PRESERVING HISTORICAL AERIAL PHOTOGRAPHS TO PROTECT OKLAHOMA GROUNDWATER

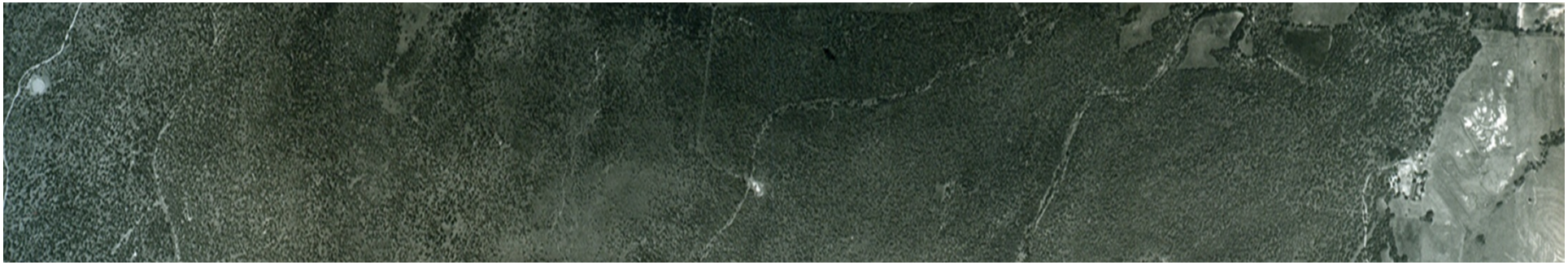
Madeline Dillner
Presented by Kellie Duncan
Oklahoma Corporation Commission

John Harrington
Association of Central Oklahoma Governments

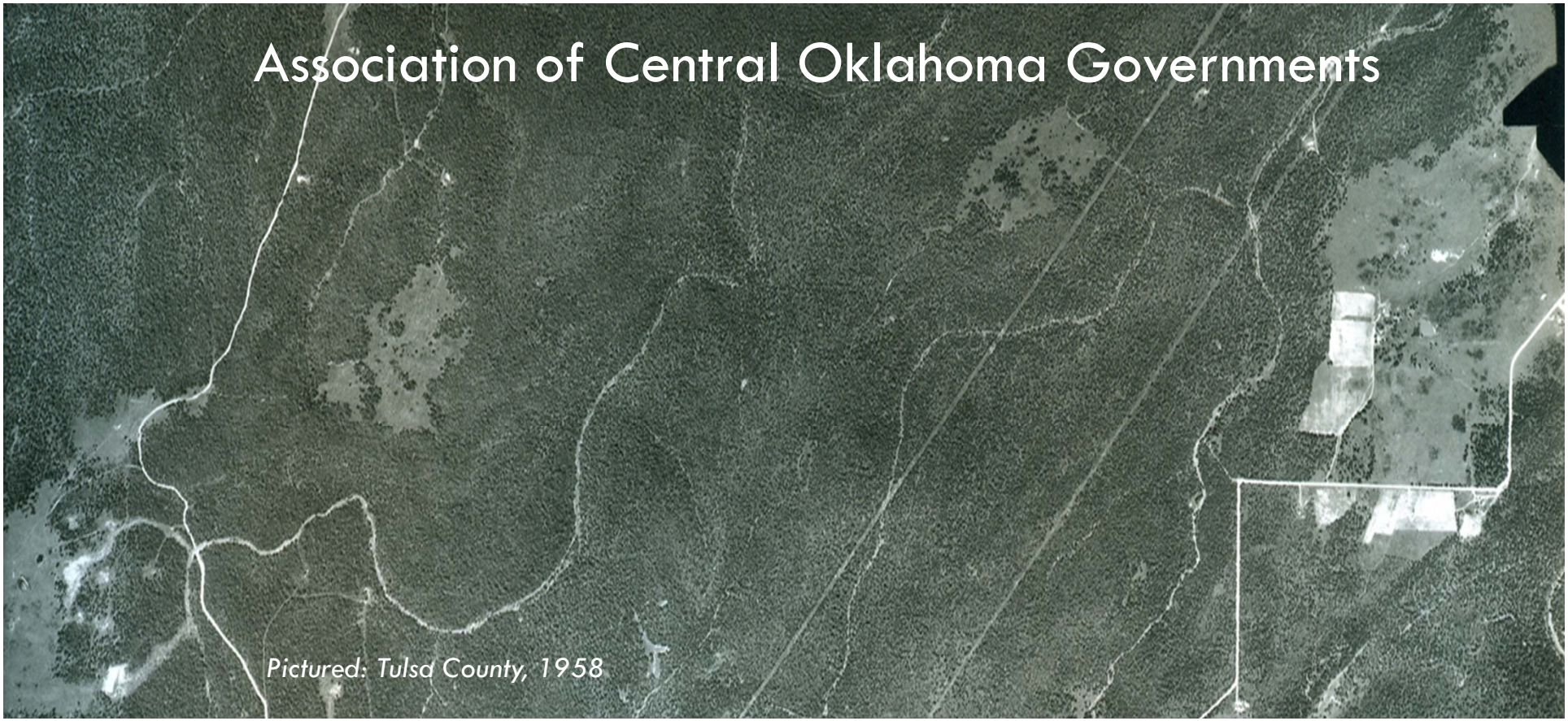
Pictured: Tulsa County, 1958

Road Map

1. ACOG surveyed the West Edmond Oilfield for patches of oilfield brine.
2. OCC used part of ACOG's white paper as a basis for the original historic dense oilfield (HDO) GIS project.
3. ACOG has used census data and shapefiles generated from the original HDO project to choose which areas for which to apply for an Area Wide Planning Grant from EPA to clean up the pollution.
4. After data quality analysis of the original HDO project, OCC is copying ACOG's original method of using historical aerial photos to more accurately identify areas of contamination around the state.

