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science for a changing world

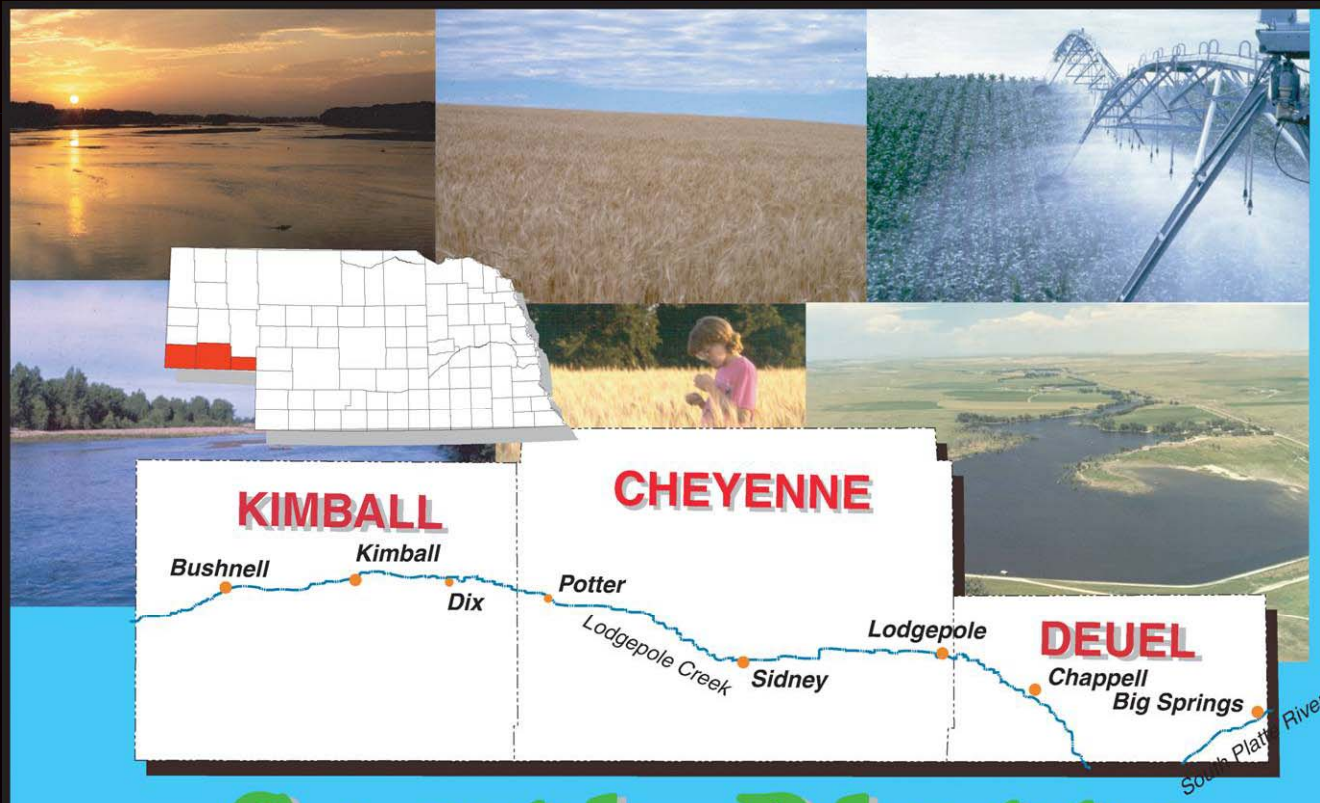
Benefits of Airborne Geophysical Surveys to Water Resources Managers in Nebraska

Minnesota Ground Water Association
May 4, 2011

by
James C. Cannia, P.G.
U.S. Geological Survey
Nebraska Water Science Center

Rod L. Horn, General Manager
South Platte Natural Resources District

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



South Platte
Natural Resources District

Our Mission:

Formulate and instigate forward-looking plans and programs through a cooperative process that will provide for the long-term protection and enhancement of the district's natural resources while ensuring that major economic and social impacts are fully considered.

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North Platte Natural Resources District

The Nebraska Environmental Trust

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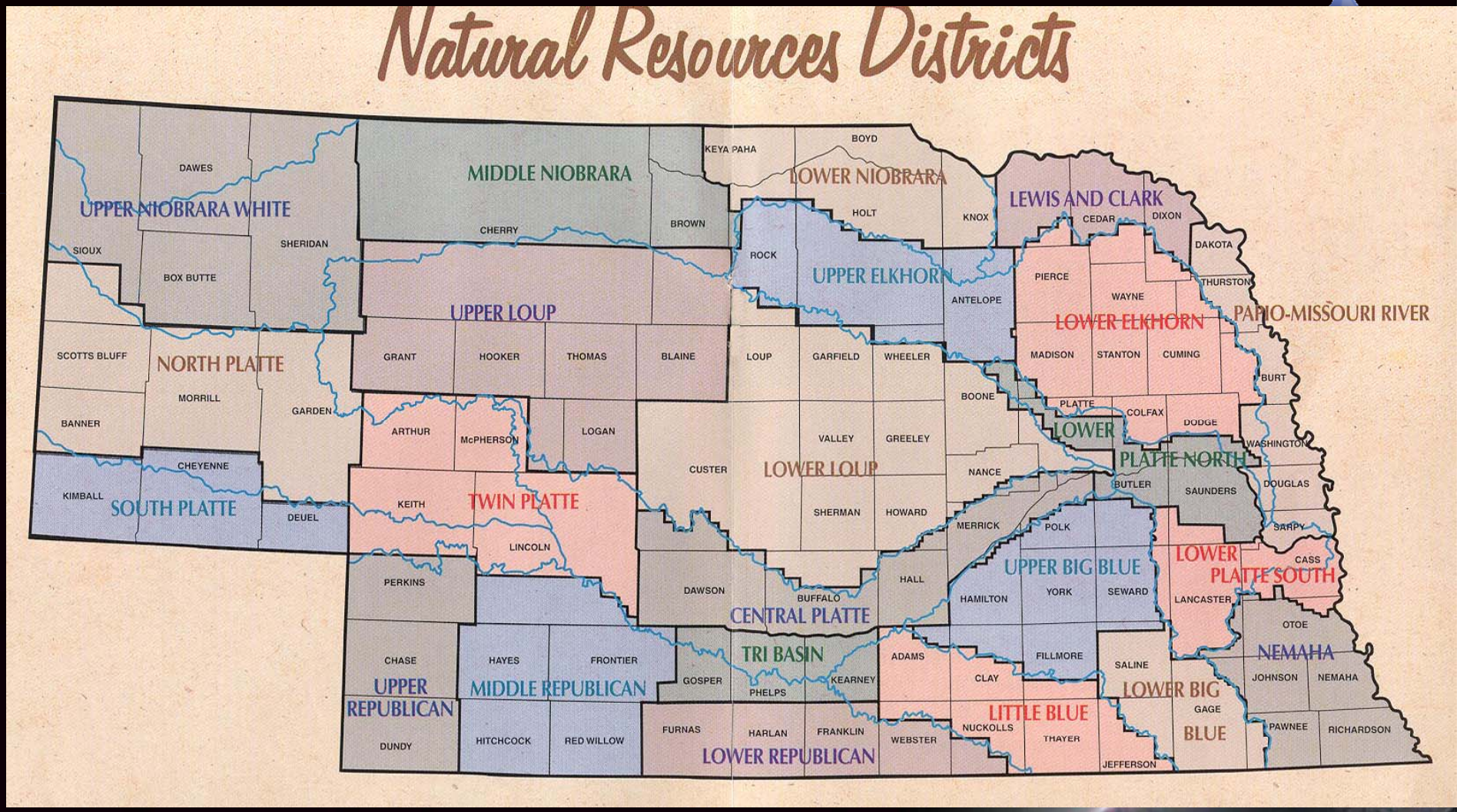
SOUTH PLATTE NATURAL RESOURCES DISTRICT

NORTH PLATTE Natural Resources District

The Nebraska Environmental Trust



Nebraska's 23 Natural Resources Districts are organized on watershed boundaries

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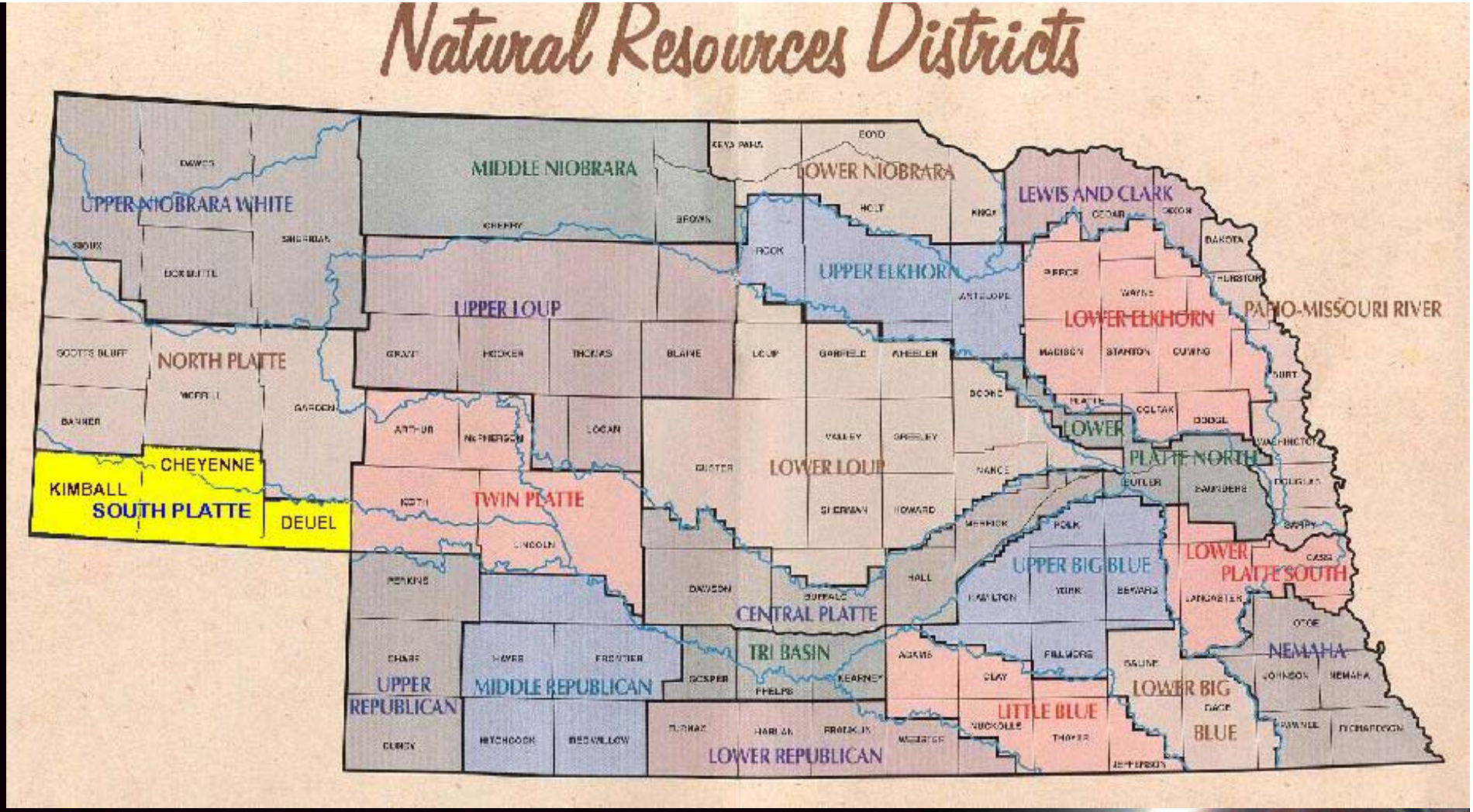

The South Platte NRD covers 1.65 million acres in Kimball, Cheyenne and Deuel counties

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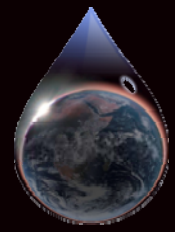
What are Natural Resources Districts?



- **NRDs are multi-purpose, local government units responsible for protecting our natural resources**
- **NRDs get funding from local property taxes, user fees and grants (SPNRD $2.6 million budget - 2.5% of all property taxes)**
  - **$100,000 home = about $48 in property taxes**
- **NRDs are governed by an elected board of directors**

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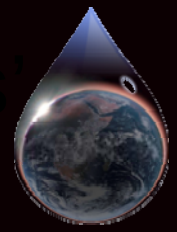
Nebraska's Natural Resources Districts' Responsibilities



- Ground and Surface Water Management
- Land Treatment
- Forestry & Range Management
- Recreation, Fish & Wildlife
- Waste Disposal & Pollution Control
- Drainage Improvement & Channel Rectification

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Nebraska's Natural Resources Districts' Responsibilities

- Ground and Surface Water Management
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Ground Water Management:
What's going on today?

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Nebraska Ground Water Management and Protection Act

- NRD's have been given the responsibility by the Legislature, through the Nebraska Ground Water Management and Protection Act, to monitor and respond to concerns regarding :
  - Ground Water Quality,
  - Ground Water Quantity,
  - Hydrologically connected Ground and Surface Water.

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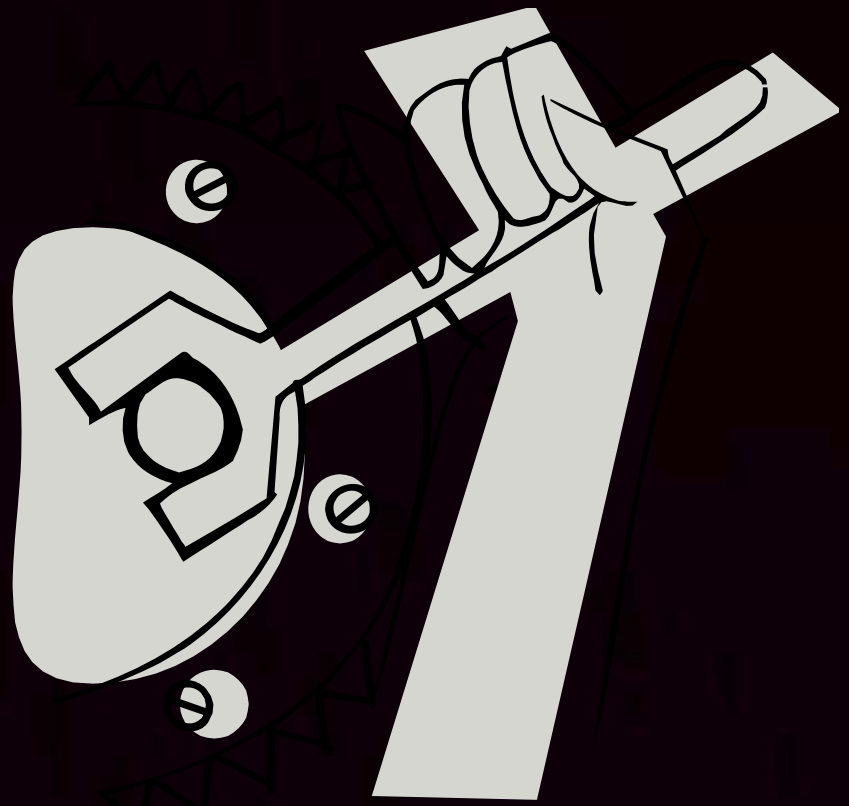
What is being done?



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Goal Statement for a South Platte NRD Integrated Management Plan

Approved by the IMP Work Group – November 1, 2004

- The goal of the South Platte Natural Resources District Integrated Management Plan is to work together for the greater good of all citizens of the South Platte Natural Resources District to cooperatively develop and implement a local Integrated Surface Water/Ground Water Plan that has an acceptable degree of certainty of (1) maintaining a sufficient water supply for use by present and future generations, (2) maintaining, enhancing and protecting the region's agricultural economy and the viability of its cities and villages and (3) promoting the growth of economic activities while seeking to avoid adverse impacts on the environment.

