Preventing New Groundwater Pollution from Old Oilfield Areas

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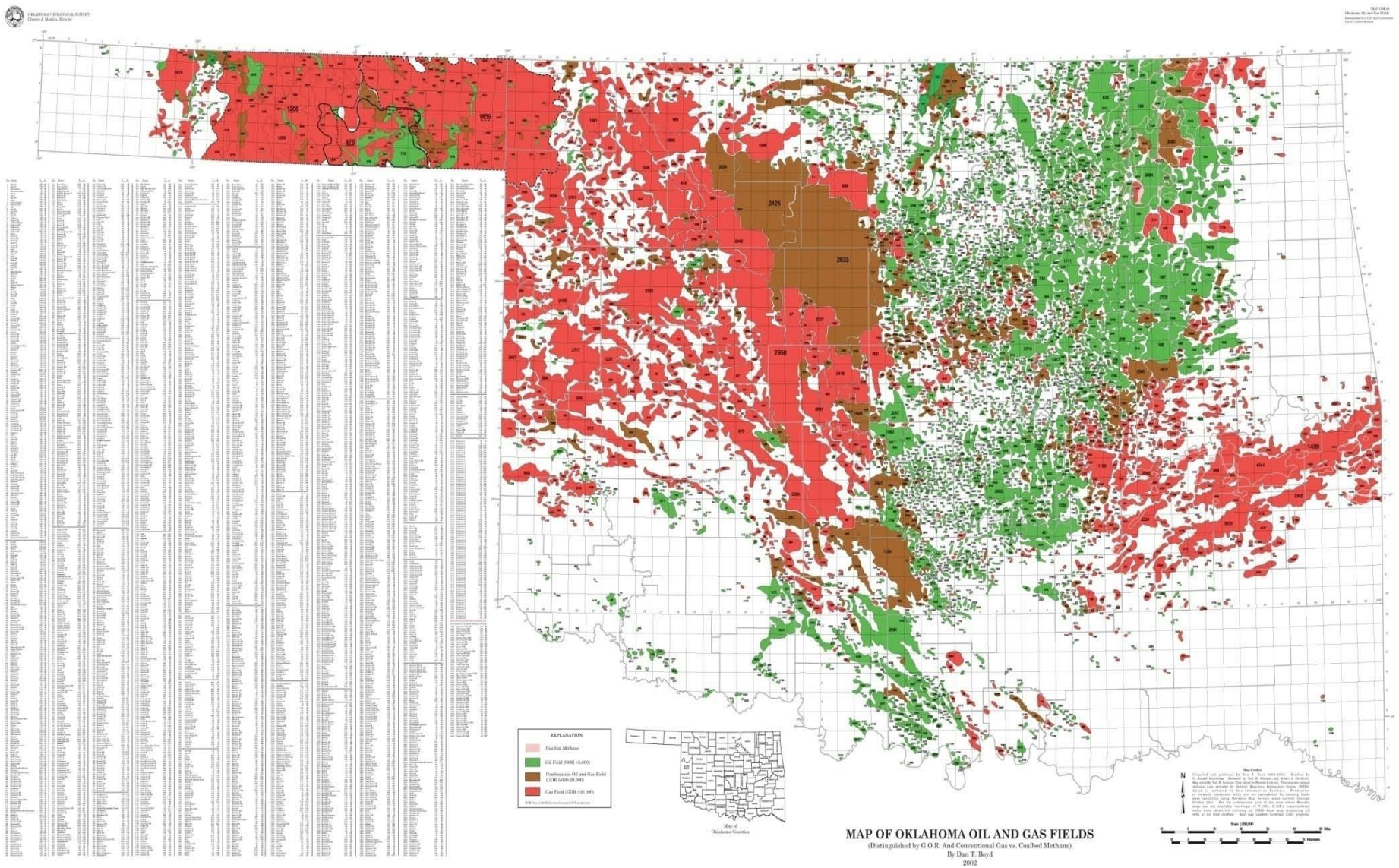
OK Once Looked Like This (View From S to N Across River Toward OKC)

Or this - Tonkawa, 90 years ago

Historic Oil & Gas Fields Affect >60% of OK Townships



Background

- The Corporation Commission has had many water well pollution complaints over 20 years
- Both suburban and rural
- In and near mostly older oilfields with activity started pre-1980, when modern regulations began
- Sometimes petroleum, most often **salinity**
- **We now understand enough about how these problems occur to propose prevention**

Corm Comm Has Taken > 2000 Groundwater/Well Samples STATEWIDE Over The Last 20 Years

- Most samples were collected after a complaint or other problem, so
- **The data is biased toward the bad**

Methodology

- Samples were taken in
  - seeps and springs;
  - shallow monitoring wells and borings, near spill sites;
  - domestic, public, and agricultural water wells of all depths.
- Salinity (Sodium, Chloride, Total Dissolved Solids), Nitrate, Boron, Barium, Petroleum, & Metals have state water quality standards – maximum limits
- The following maps show where water quality standards were EXCEEDED in groundwater samples

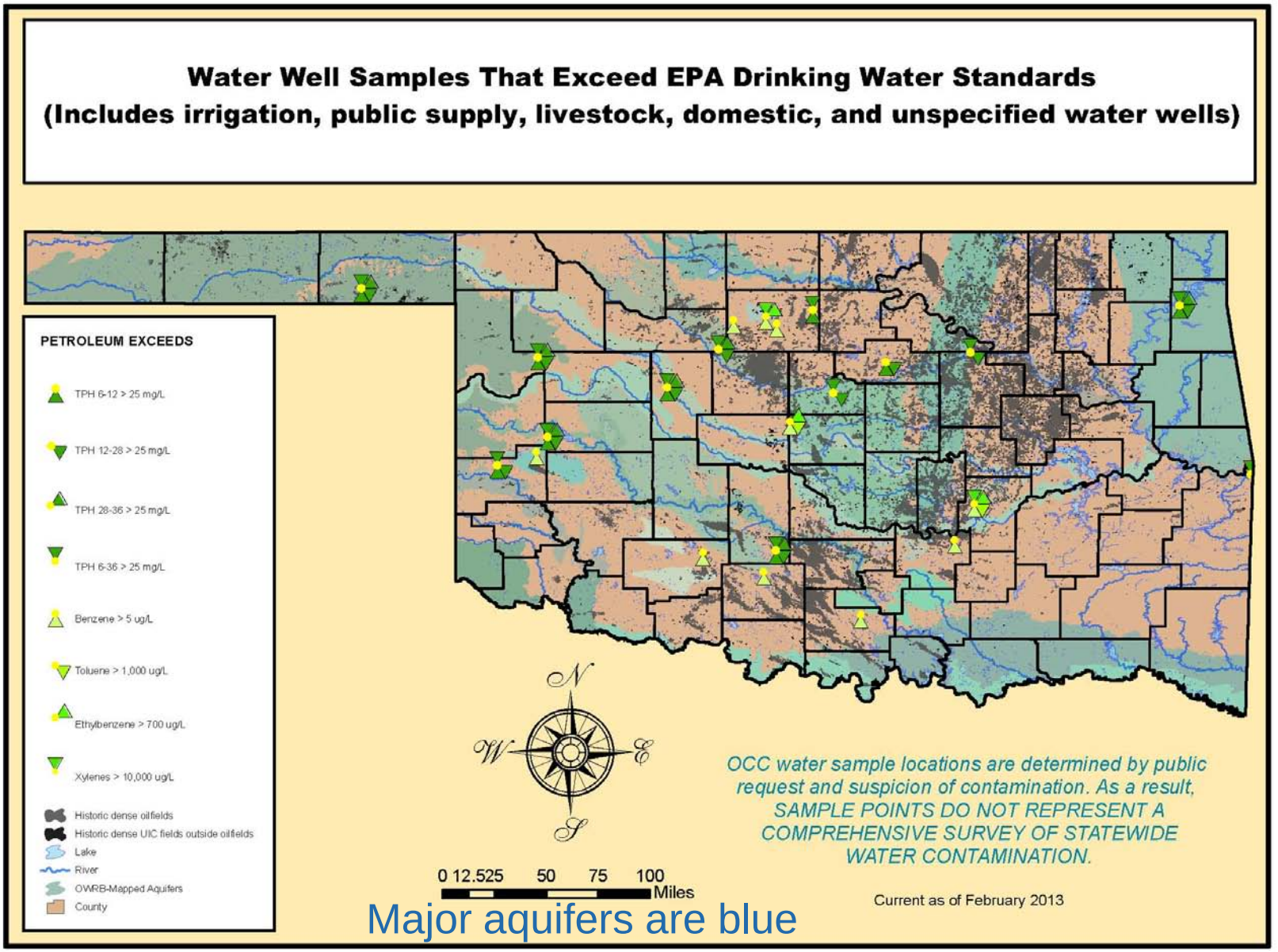
Maps Key

- The blue shaded areas on the following maps are the major aquifers of Oklahoma
- The dark grey blobs on the maps are the old oilfields.
- Petroleum, salinity and boron are associated with oil & gas production & brines, &
- Barium is found in oilfield drilling mud

BUT

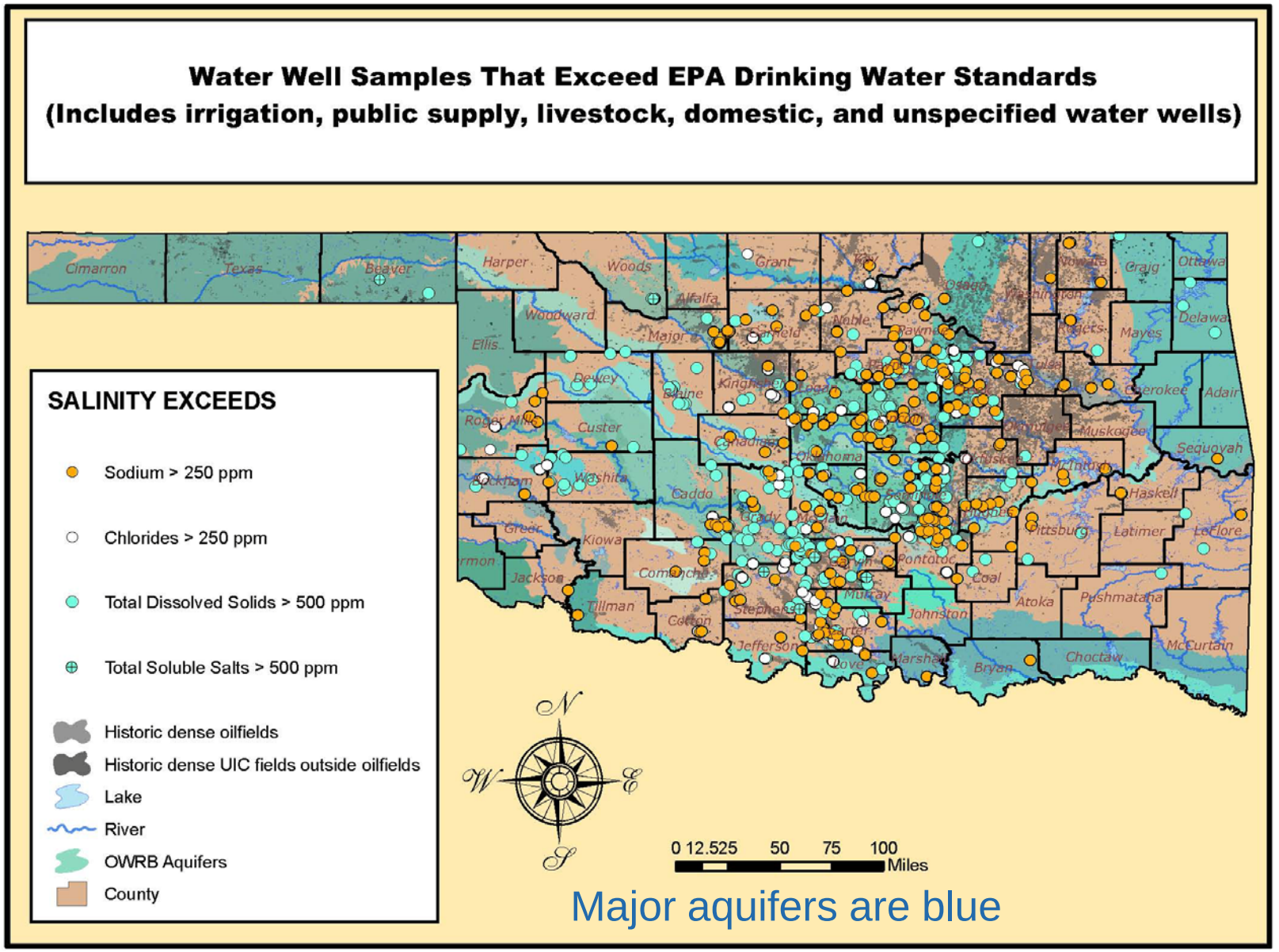
- Nitrate is NOT oilfield - from agriculture (CAFO, fertilizer, litter) or septic systems