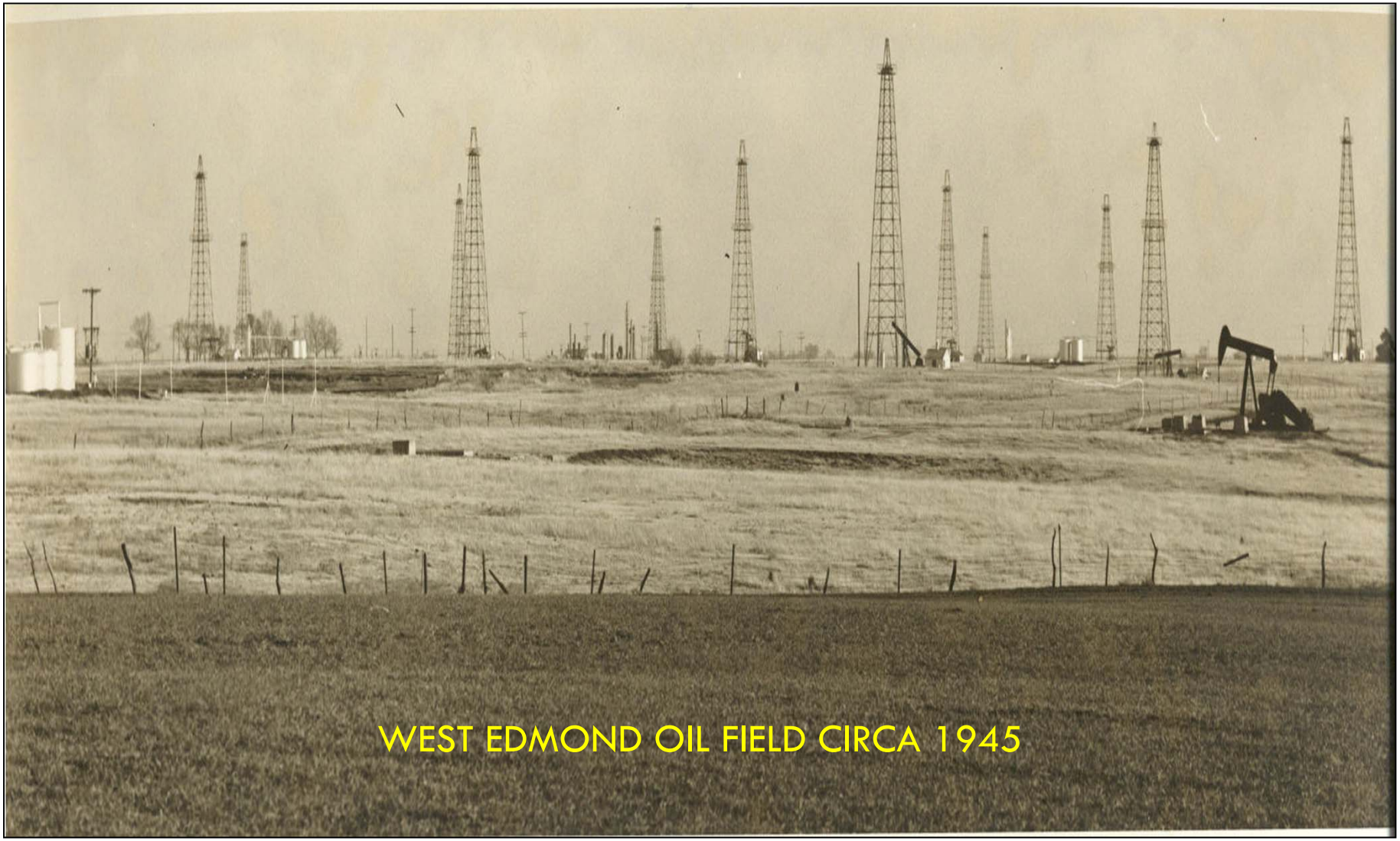


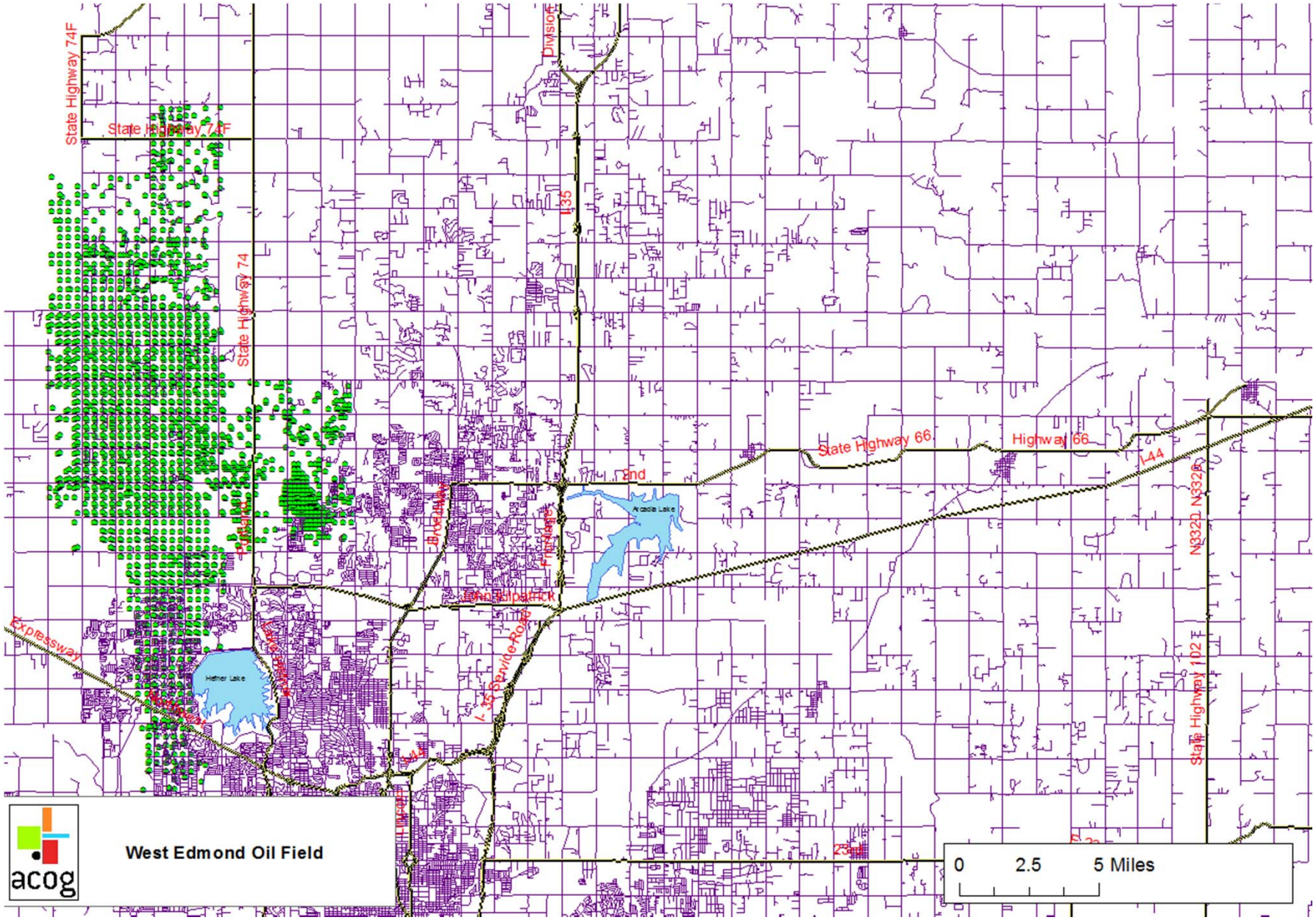
West Edmond Aerial Photo Survey



Association of Central Oklahoma Governments

Pictured: Tulsa County, 1958

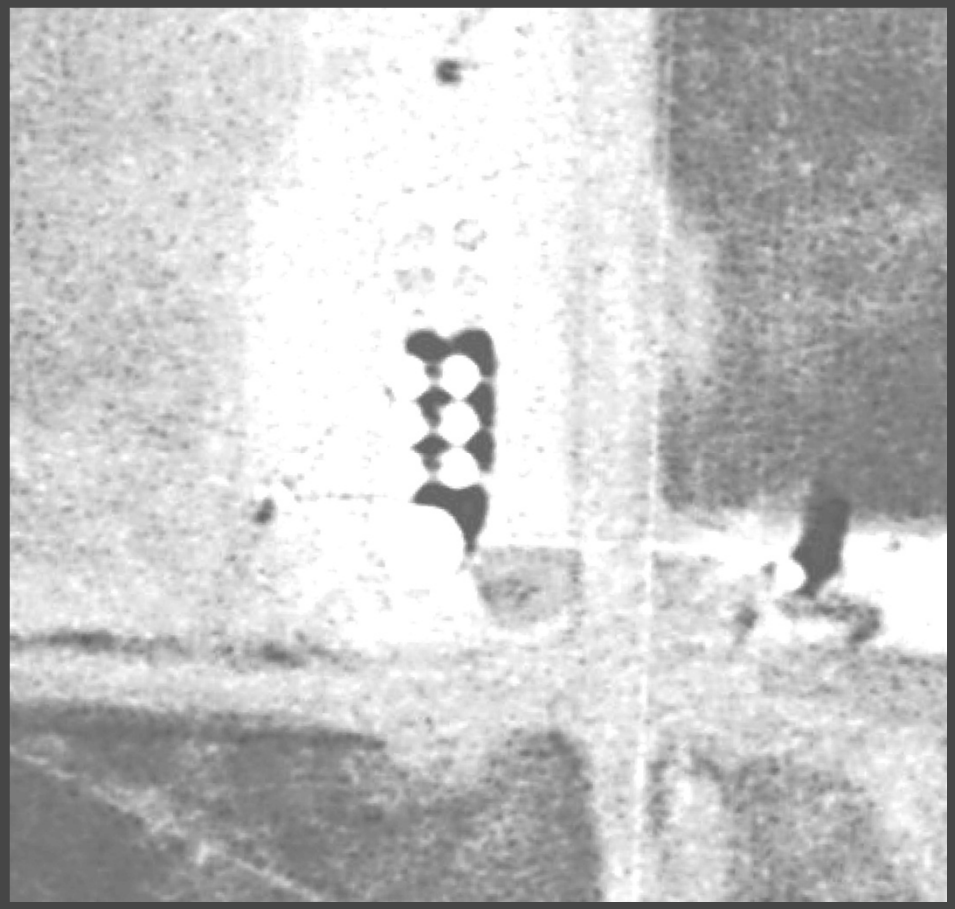

WEST EDMOND OIL FIELD CIRCA 1945


West Edmond Oil Field
acog
0
2.5
5 Miles
State Highway 74F
State Highway 74
Division
I35
State Highway 66
Highway 66
L44
N332D
N332B
Broadway
Arcadia Lake
Hefner Lake
Expressway
Sprville Road
I-35
State Highway 102 F

acog

2011

1951

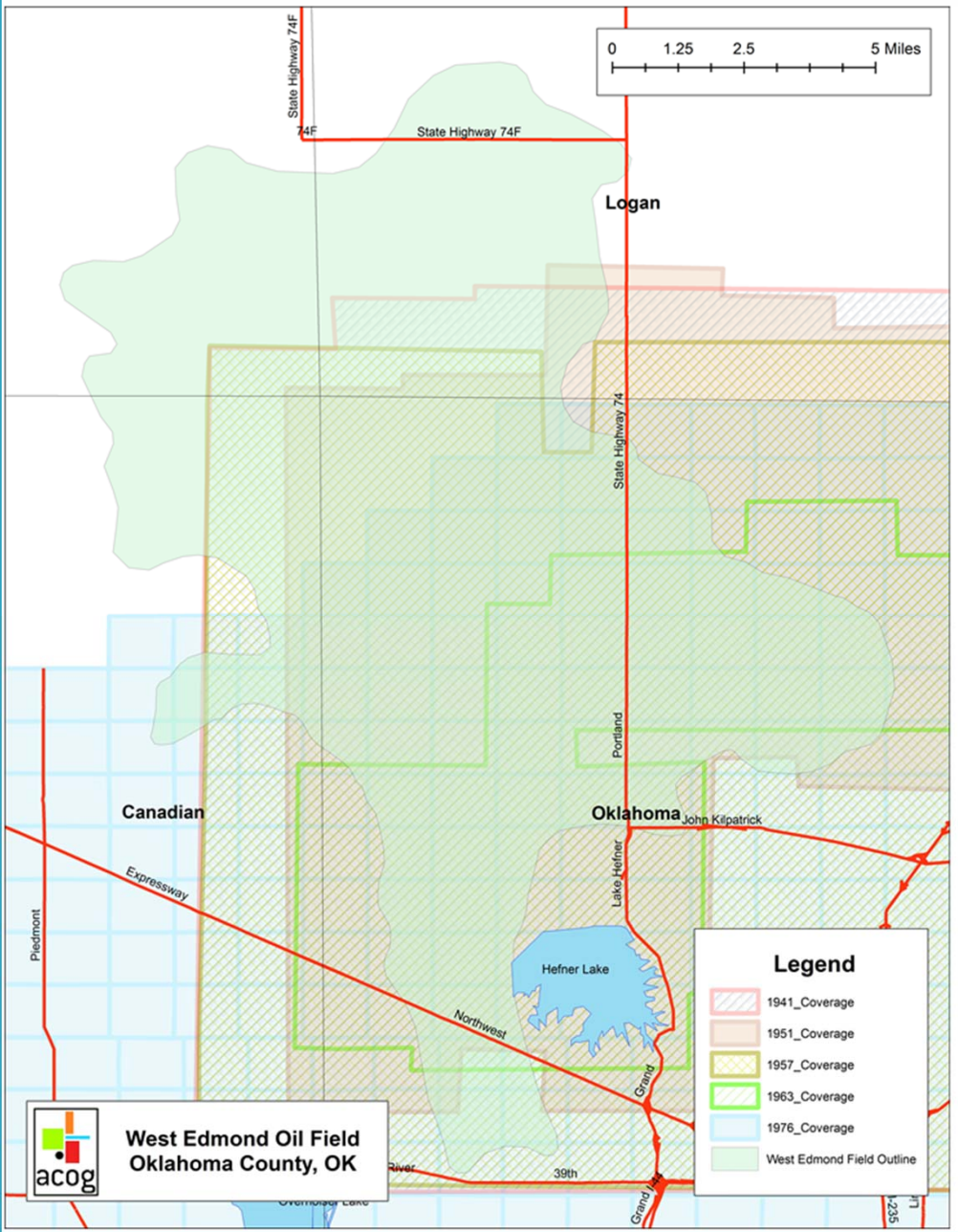


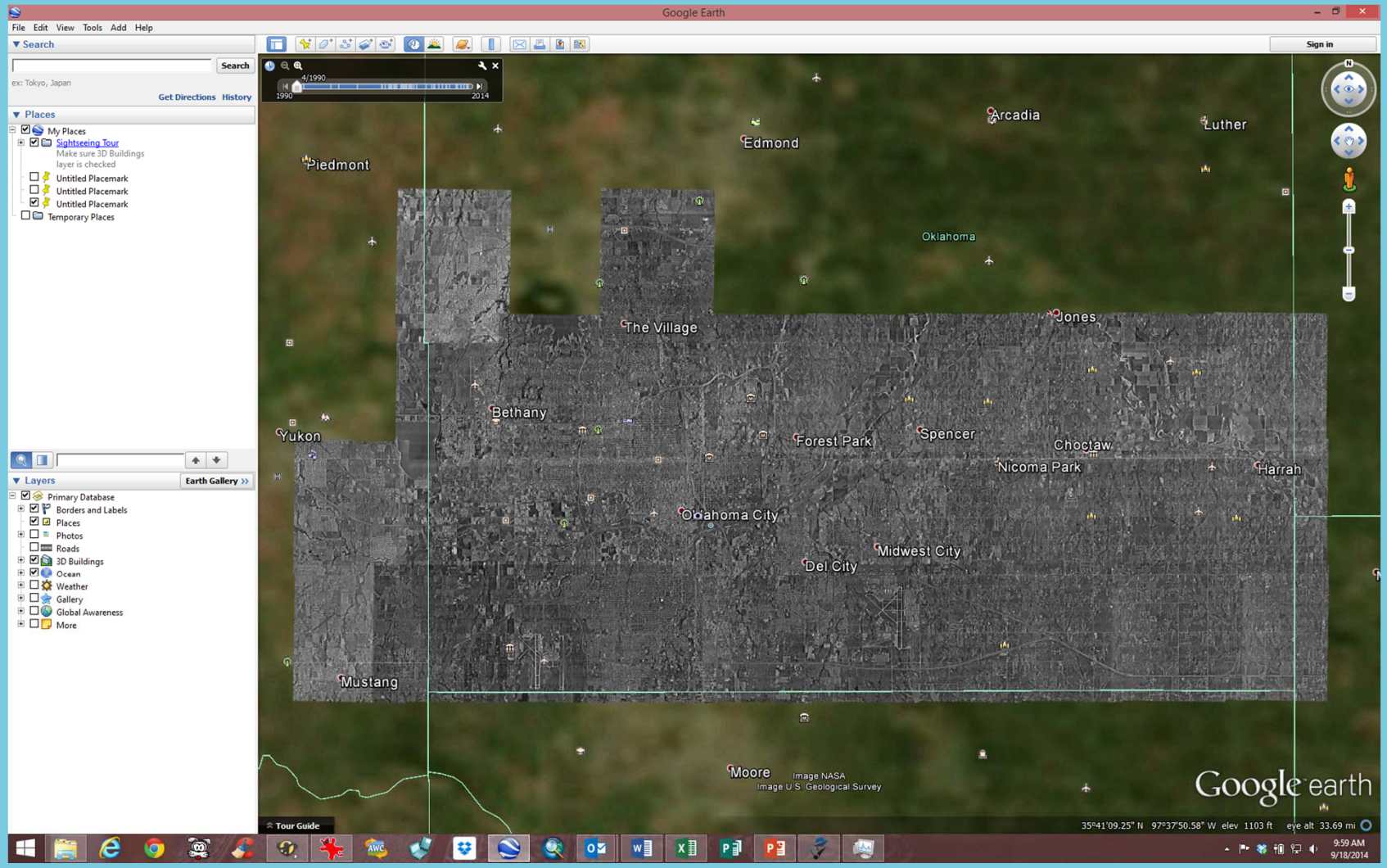
Where there were Oilfield Tank, now we have New Homes

acog

Analysis of the Aerial Photos included coverages from 1941, 1951, 1957, 1963, and 1976.

Not all coverages covered the same areas.

