Canal Leakage Potential Using Continuous Resistivity Profiling Techniques, Western Nebraska and Eastern Wyoming

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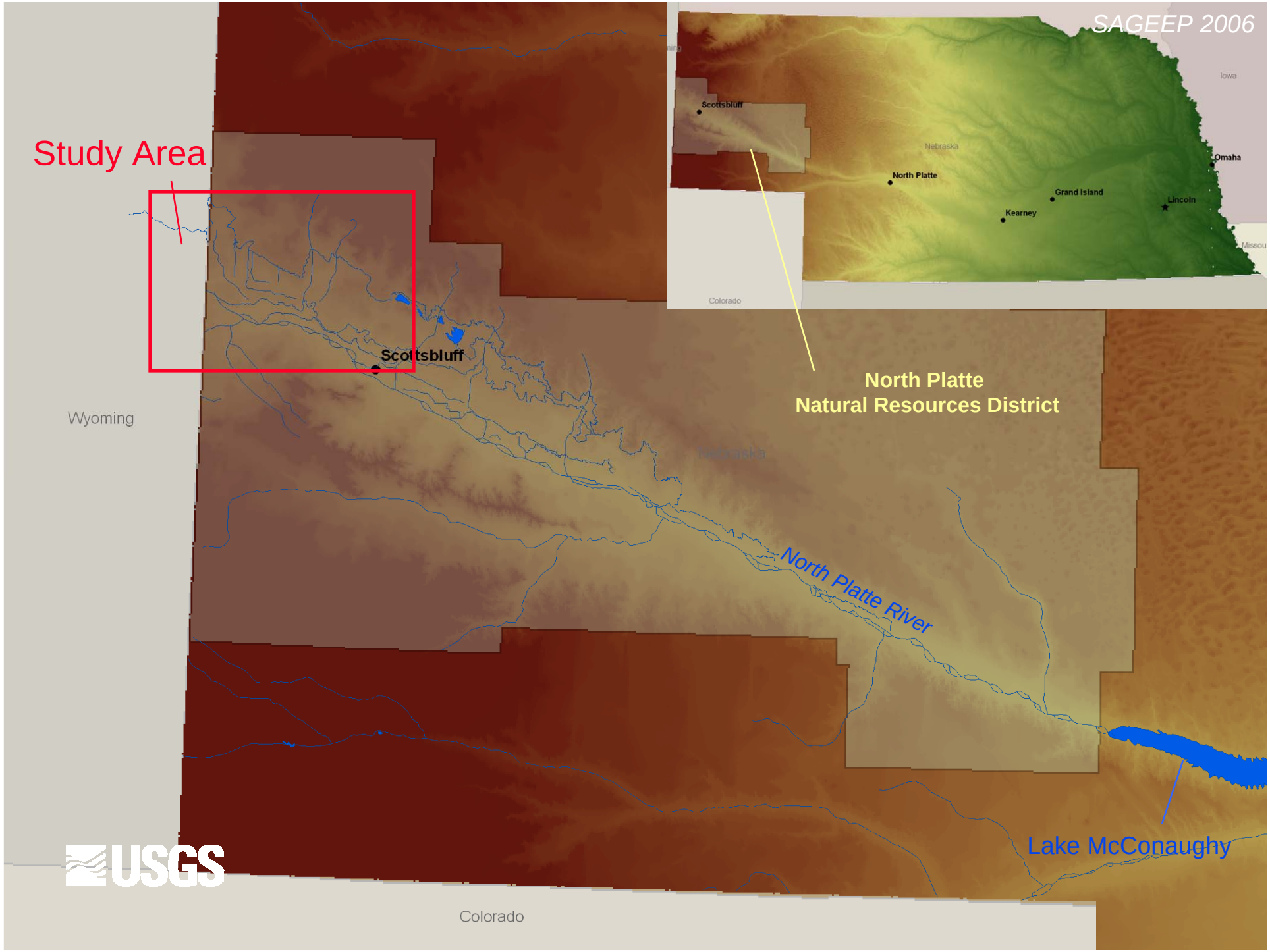
U.S. Department of the Interior
U.S. Geological Survey

1 U.S. Geological Survey
2 North Platte Natural Resources District


SAGEEP 2006
Study Area
Scottsbluff
Wyoming
Nebraska
North Platte
Natural Resources District
North Platte River
Lake McConaughy
Colorado
Iowa
Omaha
Lincoln
Grand Island
Kearney
North Platte
USGS

North Platte River Basin
Water use

- Legislative Bill 962: water-use designation
  - Fully appropriated basin-wide
  - Over-appropriated river valley and some uplands
    - Estimated water use > estimated water supply
    - Moratorium on new water-resource development
    - No expansion of irrigated acres

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North Platte River Basin
Water use

- Integrated Management Plan (IMP)

- Restoring over-appropriated areas to fully appropriated status
- Numeric ground-water flow model
  - More accurate assessment of stream depletion
  - Watershed management tool

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North Platte River Basin
Ground-water recharge

