

Preventing New Groundwater Pollution Problems from Old Oilfield Areas

**Patricia Billingsley, Brownfields Manager,
Oklahoma Corporation Commission**

Last year I presented a case study about subdivision water wells polluted by brine from 1940s-50s era oilfield gathering lines.

Today I am going to

- 1) Summarize a couple of pollution cases;
- 2) Briefly discuss old oilfield groundwater pollution statewide; and
- 3) Discuss what Oklahoma is doing via rules to minimize future groundwater pollution problems from historic oil and gas activity

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

River



11/29/2013

ditto to Thompson #1 5

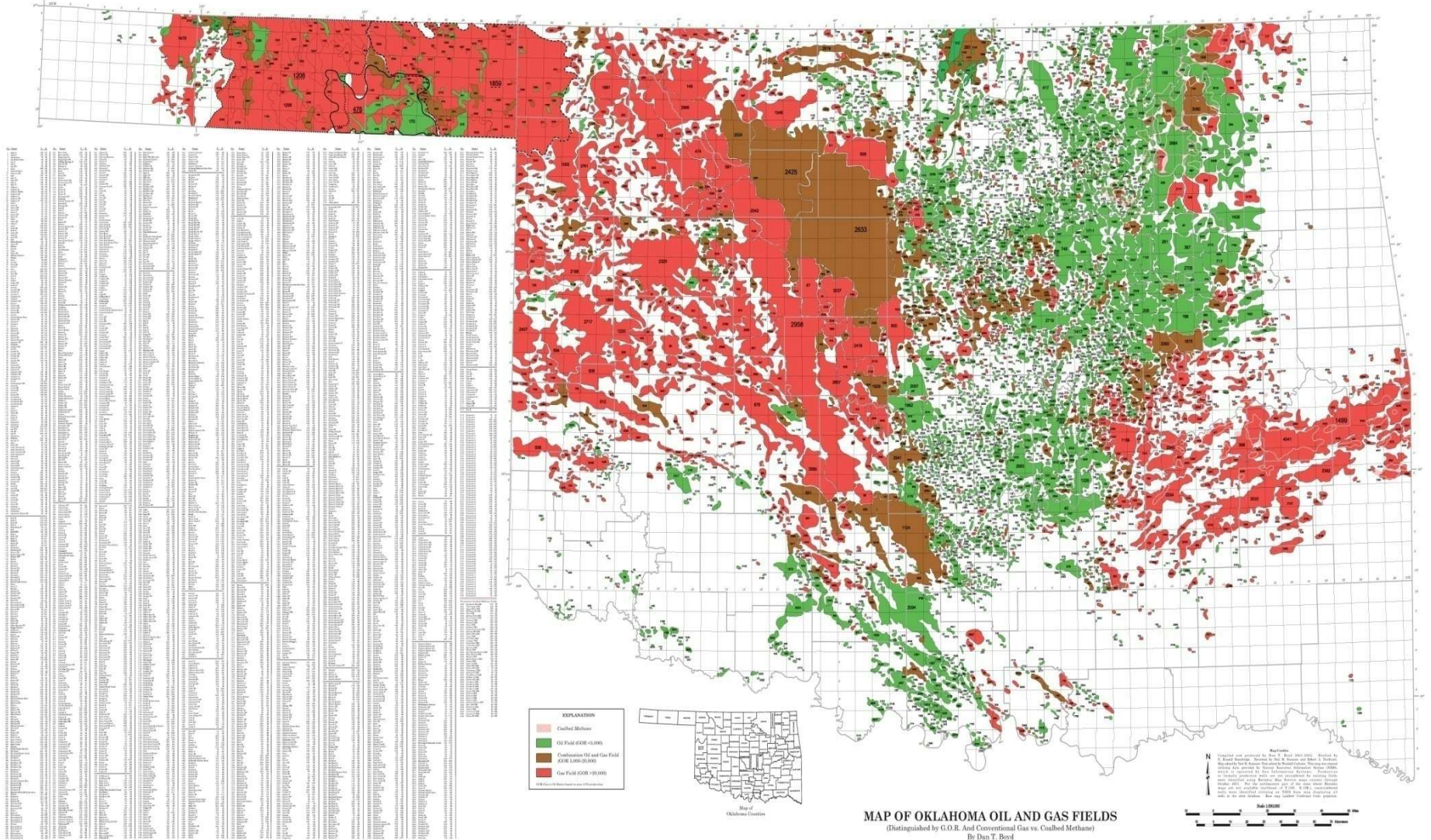
Or this - Tonkawa, 90 years ago



Historic Oil & Gas Fields (>500,000 wells) Affect >60% of Oklahoma



MAP OF OKLAHOMA OIL AND GAS FIELDS
 Distinguished by G.O.R. And Conventional Gas vs. Coalbed Methane
 By Dan T. Boyd
 2002



Corp Comm Has Taken > 2000 Groundwater Samples Over 20 Years

- Both suburban and rural, most near older oilfields with activity started pre-1980, before modern regulations;
- Most collected after complaint/problem, so
- **The data is biased toward the bad.**
- There are also areas with **Remnant soil pollution.**

Methodology; Pollutants

- Water samples were taken in
 - seeps and springs;
 - shallow monitoring wells near spills;
 - domestic, public, and agricultural **water wells** of all depths.
- Oilfield –related pollutants include
 - Petroleum, salinity, and boron from oil & gas production & saline produced water (brine)
 - Barium is found in oilfield drilling mud
- Nitrate, is NOT oilfield – septic and agriculture

The following maps show where water quality standards were EXCEEDED in groundwater.

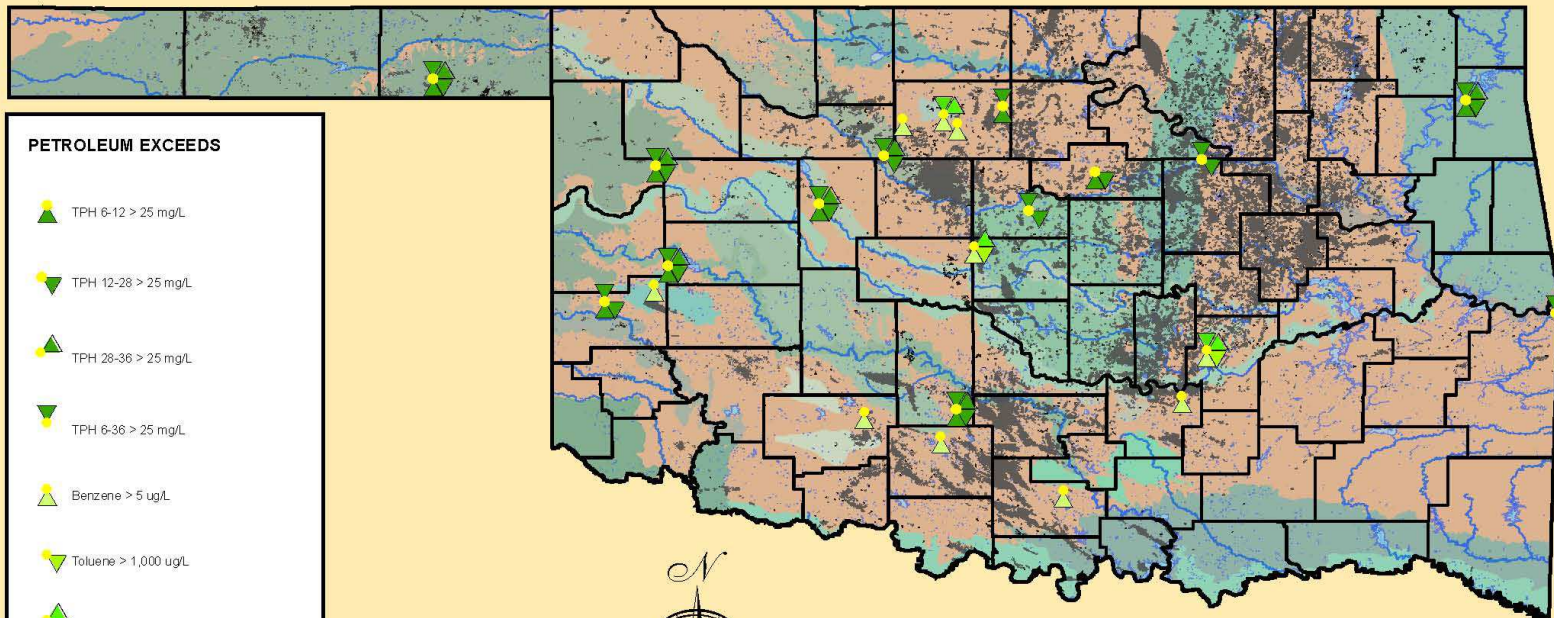
Major aquifers are Blue;

Dense Old Oilfields are Black

70% of exceeds appear in or within 1 mile of pre-1980 dense oilfields;
rest is scattered near few-well clusters or old injection wells

Petroleum, Water Wells, all Depths

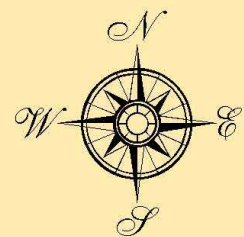
**Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)**



PETROLEUM EXCEEDS

- ▲ TPH 6-12 > 25 mg/L
- ▼ TPH 12-28 > 25 mg/L
- ▲ TPH 28-36 > 25 mg/L
- ▼ TPH 6-36 > 25 mg/L
- ▲ Benzene > 5 ug/L
- ▼ Toluene > 1,000 ug/L
- ▲ Ethylbenzene > 700 ug/L
- ▼ Xylenes > 10,000 ug/L

- Historic dense oilfields
- Historic dense UIC fields outside oilfields
- Lake
- River
- OWRB-Mapped Aquifers
- County



