Streambed Elevation Uncertainty and Implications for Modeling Stream Baseflow

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UWEC Earth Science Seminar Series

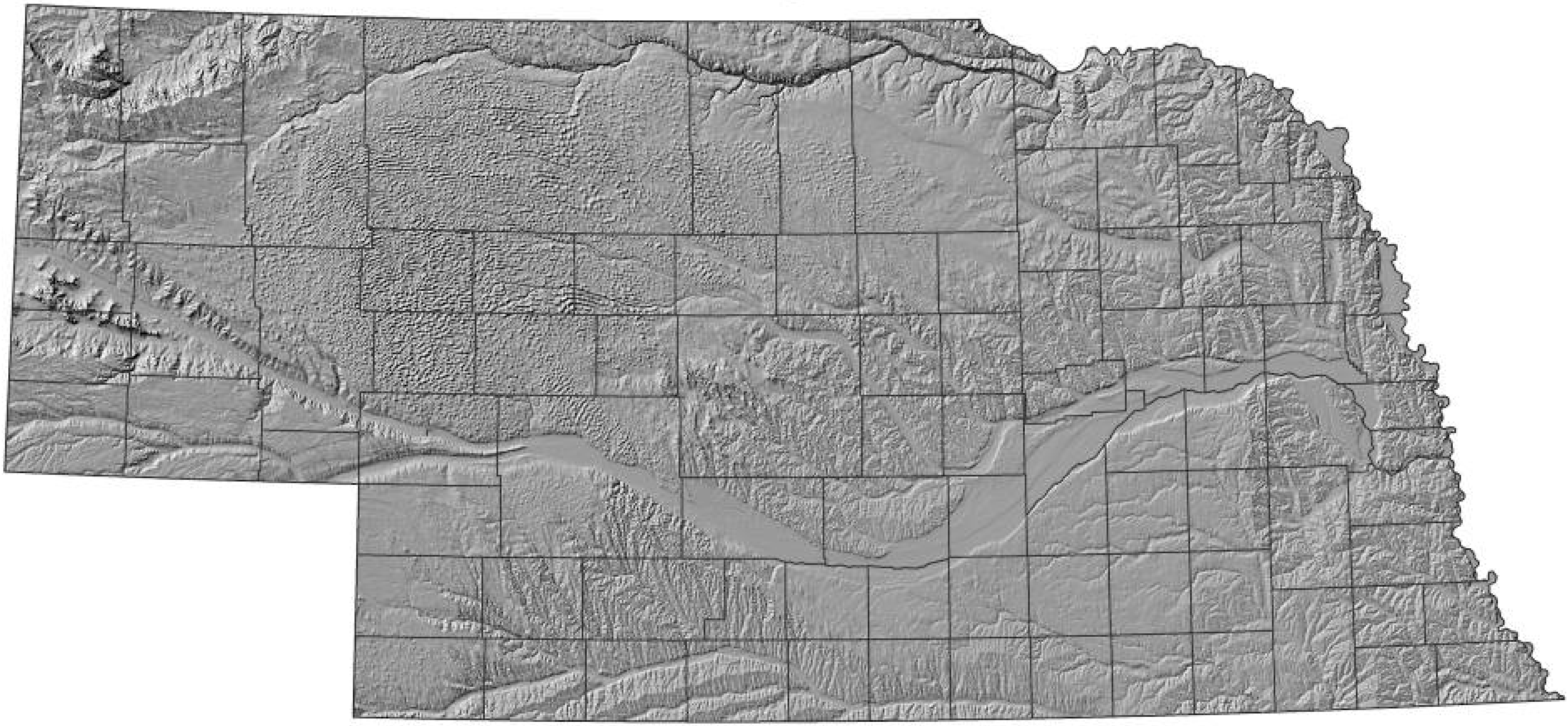
May 2, 2008

Overview

- Nebraska
- History
- Elevation
- Case Study
- What should we do?
- Can we improve?

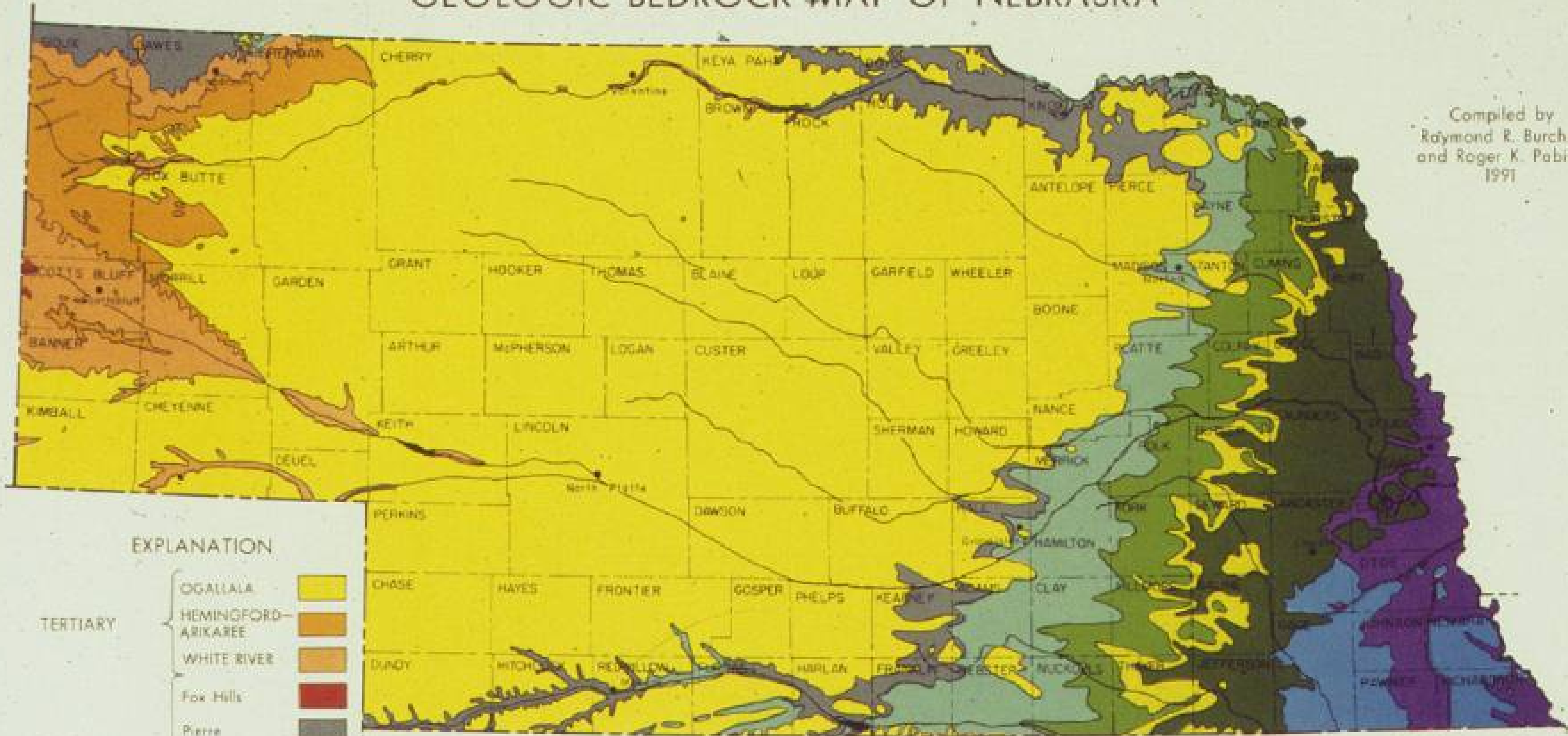
Physical Setting

Shaded Relief Map of Nebraska



GEOLOGIC BEDROCK MAP OF NEBRASKA

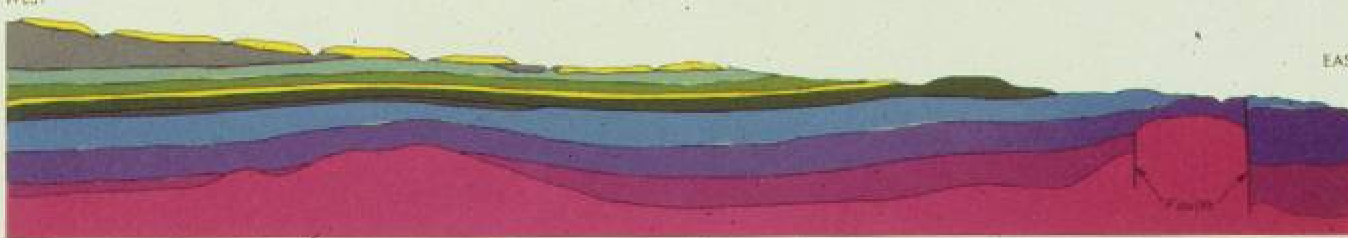
Compiled by
Raymond R. Burchett
and Roger K. Pabian
1991



Drafted by Jerry P. Leach

EXPLANATION

- TERTIARY
  - OGALLALA
  - HEMINGFORD–ARIKAREE
  - WHITE RIVER
- CRETACEOUS
  - Fox Hills
  - Pierre
  - Niobrara
  - Carlile
  - Greenhorn–Graneros
  - DAKOTA
- JURASSIC
- PERMIAN
- PENNSYLVANIAN
- MISSISSIPPIAN, DEVONIAN, SILURIAN, ORDOVICIAN, CAMBRIAN
- PRECAMBRIAN
- Fault



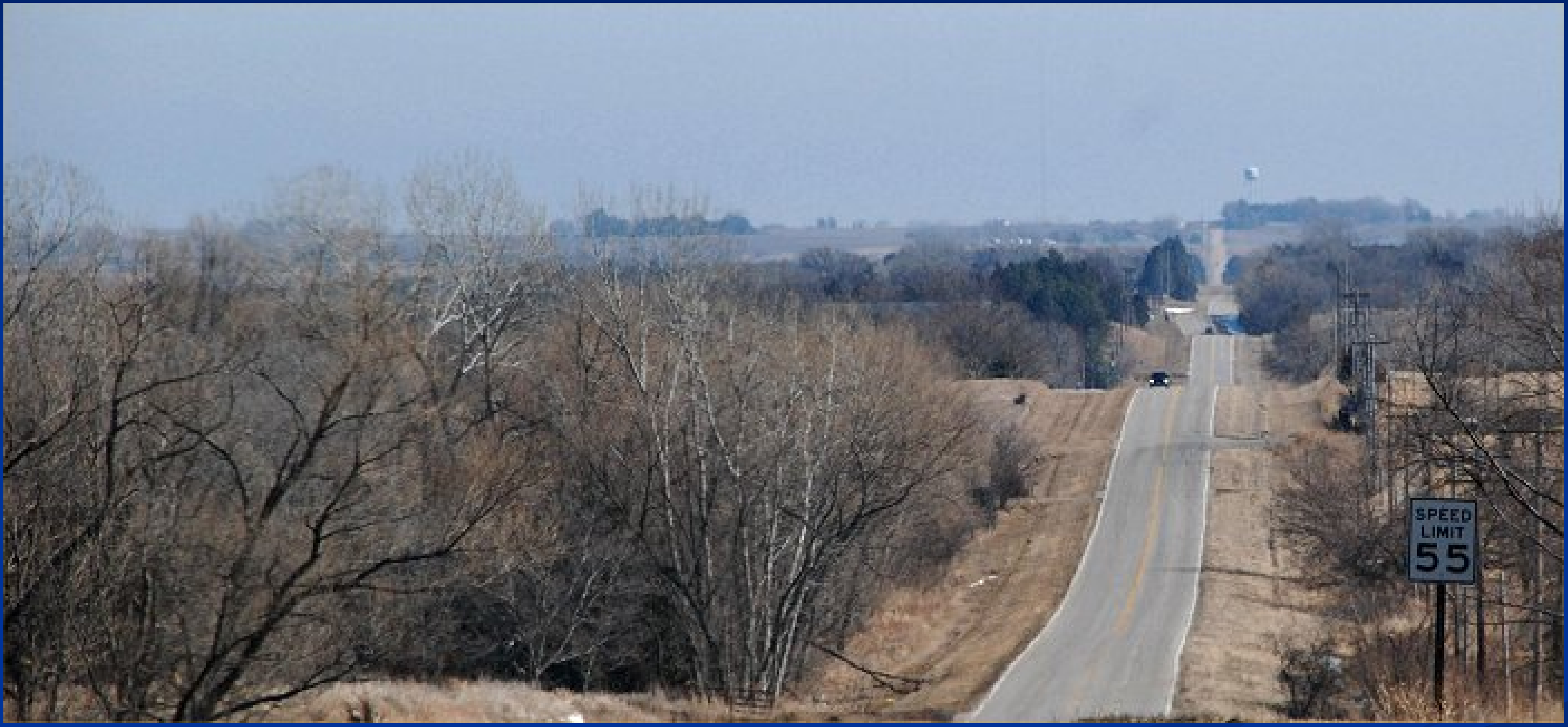
GEOLOGIC CROSS SECTION ALONG SOUTHERN NEBRASKA BORDER

20 0 20 40 60
Scale in Miles

Conservation & Survey Division
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

NOTE: Unconsolidated sediments of Recent and Pleistocene age cover the bedrock throughout much of the State and are not shown.

