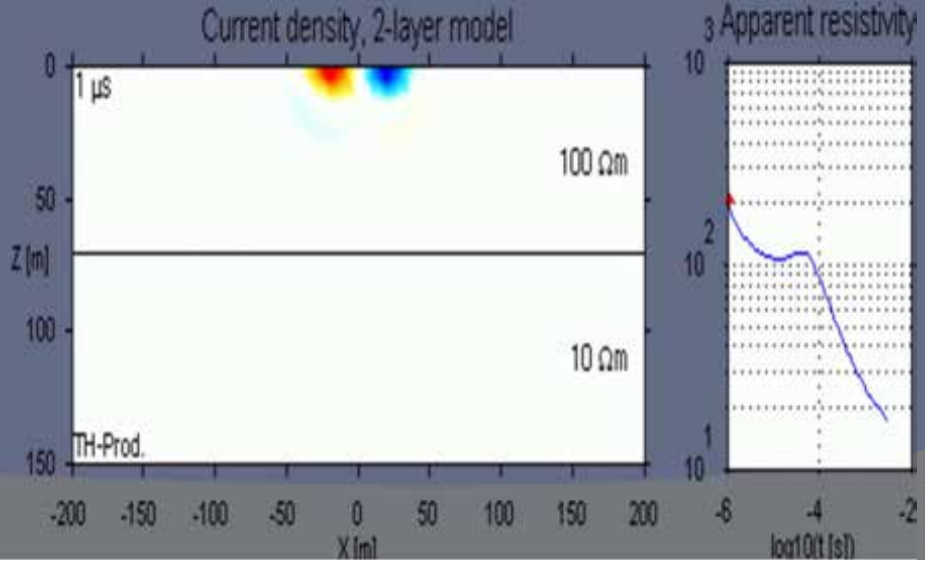
AEM survey

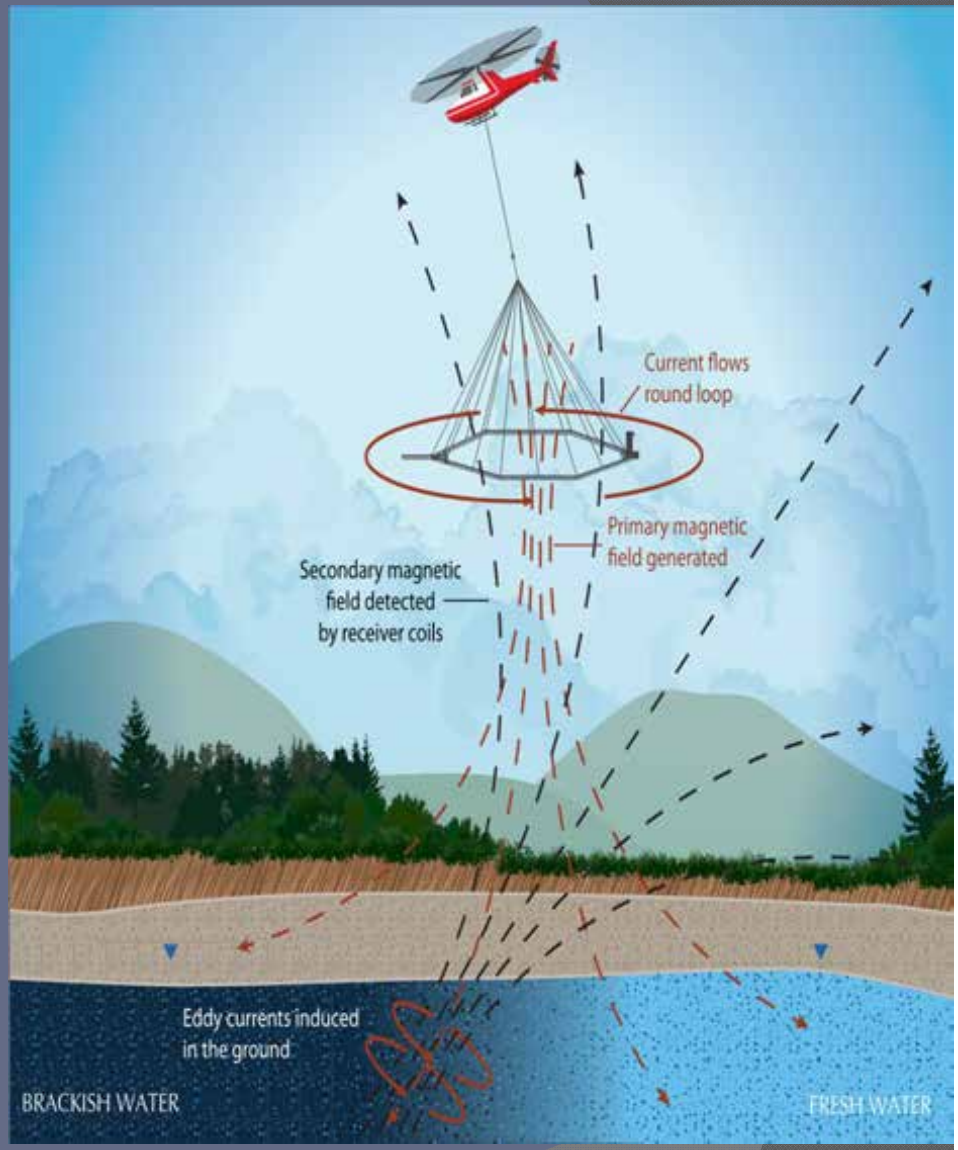
- October 2014 ENWRA Flights (~800 line-miles)
- October 2014 LENRD Flights (~700 line-miles)
- Spring 2015 ENWRA Flights (~585 miles of flight lines)



508 System







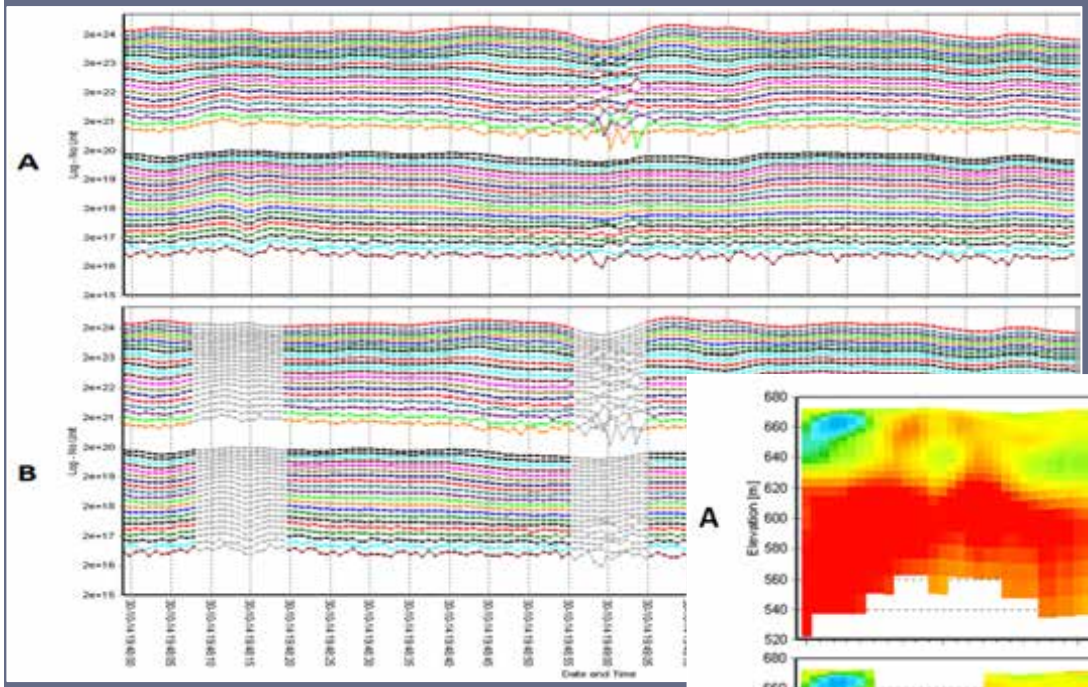
E. AUKEN, U. OF AARHUS, DENMARK

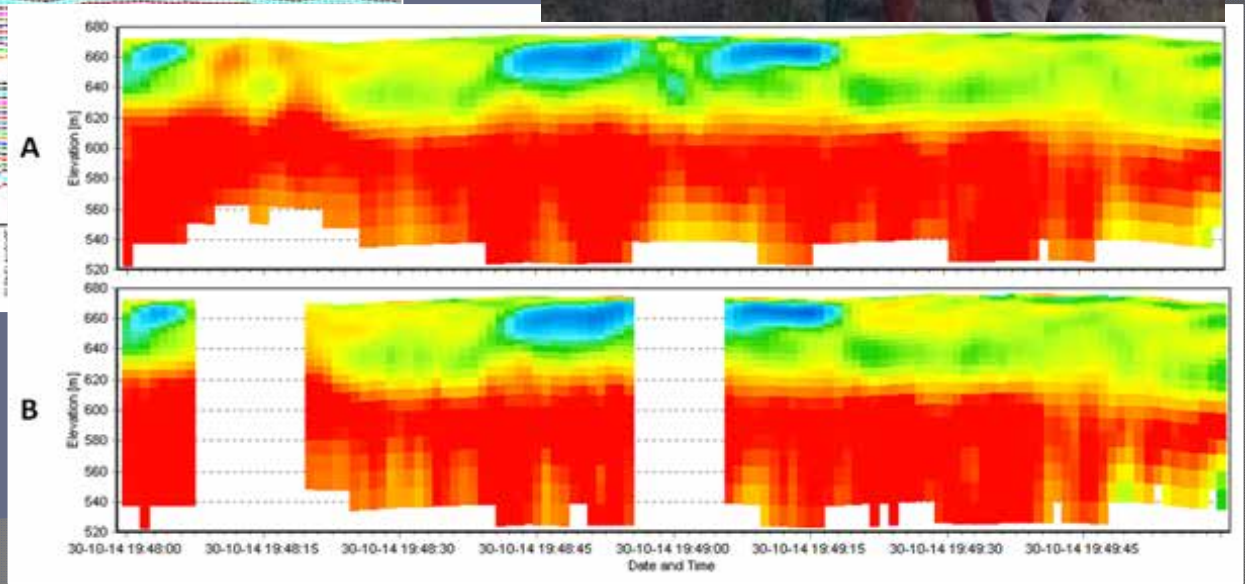
Flight Line Planning

- Lines Planned along CSD Cross Sections
- Pipeline data were acquired from Platts (www.platts.com)
- CSD/ENWRA assisted in acquiring data on public power systems
  - Auburn Board of Public Works, Burt County Power District, Butler County Power District, Cedar-Knox Power District, City of Fremont, Cornhusker Public Power District, Cuming County Power District, Elkhorn Rural Public Power District, Lincoln Electric Systems, Loup Power District, Nebraska Public Power District, Nemaha-Marshall Electric Cooperative, Norris Public Power District, North Central Public Power District, Northeast Nebraska Public Power District, Omaha Public Power District, Polk County Rural Public Power District, Seward County Public Power District, Stanton County Public Power District
- Flight lines were adjusted to optimize data collection