Petroleum, Water Wells, all Depths



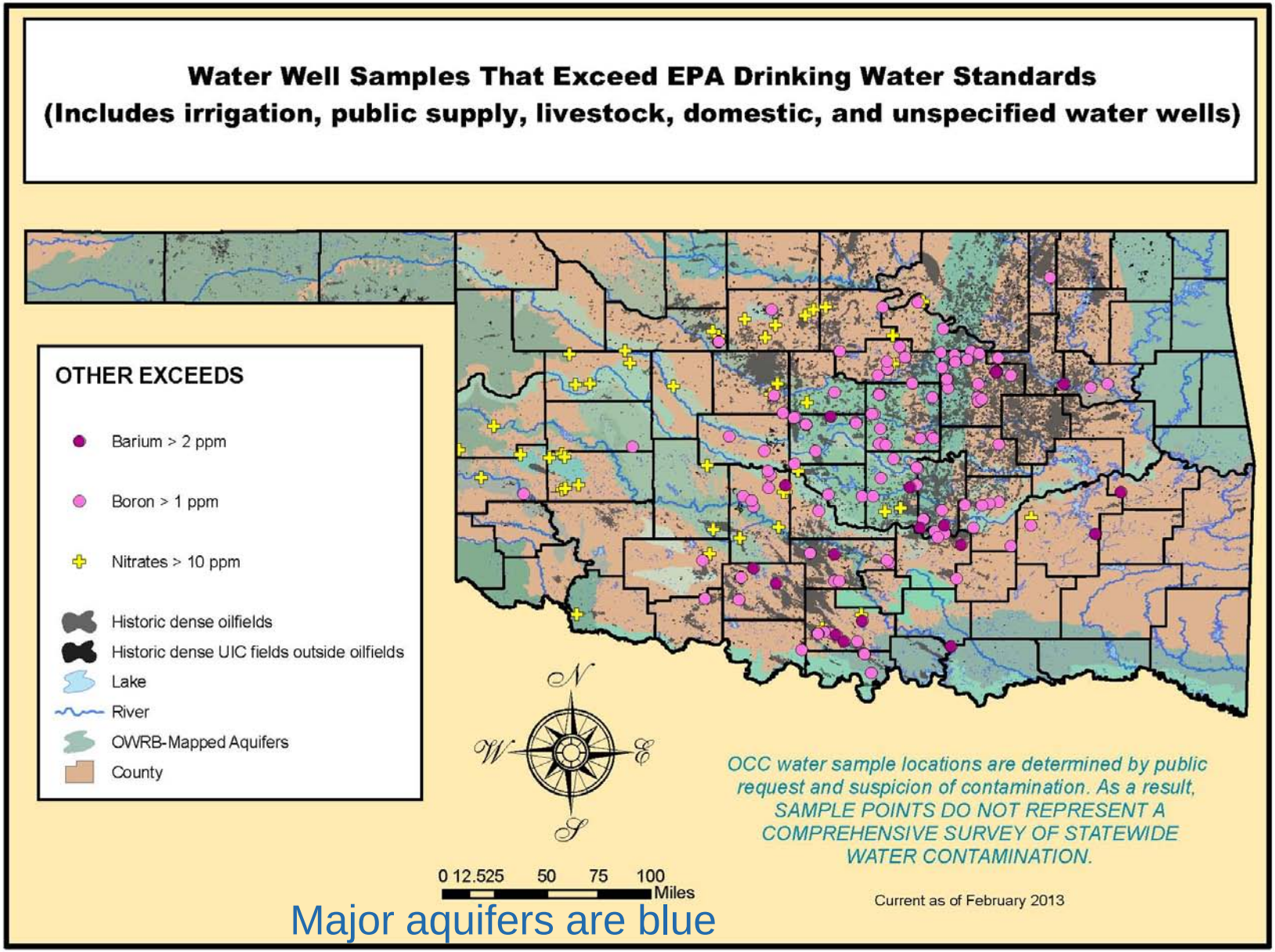
Major aquifers are blue

Salinity in Water Wells – Ouch!



Major aquifers are blue

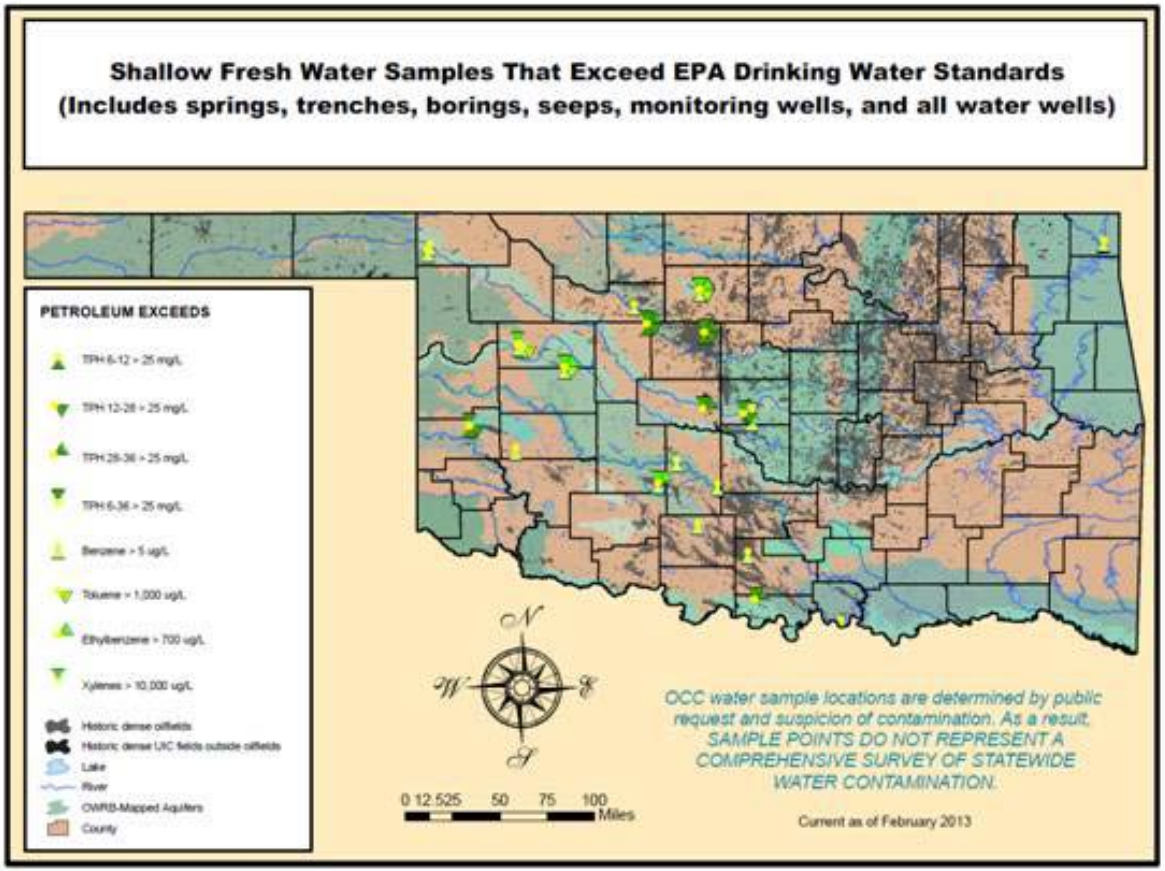
Other Pollutants in Water Wells



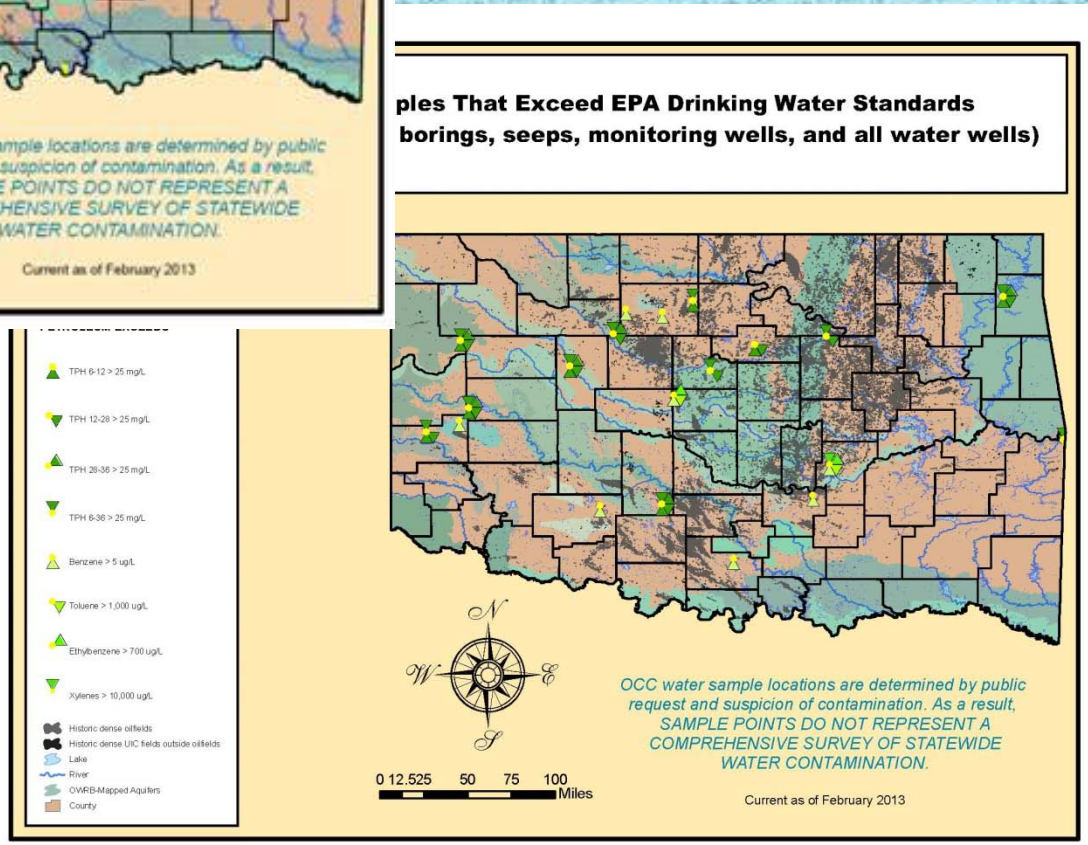
Major aquifers are blue

Shallow verses Deep – Sources?

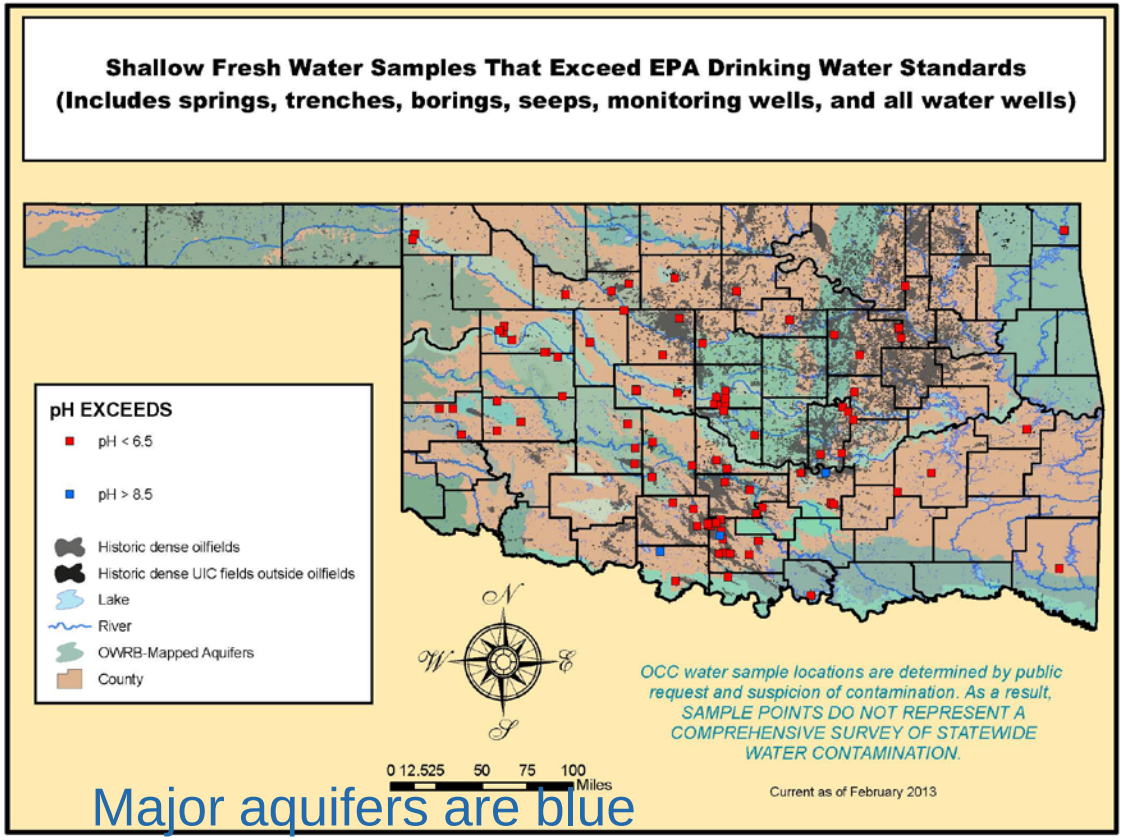
- Exceeds in SHALLOW groundwater (<25') are most likely due to surface spills, shallow pipeline leaks, while
- Deeper exceeds (>25') – are also due to:
  - old oil well casing leaks,
  - former deep oilfield brine "evaporation pits",
  - Aquifer recharge areas at the surface, &
  - poorly constructed water wells acting as conduits (explain later)
- We are starting to look at this – see maps:



Petroleum, Shallow verses Deep

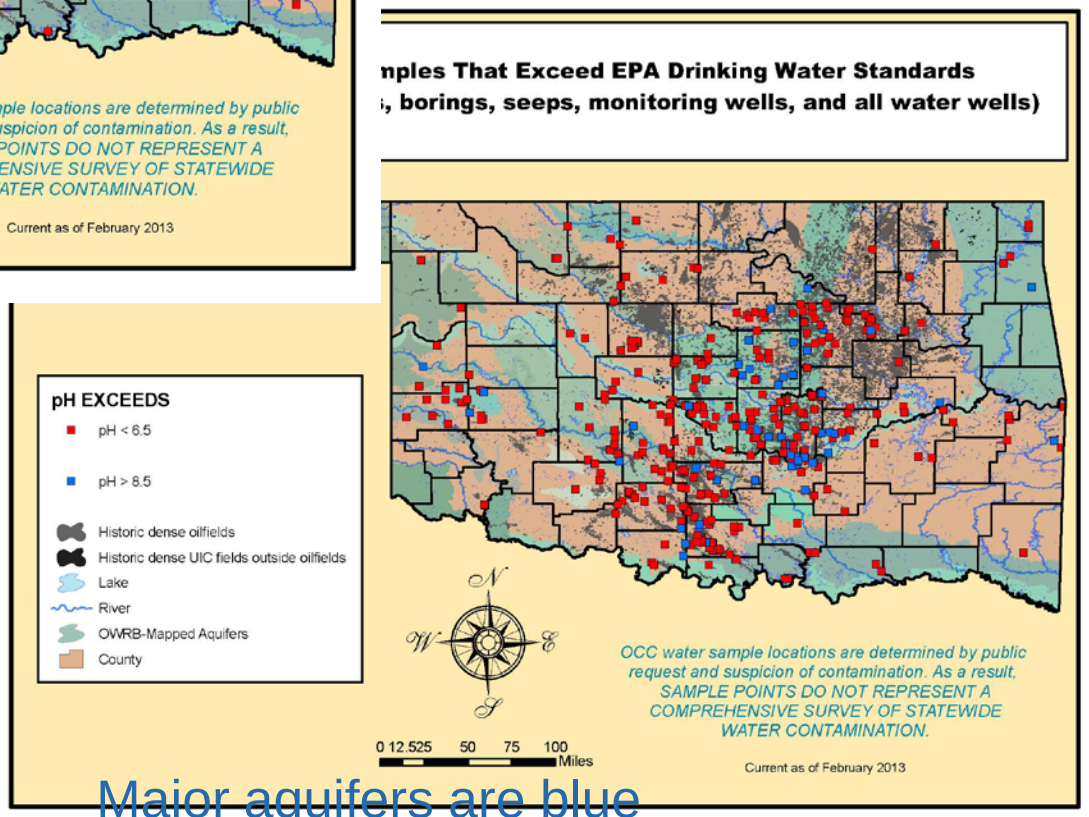


Note the different patterns, shallow verses deep



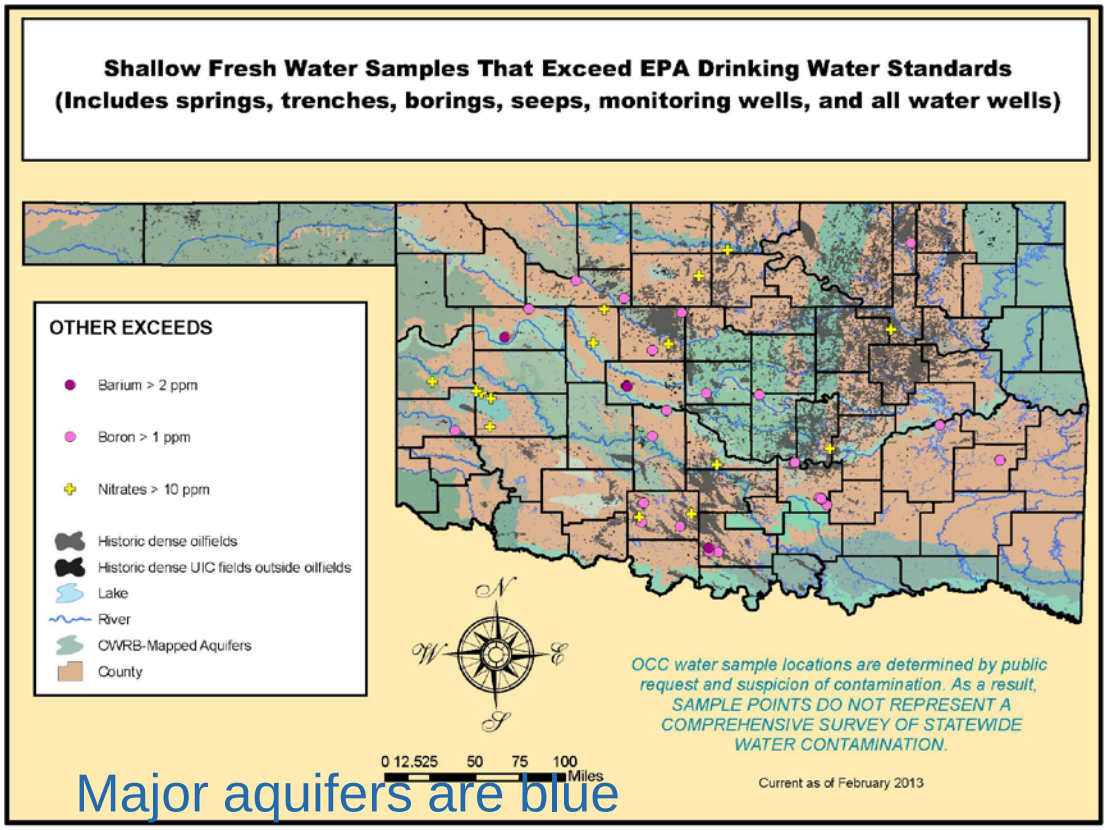
Major aquifers are blue

pH, too acidic verses too basic, Shallow verses Deep



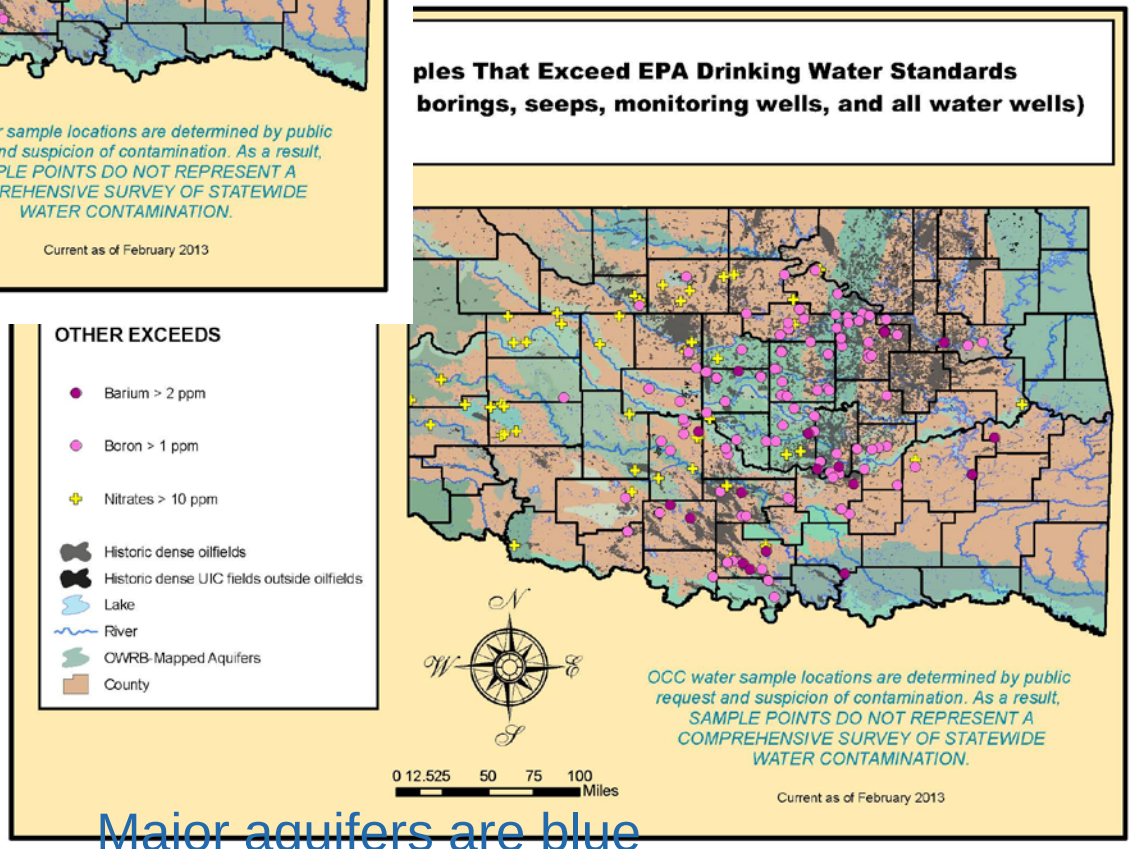
Major aquifers are blue

Note the different patterns, shallow verses deep and acidic verses basic



Major aquifers are blue

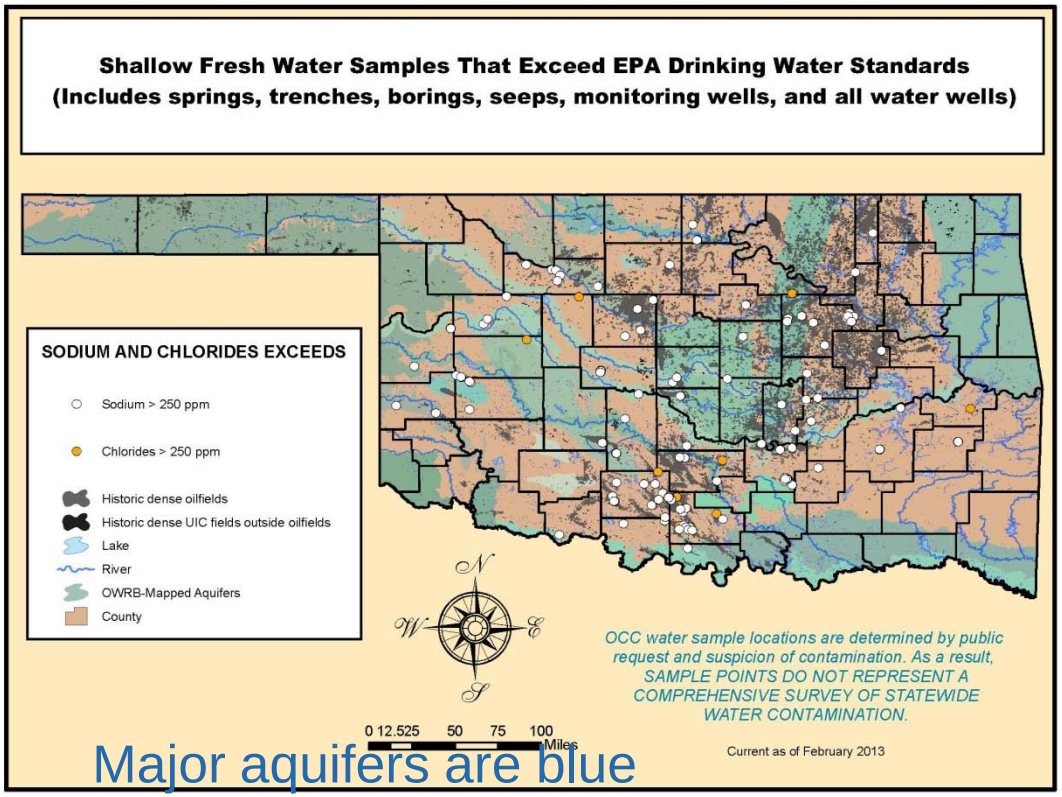
Nitrate, Barium, and Boron, Shallow verses Deep



Major aquifers are blue

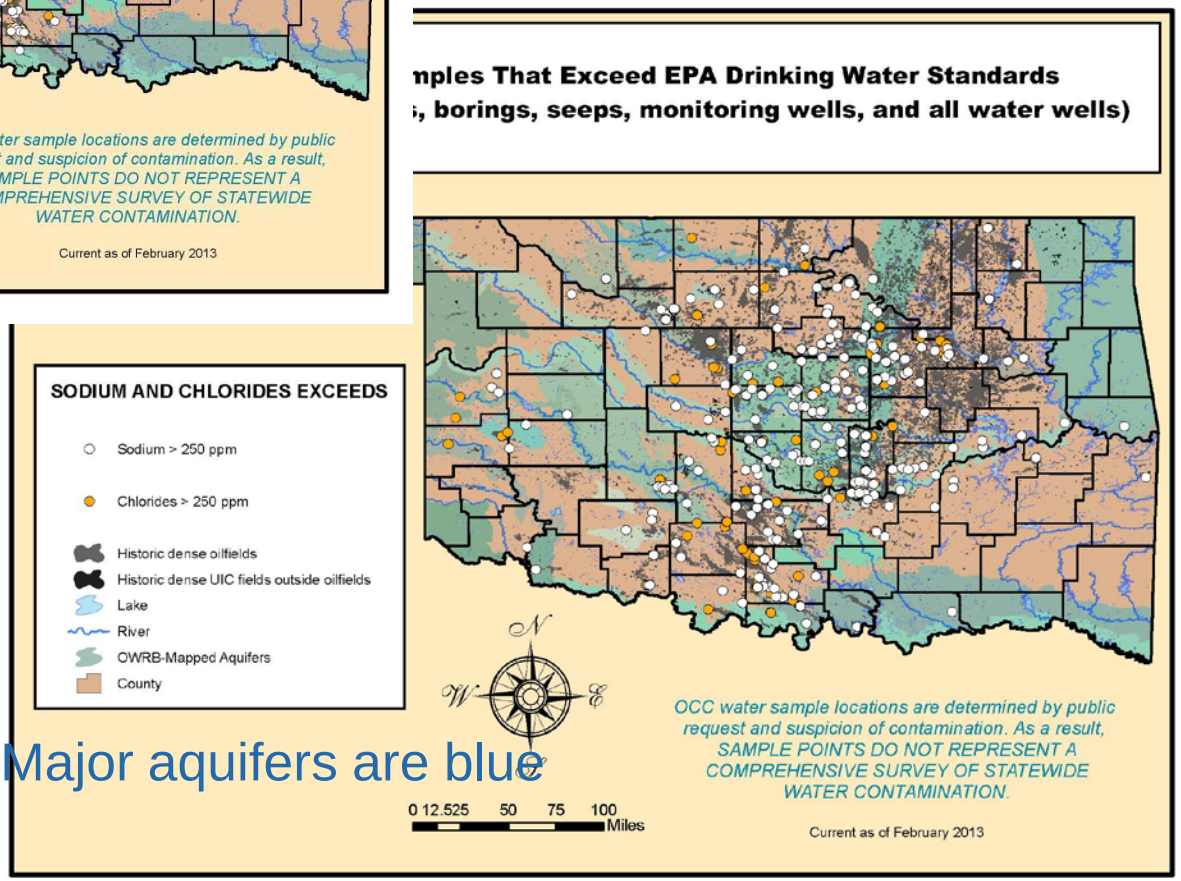
Many more exceeds in groundwater deeper than 25’

Salinity – Sodium & Chloride, Shallow verses Deep



Major aquifers are blue

Differ in both pattern and number of exceeds



Major aquifers are blue

Pollutant Focus

- Today I will focus mainly on salt/salinity – the biggest problem
- Oil and gas wells produce more water than oil – 252,000,000 gallons PER DAY in OK, in 2012
- The USGS database of Produced Oilfield water show Oklahoma oilfield brines contain up to 18% salt , while seawater is ~3% salt
- SALT DOES NOT DEGRADE – It just moves, soil to water

What Does It Matter, to OK's People?