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Areas Subject to Joint DNR/NRD Integrated Management Planning Process

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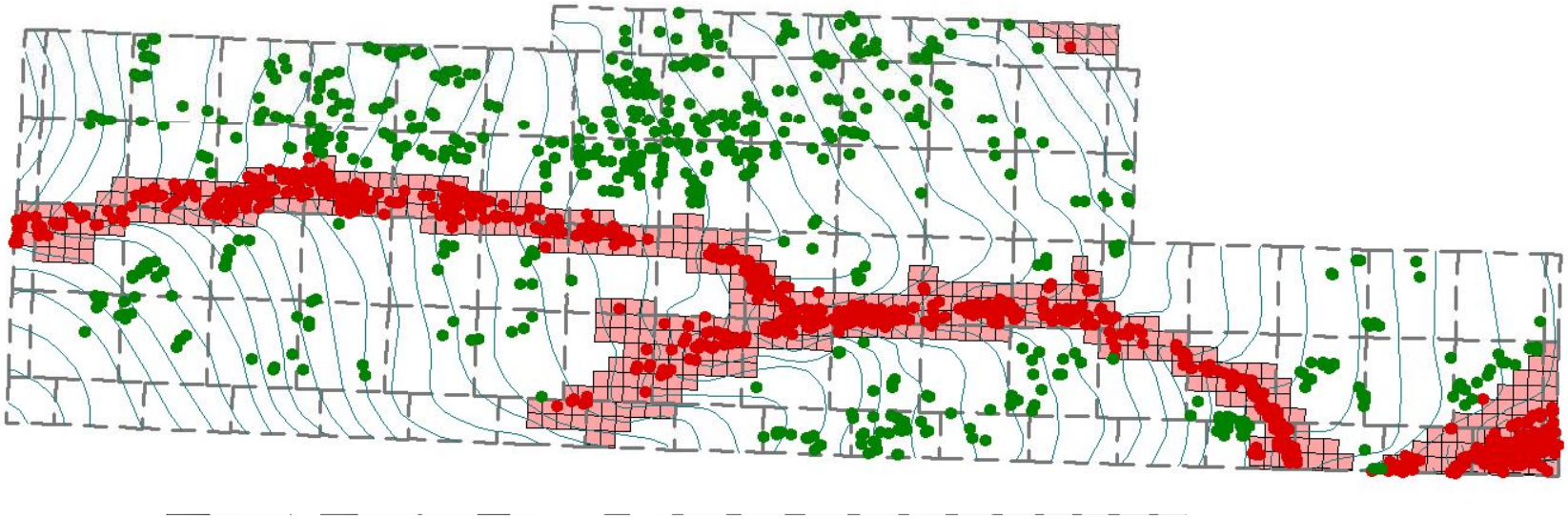
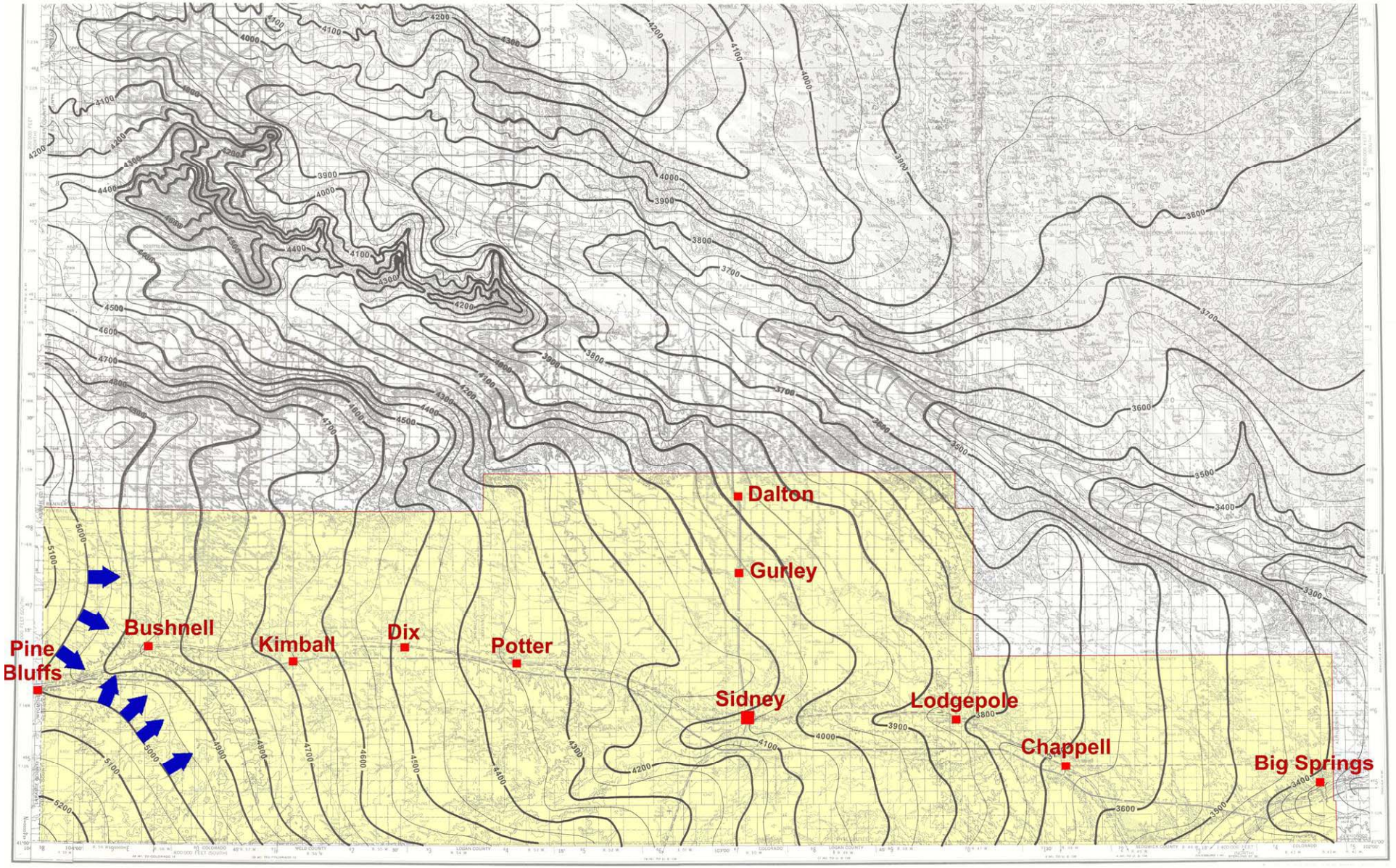
Large Capacity Wells in
Fully and Over Appropriated Areas



Configuration of the Water Table



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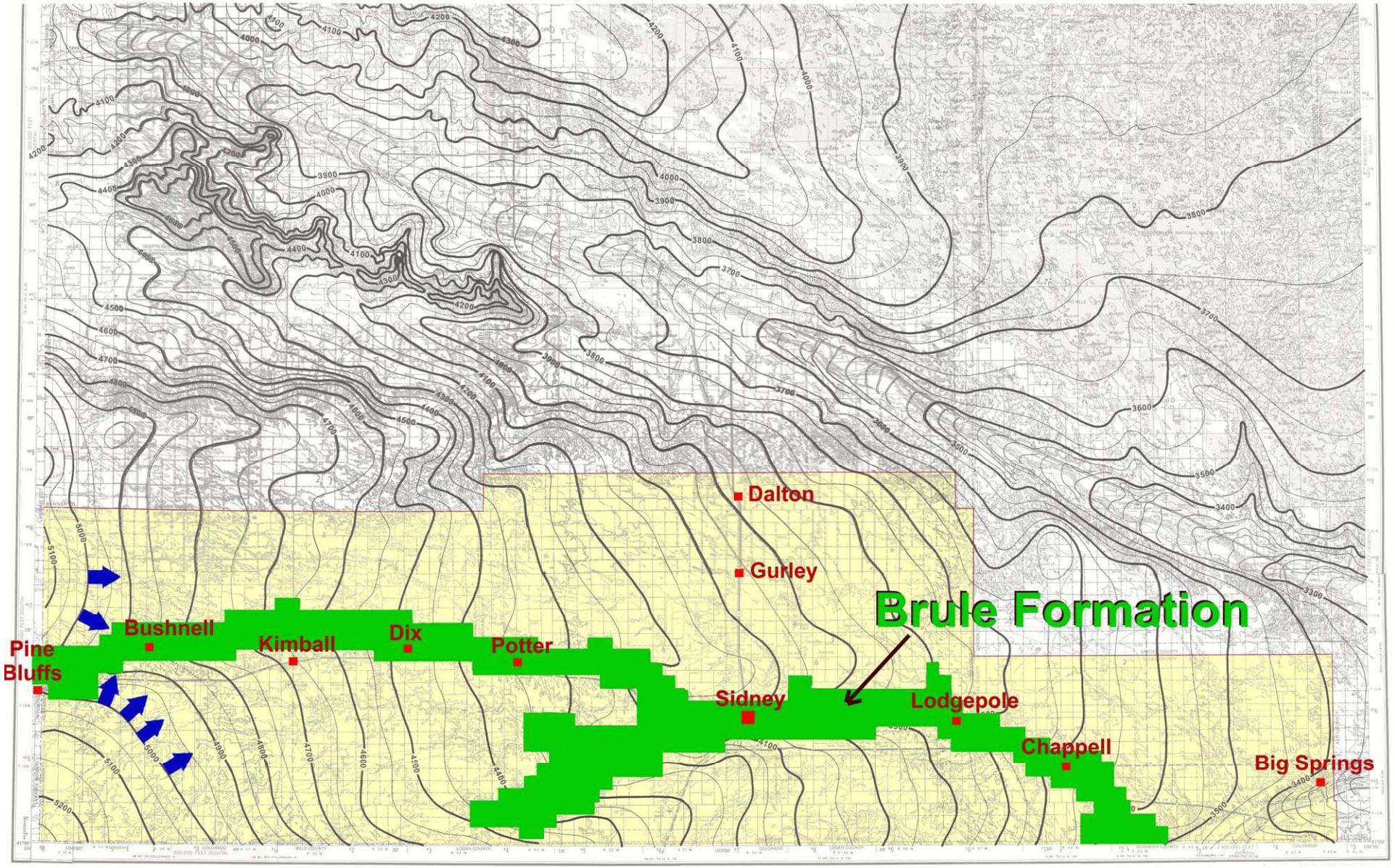

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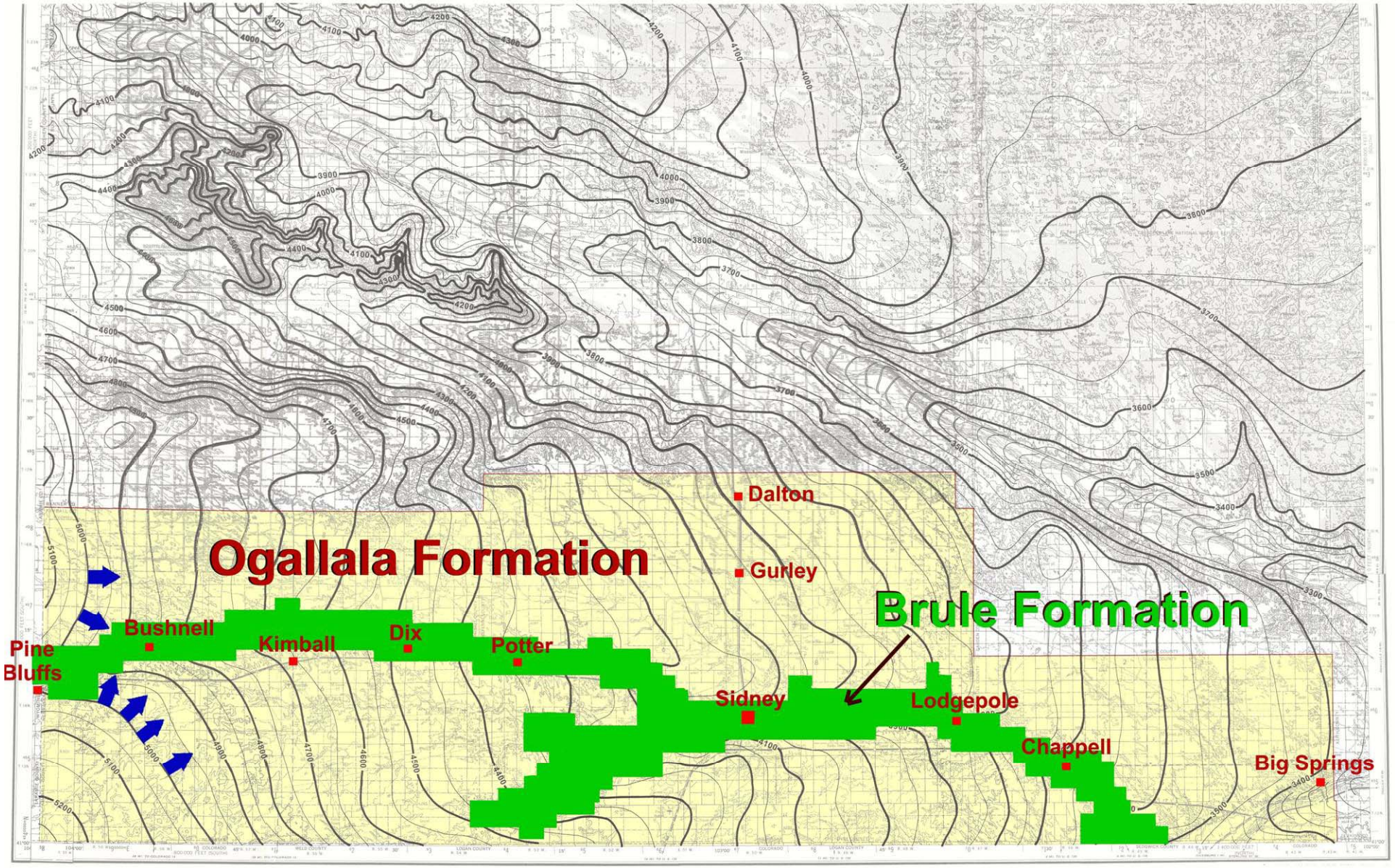
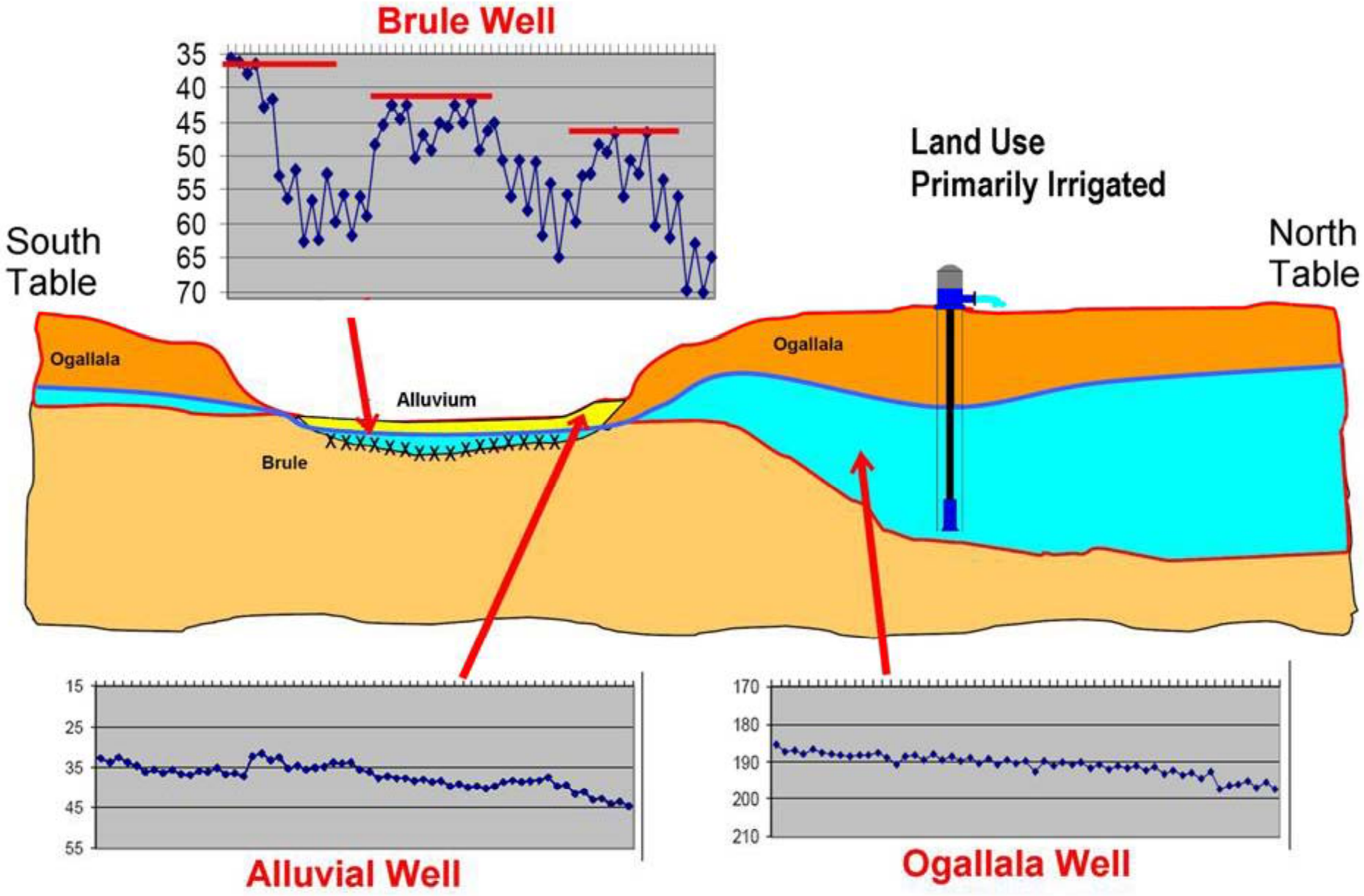
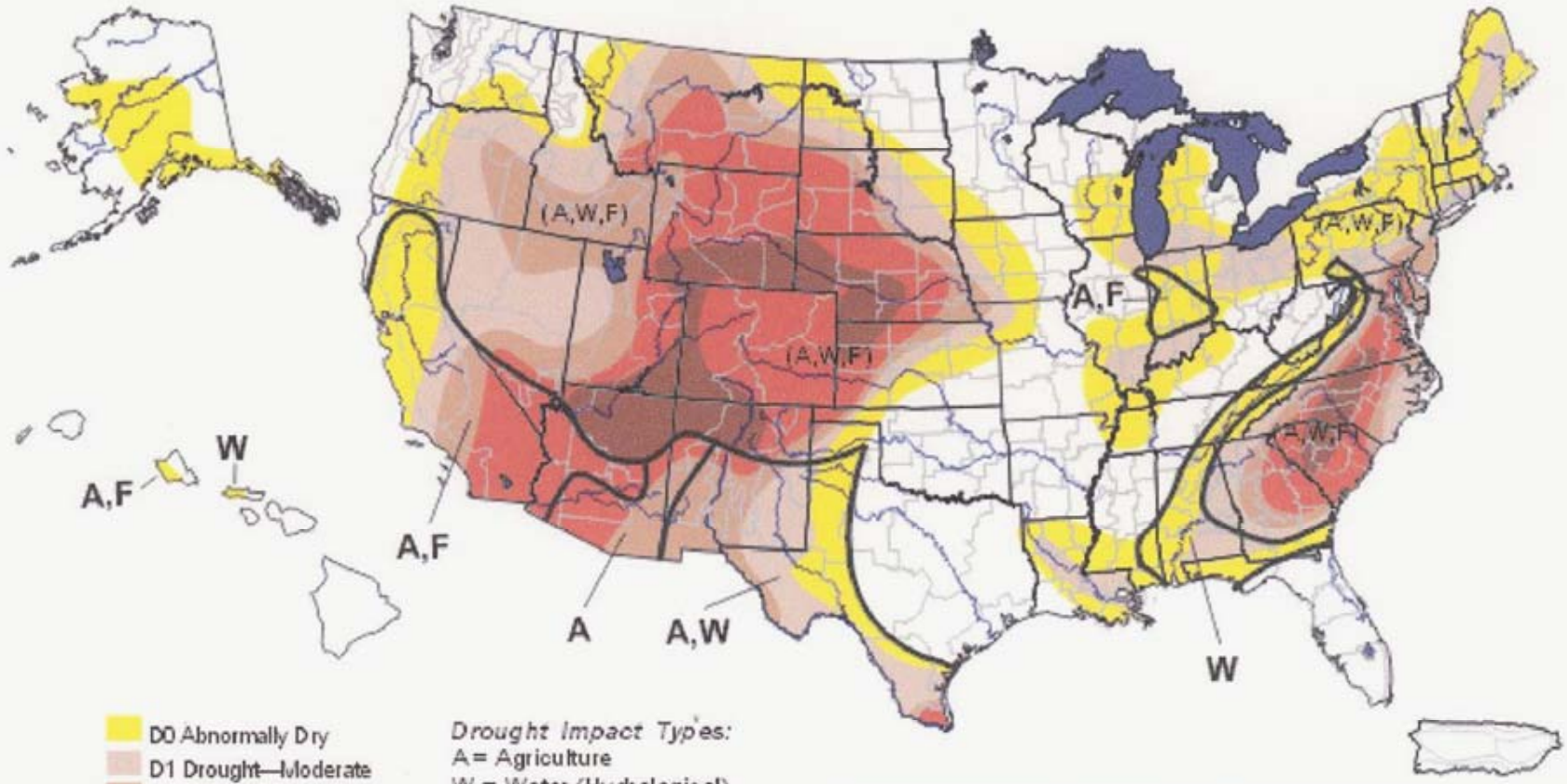