In Field QA/QC and Inversion

- Within 24 hours we have preliminary Inversions





AEM Data Interpretation

- Geophysicists and geologists interpret the data using profile analyst software
- They select contacts between the deposits for every flight line using lithological information from CSD borehole logs
- Following this separation of the deposits, the aquifer and non-aquifer materials are separated by resistivity thresholds

AEM Data Interpretation

- There are distinct contrasts
  - electrically conductive materials (clay and silt)
  - electrically resistive sediments (coarse deposits and carbonates)
- Conductive zones are generally interpreted as glacial till, loess, and shale
- Resistive intervals indicate the extent and thickness sand and gravel, carbonates or sandstone deposits

Resistivity Applied to Sediments

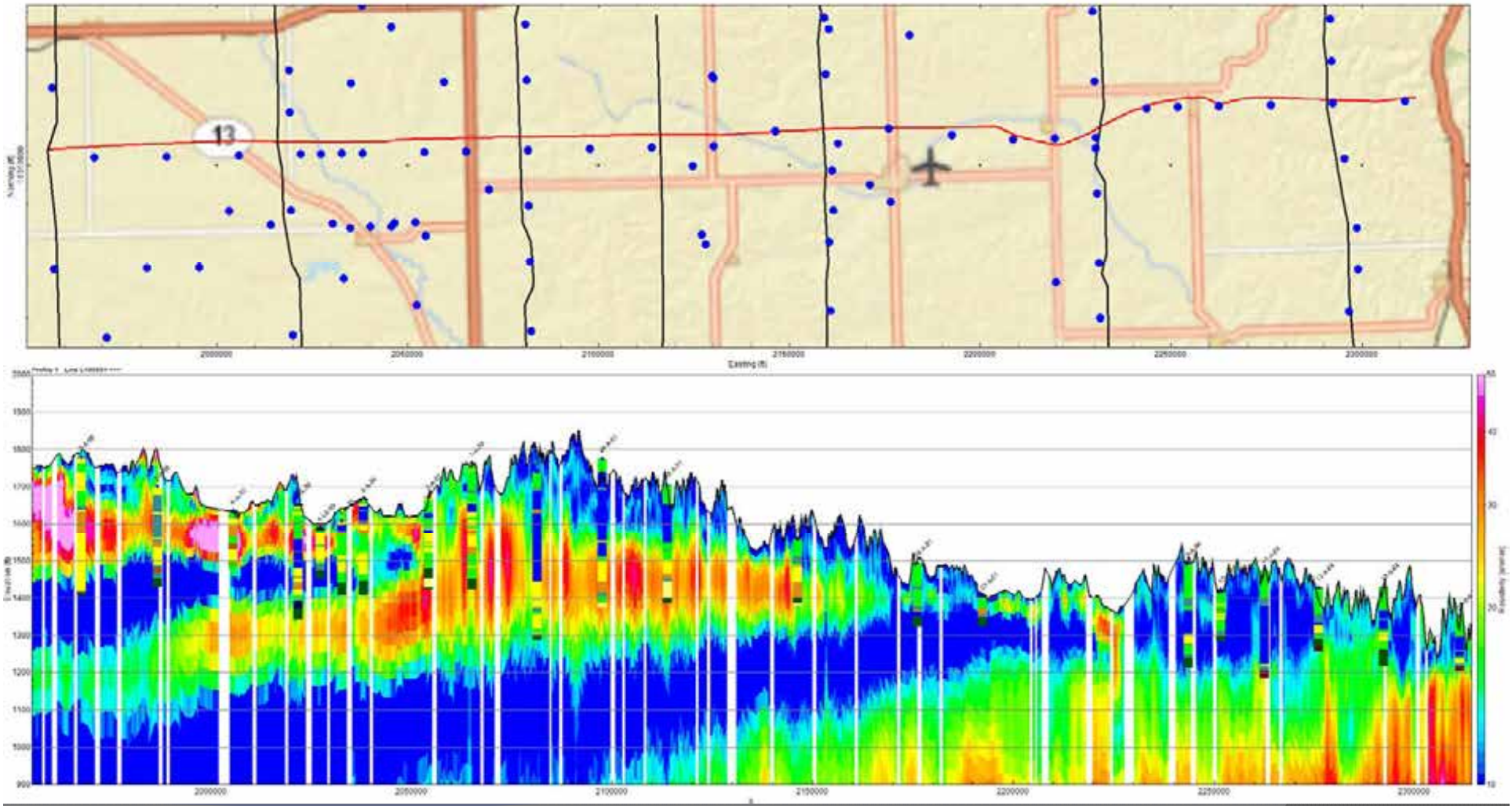
Finer-grained sediment

Decrease in resistivity