GMC–2


SPEED
LIMIT
55

A Little History

1850's – Irrigation on the Platte

1895 – Prior appropriation

1933 – Correlative rights

1996 – Integrated management

1998 to 2002 – Kansas v. Nebraska

2007 – KS v. NE Compact Accounting



NO. PLATTE SUBSTATION 51

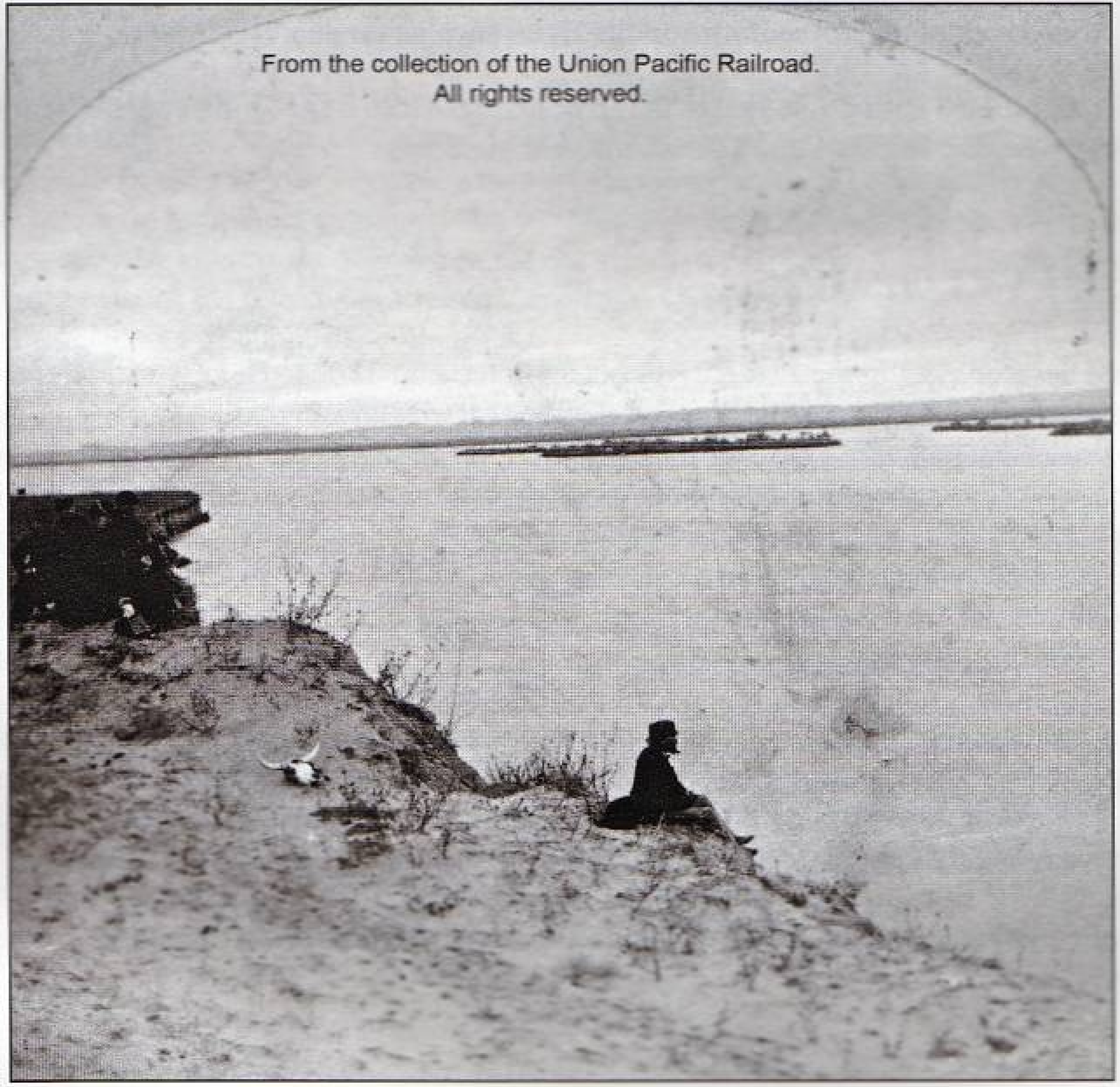
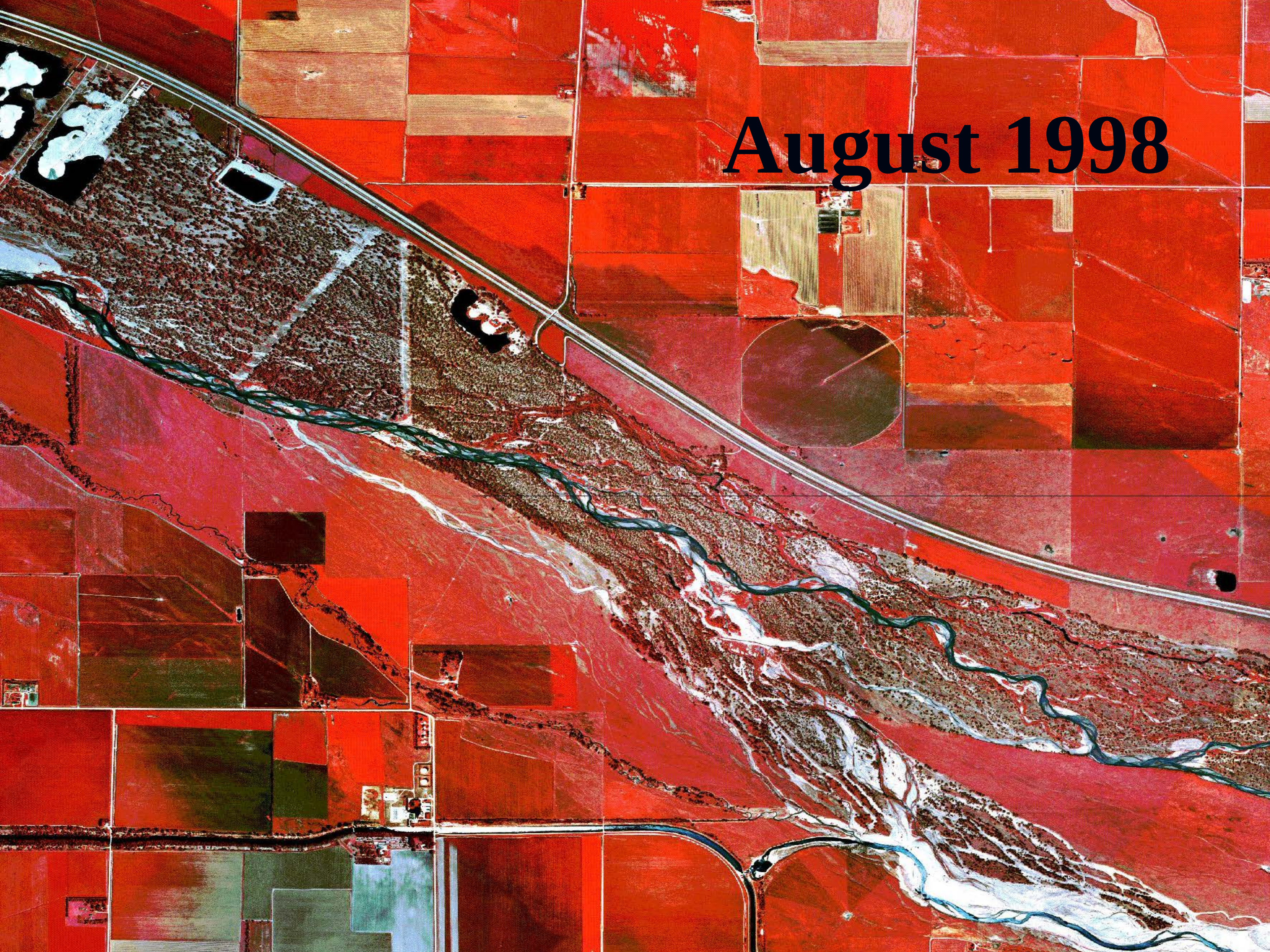



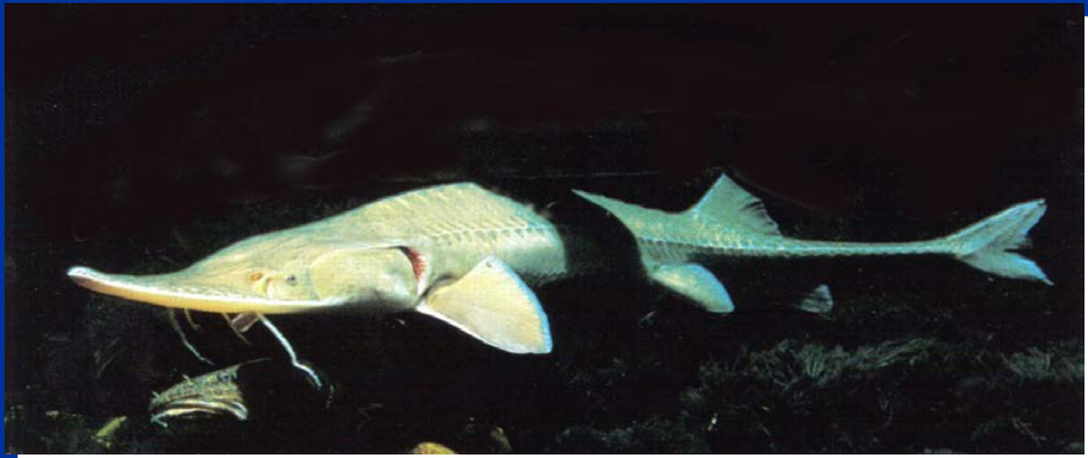
Figure S-2.—The Platte River opposite Platte City, Nebraska (near present-day Cozad, Nebraska) October 1866 (John Carbutt, photographer).