Diagrammatic Cross Section of the South Platte NRD



U.S. Drought Monitor

July 30, 2002
Valid 8 a.m. EDT



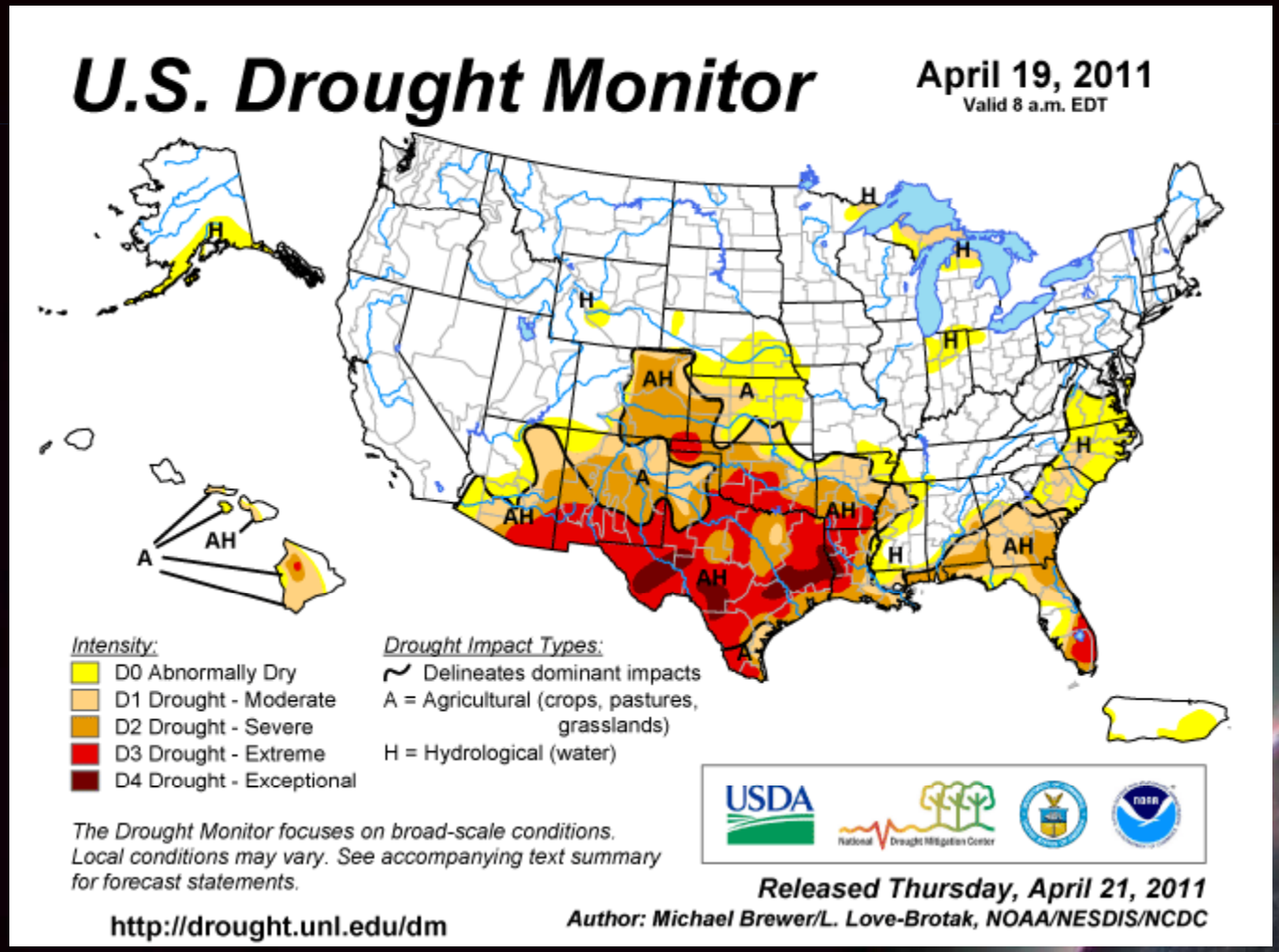
D0 Abnormally Dry
D1 Drought—Moderate
D2 Drought—Severe
D3 Drought—Extreme
D4 Drought—Exceptional

Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
Delineates dominant impacts
(No type = All 3 impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, August 1, 2002
Author: *Rich Tinker, CPC/NWS/NOAA*



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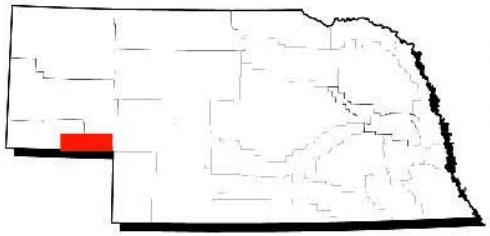

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Ground Water Quality Management Subareas

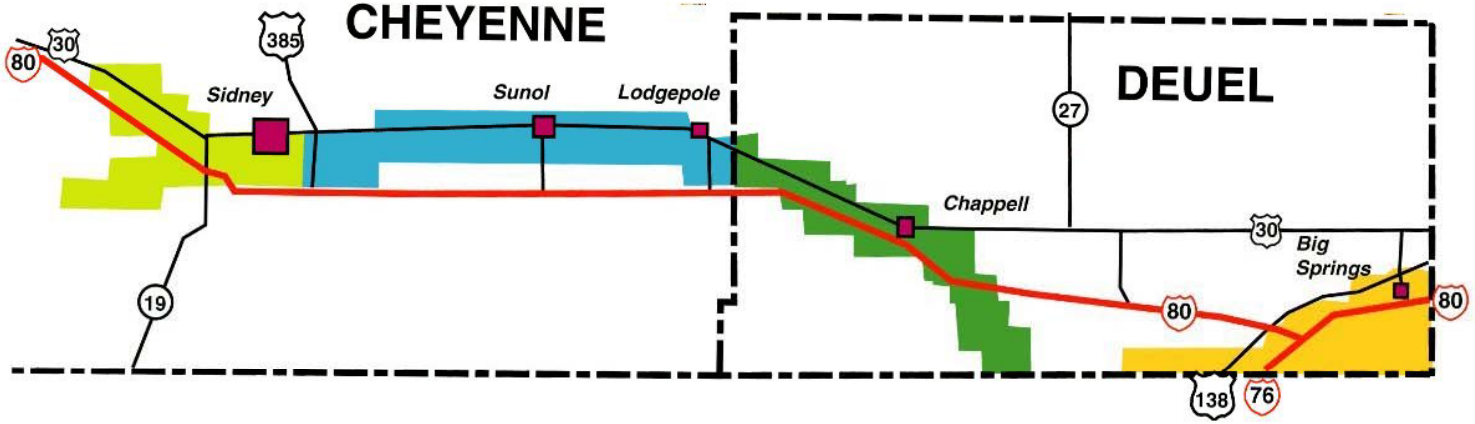
Scale in Miles
2 0 2 4 6 8 10

Sidney Ground Water Management Subarea (Phase 2)

East Lodgepole Valley Ground Water Management Subarea (Phase 1)

Lodgepole Valley Ground Water Management Subarea (Phase 1)

South Platte Valley Ground Water Management Subarea (Phase 2)



Phase I: Workshops in nitrogen and irrigation management

Phase 2: Workshops and 3 ft. soil samples, irrigation water samples, manure samples

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I WISH TO SAVE THE MINNOW!
I WISH FOR ABUNDANT CROPS!
I WISH FOR NEW INDUSTRY!
I WISH FOR MORE GOLF COURSES!
I WISH TO RESTORE RIPARIAN HABITAT!
SNAP!
LODGEPOLE CREEK VALLEY

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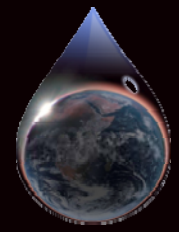
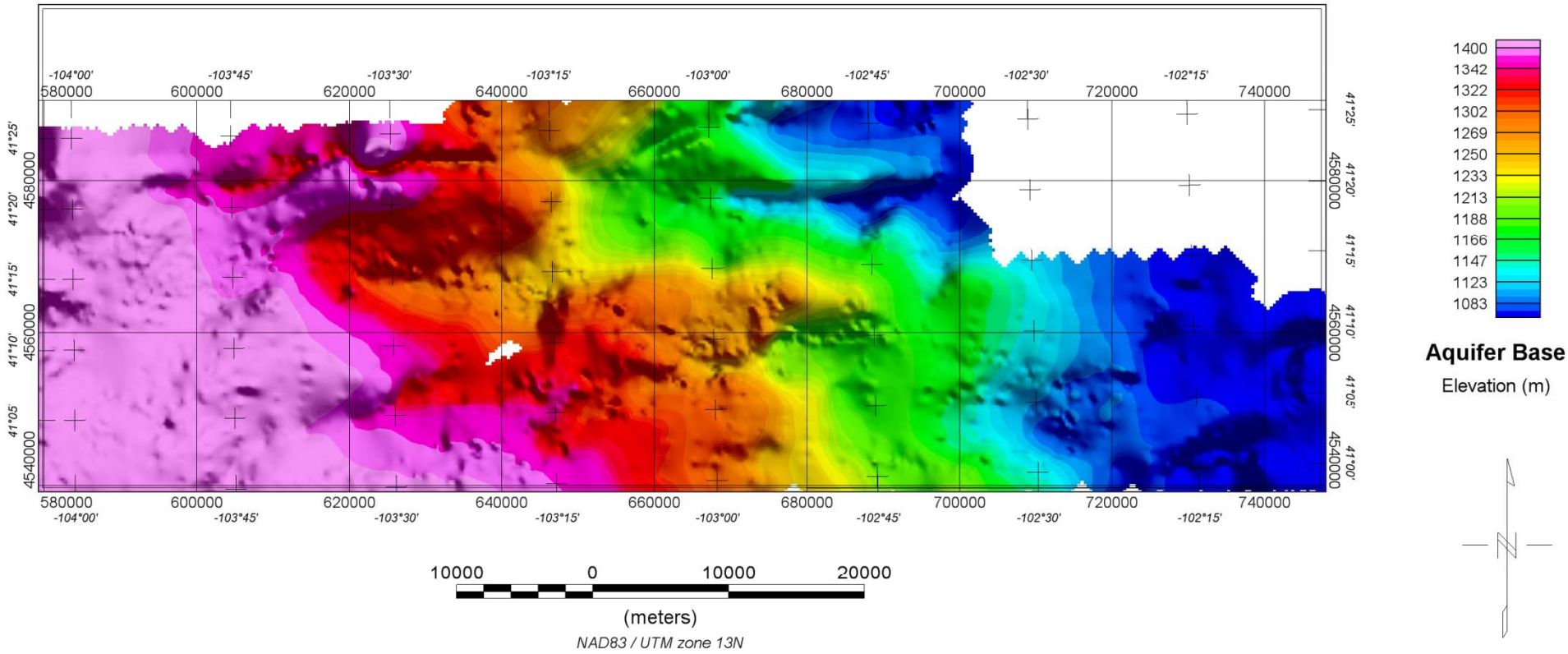
Natural Resources District