0 12.525 50 75 100 Miles

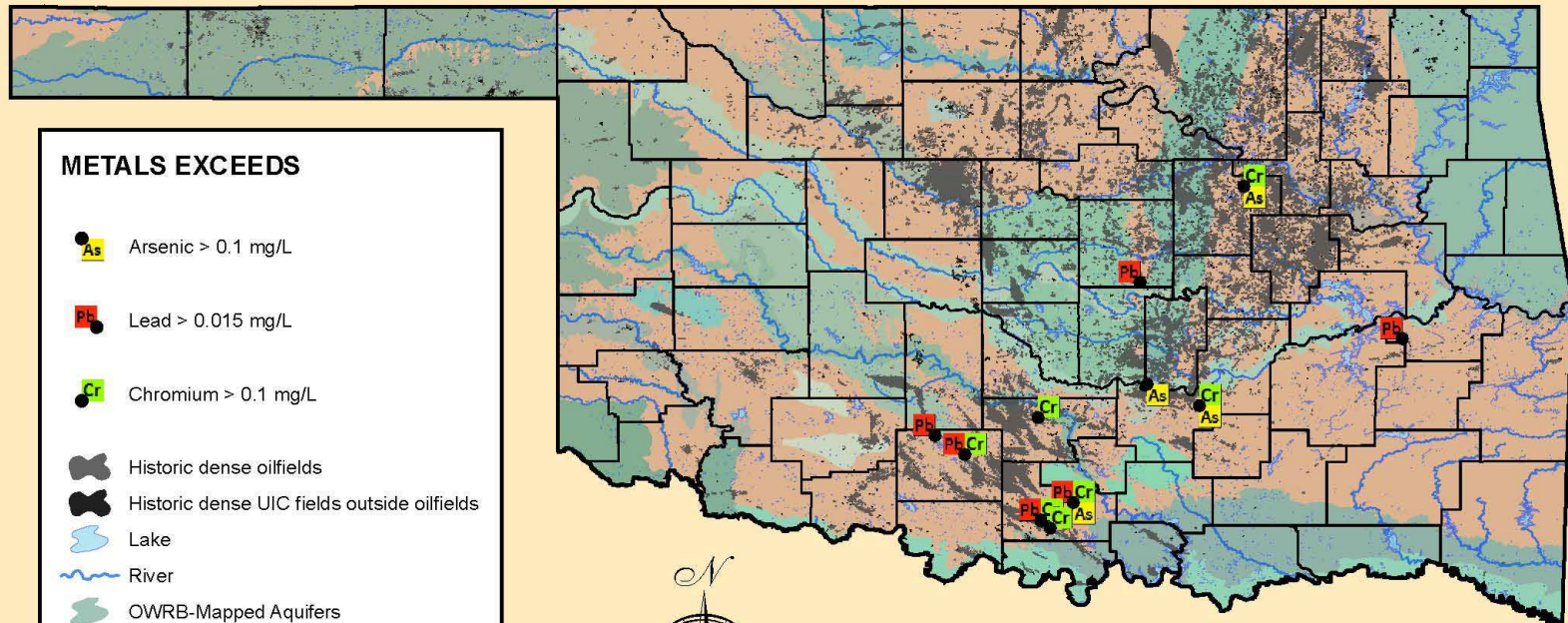
OCC water sample locations are determined by public request and suspicion of contamination. As a result, SAMPLE POINTS DO NOT REPRESENT A COMPREHENSIVE SURVEY OF STATEWIDE WATER CONTAMINATION.

Current as of February 2013

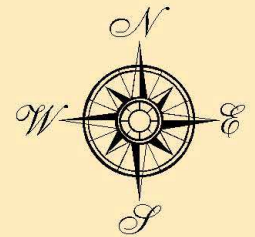
Major aquifers are Blue; Old Oilfields are Black

Heavy Metals in Water Wells – just 10

**Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)**



- METALS EXCEEDS**
- As** Arsenic > 0.1 mg/L
 - Pb** Lead > 0.015 mg/L
 - Cr** Chromium > 0.1 mg/L
 - Historic dense oilfields
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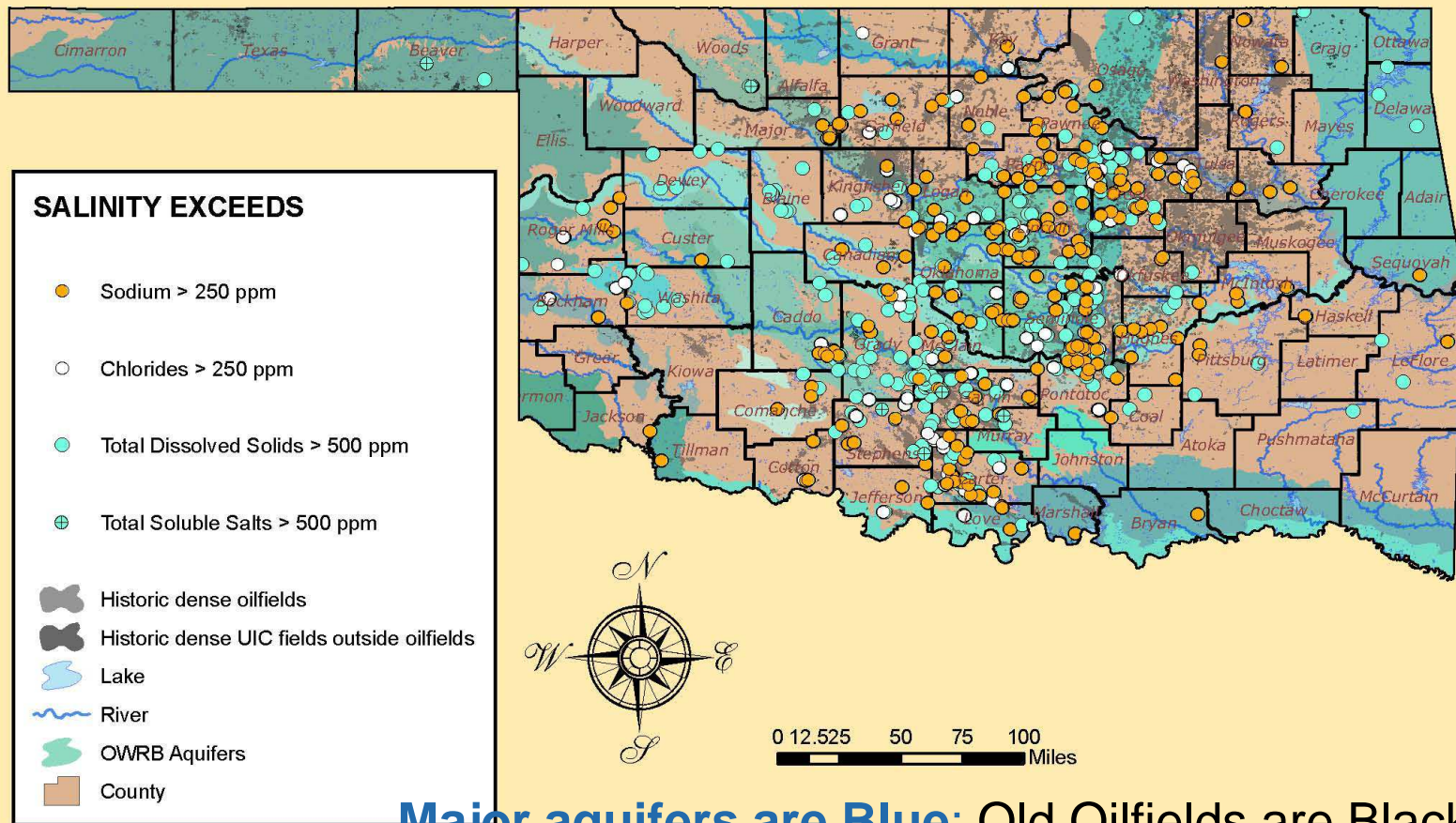
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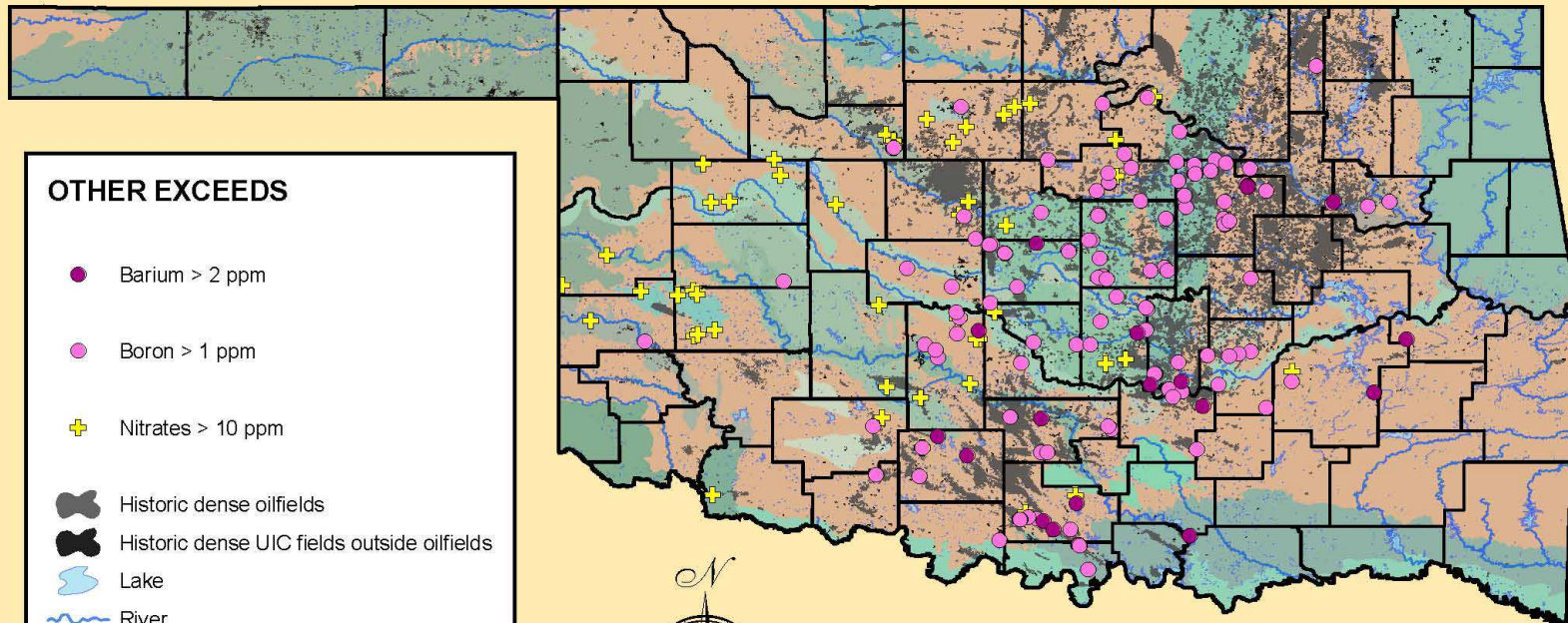
Salinity Exceeds, Water Wells – Ouch!