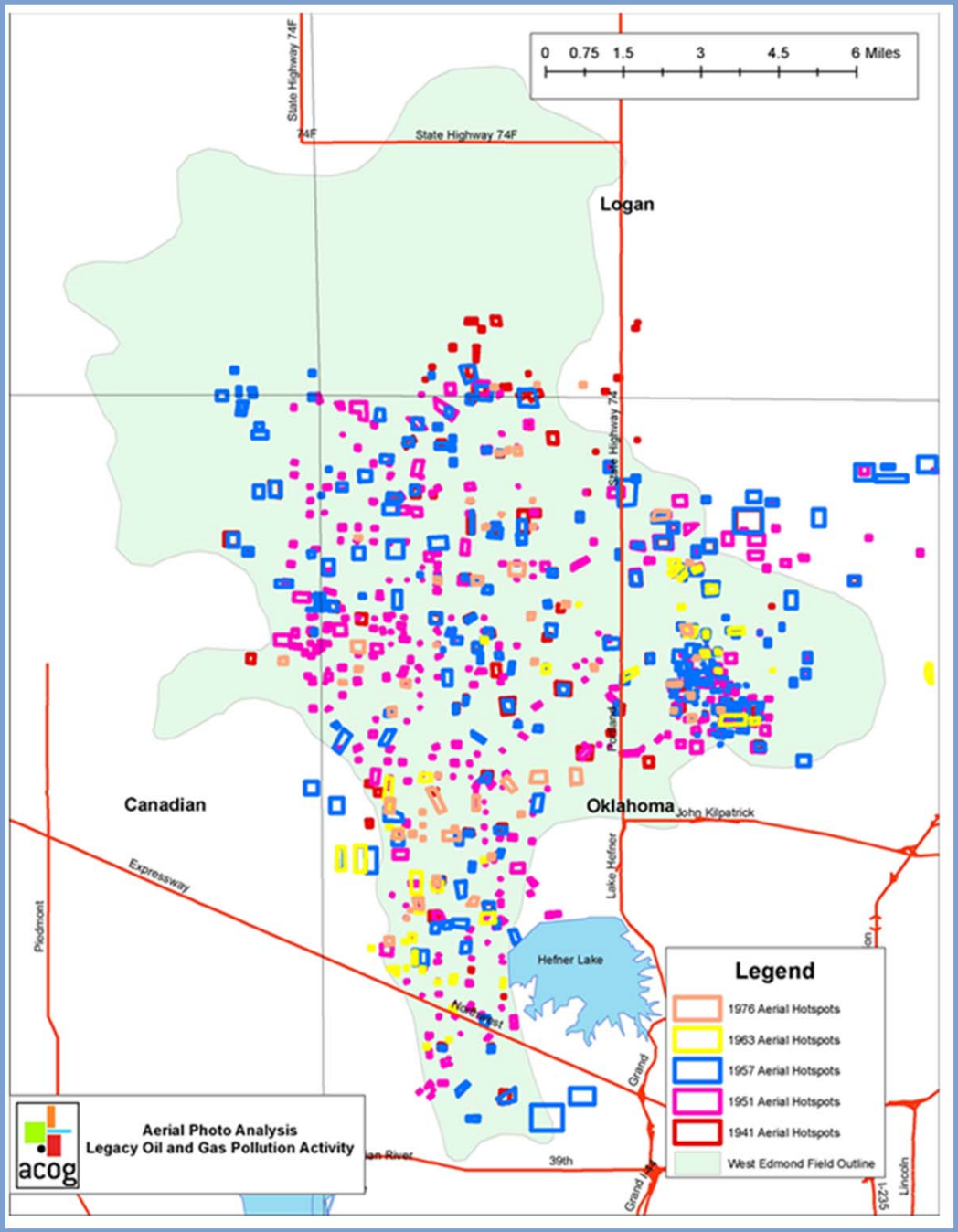


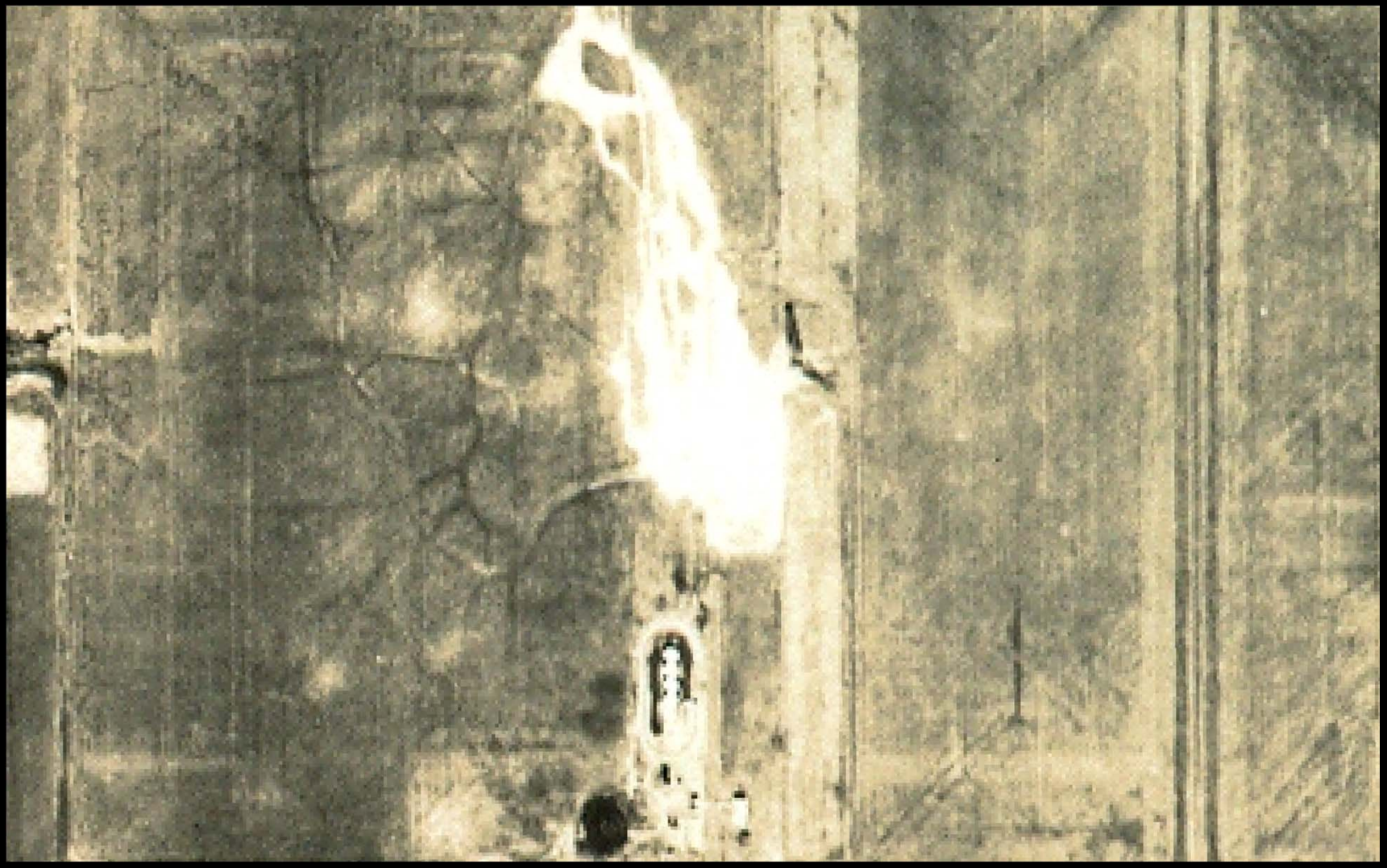


And Google Maps has now got some pretty interesting stuff too!

The “Hot Spot” Map showing anomalies.

If a site showed up on 3 or more vintages of aerial photos, it was considered to be a persistent issue worthy of a brownfield.





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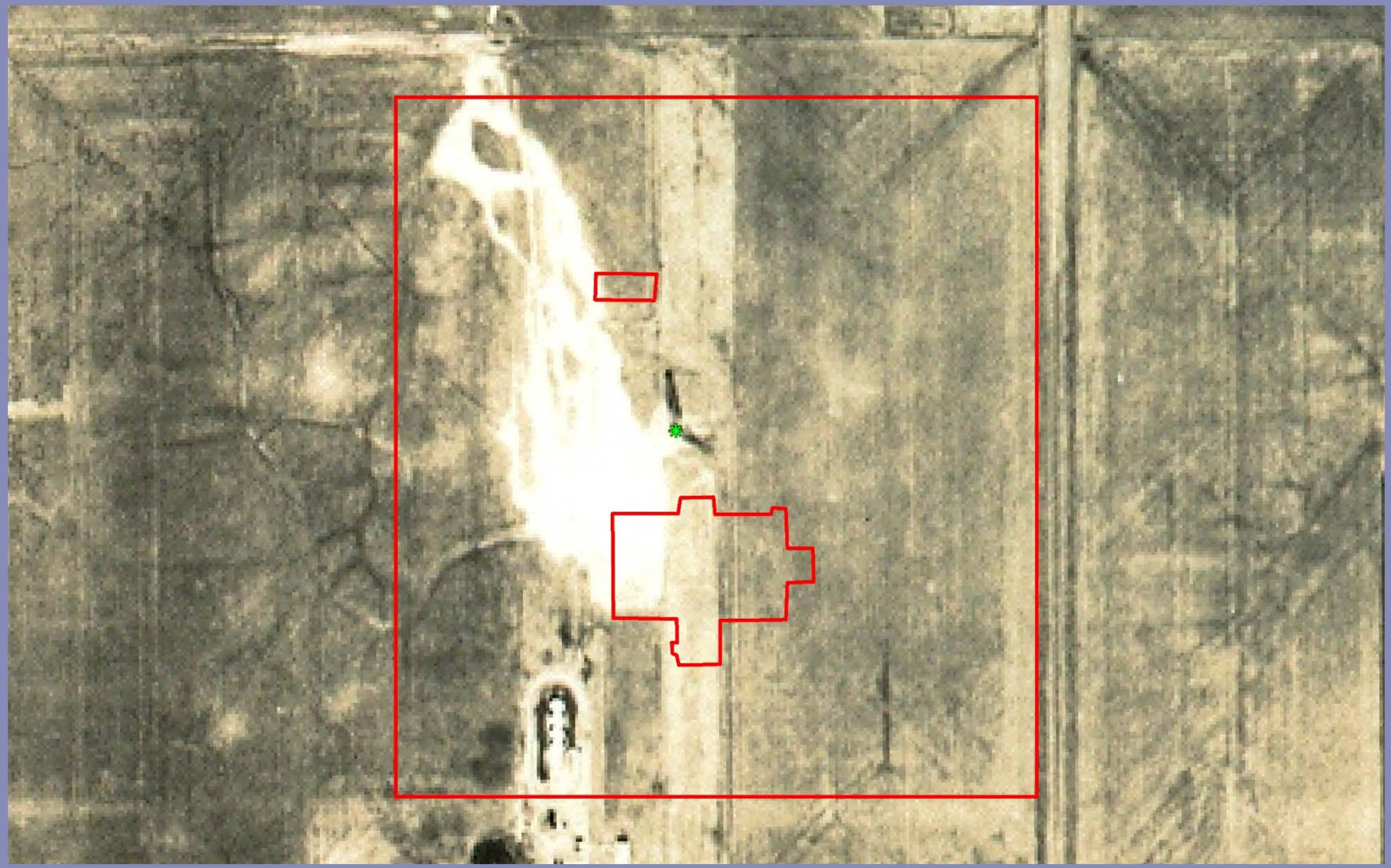
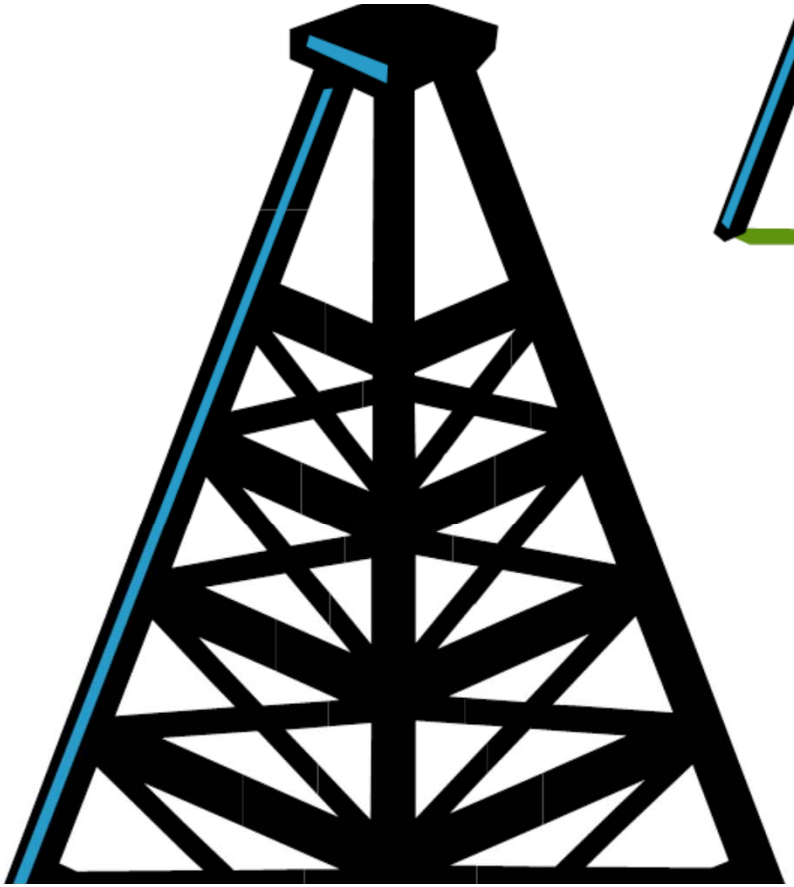
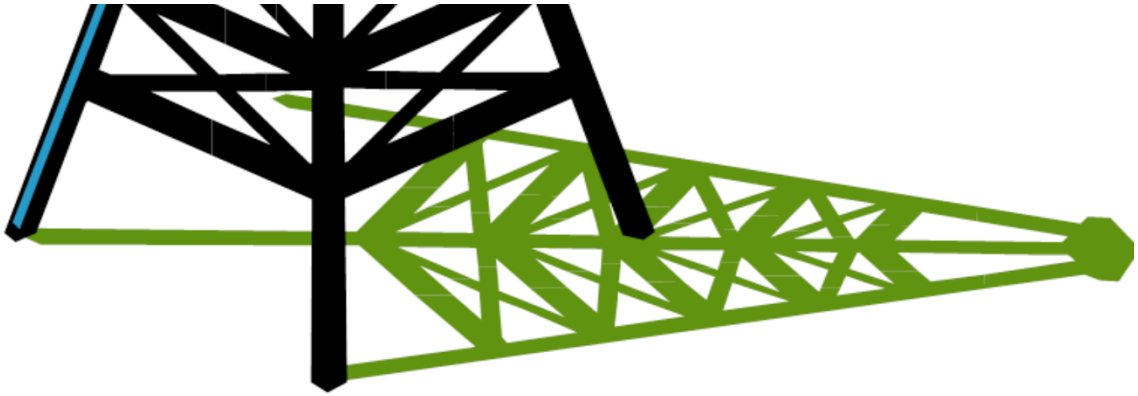


Historic Dense Oilfield Project



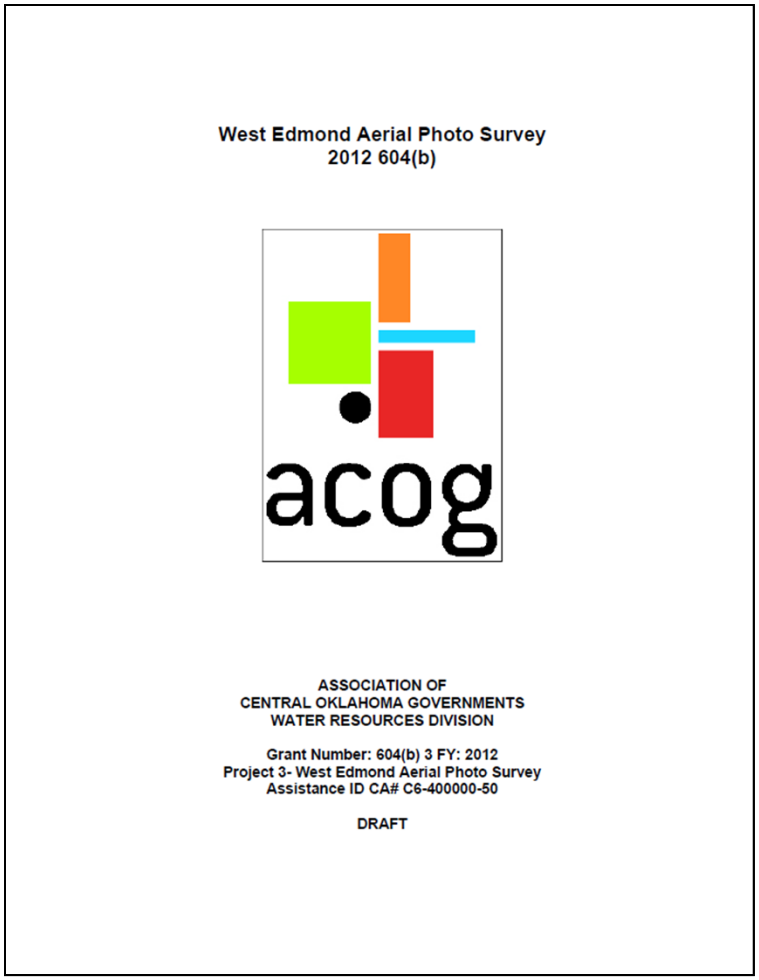


Oklahoma Corporation Commission

2012-2013

Creating Historic Dense Oilfield Maps for New Well Casing Rule

- OCC saw ACOG's white paper
- Decided to make maps of historic dense oilfields (**HDO**s) over aquifers to show areas that are **at higher risk** of being contaminated with oilfield brine
- In these areas, we will recommend that OWRB **require water wells to have deeper cement casing** to block subsurface brine from contaminating the aquifers