Environmental Trust
preserving NATURAL NEBRASKA™ for future generations

Science for Water Management





Base of Aquifer Pre-Airborne Geophysics

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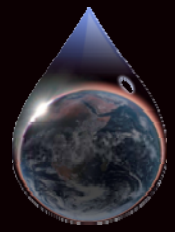
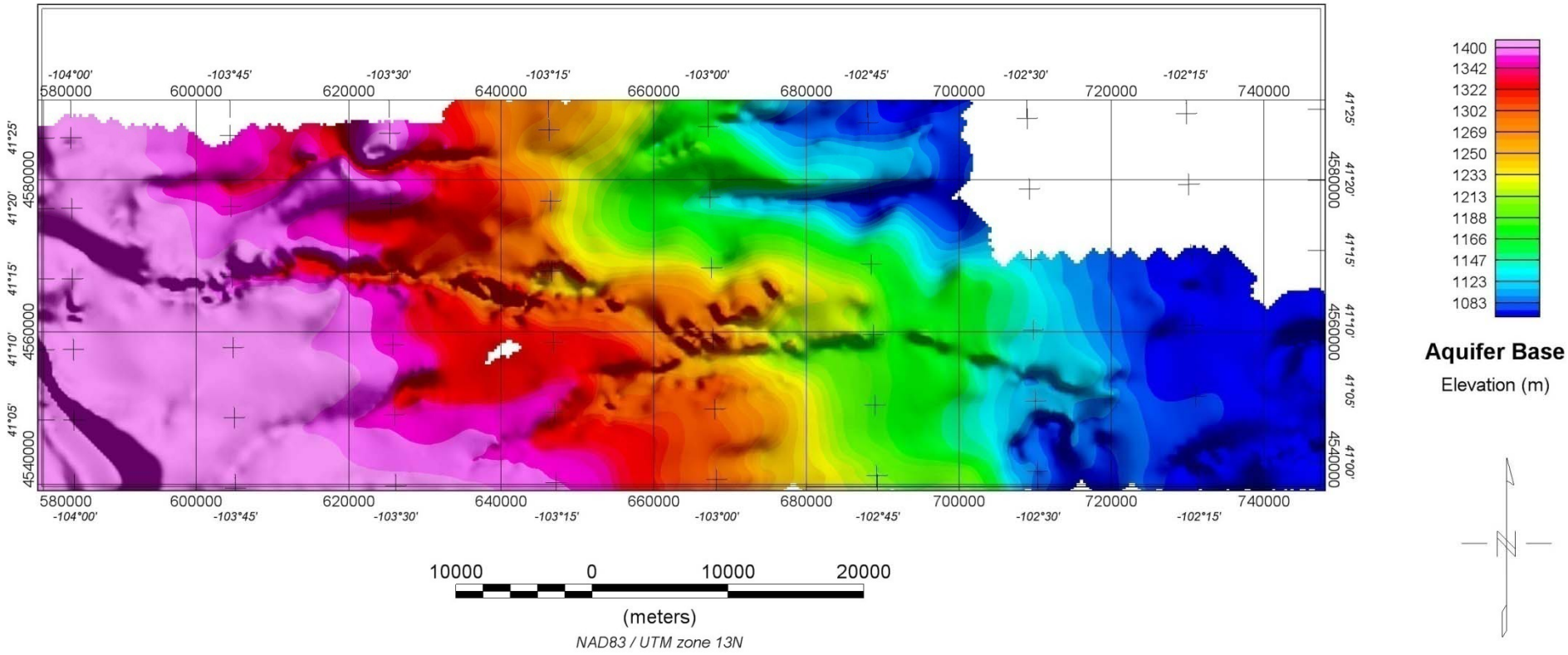
Science for Water Management





Base of Aquifer Post-Airborne Geophysics

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Nebraska Panhandle Helibourne ElectroMagnetic Surveys

- HEM Project Sponsors
  - Nebraska Environmental Trust
  - North Platte Natural Resources District
  - U.S. Geological Survey
  - South Platte Natural Resources District
  - University of Nebraska-Lincoln, School of Natural Resources, Conservation and Survey Division

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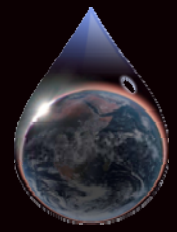
Principal Investigators



Jared D. Abraham [1],
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Steven M. Peterson[2],
Bruce D. Smith[1],
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U.S. Geological Survey
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[2]Nebraska Water Science Center

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Western Nebraska

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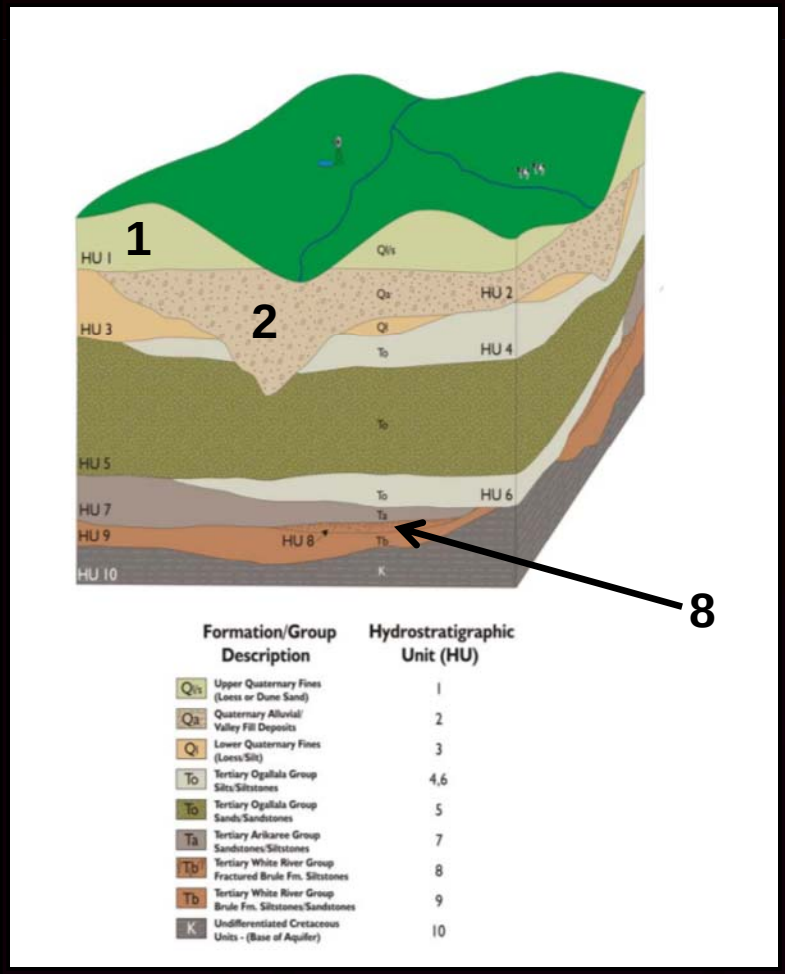
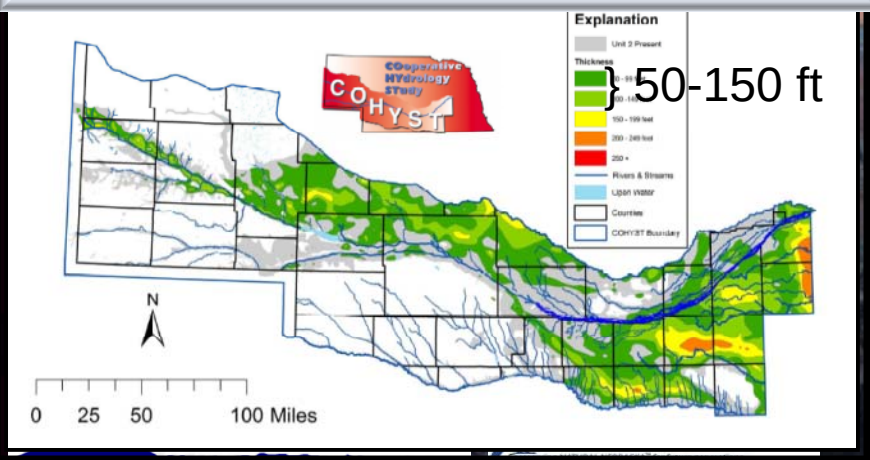
Hydrostratigraphic Units



Developed for the COHYST Model hydrostratigraphic units are designated by combining stratigraphic units with known hydrologic properties

Main hydrostratigraphic units mapped for the HEM are 1, 2, and 8

Generalized thickness of hydrostratigraphic unit 8—Quaternary sand and gravel



50-150 ft

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Airborne Electromagnetic Surveys

- Fugro Resolve
  - Aeroquest IV
  - VETEM 2009
  - HeliGEOTEM
  - SkyTEM
- Need well-calibrated data
- Effective where sands and gravel cover silt and clay

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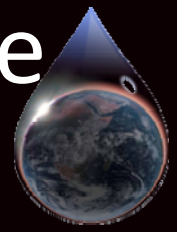
Electrical Properties of North Platte Valley Lithology



High Resistivity – Red

- sand or gravels (aquifer where saturated)

Low Resistivity – Blue

- clays and silts (confining unit)

Many combinations exist

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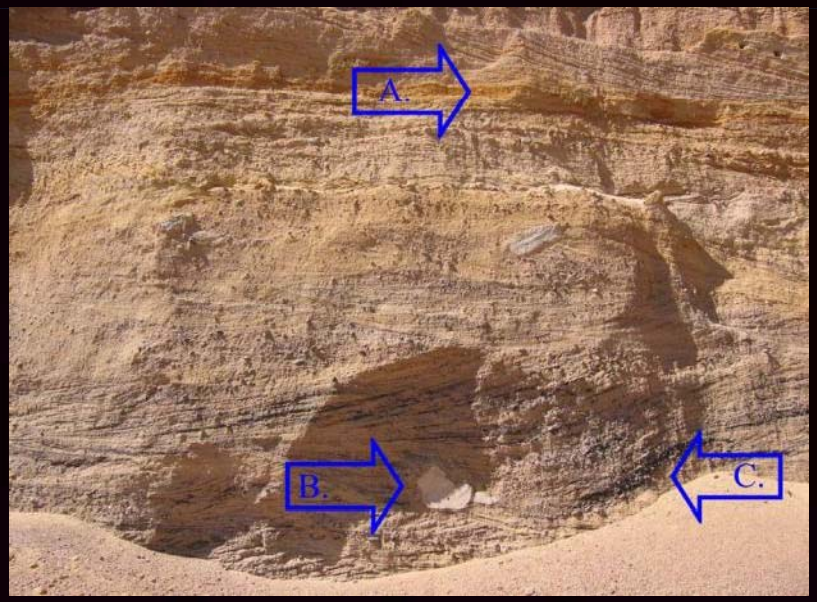
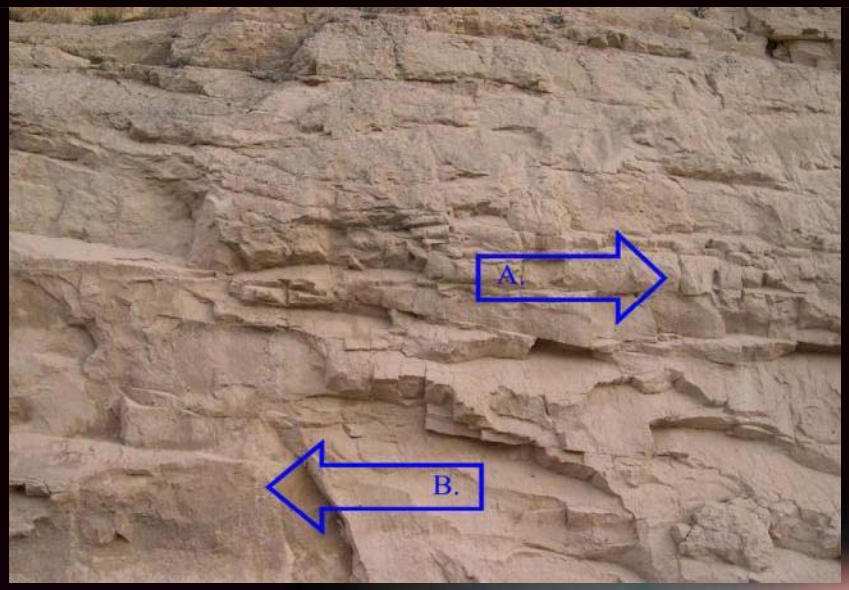
Geology and Lithology



A. Iron stained sediments
B. Siltstone clasts ~1.5 feet in diameter
C. Cross bedded, fluvial, coarse-grained sediments of the Pliocene Broadwater Formation. Manganese stained sediments.

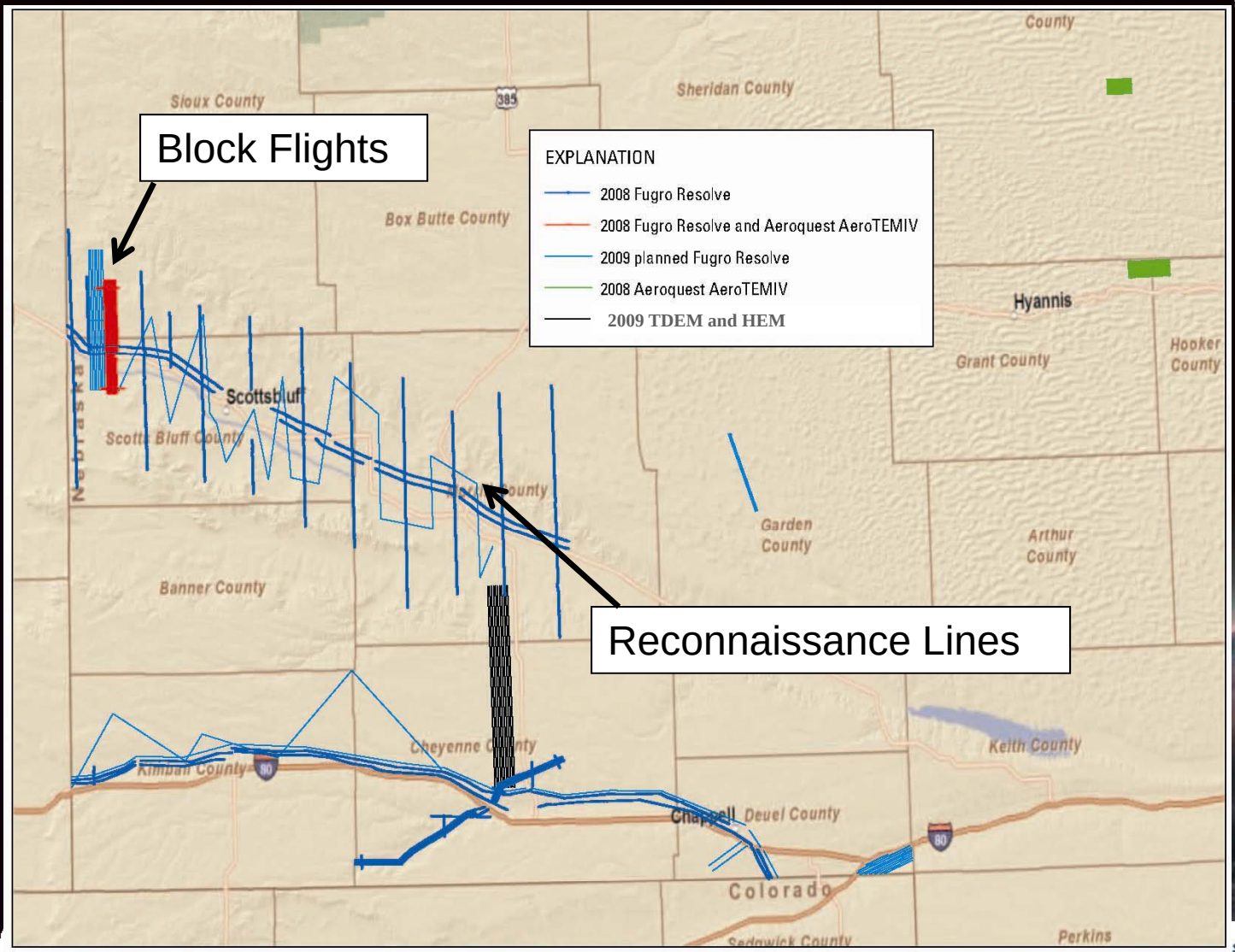
Photo taken ~ 1.5 miles north of Big Springs, Nebraska facing west.