**Water Well Samples That Exceed EPA Drinking Water Standards
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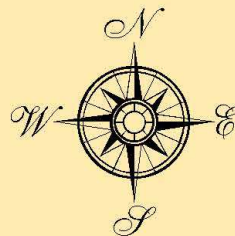
Other Pollutant Exceeds, Water Wells

**Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)**



OTHER EXCEEDS

- Barium > 2 ppm
- Boron > 1 ppm
- ✚ Nitrates > 10 ppm
- Historic dense oilfields
- Historic dense UIC fields outside oilfields
- Lake
- River
- OWRB-Mapped Aquifers
- County




0 12.525 50 75 100
Miles

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Current as of February 2013

Major aquifers are Blue; Old Oilfields are Black



Madeline Dillner's talk Wednesday
Morning, in the Waste
Minimization/Pollution Prevention
session, will go into the water sampling
results, and data problems, in much more
detail

Pollutant Focus

- Today I will focus mainly on salt/salinity – the biggest soil and groundwater 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 :

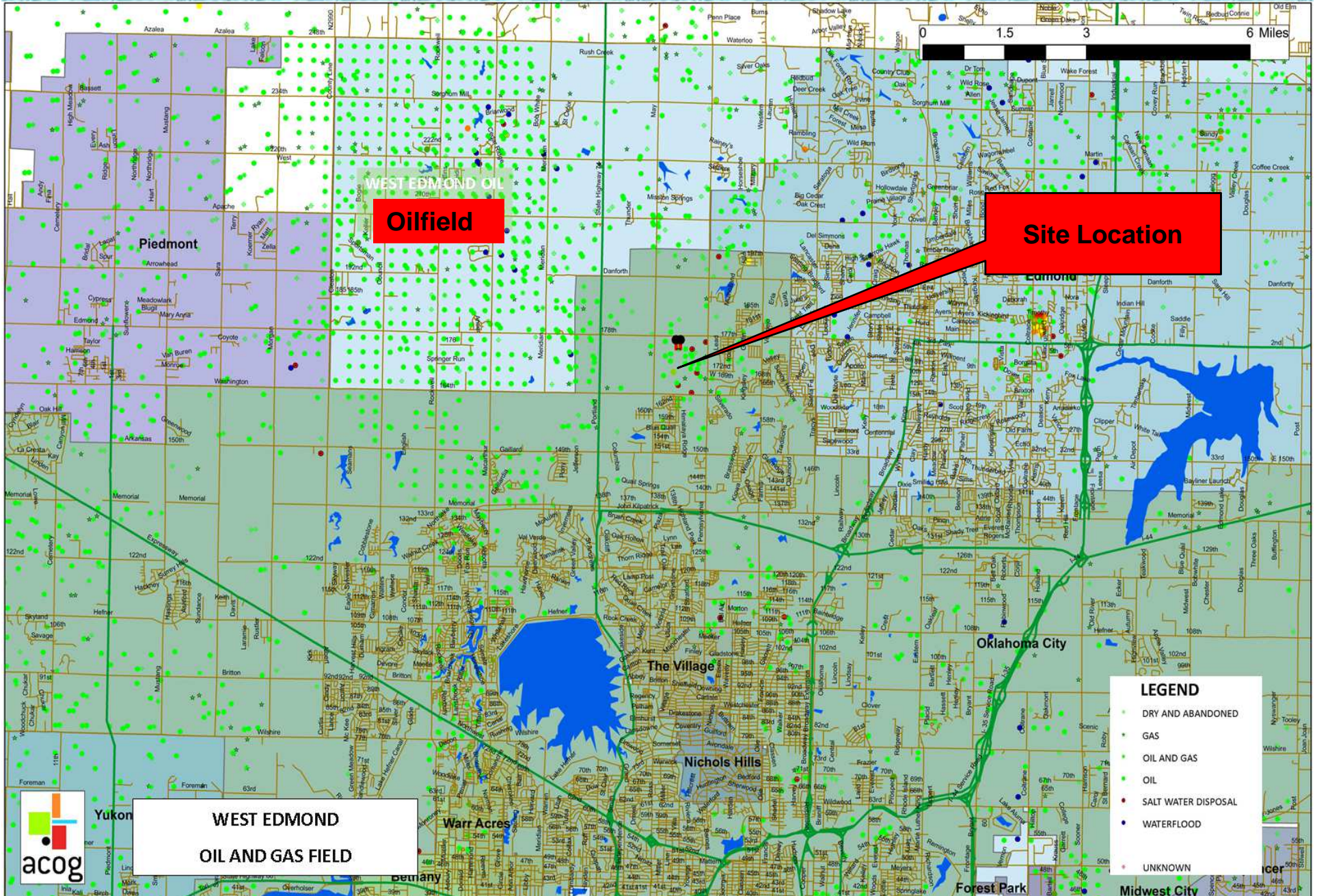
- Supplies ~40% of all water used in Oklahoma
- Provides water to > 300 Oklahoma cities and towns
- Supplies water to 295,000 Oklahomans with domestic wells
- Supplies 73% of all Irrigation water for Agriculture - It is our food too!

- I am going to summarize 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 water, 2011.
- Was a historic, until 1980s, oilfield area, so
- Our Field Inspector sampled their water wells.
- We later learned that two original 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



WEST EDMOND OIL FIELD CIRCA 1945



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	

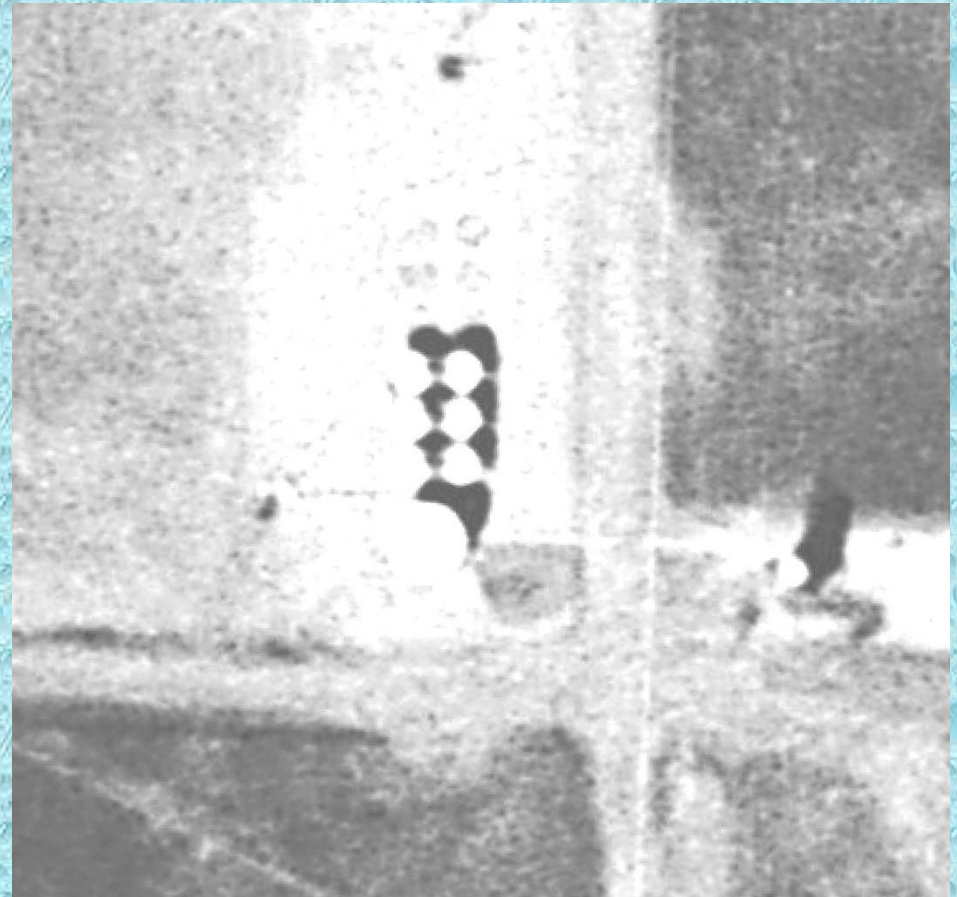
Exceeds Chloride secondary drinking water standards