Groundwater :

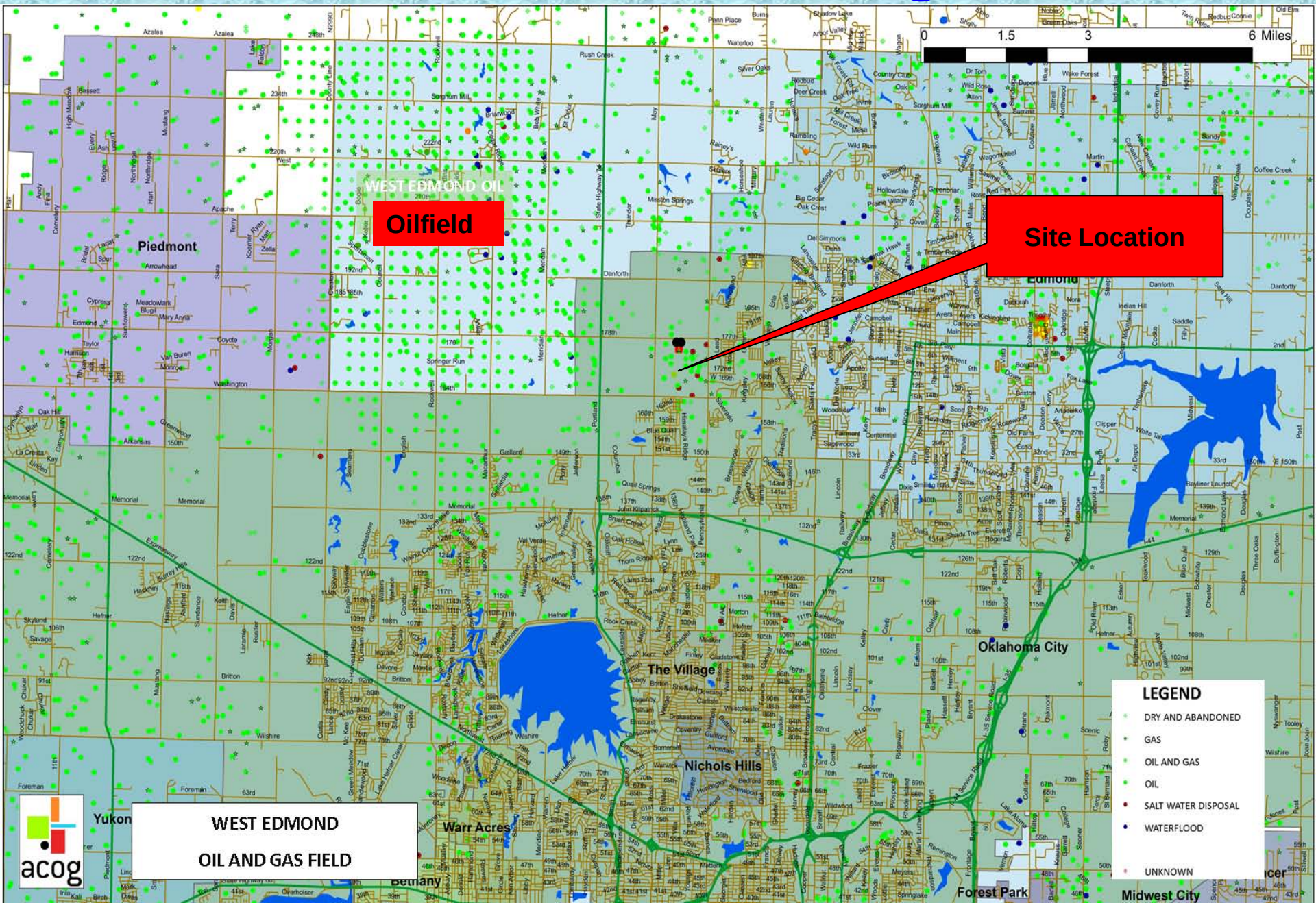
- Supplies ~40% of all water used in Oklahoma
- Provides water to > 300 Oklahoma cities and towns
- Supplies water to 295,000 Oklahomans with domestic wells
- Supplies 73% of all Irrigation water for Agriculture - It is our food too!

- I am going to show 2 typical case studies in Central OK.
- Where I also have geophysical data, so
- We can show **where the pollution originated**, and
- **How it is moving through the subsurface**.

Example 1 - Recent Case, 2011

- 15 year old gated community in NW OKC
- Homeowner complaints of salty well water.
- Was a historic, until 1980s, oilfield area; our Field Inspector sampled their water wells.
- Later learned that two original subdivision homeowners had had bad wells in their backyard, with later new wells in the front yards. Red Flag!

Area was once an oilfield-green dots



Sampling Results

Wells ~300’ deep; only reached ~150’ backyard

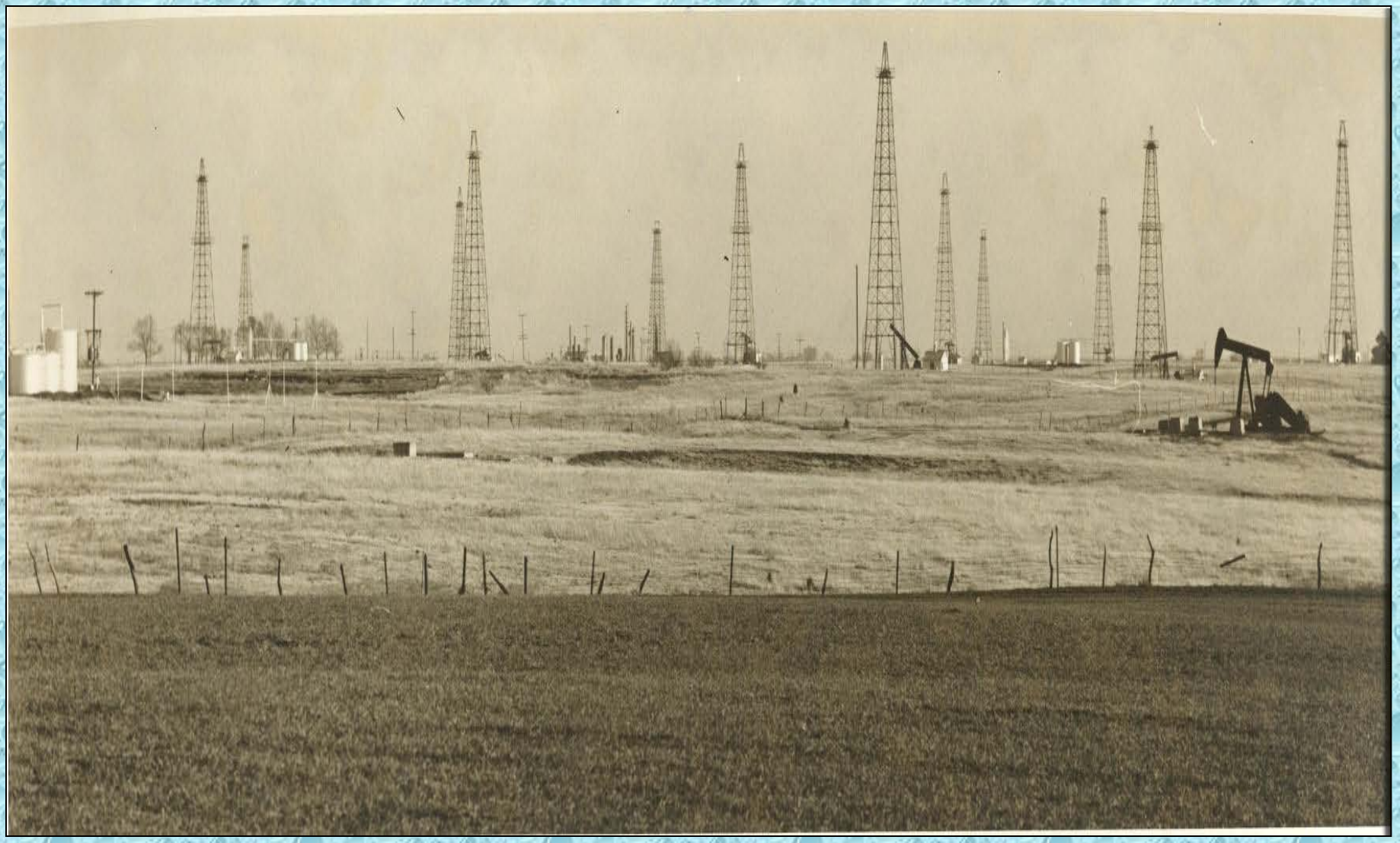
Who	Na ppm	Cl ppm	SO4 ppm	TDS or TotlSolSalts	Na/Cl
Z	1314	3323	798	7597	0.395
L	665	2171	370	4996	0.306
C	438	1047	722	3247	0.418
D	210	460	357	1756	0.457
N	184	139	302	1095	0.662
B Front yard	92	417	79	1327	0.441
B Backyard				1600	

Exceeds Chloride secondary drinking water standards

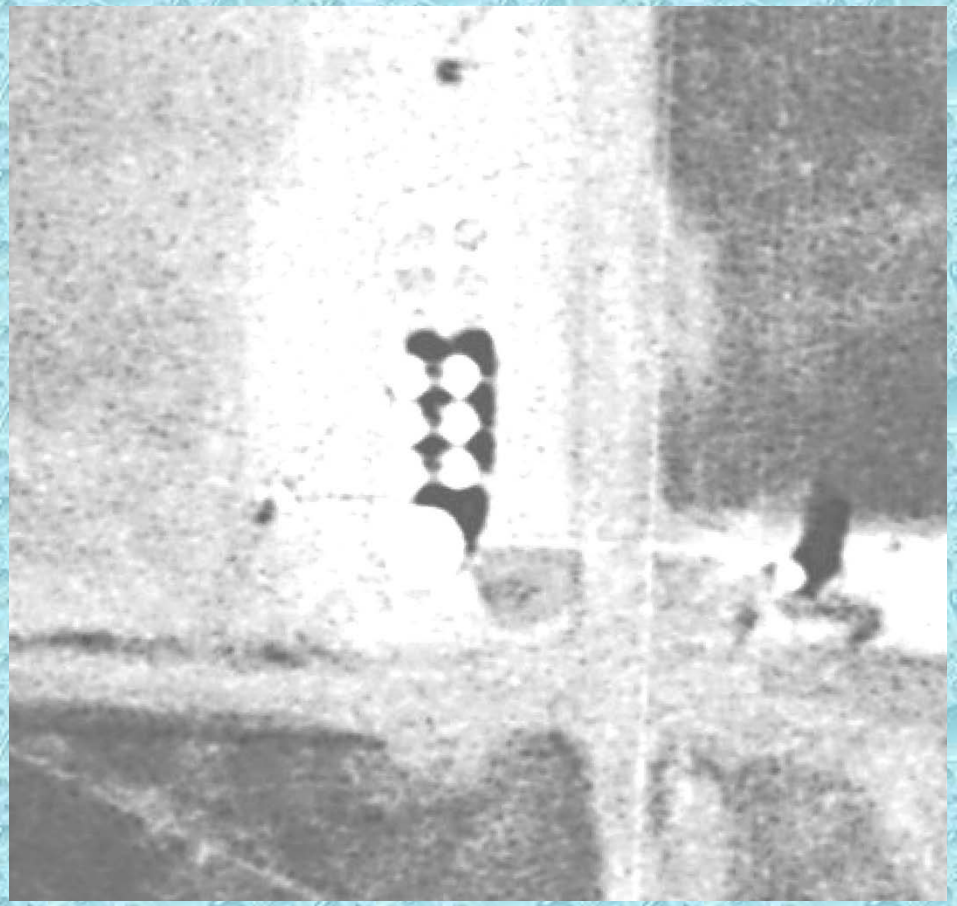
Na/Cl Ratio <0.6 indicates oilfield source

