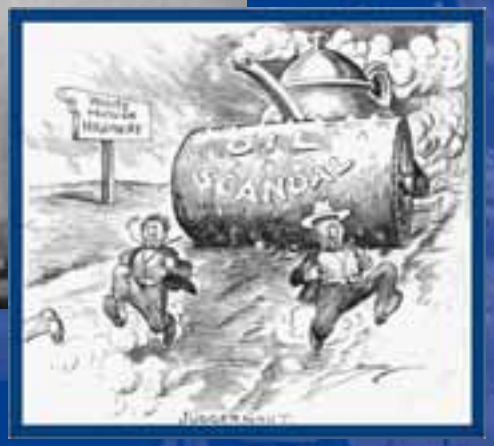
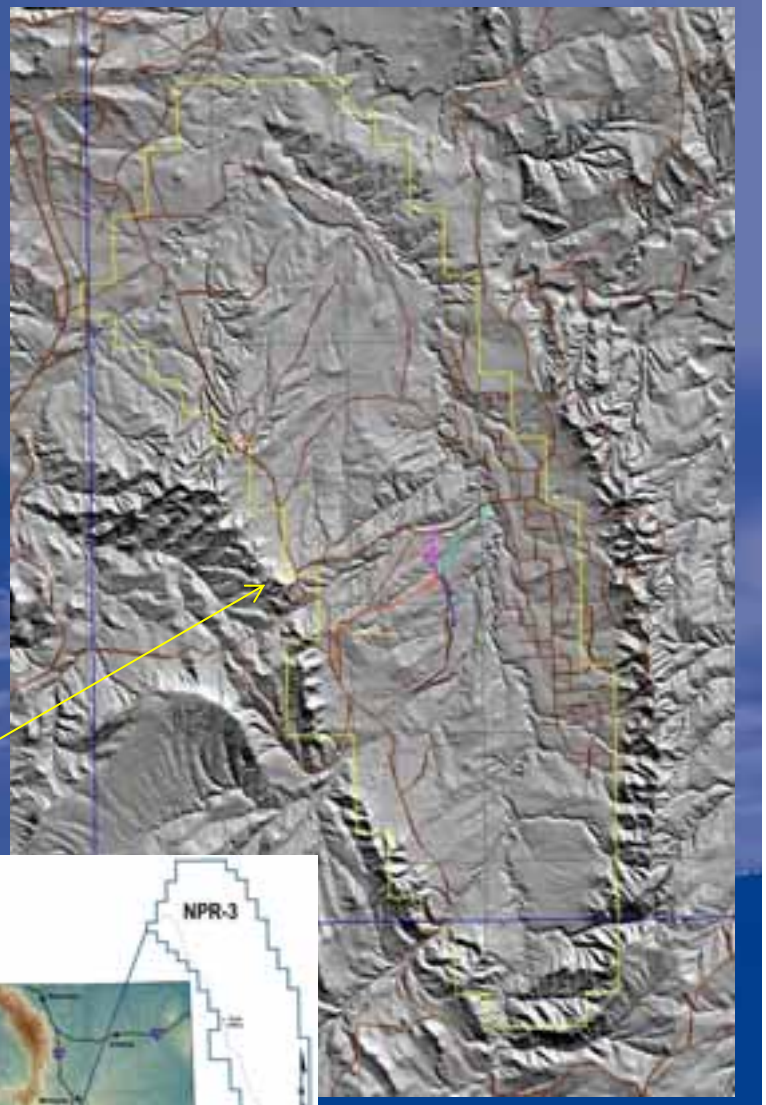
GIS for Oil Operations, History, Geology, and Imagery at Teapot Dome, Wyoming

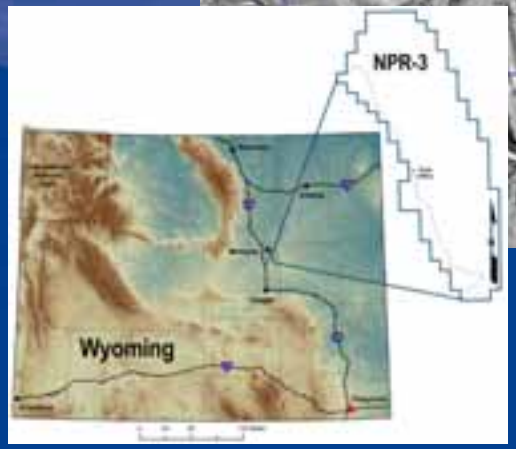


Tom Anderson, Chief Scientist, Rocky Mountain Oilfield Testing Center (RMOTC), Casper, Wyoming

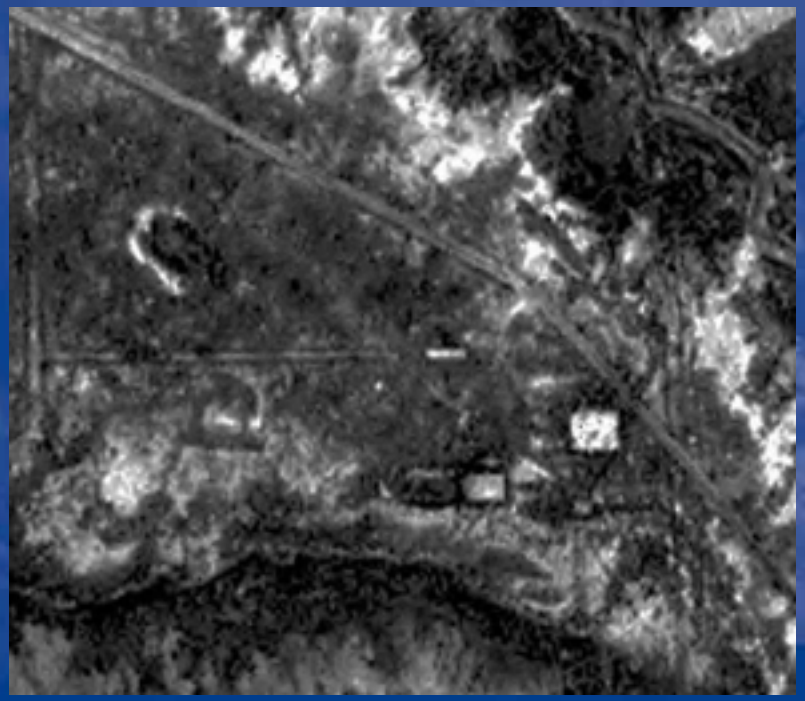
Outline



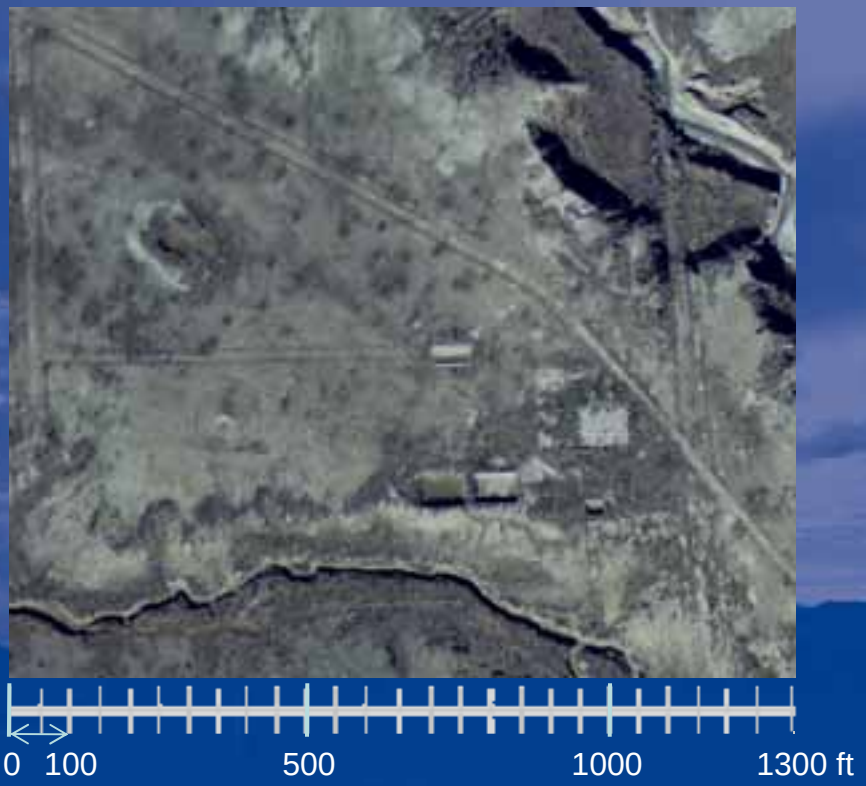
- What is RMOTC
- Imagery
  - Photomosaic from DOQQ's
  - "Pre-development" low-altitude air photos (1976)
- History
  - Teapot Dome
  - RMOTC
- Geology
  - Mapping Quaternary Terraces
  - Surface geologic mapping
  - Research studies