Na/Cl Ratio <0.6 indicates oilfield source

Sulfate SO4 – from natural BaSO4, which makes Rose Rocks



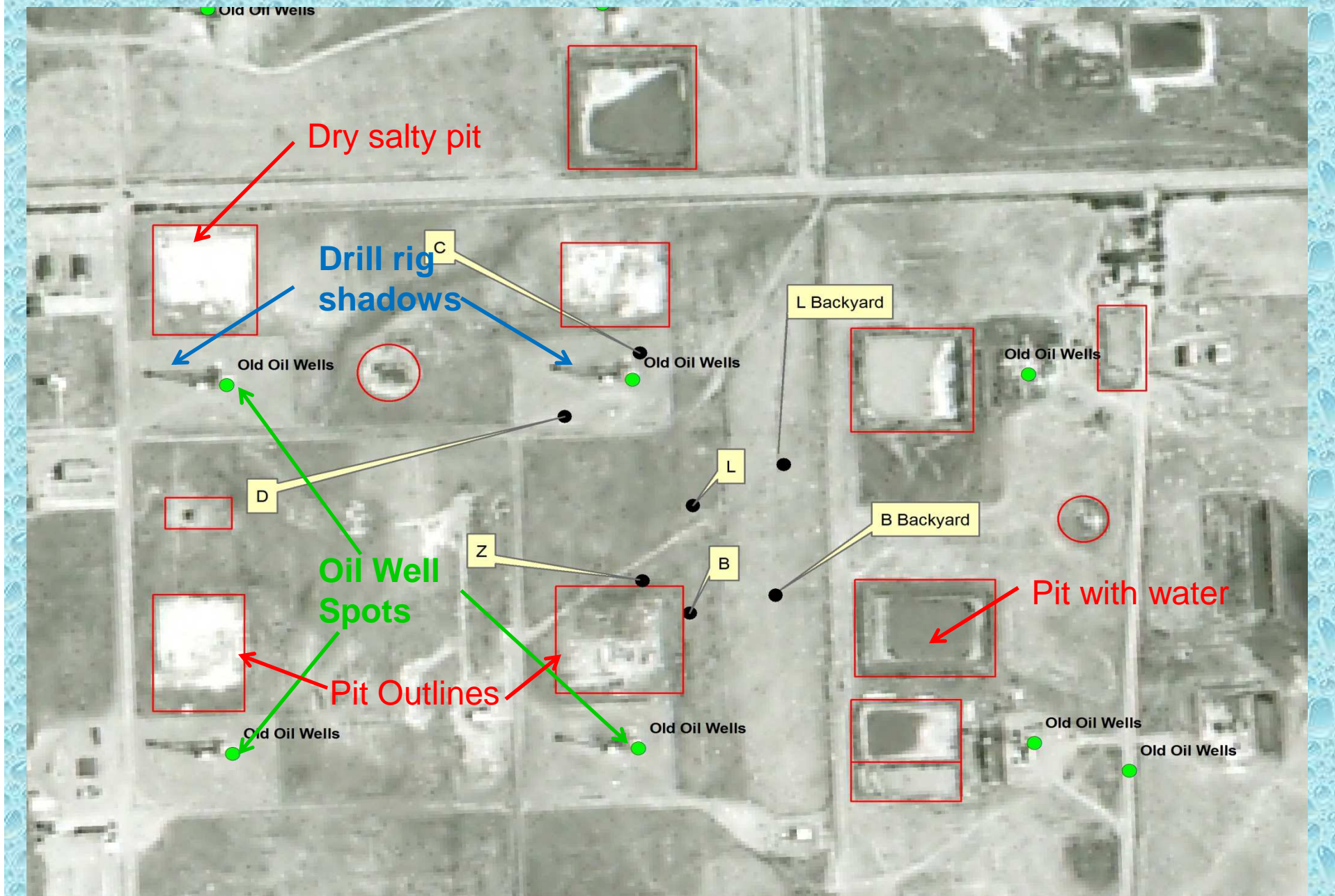
Where there were Oilfield Tank, now we have New Homes