OCT 20 1938
BMS 154 08
BMW
October 1938


August 1998


PUMPKIN CREEK
04223

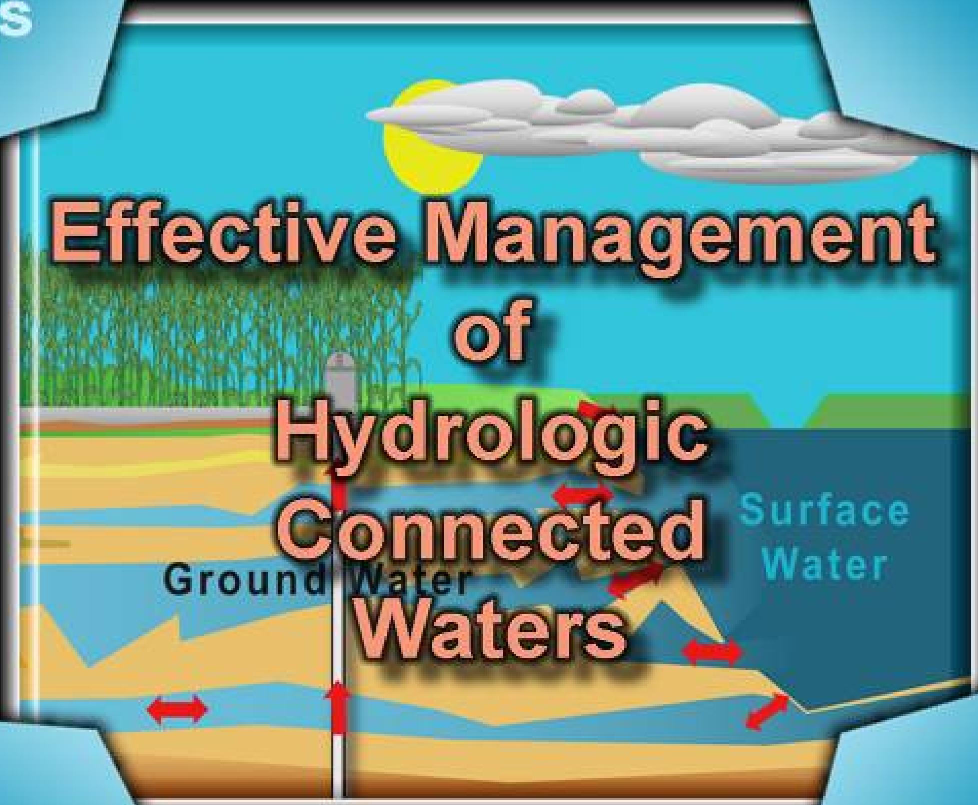
Endangered/Protected Species



Surface Water Prior Appropriations

Ground Water Correlative Rights

Effective Management of Hydrologic Connected Waters

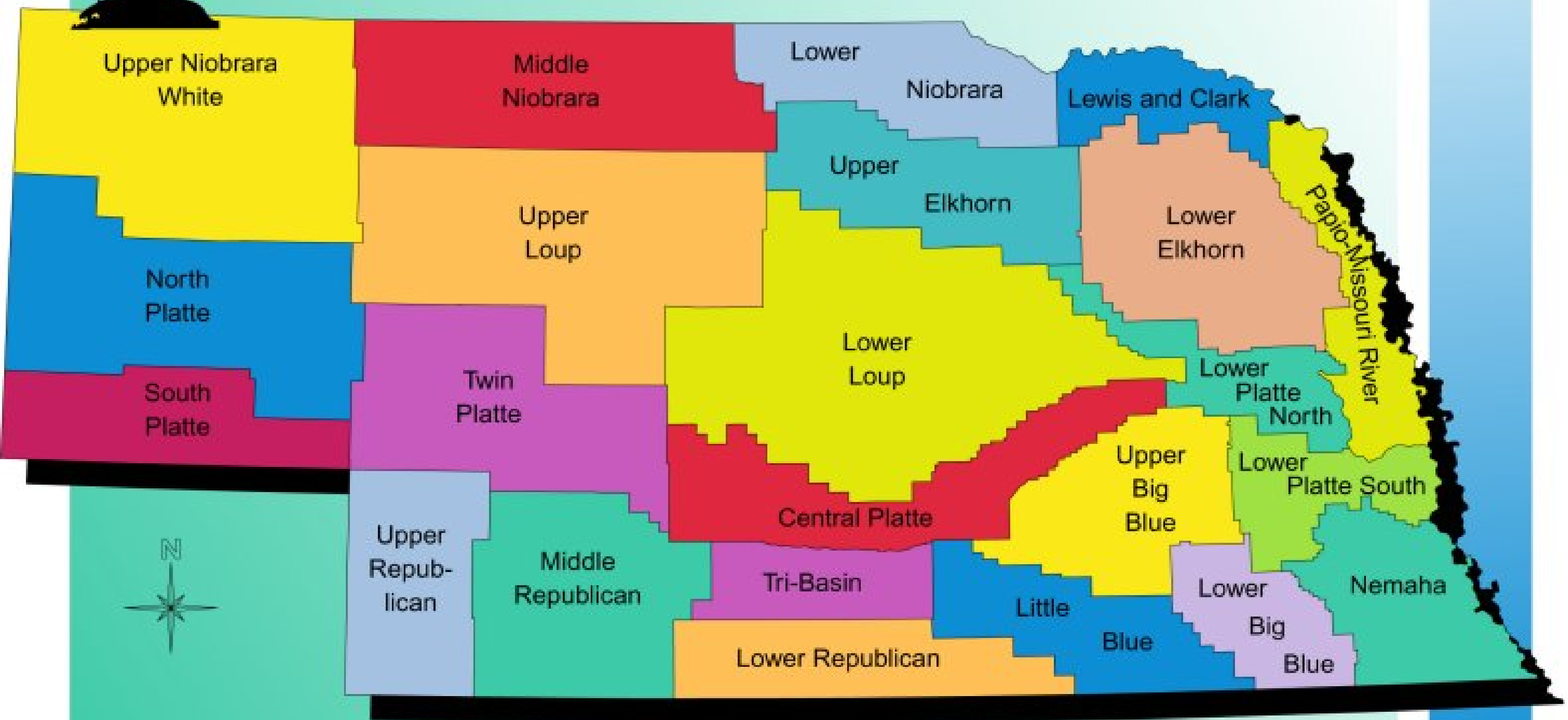


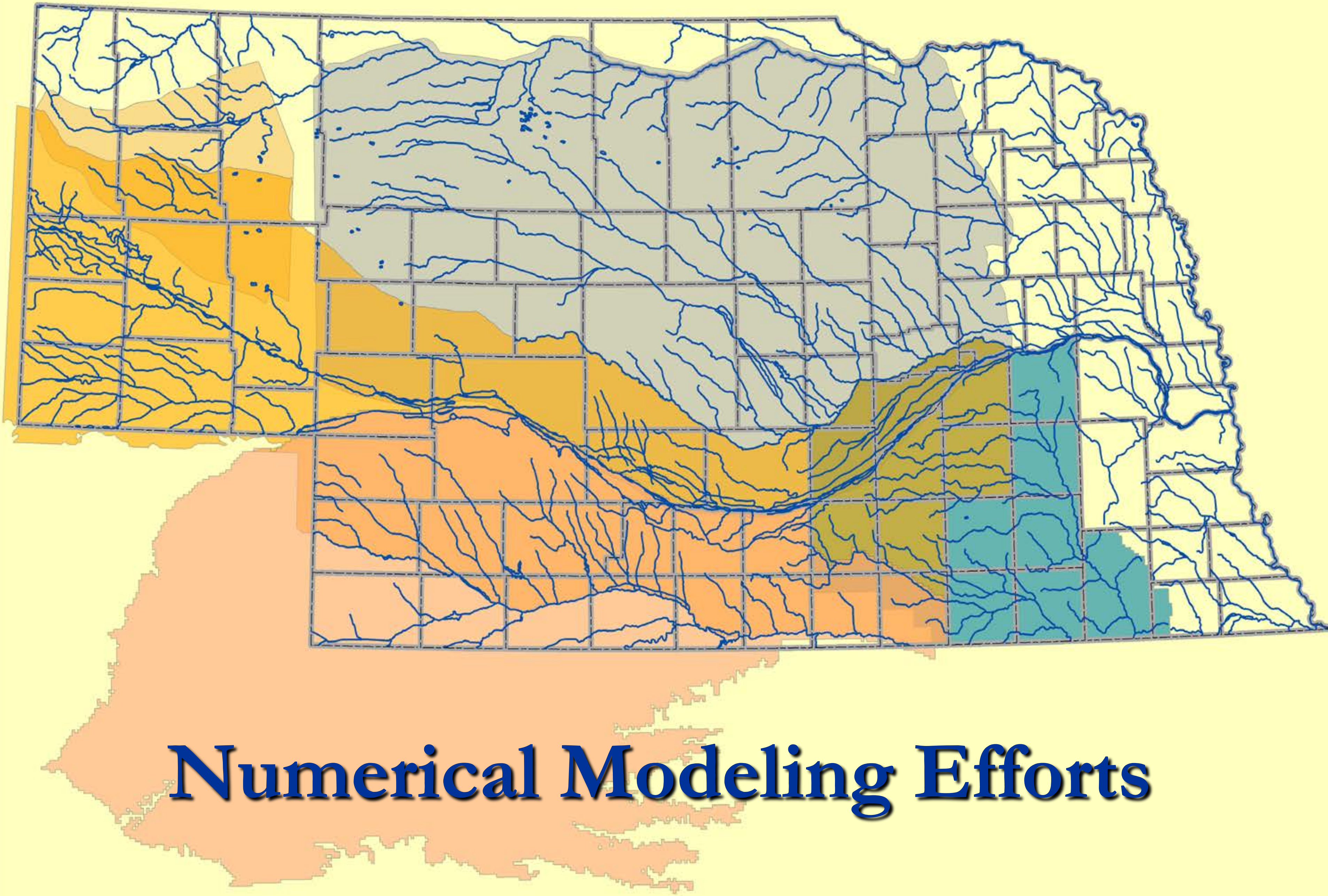
Surface Water Regulated by DNR

Ground Water Regulated by NRDs

Nebraska's

Natural Resources Districts



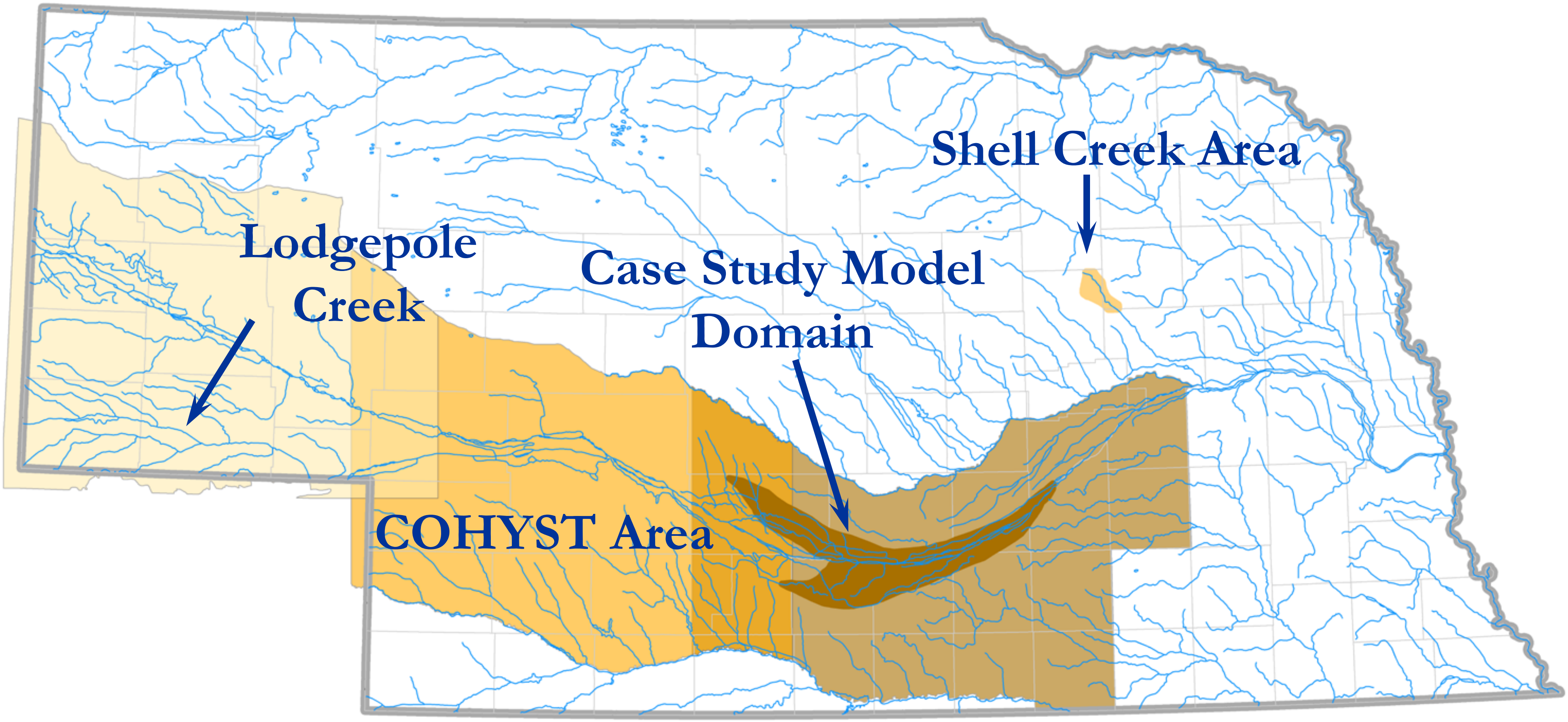


Numerical Modeling Efforts

How well do we know elevation?