Sulfate SO4 – from **natural** BaSO4, which makes Rose Rocks

WEST EDMOND OIL FIELD CIRCA 1945

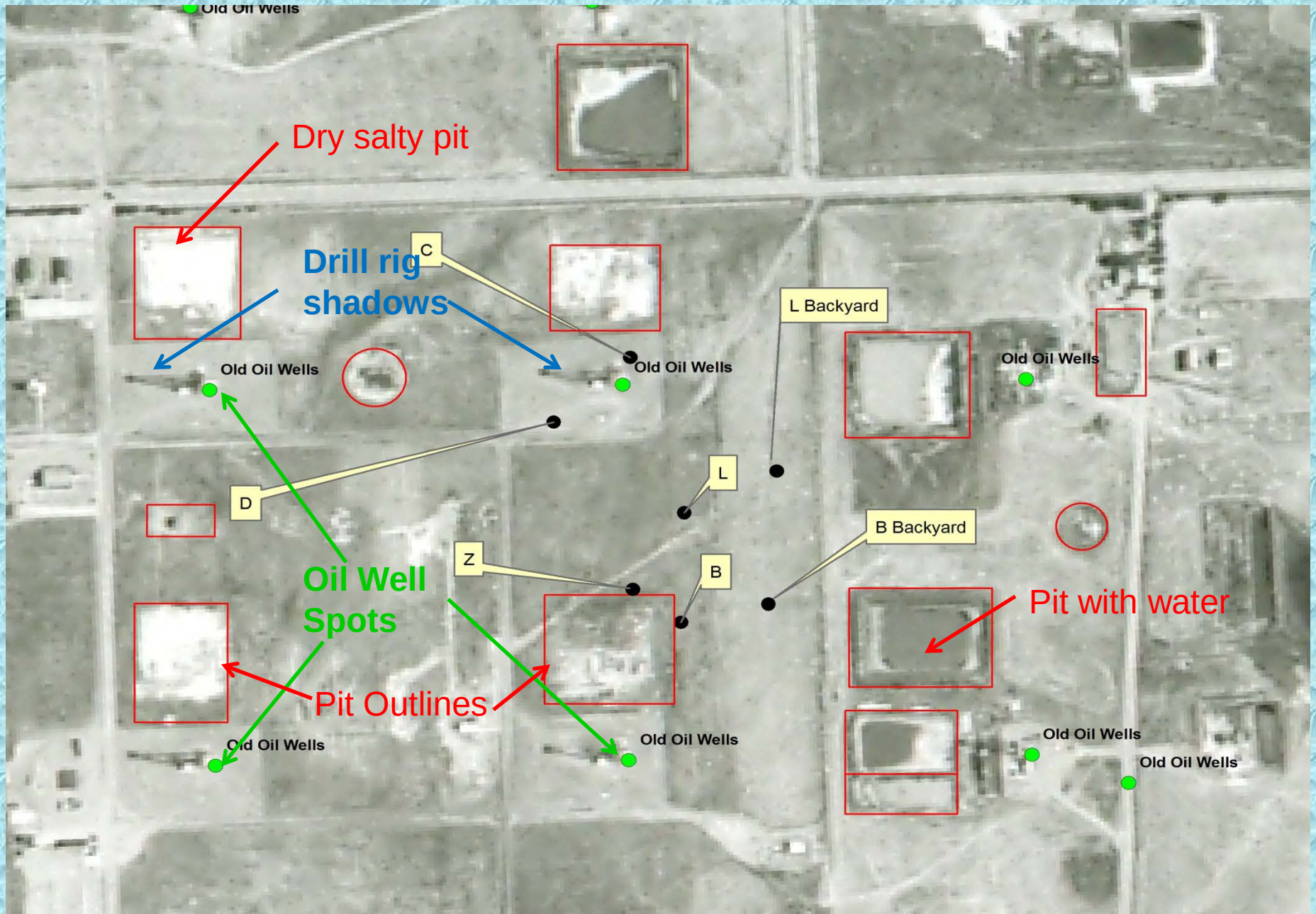


Where there were Oilfield Tank, now we have New Homes

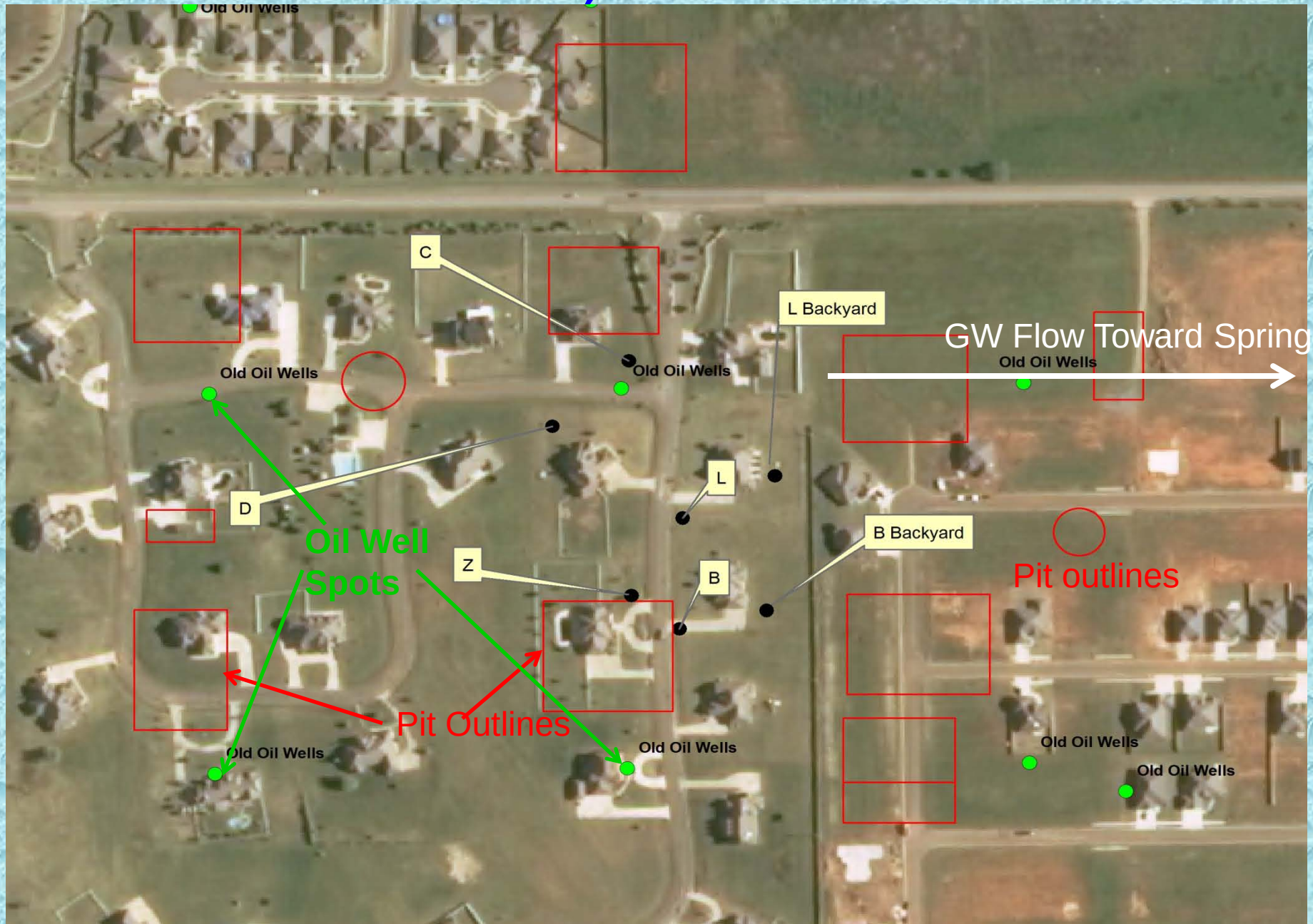


Tank group @ end of gathering system

1941 Aerial Showing Drill Rigs, Pits



Old Pits & Wells, Modern Air Photo

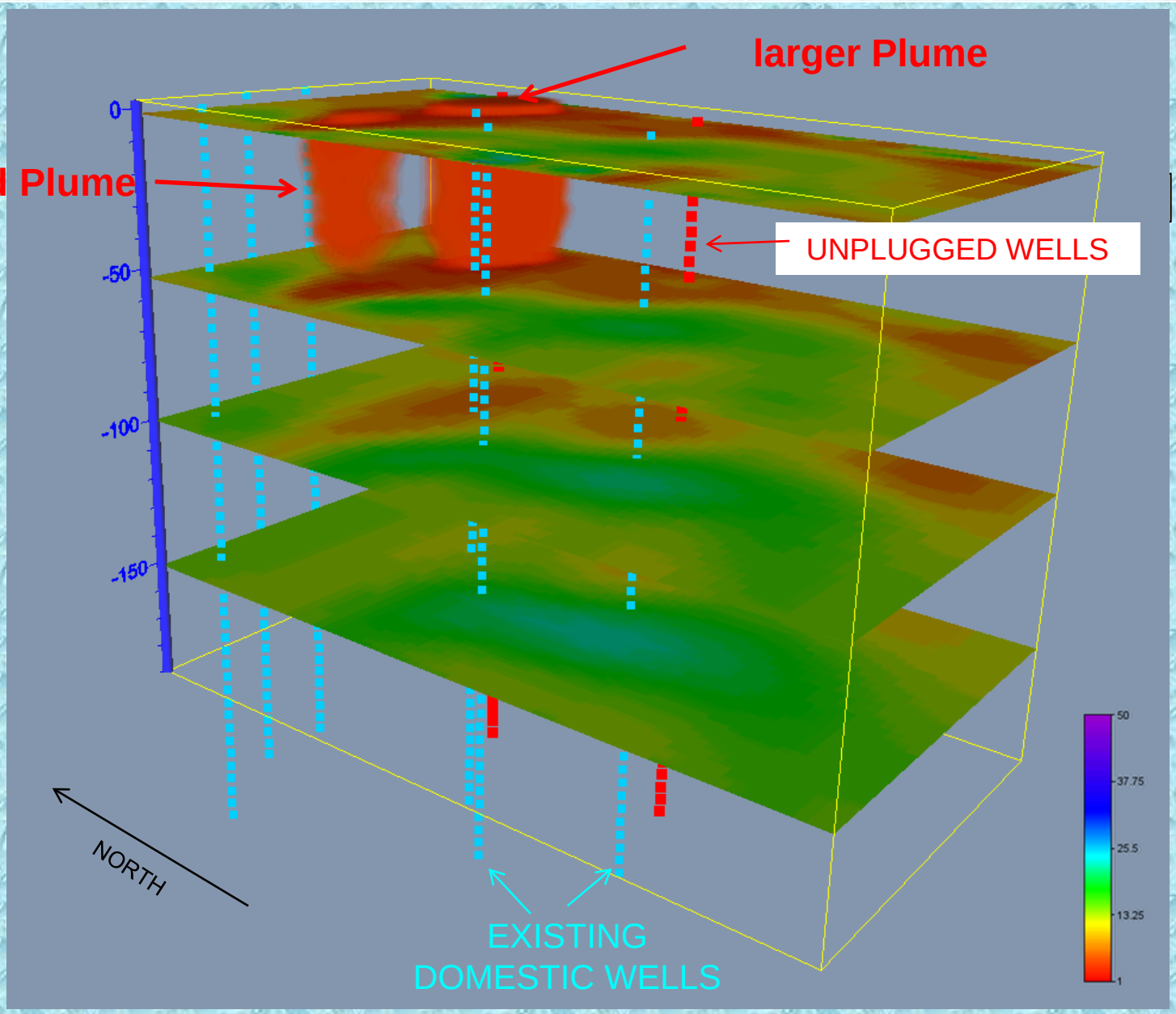


Geophysics – At The Surface

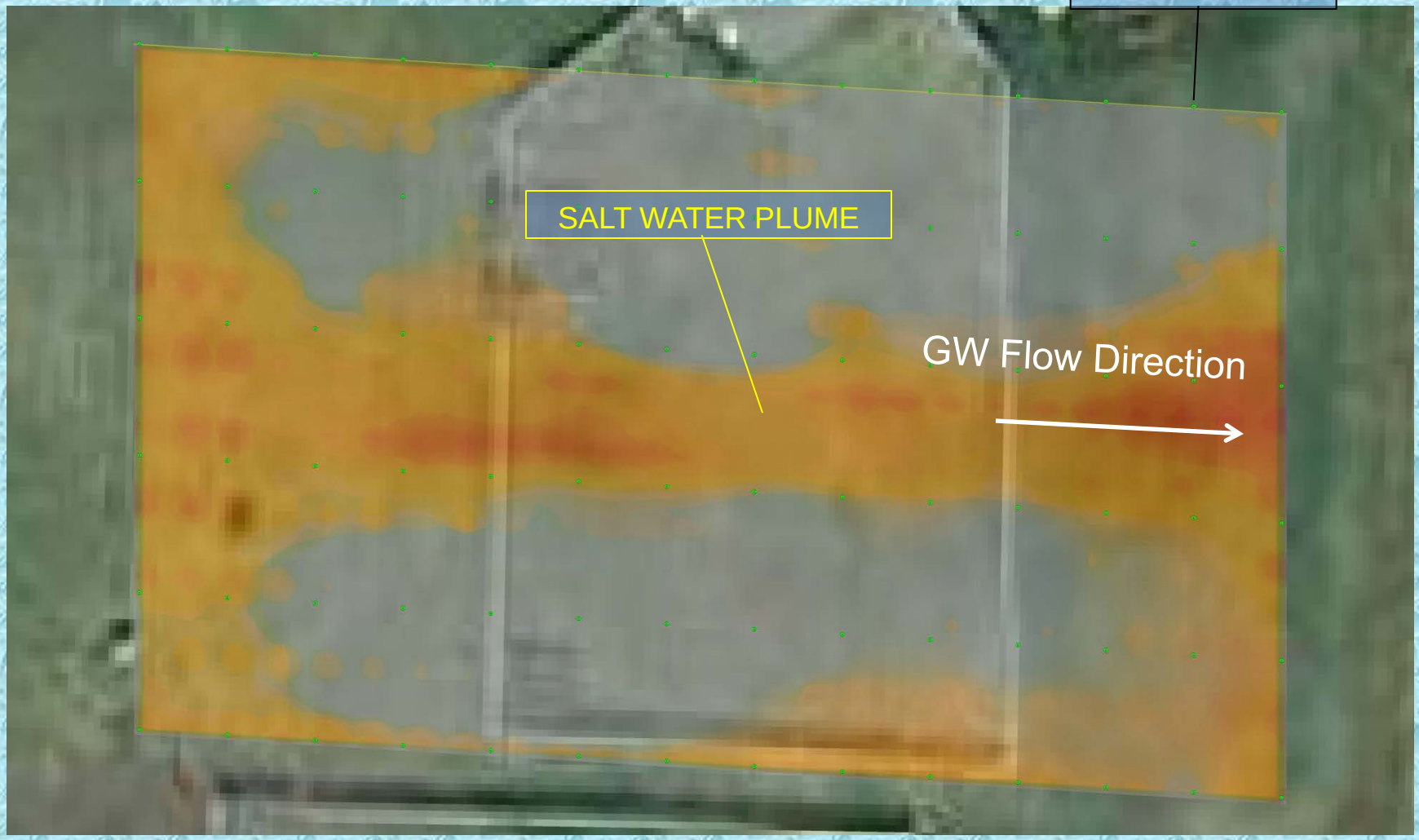
Geophysical Array CF03

acog

Geophysics – 3D, both saline plumes



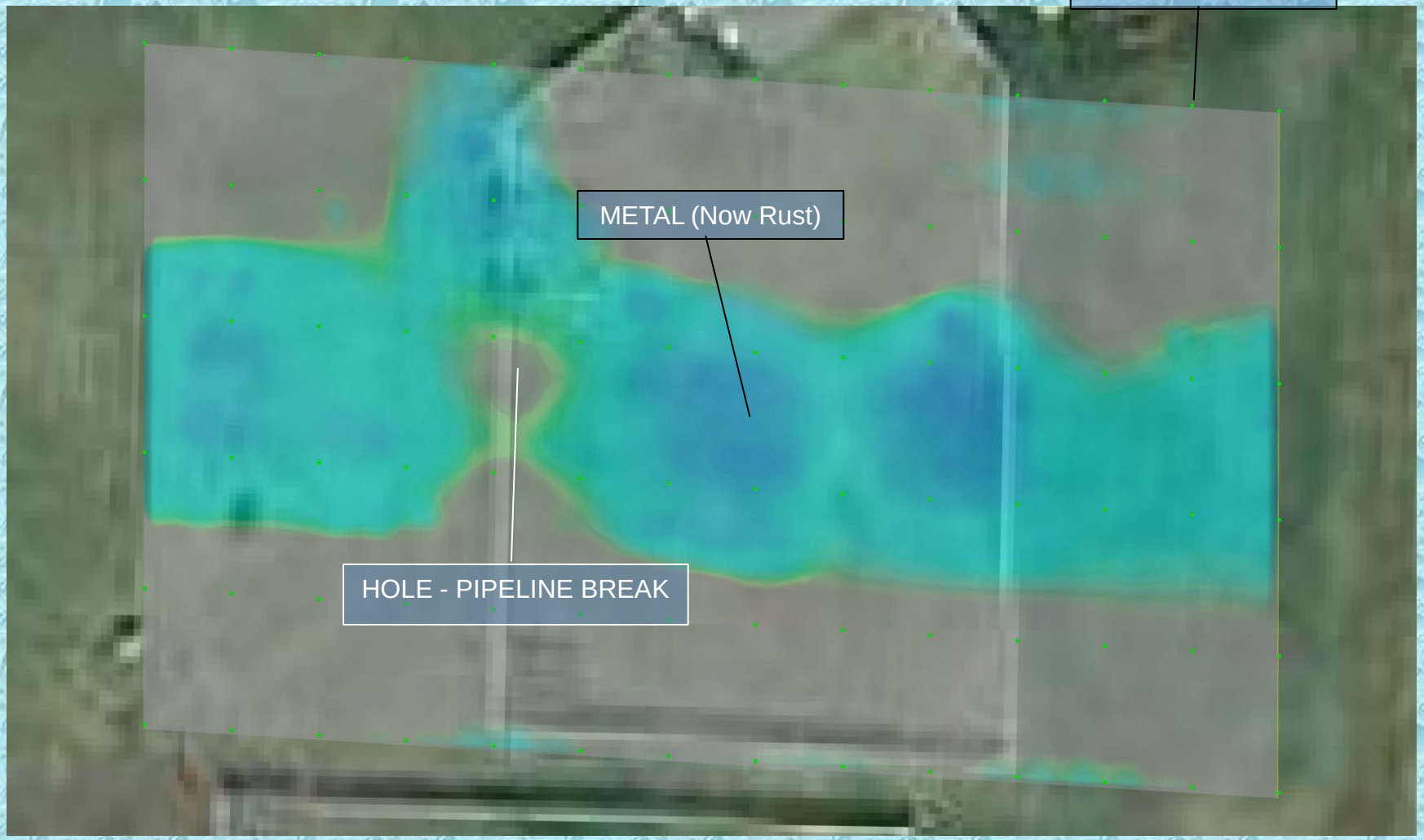
Geophysics – Linear Saline Plume, Backyard to East