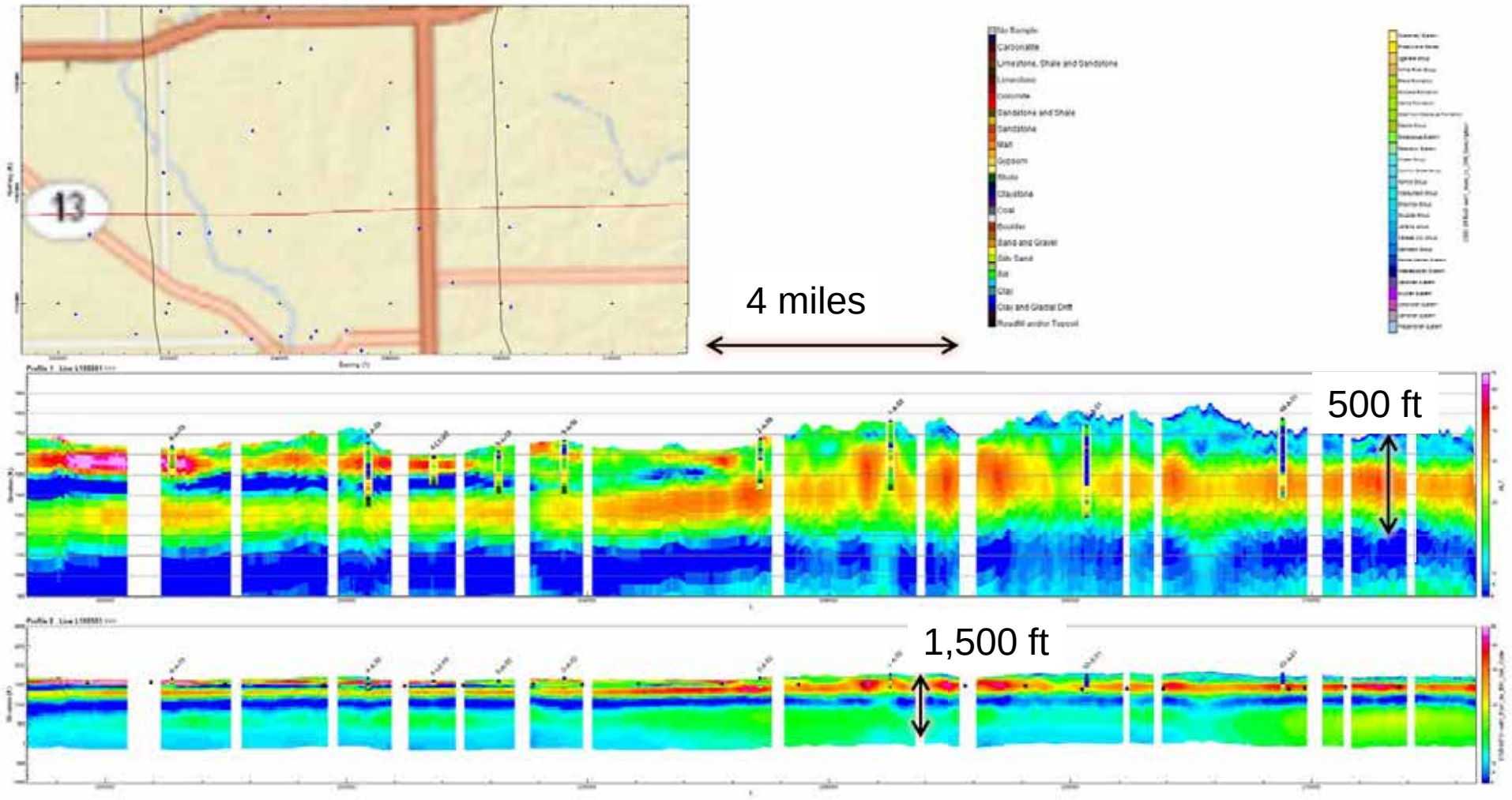
Increase in resistivity

Coarser-grained sediment

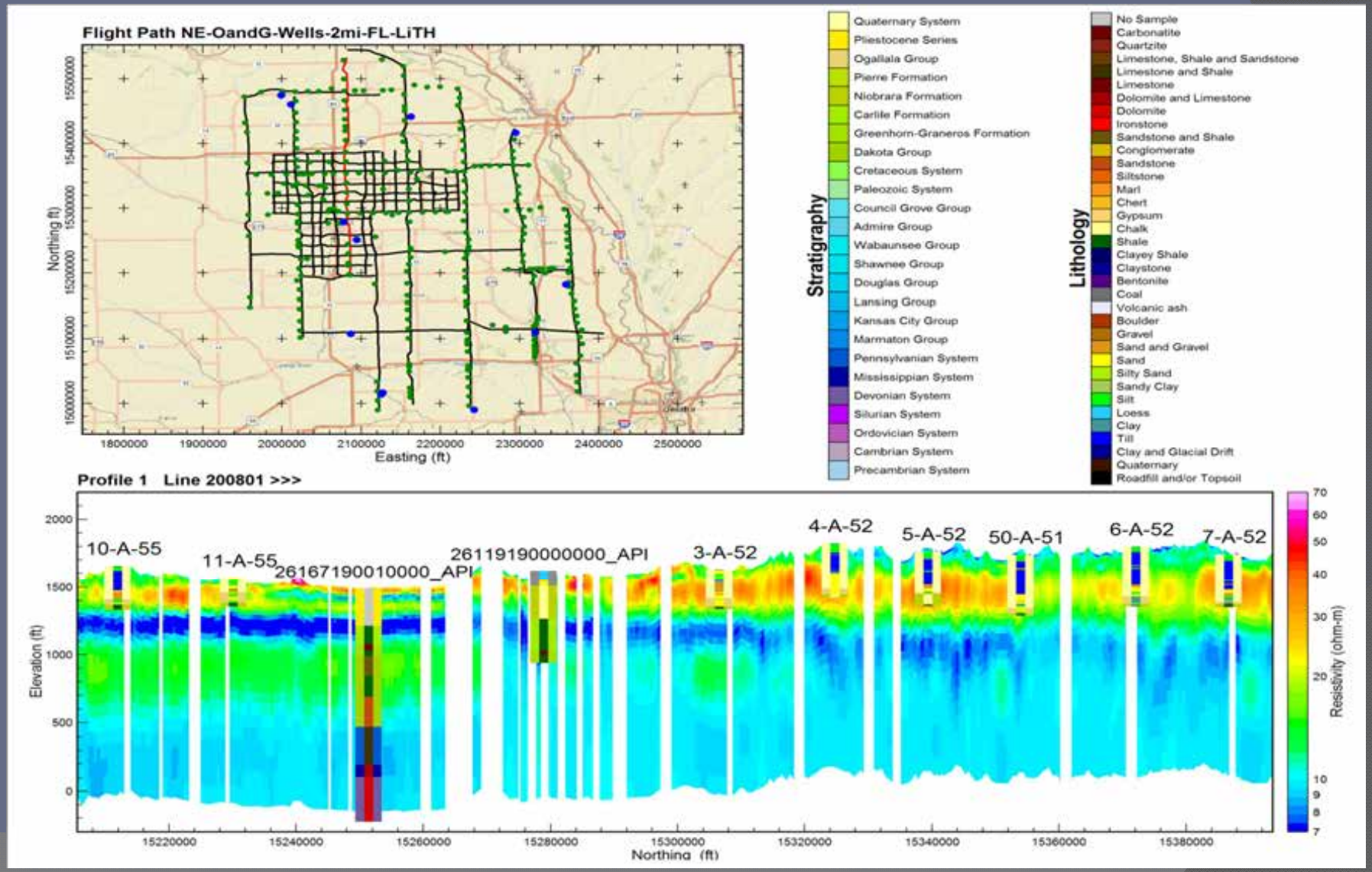
Step by Step Interpretation



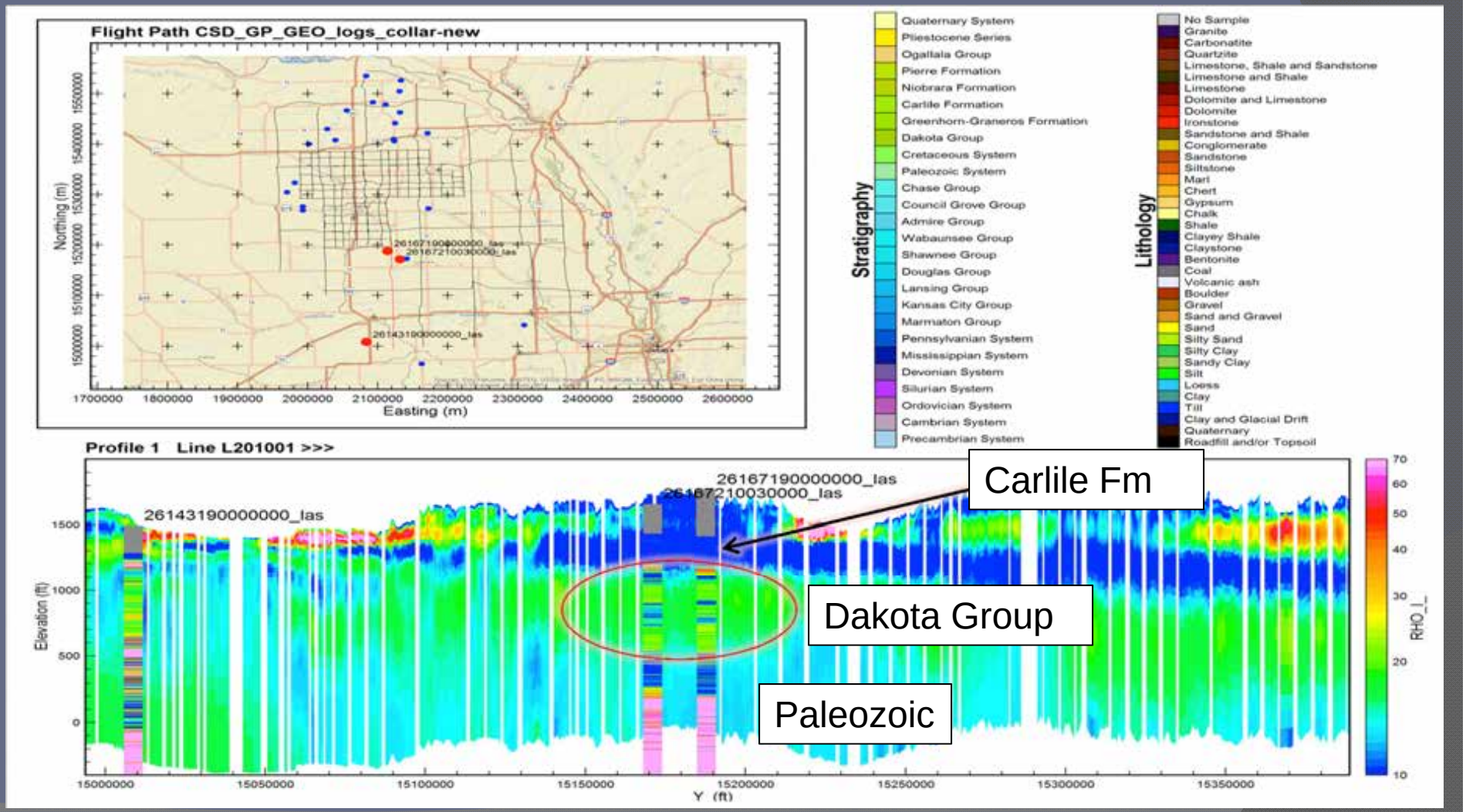
Zoom to Areas Along Section

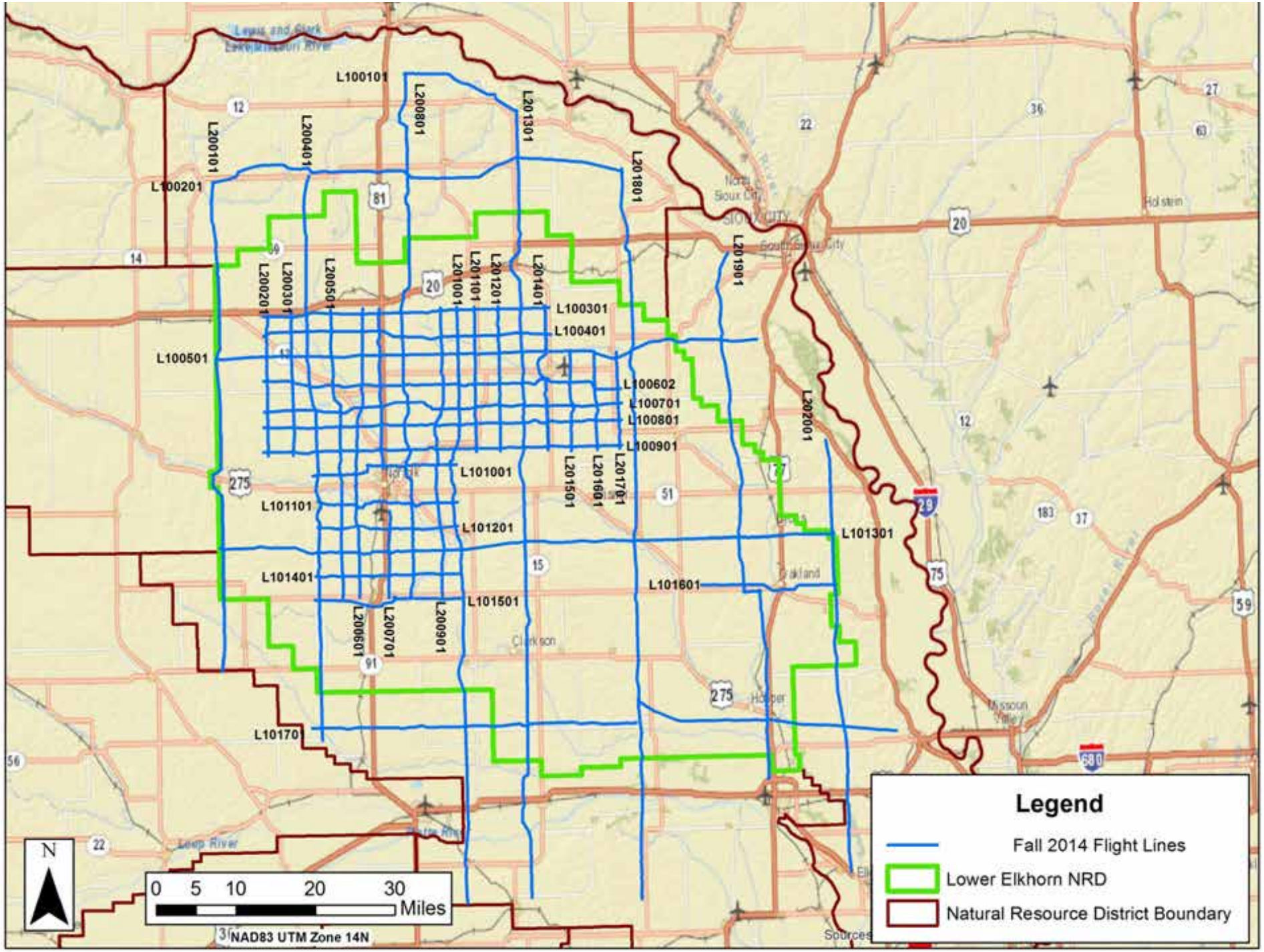


Deep Imaging in Eastern NE

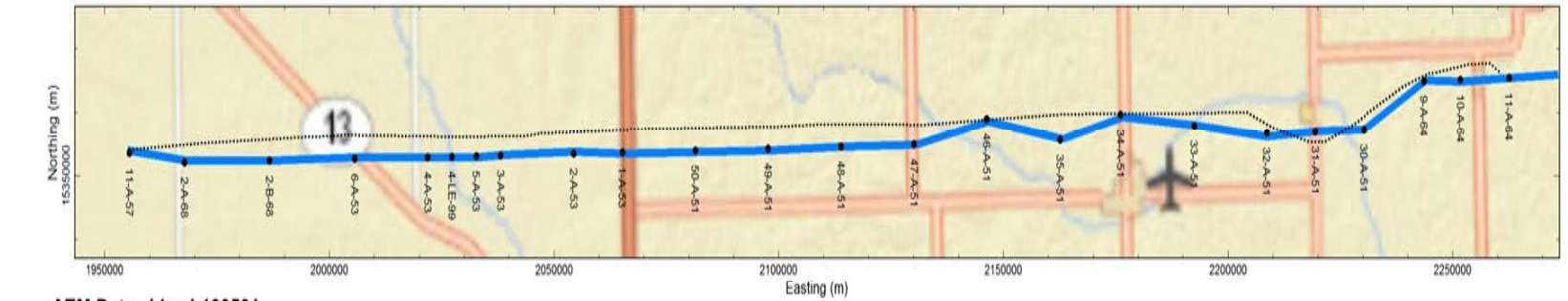


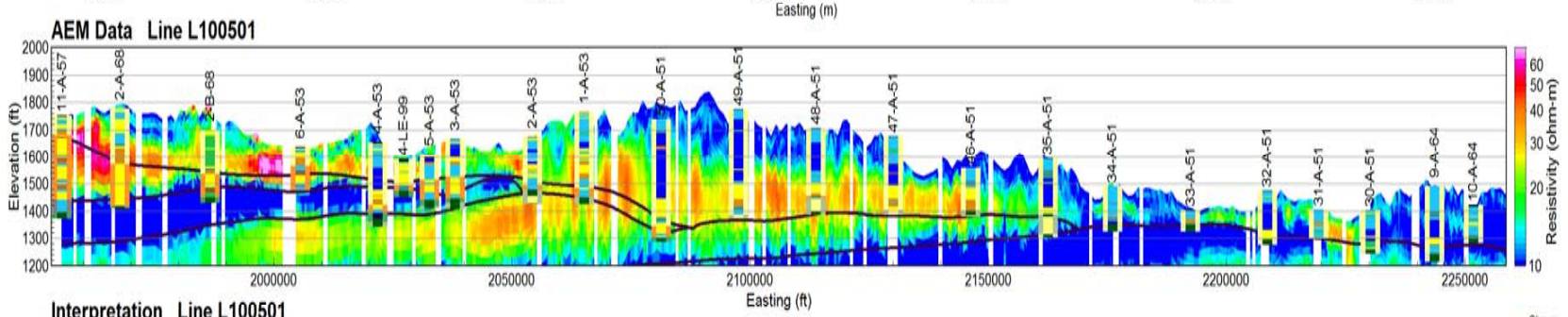
Oil and Gas E-Logs vs. AEM

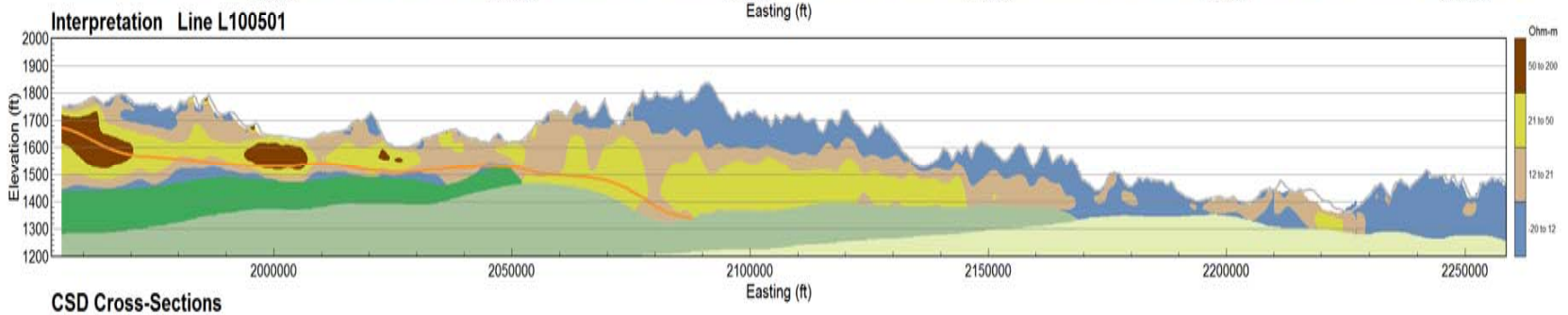


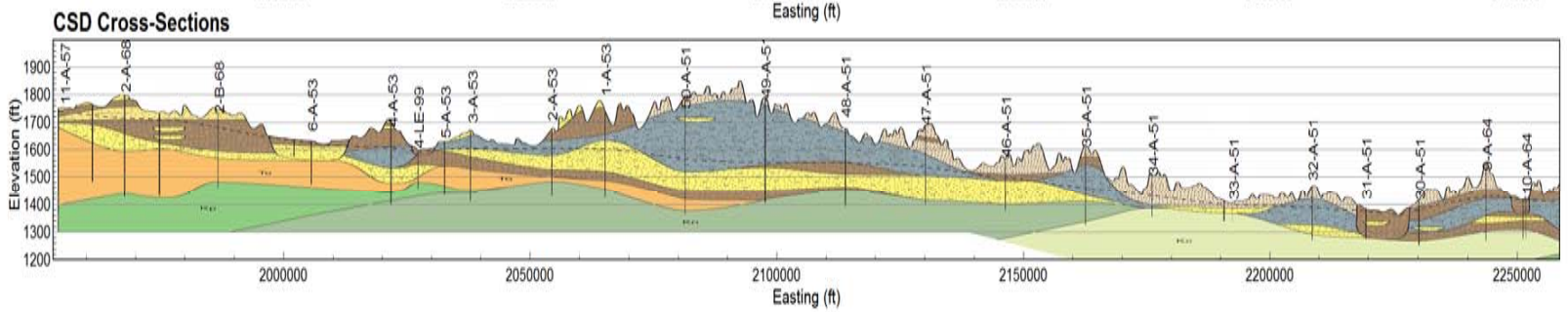

L100101
L200101
L200401
L200801
L201301
L201801
L100201
L200201
L200301
L200501
L201001
L201101
L201201
L201401
L201901
L100301
L100401
L100501
L100602
L100701
L100801
L100901
L202001
L101001
L201501
L201601
L201701
L101101
L101201
L101301
L101401
L101601
L101501
L200501
L200701
L200901
L10170
Legend
Fall 2014 Flight Lines
Lower Elkhorn NRD
Natural Resource District Boundary
N
0 5 10 20 30
Miles
NAD83 UTM Zone 14N

