

# Quantifying the Impact to Oklahoma's Waters from Oil and Gas Production

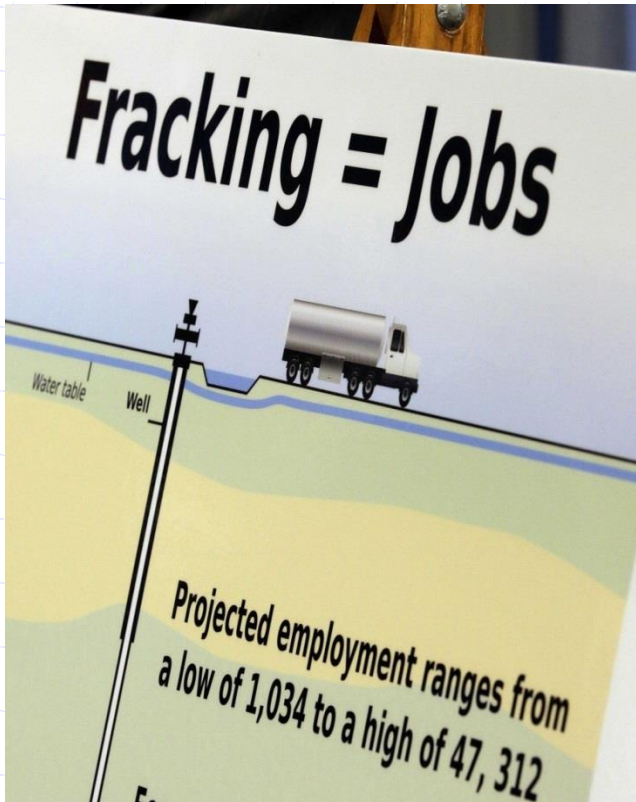
Glenn Brown and Nelly J. Ruiz  
Biosystems and Agricultural Engineering



Oklahoma Clean Lakes and Watersheds Association  
Annual Conference, March 29 & 30, 2016, Stillwater

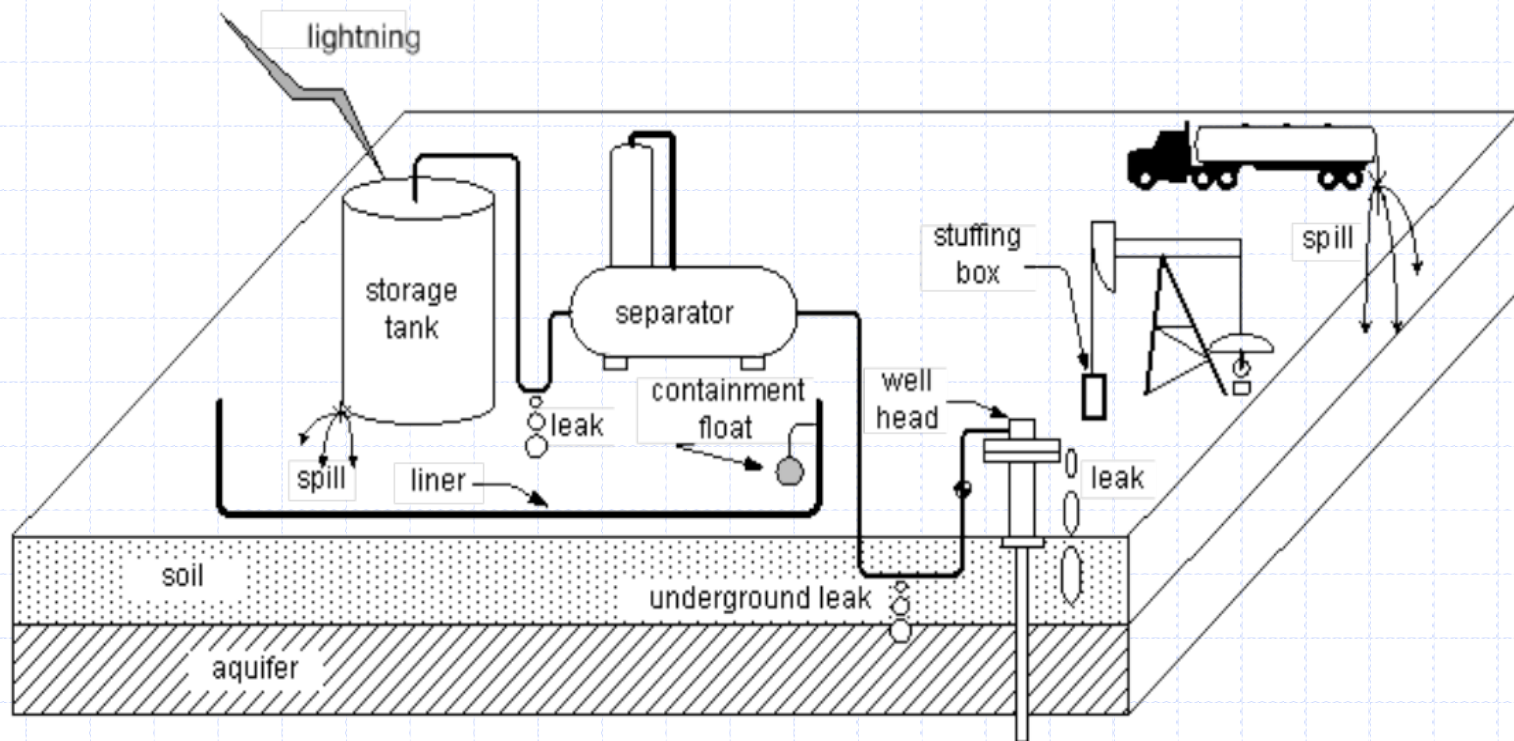
# Public concern with oil & gas

- Very divergent statements in the media.
- Little independent analysis.