- What we use:
  - USGS topographic maps – 1:24,000 hypsography
  - DEM – from USGS 1:24,000 hypsography
  - Surveyed: (Benchmark, GPS, Photogrammetric)

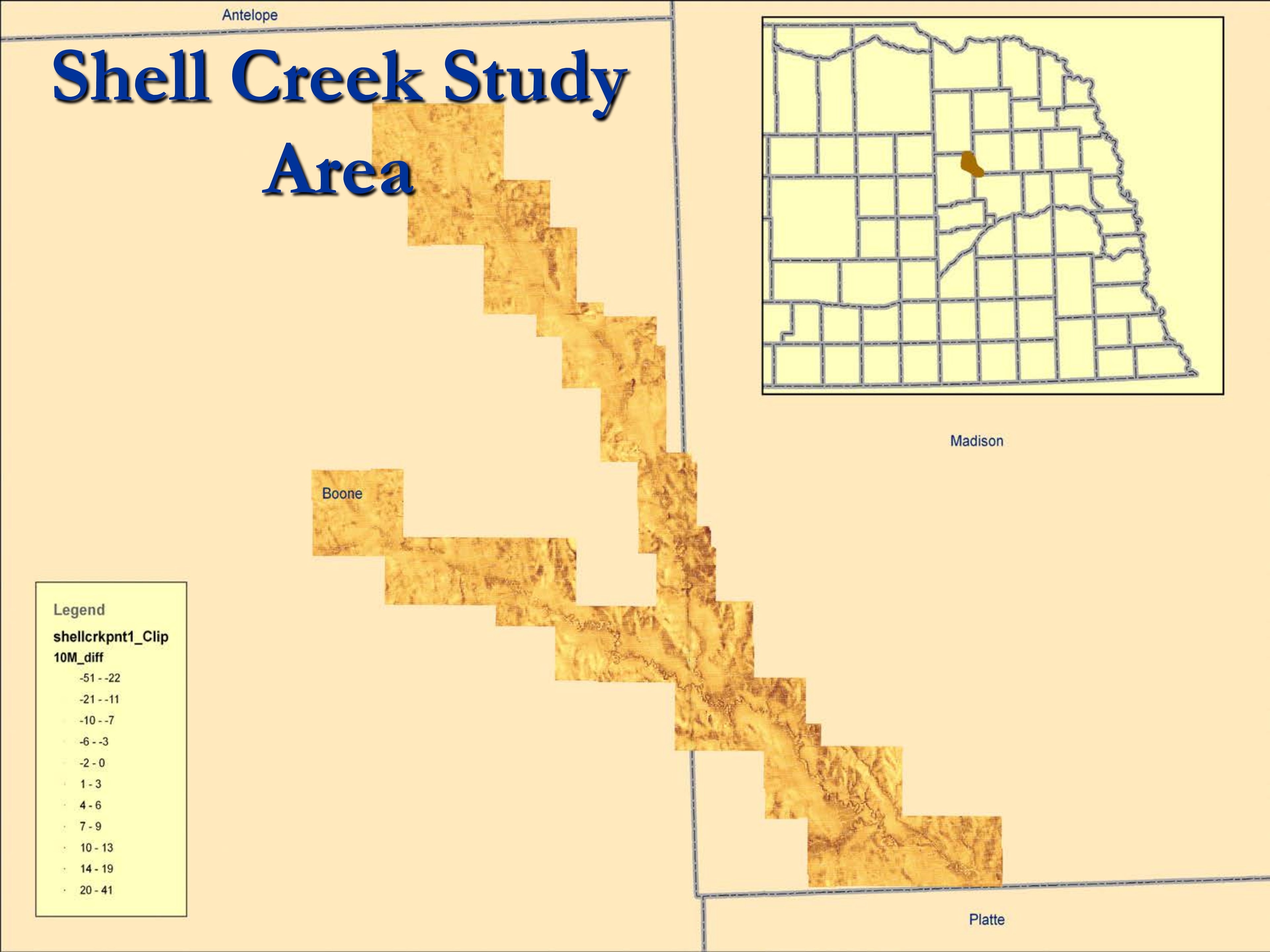
Areas of Investigation



Problem 1

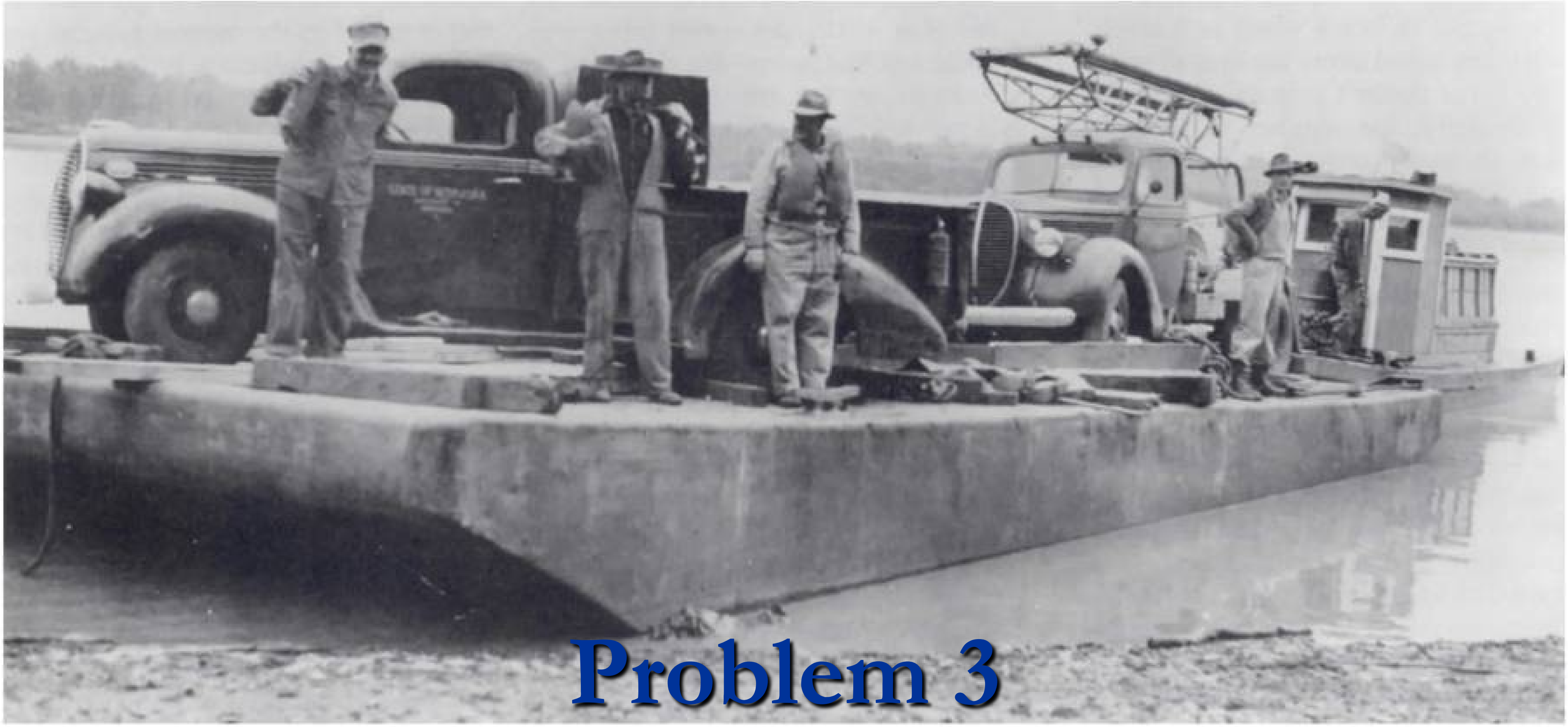
- Elevation is uncertain, comparisons show:
  - DOR Bridge/10M DEM ~11 ft.
  - 30M DEM/DNR Survey ~10 ft.
  - USGS Topo/DNR Survey ~17 ft.
  - 10M DEM/DNR Survey ~1 ft.

Shell Creek Study Area



Problem 2

- Using different elevation datasets produces different baseflow.
  - Lodgepole Creek Example:
    - USGS Topo defined elevation = 17cfs
    - 30M DEM defined elevation = 10cfs
  - Platte River Case Study
    - Baseflow = 145cfs loss to 85cfs gain

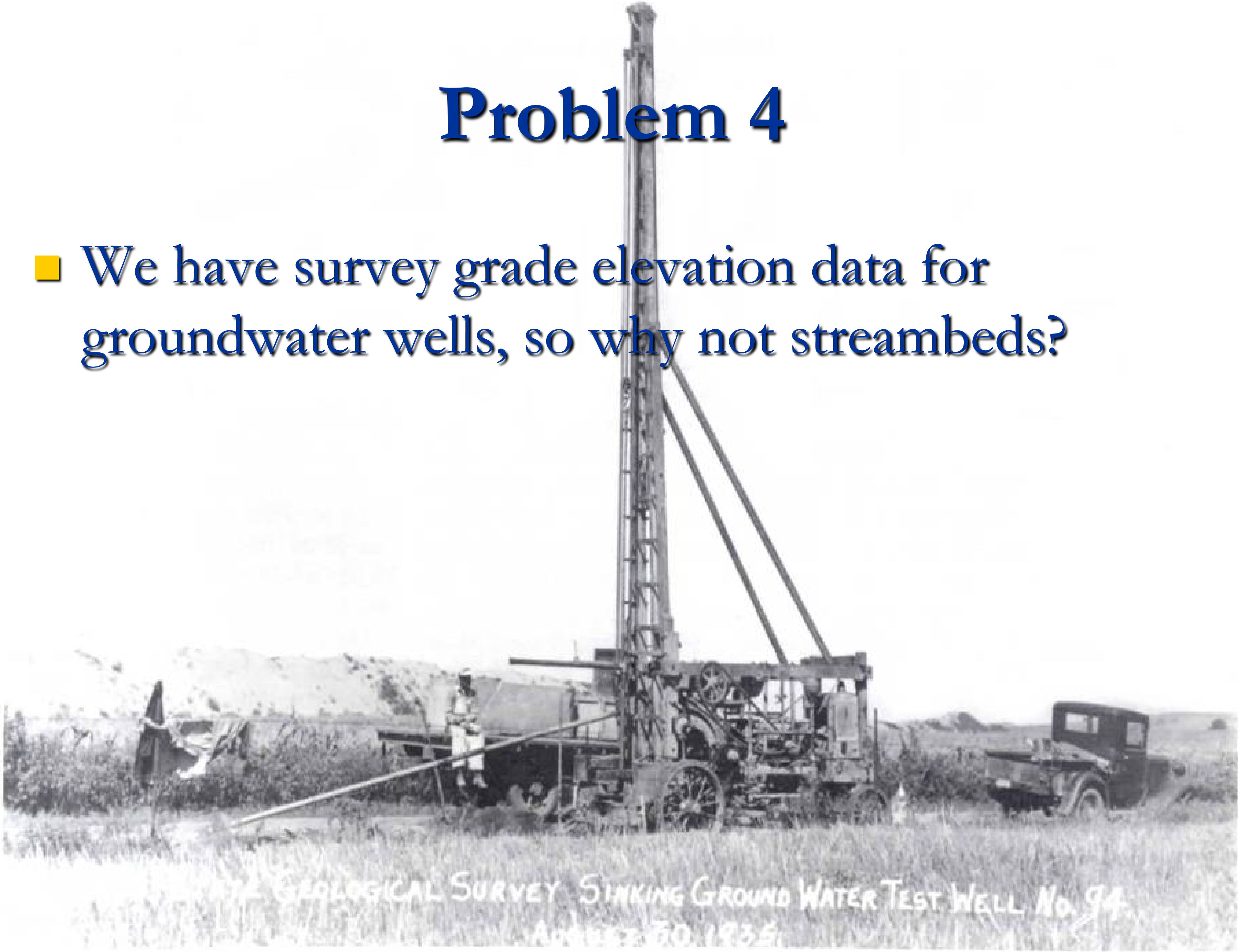


Problem 3

- The essence of conjunctive management is the relationship between groundwater and surface water… we use generic values

Problem 4

- We have survey grade elevation data for groundwater wells, so why not streambeds?