Imagery Comparison

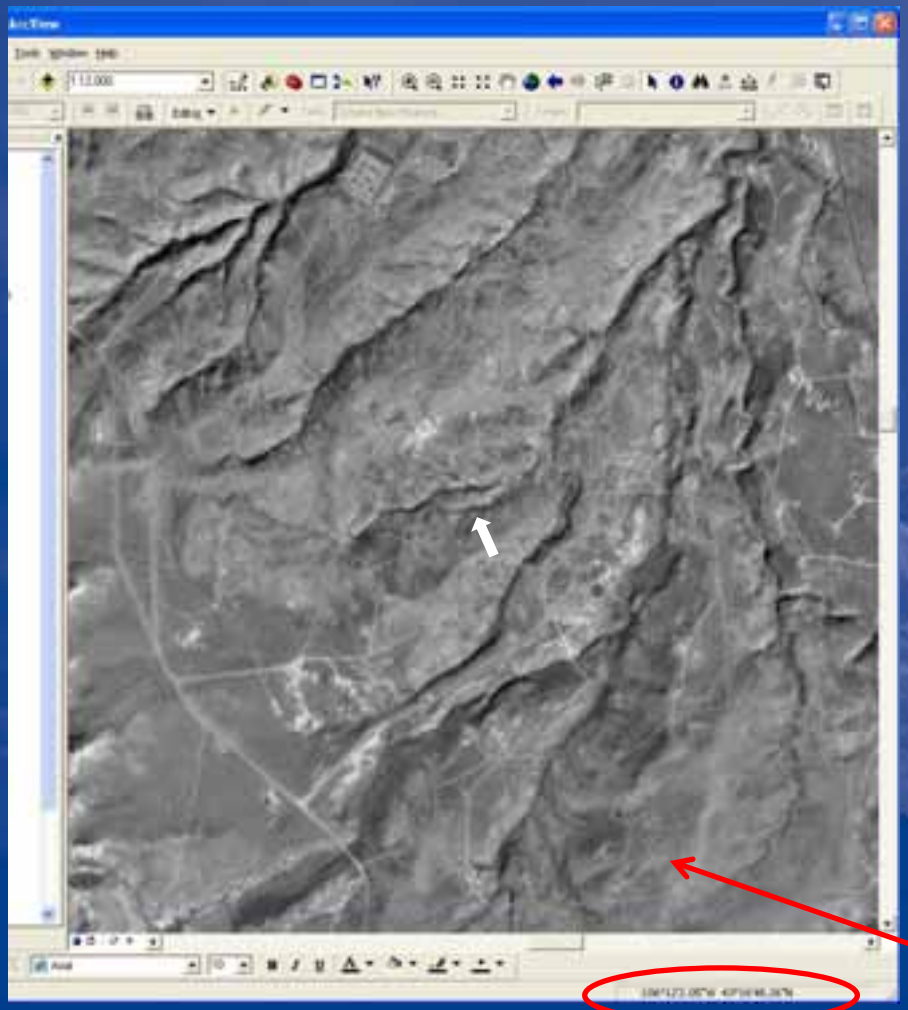


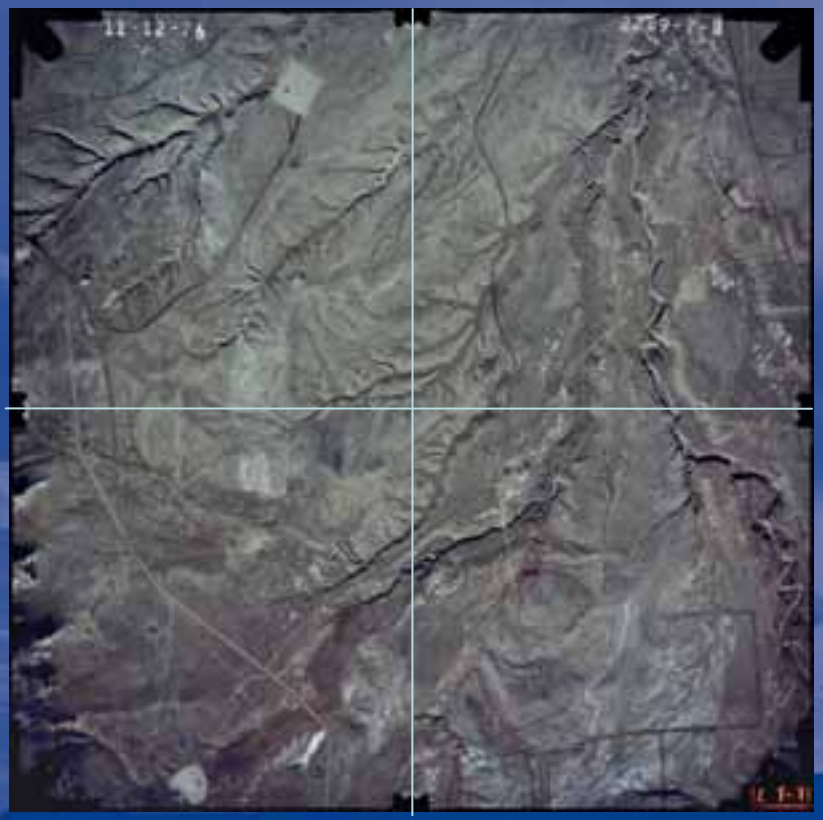
DOQQ 1m photomosaic



Air photo (1976)

Capturing Photo Center Coordinates





1976 low altitude air photo

DOQQ-based photomosaic (1m), plus hill-shade on DEM (5m), w/ 50% transparency

ID lat-long, put in spreadsheet

Point	Long Deg	Long Min	Long Sec	Lat Deg	Lat Min	Lat Sec	Long Dec	Lat Dec
7-8	-106	12	2	43	16	48	-106.200556	43.280000

Capturing Photo Center Coordinates and Calculating Photo Corners

Point	Long Deg	Long Min	Long Sec	Lat Deg	Lat Min	Lat Sec	Long Dec	Lat Dec
4-1	-106	15	52	43	12	41	-106.264444	43.211389
4-2	-106	15	49	43	13	19	-106.263611	43.221944
4-3	-106	15	48	43	13	56	-106.263333	43.232222
4-4	-106	15	44	43	14	33	-106.262222	43.242500

Low altitude:

Point	Long Deg	Long Min	Long Sec	Lat Deg	Lat Min	Lat Sec	Long Dec	Lat Dec
7-9	-106	12	4	43	17	25	-106.201111	43.290278
UL	-106	12	57	43	18	6	-106.215833	43.301667
UR	-106	11	8	43	18	6	-106.185556	43.301667
LR	-106	11	8	43	16	45	-106.185556	43.279167
LL	-106	12	57	43	16	45	-106.215833	43.279167

	0.030278	0.015139	Δ longitude east and west of center point
0.011250		0.011250	Δ latitude above center point
0.022500	+	0.022500	latitude range in decimal degrees
		0.011250	Δ latitude below center point
	0.030278	0.015139	

longitude range in decimal degrees

Calculating Photo Corner Coordinates

Point		PolyID	Long Dec	Lat Dec		
4-1	center	4-1center	-106.264444	43.211389		
4-1	UL	4-1UL	-106.279583	43.222639	0.015139	Δ longitude east/west of center point
4-1	UR	4-1UR	-106.249305	43.222639	0.01125	Δ latitude above/below center point
4-1	LR	4-1LR	-106.249305	43.200139		
4-1	LL	4-1LL	-106.279583	43.200139		
4-2	center	4-2center	-106.263611	43.221944		
4-2	UL	4-2UL	-106.278750	43.233194		
4-2	UR	4-2UR	-106.248472	43.233194		
4-2	LR	4-2LR	-106.248472	43.210694		
4-2	LL	4-2LL	-106.278750	43.210694		
4-3	center	4-3center	-106.263333	43.232222		
4-3	UL	4-3UL	-106.278472	43.243472		
4-3	UR	4-3UR	-106.248194	43.243472		
4-3	LR	4-3LR	-106.248194	43.220972		
4-3	LL	4-3LL	-106.278472	43.220972		
4-4	center	4-4center	-106.262222	43.242500		
4-4	UL	4-4UL	-106.277361	43.253750		
4-4	UR	4-4UR	-106.247083	43.253750		
4-4	LR	4-4LR	-106.247083	43.231250		

=E2+0.01125

=D2-0.015139

Plotting Photo Centers and Creation of Photo Polygons (High Altitude Set)