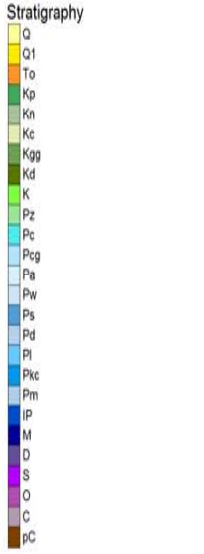
AEM versus CSD Cross Section



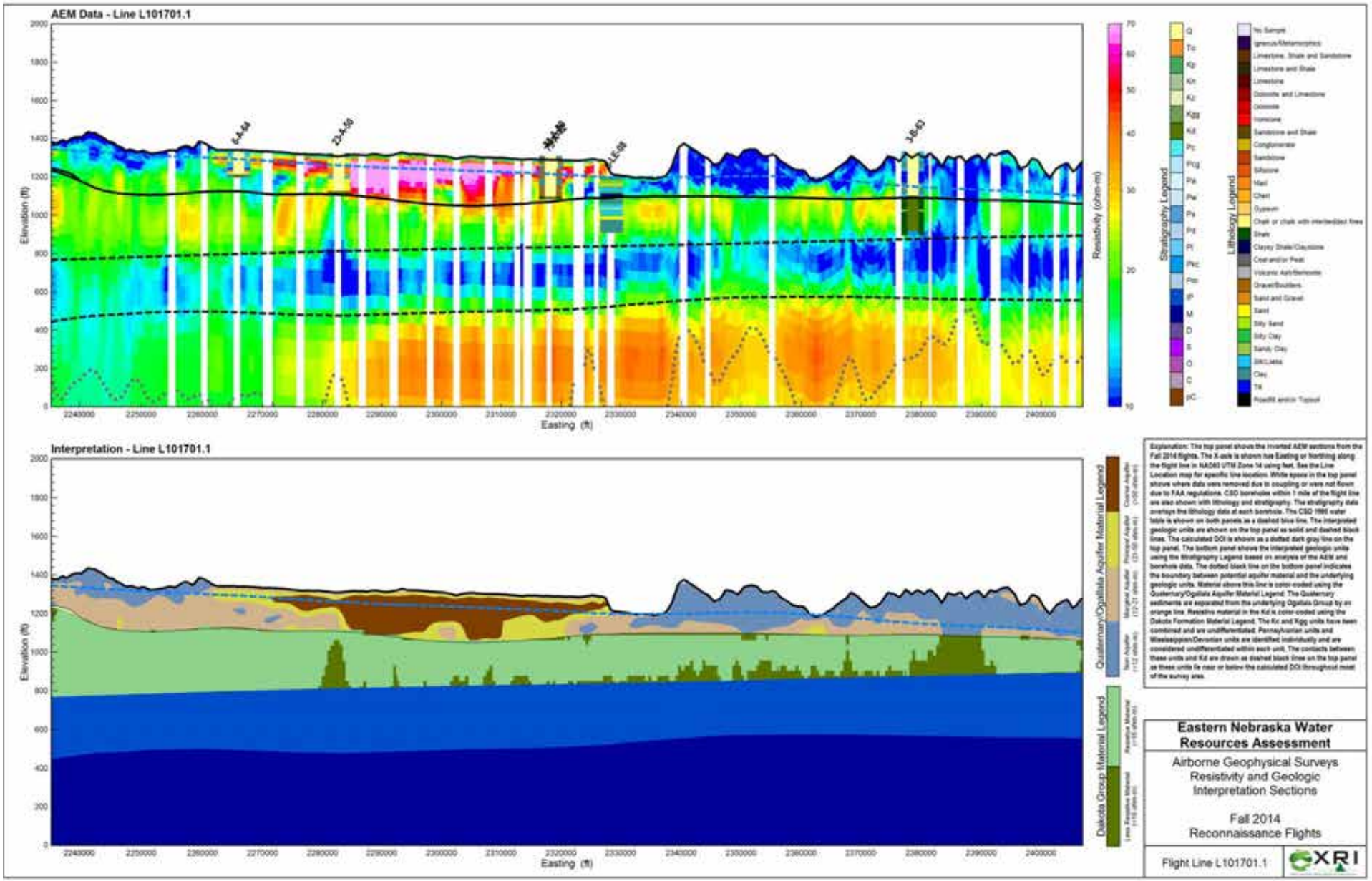


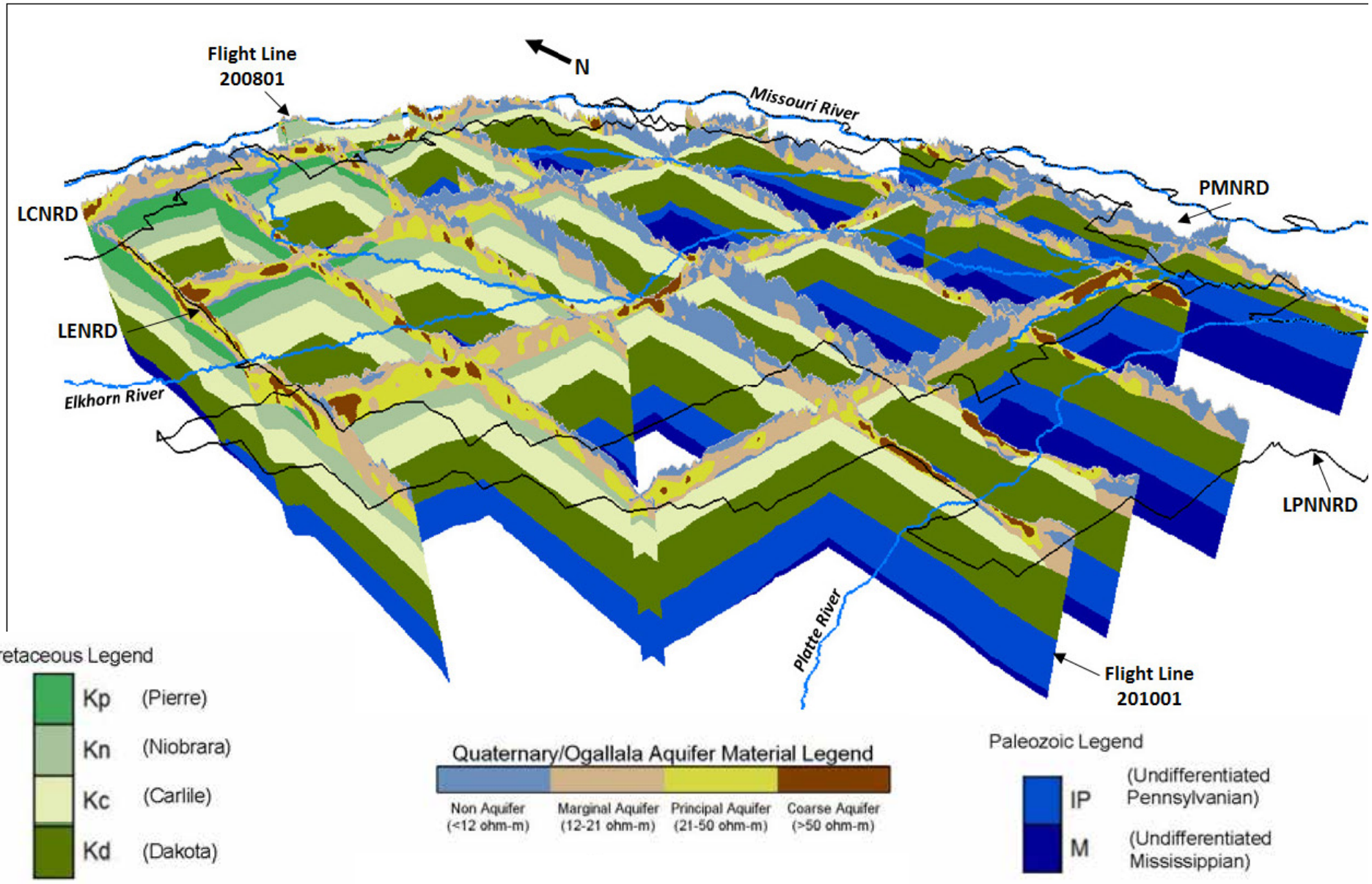




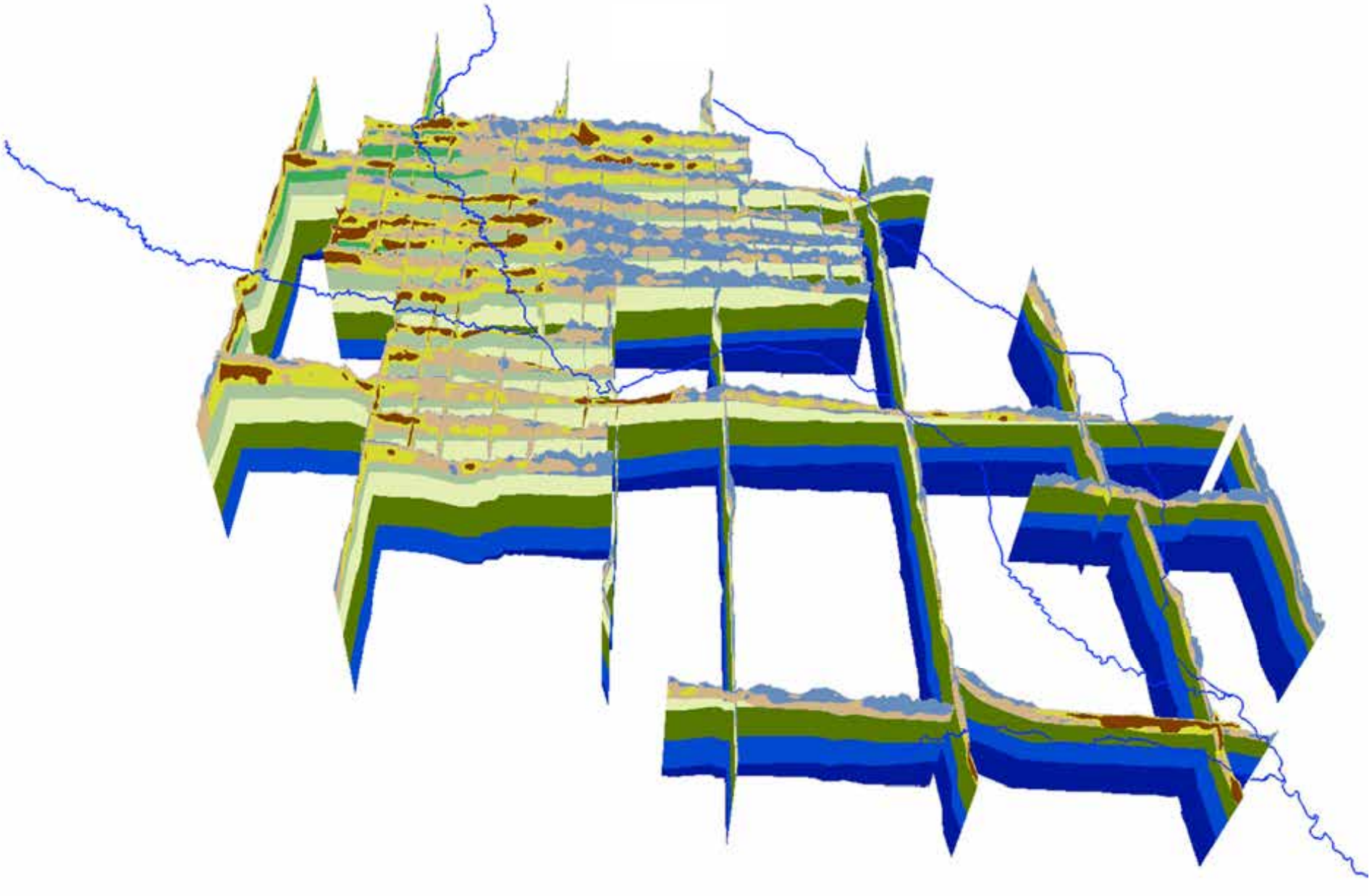


Example East-West Flight Line

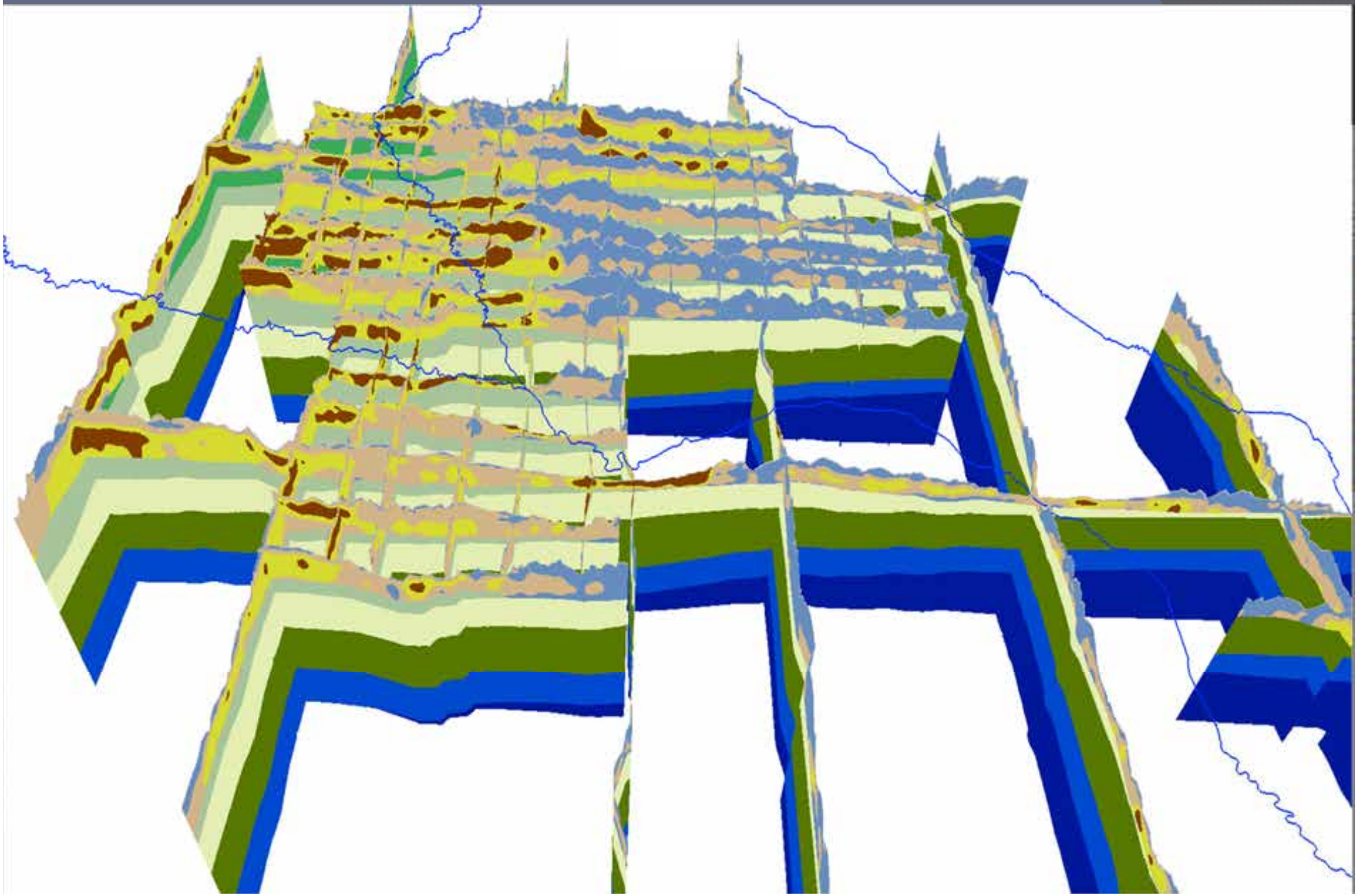



Flight Line
200801
N
Missouri River
LCNRD
PMNRD
LENRD
Elkhorn River
LPNNRD
Platte River
Flight Line
201001
Cretaceous Legend
Kp (Pierre)
Kn (Niobrara)
Kc (Carlile)
Kd (Dakota)
Quaternary/Ogallala Aquifer Material Legend
Non Aquifer (<12 ohm-m)
Marginal Aquifer (12-21 ohm-m)
Principal Aquifer (21-50 ohm-m)
Coarse Aquifer (>50 ohm-m)
Paleozoic Legend
IP (Undifferentiated Pennsylvanian)
M (Undifferentiated Mississippian)