Conservation and Survey

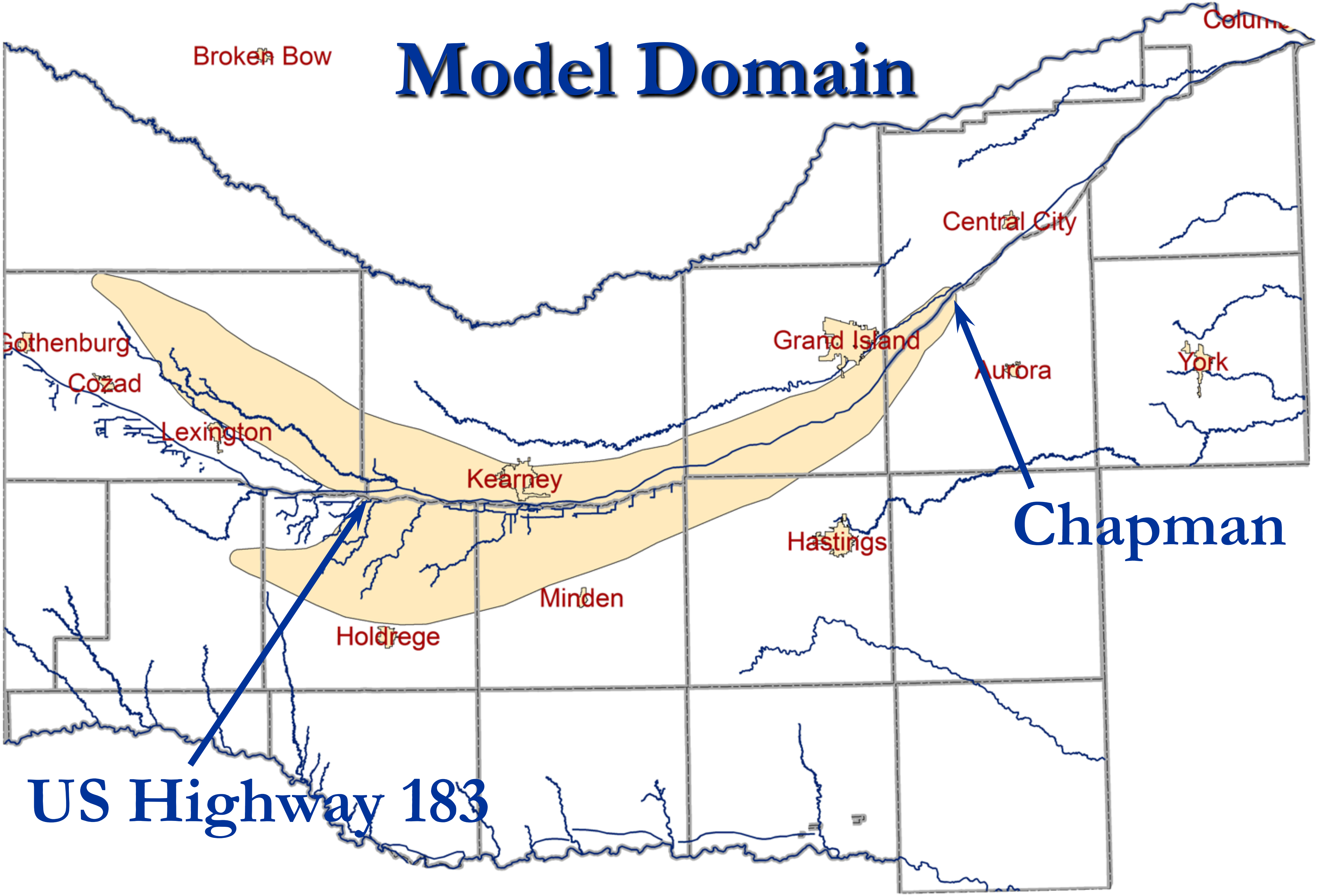
Problem 5

- There is no systematic elevation analysis regarding modeled baseflow in Nebraska.

Case Study – Platte River Model

- Concepts:
  - Currently modeled area.
  - Convert 5 layers to 1 layer model.
  - Refine the model grid.
  - Use steady state condition.
  - Systematically vary stream elevation.
  - Run model with varying inflow.

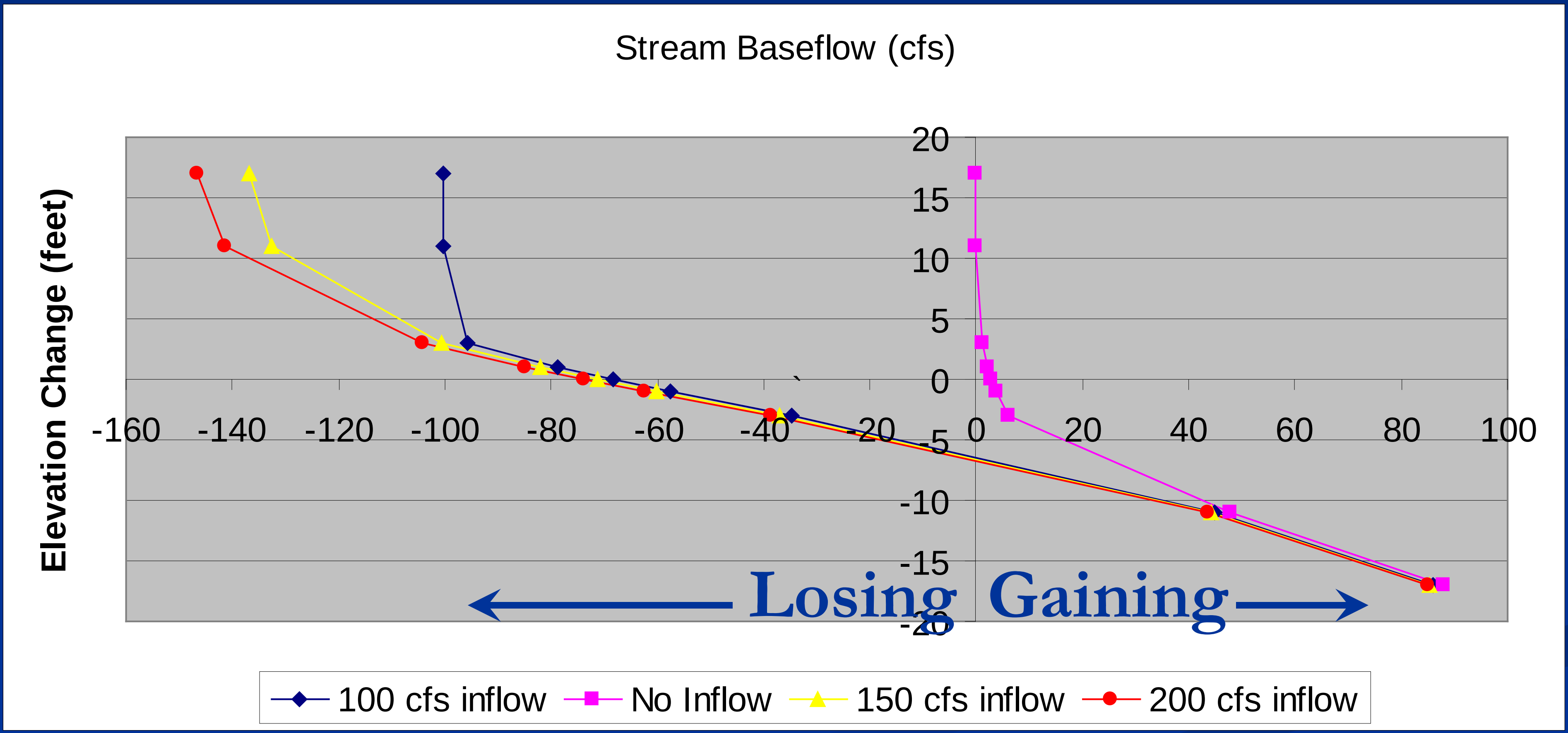
Model Domain



Model Design

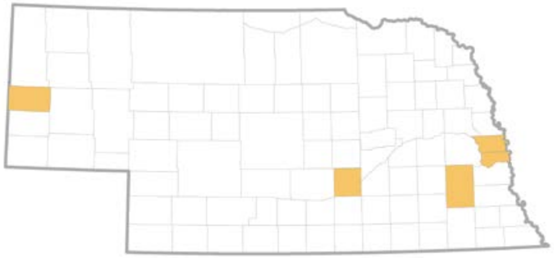
Layers:	1
Rows:	163
Columns:	398
Cell Size:	1320x1320 ft (40 acre)
Base of aquifer:	COHYST Archive
Land surface:	COHYST Archive
Projection:	Stateplane Feet
Code:	mf2k / GMS 6.0

Results

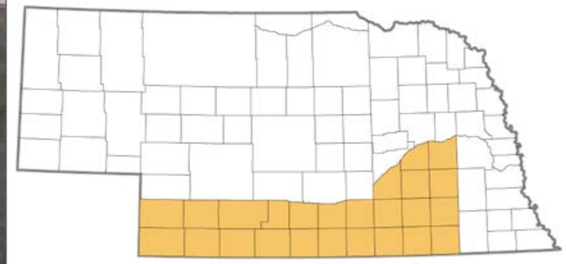

Stream Baseflow (cfs)
Elevation Change (feet)
20
15
10
5
0
-5
-10
-15
-20
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
Losing
Gaining
100 cfs inflow
No Inflow
150 cfs inflow
200 cfs inflow

What should we do?

- Apply the most accurate spatially consistent technology
  - DEM, LiDAR, Surveys
- Buy into the Statewide LiDAR initiative
- Develop tools to use LiDAR technology