- Irrigation canal leakage is a major source of ground-water recharge
  - Sediments of varying permeability underlie the canals
  - Geology controls the spatial distribution of canal leakage

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Understanding recharge

- Ground-water model inputs of leakage
  - Based on the water balance of canal inflows and outflows
  - Existing test hole data were insufficient to spatially distribute leakage
- Additional lithologic information is traditionally provided through drilling
  - Time-consuming and expensive
  - Discrete point data
- Study approach
  - Use resistivity profiling in combination with a more strategic drilling plan

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Mapping canal leakage

- Phase I and II
  - Continuous resistivity profiling (CRP)
    - Land-based capacitively coupled (CC)
    - Water-borne direct-current (DC)
- Phase III
  - Continuous core sampling
- Objectives
  - Determine spatial variability of grain-size distribution using resistivity contrasts
  - Assess effectiveness of both CC and DC techniques

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Phase I:
Land-based resistivity
OhmMapper TR-5

Phase II:
Water-borne resistivity
Syscal Pro

Phase III:
Ground-truthing
Geoprobe

Resistivity data processing

- Two-dimensional (2-D) inversion
  - Finite Element
  - RES2DINV version 3.54w (Geotomo software)
- Georeferenced
- Compiled 2-D georeferenced inverted profiles into three-dimensional (3-D) databases

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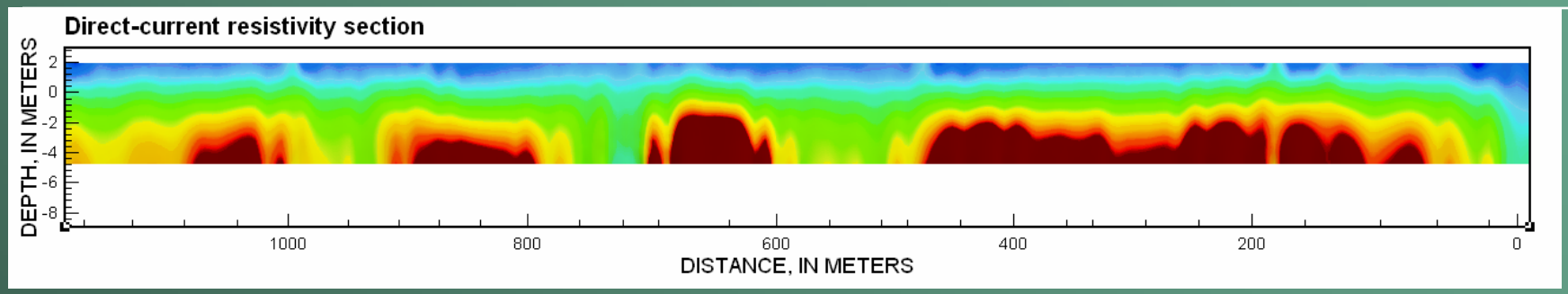
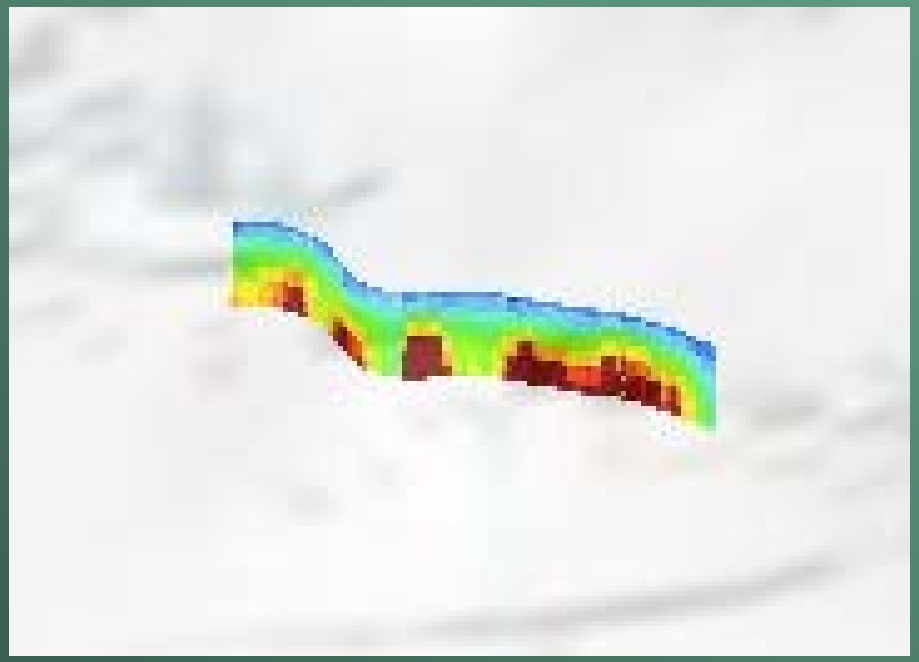
Georeferencing