# Objective

Use existing data resources to provide quantitative measures of current and potential impacts due to oil and gas extraction in Oklahoma.



# Tasks

- Quantify private water wells allegedly polluted during the period from May 2012 to May 2013, and correlate their location with nearby oil and gas production wells.
- Quantify saltwater spills that had occurred from May 2012 to May 2013, and determine the vulnerability of the underlining ground water aquifers.
- Quantify the proximity of saltwater spills from May 2012 to May 2013 to public water supply intakes.

# Agencies with data resources

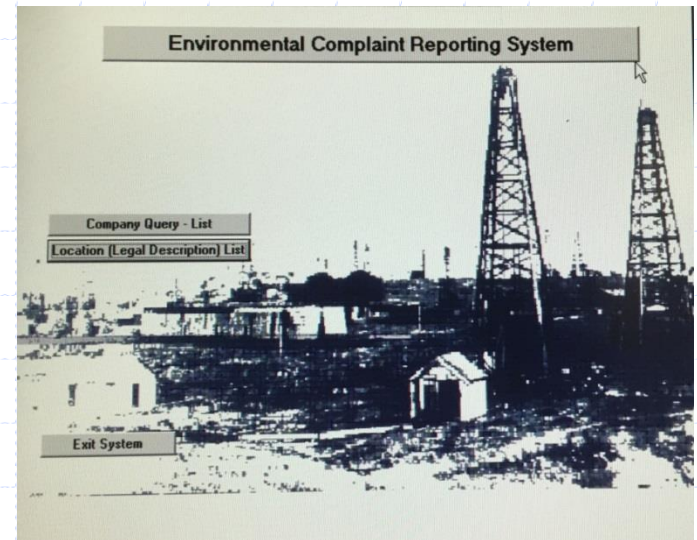
- Oklahoma Corporation Commission (OCC)
- Oklahoma Water Resources Board (OWRB)
- Oklahoma Department of Environmental Quality (DEQ)
- U.S. Geological Survey (USGS)





# OCC Databases

- Environmental Compliance Reporting System ([ECRS](#))
  - 94,546 records from July 1993 to May 2013
  - Raw digital database obtained in August 2013
- Risk Based Data Management System (RBDM)
  - Launched in early 2013
- Drilling completion reports (1002A Forms).
- Base of Treatable Water mapping.



# ECRS

- Unorganized.
- Missing information.
- Difficult to interpret many entries.
- Clear errors in recorded longitude.
- Work required to make information useful
  - Manually categorize 2,078 incidents from May 2012 to May 2013.
  - Defined violation type and location.
  - Corrected longitude error by legal description.

The screenshot displays the Oracle Forms Runtime interface for the C20INC\_DISPLAY form. The title bar indicates the application is running in Oracle Forms Runtime - [C20INC\_DISPLAY]. The menu bar includes Action, Edit, Query, Block, Record, Field, Window, and Help. The toolbar contains various icons for navigation and editing. The main window is titled "INCIDENT / COMPLAINT DISPLAY" and contains the following fields:

- FULL INCIDENT NUMBER:** 185130G0010525
- DISTRICT:** 001, Oil and Gas District 1
- POLLUTION:** P, POLLUTION
- INCIDENT TYPE:** C, COMPLAINT
- IND/COMPANY:** I, INDIVIDUAL
- CONFIRMATION STATUS:** F, CONFIRMED - VIOLATION
- REFERRED FROM / RECEIVING AGENCY:** 185, Corporation Commission
- TAKEN BY & DATE:** 608, 08/27/2012
- RECEIVED DATE & TIME:** 08/27/2012, 11:08:00
- RESOLVED:** 12/14/2012
- REPORTED INCIDENT:**
  - ALLEGATION:** BAD WATER WELL
  - COUNTY:** 37, CREEK
  - GENERAL LOCATION:**
  - WATERBODY AFFECTED:**
  - FISH / WILDLIFE KILL:**
- JURISDICTION:** 185, Corporation Commission
- REFERRED TO:** LAST, FIRST, MI, POLLUTION ABATEME
- RESPONSE DATES:**
  - FIRST INVESTIGATION:**
  - REFERRED:** 08/27/2012
  - MEDIATION:**
- CORRESPONDENCE DATES:**
  - 2 DAY:** 08/27/2012
  - 7 DAY:** 08/27/2012
  - REFERRED:**
  - RESOLVE:** 12/14/2012

# 1002A form

PLEASE TYPE OR USE BLACK INK ONLY

(To be filed within 30 days after drilling is completed)

Form 1002A  
Rev 1979

**OKLAHOMA CORPORATION COMMISSION**  
OIL AND GAS CONSERVATION DIVISION  
Jim Thorpe Building / Oklahoma City Oklahoma 73105

API NO 35-017-22421  
640 Acres

COUNTY Canadian SEC 12 TWP 14N RGE 5W

COMPANY OPERATING Tenneco Oil Company  
OFFICE ADDRESS 3000 United Founders Bldg.  
TOWN Oklahoma City STATE OK ZIP 73112