A. Tertiary Brule Formation fractures
B. Unfractured Tertiary Brule Formation

Photo taken along summit road between tunnels 1 and 2, Scottsbluff National Monument, facing east.

Location of Flights 2008-9



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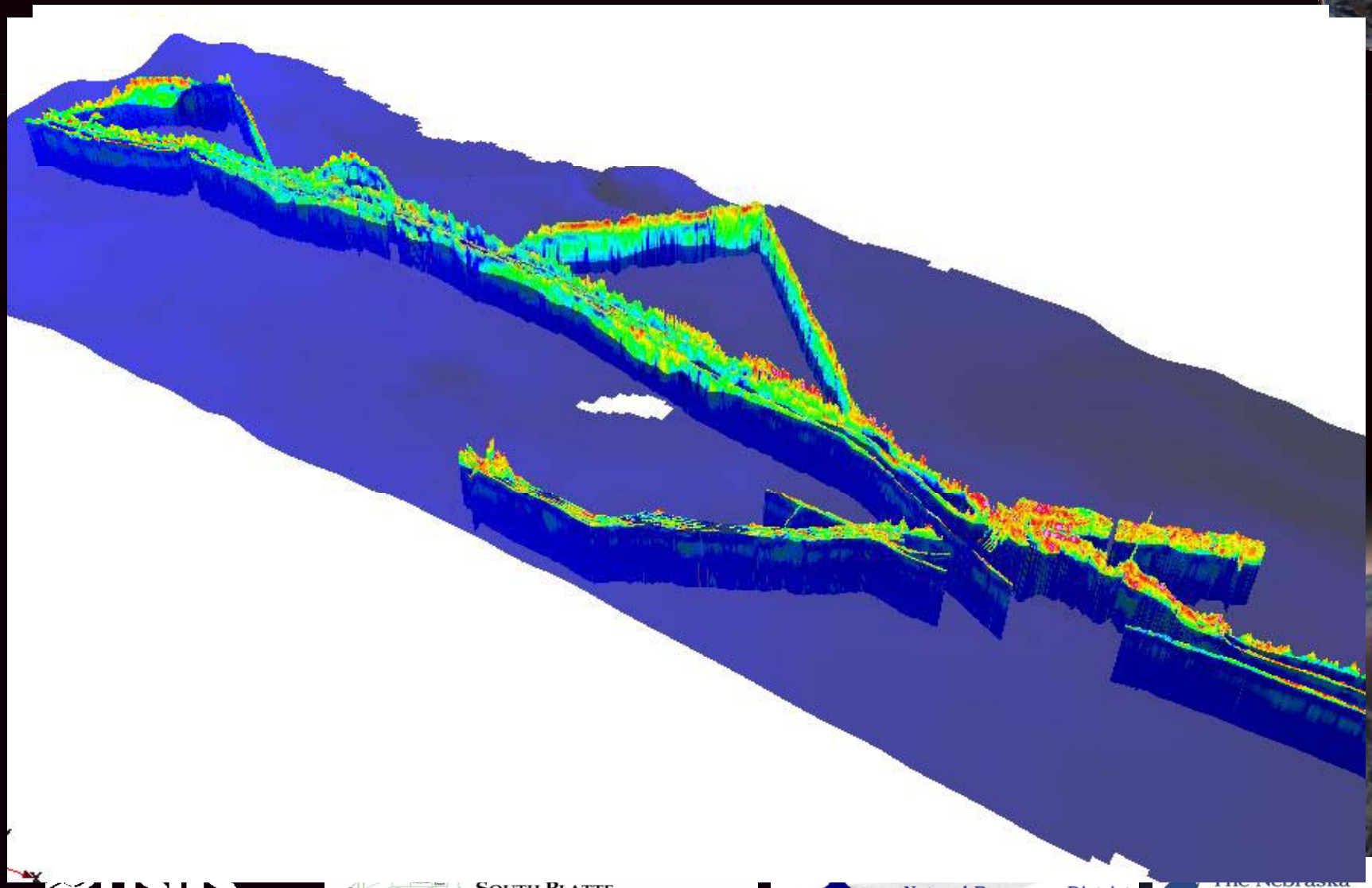
Results in the SPNRD



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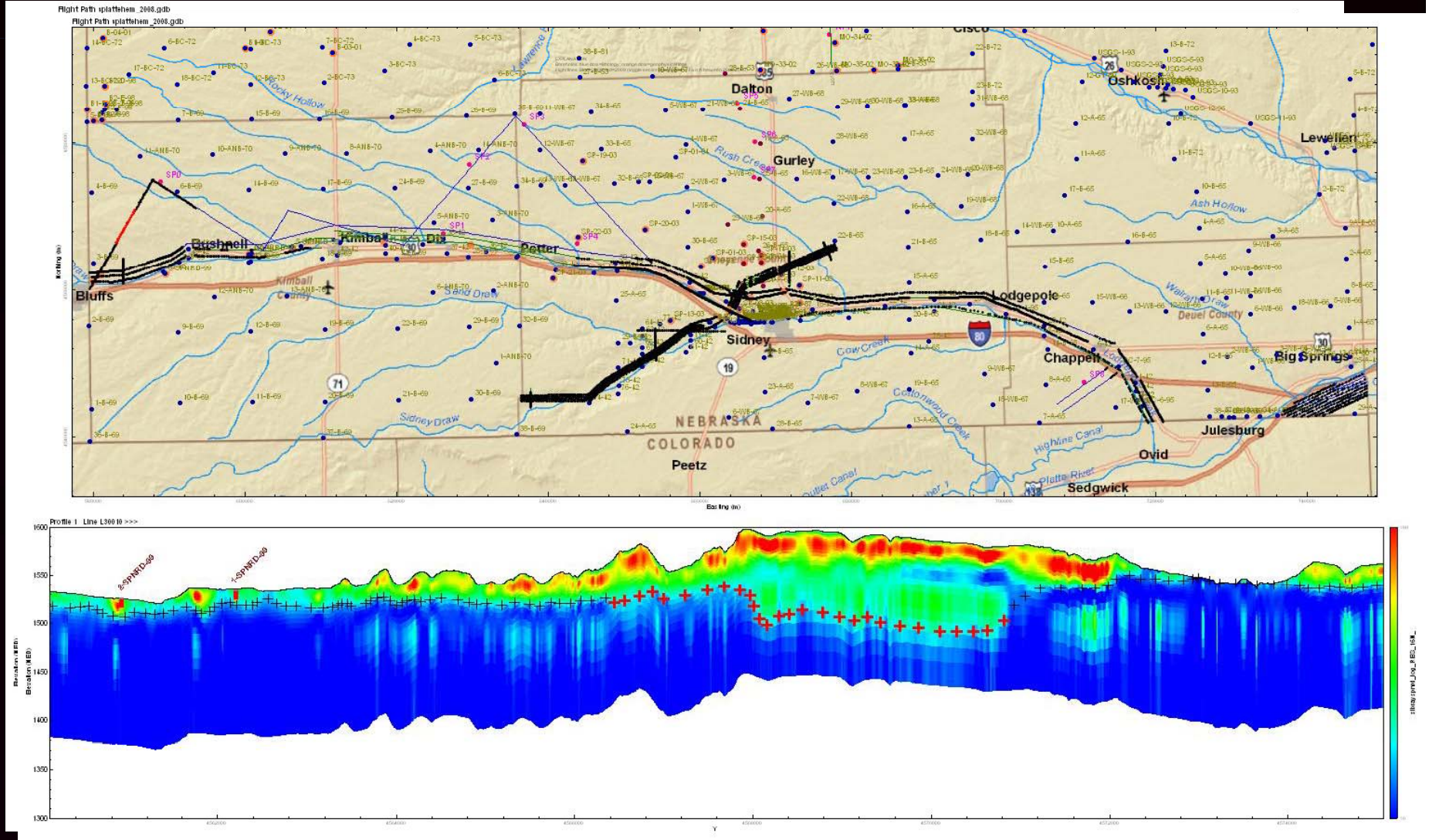
New Interpretations



The New Bedrock Maps

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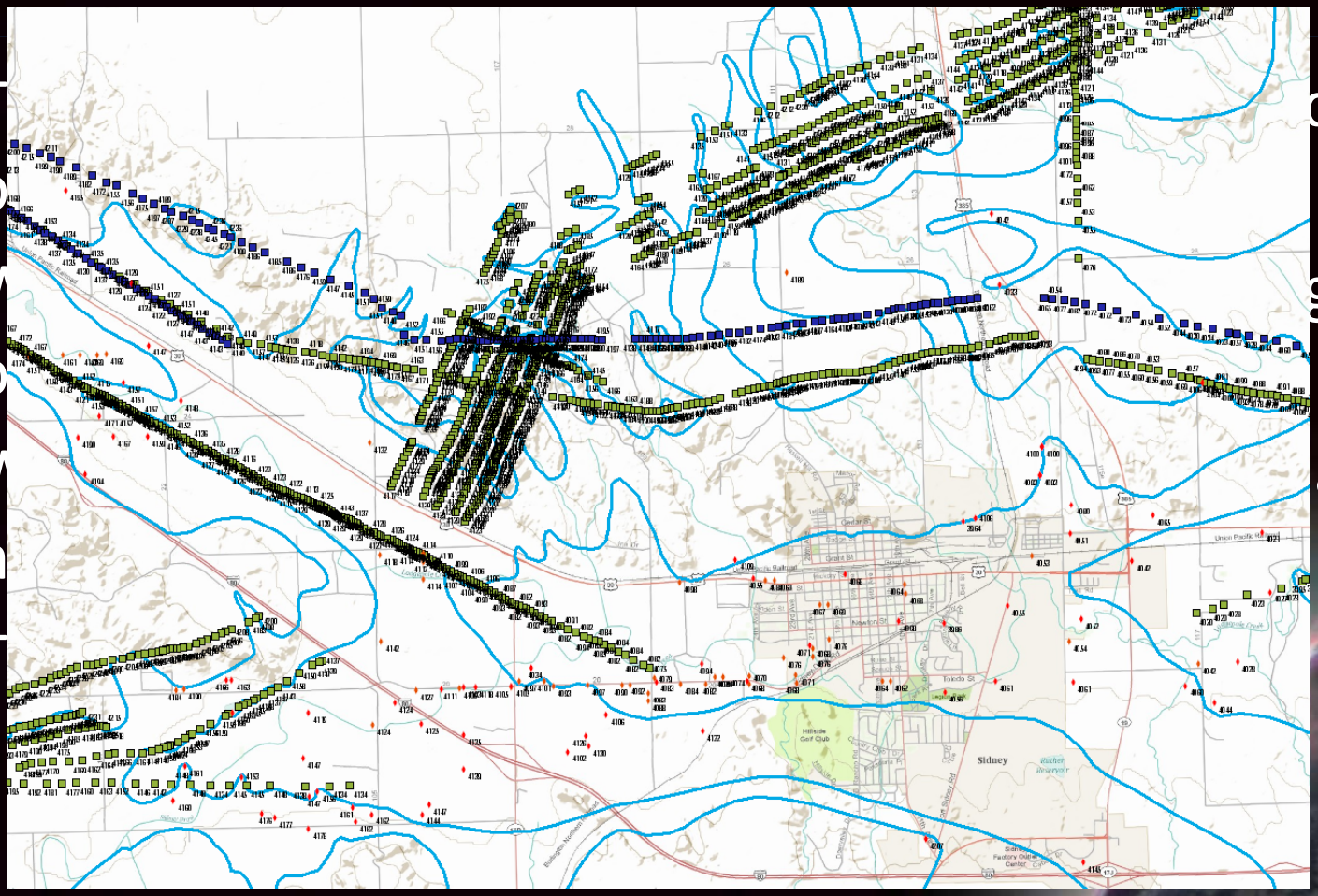

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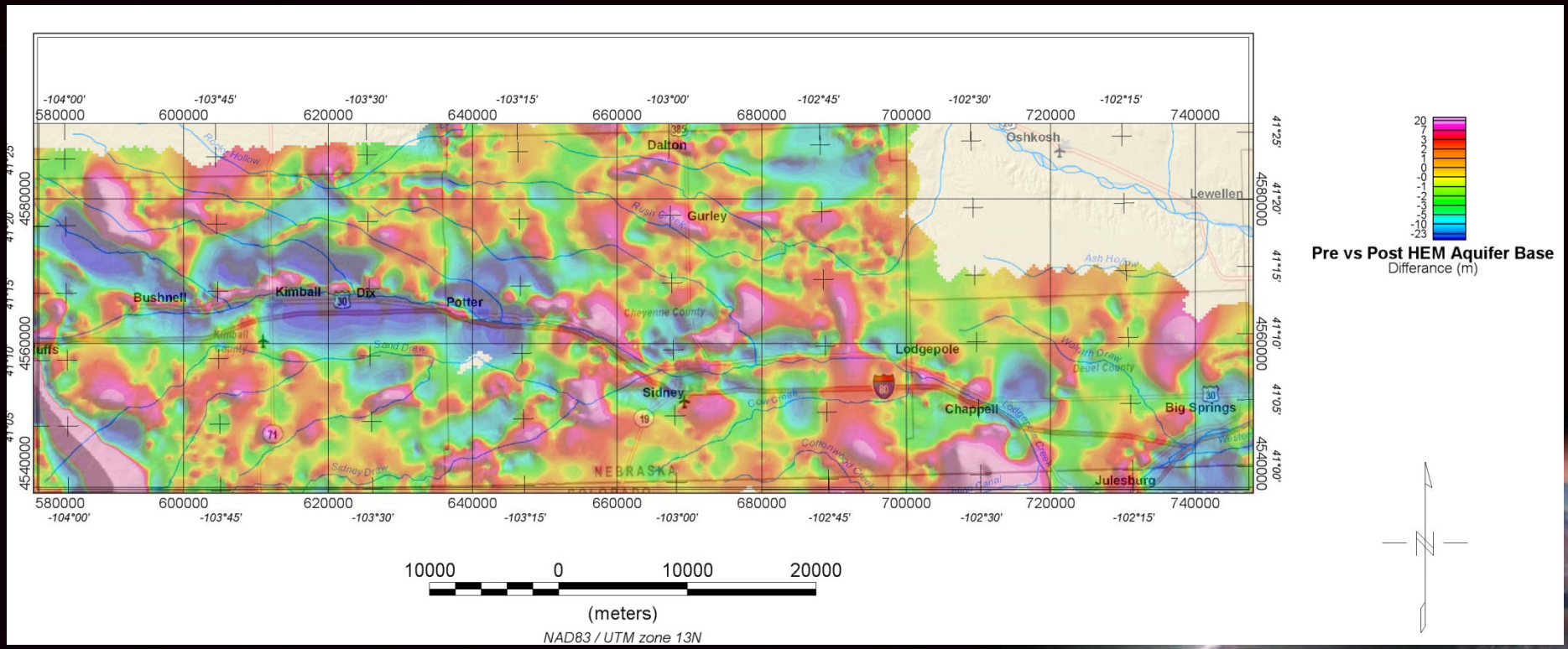
Change in Aquifer Material