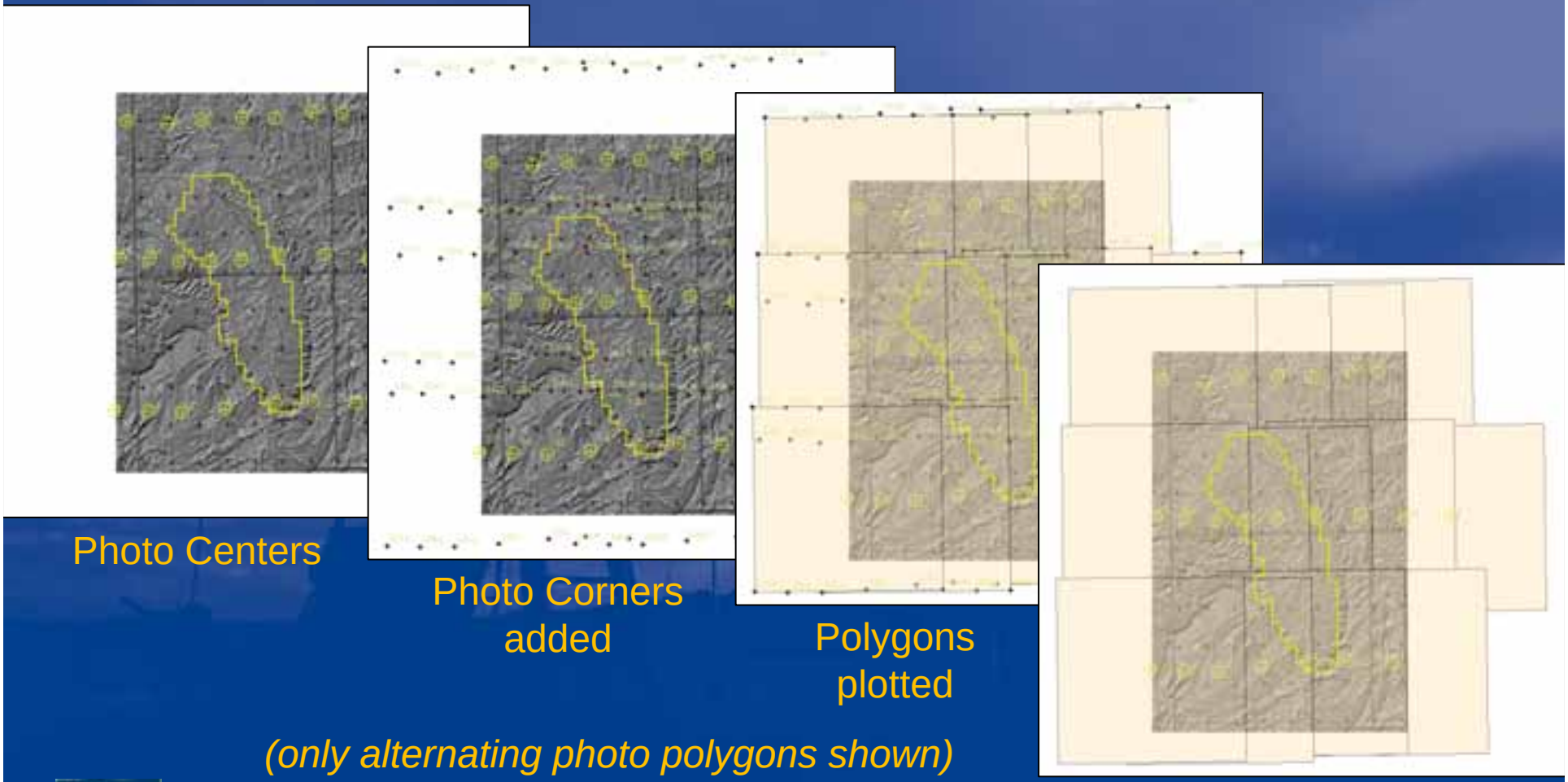


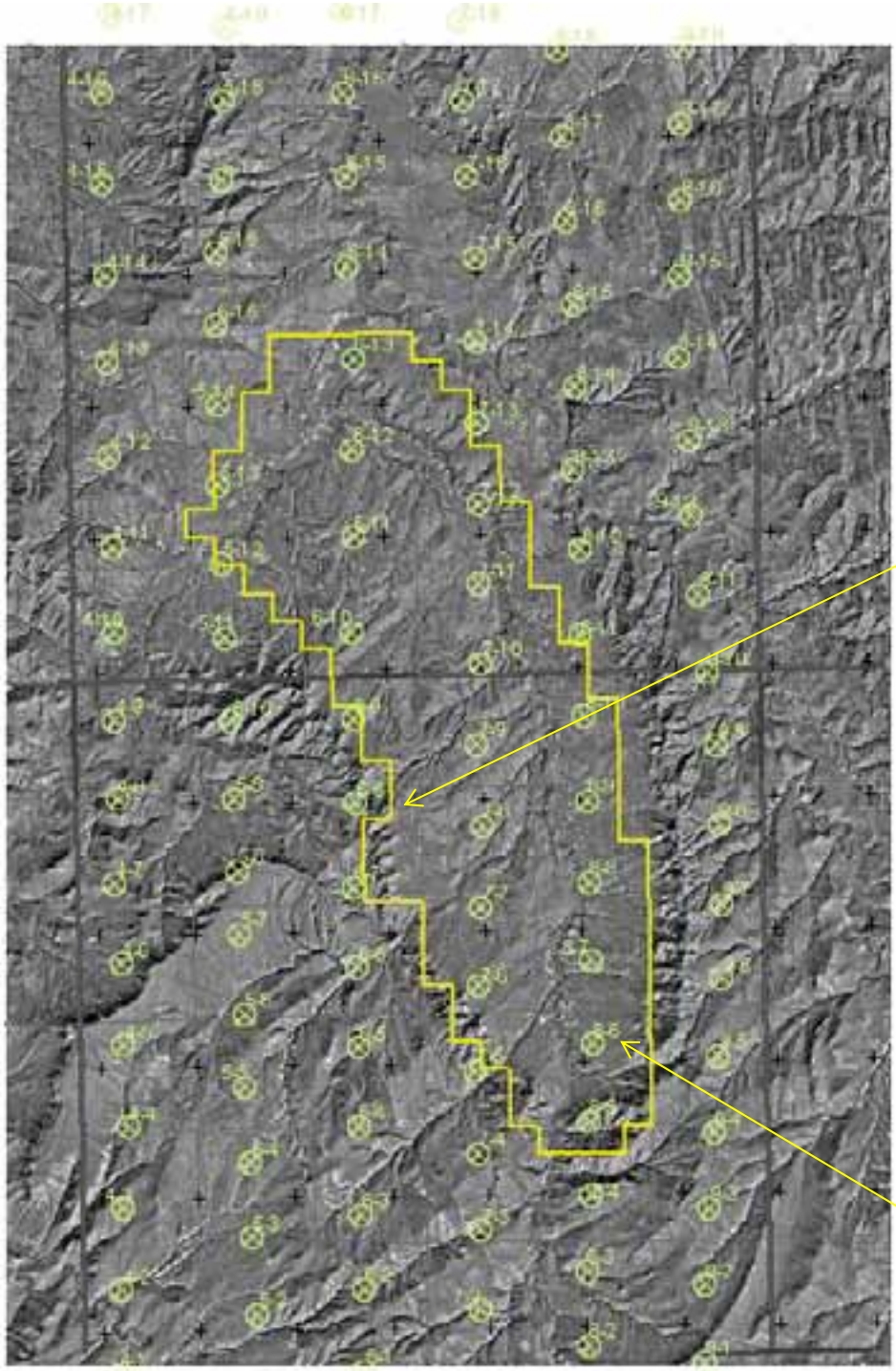
Photo Centers

Photo Corners added

Polygons plotted

Final result

(only alternating photo polygons shown)

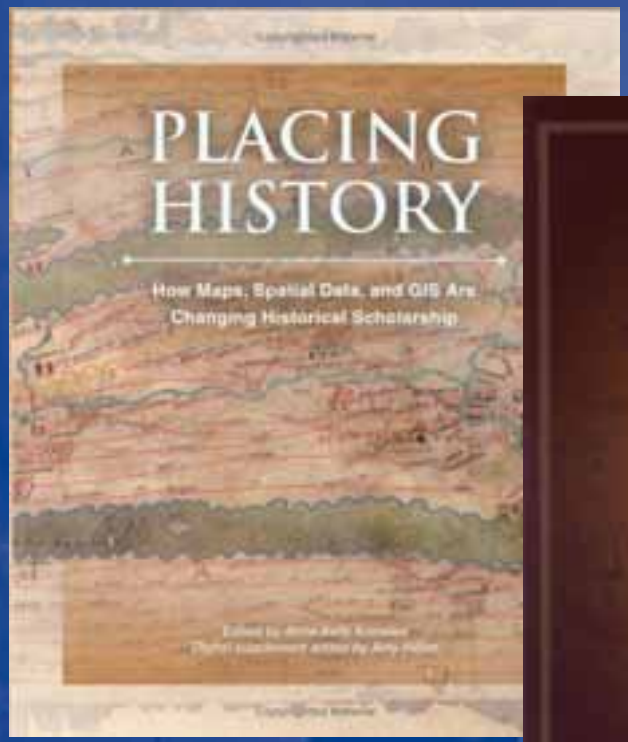


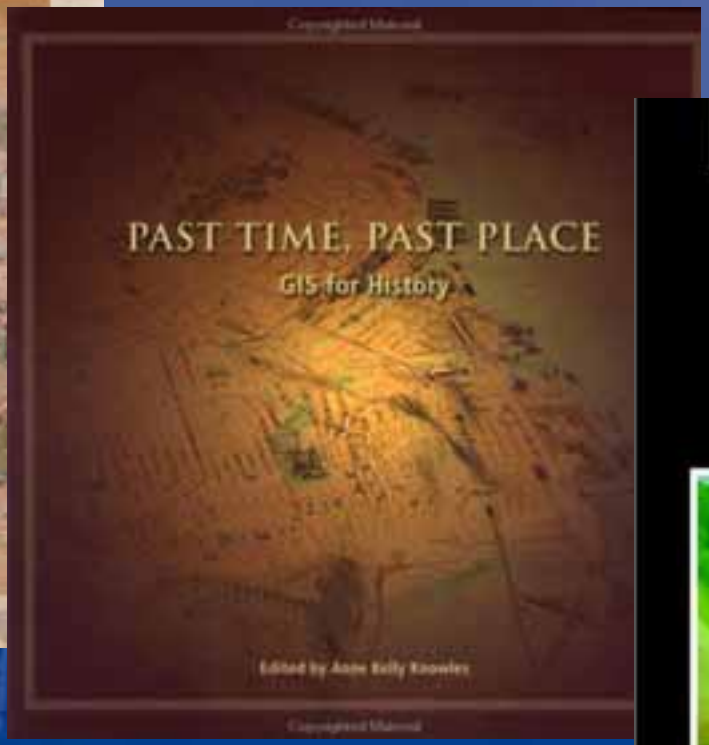
Low Altitude (1976) Air Photo Centers

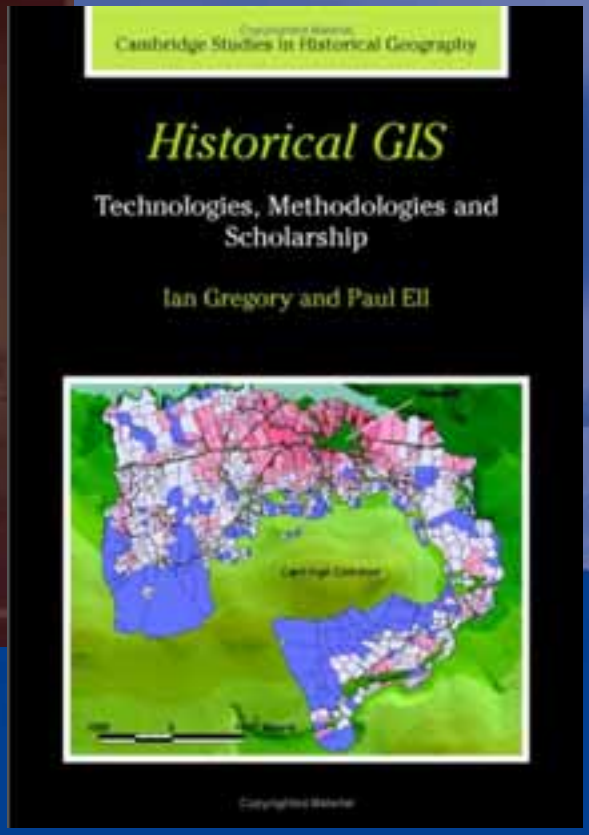
1927

2008

History and GIS – an emerging field







Naval Petroleum Reserves Are Born

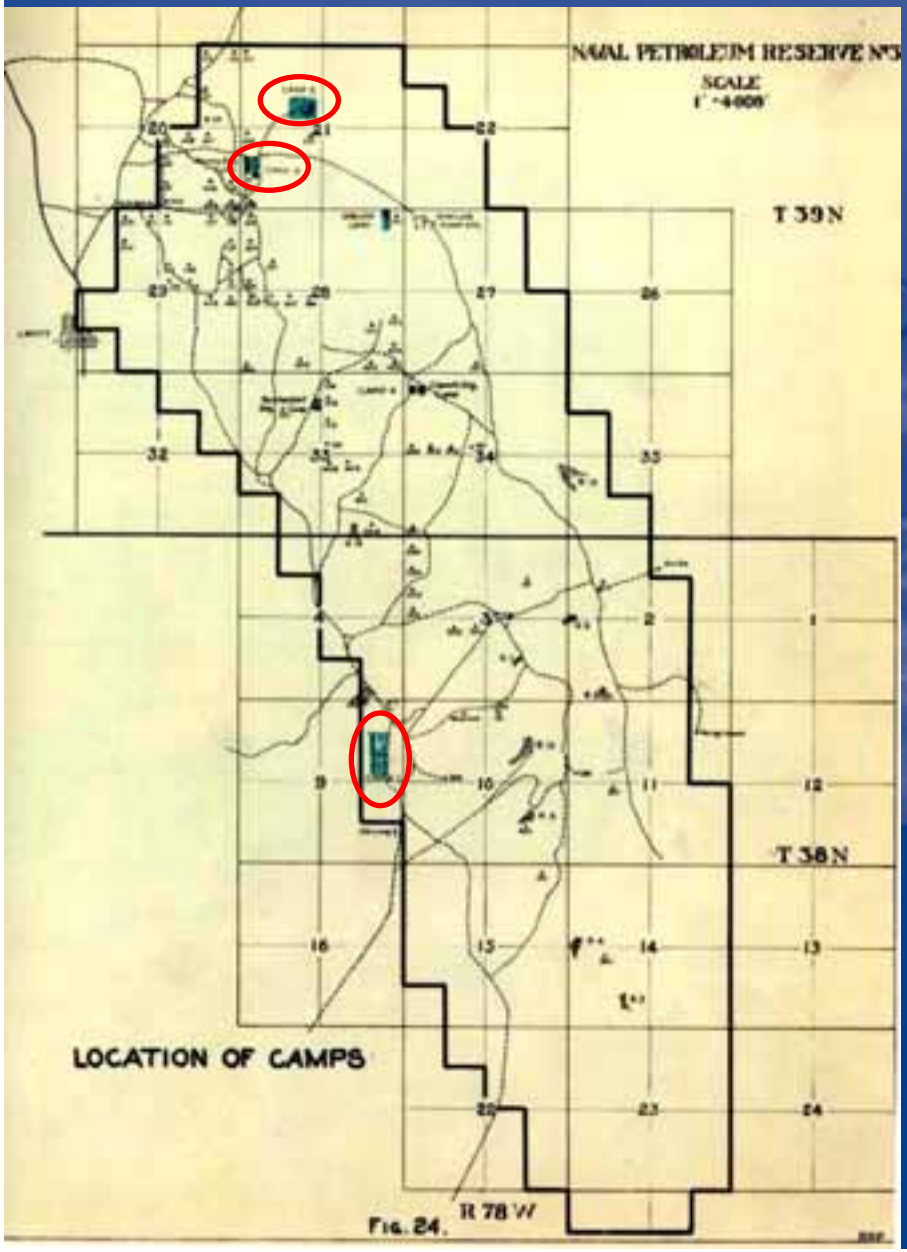
- 1908: Dr. Otis Smith, USGS Director, recommends DOI retain oil lands for fuel reserve for Navy.
- 1909: President Taft withdraws 3,000,000 acres in Wyoming and California.
- 1910: Concern over the President's authority to withdraw lands, so Congress passes the Pickett Act.
- 1912: President Taft Executive Order creates NPR-1 and NPR-2 in California.
- 1915: President Wilson Executive Order creates NPR-3 at Teapot Dome.
- 1921: Senator Albert Fall (NM) becomes President Harding's Secretary of the Interior, has NPRs moved to DOI, then quickly moves to open reserves to private exploitation.
- 2/22: Harry Sinclair incorporates Mammoth Oil Company.
- 3/22: Sinclair buys and quitclaims all existing mining claim rights at Teapot Dome, and applies for a lease on all of Teapot Dome.
- 4/22: Mammoth is secretly awarded a noncompetitive lease covering all of Teapot Dome, with no restrictions.
- 4/22: Congress calls for an investigation of NPR-3.