2-D coordinate system:
based on distance

3-D coordinate system:
Based on geographic location



Integration of results:
Phase I, II, III

- Compare CC and DC resistivity techniques
- Compare overall results of resistivity survey to lithologic information
- Create a basic interpretation of leakage potential

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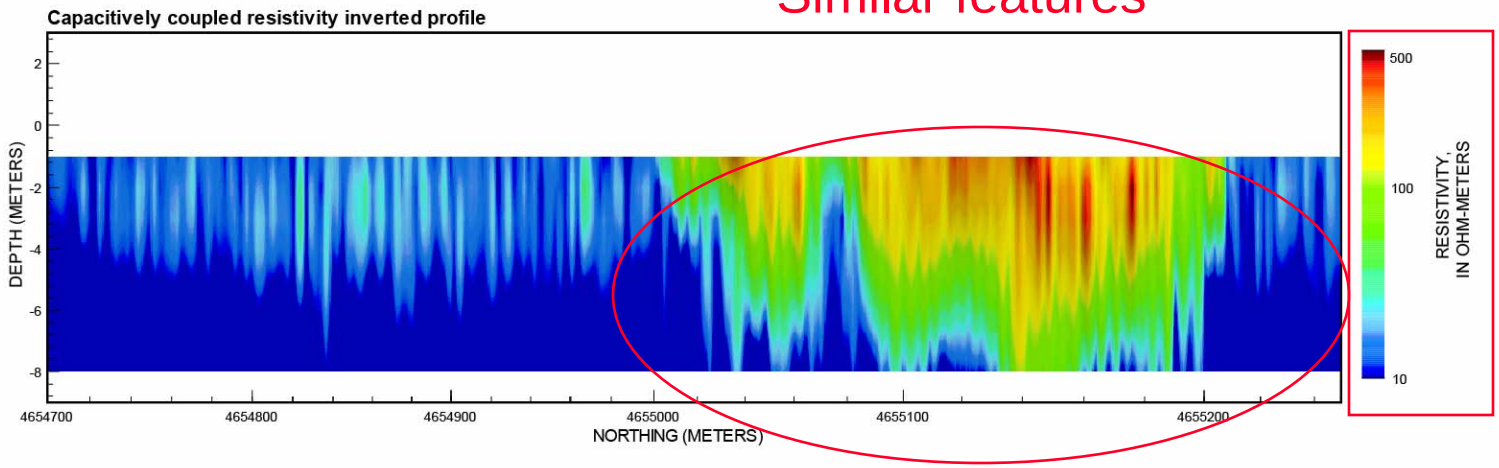
Analysis:
CC/DC comparison