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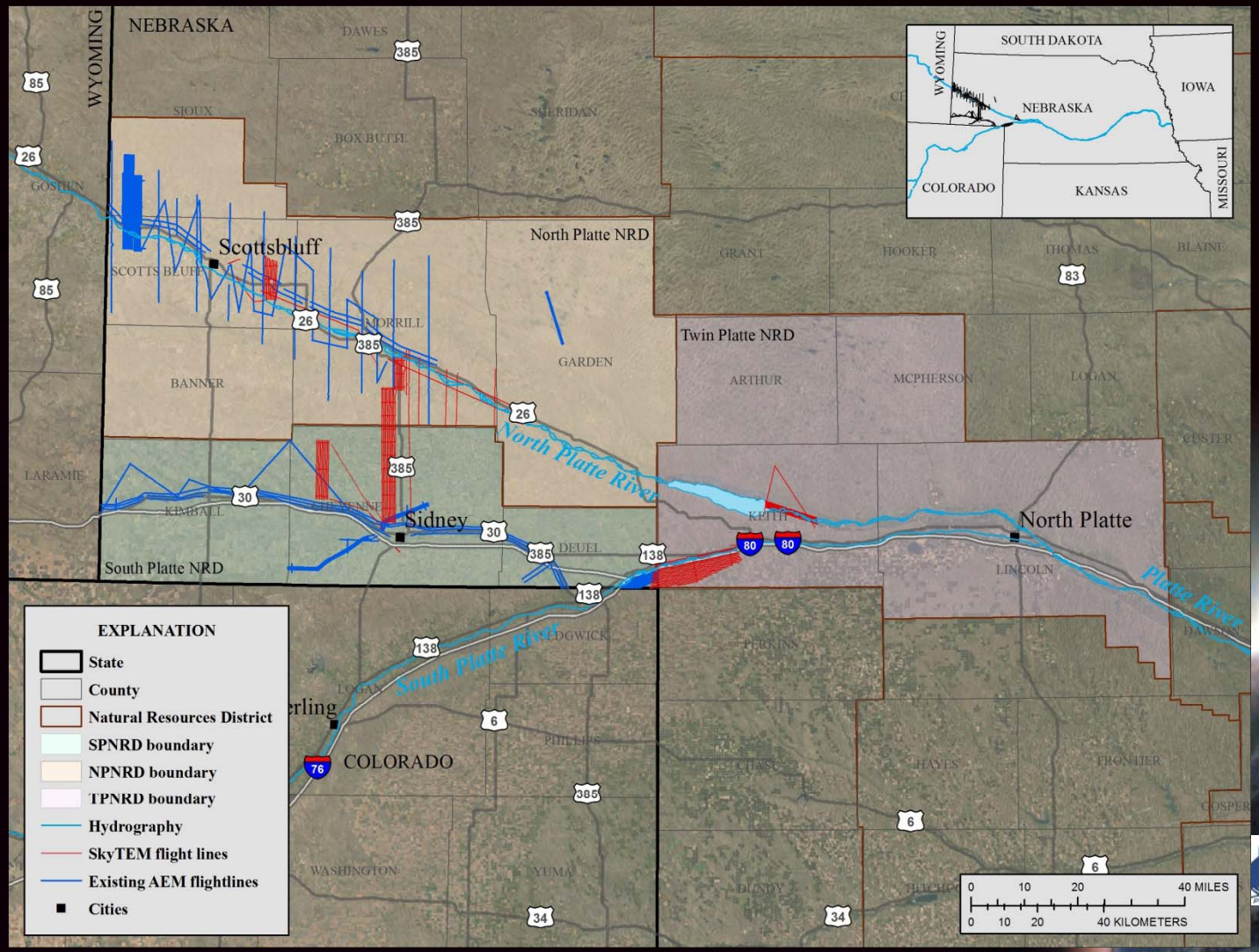
The Path Forward

- Inversion of 2010 Airborne TEM data
- Add new test-hole data
- Complete new Geologic interpretations
- Plan MRS soundings
- Publish new results

Add Data Where Groundwater Model is Having Problems



Red flight lines are where data was collected in 2010 based on model needs

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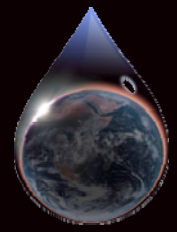
Eastern Nebraska HEM



- Glaciated areas?

- How did HEM work in glacial areas of eastern Nebraska?

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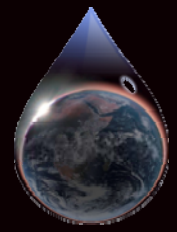
Sponsors for Eastern Nebr. Study



- Lewis and Clark NRD
- Lower Elkhorn NRD
- Lower Platte North NRD
- Lower Platte South NRD
- Nemaha NRD
- Papio-Missouri River NRD

Technical Advisors

- U.S. Geological Survey
- University of Nebraska-Lincoln, School of Natural Resources, Conservation and Survey Division
- Nebraska Department of Natural Resources
- Nebraska Department of Environmental Quality
- Nebraska Association of Resources Districts

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Background

- 70% of the state's population
- Water supplies are limited
- Basic hydrogeologic data is limited
- Difficult to map glaciated groundwater region
- Local governments require information to guide "wise water resources development" as populations grow and expand

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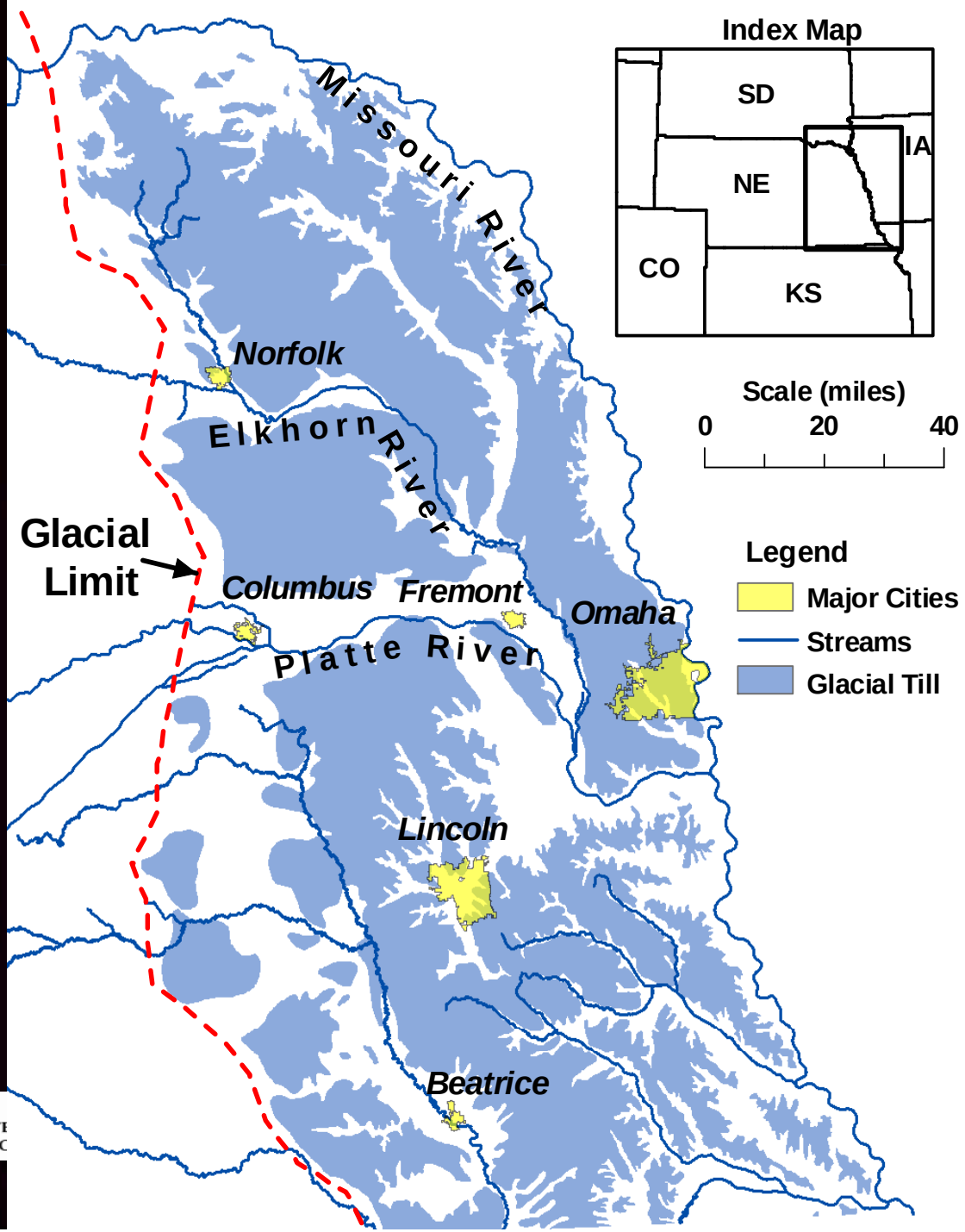
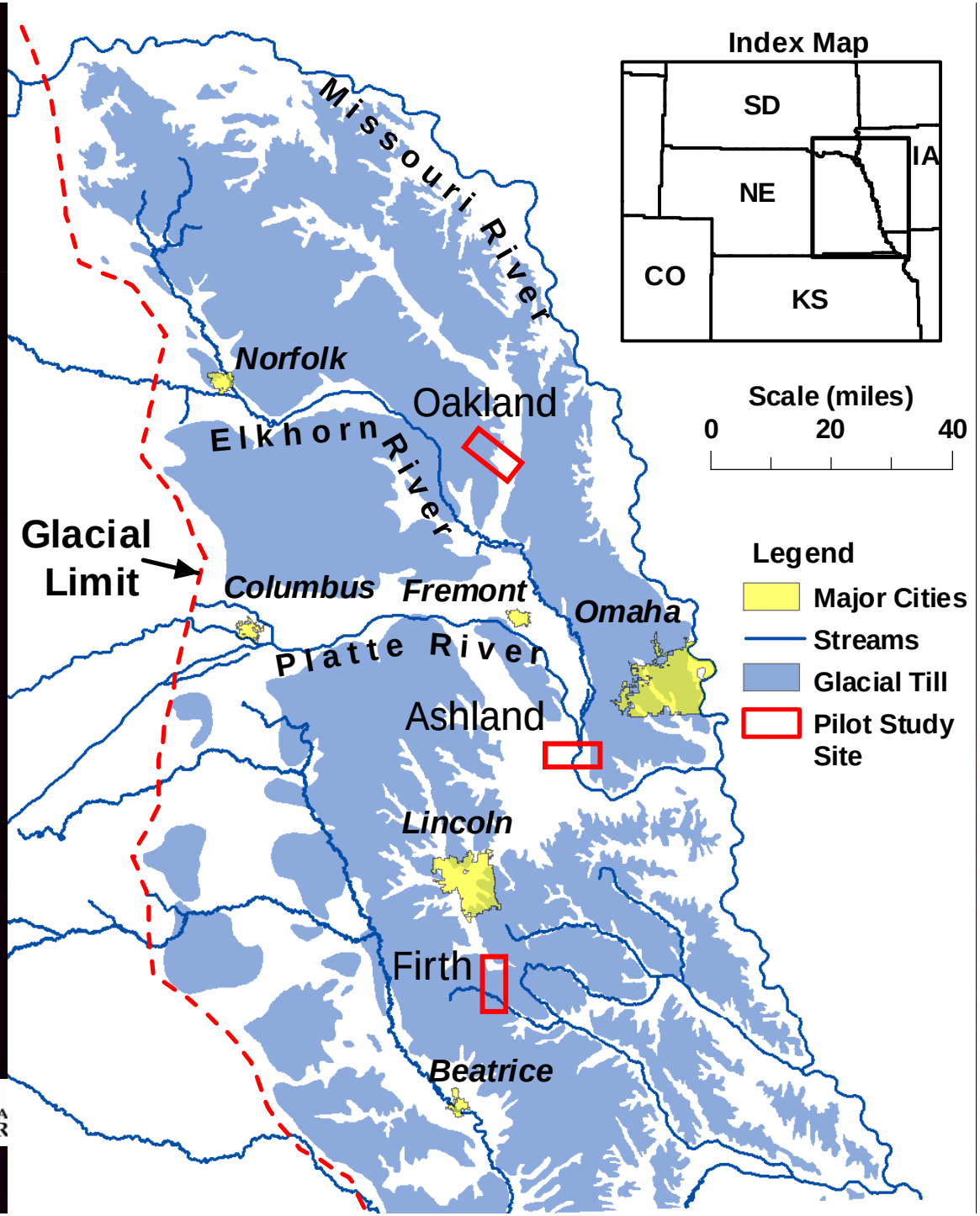


Approach: Pilot Study Locations

- Public education
- Airborne geophysics
- Surface geophysics
- Test-hole drilling & monitoring-well installation
- Historic test-hole & well logs
- Existing maps



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Test Holes by Site

- Ashland, Firth, and Oakland
  - Each represents a unique hydrogeologic setting
- Ashland: 10 Test holes
- Firth: 11 Test holes
- Oakland: 12 Test holes

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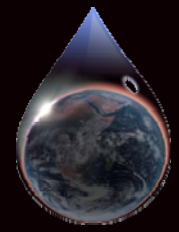
AEM Geophysics Goals



- Conduct a 36-sq-mile survey for each of the three study areas
- Evaluate the HEM surveys as a cost-effective hydrogeologic mapping tool

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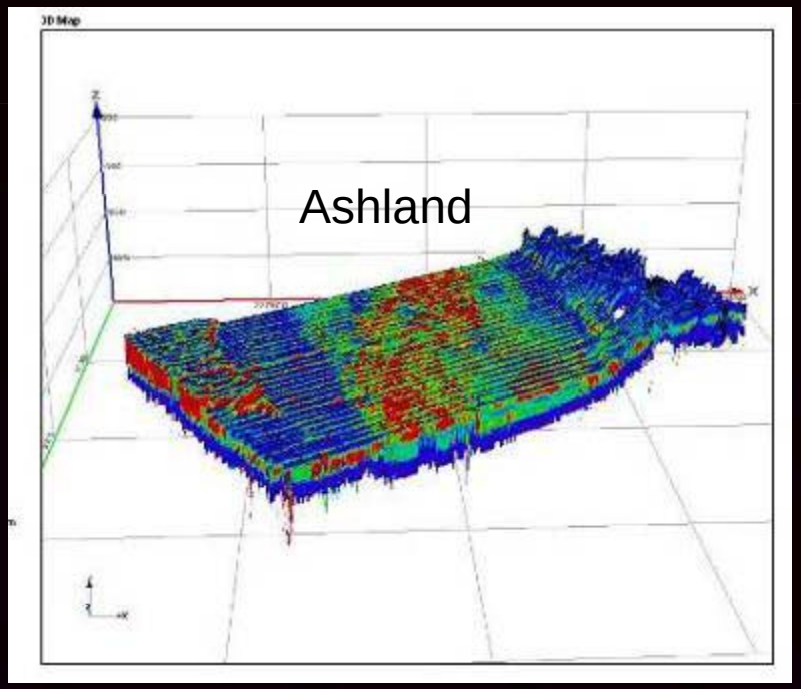
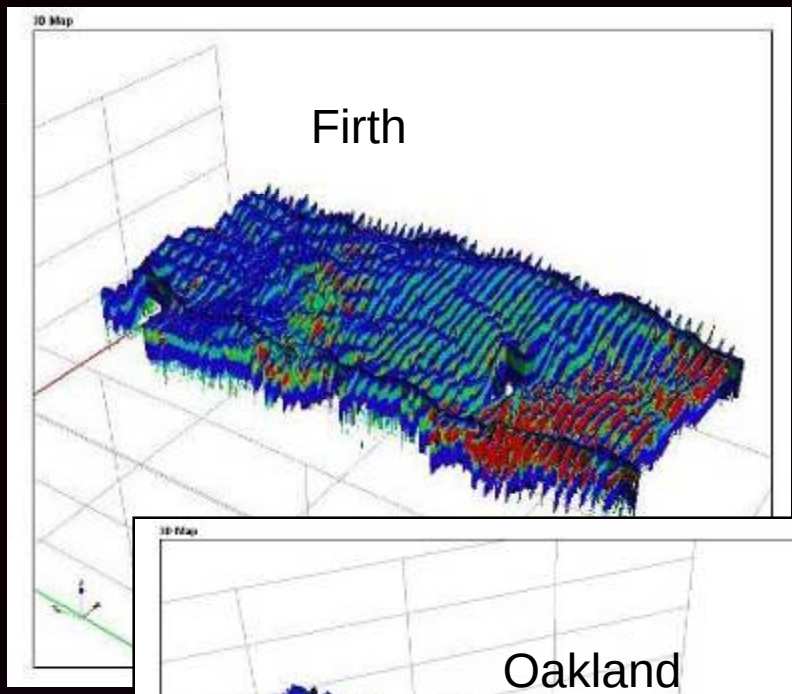
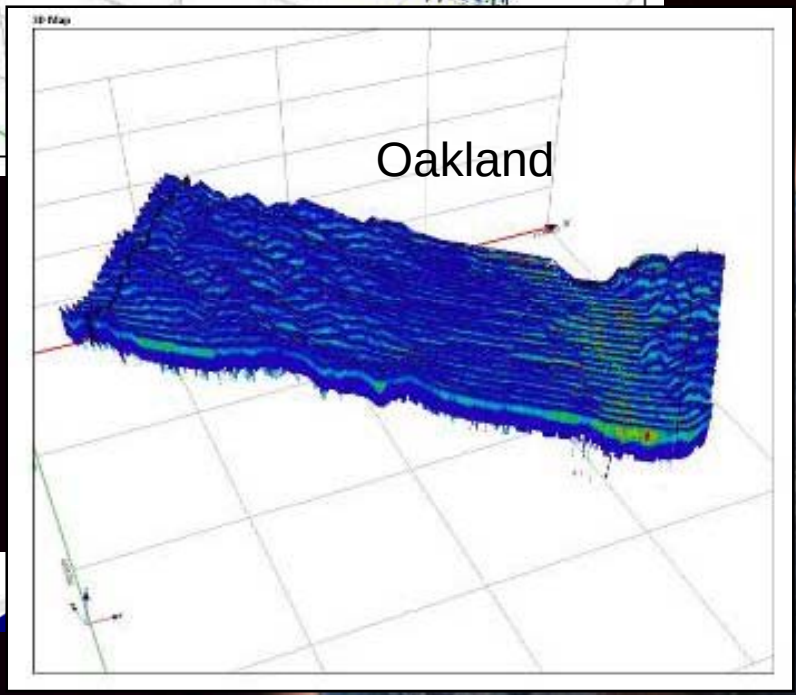
AEM Accomplishments