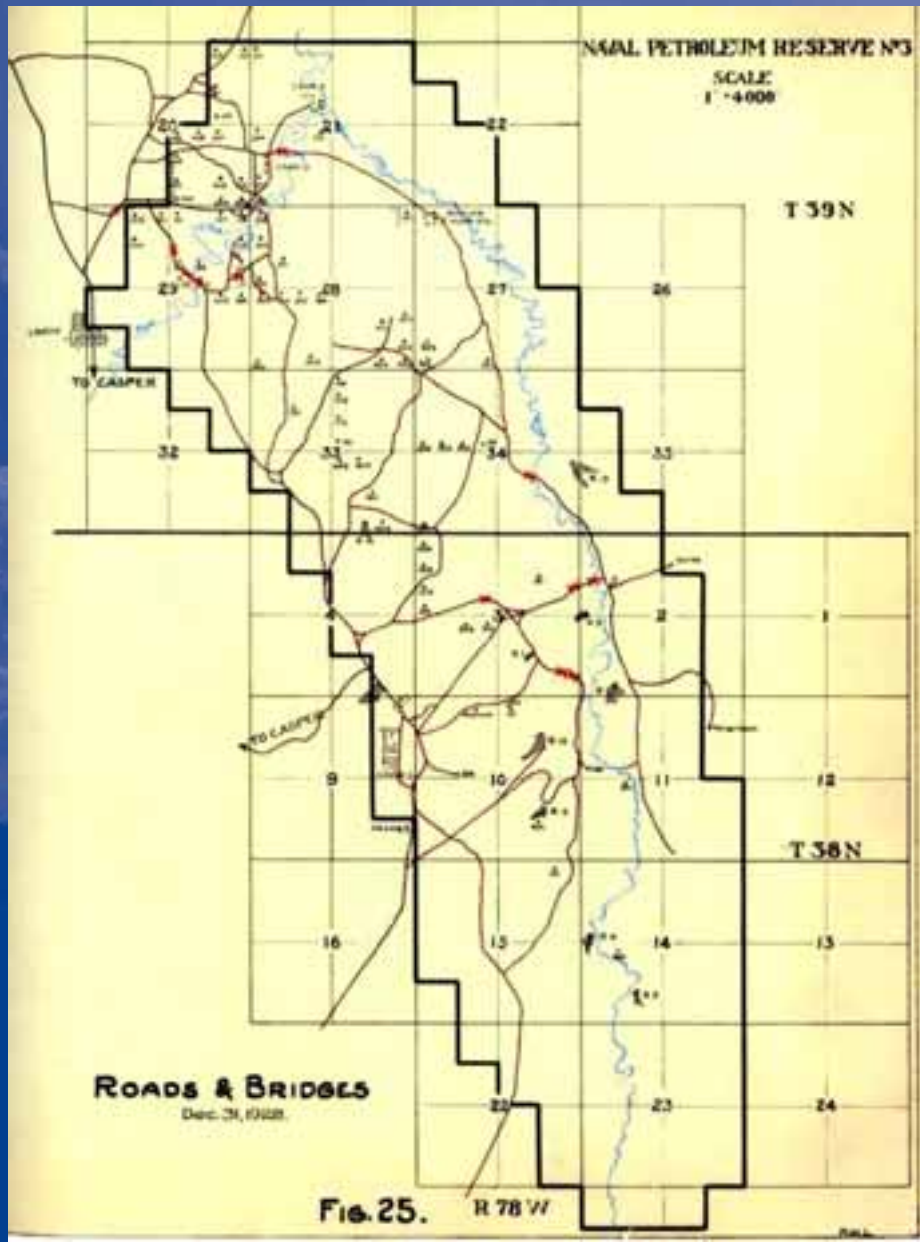
Congress Investigates

- 8/23: Harding dies, and Coolidge becomes President.
- 10/23: Senate Committee hearings are convened.
- Investigators find that the Sinclair leases were fraudulent, and that EO 3474, transferring lands from Navy to DOI, was illegal and should be set aside.

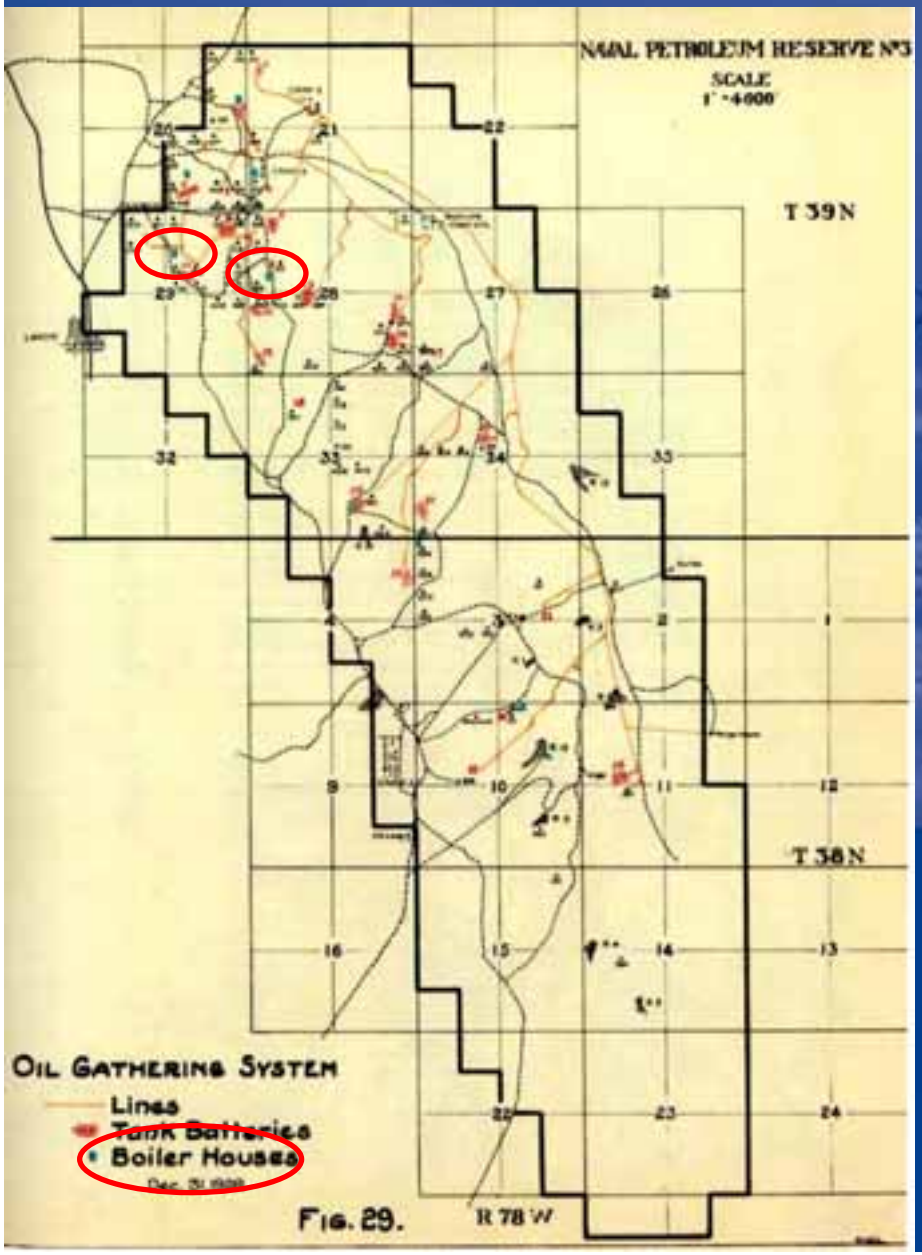
- 3/24: U.S. files suit to cancel Mammoth's Teapot Dome lease.
- 6/25: Court overrules the U.S., and upholds Sinclair. The U.S. appeals.
- 3/27: President Coolidge EO 4614 overturns EO 3474, and returns NPRs to Navy control.
- 10/27: Supreme Court rules in favor of U.S. and immediately shuts in Teapot Dome.
- 2/28: Just to be sure, Congress passes an Act to transfer jurisdiction of NPRs from DOI back to the Navy.
- 1930: Lt. Trexel Report