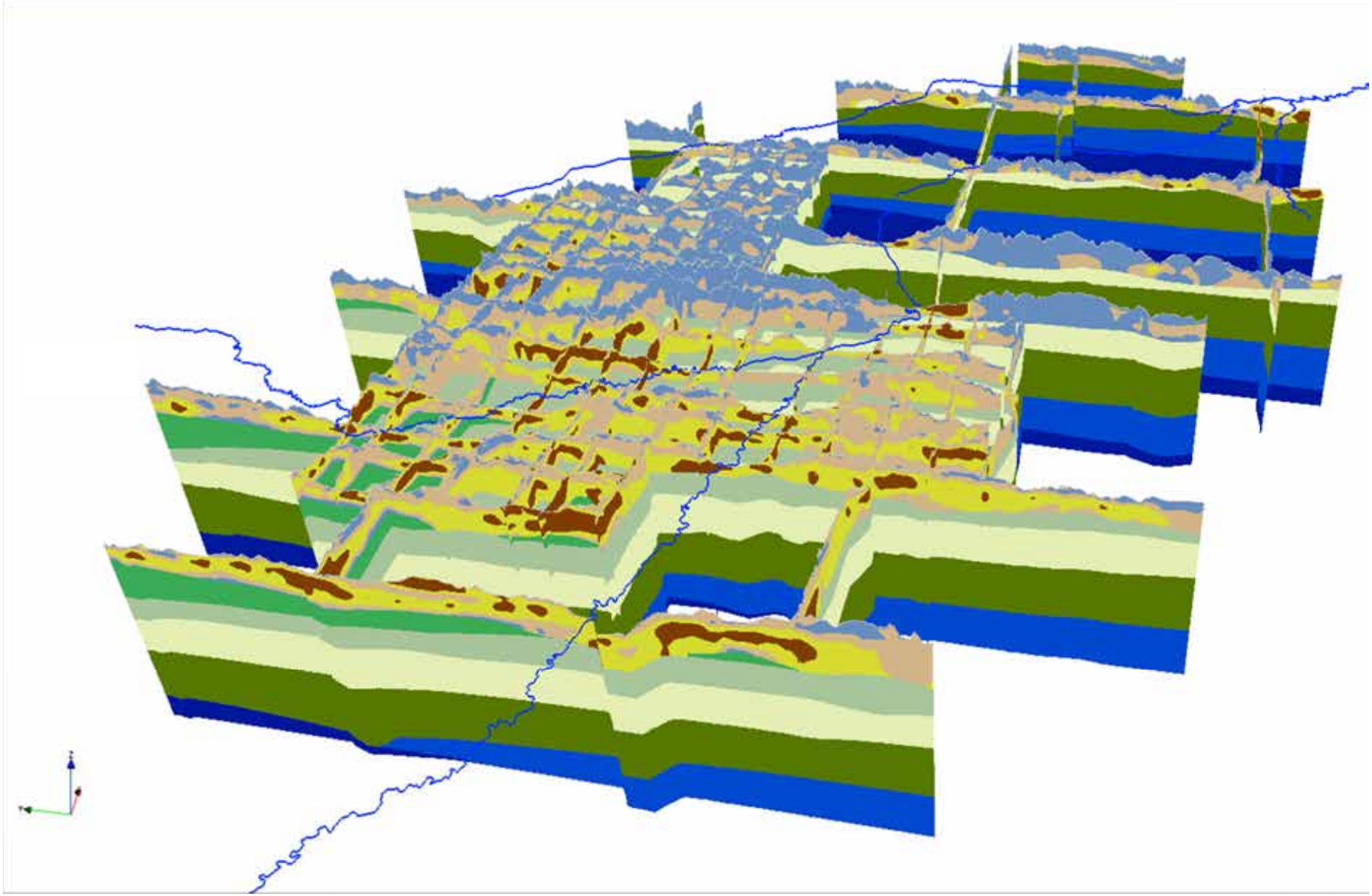
3D of the 2014 AEM in LENRD



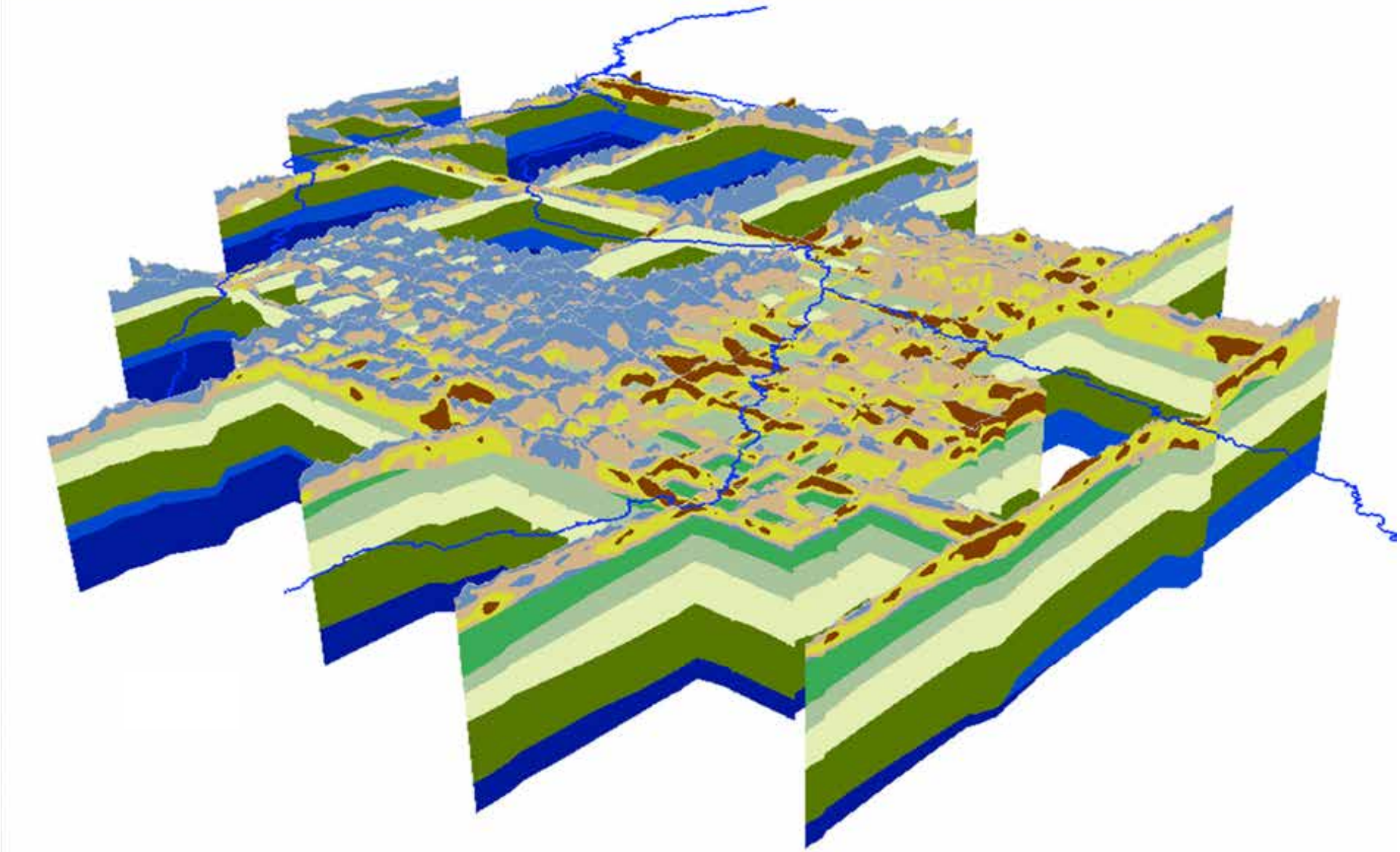
3D of the 2014 AEM in LENRD



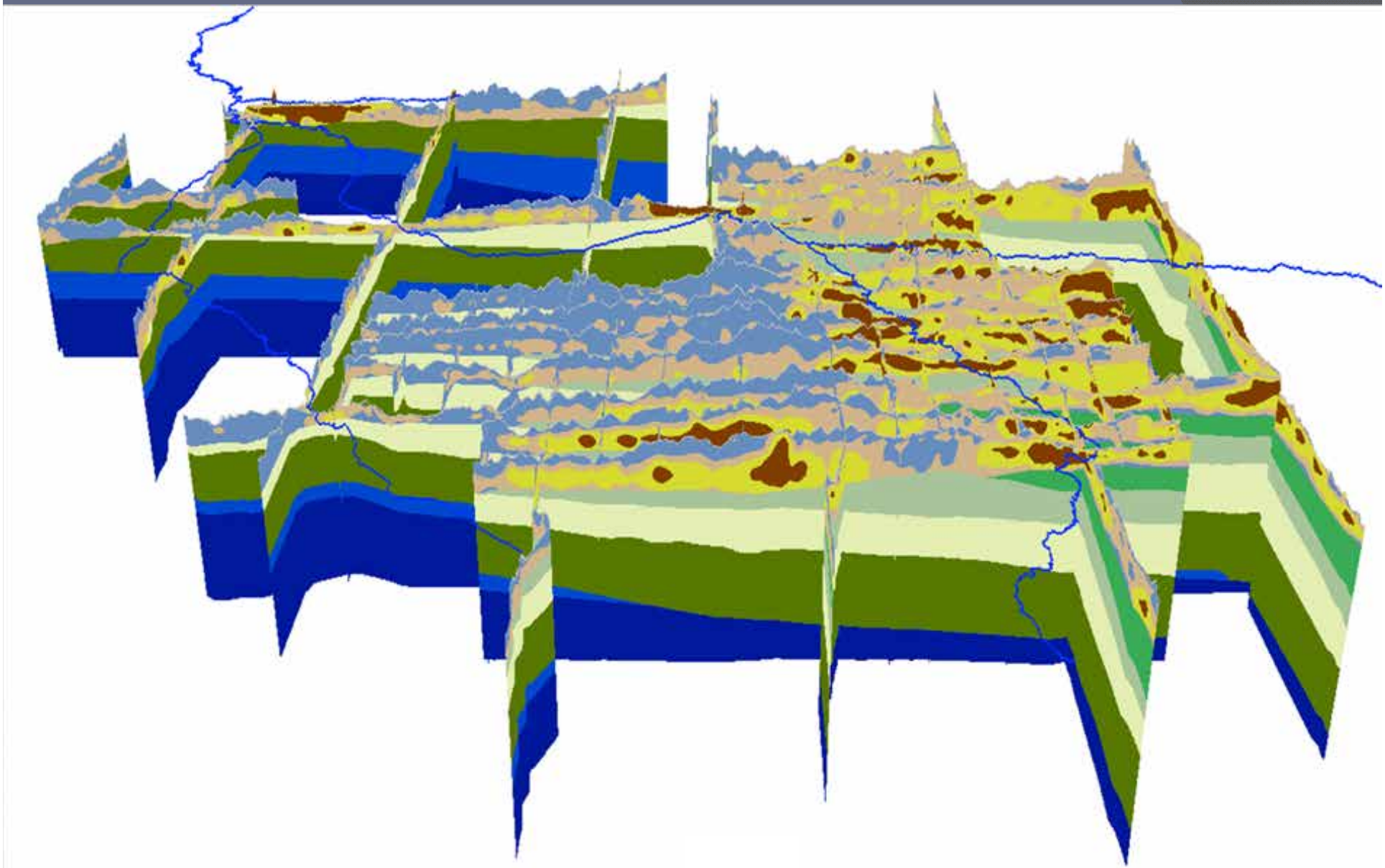
3D of the 2014 AEM in LENRD



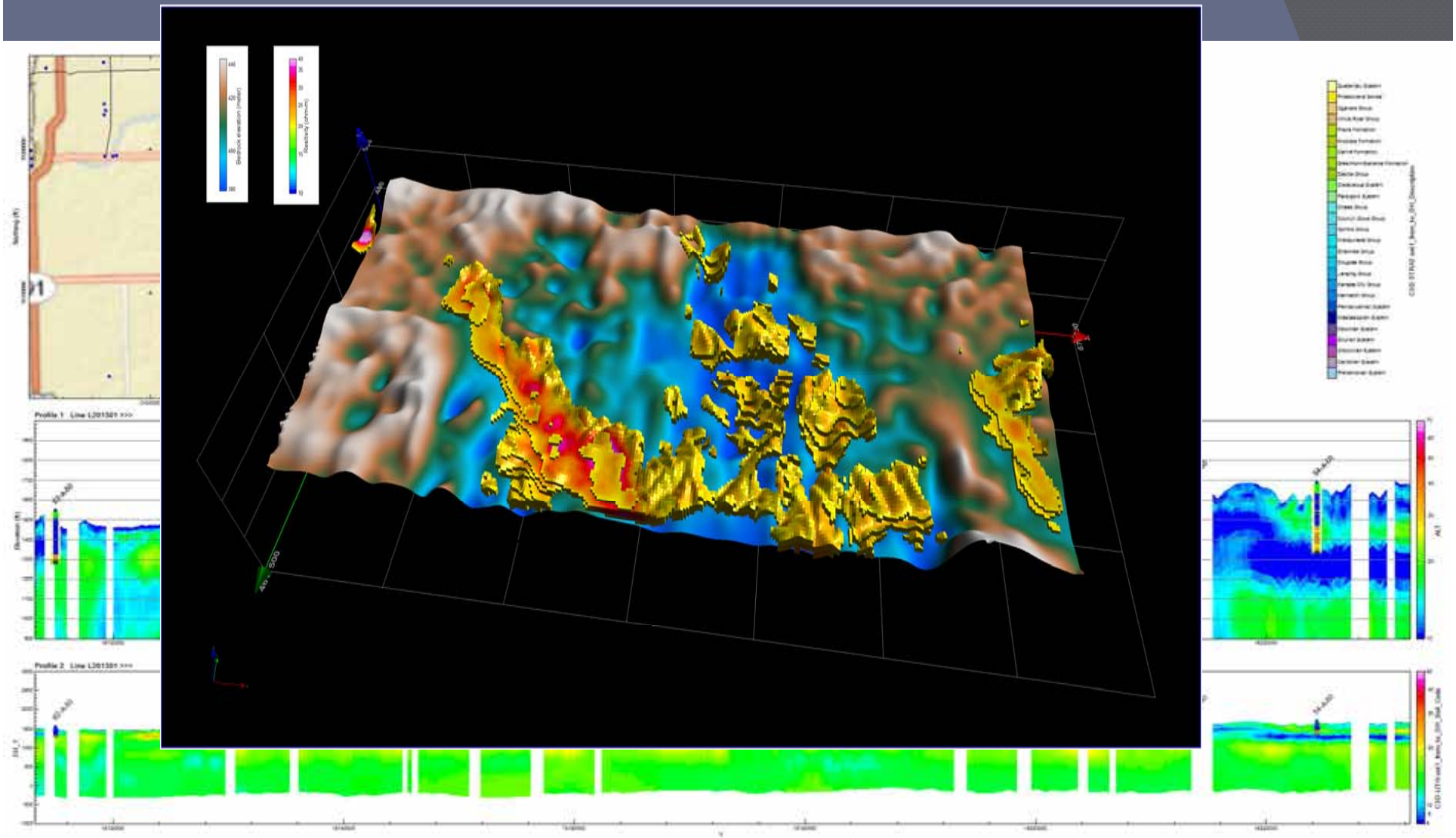
3D of the 2014 AEM in LENRD



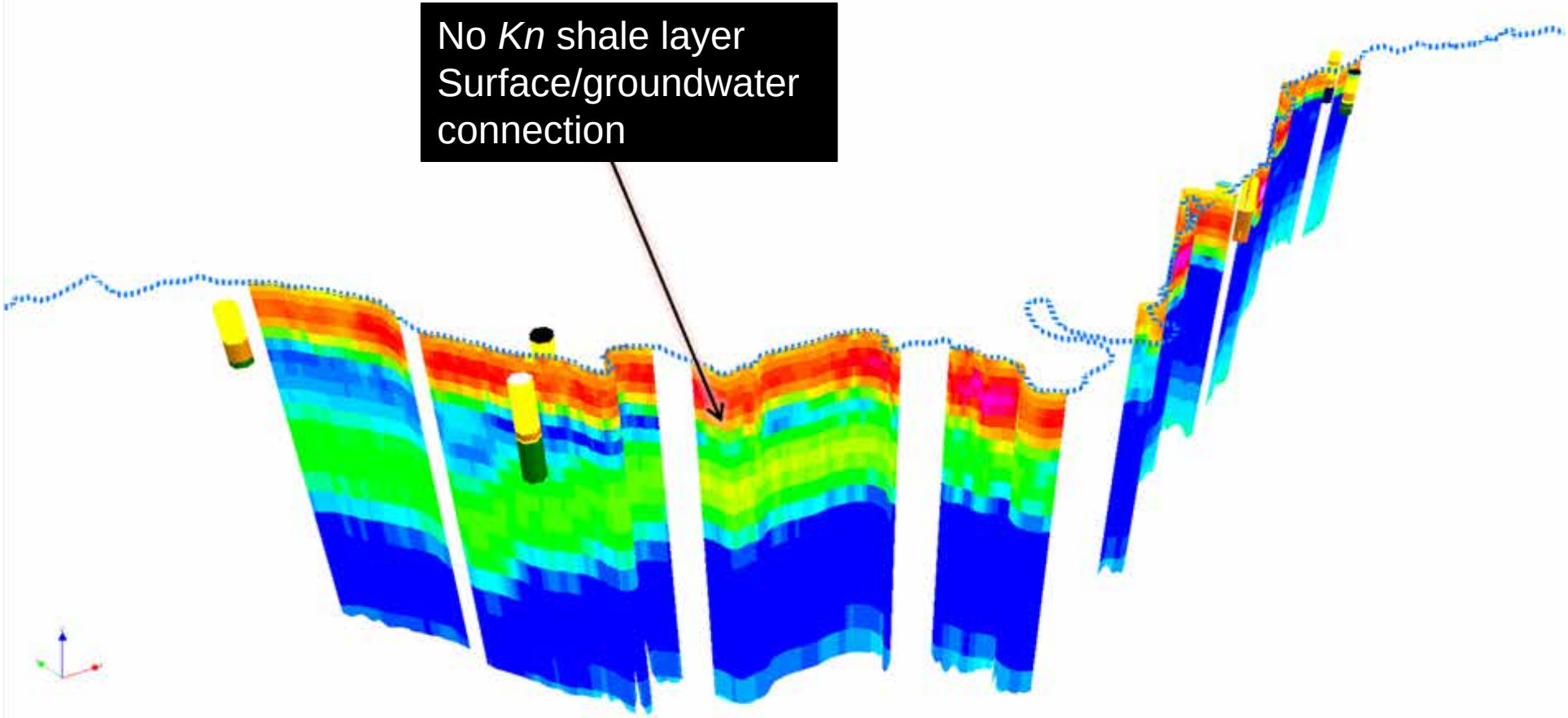
3D of the 2014 AEM in LENRD



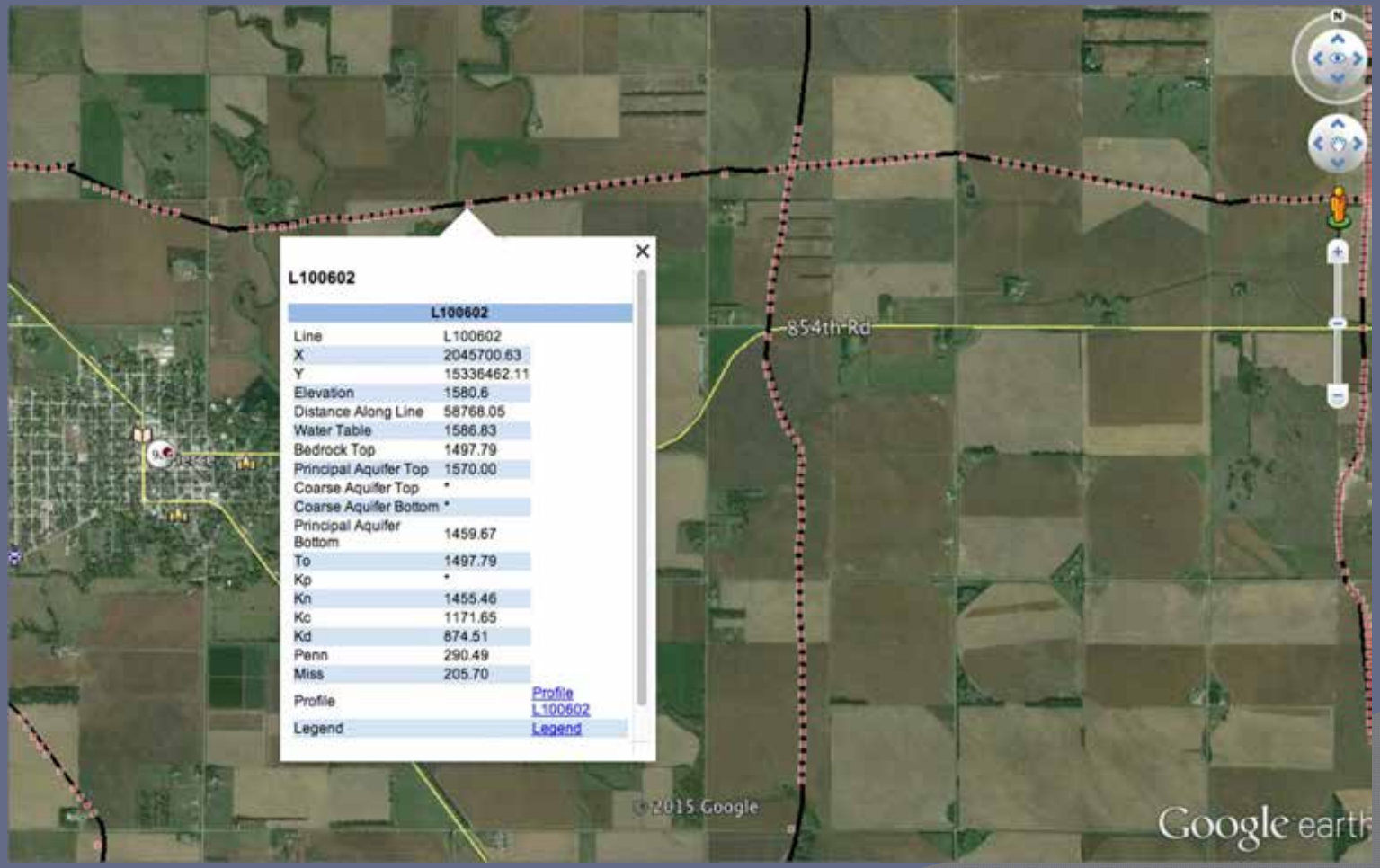
Recon Lines versus Block Flight (Clarkson Example)

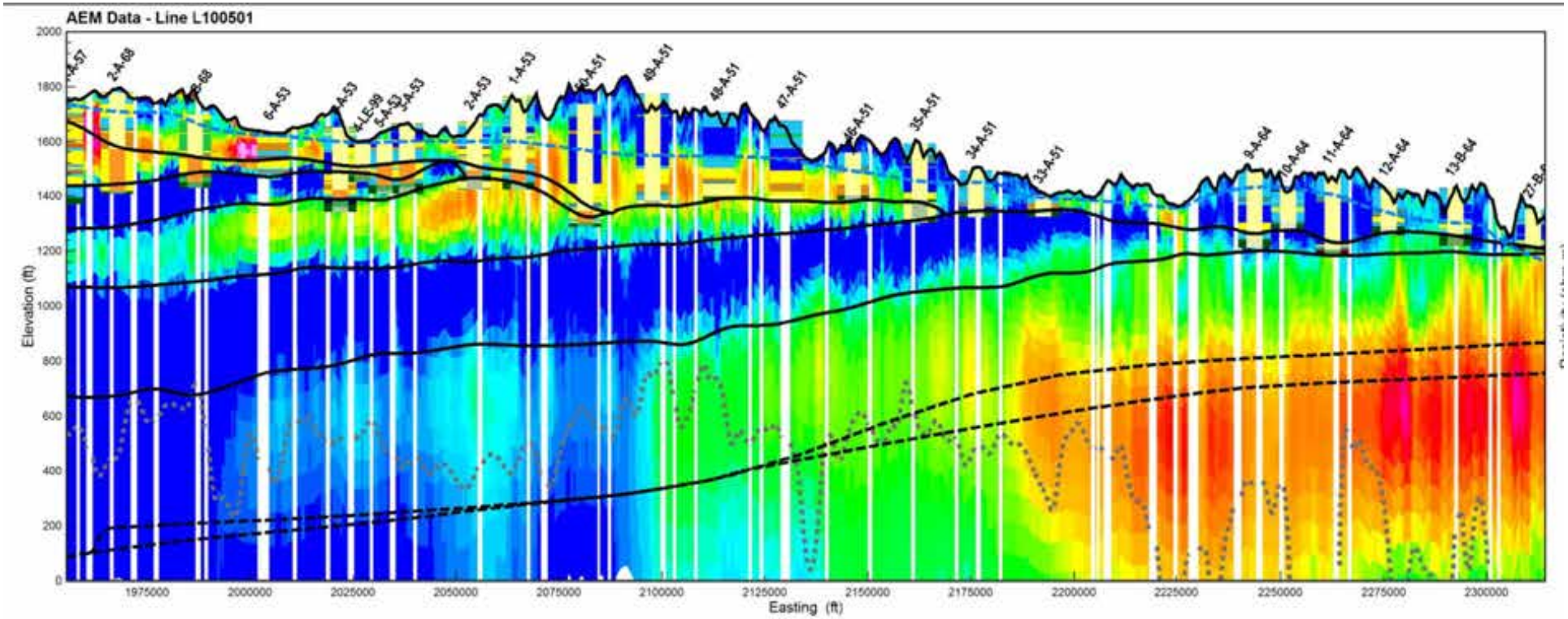


301 System – More Shallow Detail



KMZ File Example




AEM Data - Line L100501
Elevation (ft)