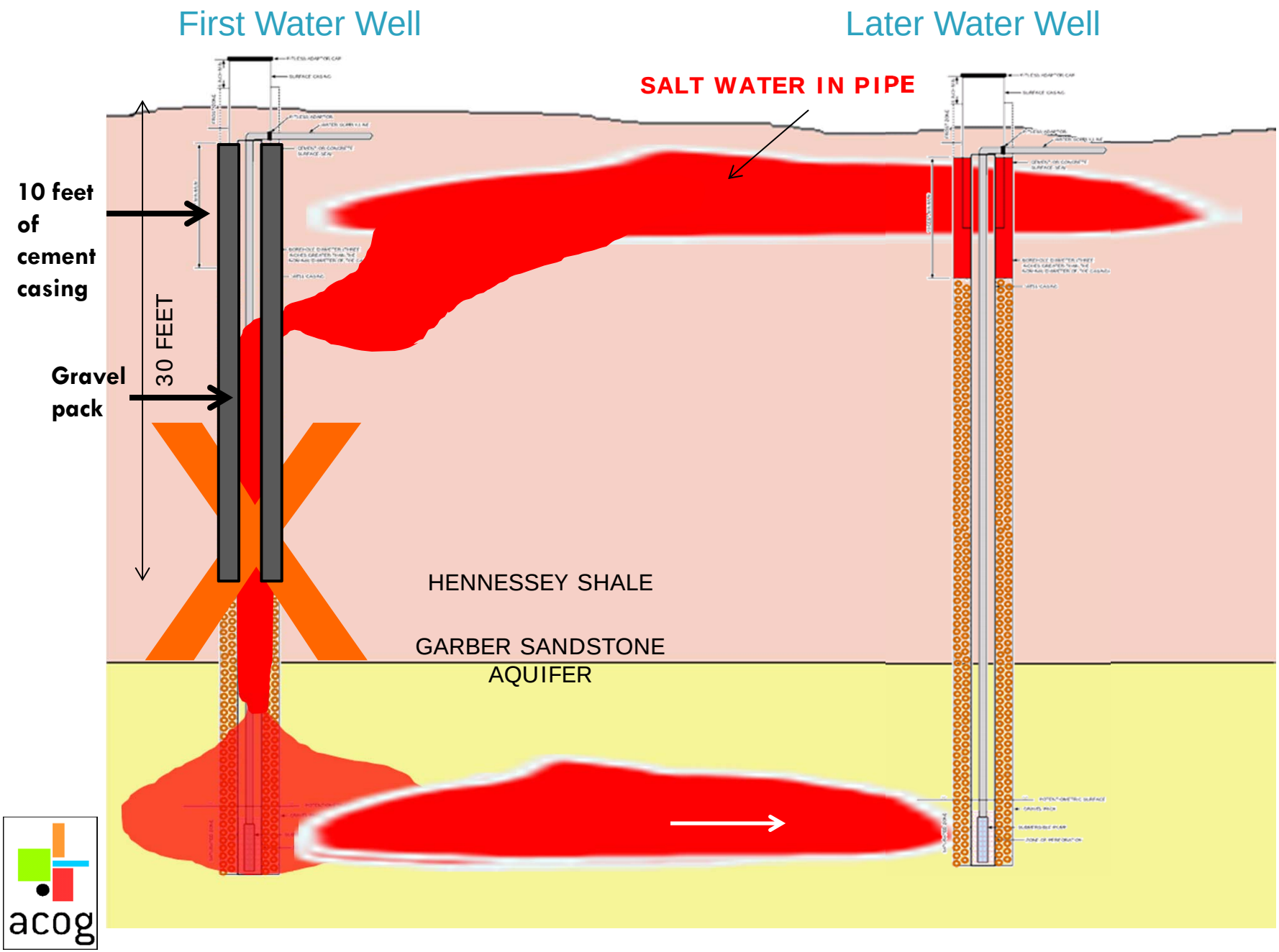
West Edmond Aerial Photo Survey
2012 604(b)

acog

ASSOCIATION OF
CENTRAL OKLAHOMA GOVERNMENTS
WATER RESOURCES DIVISION

Grant Number: 604(b) 3 FY: 2012
Project 3- West Edmond Aerial Photo Survey
Assistance ID CA# C6-400000-50

DRAFT

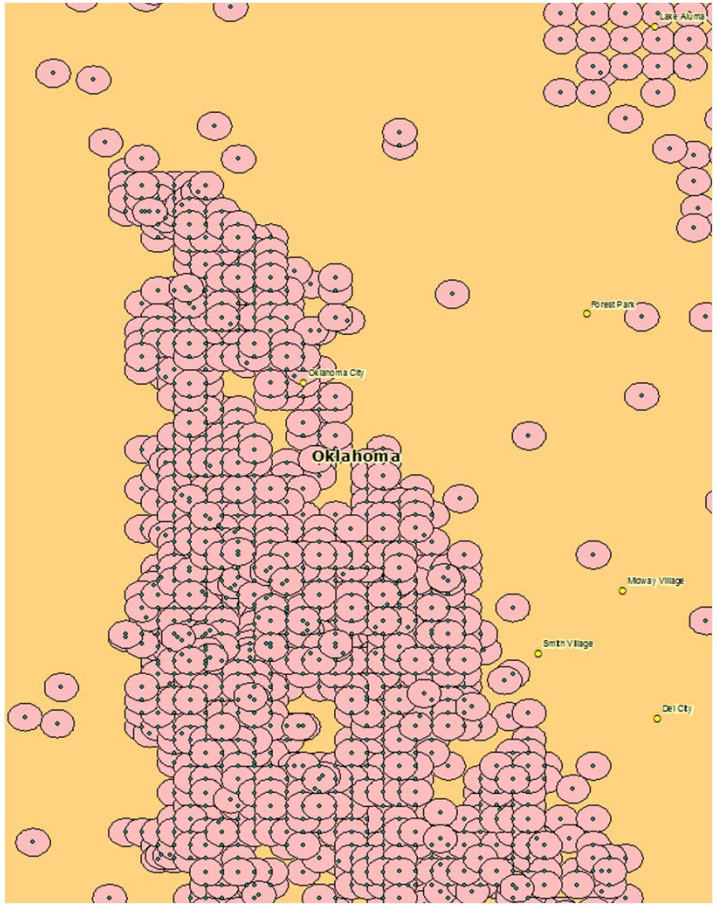

First Water Well
Later Water Well
SALT WATER IN PIPE
10 feet of cement casing
Gravel pack
30 FEET
HENNESSEY SHALE
GARBER SANDSTONE AQUIFER
acog

HDO Project Data: Point Shapefile

- Each point is an oil, gas, and/or injection well location
- GPS locations come from well records given to the OCC by operators over the years
- **On these forms, locations are recorded by legal locations for old wells, legal locations and GPS for newer wells.**
  - OCC used a tool which converted legal locations to GPS coordinates by grabbing the coordinates of the centroid of the smallest unit of location recorded for the well.
- Chose to look at only wells completed before Jan. 1, 1980, because after 1980, OCC's environmental regulations changed.
  - much stricter restrictions for well drilling
  - started requiring pit liners
  - doubled number of field inspectors to enforce the new rules.

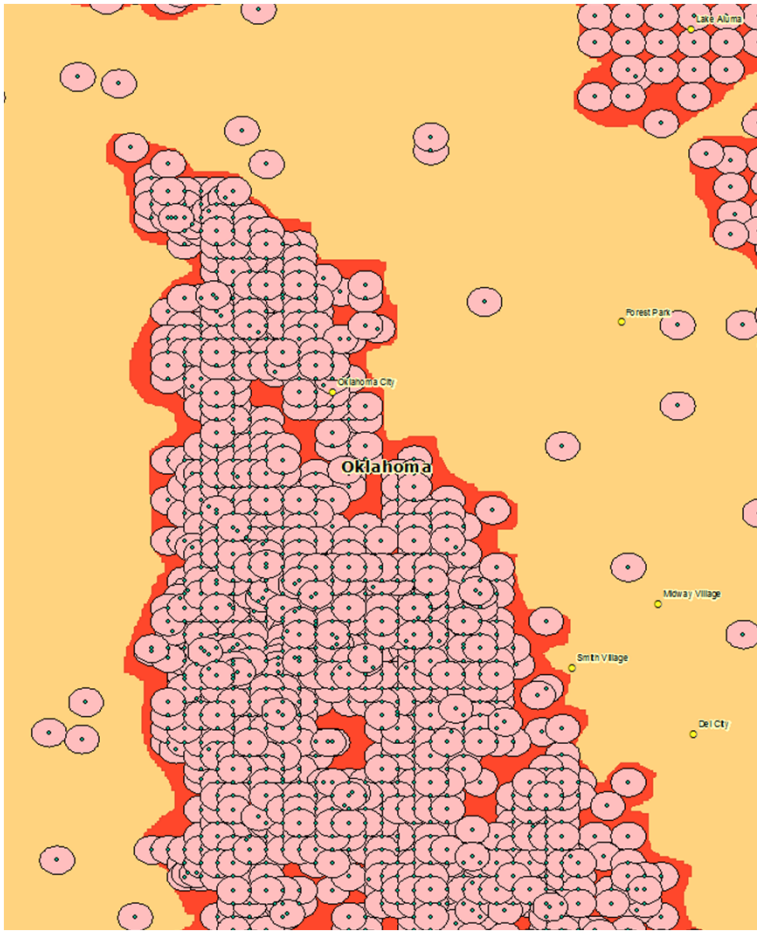
HDO Project Data: Buffers

- Chose a density of 1 well/40 acres to define a historic "dense" oilfield
- 1 well/40 acres = 16 wells/square mile
  - This means if you were driving down 1-mile a strip of country road, you would see 4 wells.
- There are 1,320 feet between wells at this density. Buffering each well with over half that distance will ensure wells at this distance overlap. 1,320/2 = 660…
- **700-foot buffers on each point**



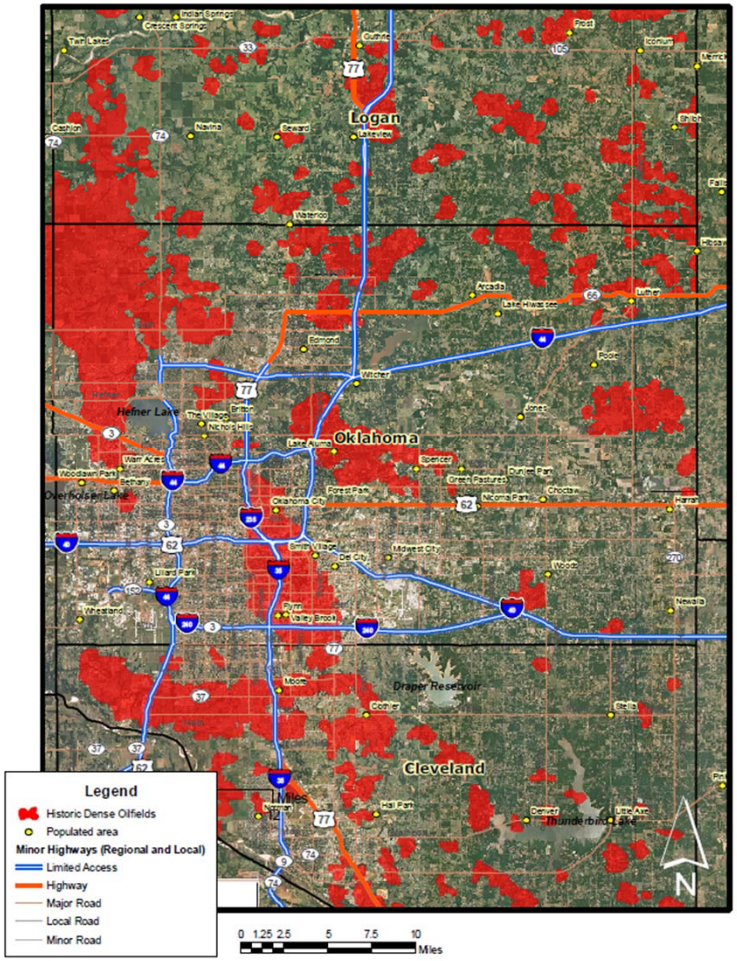
HDO Project Process…Round 1 (The Hard Way)

- Still in college
- Still getting comfortable with the Toolbox
- Created shapefile by outlining the oilfields **by hand**
- Only discovered the streaming vertices method of creating a polygon **halfway through**
- Took months