- Collected AEM data per site
  - –Approximately 110,000 soundings
  - –Approximately 240 flight miles
  - –36 square miles of data covered

AEM Results







Warm colors resistive
(sand – gravel)

Cool colors conductive
(clay – shale – siltstone)

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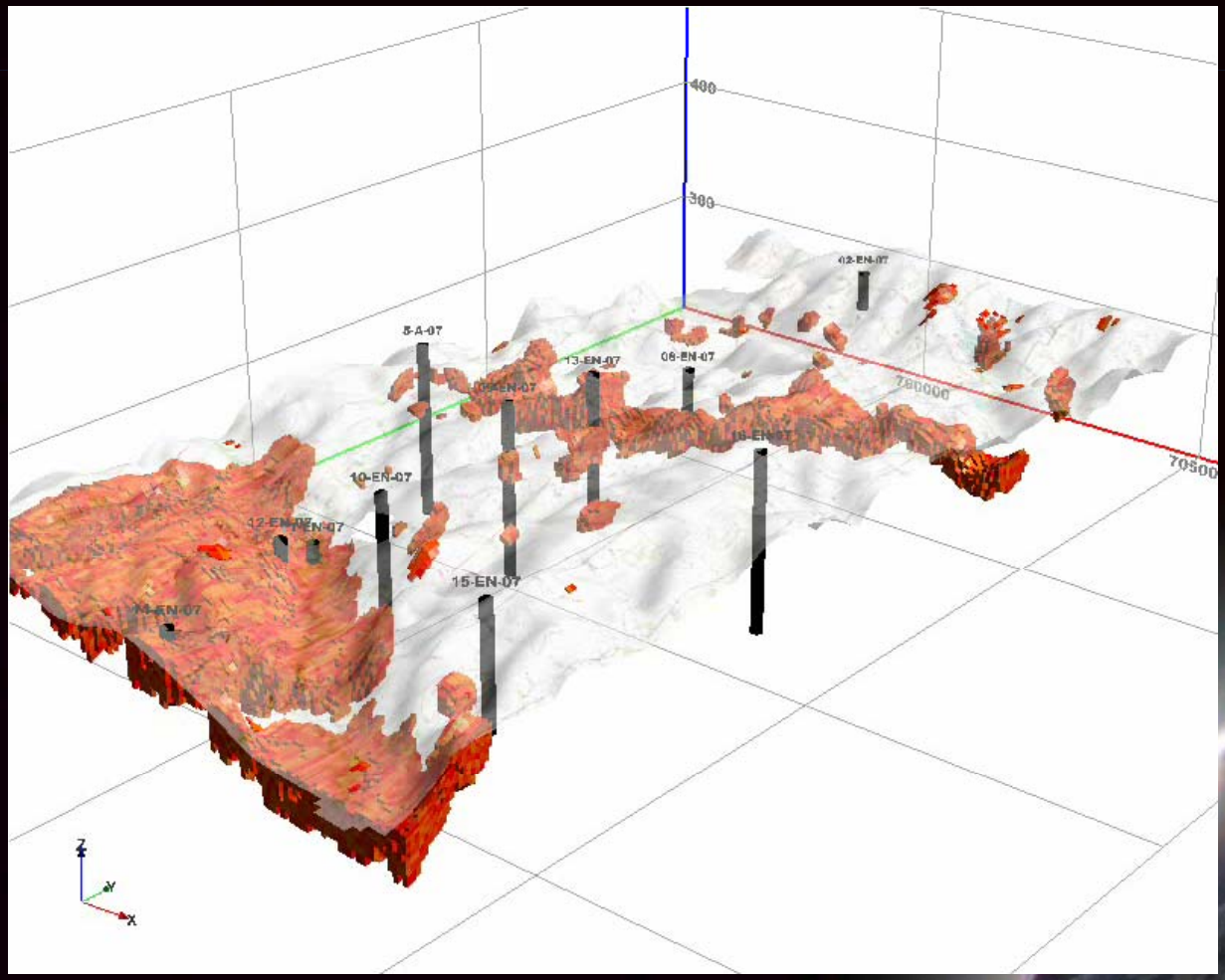
Firth Voxel Model >80 ohm-m



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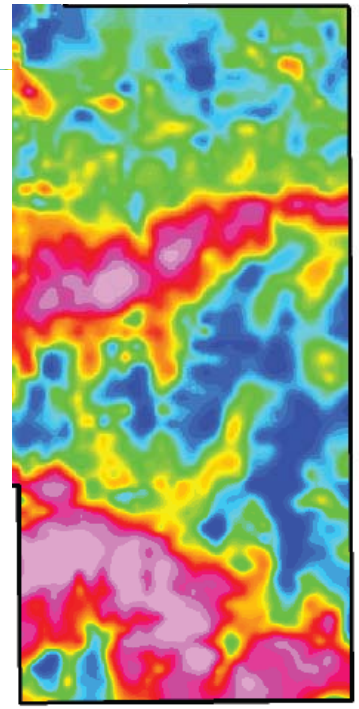
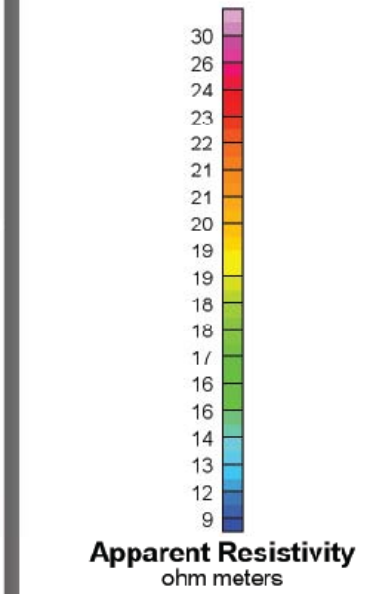
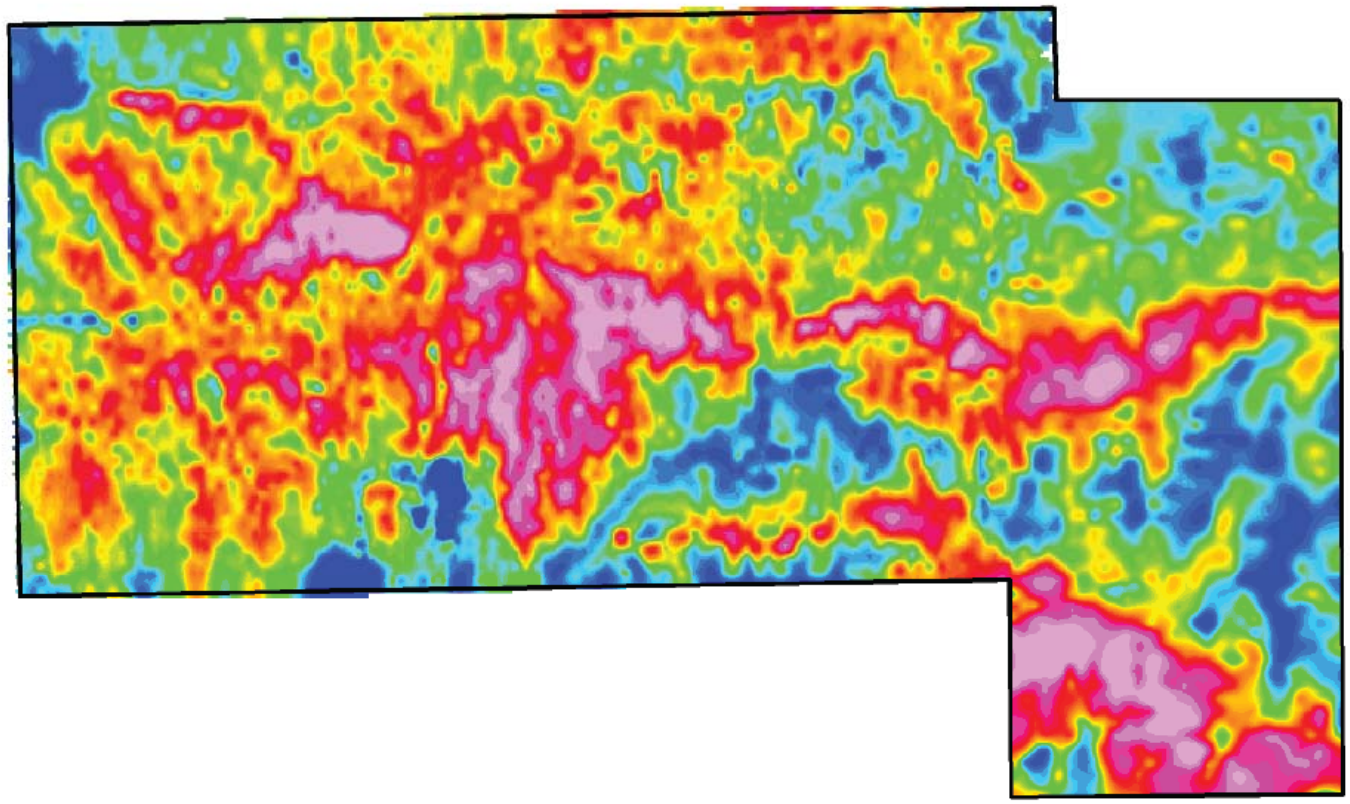
Firth Block Flown 2007





Sprague Block Flown 2009



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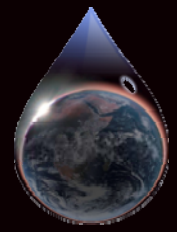
Apparent Resistivity
ohm meters

HEM Evaluation



- Effective tool for mapping:
  - alluvial areas
  - upland areas with thin and sandy tills, HEM penetrates up to 150 feet
- Not an effective tool on:
  - uplands with thick till
  - areas with dense infrastructure
- Test-hole logs (existing and new) must be used to support HEM interpretations

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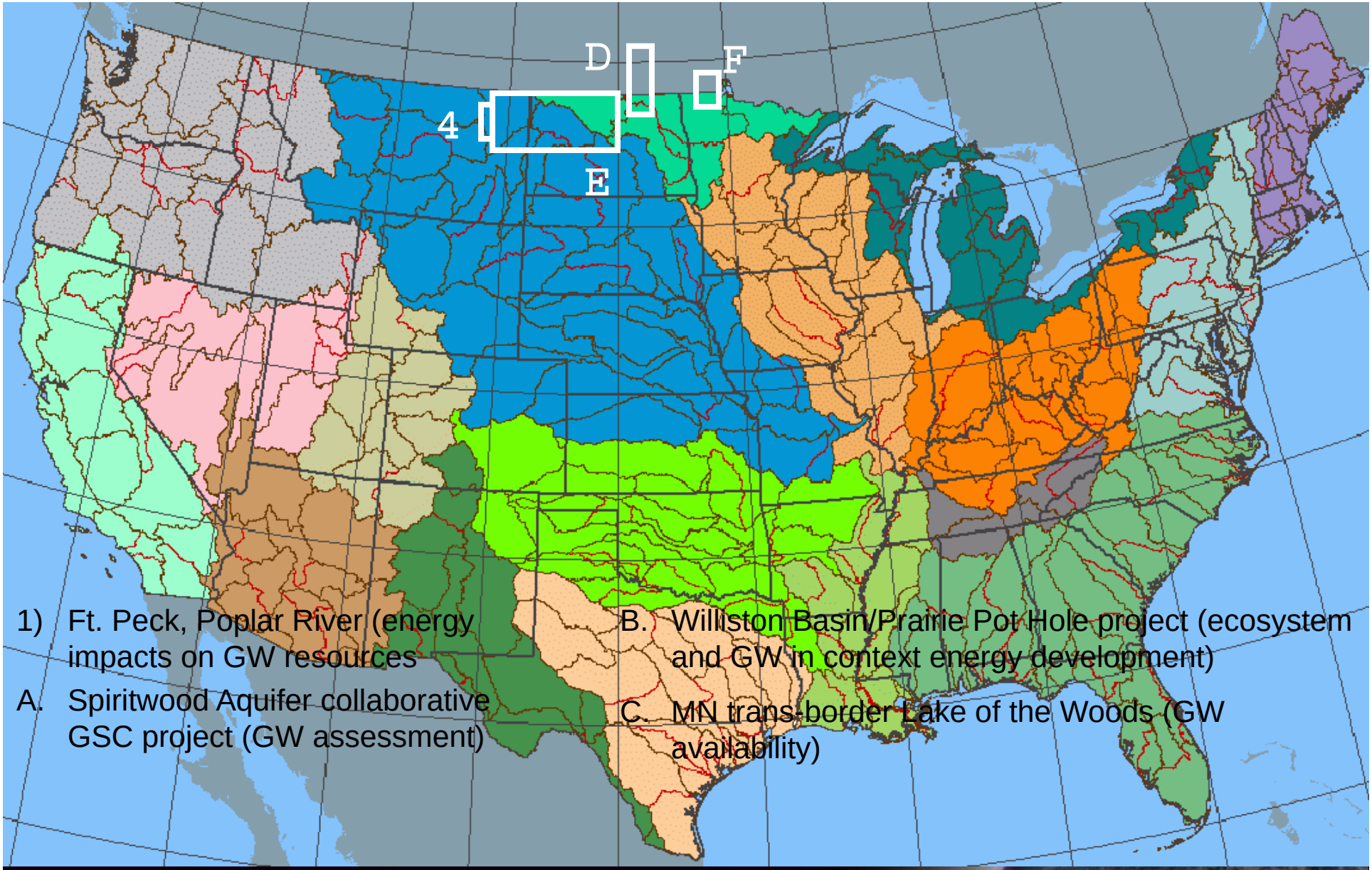

1) Ft. Peck, Poplar River (energy impacts on GW resources

A. Spiritwood Aquifer collaborative GSC project (GW assessment)

B. Williston Basin/Prairie Pot Hole project (ecosystem and GW in context energy development)

C. MN trans-border Lake of the Woods (GW availability)

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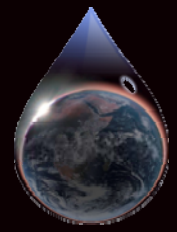

- **Spiritwood** CGS project with USGS collaboration with ND state data collaboration
- **Poplar River** (MT) energy impacted from oil and gas development –groundwater contamination
- **Williston Basin Prairie Pot Hole** ecosystem impacts from past and future energy development and climate change
- **Lake of the Woods** (MN) trans-border aquifer water resource assessment in cooperation with state