Easting (ft)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1975000
2000000
2025000
2050000
2075000
2100000
2125000
2150000
2175000
2200000
2225000
2250000
2275000
2300000
2-A-68
6-A-53
7-A-53
4-LE-99
5-A-53
3-A-53
2-A-53
1-A-53
50-A-51
49-A-51
48-A-51
47-A-51
46-A-51
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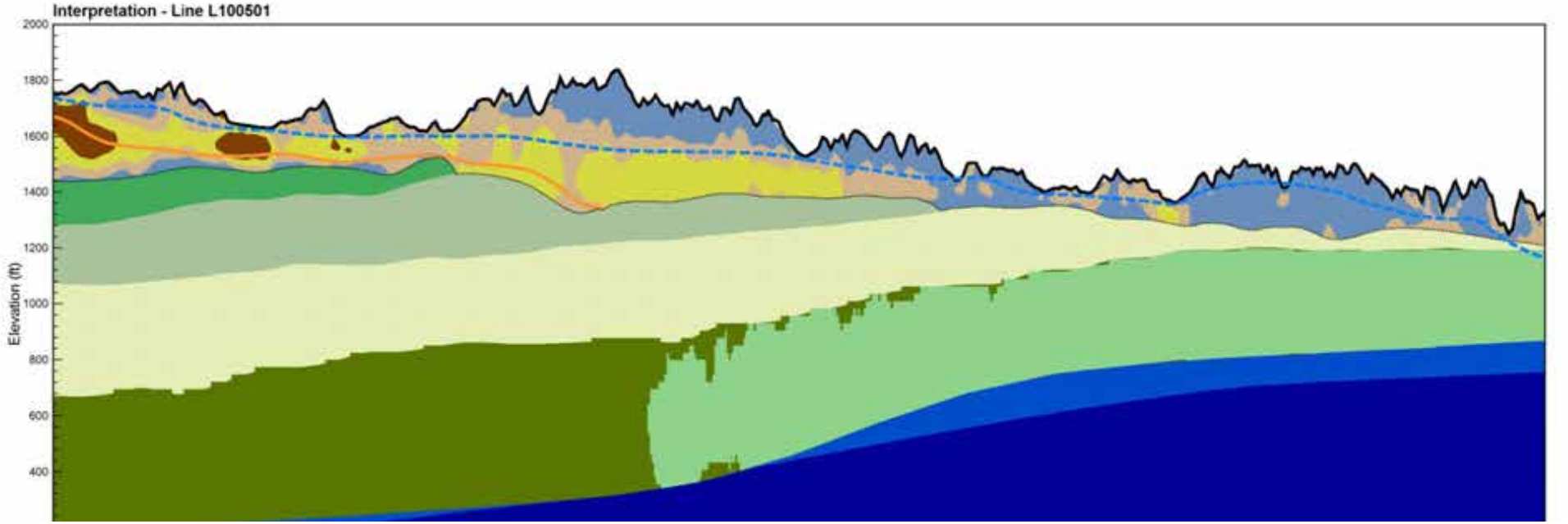
10-A-64
11-A-64
12-A-64
13-B-64


Interpretation - Line L100501
Elevation (ft)
2000
1800
1600
1400
1200
1000
800
600
400

Preliminary Observations

- Flight line planning is critical
- 508 can detect formations to 1,500 ft depth
- 24 hour QA/QC Inversions
- CSD data is critical
- Historical geophysical logs verify resistivity values
- 2007 and 2013 HEM and AEM are equivalent with the exception of depth of investigation

Final Products

- Report
  - LENRD report for 3X3 mile grids is out on web
  - ENWRA Final Report due July 30th 2015 (Spring 2015 flights done today)
- KMZ and GIS data files
- Interpretations of the identified Quaternary and Tertiary deposits:
  - non-aquifer, marginal aquifer, principal aquifer, and coarse materials
- Bedrock units identified:
  - Ogallala Group, Pierre Fm, Niobrara Fm, Carlile/Greenhorn/Graneros Fm undifferentiated, Dakota Group, and some Paleozoic
- Recommendations

Thank You