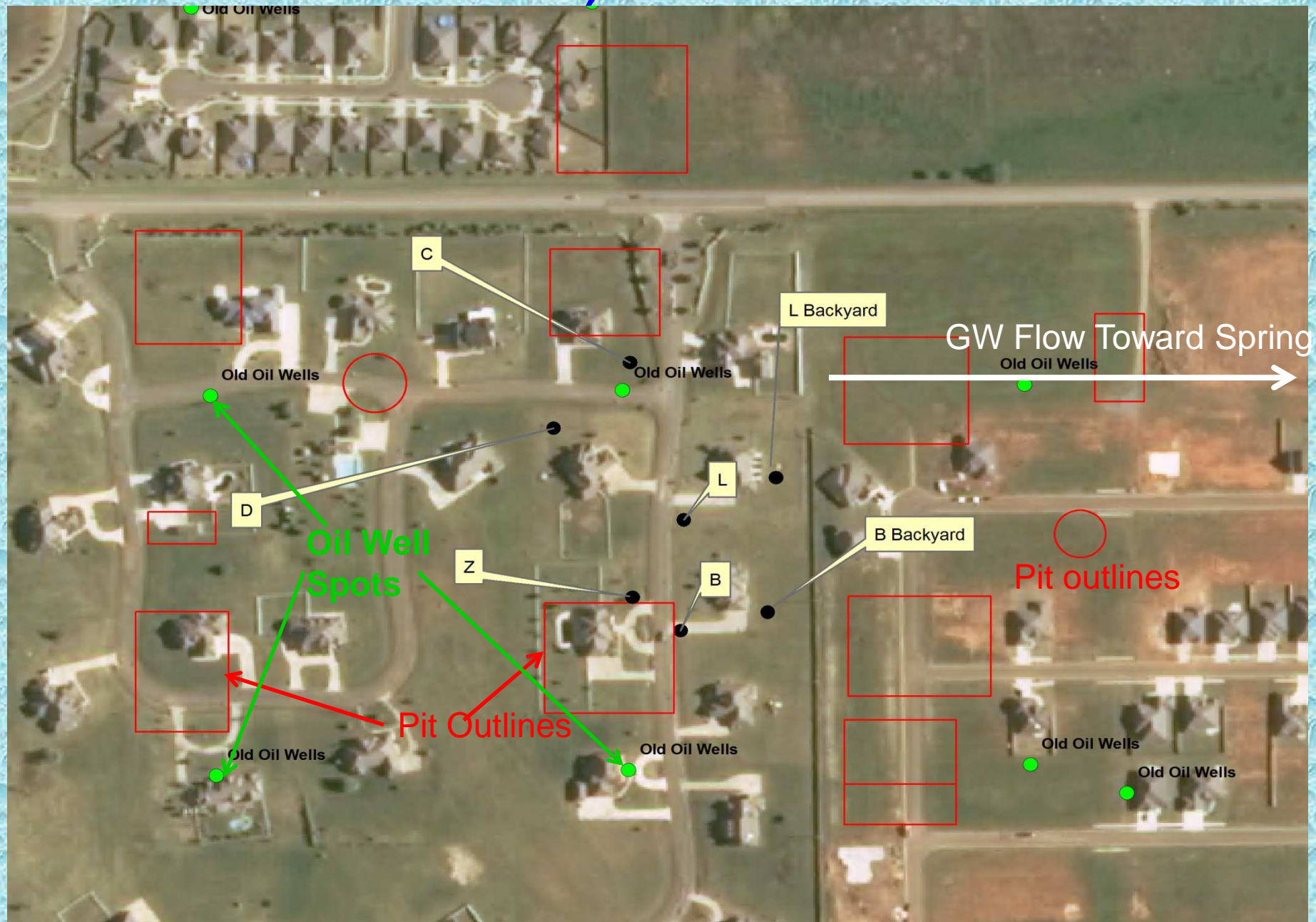
Tank group @
end of
gathering
system



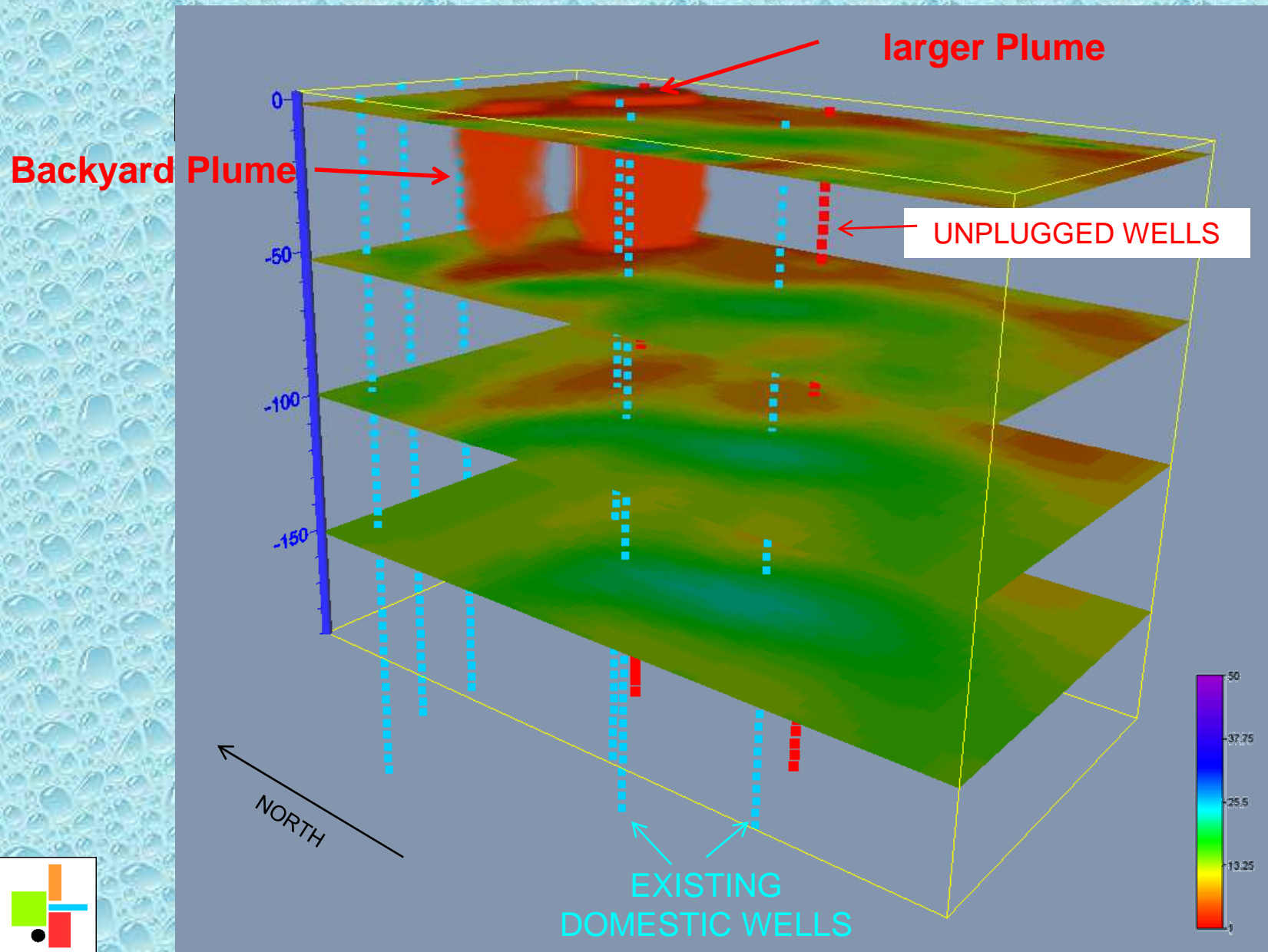
1941 Aerial Showing Drill Rigs, Pits



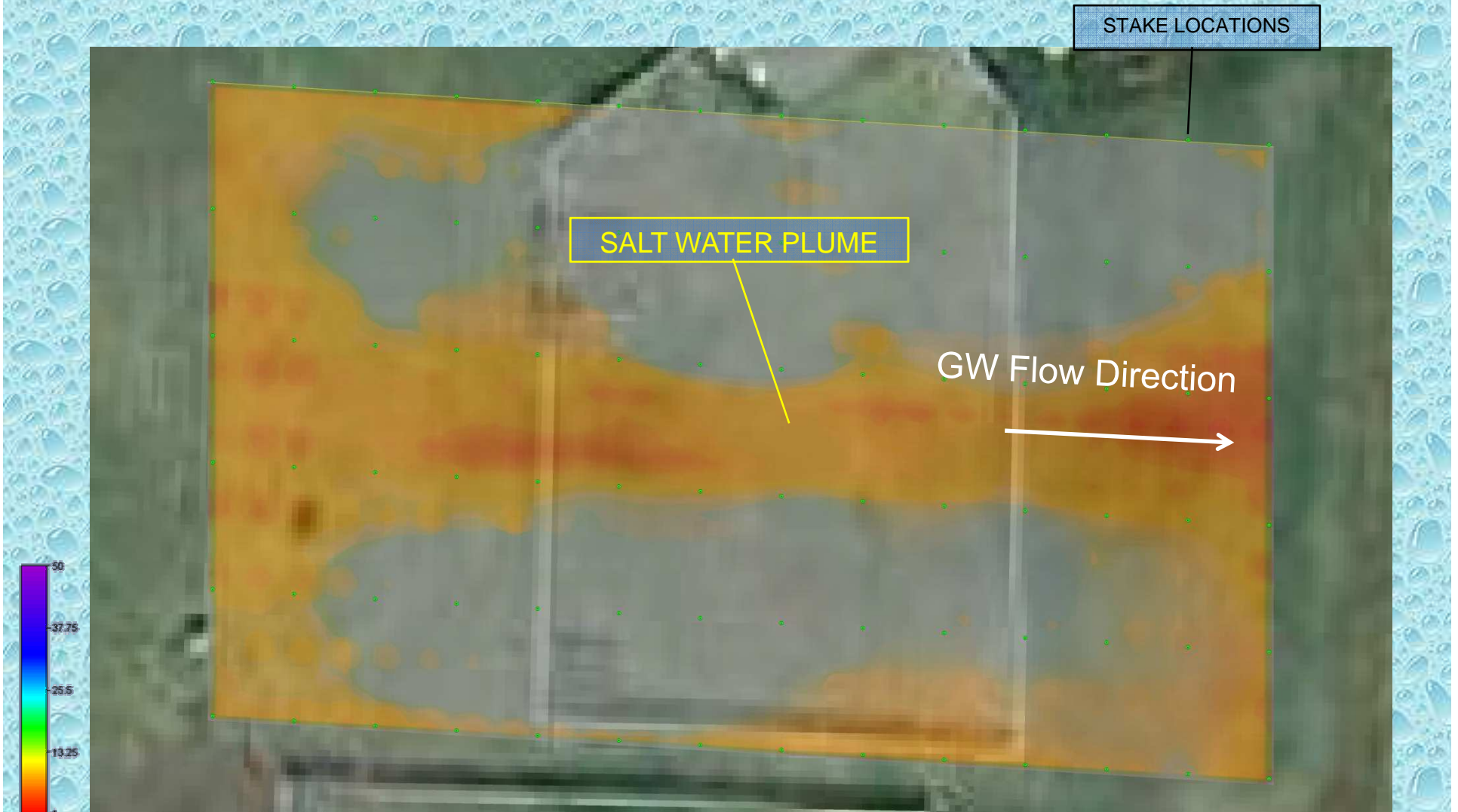
Old Pits & Wells, Modern Air Photo



Geophysics – 3D, both saline plumes

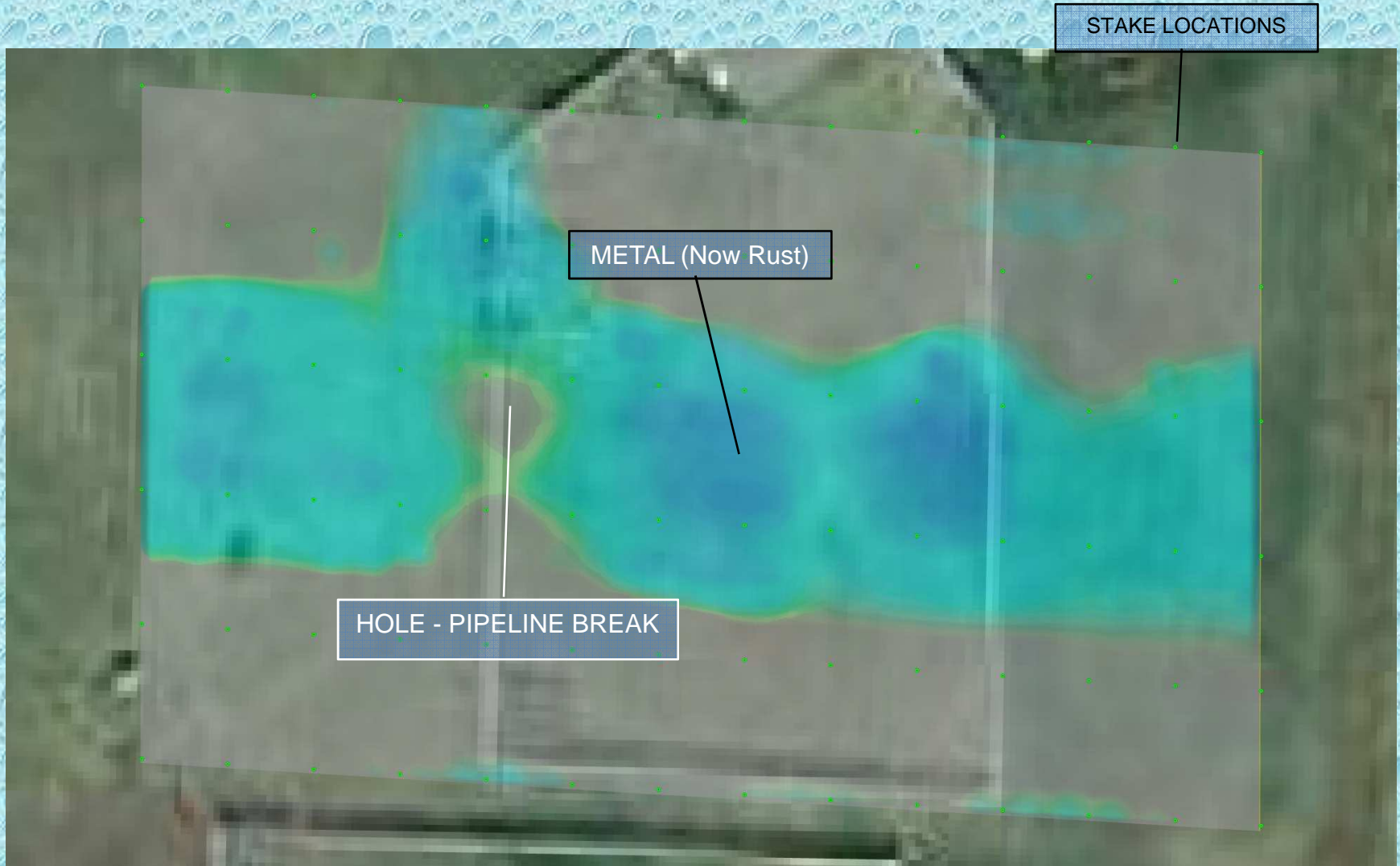


Geophysics – Linear Saline Plume, Backyard



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

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



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

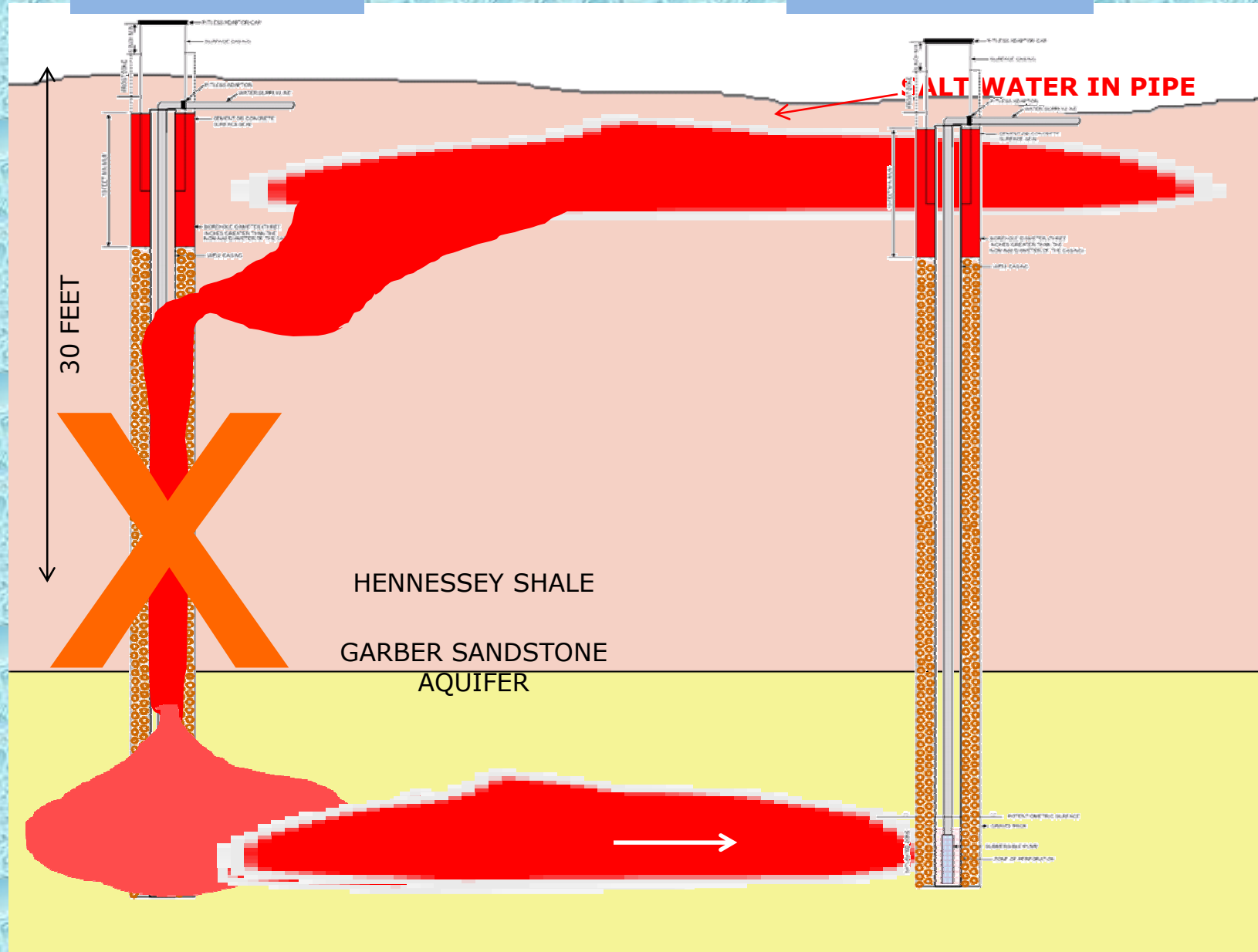
1951 Aerial – Linear Scars Were Gathering Line System?