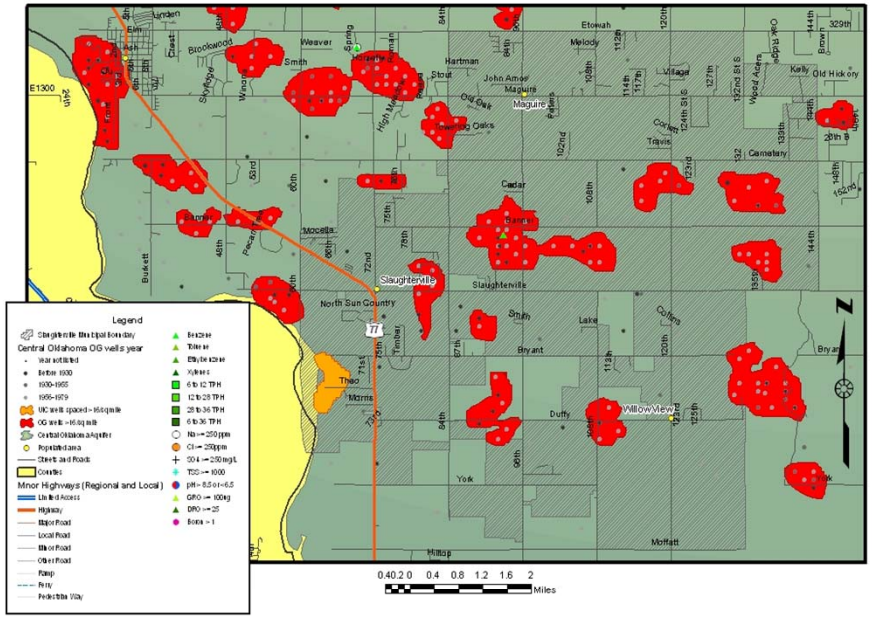


Round 1 Maps

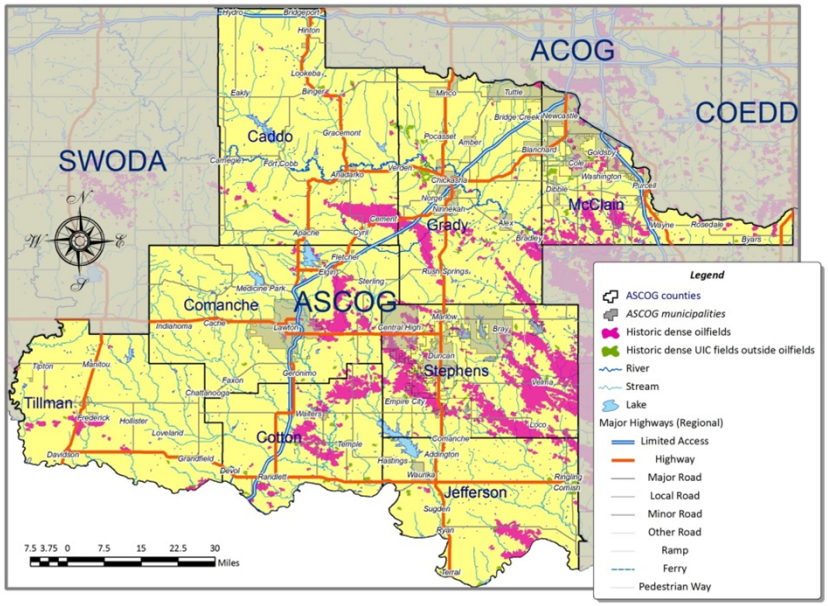
Oklahoma City Region - Garber Wellington Aquifer
Historic Dense Oilfields



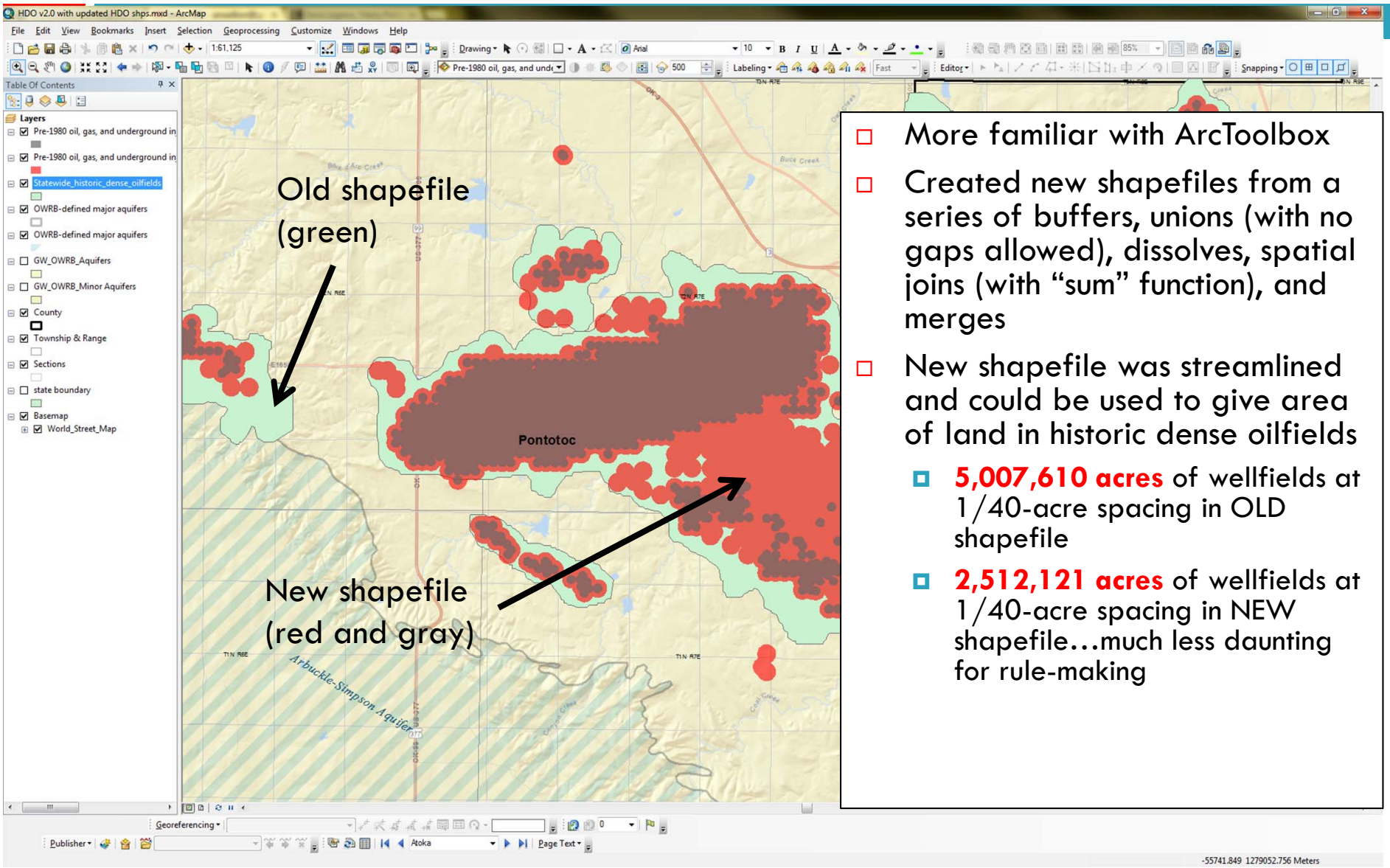
Slaughterville
Pre-1980 Oil Wells and Dense Wellfields



ASCOG Historic Dense Oilfields



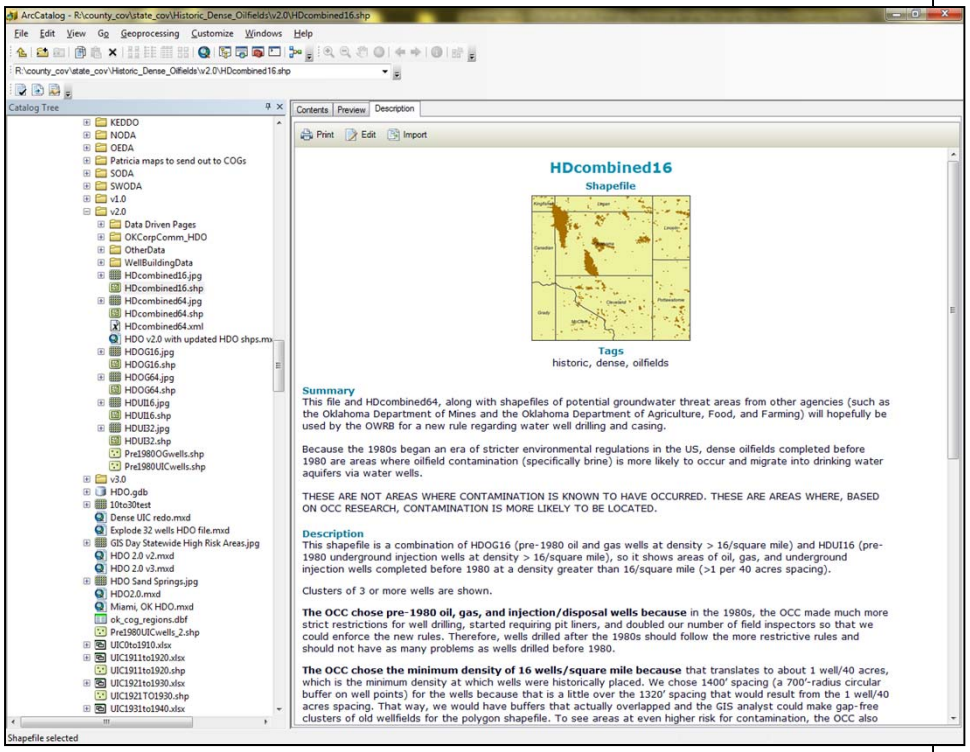
HDO Project Process…Round 2 (The Easy Way)

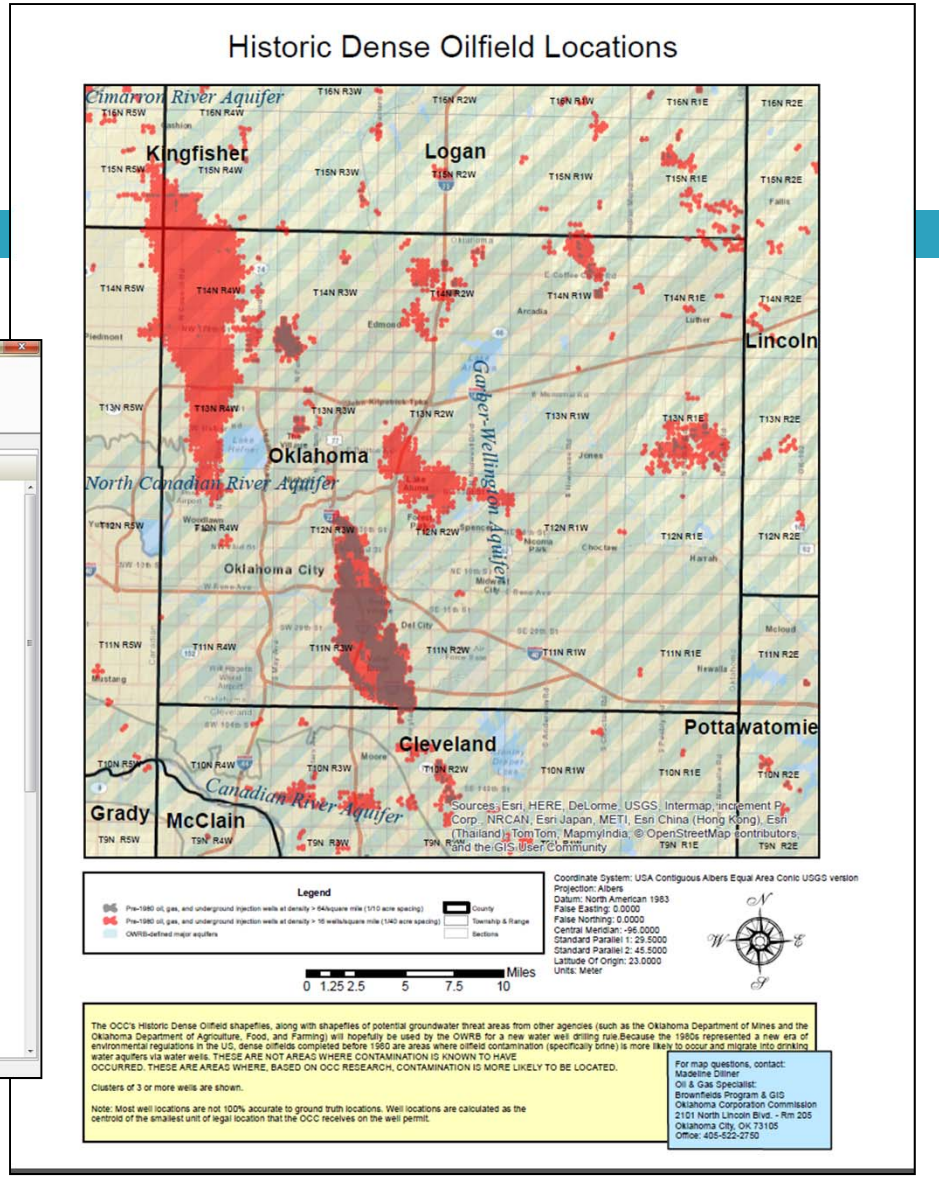


- More familiar with ArcToolbox
- Created new shapefiles from a series of buffers, unions (with no gaps allowed), dissolves, spatial joins (with "sum" function), and merges
- New shapefile was streamlined and could be used to give area of land in historic dense oilfields
  - **5,007,610 acres** of wellfields at 1/40-acre spacing in OLD shapefile
  - **2,512,121 acres** of wellfields at 1/40-acre spacing in NEW shapefile…much less daunting for rule-making

Round 2 Maps

and metadata!