Geophysical Array CF03
Resistivity Values <= 1 ohm-meter
Depth ~ 20 Feet

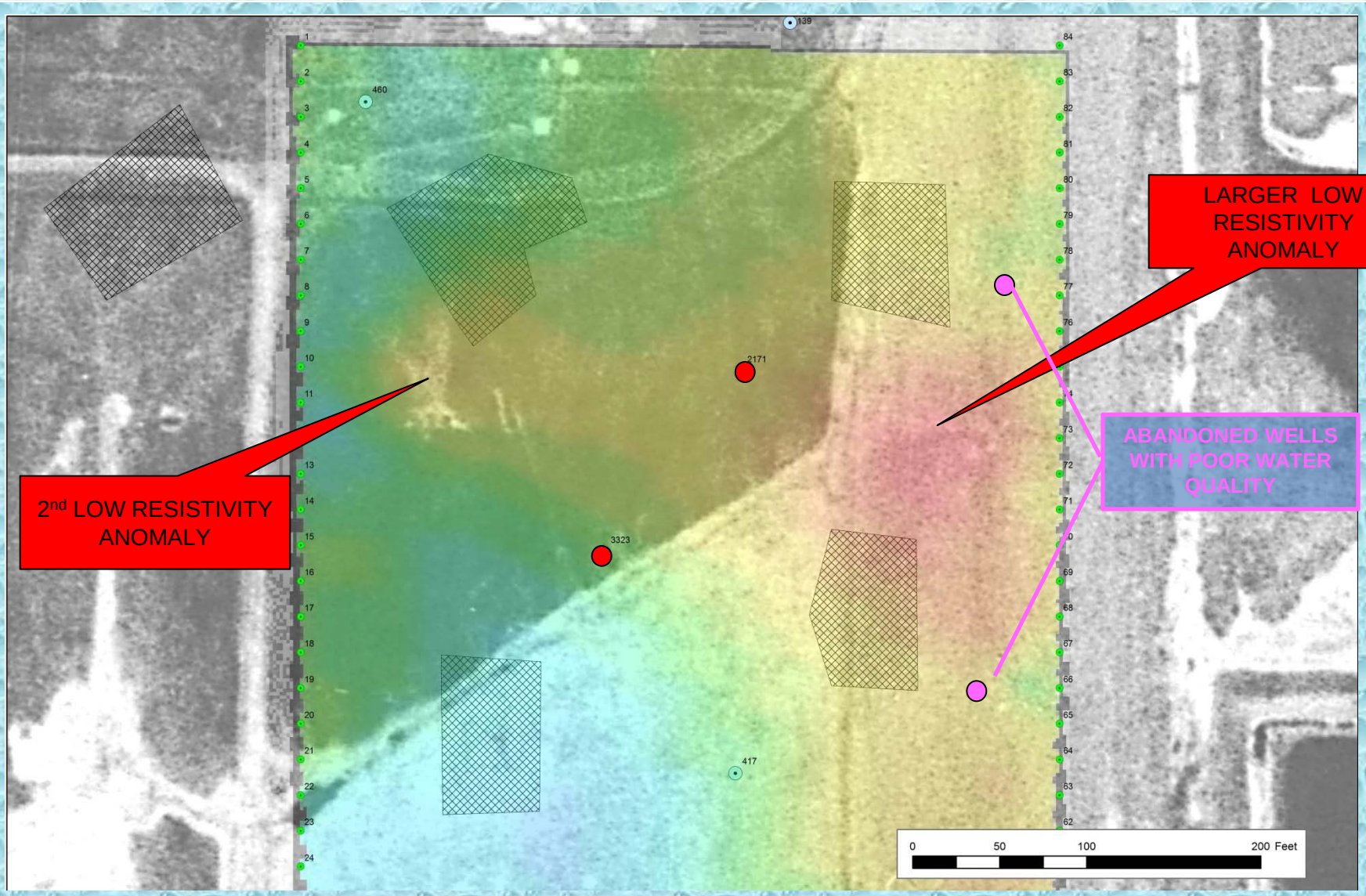
acog

Geophysics, IP – METAL! Was A Gathering Line – With a Hole



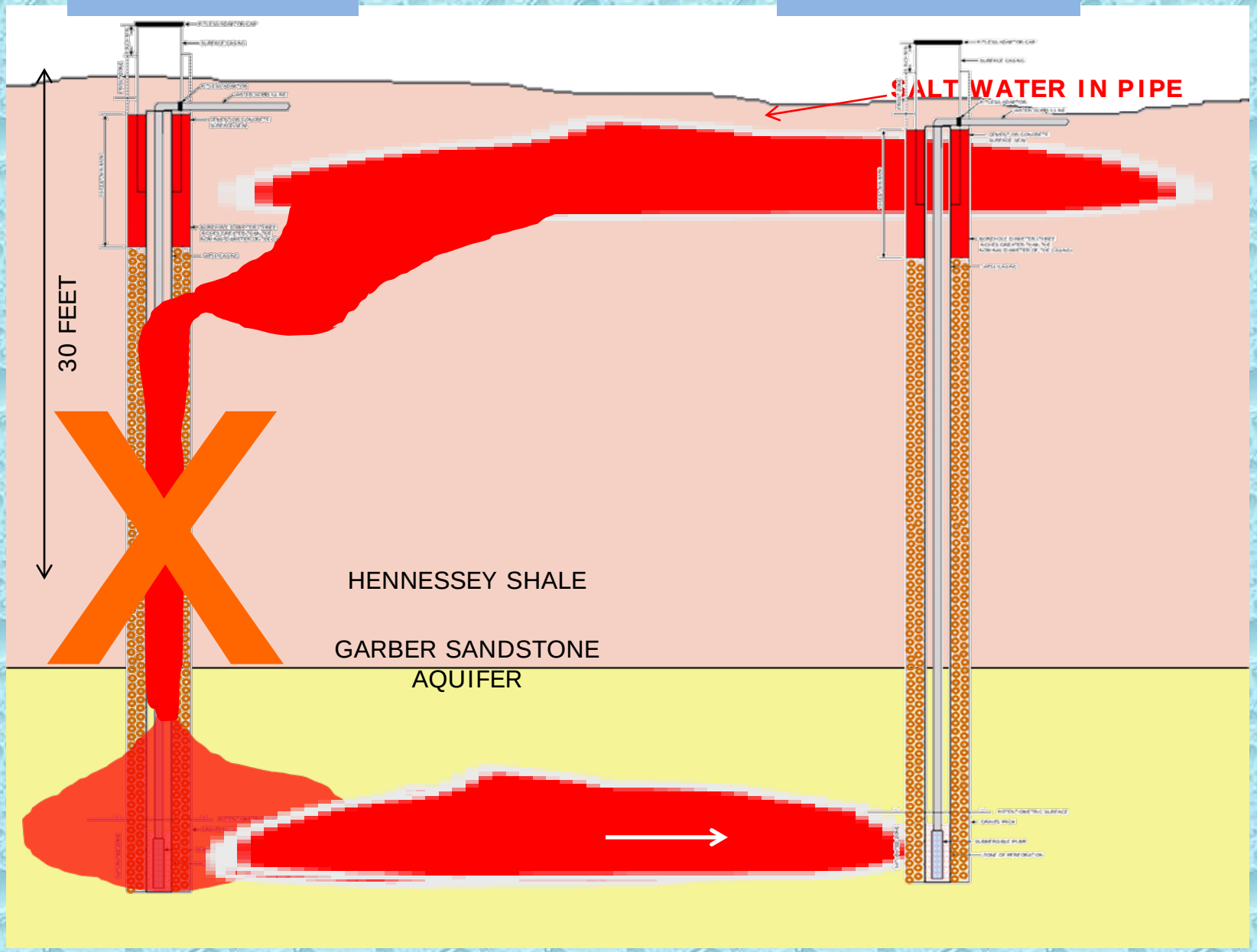
Geophysical Array CF03 IP
Induced Potential Values > 100 ms
Depth ~ 20 Feet

1951 Aerial Photo – Definite Scar; Note Linear Features Also



1951 Aerial Photo

What Happened



Conclusions

- **Old (1940's-80s) Oilfield Activity Caused problem;** Chlorides to 217,587 ppm in brines
- Open, surface to 300' deep gravel pack water well construction channeled shallow pollutants down into the Garber Aquifer.
- **In effect, the water wells, by their standard design, polluted themselves - and the aquifer**
- Especially the unplugged backyard wells

Intermediate Solutions

- The city Brought a water line into the subdivision - at a $$ cost;

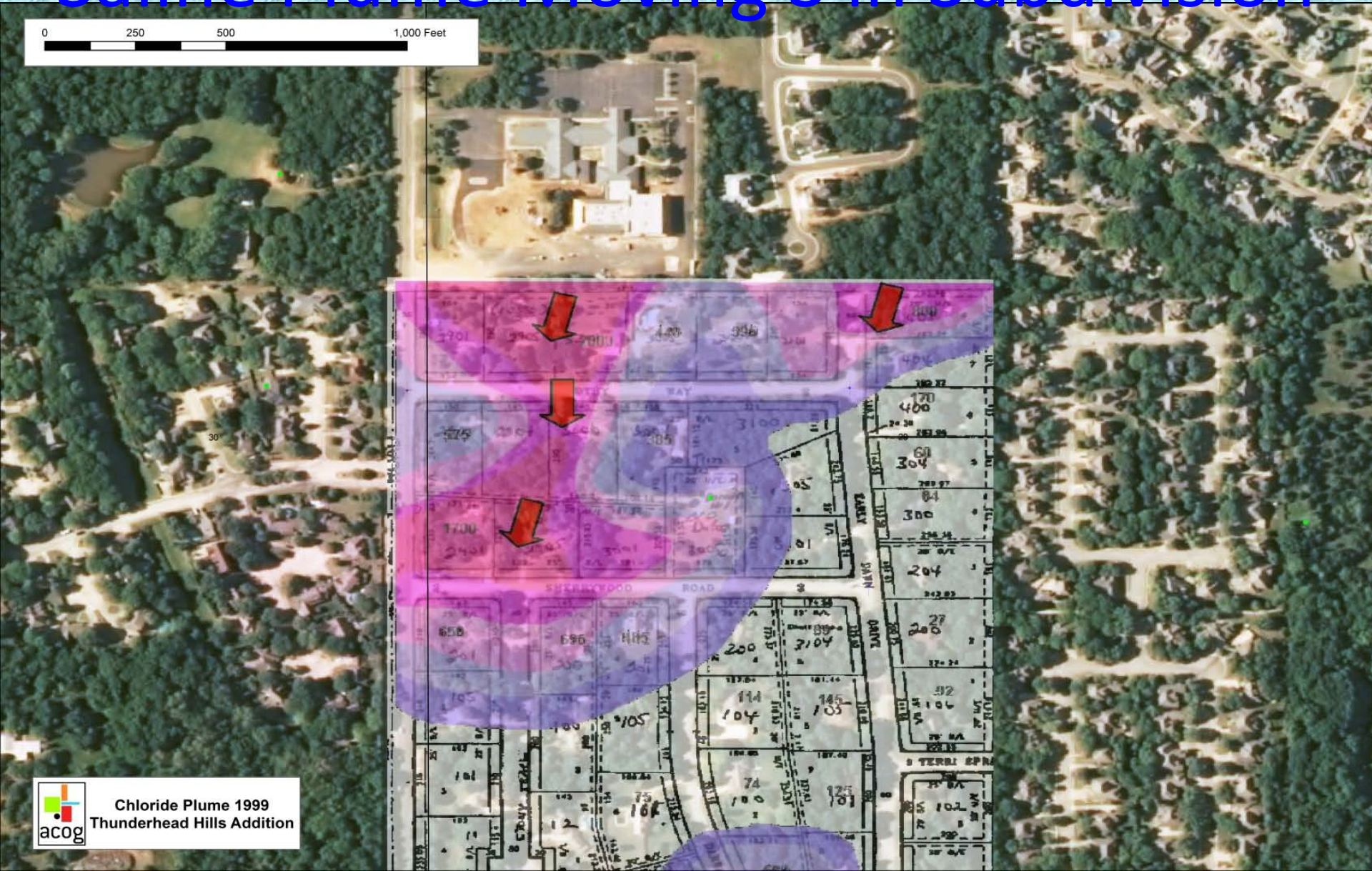
And

- Corp Comm's Brownfields program paid for plugging the water wells to prevent the spread of more contaminants down into the aquifer .