FARM NAME Mulvey WELL NO 1-12

DRILLING STARTED 9-20-82 DRILLING FINISHED 1-4-83  
DATE OF FIRST PRODUCTION 1-10-83 COMPLETED 1-10-83

WELL LOCATED C E/2 NW SW

1980 FT FROM SL OF 1/4 SEC & 990 FT FROM WL OF 1/4 SEC  
ELEVATION DERRICK FLOOR 1168 GROUND 1158

LOCATE WELL CORRECTLY  
AND OUTLINE LEASE

**TYPE COMPLETION**  
Single Zone X Order No \_\_\_\_\_  
Multiple Zone \_\_\_\_\_ Order No \_\_\_\_\_  
Commungled \_\_\_\_\_ Order No \_\_\_\_\_

**LOCATION EXCEPTION** Order No \_\_\_\_\_ Penalty \_\_\_\_\_

**OIL OR GAS ZONES**

Name	From	To	Name	From	To
Skinner	6829	6852			

**CASING & CEMENT**

Casing Set				Csg Test		Cement		
Size	Wgt	Grade	Feet	Psi	Sax	Fillup	Top	
8-5/8"	24#	K-55	736	3000	390	---	Surface	
5-1/2"	15.5#	K-55	7303	3000	350	688	6615	

**PACKERS SET**  
Depth 6,843'  
Make Baker "EA"

**COMPLETION & TEST DATA BY PRODUCING FORMATION**

	1	2	3
FORMATION	Skinner		
SPACING & SPACING ORDER NO	160-190134	00586	
CLASSIFICATION (Oil Gas Dry Inj Well)	Oil		
PERFORATED	6830-6838		
INTERVALS			
ACIDIZED?	Yes		
FRACTURE TREATED?	Yes		

**INITIAL TEST DATA**

Date	Oil-bbl/day	Oil Gravity	Gas-Cu Ft/day	Gas Oil Ratio Cu Ft/Bbl	Water-Bbl/day	Pumping or flowing	CHOKE SIZE	FLOW TUBING PRESSURE
Jan. 10, 1983	10	---	---	---	---	Pumping	---	---

A record of the formations drilled through and pertinent remarks are presented on the reverse

(OVER)

I, Flint A. Lalli, being first duly sworn upon oath, state that this well record is true, correct and complete according to the records of this office and the best of my knowledge and belief.

Signature Flint A. Lalli Production Analyst  
Name and title of representative of company

Subscribed and sworn before me this 11th day of January, 1983

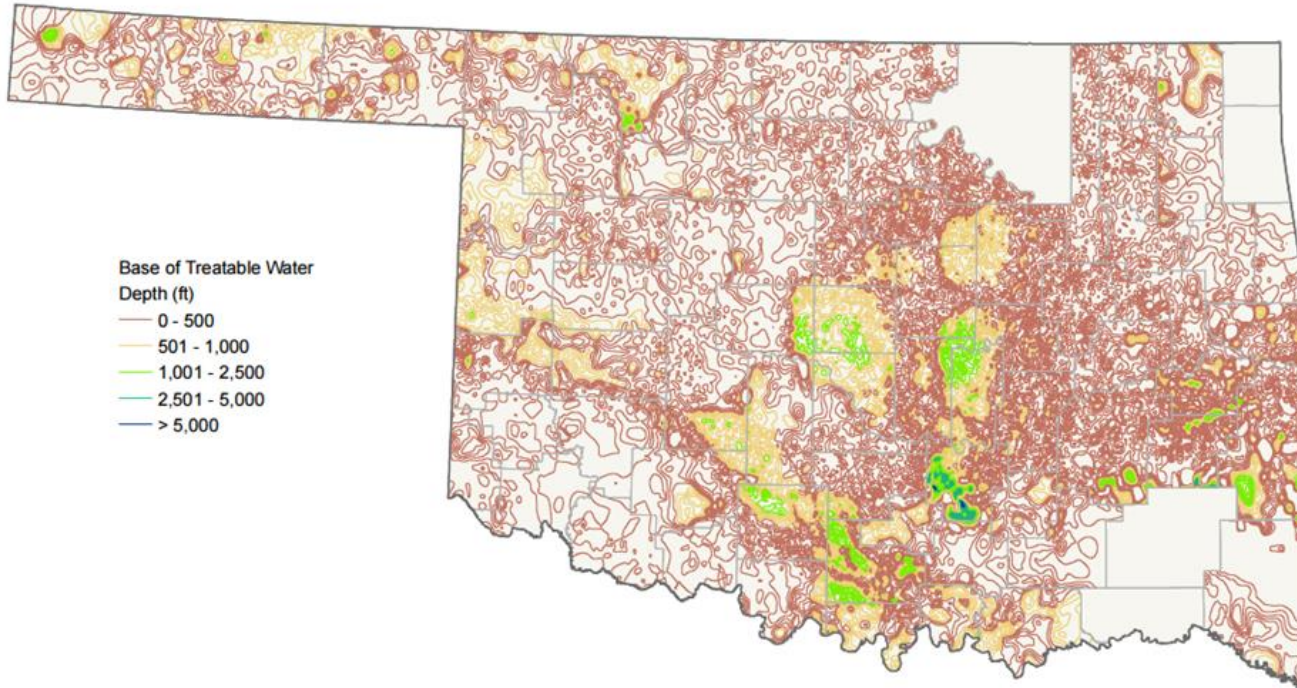
My commission expires 5-7-85 Karen D. Kemler  
Notary Public