Area Grant Projects

Association of Central Oklahoma Governments

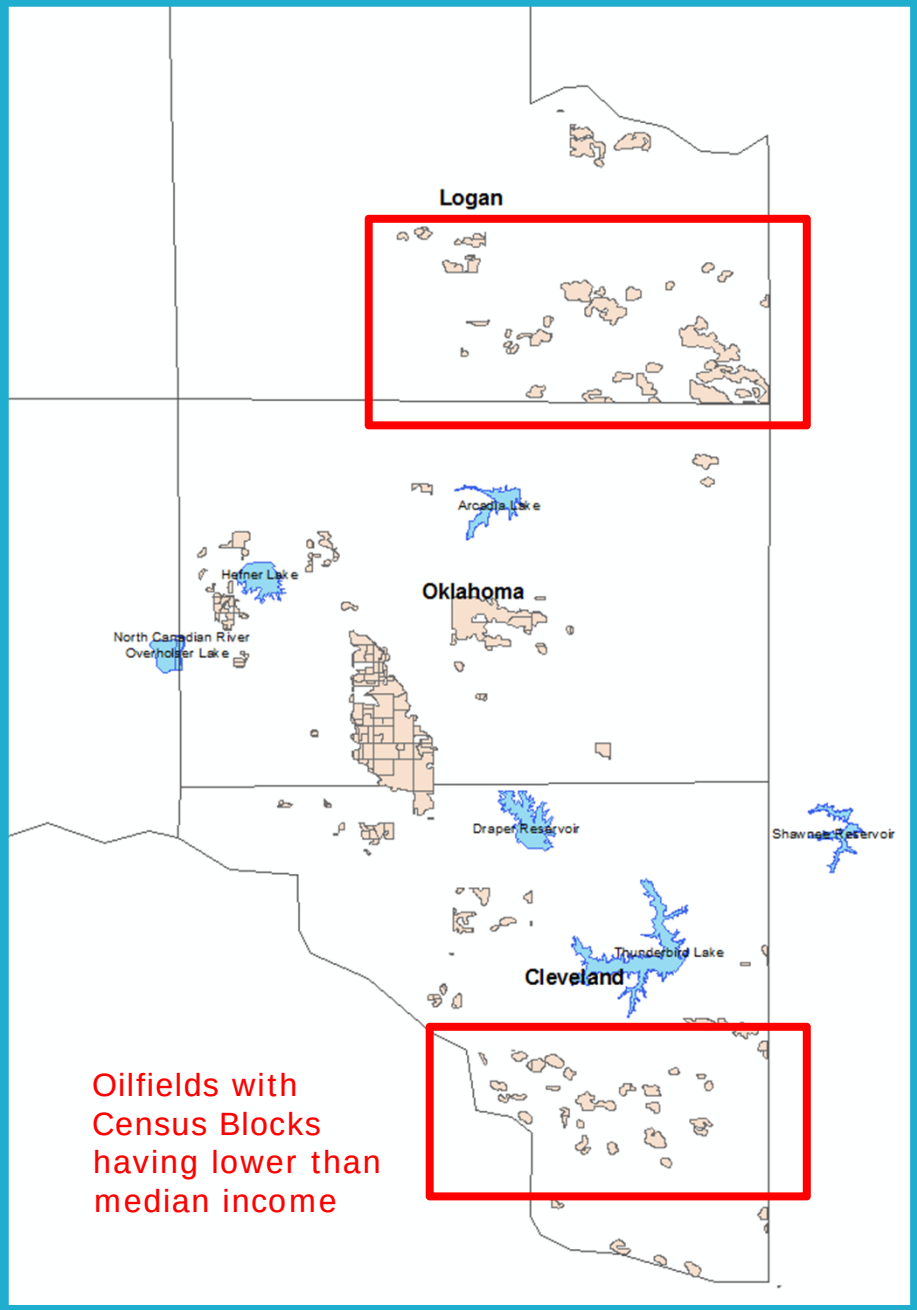
YEAR

ACOG is applying for an Area-wide Assessment Grant. However, the environmental justice requirement necessitates that we look at areas with lower income levels.

Demographic Information (5 Points)

Provide demographic information about your targeted community including pertinent indicators of population, unemployment, poverty, minorities, and income such as those shown in the suggested table below, and clearly cite the sources of your data.

Assessment Grant 2014



Assessment Grant Proposal will target legacy oil and gas areas with low income census blocks.

Demographic Information (5 Points)

Provide demographic information about your targeted community including pertinent indicators of population, unemployment, poverty, minorities, and income such as those shown in the suggested table below, and clearly cite the sources of your data.

	Targeted Community Cleveland Co	Targeted Community Logan Co	Statewide	National
Population	21,103[1]	24,355[1]	3,751,351[1]	308,745,538[1]
Unemployment	7.4%[1]	6.8%[1]	6.8%[1]	7.2%[2]
Poverty Rate	22.0%[1]	13.9%[1]	16.6%[3]	15.1%[3]
Percent Minority	25.6%[1]	17.8%[1]	26.3%[1]	26.7%[1]
Median Household Income	$ 38,000[1]	$ 41,217[1]	$ 44,891[3]	$ 49,445[3]
Other				

[1]Data is from the 2010 U.S. Census data and is available at http://www.census.gov/
[2]Data is from the Bureau of Labor Statistics and is available at http://www.bls.gov/
[3]Data is from the 2010 American Community Survey and is available at: http://www.census.gov/acs/www/

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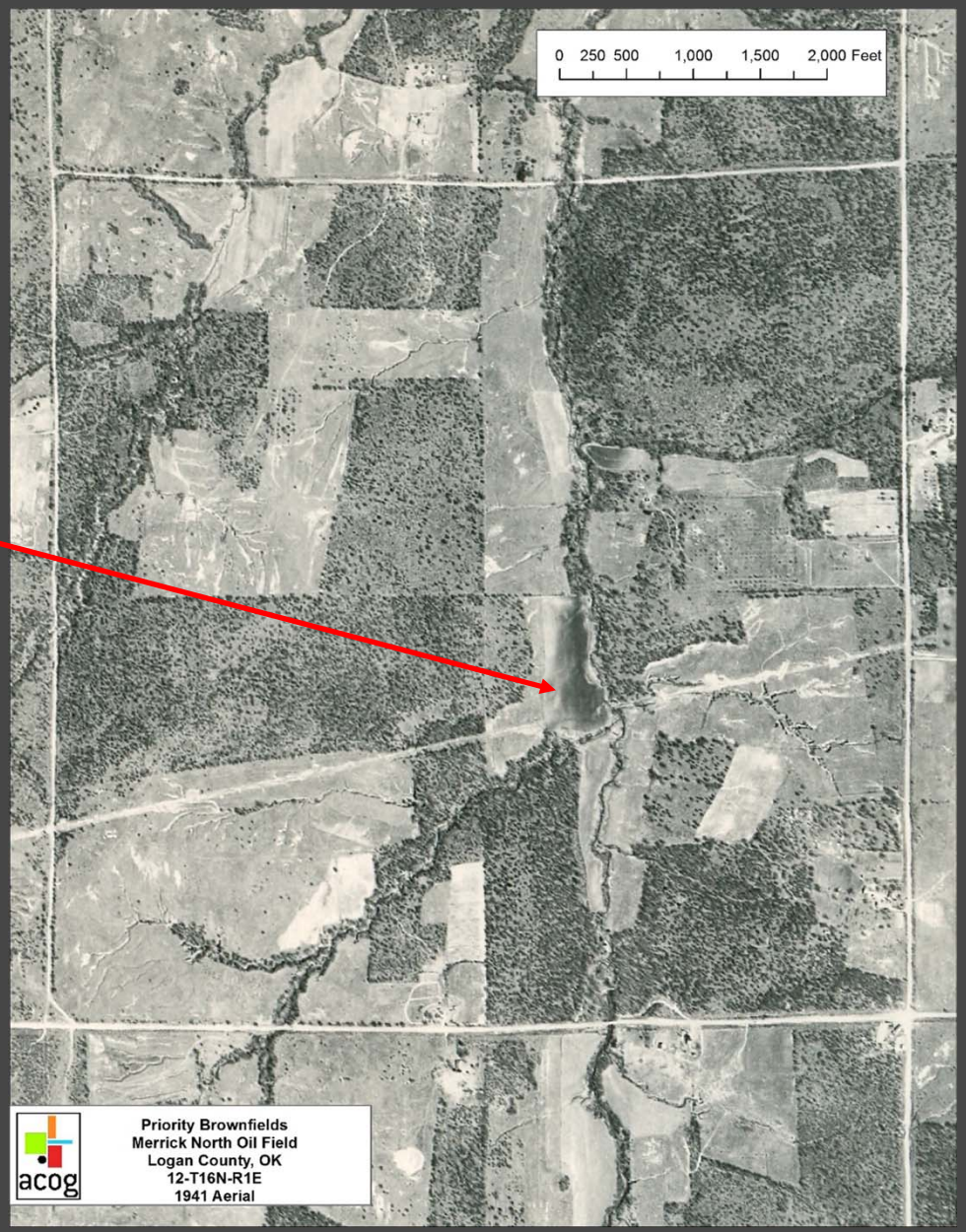
Assessment Grant 2014

Leaking Oil Pipeline



Assessment Grant 2014

Leaking Oil Pipeline

HDO Data Analysis and New Project Direction

Oklahoma Corporation Commission

2014 – future!

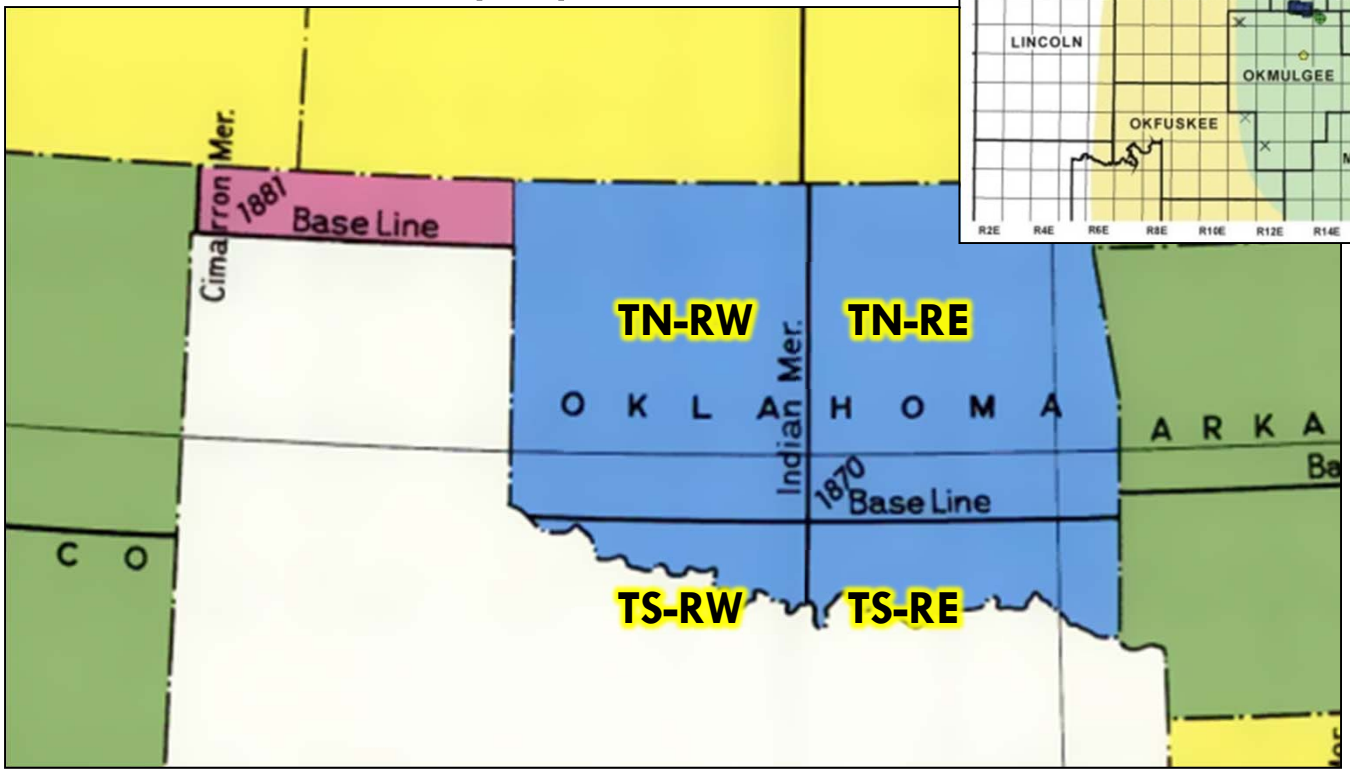
Gathering Metadata

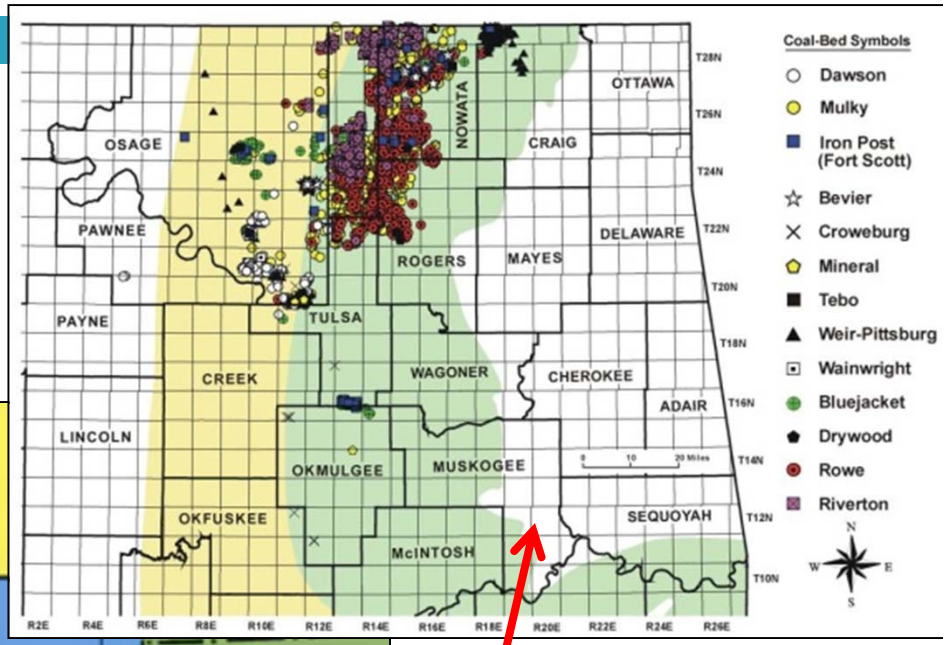
- We wanted some data on our data…specifically: we wanted information about the ***quality*** of the well location data. We found…
- There are inaccuracies:
  - Sometimes people don't understand quarter calls and write them in backwards. We've caught some of the errors, but there are a lot of wells.
- The locations are imprecise:
  - Assuming that wells are located at the centroids of the **legal location** blocks can give errors of up to 3,733 feet.