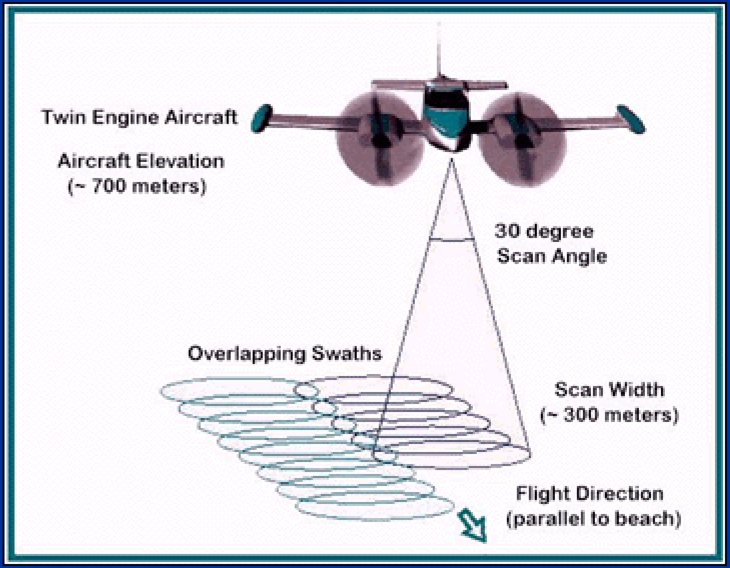
Counties with Data

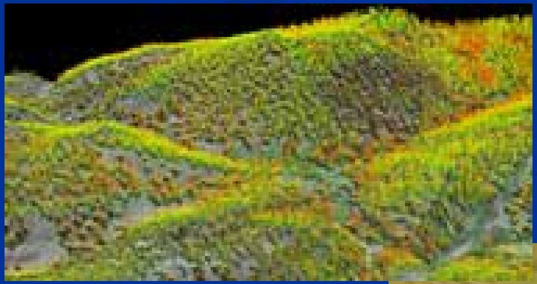


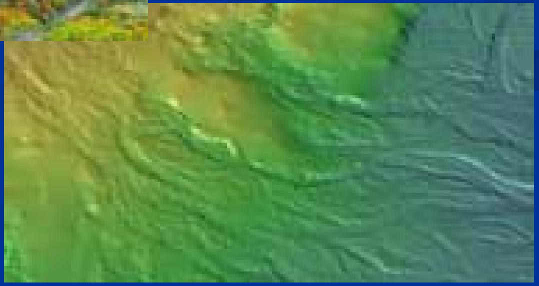
Counties with funds

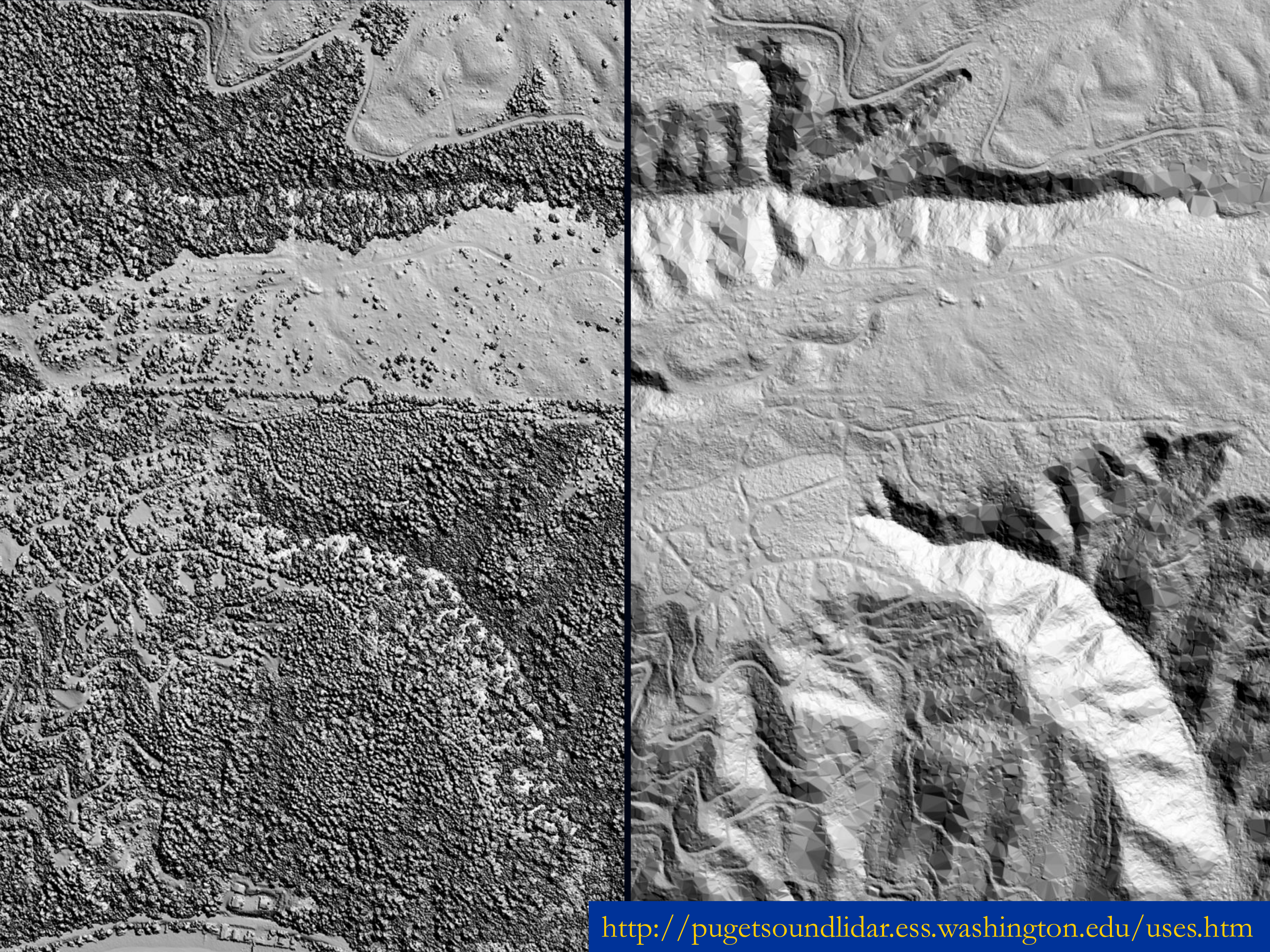
What is LiDAR?

- Light Detection and Ranging
- Go to the USGS Center for LIDAR Information Coordination and Knowledge (CLICK) at: http://lidar.cr.usgs.gov/

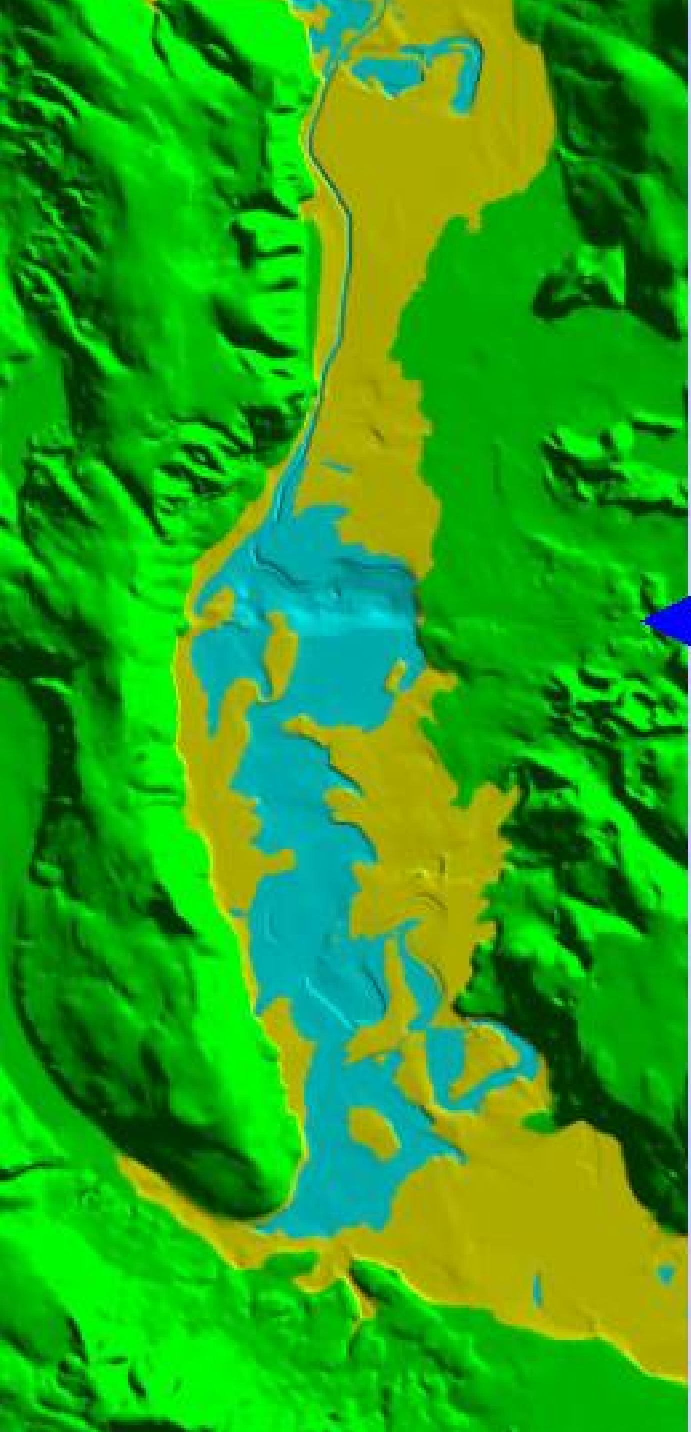








http://pugetsoundlidar.ess.washington.edu/uses.htm



Flood forecasting

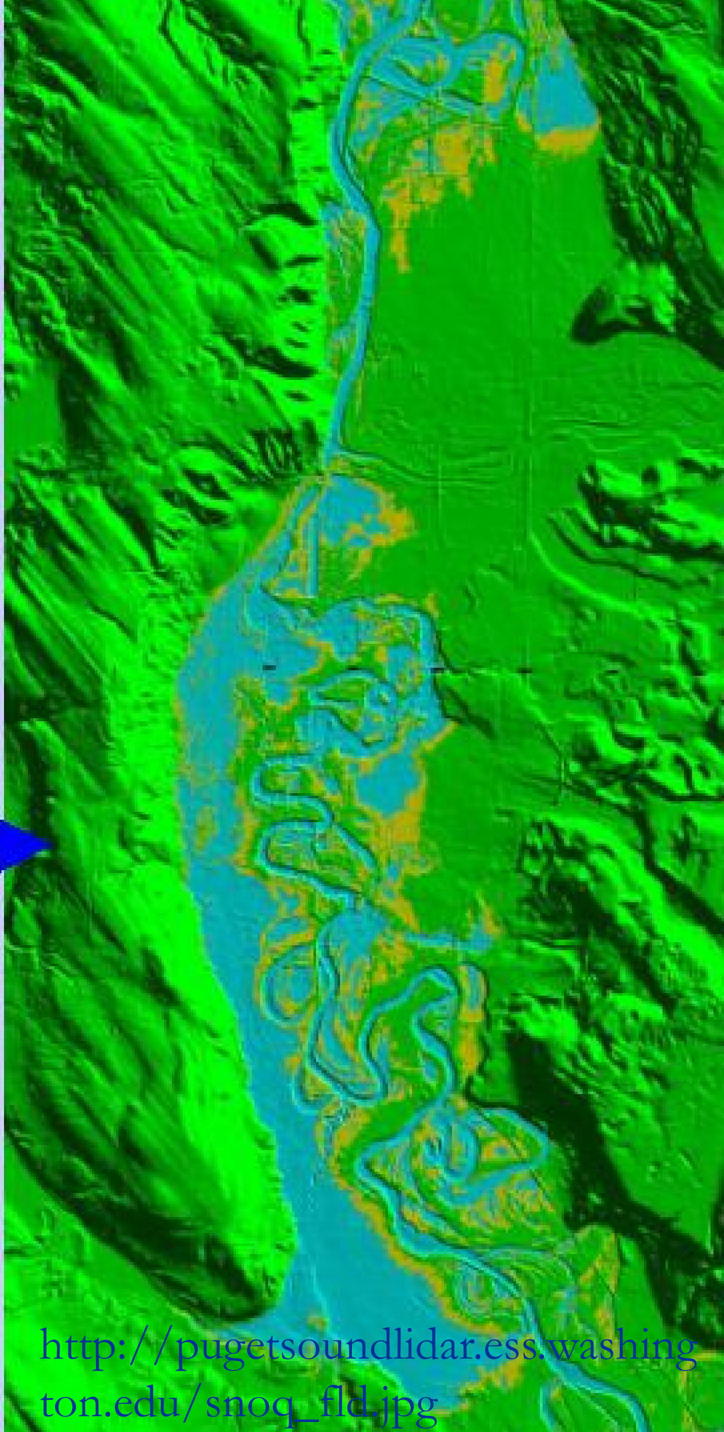
The effect of elevation uncertainty:

10m DEM, ± 1/3 contour interval (7 ft)