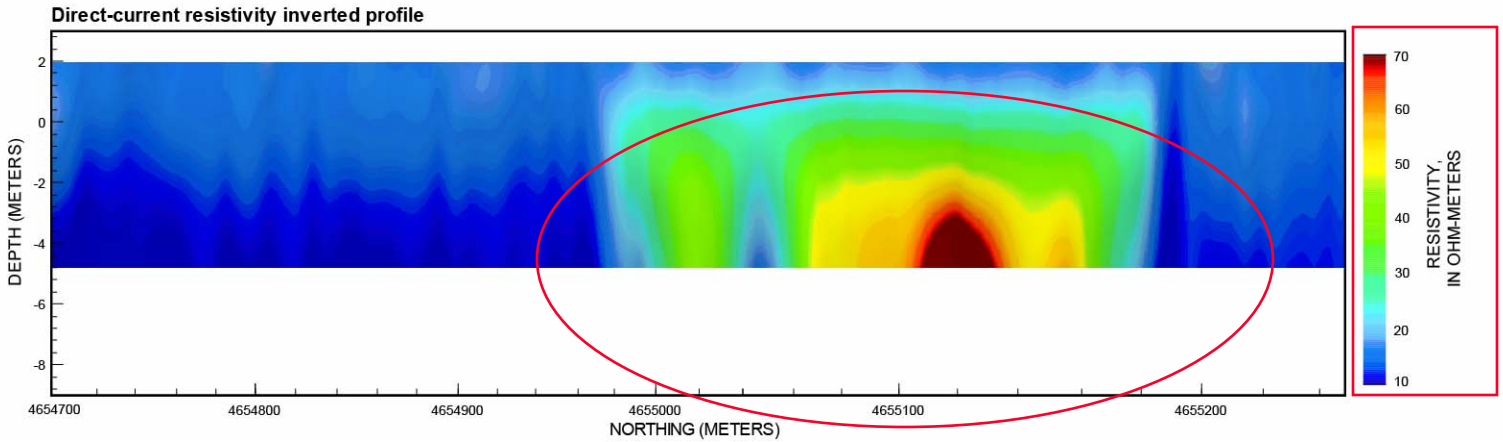
Differing range in resistivity values

Similar features

Land-based

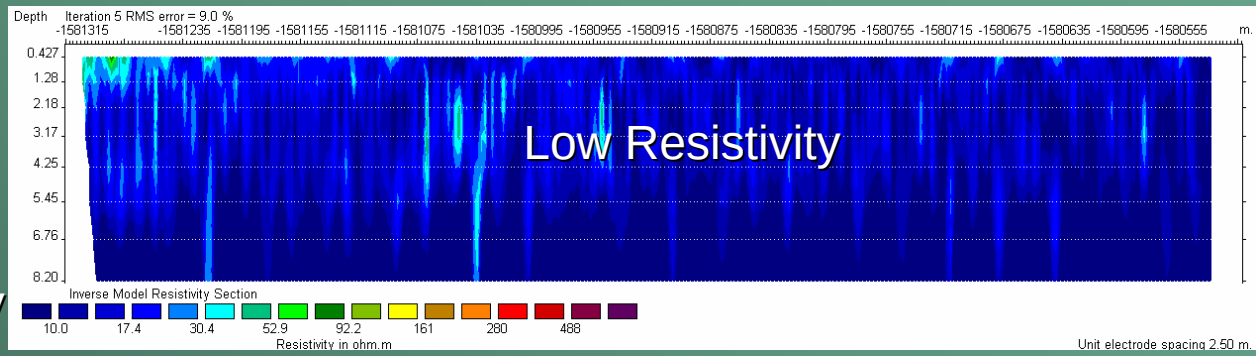


Water-borne

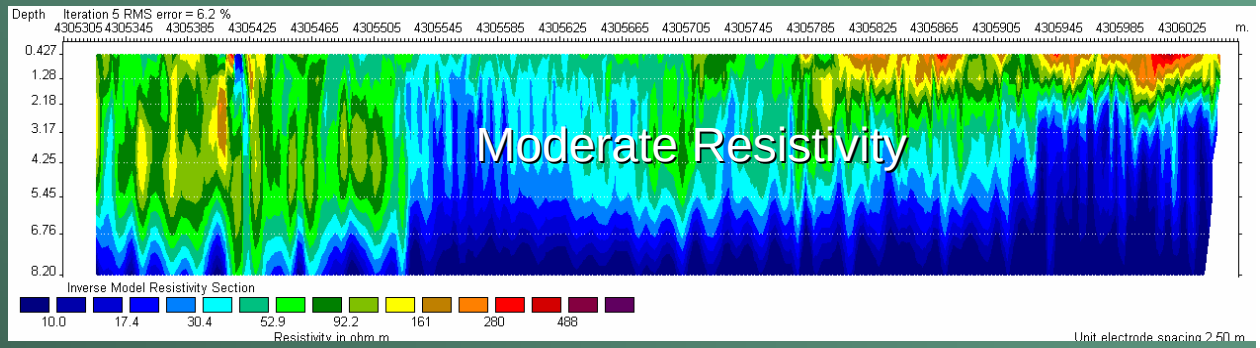


Analysis: Lithology/resistivity comparison

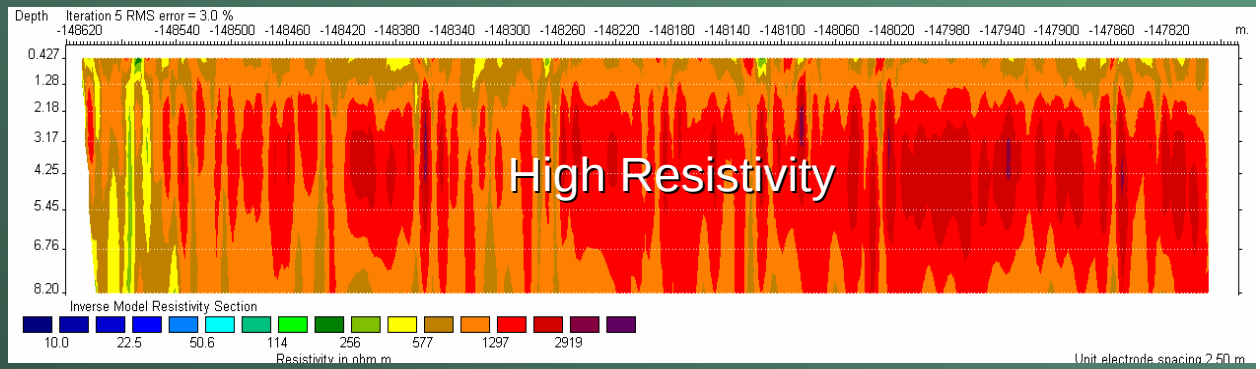
Brule Formation/silt and clay



Well-sorted fine sand/silt



Poorly sorted sand/gravel



Analysis:
Interpretation

- Individual sections
  - Not readily accessible
  - Requires additional interpretation for ground-water modelers and water-resource managers
- Difficult to communicate results for 110-km study area
- Consistent interpretation needed