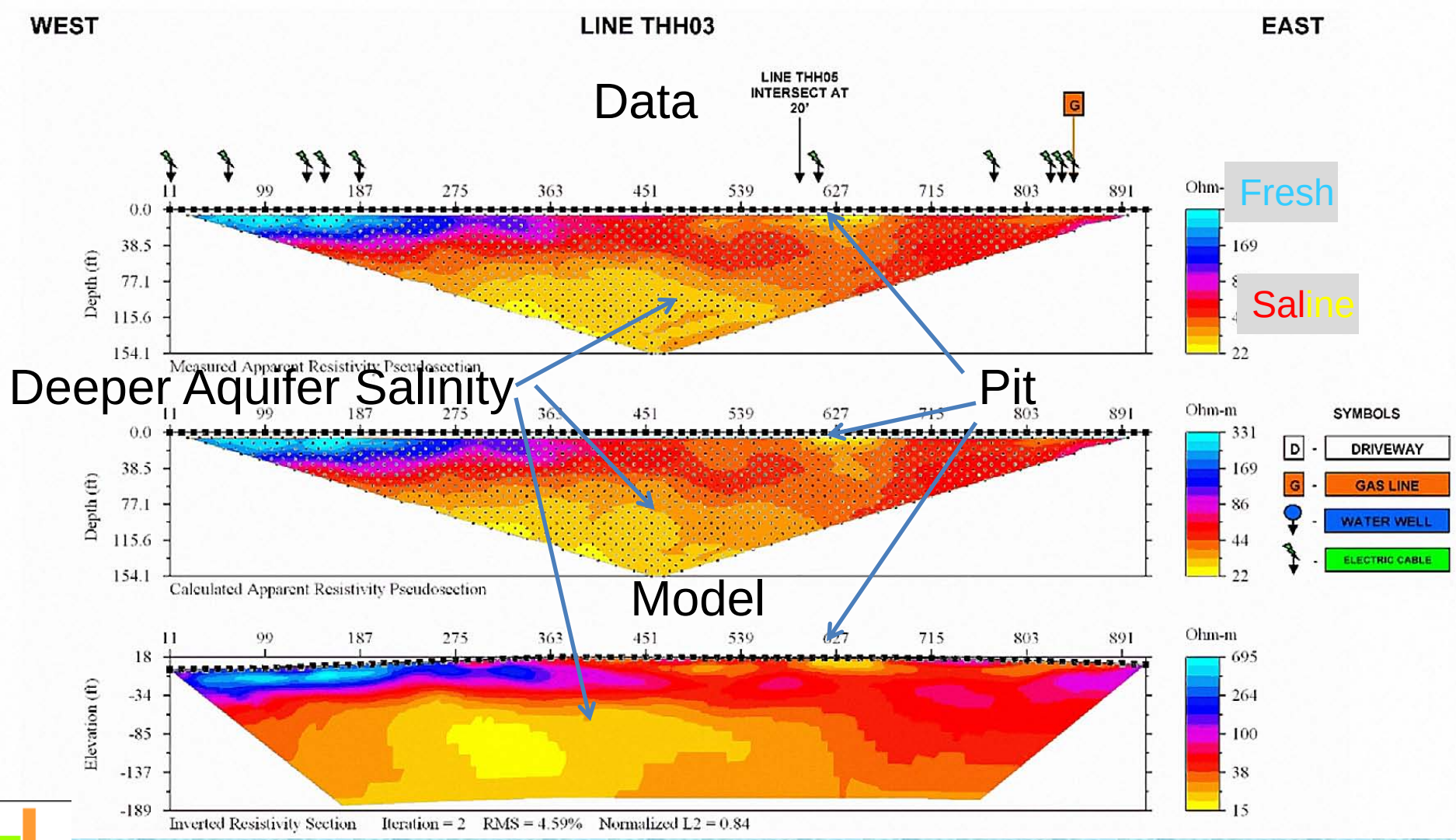
Another Example
Water Well Samples, T Hills Edmond

Address	Sodium ppm	Chloride ppm	Total Soluble Salts
3101 Sherrywood	153	577	1518
3009 Timothy	308	928	2066
200 Stony Trail	377	1001	2363
3005 Sherrywood	410	1056	2373
2901 Sherrywood		1237	2402
3001 Timothy Way	575	1258	2924
Produced Water, Darwin #1 T Hills Oil Well	79,830	123,947	222,996

Another Example
Saline Plume Moving S in Subdivision



Old Pits on the Garber Sandstone Leaked, Wells helped deeper into aquifer @ 90’



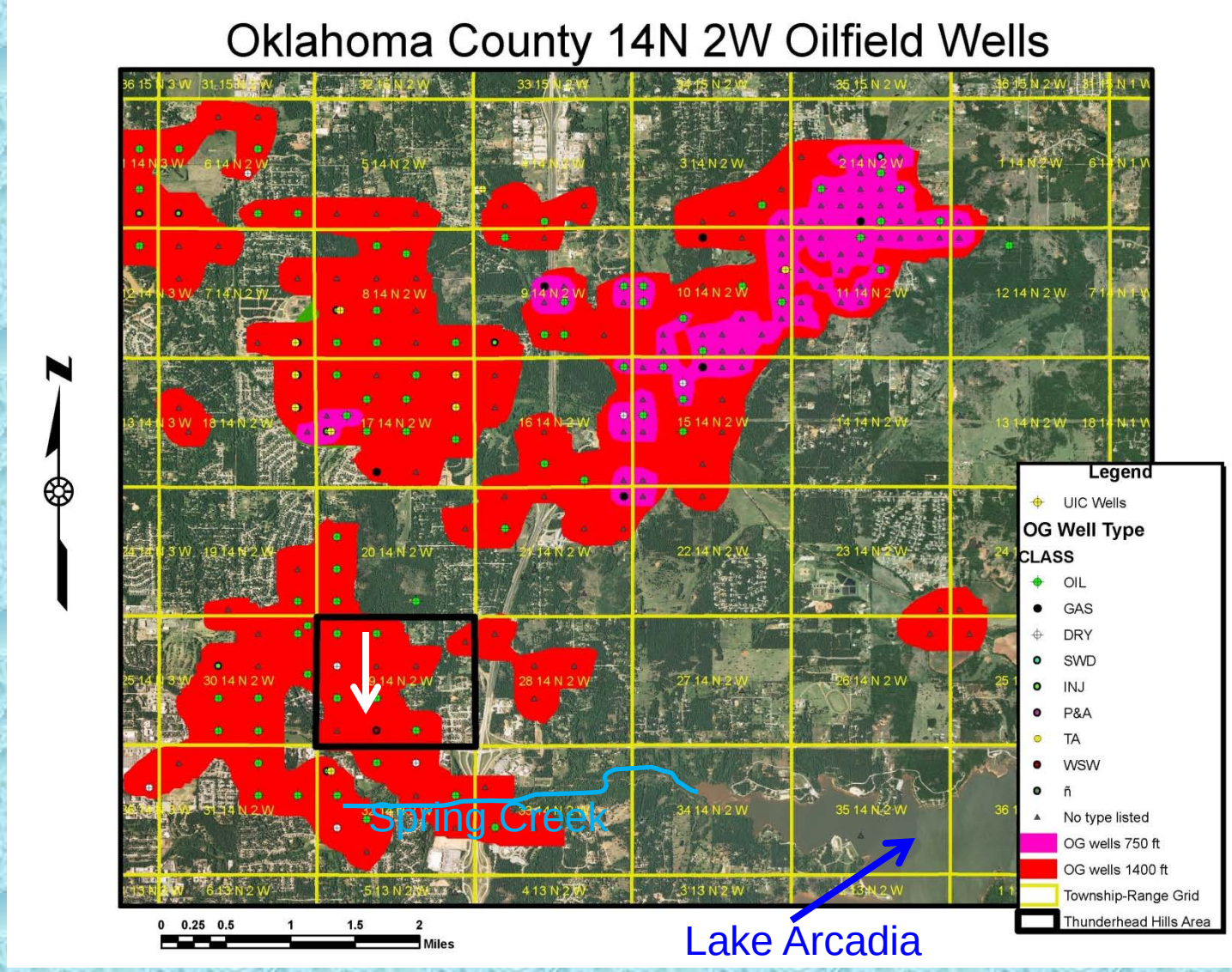
Processed Data Showing Inferred Groundwater Conditions

Edmond – A Bonus!

T Hills homes: groundwater pollution plume moving SOUTH since 1990s 90' per year, dozens of water wells being ruined

Apparent Source: Old pits

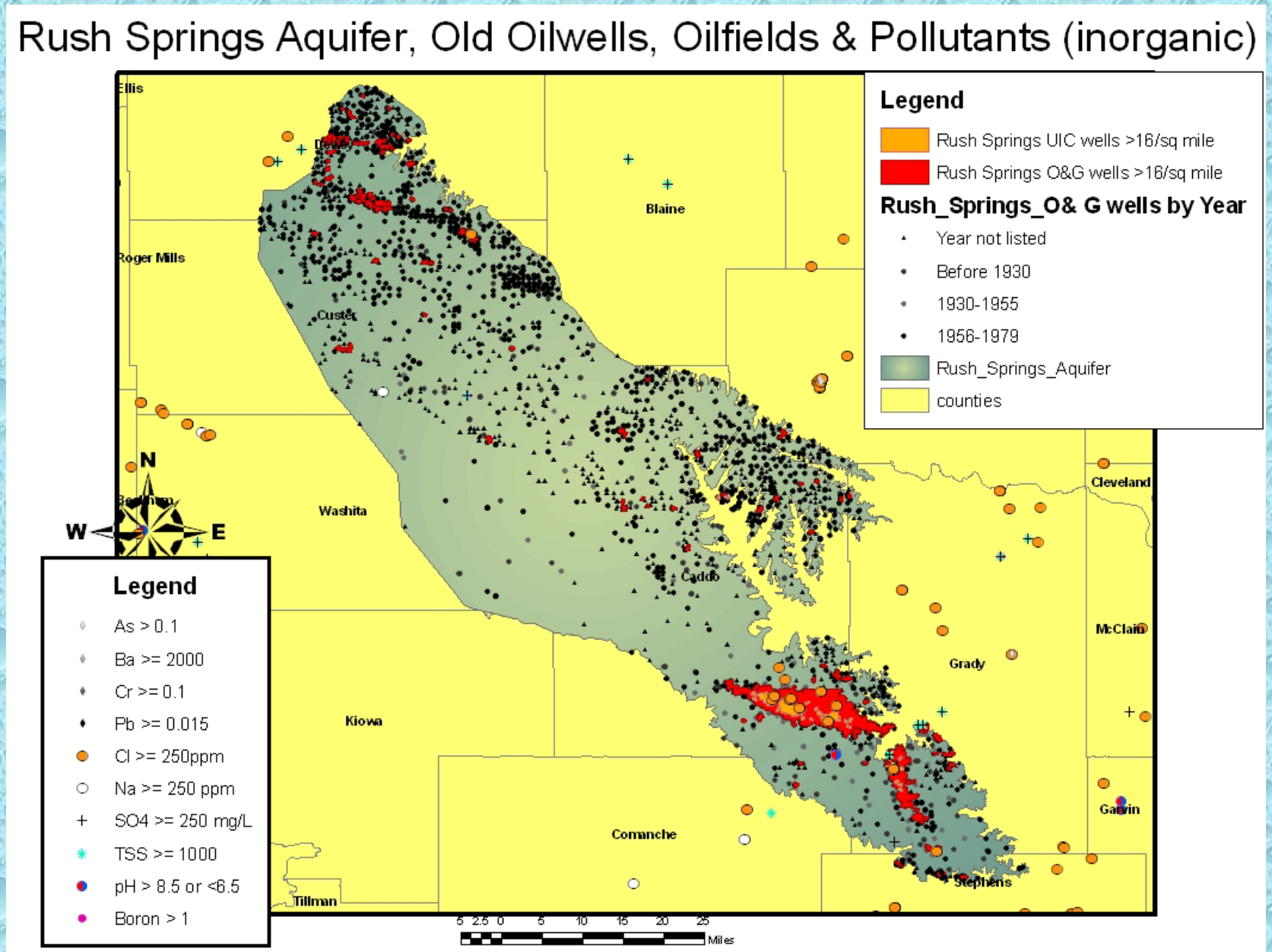
Special "Bonus" – stream and reservoir



Because of problems in old oilfields and cases like the above, Corp Comm is Mapping Old (pre 1980) well fields, especially on Oklahoma's Aquifers

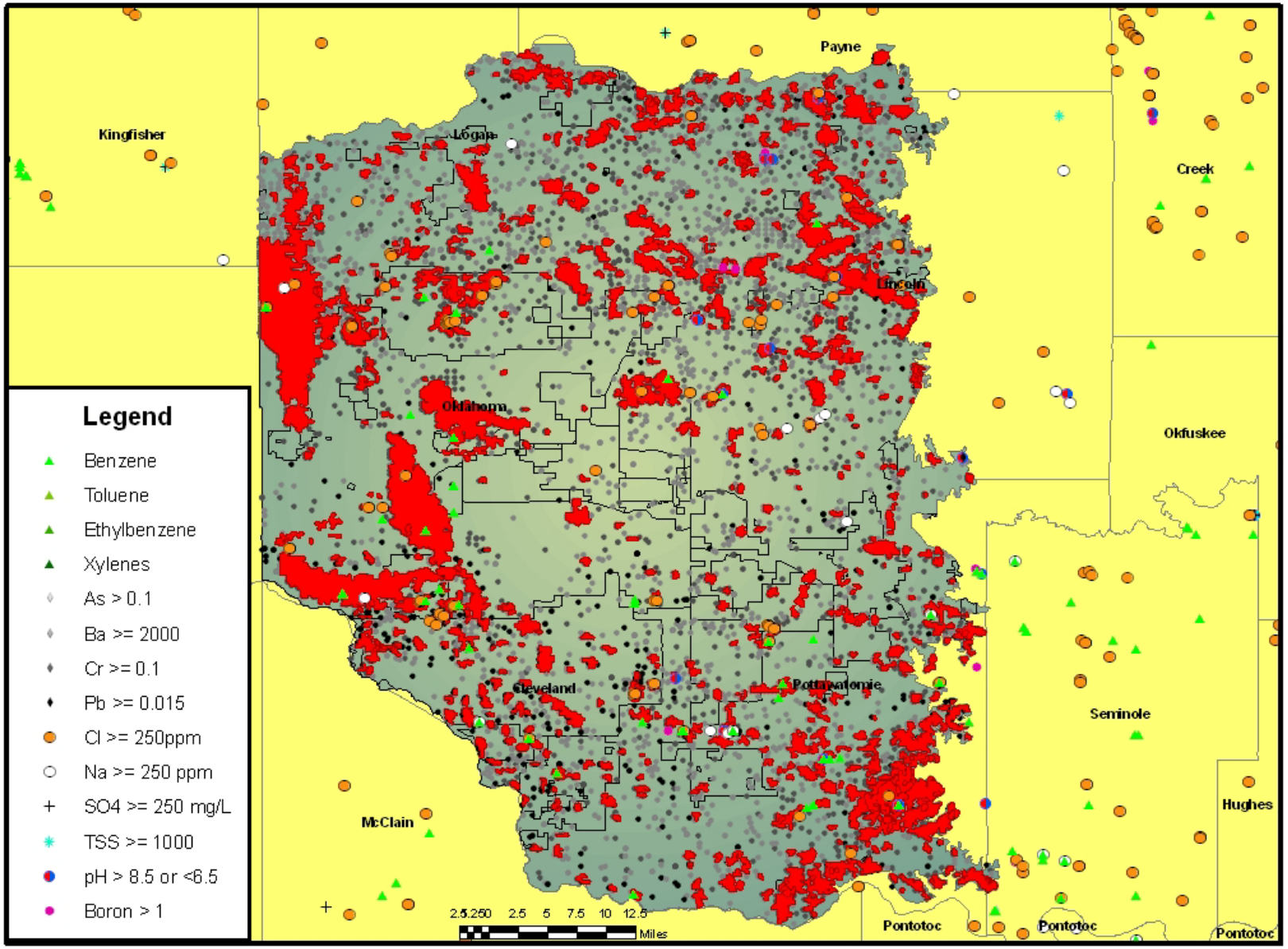
- Before 1980, pit design, well plugging oversite, field inspection not as "rigorous" as after 1980
- E.g. Regular Mechanical Integrity testing of well casing, lines, equipment was not required pre-1980

More Wells/Oilfields, More Pollution



More Wells/Oilfields, More Pollution

Central OK Aquifer, Old Oilwells, Oilfields & Pollutants



Unfortunately, many of these old pre-1980 oilfields are just open fields today –

So Pollution Risks are often NOT obvious to developers or well drillers

Who will be hurt – Too many?