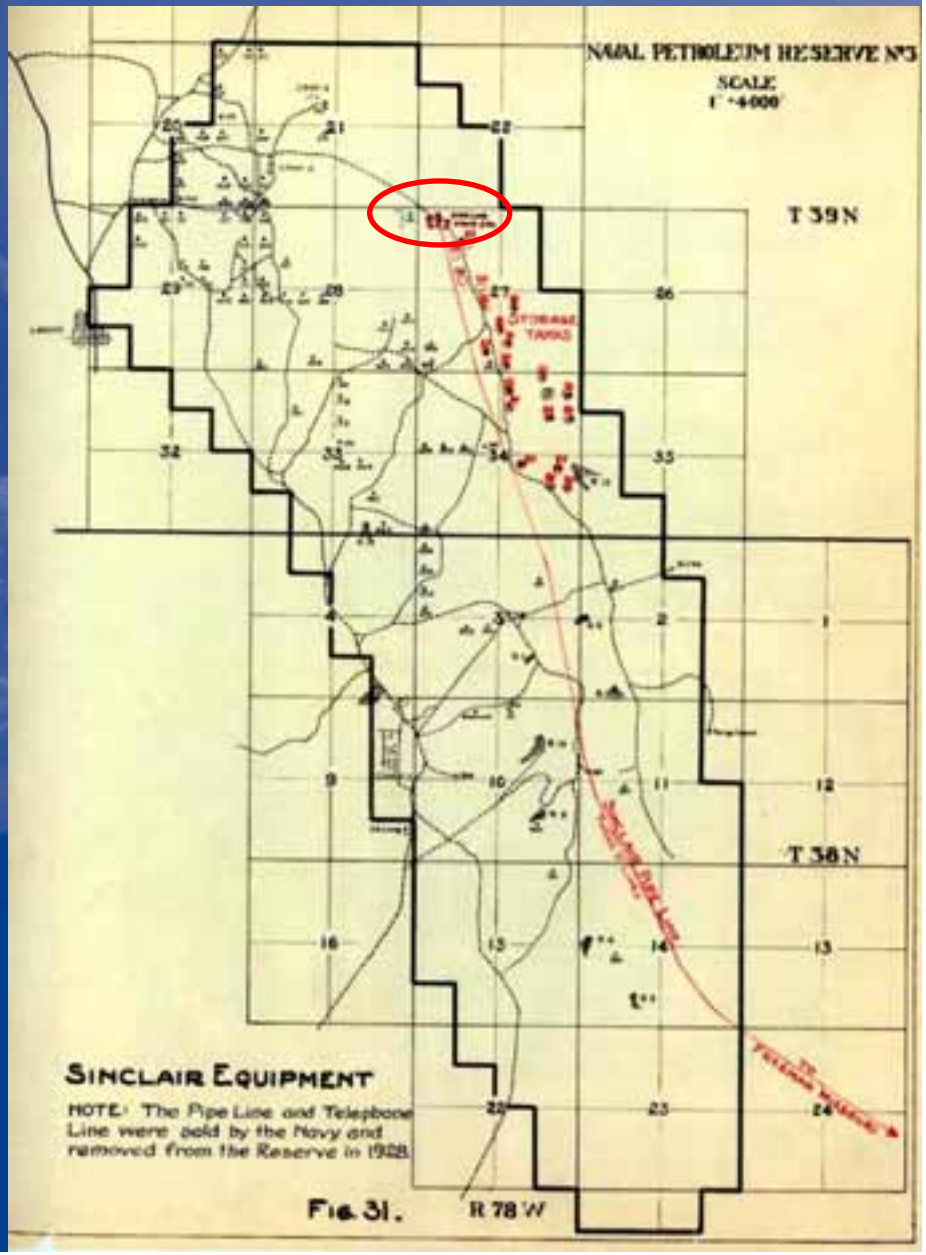
Maps from Trexel Report, 1930





Maps from Trexel Report, 1930



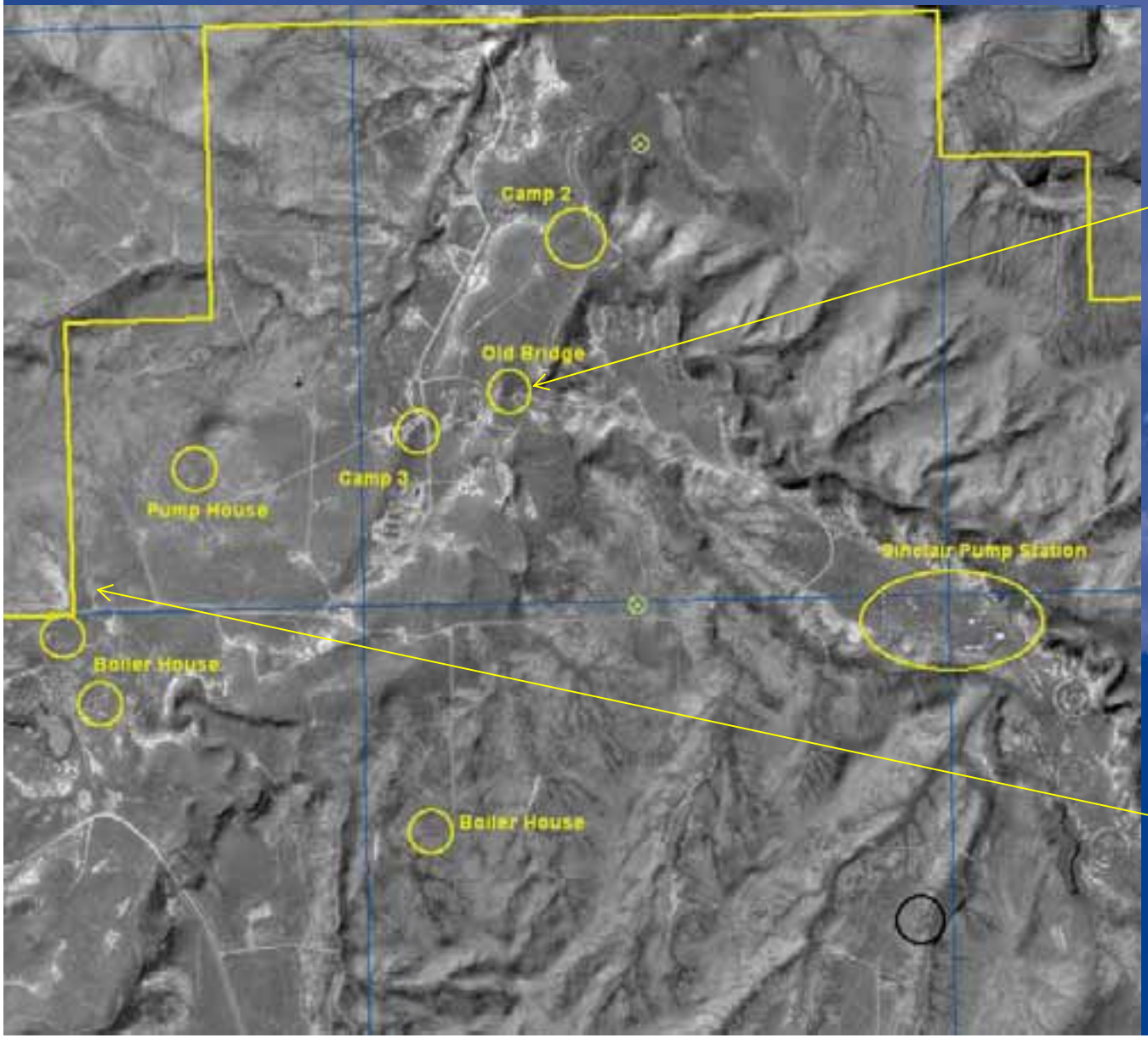


Teapot Dome Since Then

- Some exploratory and drainage offset wells were drilled in the ‘50s and ‘60s.
- NPR-1 and NPR-3 opened to full development in 1976.
- 1977: NPR jurisdiction transferred from Navy to (newly created) DOE.
- Subsequent development and IOR projects raised rates to 5000 BOPD in 1979-80.
- 1995 - present: Rocky Mountain Oilfield Testing Center.
- (1998: NPR-1 (Elk Hills, CA) sold to Occidental)
- (2000: NOSR-2 transferred to Ute Tribe, and NOSR-1, NOSR-3, and NPR-2 (Buena Vista Hills, CA) transferred to DOI)
- Current production is 200-300 BOPD.

RMOTC
Rocky Mountain Oilfield Testing Center

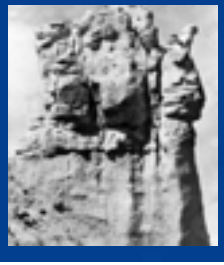
Historic Sites in the North End of NPR-3



Well 402-20
22nd well drilled, 20 Feb 1923
Cost $30,000
IP 8000 BOPD
Flowing 510 BOPD March, 1924
Cum 582,000 BO 31 Dec 1927

"Best Second Wall Creek well in the field"

Historic Photos of Teapot Dome, 1927



Then vs Now – Gas Plant

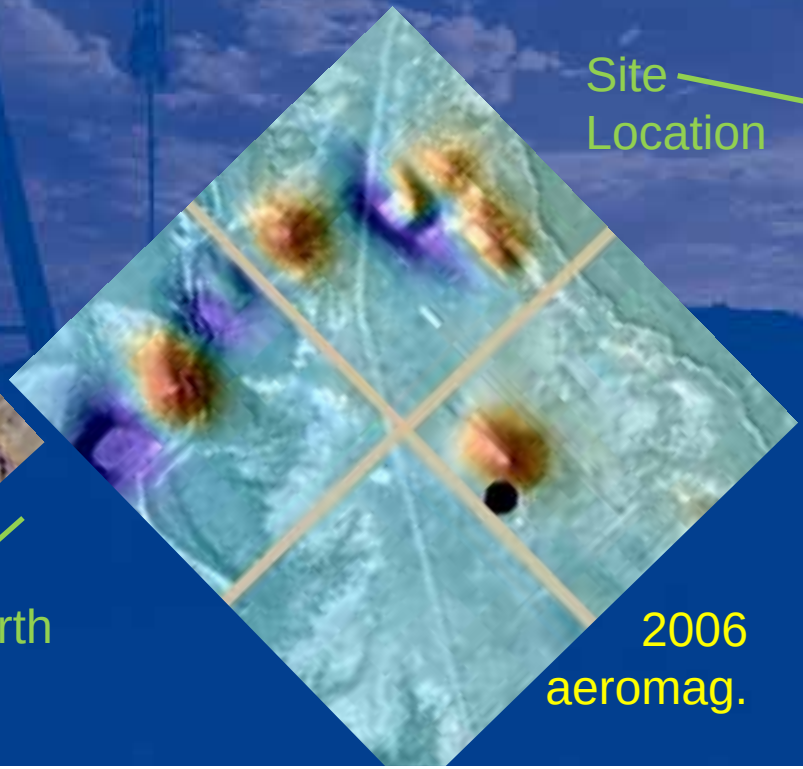
Sinclair Pump Station

1927

2008

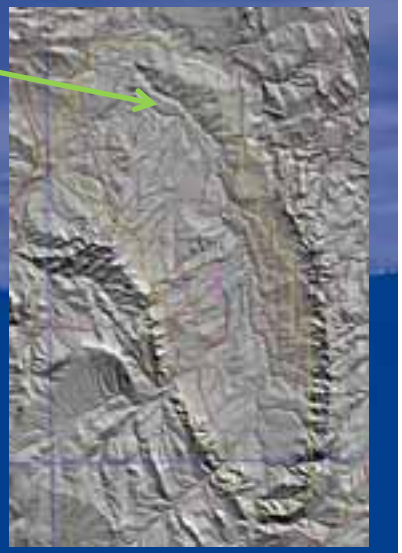
1976 air photo

North



2006 aeromag.

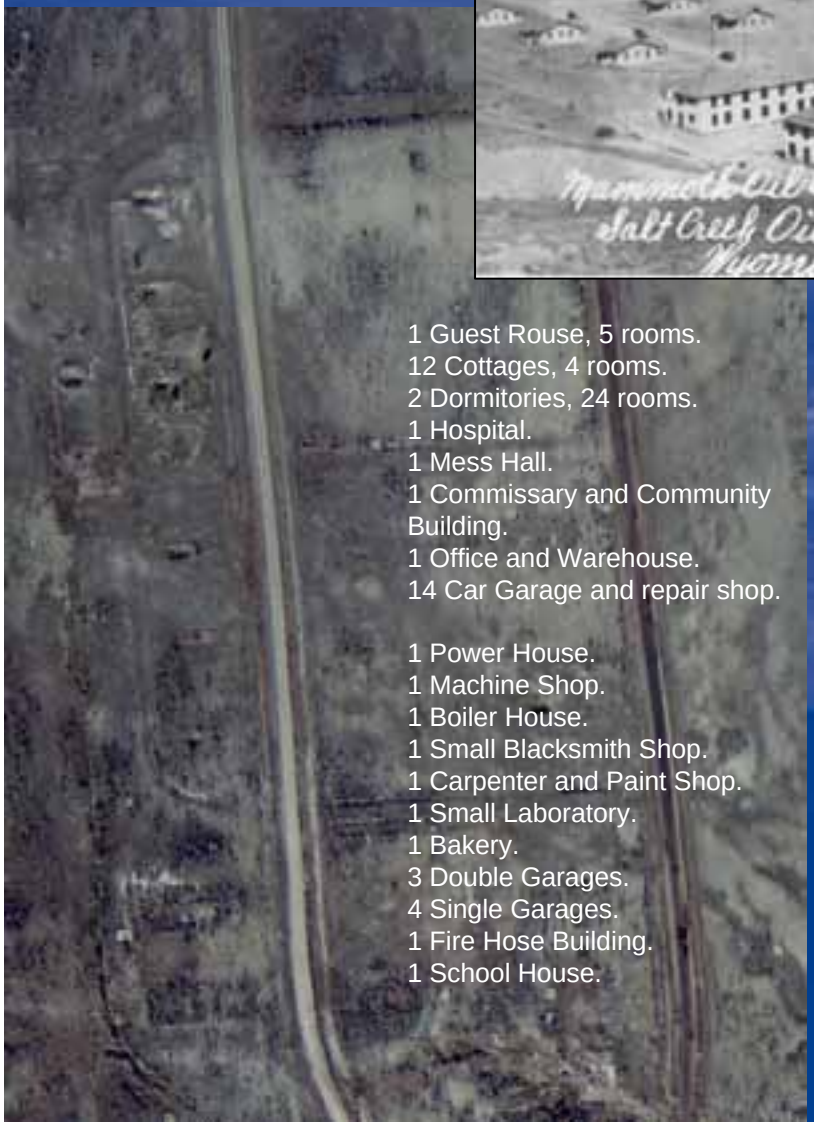
Site Location



Sinclair Pump Station Remnants

Mammoth Main Camp

1976 air photo



1 Guest Rouse, 5 rooms.
12 Cottages, 4 rooms.
2 Dormitories, 24 rooms.
1 Hospital.
1 Mess Hall.
1 Commissary and Community Building.
1 Office and Warehouse.
14 Car Garage and repair shop.