LIDAR DEM ± 1 ft

an arbitrary model flood

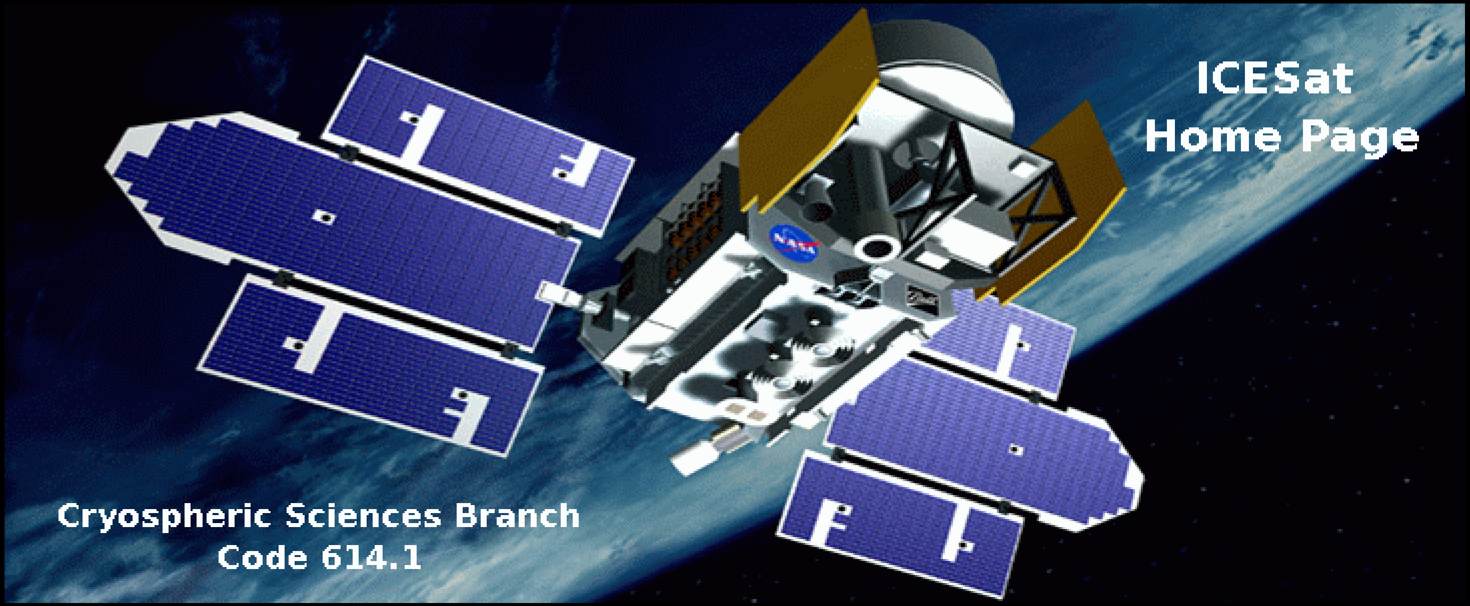
- dry
- ??
- wet

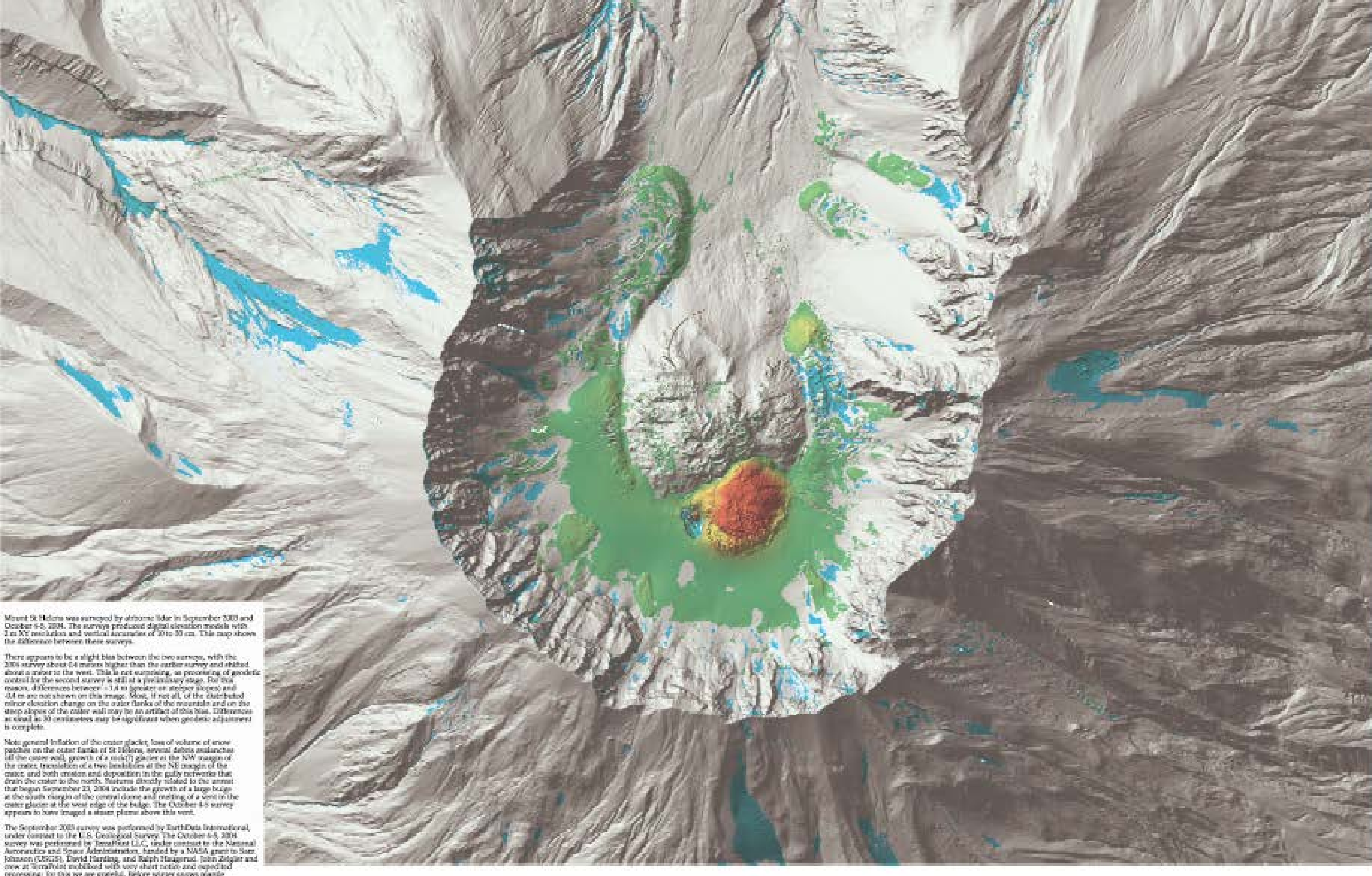


http://pugetsoundlidar.ess.washington.edu/snoq_fld.jpg

NASA ICESat

http://icesat.gsfc.nasa.gov/





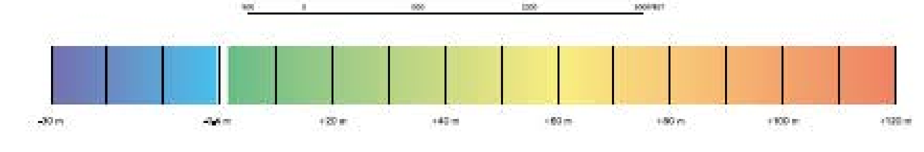
Mount St Helens was surveyed by airborne lidar in September 2003 and October 4-5, 2004. The surveys produced digital elevation models with 2 m XY resolution and vertical accuracies of 10 to 30 cm. This map shows the difference between these surveys.

There appears to be a slight bias between the two surveys, with the 2004 survey about 0.4 meters higher than the earlier survey and shifted about a meter to the west. This is not surprising, as processing of geodetic control for the second survey is still at a preliminary stage. For this reason, differences between +1.4 m (greater on steeper slopes) and -0.4 m are not shown on this image. Most, if not all, of the distributed minor elevation change on the outer flanks of the mountain and on the steep slopes of the crater wall may be an artifact of this bias. Differences as small as 30 centimeters may be significant when geodetic adjustment is complete.

Note general inflation of the crater glacier, loss of volume of snow patches on the outer flanks of St Helens, several debris avalanches off the crater wall, growth of a rock(?) glacier at the NW margin of the crater, translation of a few landslides at the NE margin of the crater, and both erosion and deposition in the gully networks that drain the crater to the north. Features directly related to the unrest that began September 23, 2004 include the growth of a large bulge at the south margin of the central dome and melting of a vent in the crater glacier at the west edge of the bulge. The October 4-5 survey appears to have imaged a steam plume above this vent.

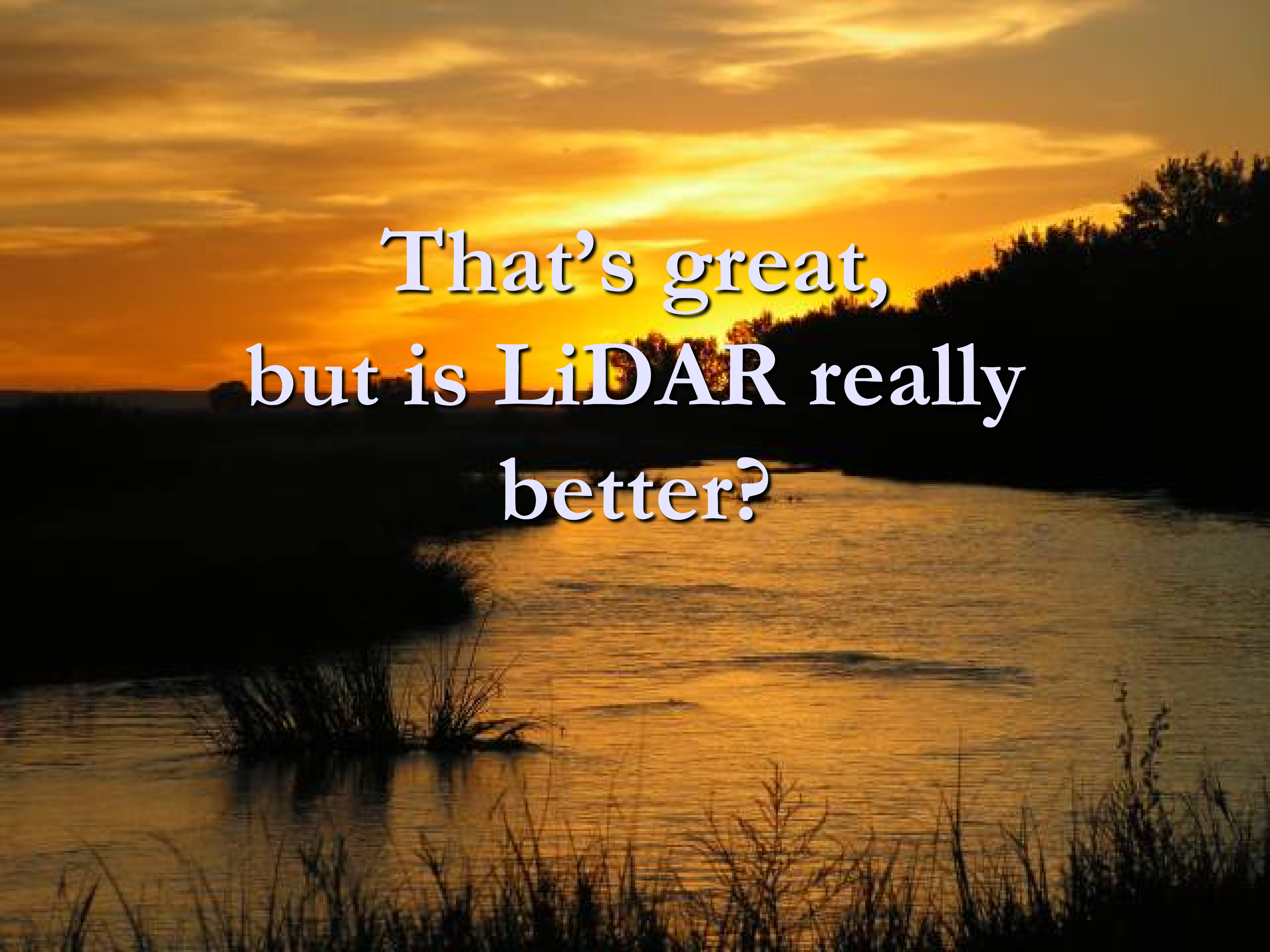
The September 2003 survey was performed by EarthData International, under contract to the U.S. Geological Survey. The October 4-5, 2004 survey was performed by TerraPoint LLC, under contract to the National Aeronautics and Space Administration, funded by a NASA grant to Sam Johnson (USGS), David Harding, and Ralph Haugerud. John Ziegler and crew at TerraPoint mobilized with very short notice and expedited processing; for this we are grateful. Before winter snows blanket Mount St Helens we may be able to secure as many as 4 additional surveys to document changes during this period of volcanic activity.