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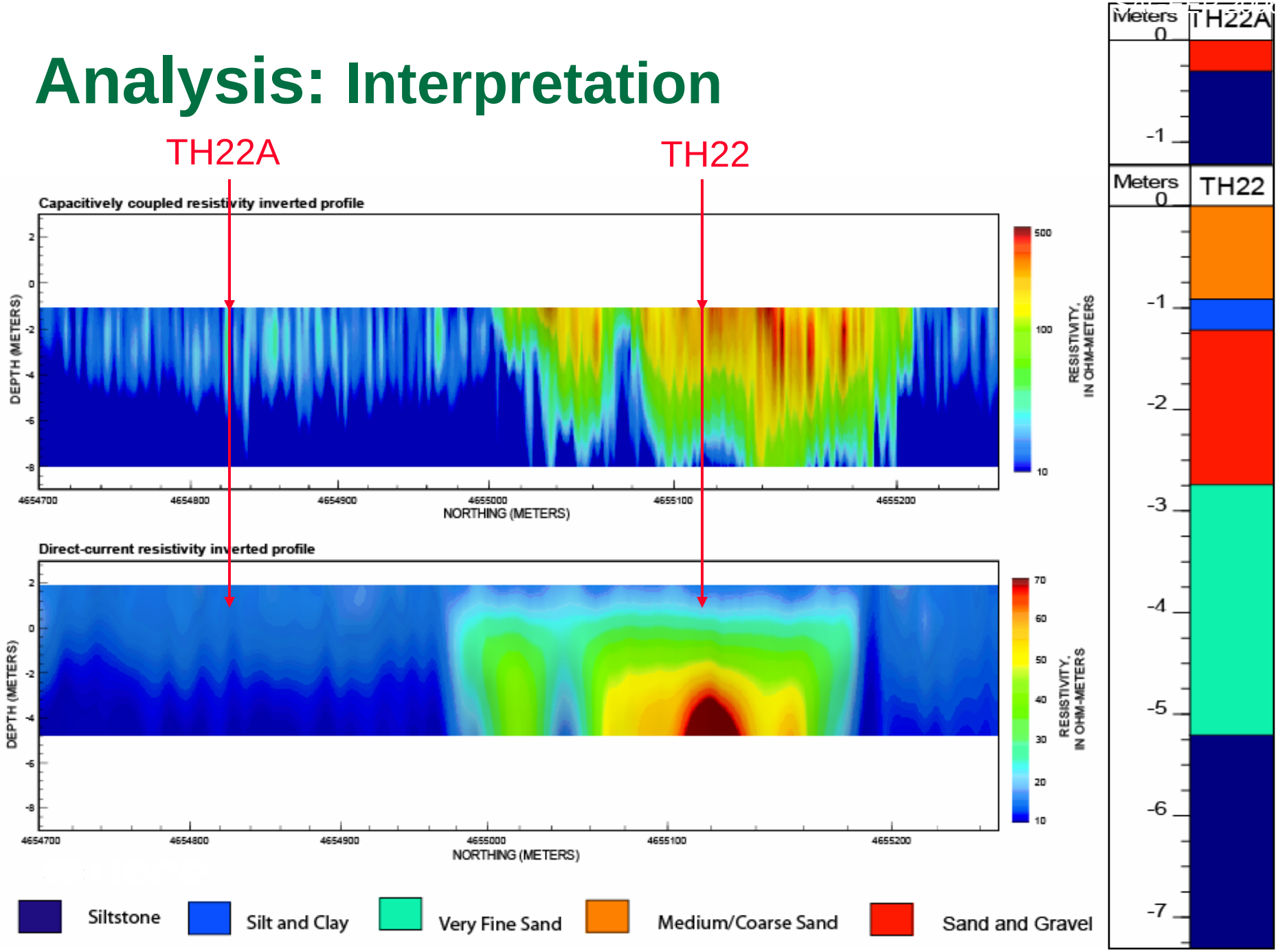