What Happened

First Water Well

Later Water Well



Conclusions

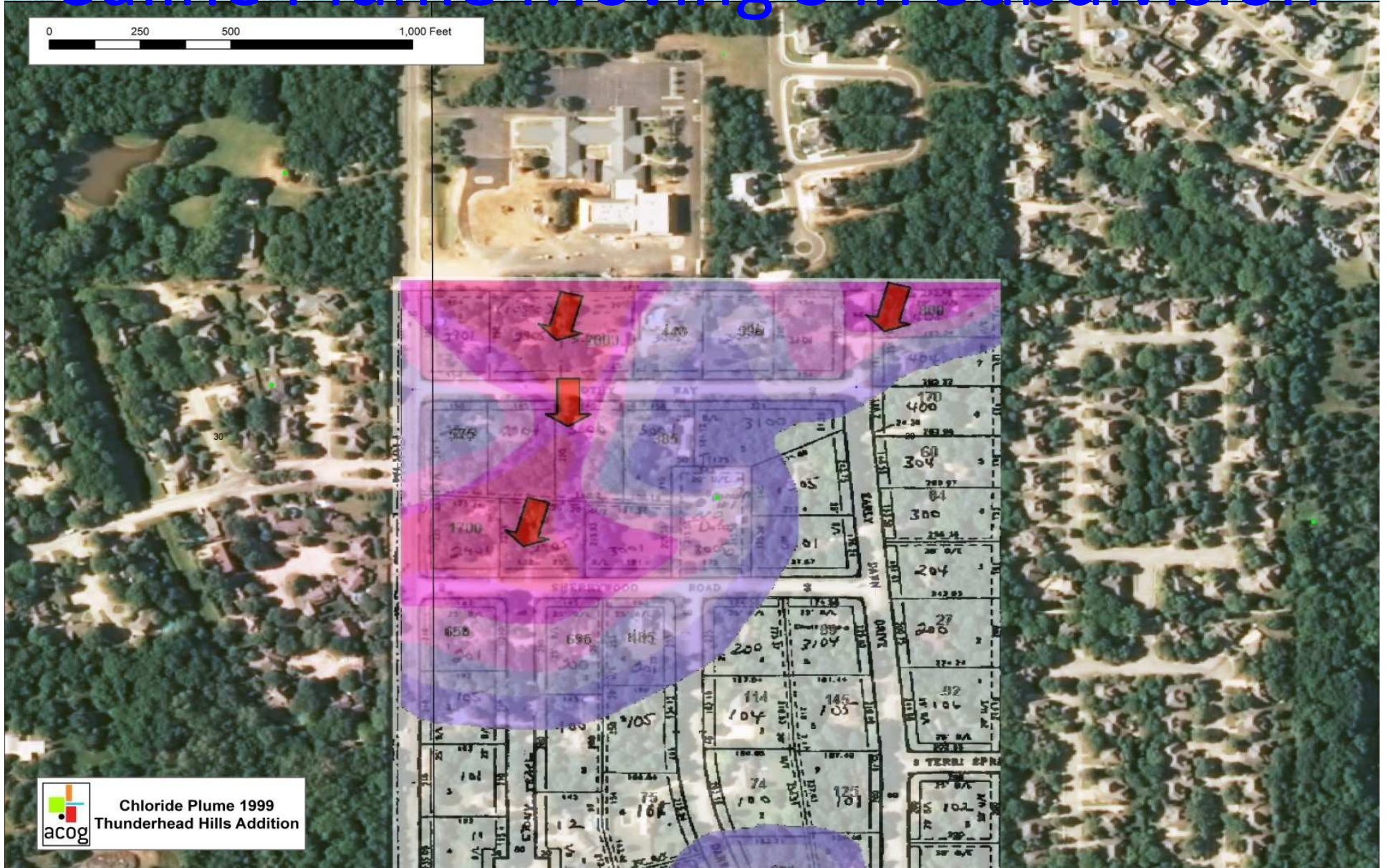
- **Old (1940's-80s) Oilfield Activity Caused problem – highly saline brine leaks;**
- Open, surface to 300' deep gravel pack water well construction channeled shallow pollutants down into the Garber Aquifer.
- **In effect, the water wells, by their standard design, polluted themselves - and the aquifer**
- Especially the unplugged backyard wells.
- All wells are now plugged.

Another Example – started late 1990's Water Well Samples, T Hills Edmond

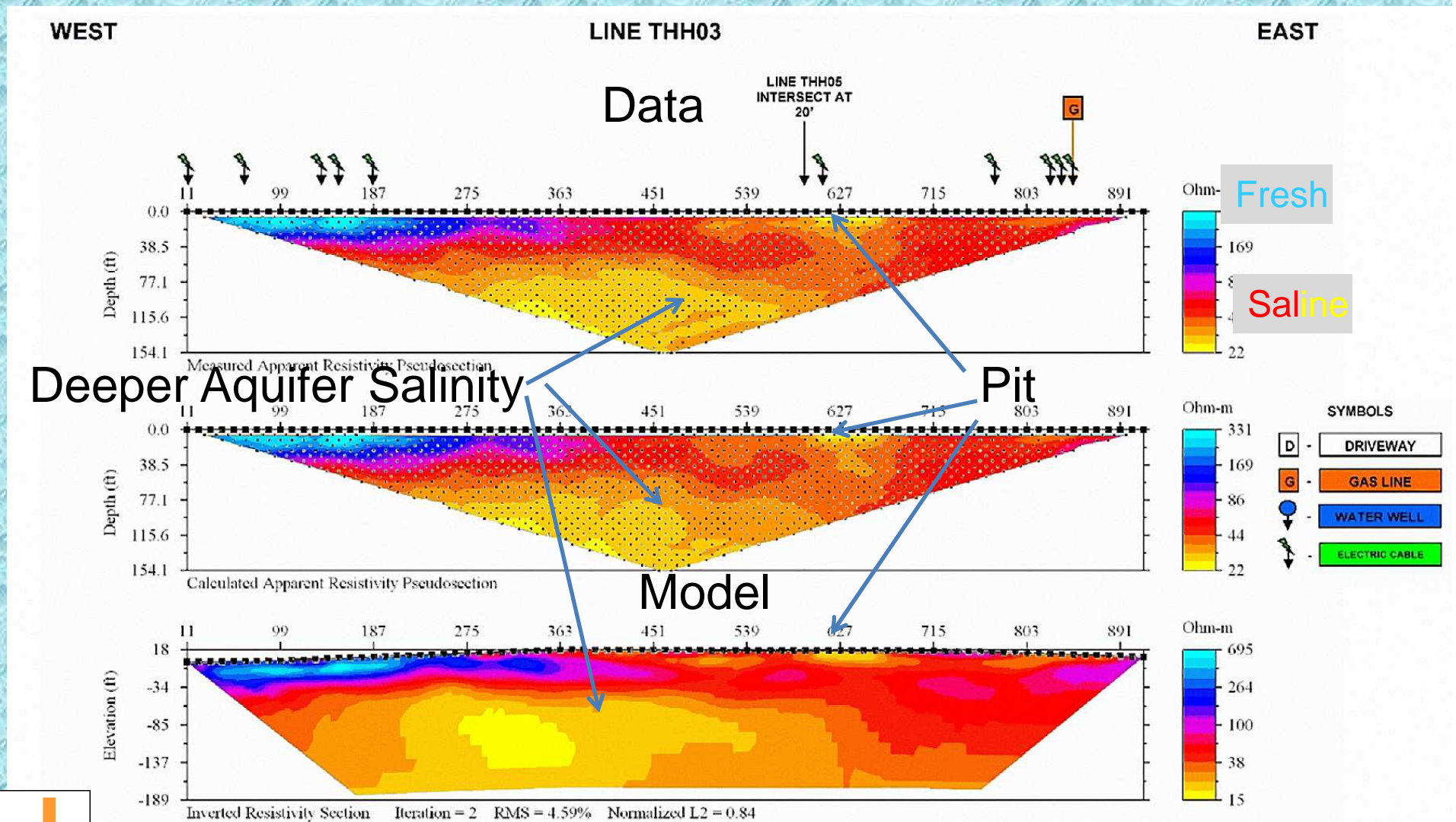
Address	Sodium ppm	Chloride ppm	Total Soluble Salts
3101 Sherrywood	153	577	1518
3009 Timothy	308	928	2066
200 Stony Trail	377	1001	2363
3005 Sherrywood	410	1056	2373
2901 Sherrywood		1237	2402
3001 Timothy Way	575	1258	2924
Produced Water, Darwin #1 T Hills Oil Well	79,830	123,947	222,996

Another Example

Saline Plume Moving S in Subdivision



Old Pits on the Garber Sandstone Leaked, Wells helped move salt deeper into aquifer