TOTAL DEPTH 7,885'



# Base of Treatable Water

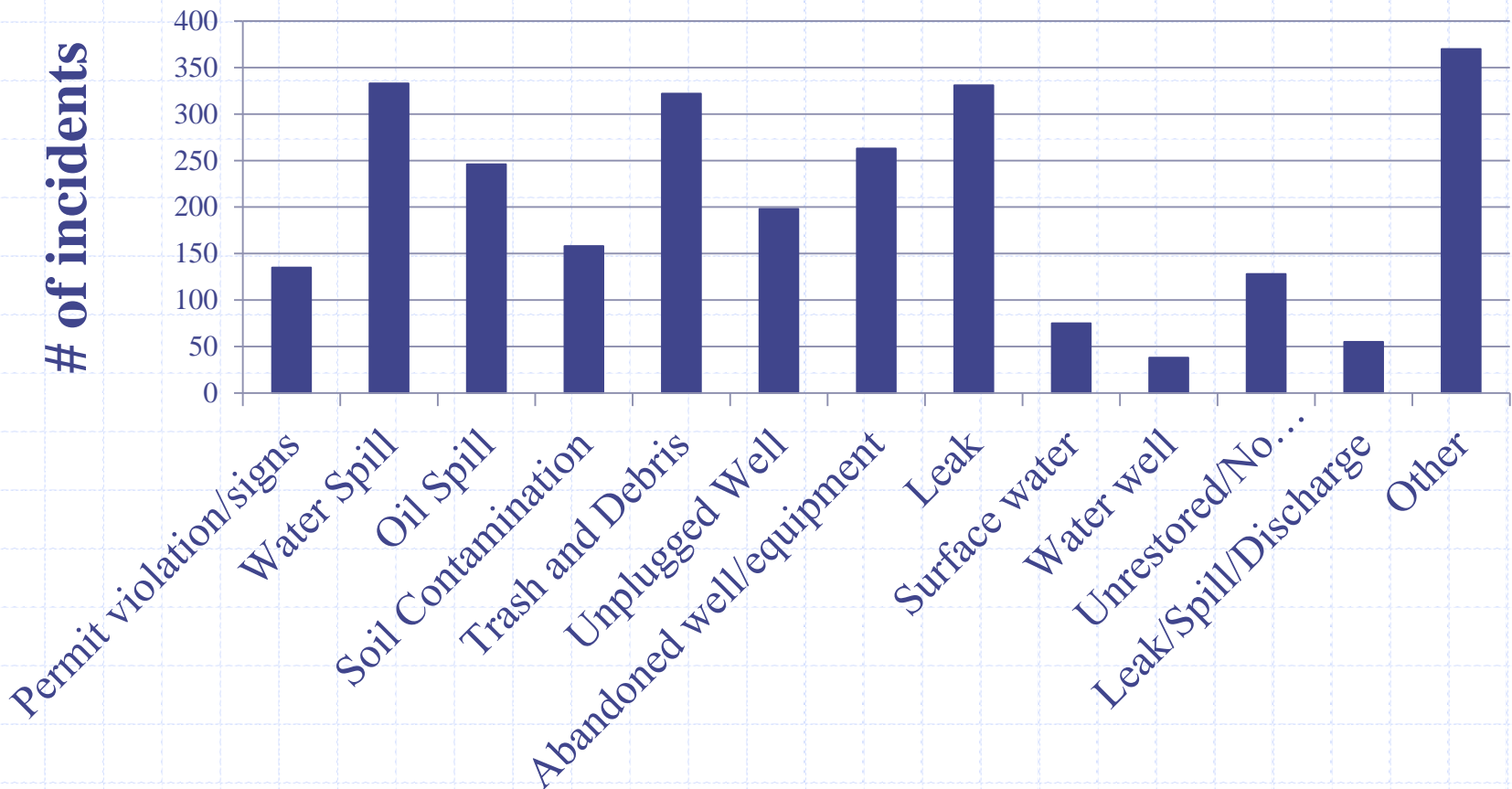
## Oklahoma Corporation Commission Base of Treatable Water



This map contains contour lines representing the base of treatable water for most areas in Oklahoma. The dataset was created by and is maintained by the Oklahoma Corporation Commission. For more information regarding this data visit the OCC web site at: ( <http://www.ocoweb.com/vogloghome.htm> )