Side Note: Legal Locations 101

PLSS Grid

- Legal locations in Oklahoma are based on the township-range grid of the Public Land Survey System



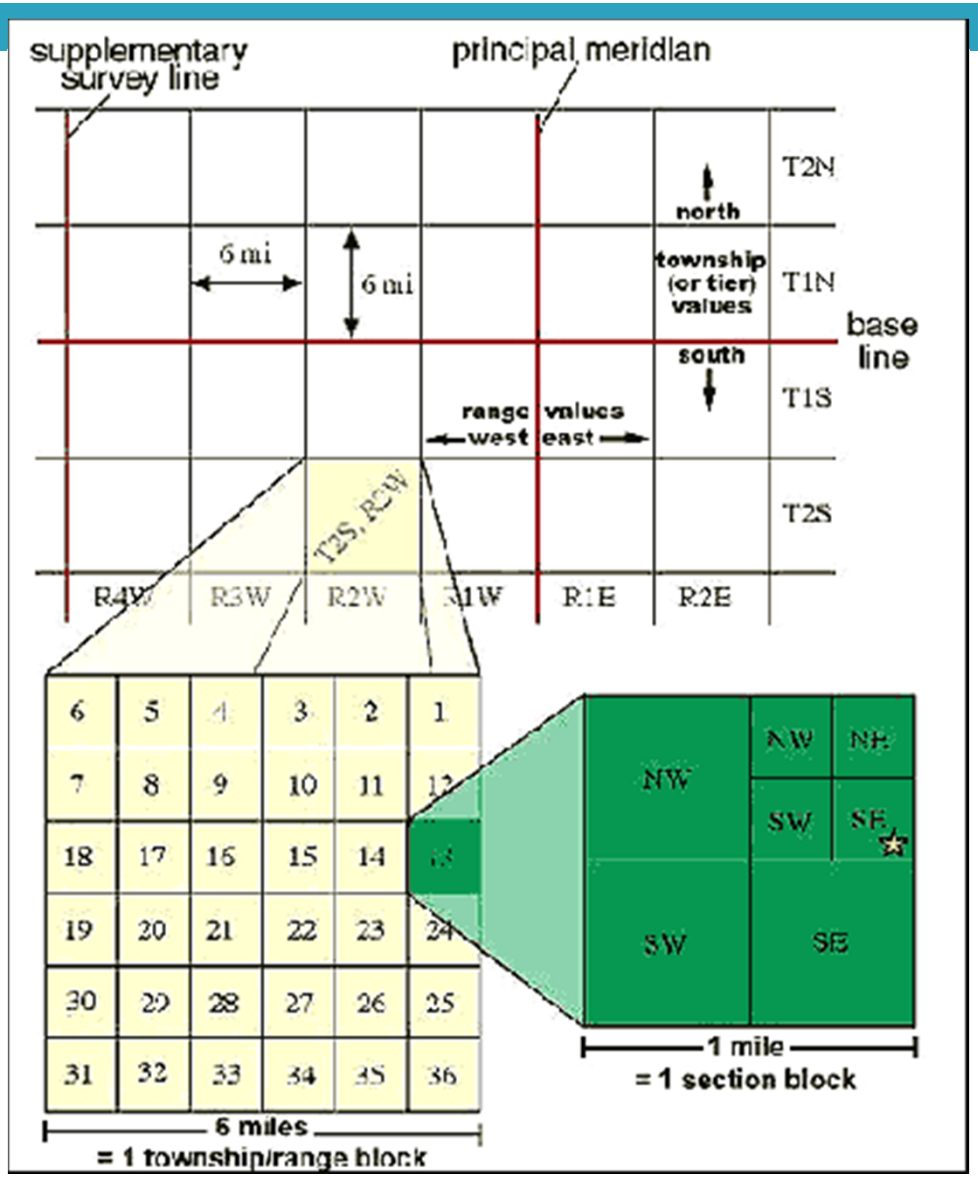


Each square block is a township/range

Side Note: Legal Locations 101

Townships/Ranges and Sections

- Each township/range block is 6 miles x 6 miles, and contains 36 Sections
- Each Section is 1 mile x 1 mile (640 acres)
- Each Section is divided into quarters (160 acres), which can also be split into quarters (40 acres), which can be split again into 10-acre and 2.5-acre quarters.



Side Note: Legal Locations 101

Quarter Calls and Location Precision

- The amount of "quarter calls" we get for a well determines how accurate its GPS location is.

2.5-acre	10-acre	40-acre	160-acre	Section (640-acre)	Township	Range
NE	SW	SE	NW	28	T7N	R3W
			NW	28	T7N	R3W

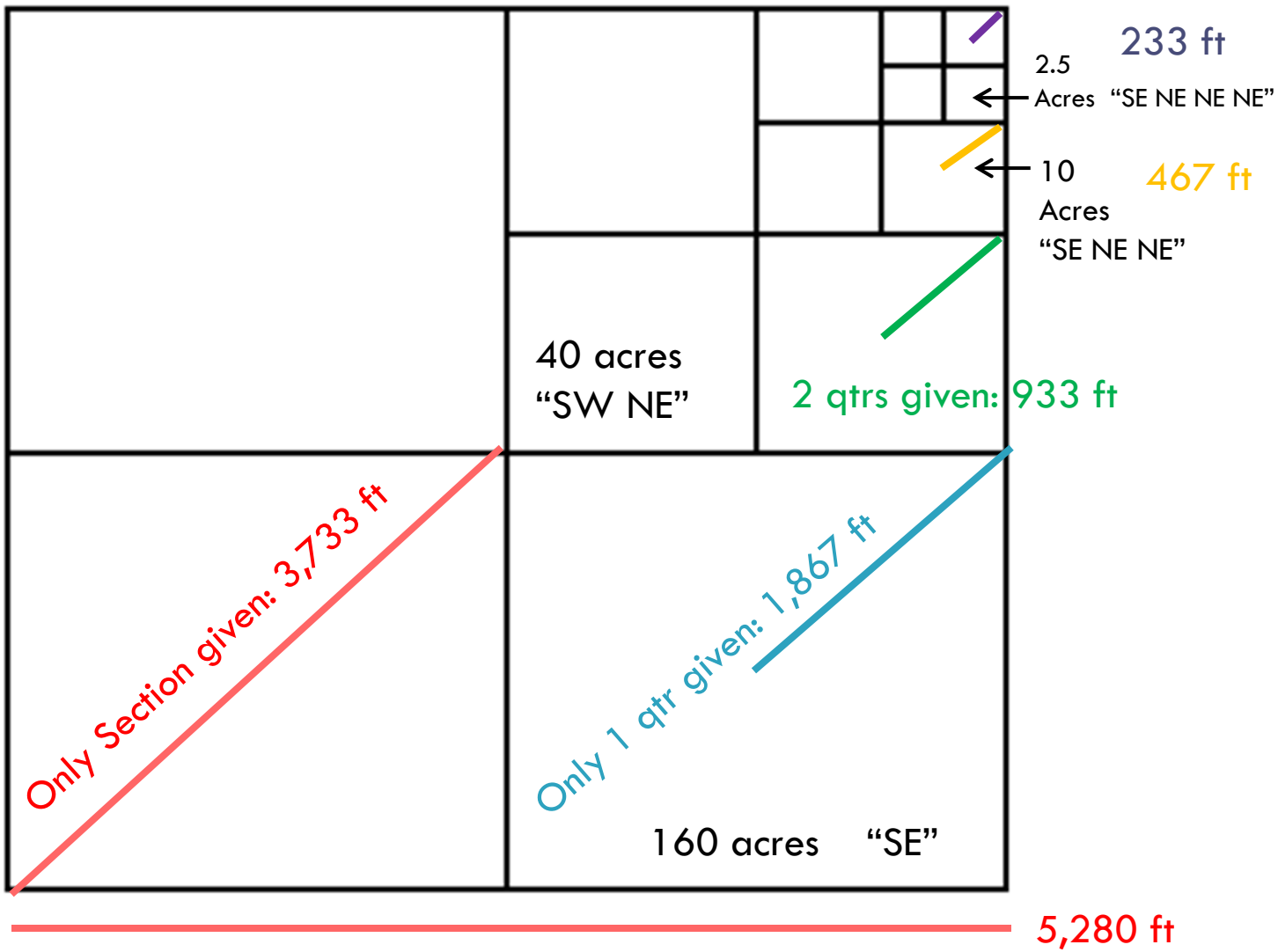
We know that this well is somewhere in 2.5 acres.

We only know this well is somewhere in 160 acres.

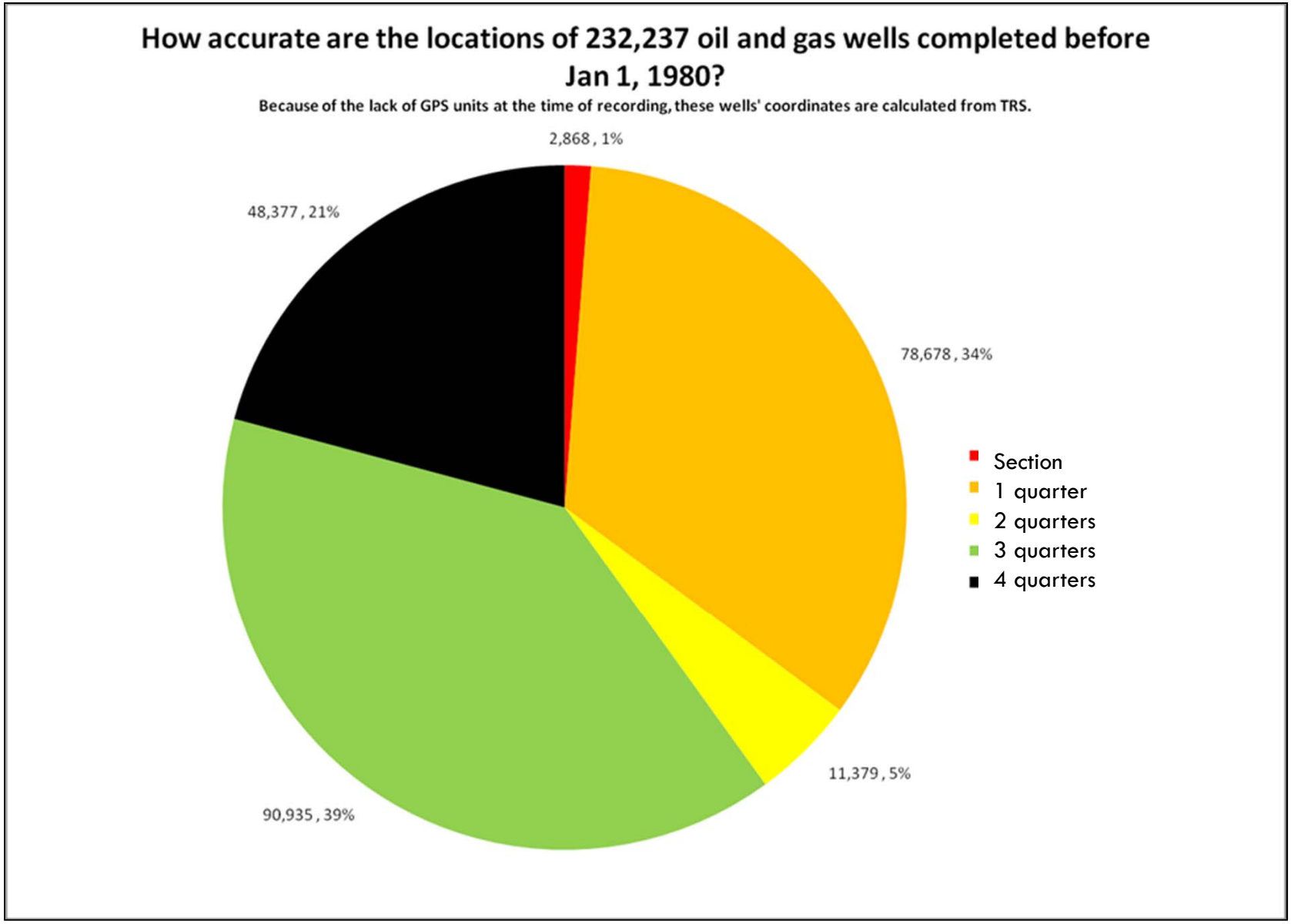
How much imprecision?

"Maximum error" values (in color) are based on assumption that the well in question had its GPS location calculated as center of block, but is actually located in the corner.

Each additional quarter-call given cuts our potential maximum error for that well's location **in half.**



So, How Precise is our Well Data?



How Accurate Is Our Well Data?