Processed Data Showing Inferred Groundwater Conditions



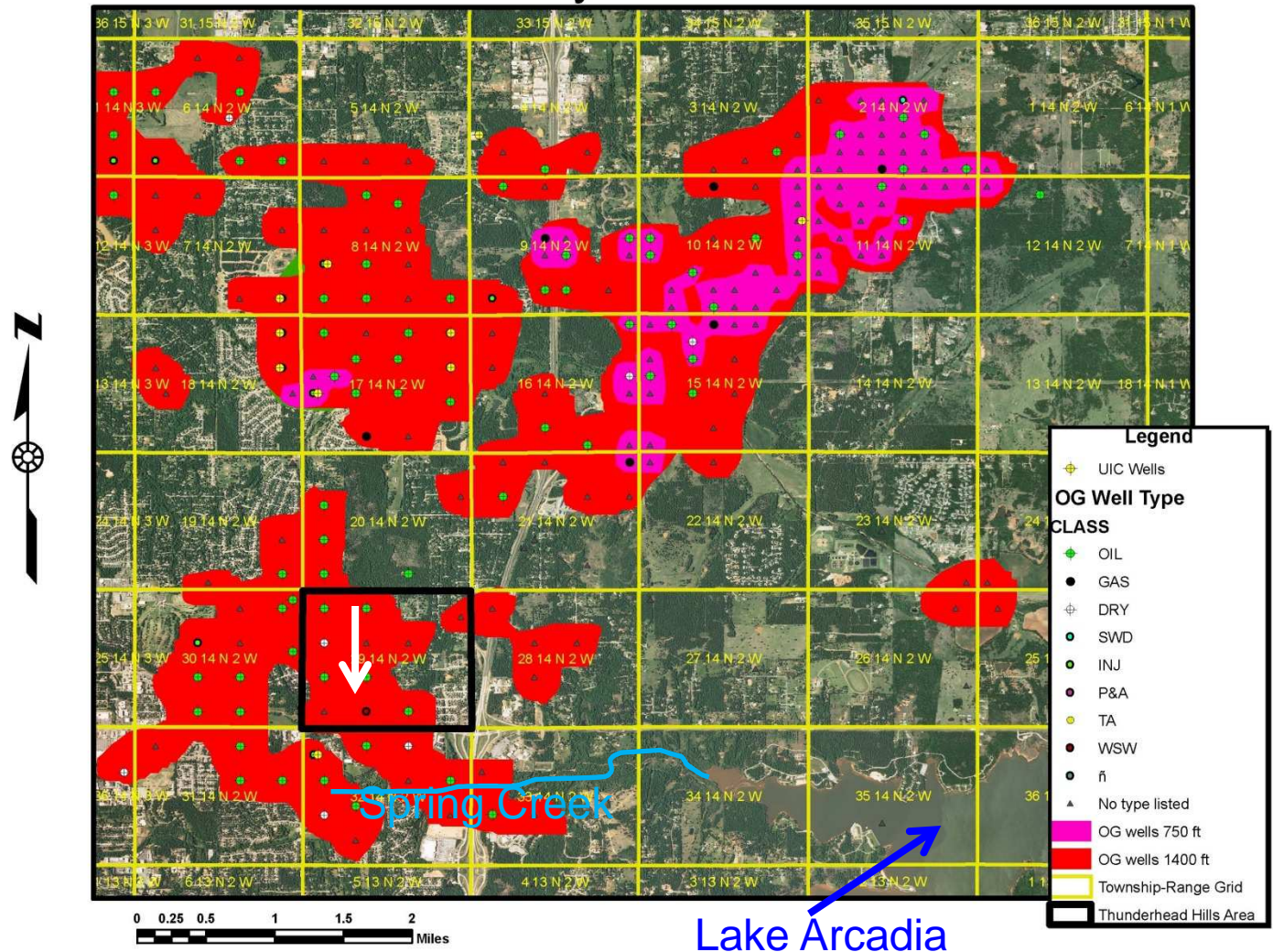
Edmond – A Bonus!

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

Oklahoma County 14N 2W Oilfield Wells

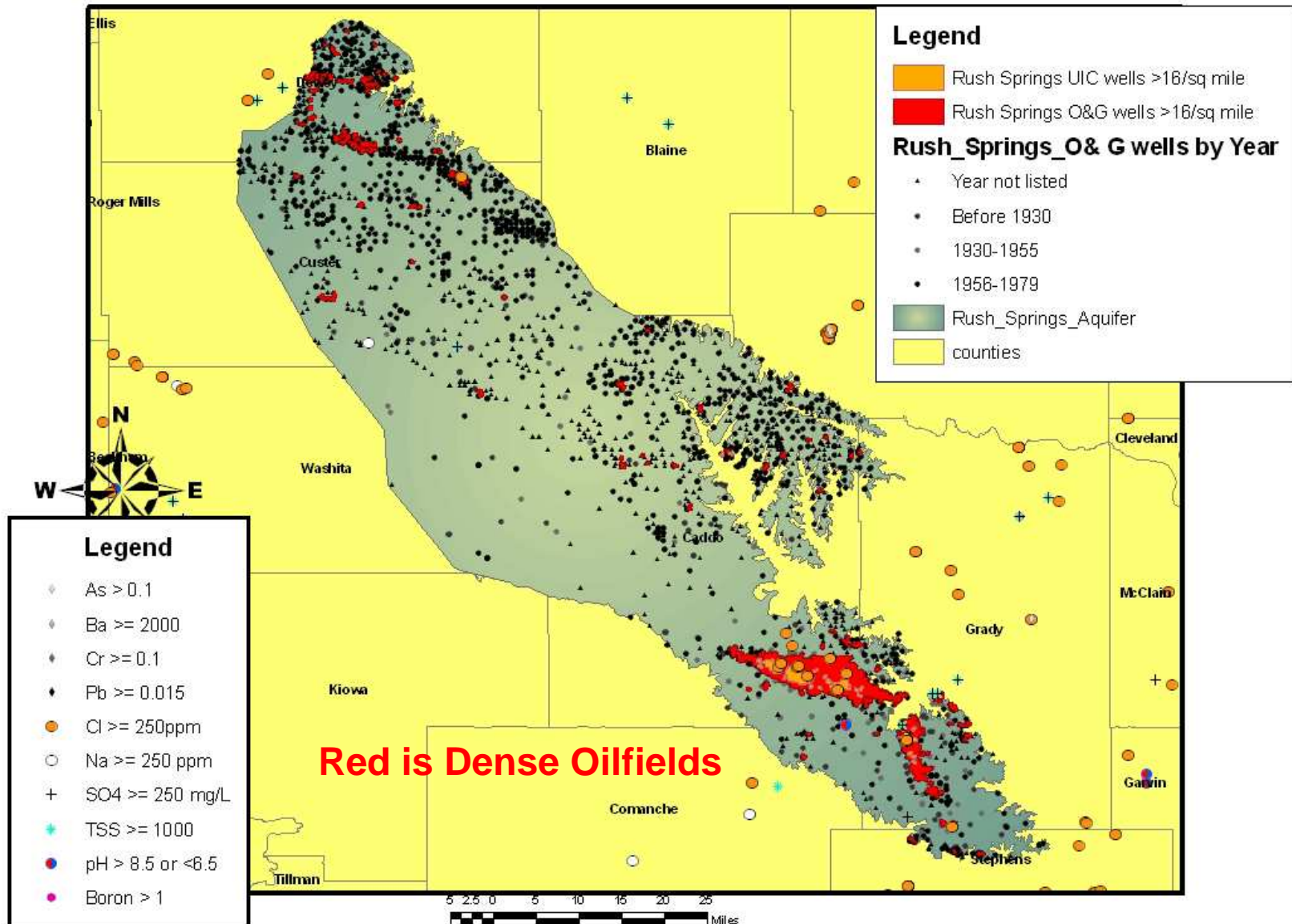


Because of problems in old oilfields and cases like the above, Corp Comm is has mapped old (pre 1980) well fields, especially on Oklahoma's aquifers

- Before 1980, pit design, well plugging oversight, field inspection etc. not as “rigorous” as after; For example, no regular Mechanical Integrity testing of injection wells was done then, is done now.

More Wells/Oilfields, More Pollution

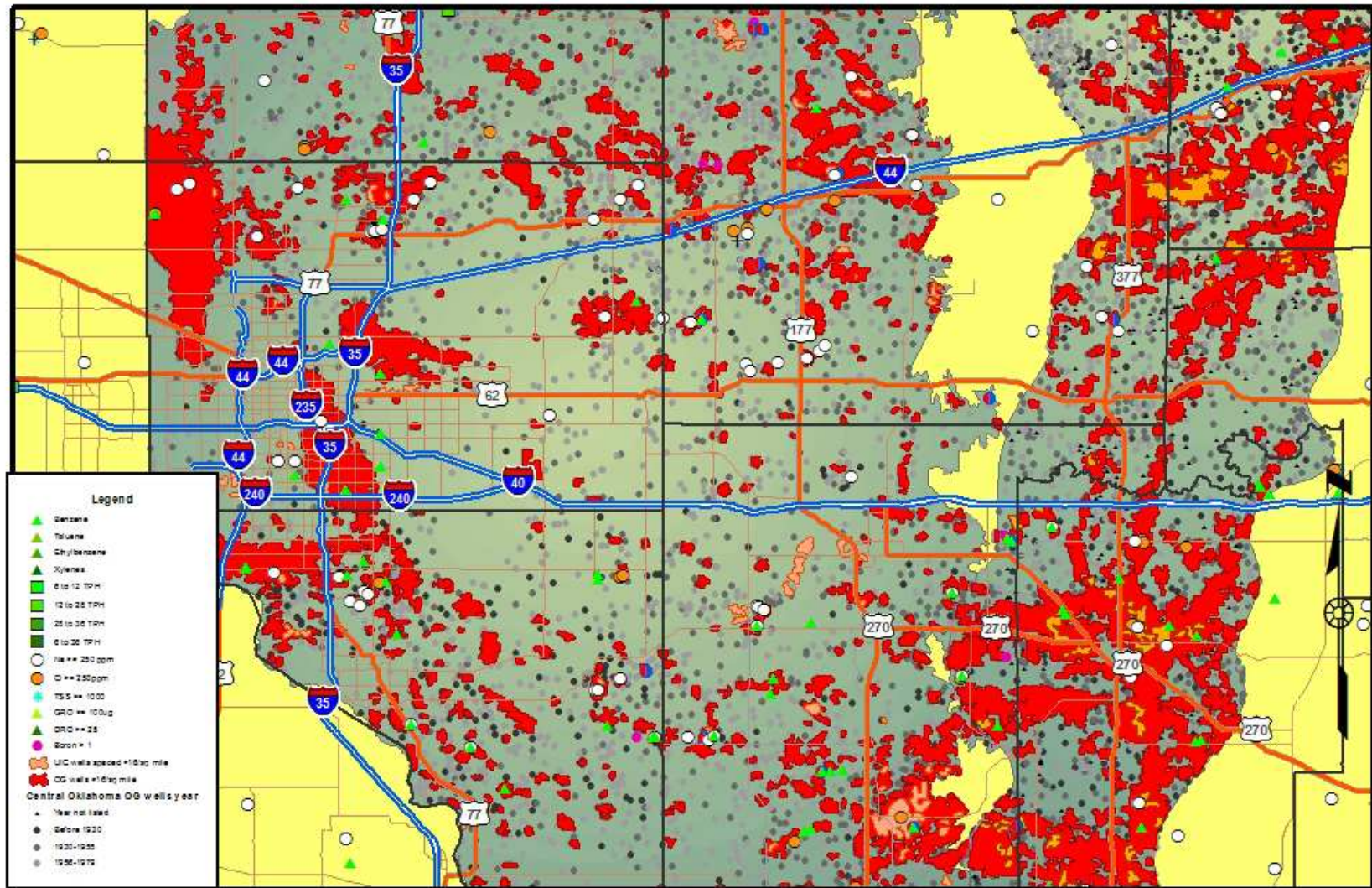
Rush Springs Aquifer, Old Oilwells, Oilfields & Pollutants (inorganic)