1 Power House.
1 Machine Shop.
1 Boiler House.
1 Small Blacksmith Shop.
1 Carpenter and Paint Shop.
1 Small Laboratory.
1 Bakery.
3 Double Garages.
4 Single Garages.
1 Fire Hose Building.
1 School House.

North

This camp was in reality a pump station to which the oil from the Reserve was run by gravity through the oil gathering system, there gauged, and pumped to the tanks of the Sinclair Pipeline Company. This camp included 1 Cottage, 5 rooms, 1 Boiler House with 3 boilers, 1 Pump Building, 40'x 80', 6 Steel Tanks.

Camp 2

North

1976 air photo

Mammoth Camp 3

North

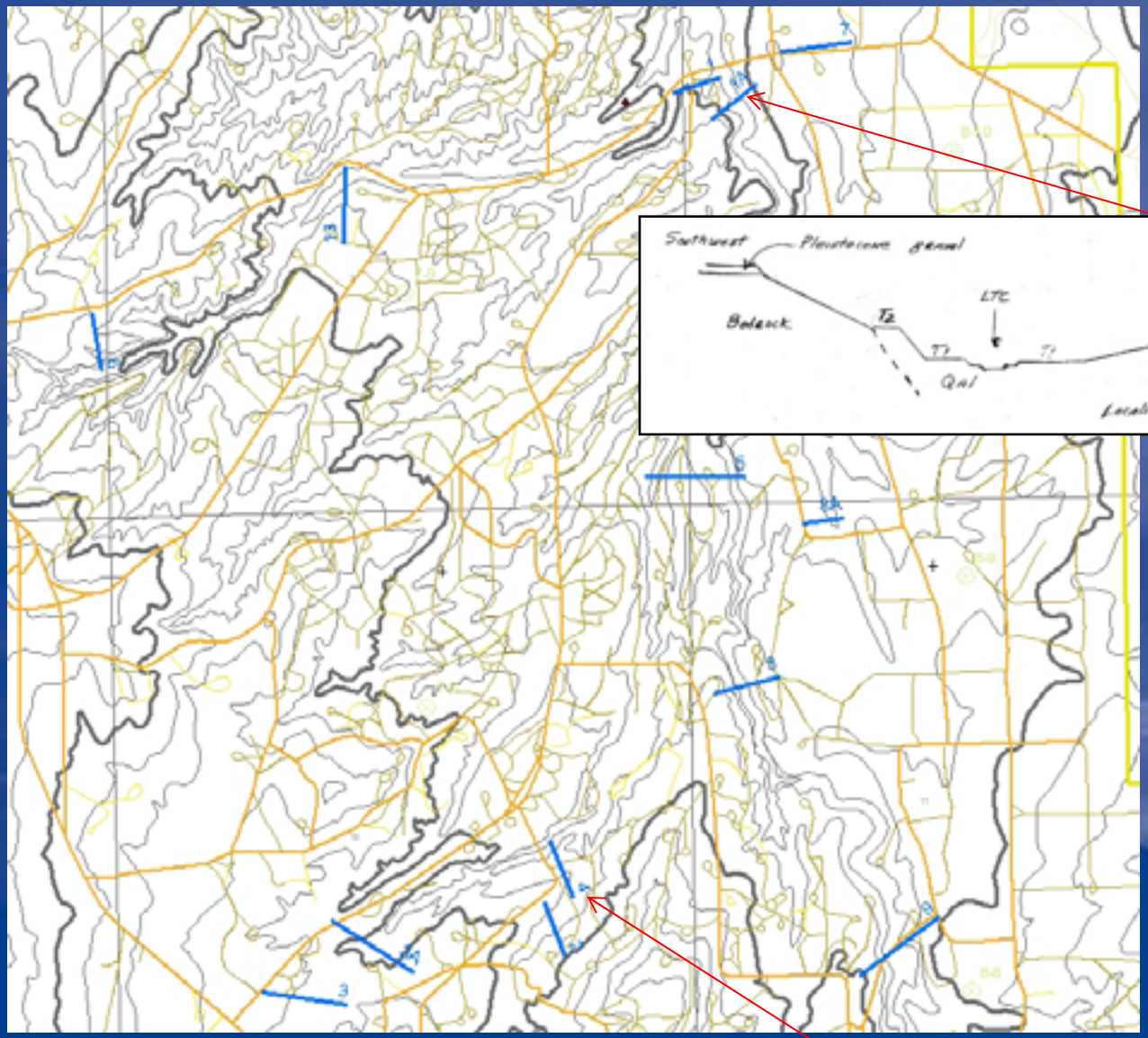
This camp was constructed for employees who were working in the north end of the Reserve and included:
2 Cottages, 3 rooms.
2 Dormitories.
1 Mess Hall.
1 4 Car Garage.
1 50 Barrel Water Tank.
1 Small Meat House.

“Pumping Power” – Boiler House Sec 29

North

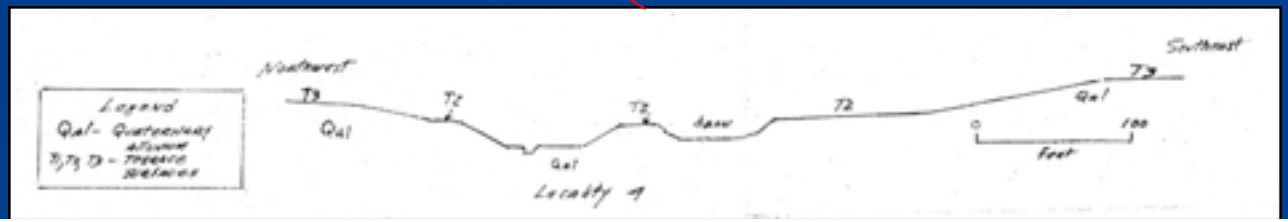
Mapping Quaternary Terraces

Terrace Mapping



Terrace profiles interpreted by John Albanese, Consulting Geo-Archeologist. He provided hand-drawn profiles (cross-sections) and a topographic base with hand-drawn profile localities. My goal was to input his data into GIS and create a full areal coverage map of these terraces:

- T3 (oldest, 10,000 YBP)
- T2 (2,000 YBP)
- T1 (500 YBP)
- T0 (present stream)