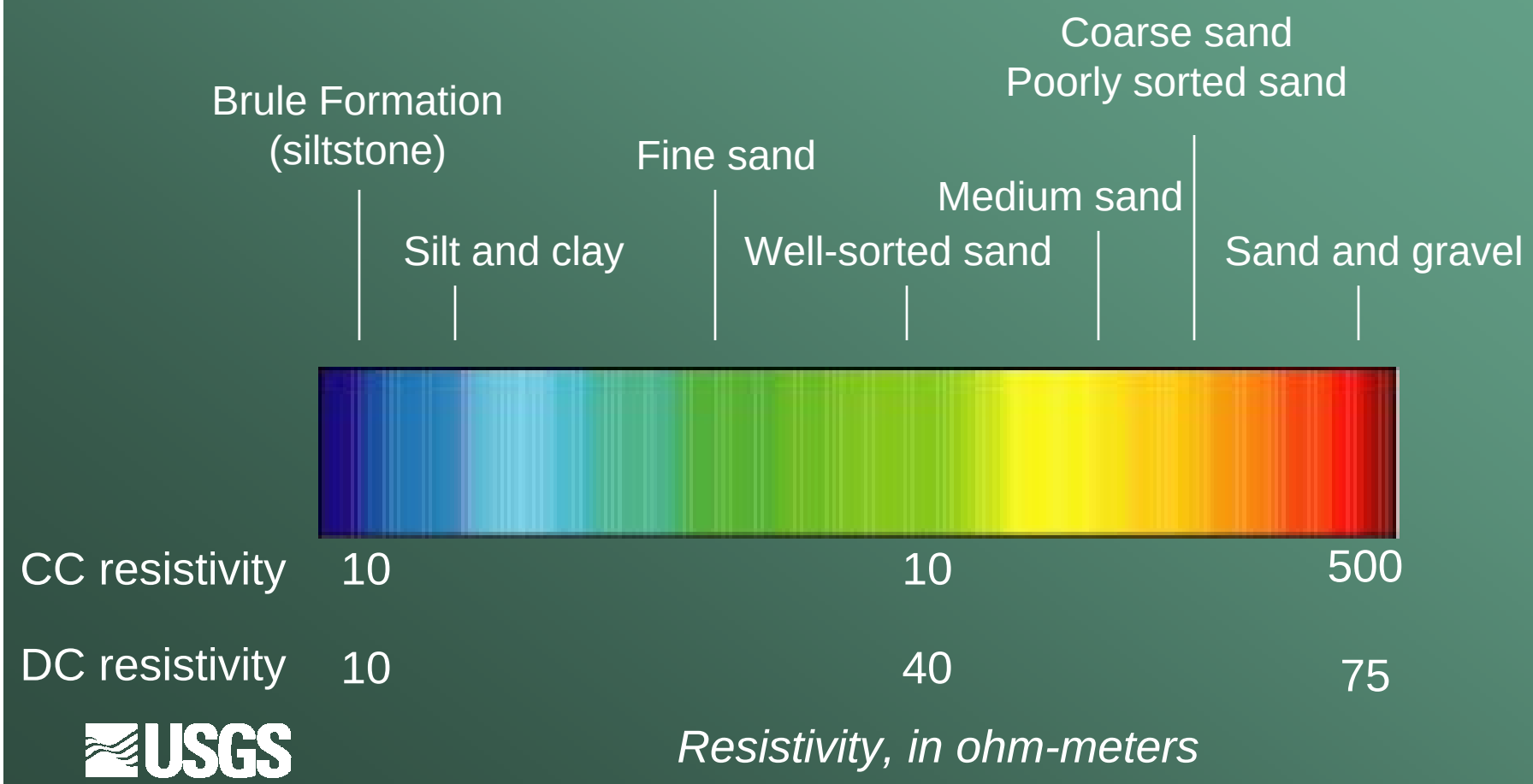
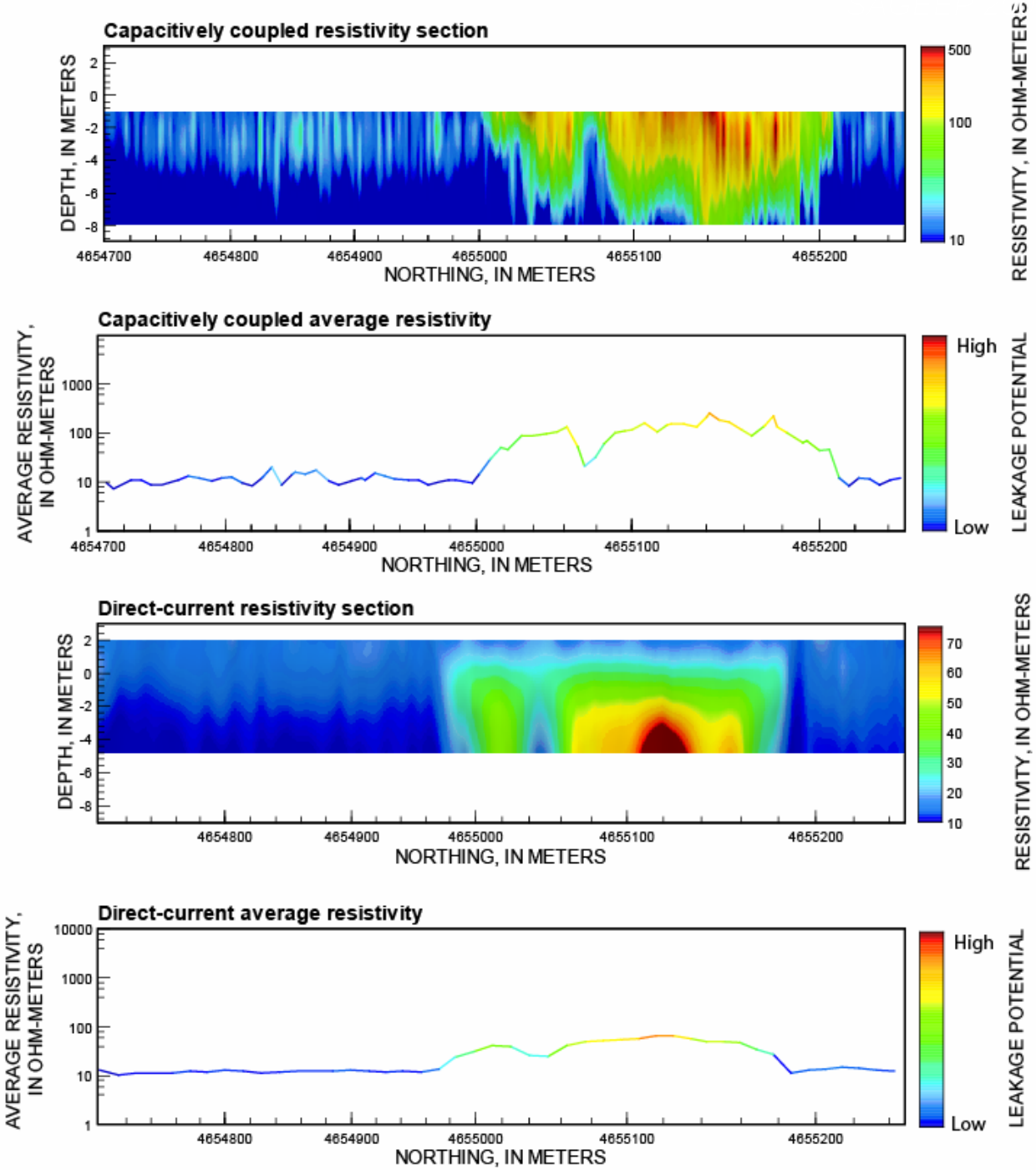
Analysis: Interpretation