Volume increase in area of new dome: 5.3 million cubic meters



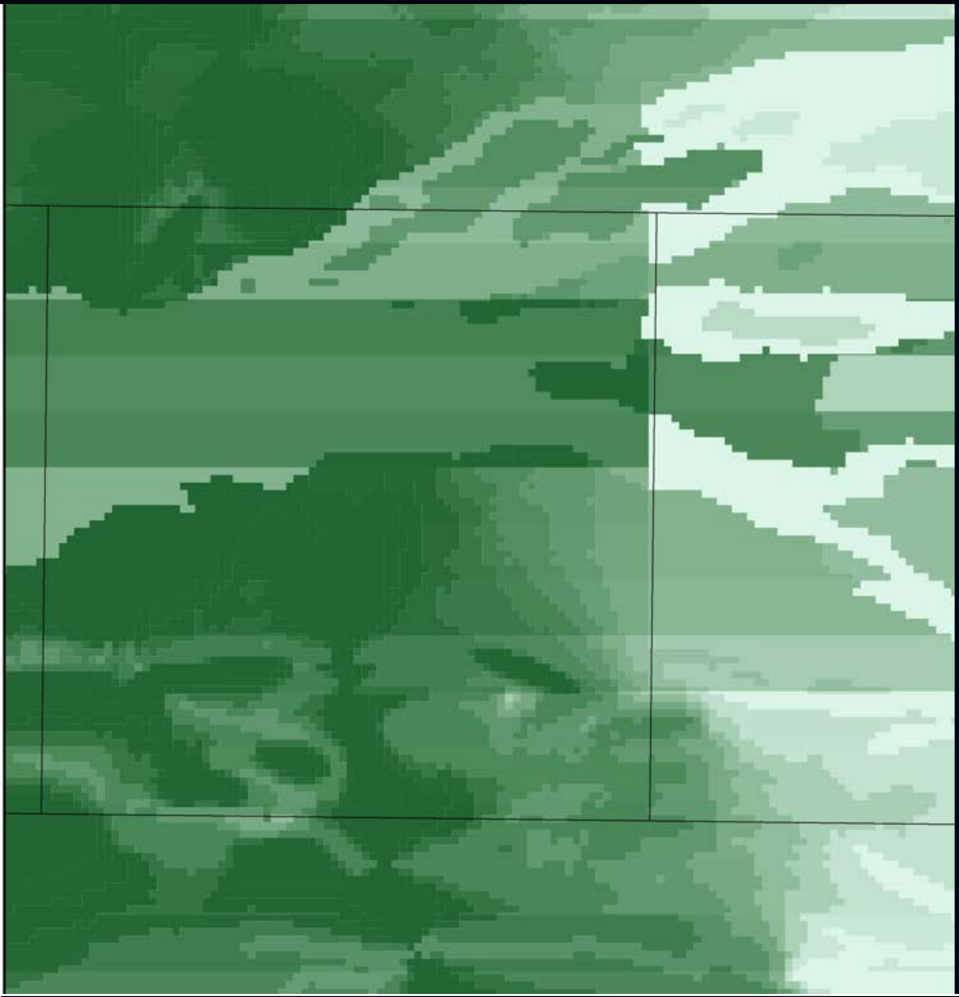
Elevation change at Mt St Helens, September 2003 to October 4-5, 2004

Ralph Haugerud (USGS), David Harding (NASA), Vivian Queija (USGS), Linda Mark (USGS)


That's great,
but is LiDAR really
better?

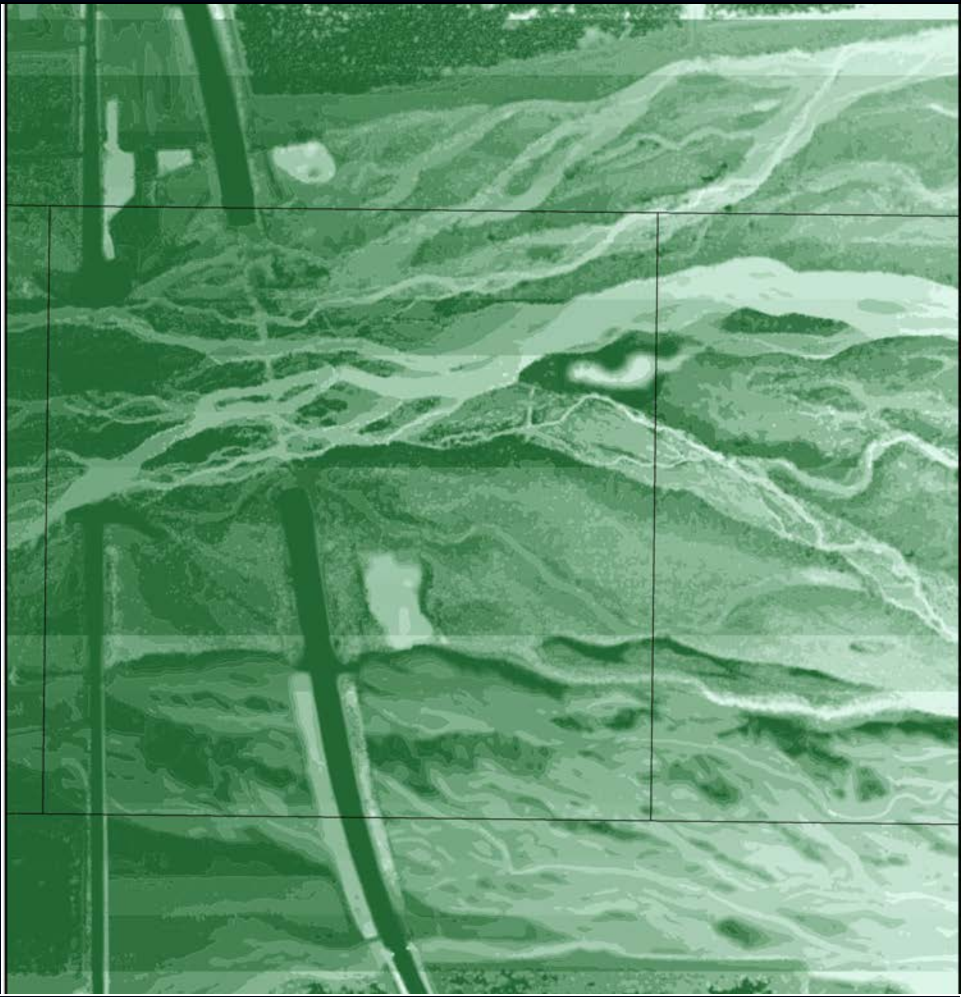
10 Meter DEM

Vertical accuracy = +/- ½ contour interval +/- processing error (10 ft.)



1 Meter LiDAR

Vertical accuracy = +/- 15cm (~0.5ft)



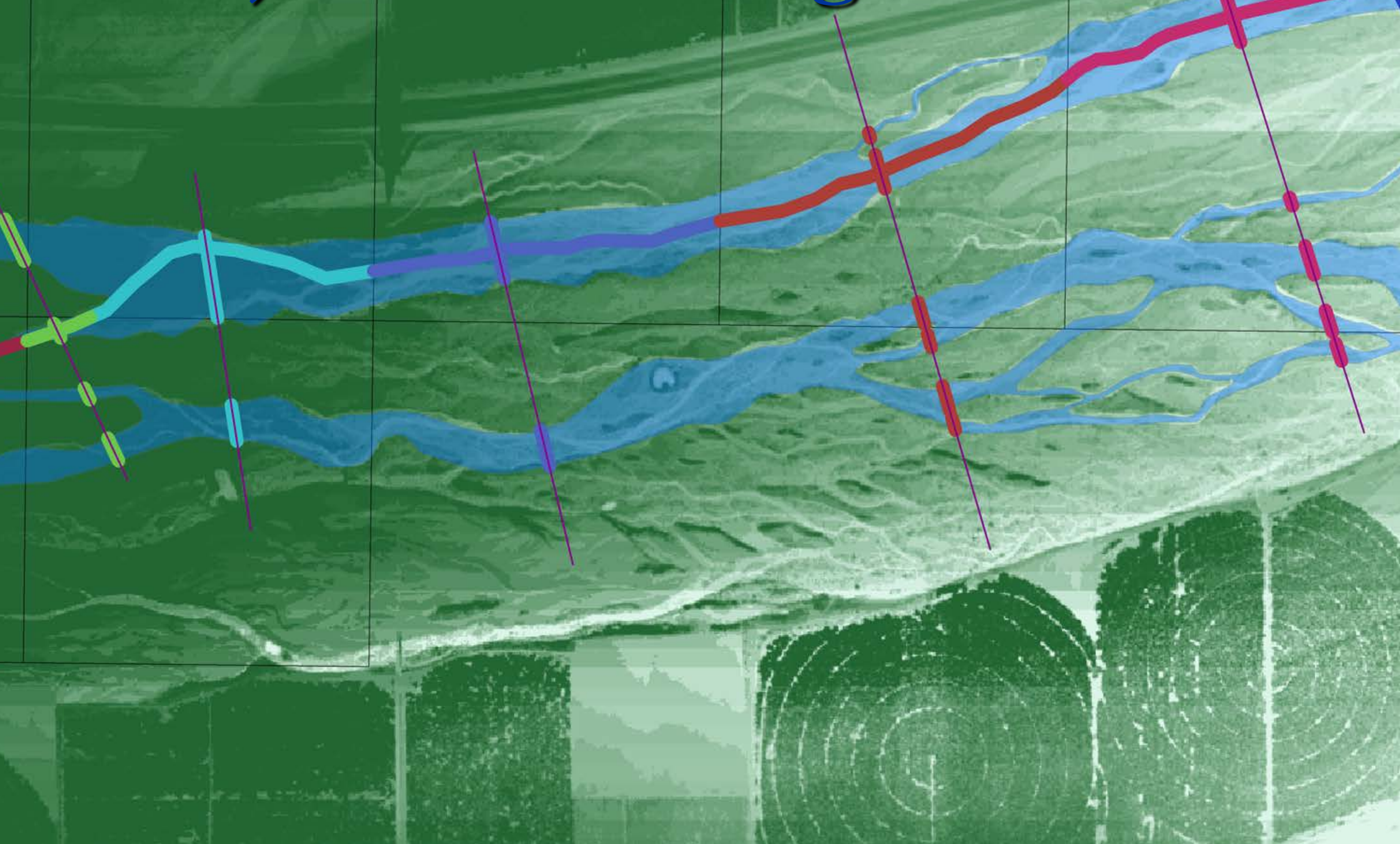
LiDAR data from: Woodward, B.K., 2008, Streamflow and Topographic Characteristics of the Platte River near Grand Island, Nebraska, 1938-2007: U.S. Geological Survey Data Series Report 2008-xxxx, xx p.

Can we improve the models?

DNR is building:

- Conjunctive Management Tool
- Conservation Practices Tool
- Recharge Distribution Tool

Conjunctive Management Tool



rom: Woodward, B.K., 2008, Streamflow and Topographic Characteristics of the Platte River near Grand Island,

Conservation Practices Tool

- Use high resolution LiDAR to delineate:
  - Terraces
  - Contour cultivation
  - Reuse pits
  - Small reservoirs
  - Others?

From: Woodward, B.K., 2008, Streamflow and Topographic Characteristics of the Platte River near Grand Island, Nebraska, 1938-2007: U.S. Geological Survey Data Series Report 2008-xxxx, xx p.

Recharge Distribution Tool

- Use LiDAR to identify locations where water collects:
  - Road ditches
  - Closed basins
  - Terraces
  - Beaver Dams?
  - Others?


Questions?