New Rules Request Made to OWRB

- To help prevent shallow pollutants from traveling down water well the gravel packs into aquifer(s) -
- In the higher risk mapped areas (old oil wells, pits etc <1400’ apart, >16 per square mile),
- Corp Comm has requested a New Rule requiring future water wells to be cased and cemented from the surface to at least 30’deep, gravel pack only BELOW 30’ –
- RULEMAKING THIS FALL

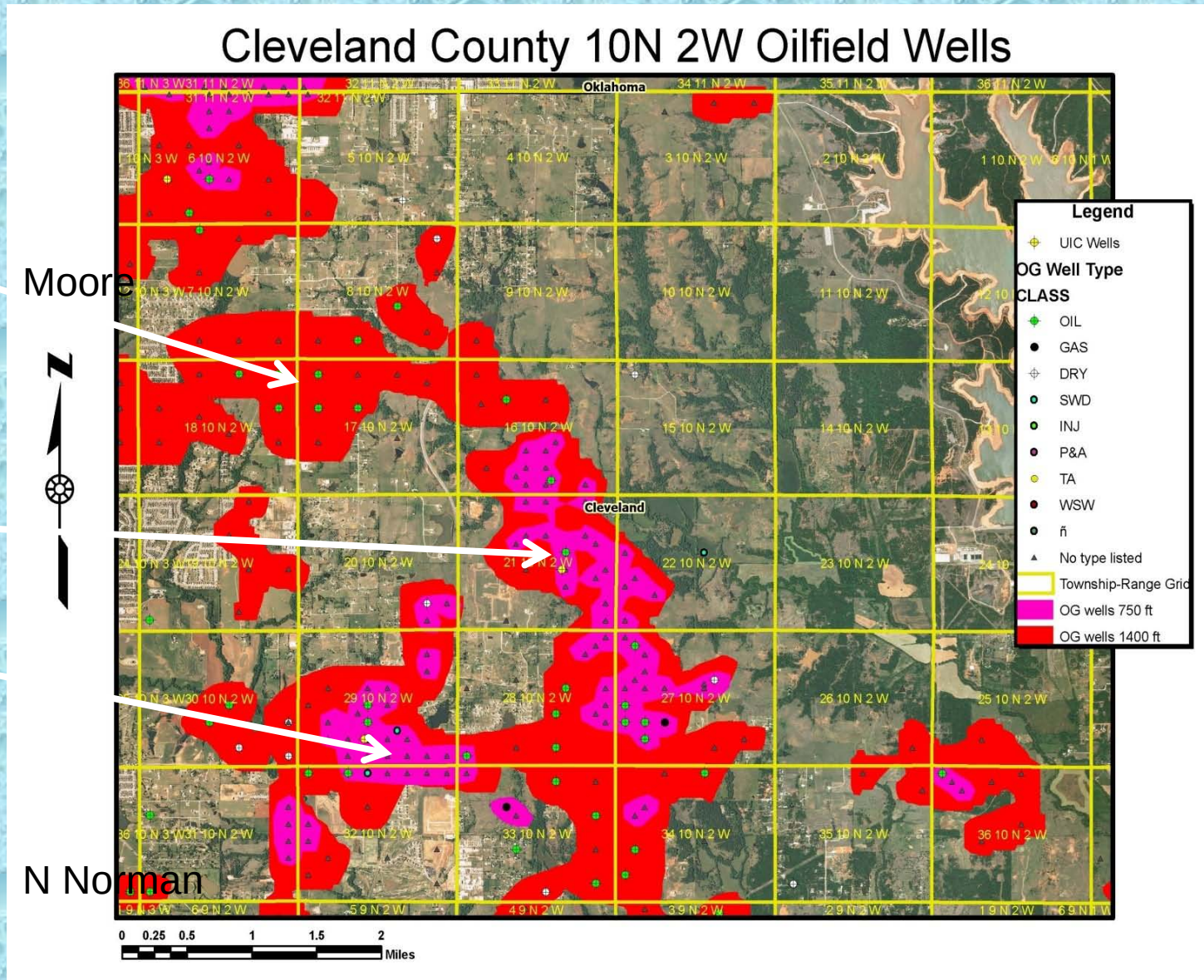
Agency, Town, Water District Maps

- These GIS maps can be made by aquifer, county, town, or Water District.
- Regional planners (COGS) & town building permit departments can also use them???
- All maps are being loaded onto OWRB's map viewer, for viewing by anyone on the internet
- So far, 2COGs - ACOG and INCOG - **have agreed to make old oilfield maps for any city/town that wants them,** for planning;

Role For Town Planners/Permits?

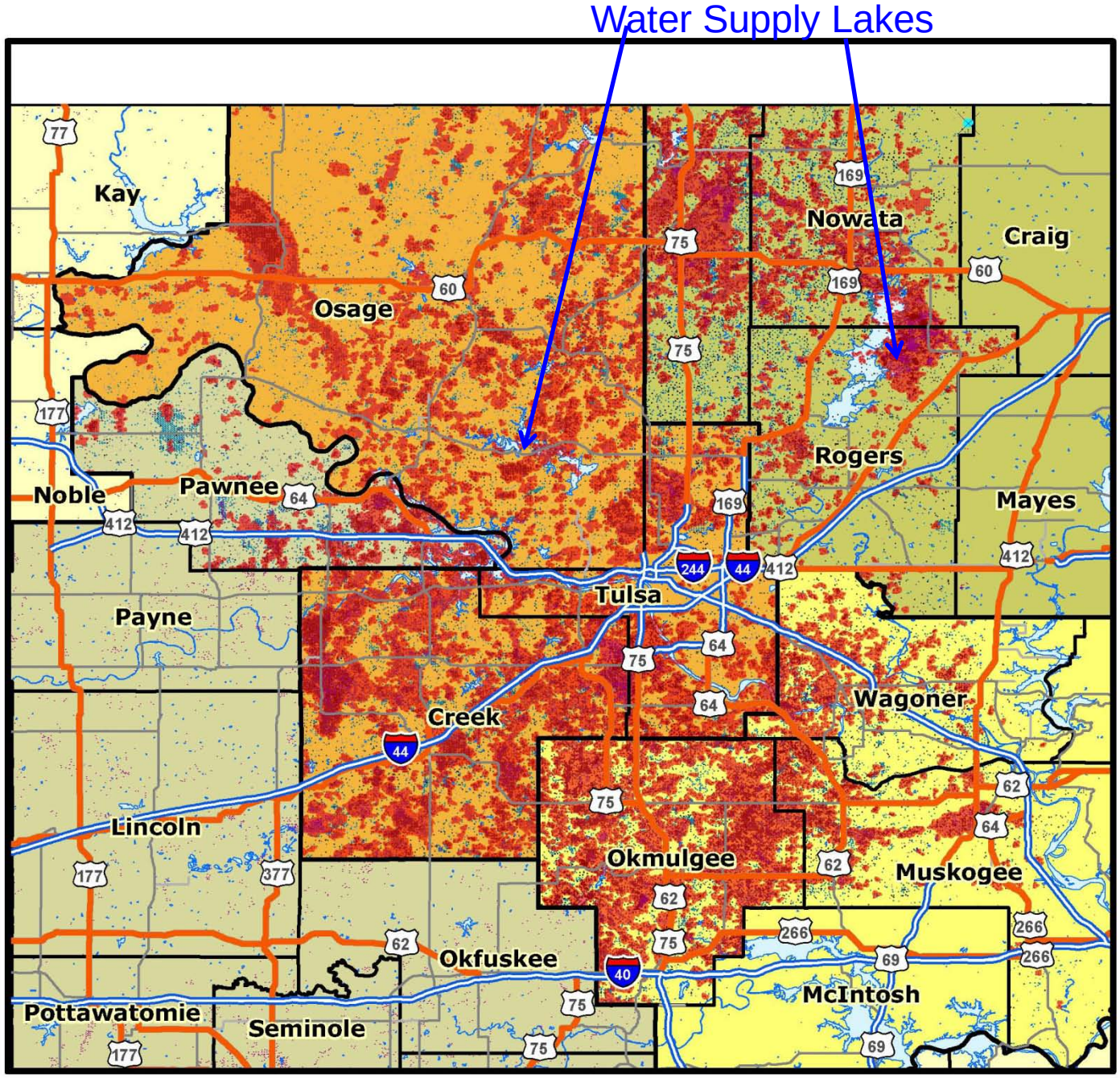
City permit Dept - soil pre-tested here BEFORE buildings get permitted?

Or
Wwant pre-testing of the groundwater before home water wells are installed here – or require city water?

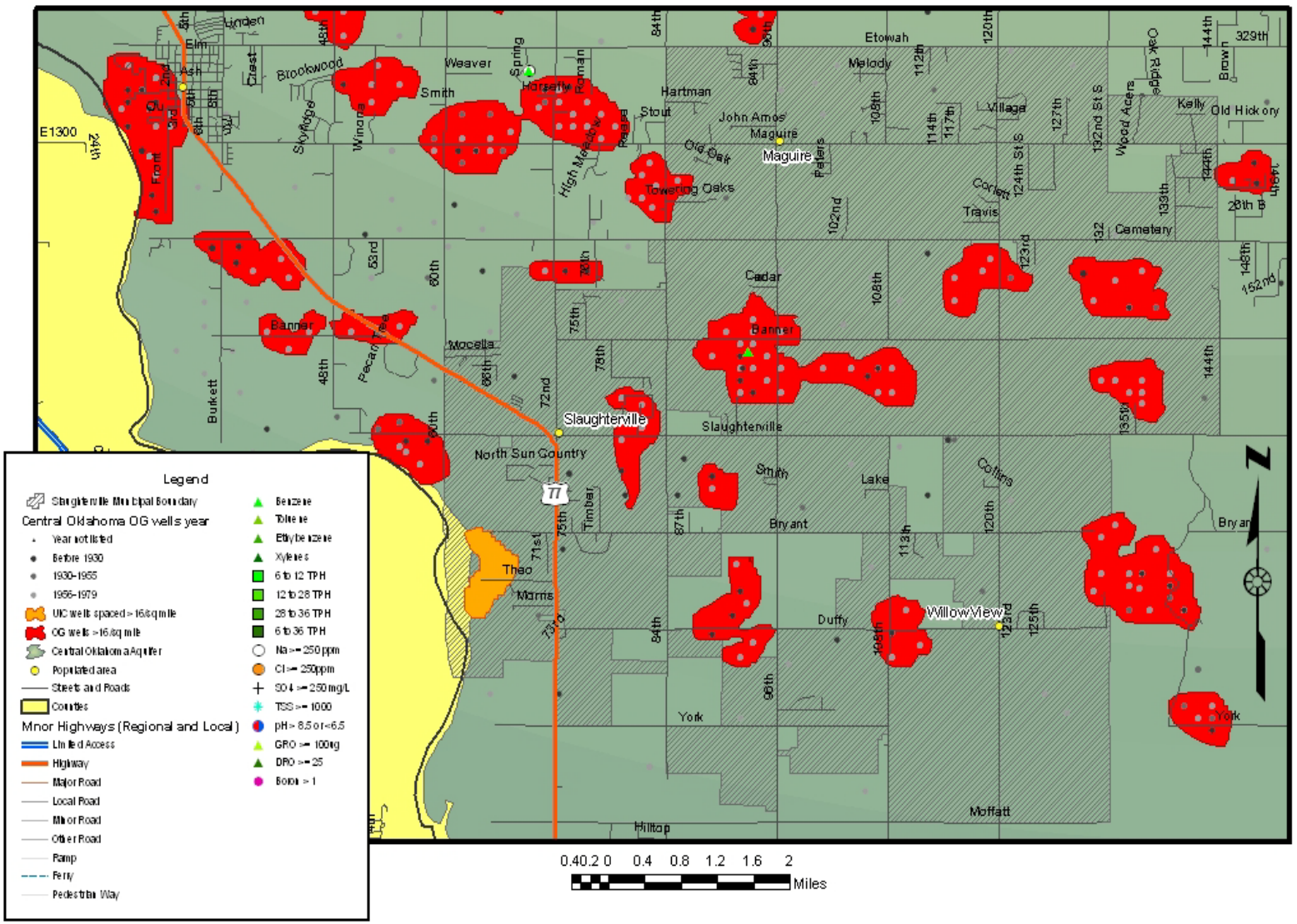


Indian Nations Council of Governments Area

Dense OG Fields and All UIC Wells



Town Example -Map for Slaughterville



Questions?