Analysis:
Lithology/resistivity comparison



Analysis: Interpretation



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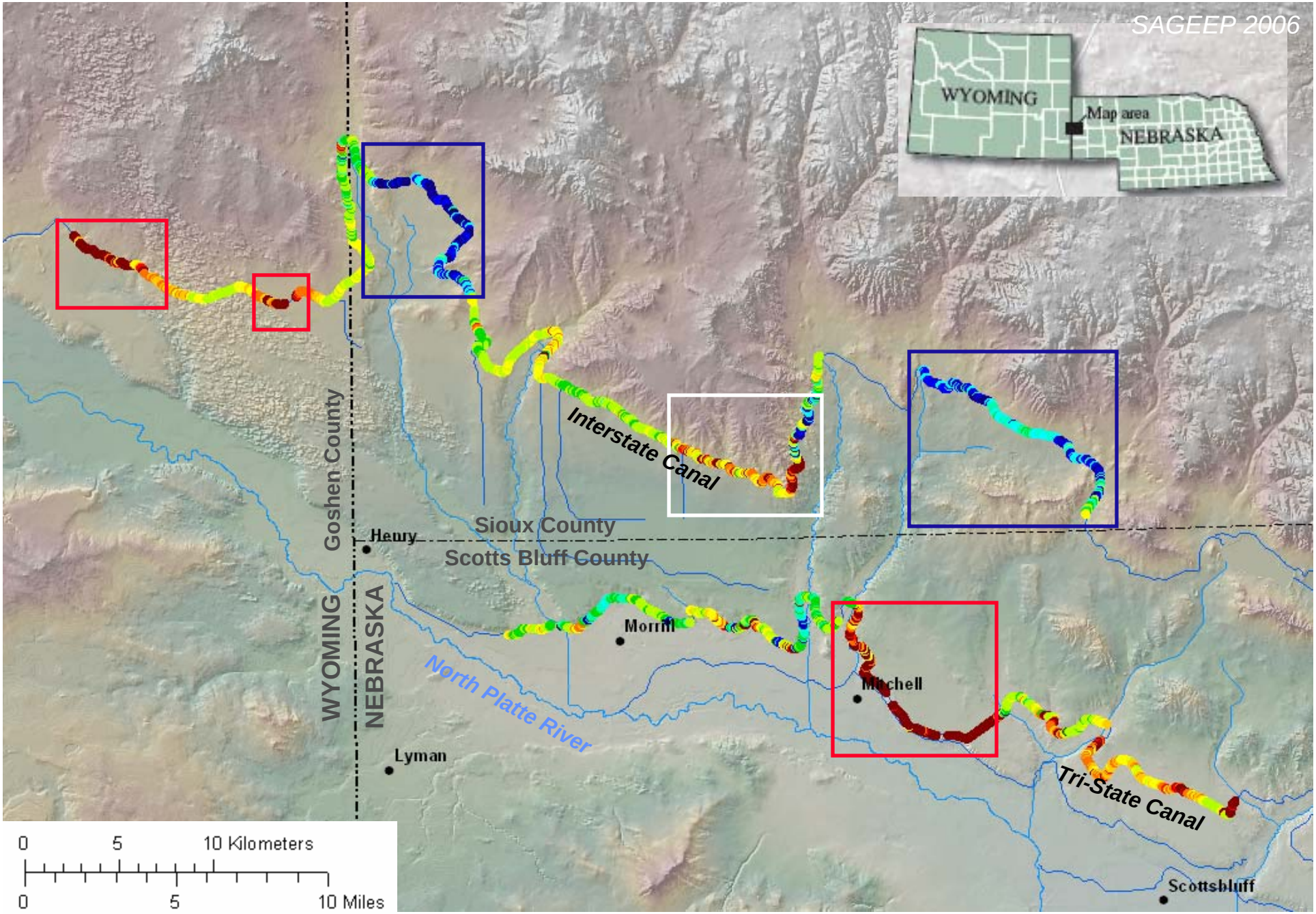