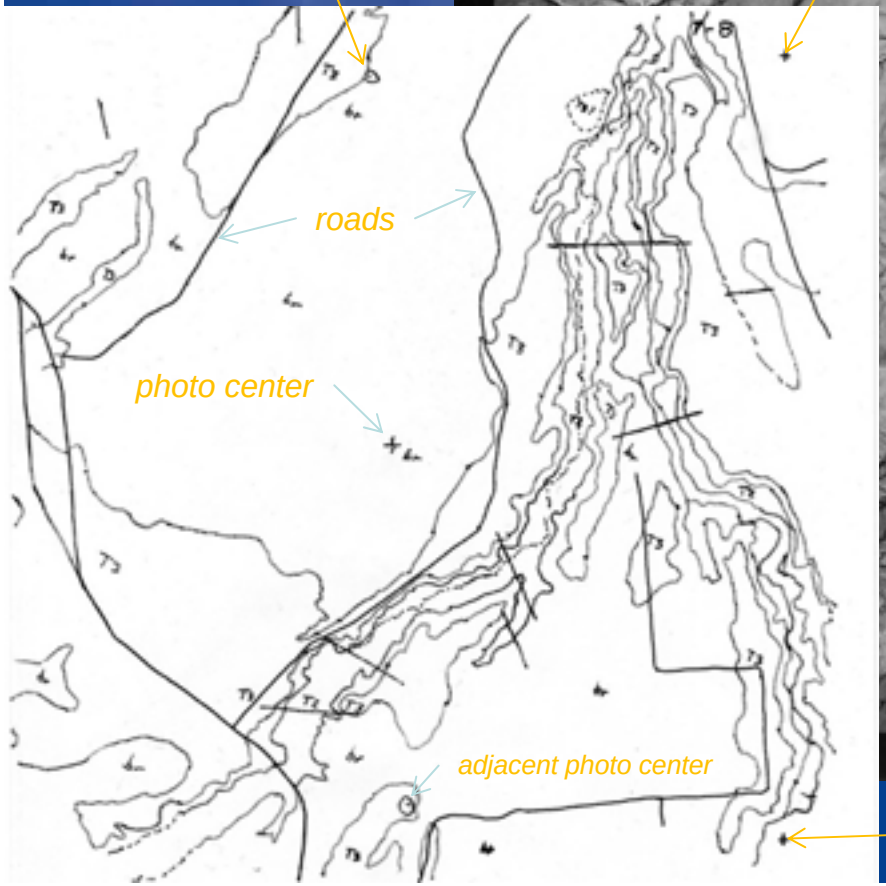


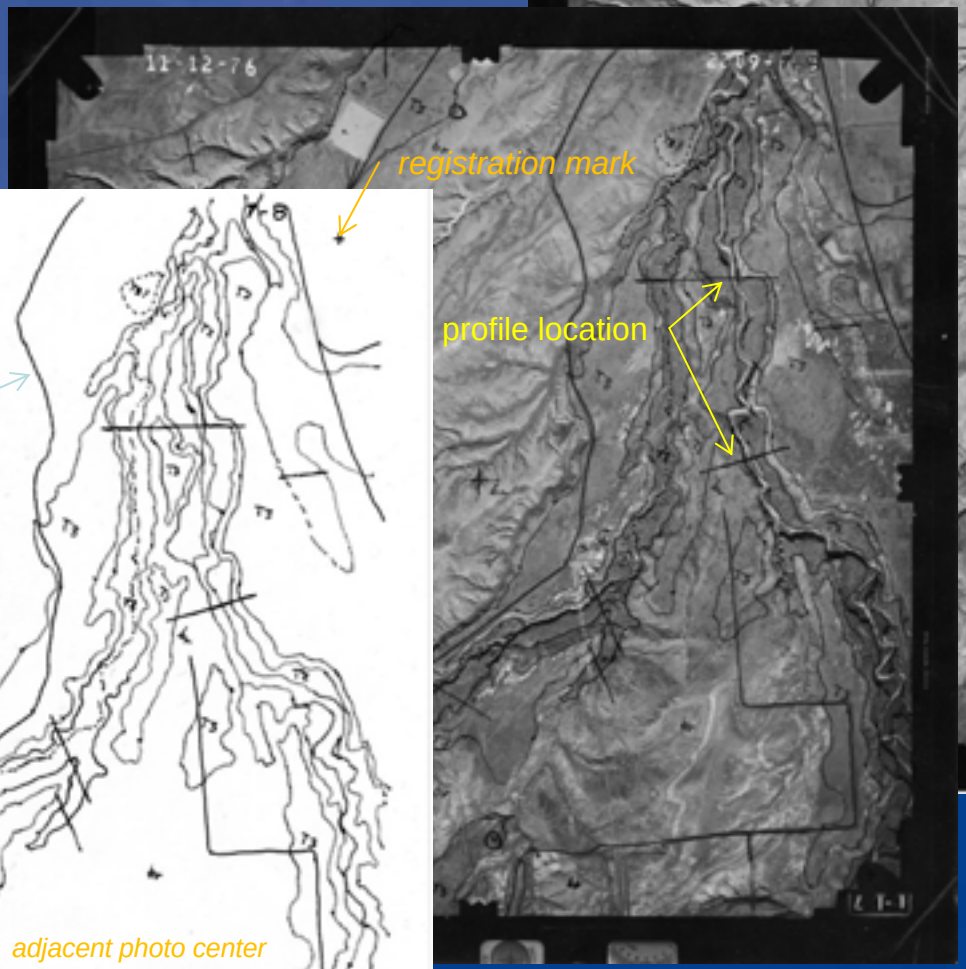
Stereo Viewing with Air Photo Pairs

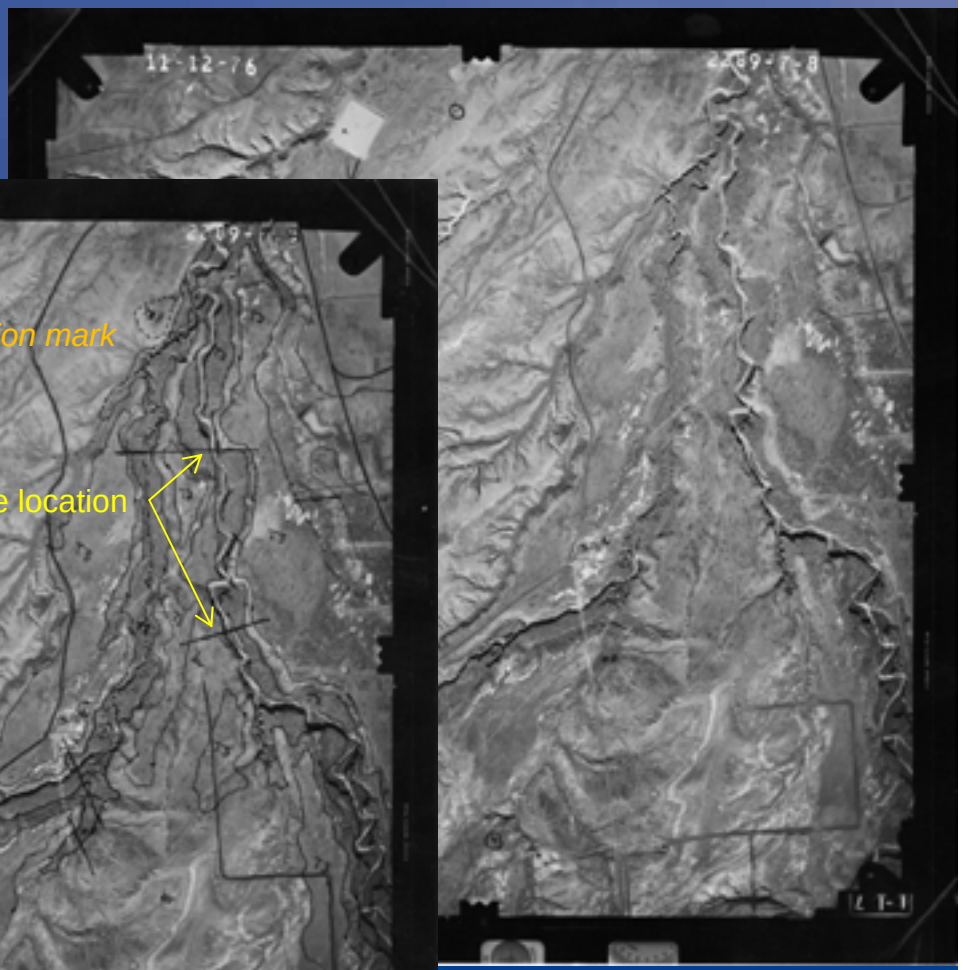
Usually performed with a stereoscope (or advanced photogrammetry equipment), but some individuals can achieve this unaided (I can)

Mapping Terrace Contacts on Photos

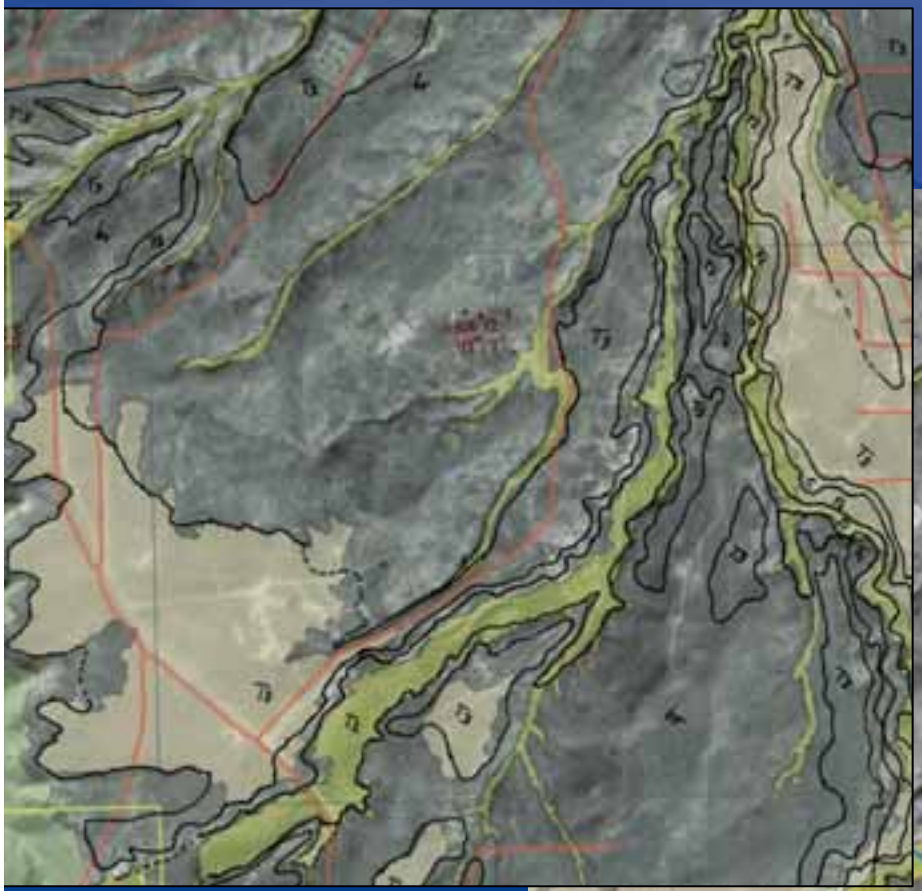
(actually inked on clear plastic overlay rather than directly on air photo, which facilitated the next step)