More Wells/Oilfields, More Pollution

Central OK and Vamoosa Aquifers

Pre-1980 Oil Wells and Dense Wellfields and Sample Exceeds



2.5 250 2.5 5 7.5 10 12.5
Miles

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

So

All of our Old Oilfield maps are being loaded onto OWRB's map viewer, for viewing by anyone on the internet

New Rules Request Made to OWRB

- To help prevent shallow pollutants from traveling down water well gravel packs into aquifer(s) -
- **In the higher risk areas Corp Comm has mapped** (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

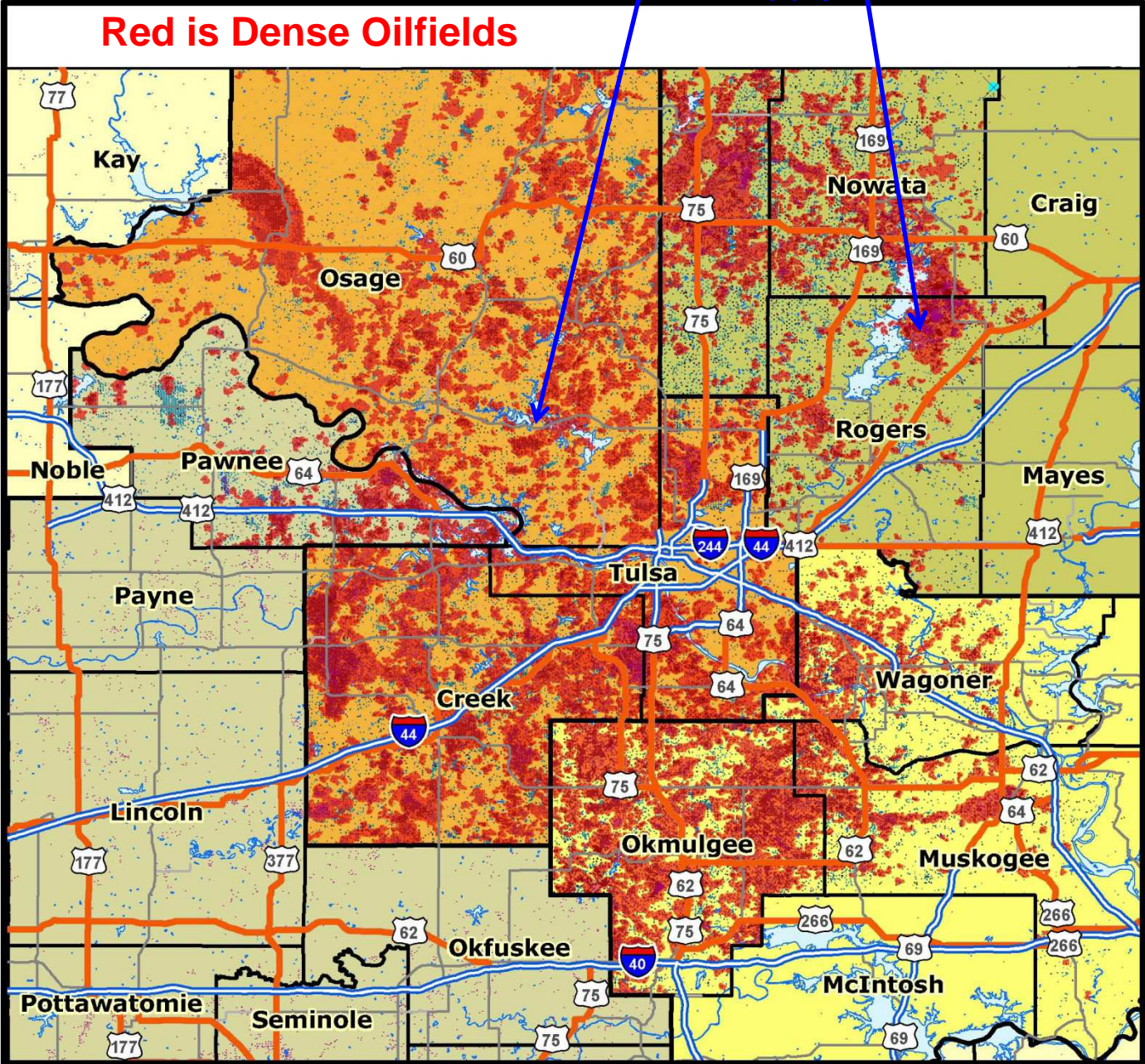
- These GIS maps can be made **by aquifer, county, town, or Water District.**
- Regional planners (COGS) & town building permit departments can also use them???
- So far, 2COGs - ACOG and INCOG - **have our map coverages and have agreed to make old oilfield maps for any city/town that wants them,** for planning purposes; working on the rest

Indian Nations Council of Governments Area

Dense OG Fields and All UIC Wells

Water Supply Lakes

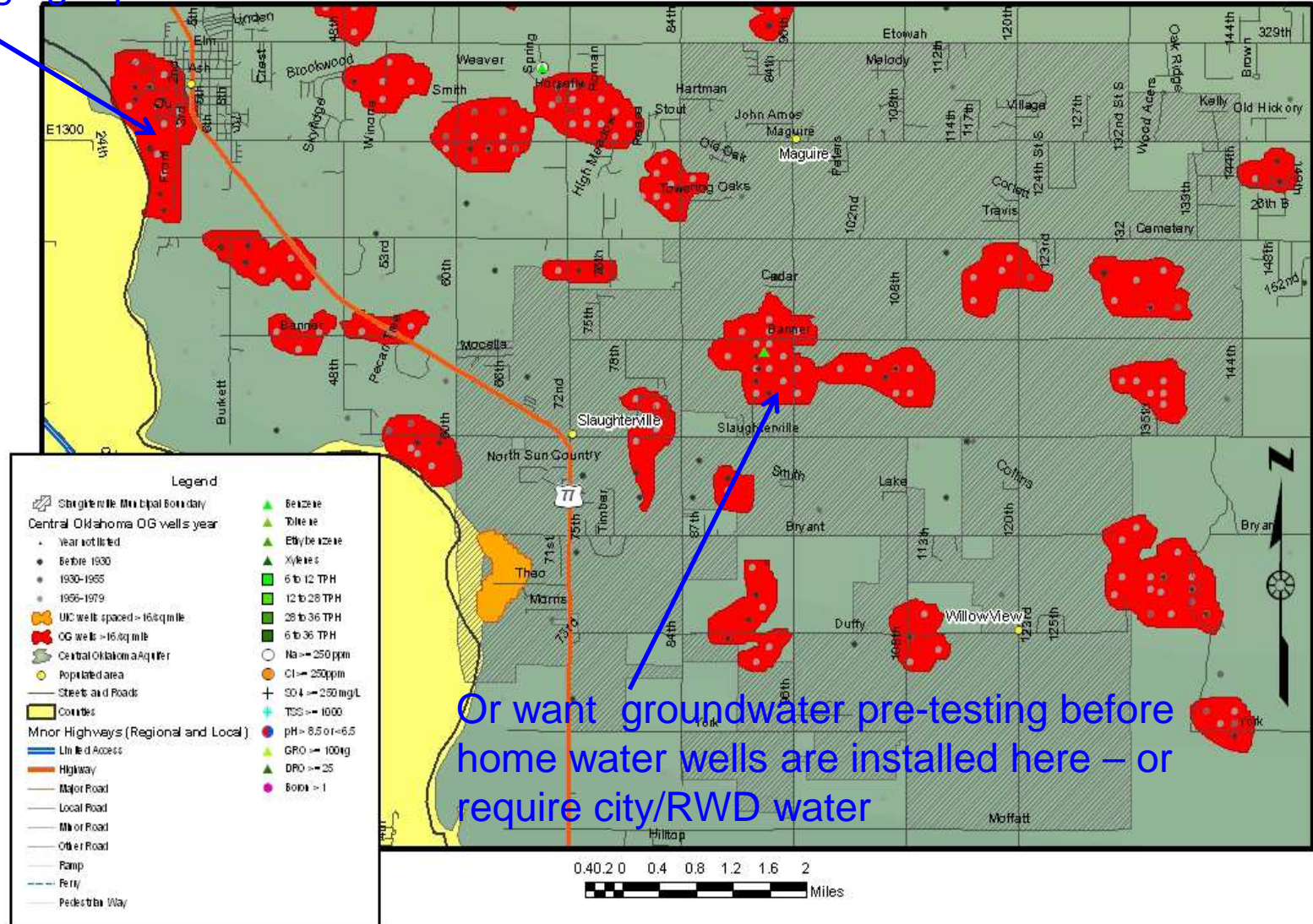
Red is Dense Oilfields



Town Example -Map for Slaughterville

City permit Dept - Pre-test
for salt here BEFORE
buildings get permitted?

Slaughterville Pre-1980 Oil Wells and Dense Wellfields



Or want groundwater pre-testing before
home water wells are installed here – or
require city/RWD water

The background of the slide is a light blue surface covered with numerous small, glistening water droplets of varying sizes, creating a textured, dewy appearance. The droplets are more densely packed in some areas and more sparse in others, with some showing highlights and shadows that give them a three-dimensional look.

Questions?