Relative canal leakage potential

Low — Moderate — High

Conclusions

- Resistivity techniques were successful in detecting changes in grain size along Interstate and Tri-State Canals
- Both CC and DC resistivity techniques were capable of mapping coarse-grained and fine-grained sediments
- Canal leakage can be more accurately simulated in ground-water models
- Improved understanding of hydrogeology
  - Areas of maximum ground-water recharge

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Acknowledgements

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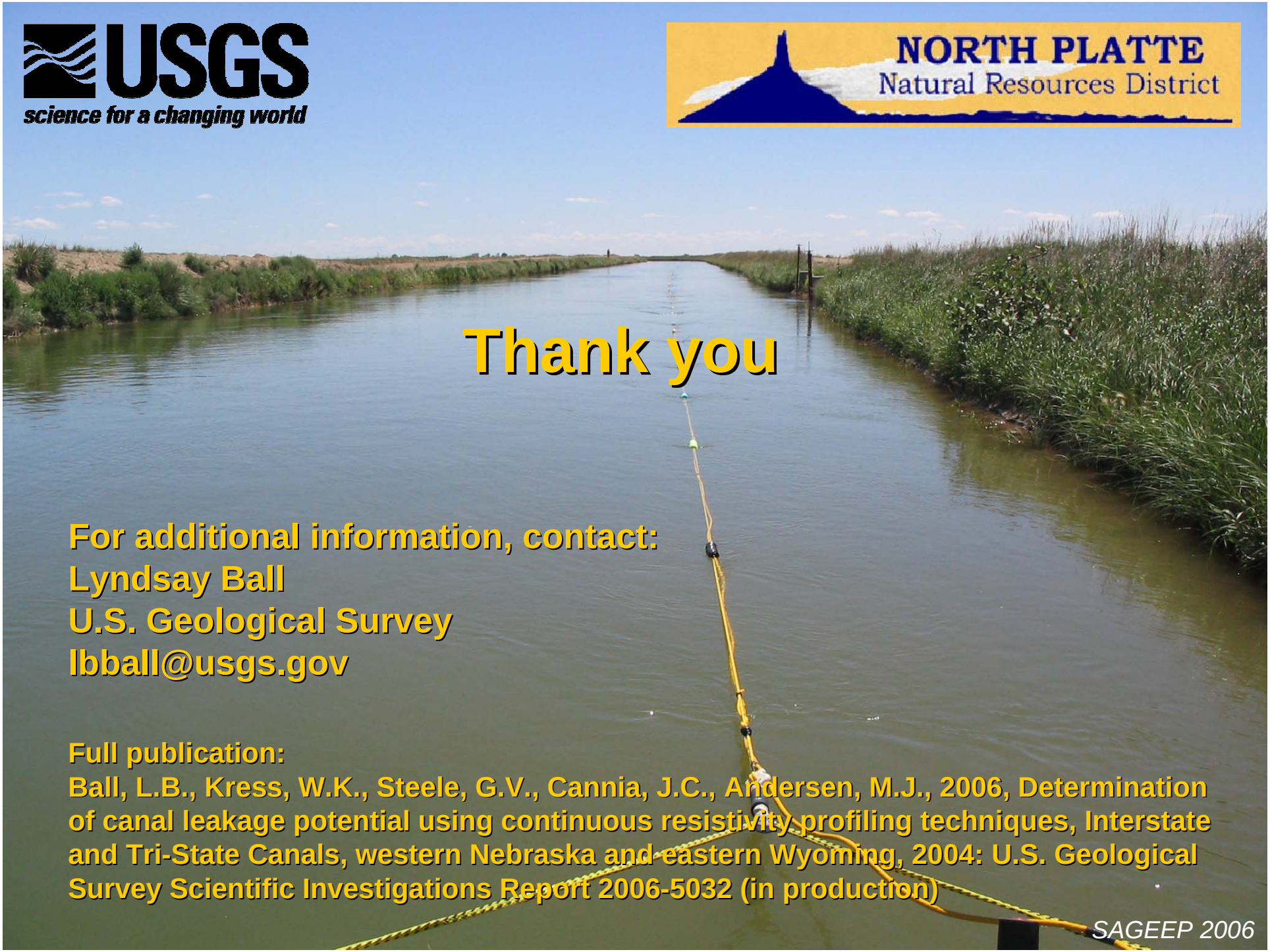

Thank you

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Full publication:
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