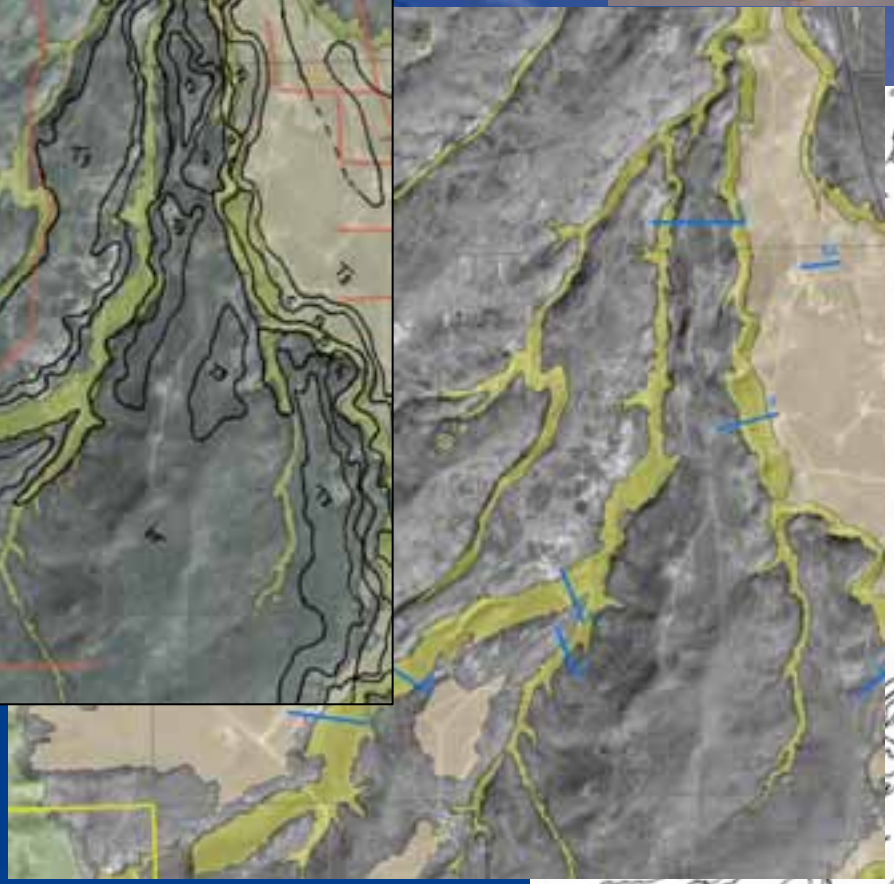


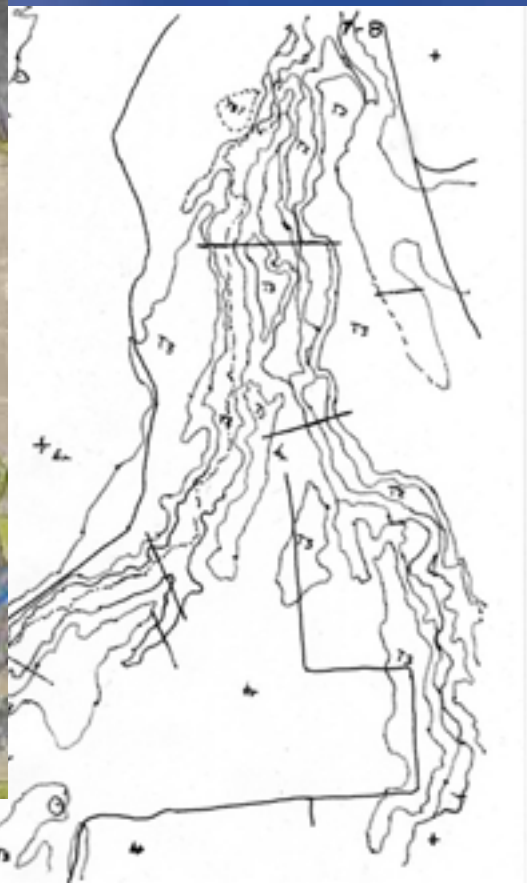




Transfer to Basemap on Light Table

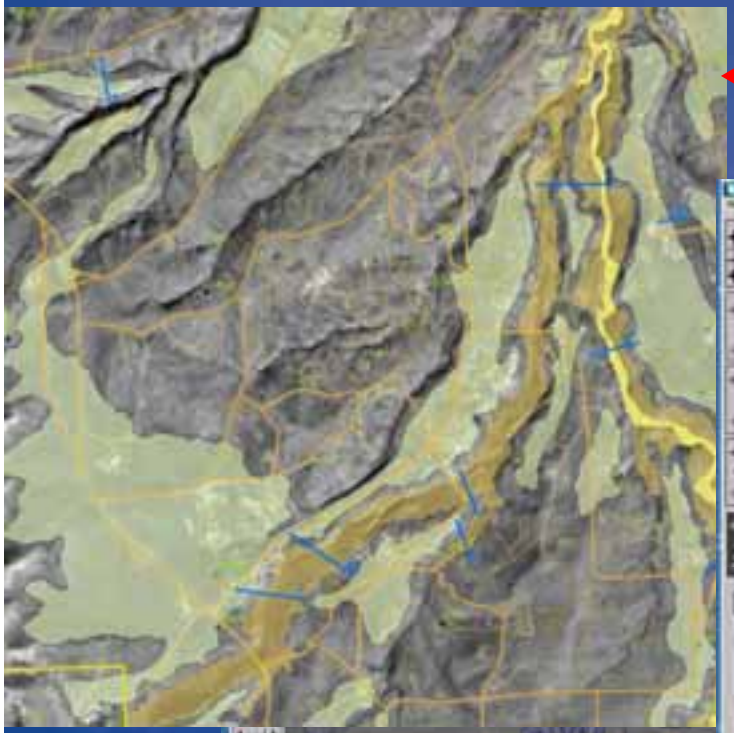




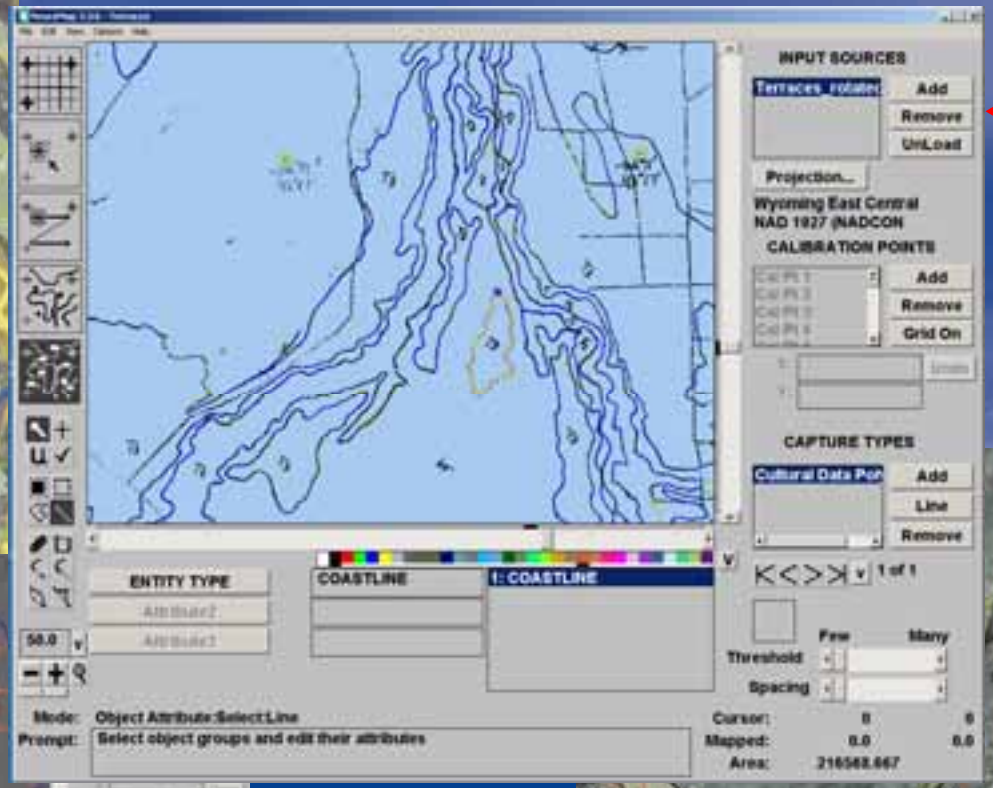


Basemap plotted at 1:12000 (same scale as air photos) with selected geologic units from old map

Digitize in NeuraMap, Export Shapefile



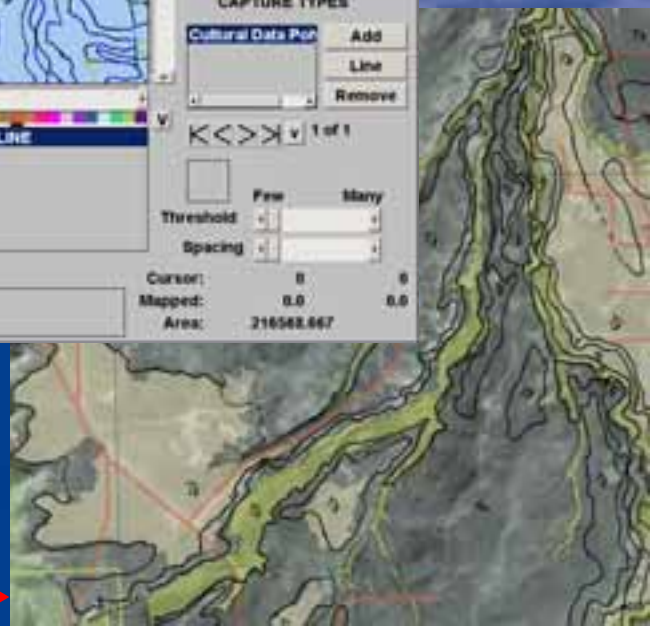
Resulting ArcMAP after importing shape file polygons



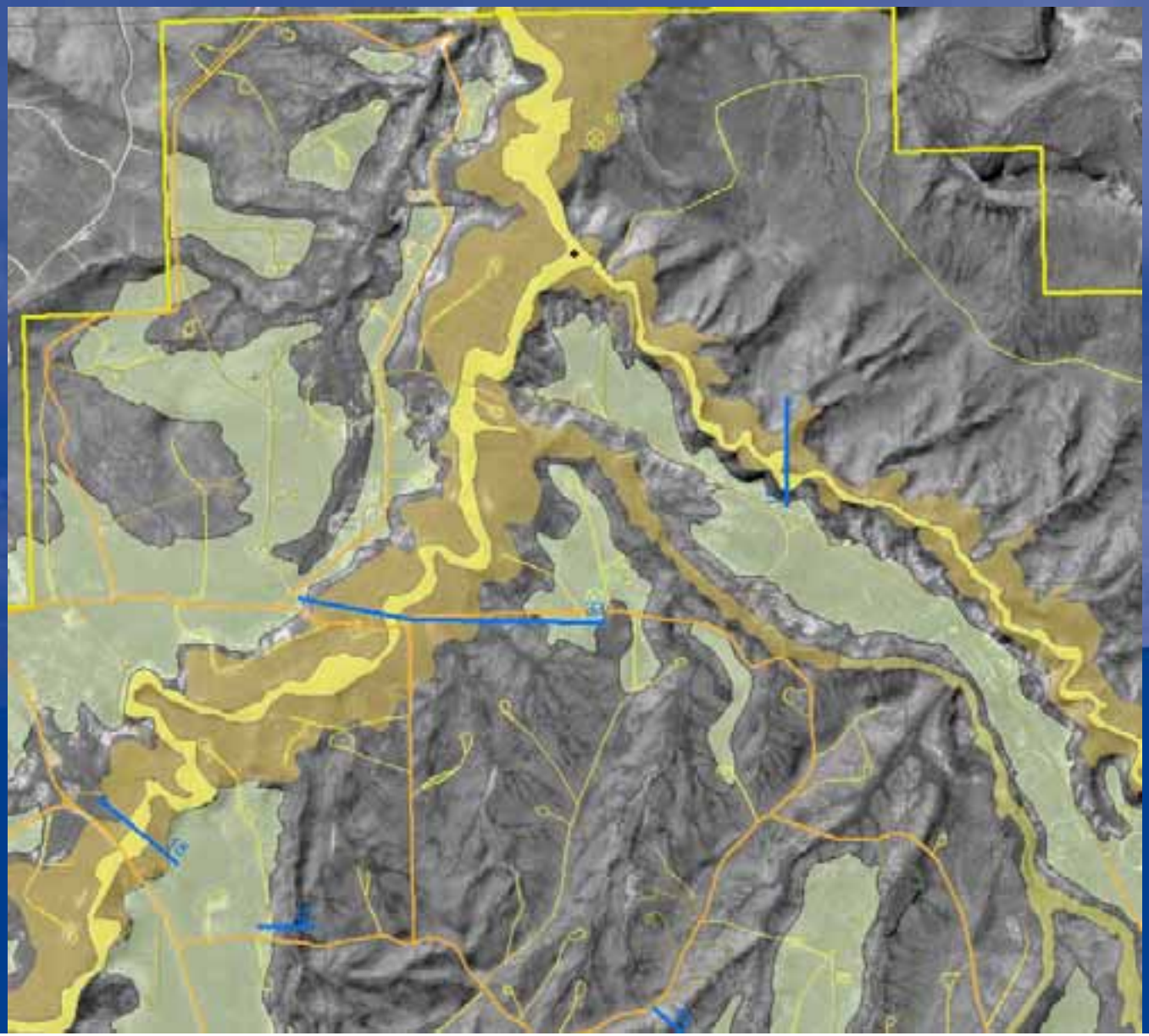
NeuraMap B&W view

NeuraMap color view

Scanned (TIFF) basemap image



Final Composite Map – N End



Surface Mapping

The “bedrock” areas exposed between the terraces will be mapped next, working with summer geologic interns to augment our own staff.

Another surface mapping task is to complete the mapping of the Mesaverde Fm hogbacks rimming the dome

Prior and Ongoing Research Partners

- University of Houston
- Stanford University
- University of Wyoming
- Enhanced Oil Recovery Institute (UW)
- Wyoming State Geological Survey
- University of Manchester
- Cambridge University
- Energy and Geoscience Institute
- Energistics
- Public Petroleum Data Model
- ESRI
- National Energy Technology Laboratory
- Colorado School of Mines
- Colorado Energy Research Institute
- Lawrence Livermore National Laboratory
- Princeton University
- West Virginia University
- Brigham Young University
- Sandia National Laboratory
- Southwest Research Institute
- U. S. Geological Survey
- Texas A&M University
- Lawrence Berkeley National Laboratory
- Los Alamos National Laboratory

GIS technology at RMOTC provides a visual integration tool for compiling and relating scientific results for Teapot Dome