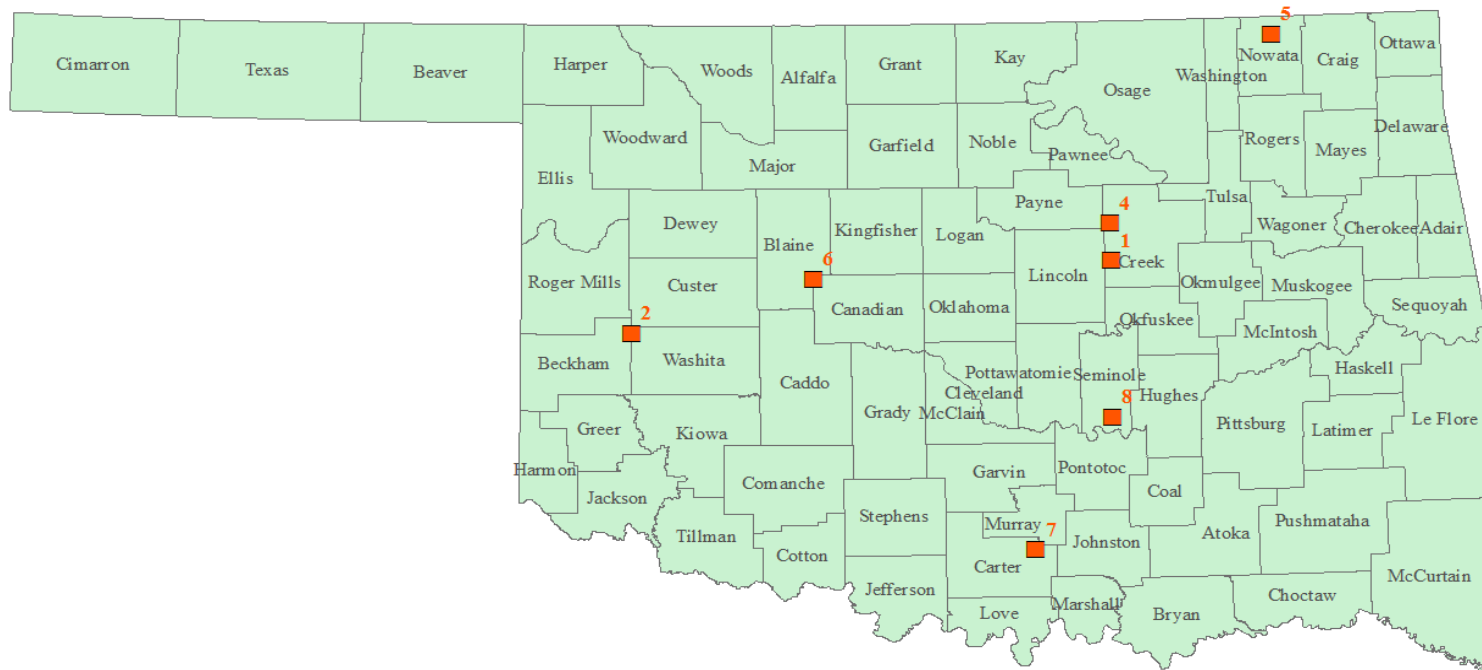
# Results: Violation category



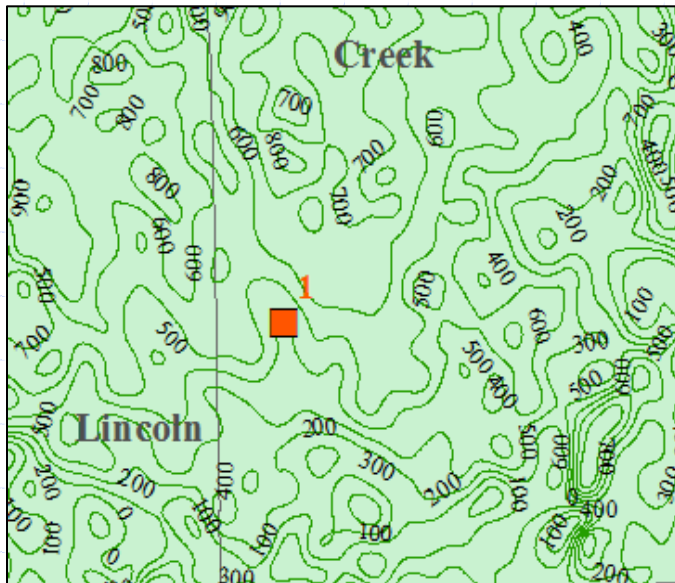
# Water well related incidents

- During May 2012 to May 2013 there were 38 complaints of polluted ground water wells
- OCC inspector assesses the complaint by talking to the individual, inspecting the water and usually collected a water sample for laboratory analysis.
- OCC determined that 30 were not polluted by oil and gas operations.
- The reasons for exclusion were:
  - Solutes consistent with agriculture pollution
  - Wells drilled deeper than BTW
  - Well distant from oil and gas production
  - No observable free hydrocarbons (rainbow, sheen)

# 8 Pollution abatement incidents



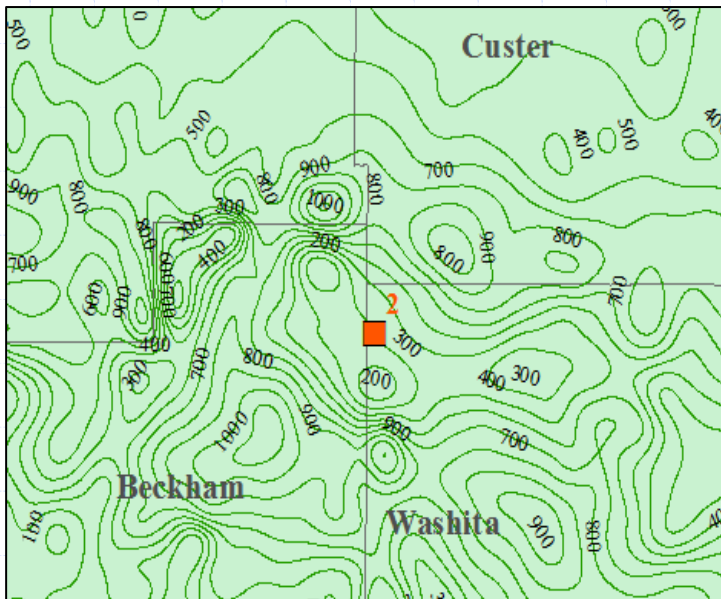
# Example (Incident #1)



- BTW at 400 feet.
- 25 adjacent production wells dating from 1941-1956, and 1 drilled in 2010.
- Pre – 1956, surface casing on all wells to depths ranging from 102 to 266 feet.
- 2010 drilled well had casing set to a depth of 610 feet.