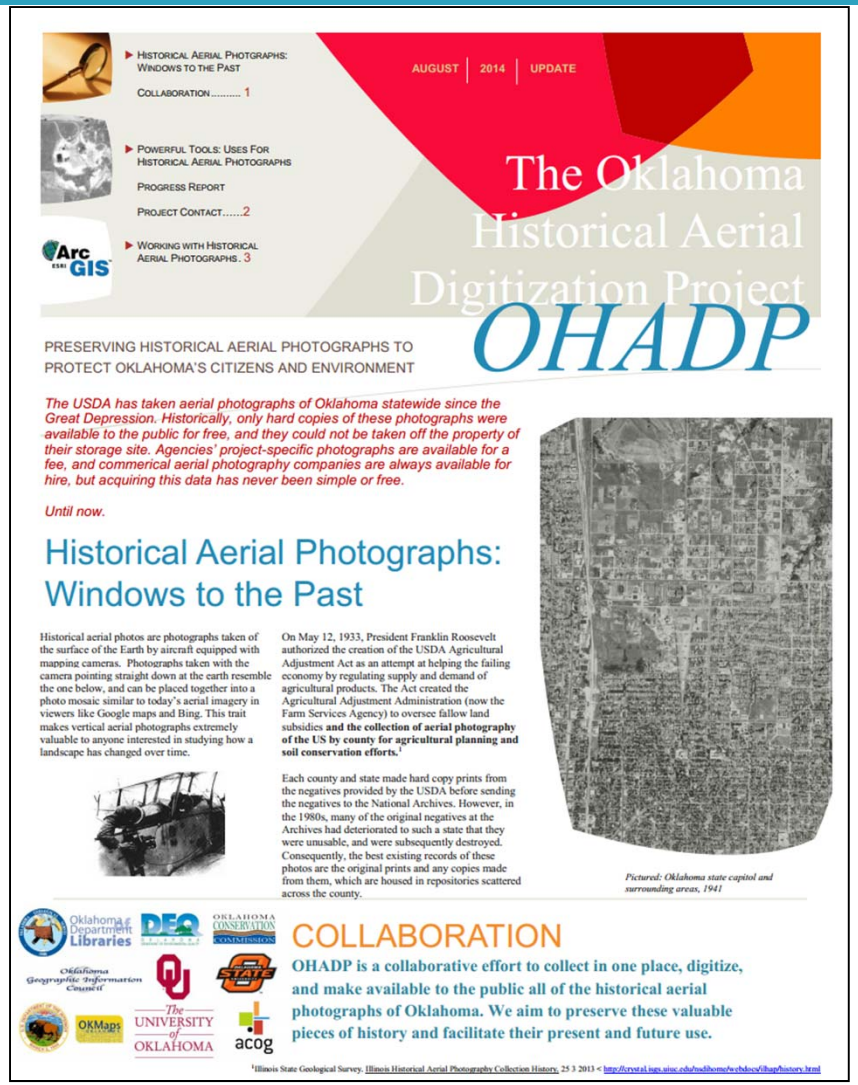
As accurate as it can be, given the technology at the time the wells were drilled, and the number of well records that exist. But it could be better.

We want the most accurate maps possible when suggesting people place extra casing in water wells in those areas. **We don't want** to cause people to spend money they don't have to, or miss areas that need protection!

Improving Accuracy of Maps of Potential Contamination Zones Using Historical Aerial Photographs

- OCC is going to copy ACOG's original study, in which they outlined brine spills on historical aerial photographs
- Since 2007, OCC has been collecting, digitizing, and georectifying historical aerial photographs from around the state.
- We currently have over 100,000 photographs
- For more information on this project: http://www.occeweb.com/og/OHADP%20newsletter%202014-08%20update.pdf

  (pictured on right)



Historical Aerial Photographs: Windows to the Past 1

Powerful Tools: Uses For Historical Aerial Photographs

Progress Report

Project Contact.....2

Working with Historical Aerial Photographs.. 3

AUGUST | 2014 | UPDATE

The Oklahoma Historical Aerial Digitization Project

OHADP

PRESERVING HISTORICAL AERIAL PHOTOGRAPHS TO PROTECT OKLAHOMA'S CITIZENS AND ENVIRONMENT

The USDA has taken aerial photographs of Oklahoma statewide since the Great Depression. Historically, only hard copies of these photographs were available to the public for free, and they could not be taken off the property of their storage site. Agencies' project-specific photographs are available for a fee, and commerical aerial photography companies are always available for hire, but acquiring this data has never been simple or free.

Until now.

Historical Aerial Photographs: Windows to the Past

Historical aerial photos are photographs taken of the surface of the Earth by aircraft equipped with mapping cameras. Photographs taken with the camera pointing straight down at the earth resemble the one below, and can be placed together into a photo mosaic similar to today's aerial imagery in viewers like Google maps and Bing. This trait makes vertical aerial photographs extremely valuable to anyone interested in studying how a landscape has changed over time.

On May 12, 1933, President Franklin Roosevelt authorized the creation of the USDA Agricultural Adjustment Act as an attempt at helping the failing economy by regulating supply and demand of agricultural products. The Act created the Agricultural Adjustment Administration (now the Farm Services Agency) to oversee fallow land subsidies **and the collection of aerial photography of the US by county for agricultural planning and soil conservation efforts.**[1]

Each county and state made hard copy prints from the negatives provided by the USDA before sending the negatives to the National Archives. However, in the 1980s, many of the original negatives at the Archives had deteriorated to such a state that they were unusable, and were subsequently destroyed. Consequently, the best existing records of these photos are the original prints and any copies made from them, which are housed in repositories scattered across the county.

Pictured: Oklahoma state capitol and surrounding areas, 1941

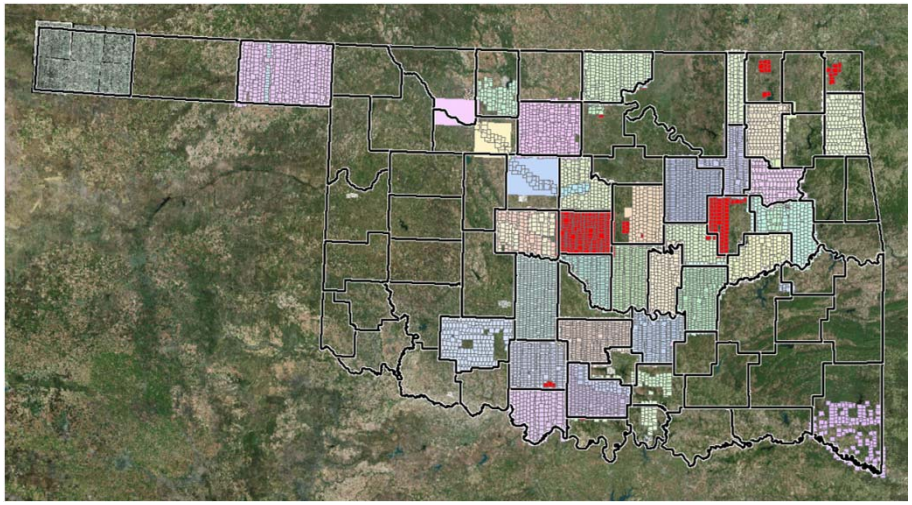
COLLABORATION

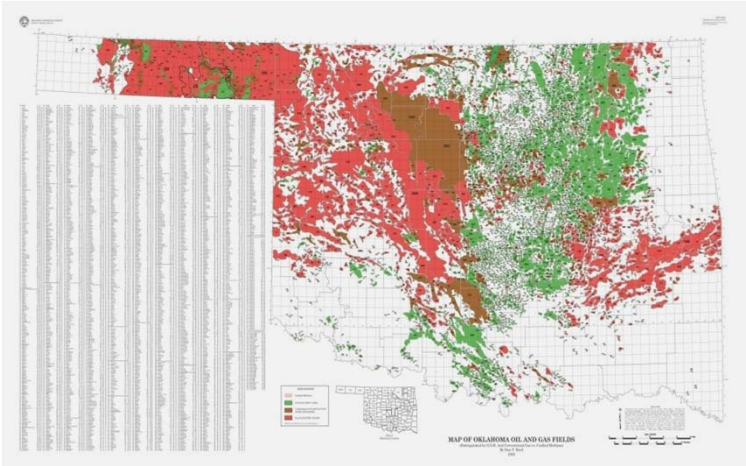
OHADP is a collaborative effort to collect in one place, digitize, and make available to the public all of the historical aerial photographs of Oklahoma. We aim to preserve these valuable pieces of history and facilitate their present and future use.

[1] Illinois State Geological Survey. Illinois Historical Aerial Photography Collection History. 25 3 2013 < http://crystal.isgs.uiuc.edu/mdihome/webdocs/ihap/history.html

Limited Project Range

- Obviously, we can only outline brine patches in areas for which we have historical aerial coverage.
- Our aerial coverage matches up fairly well to old oilfields (not so much gas, unfortunately)—by design. We rectify oilfield counties first.

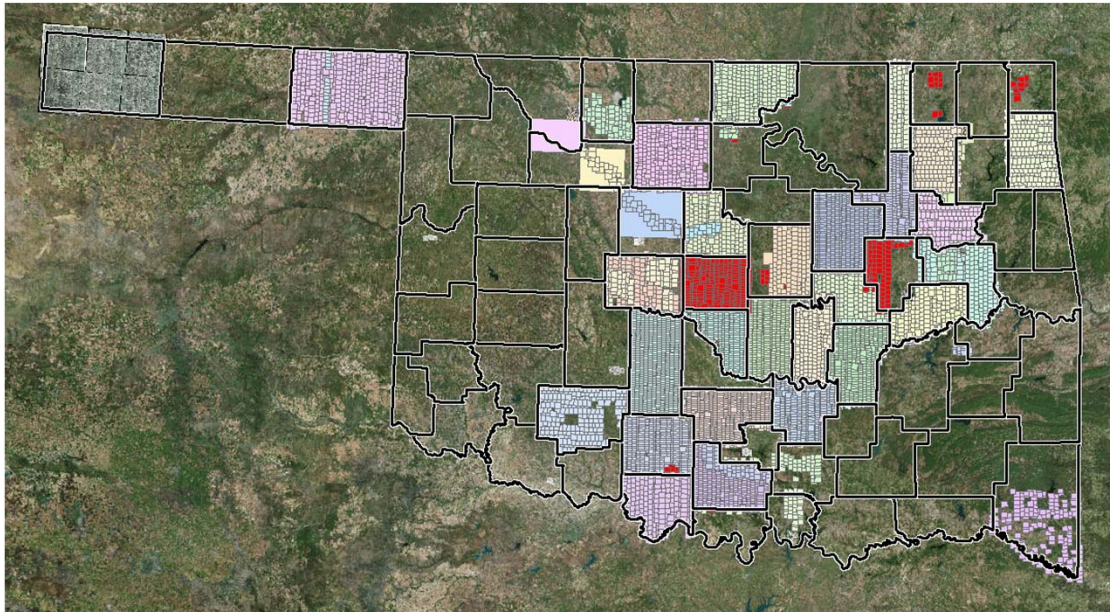




Oil Gas
Combination

Making the Georeferenced Extent Maps

- Started off pulling all georectified county-year .jpgs directly into ArcMap and creating a "historical aerial photographs extent" shapefile by outlining them **by hand…** like the first HDO maps.
- Recognizing a pattern, did some research…
- ***Learned about raster catalogs and wireframes!***

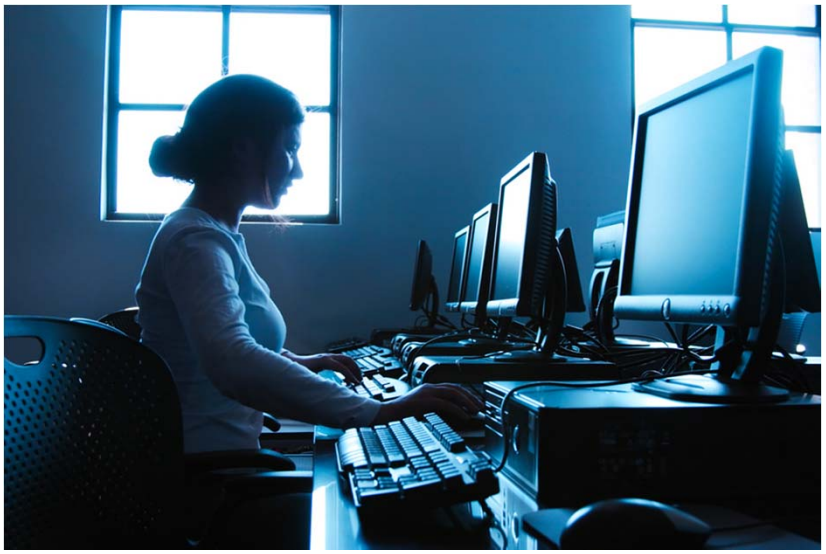


Pastels show what we have georectified.

Reds are county-years whose georectification is in progress.

Extending the Project's Range with OKMAPS

- OCC has given all of our 100,000 historical aerial photographs to the Conservation Commission
  - FTP site
  - Data viewer, OKMAPS
  - ***FREE PUBLIC DOWNLOAD.***
- Hope: Crowdsource georectification of the aerial photographs
  - We request that anyone who georectifies photographs from this source return them to Madeline Dillner at the Corporation Commission, so they can be added to our collection and OKMAPS'



University GIS classes could be powerful crowdsourcing partners.

In Conclusion…

1. Oilfield brine is a common and persistent problem in Oklahoma due to extensive historic oil and gas exploration and production activity.
2. Brine patches can be identified in historical aerial photographs as asymmetrical white smears—brine pits will be rectangular.
3. It is possible to make shapefile of where contamination is more likely to occur. This method is fast and gives people a general idea of where they need to be careful when drilling water wells—or at least gives them the idea that they **should** be careful. It also gives governmental bodies a better idea of what areas in their jurisdiction may be most in need of environmental cleanup.
4. Crowdsourcing the georectification of the state's historical aerial photographs will allow the method of outlining brine patches on aerial photographs used in ACOG's West Edmond Oilfield Study to be applied across the state.
5. Knowing where brine contamination is across the state and requiring deeper cement casing on water wells in those areas will help protect Oklahoma's valuable groundwater resources from being contaminated with oilfield brine via the gravel-pack of water wells.

Questions?

Contact:

John Harrington	Madeline Dillner
jharrington@acogok.org	m.dillner@occemail.com
(405) 234-2264	(405) 522-2750

Pictured: Area around Altus Dam, 1984