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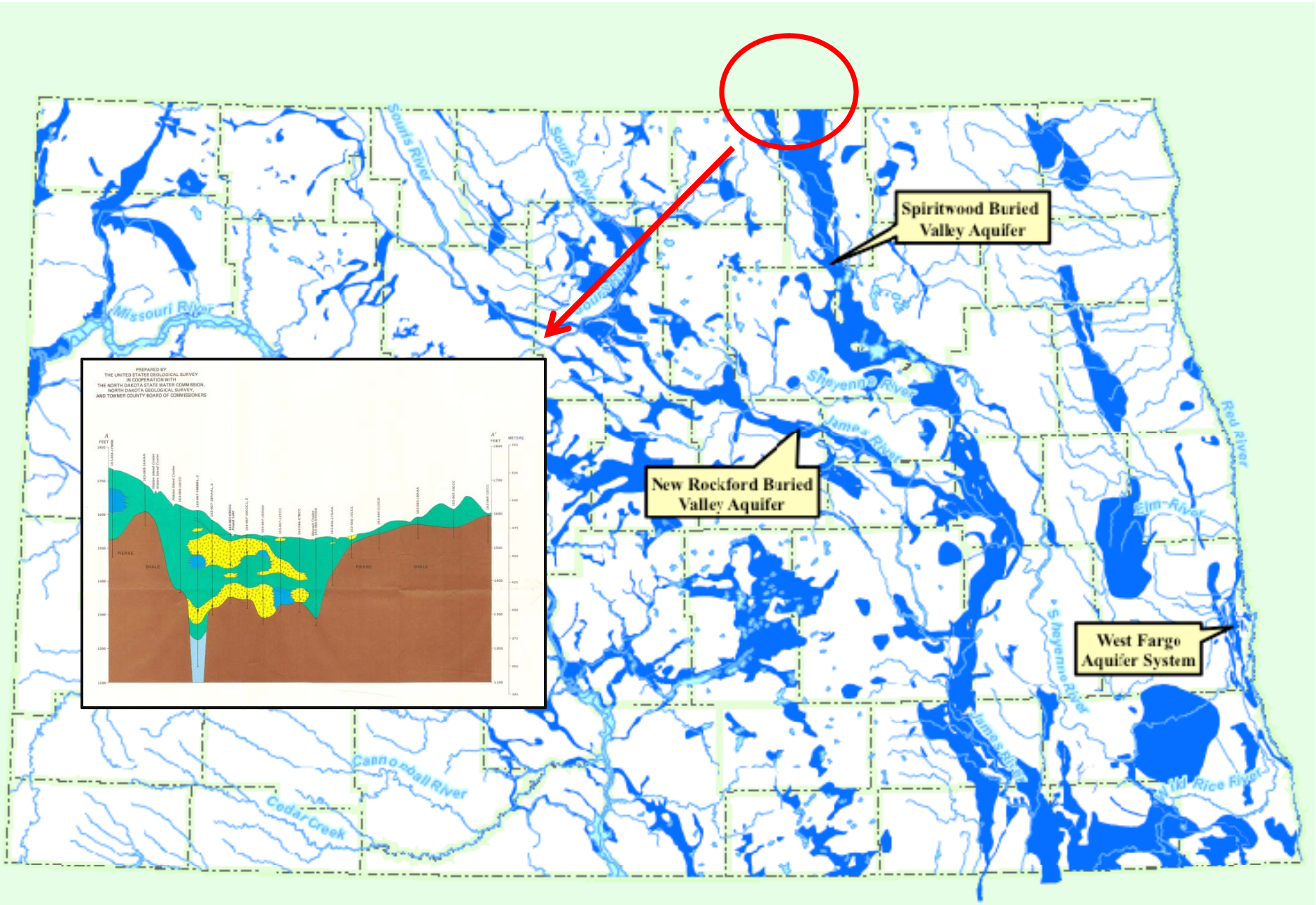
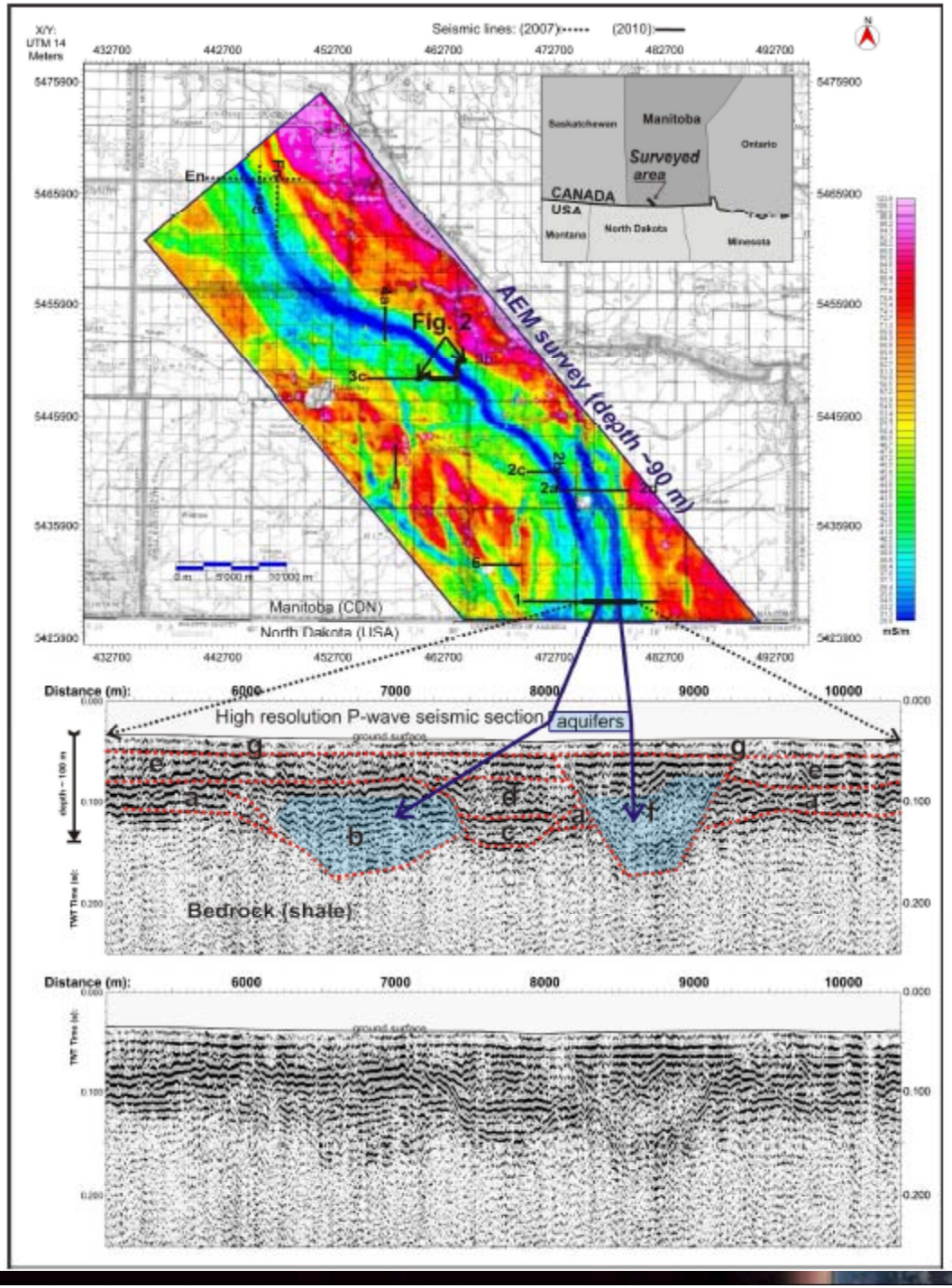


Glacial Drift Aquifers in North Dakota



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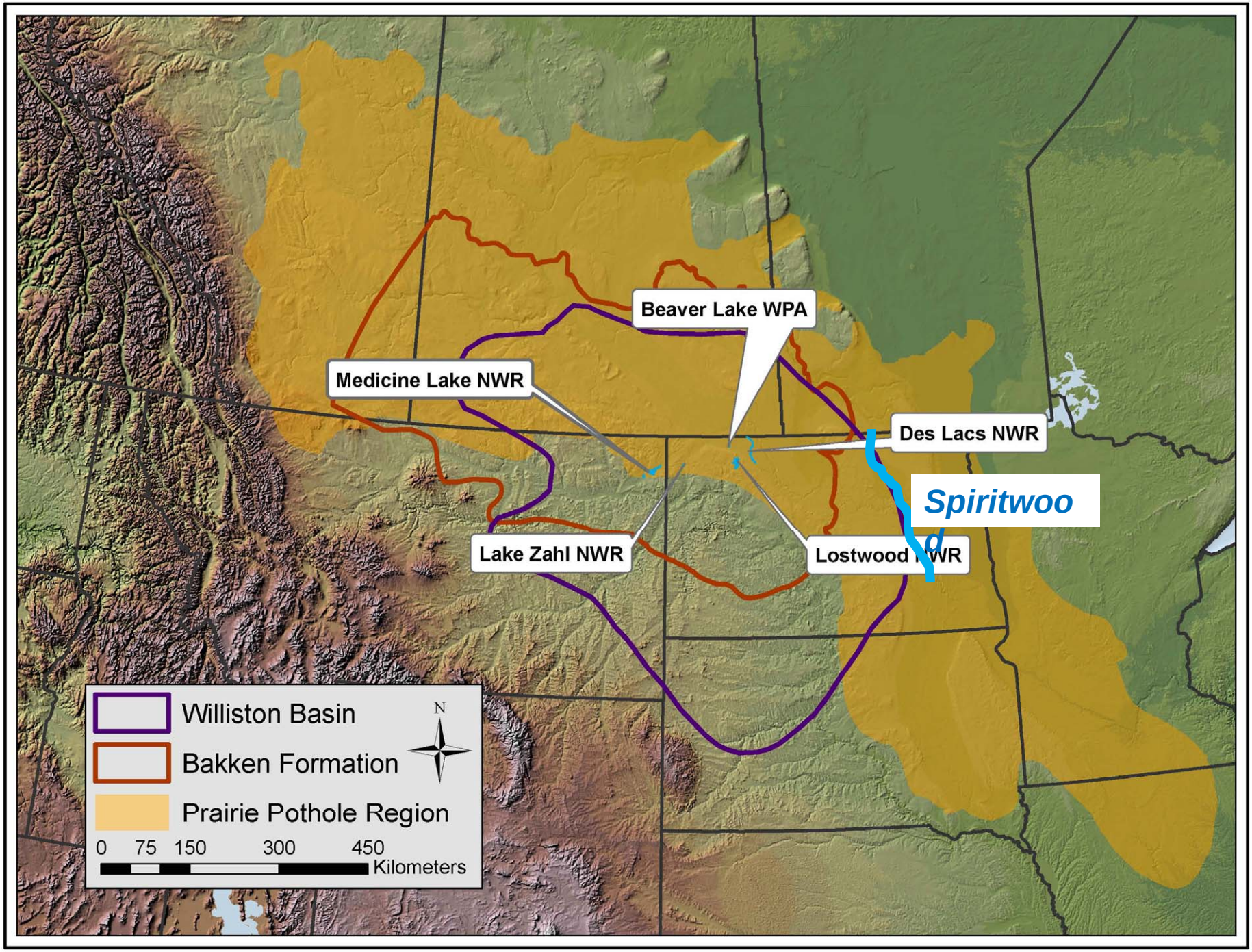
Conserving NATURAL NEBRASKA™ for future generations


Beaver Lake WPA
Medicine Lake NWR
Des Lacs NWR
Spiritwood
Lake Zahl NWR
Lostwood NWR
Williston Basin
Bakken Formation
Prairie Pothole Region
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- Spiritwood
  - Integration of geophysical modeling tools
  - geophysical characterization in the context of USGS and ND state programs in glacial aquifers; ND drilling program provides detailed subsurface information
  - Development of funding for studies on US side for airborne survey; ND state support with drilling and aquifer tests; groundwater modeling by group

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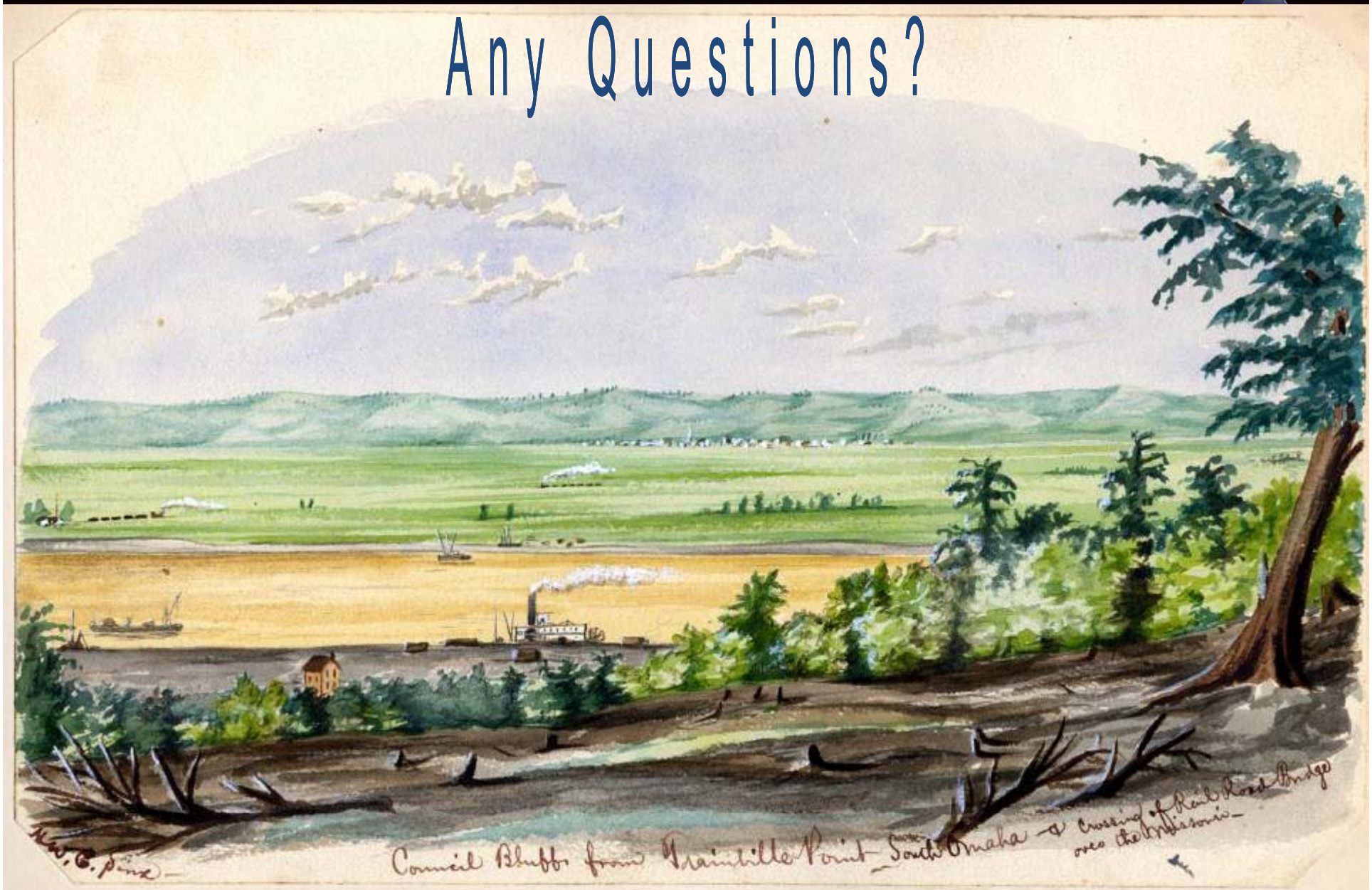
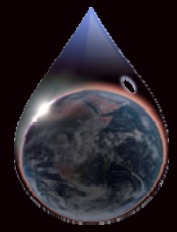
don't stop your curiosity,

Any Questions?



CONTACT INFORMATION



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