# Example (Incident #2)



- BTW at 300 feet.
- Only one well drilled in 2010 producing horizontally from the Woodford formation .
- Surface casing was set to a depth of 1510 feet

# Water well incident results

- 38 water wells were reported contaminated from May 2012 to May 2013.
- 8 were referred to pollution abatement.
- 1 polluted water well did not include an adequate location.
- 5 were surrounded by a mix of old and new production.
- 2 incidents were only near newer production and warrant additional investigation.

# Saltwater spills

- Saltwater spills are the most common and largest volume spills with 333 during the year examined.
- Spills have the potential to infiltrate into the groundwater or to travel to drinking water intakes.



750,000 gallon wastewater spill in Polecat Creek, Grant County, March 2, 2016.

Source: kfor.com

# USGS and OWRB Databases

- The USGS publishes geospatial data sets that describe aquifer characteristics and created grid layers used to calculate the DRASTIC index.
- The OWRB used the grid layers to compute DRASTIC indices and to produce the aquifer vulnerability maps for the state.
- Shapefiles of DRASTIC indices and the different components were obtained from the OWRB.

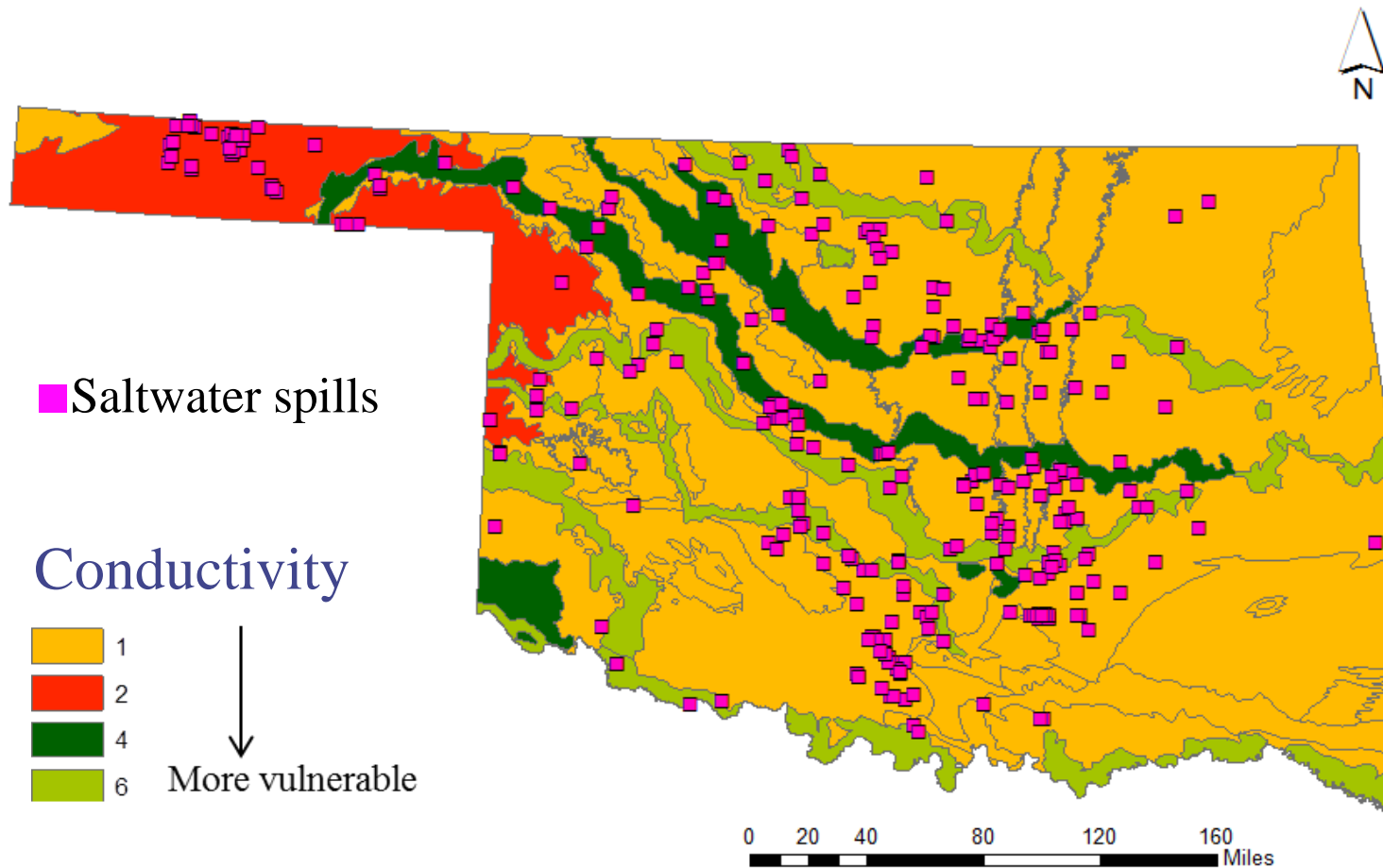


# DRASTIC model

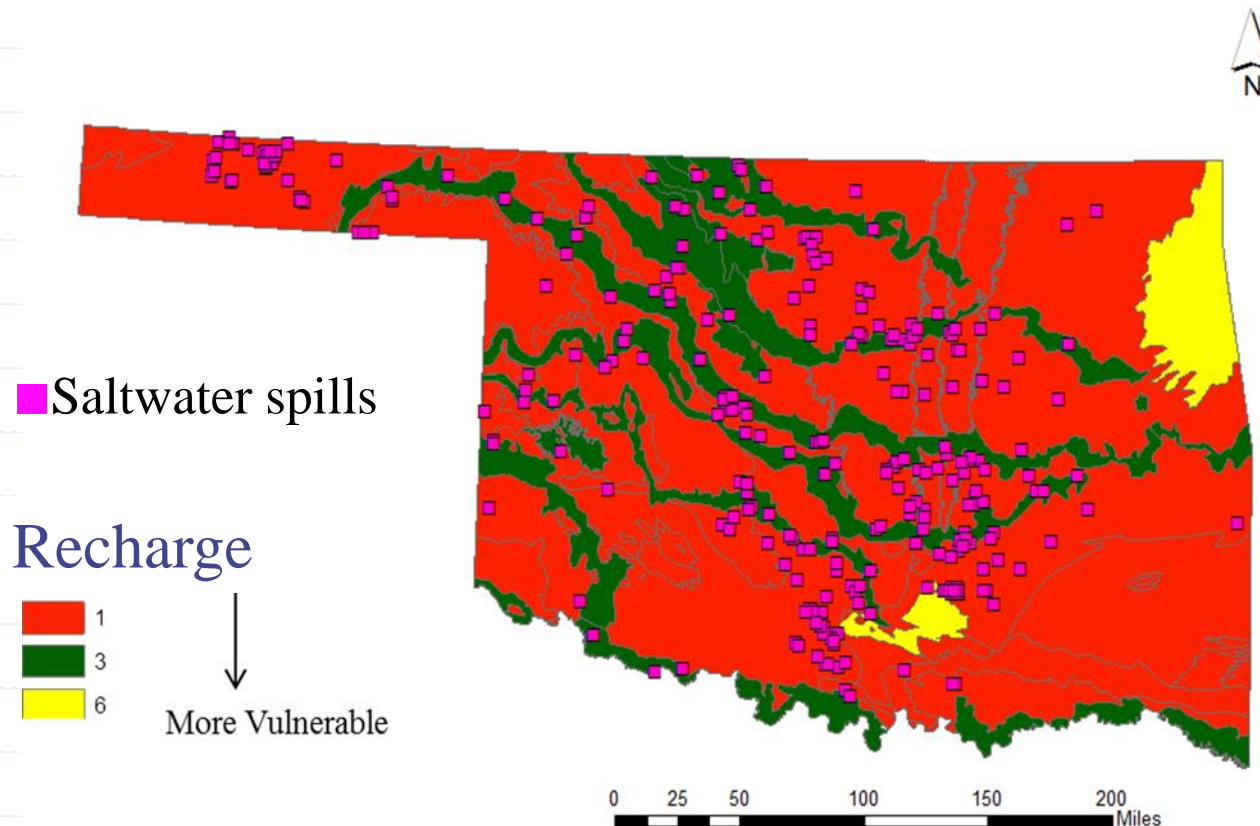
- DRASTIC is an acronym for:  
**D**epth to water, **N**et **R**echarge, **A**quifer media, **S**oil media, **T**opography, **I**mpact of the vadose zone, **H**ydraulic **C**onductivity.
- Inputs of rank and weighting for
  - Depth to water
  - Recharge
  - Aquifer media
  - Soil
  - Topography
  - Hydraulic conductivity
- Drastic rating determined for the aquifers underlying 333 salt water spills.



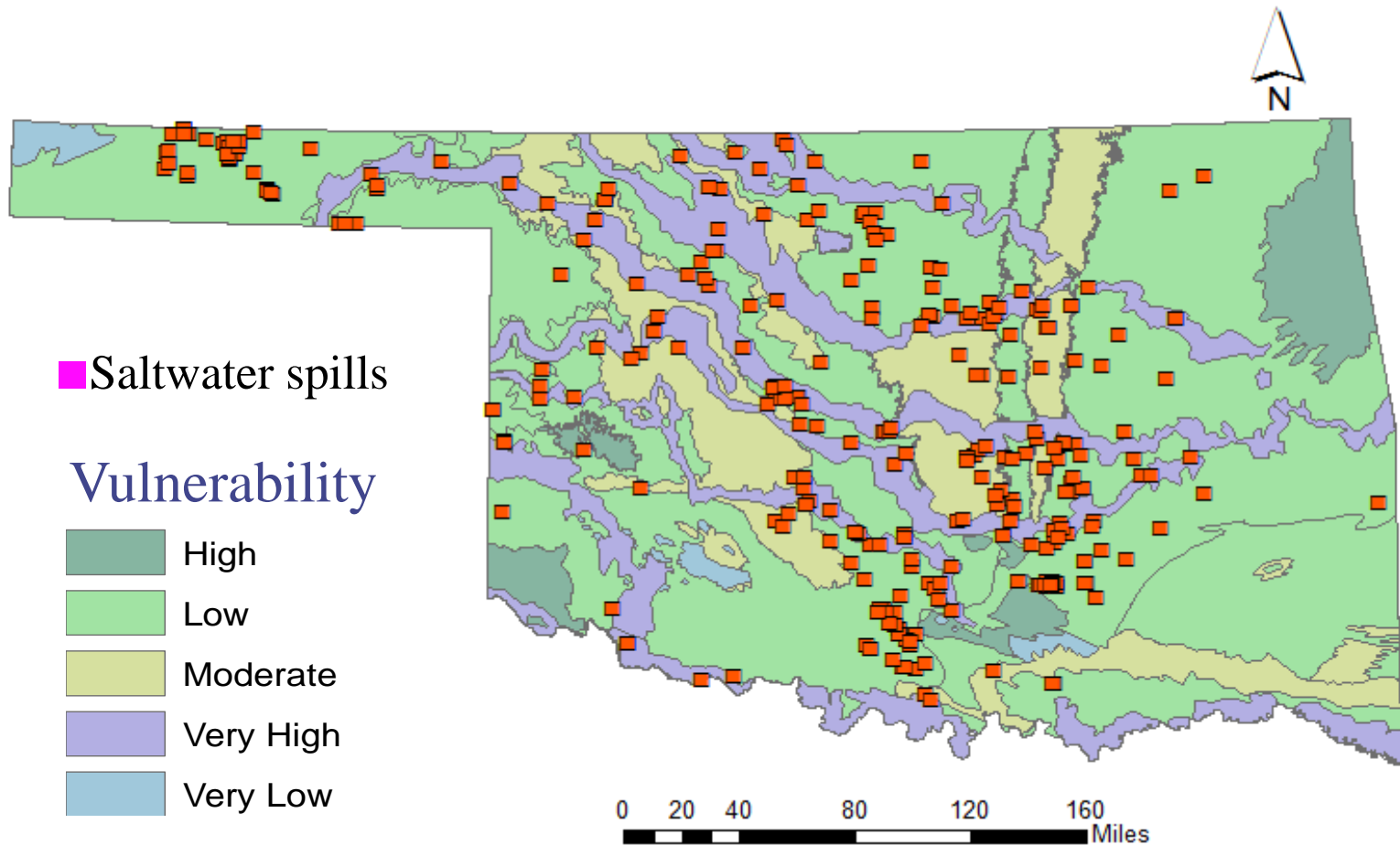
# Example layer: hydraulic Conductivity



# Example layer: net recharge

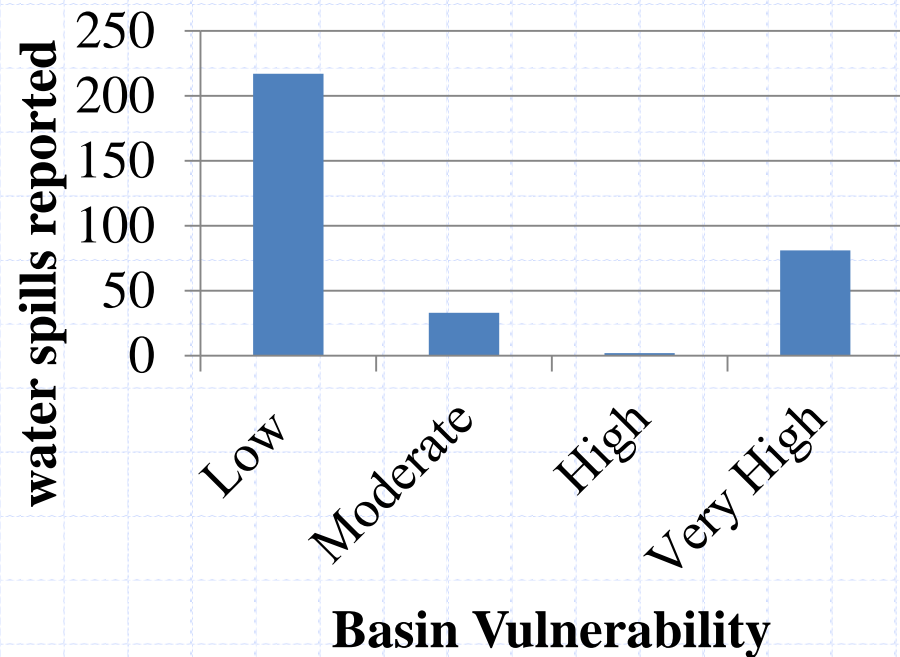
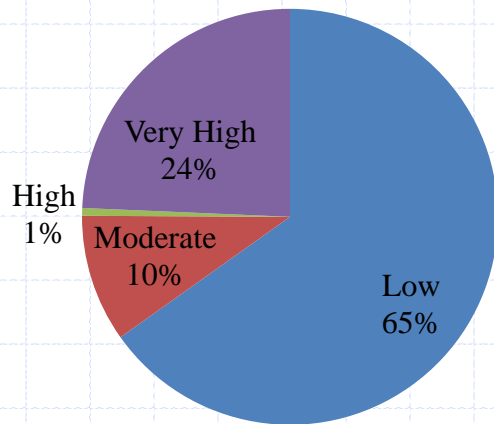


# DRASTIC Results



# Saltwater spill results

## Vulnerability



# DEQ public water supply database

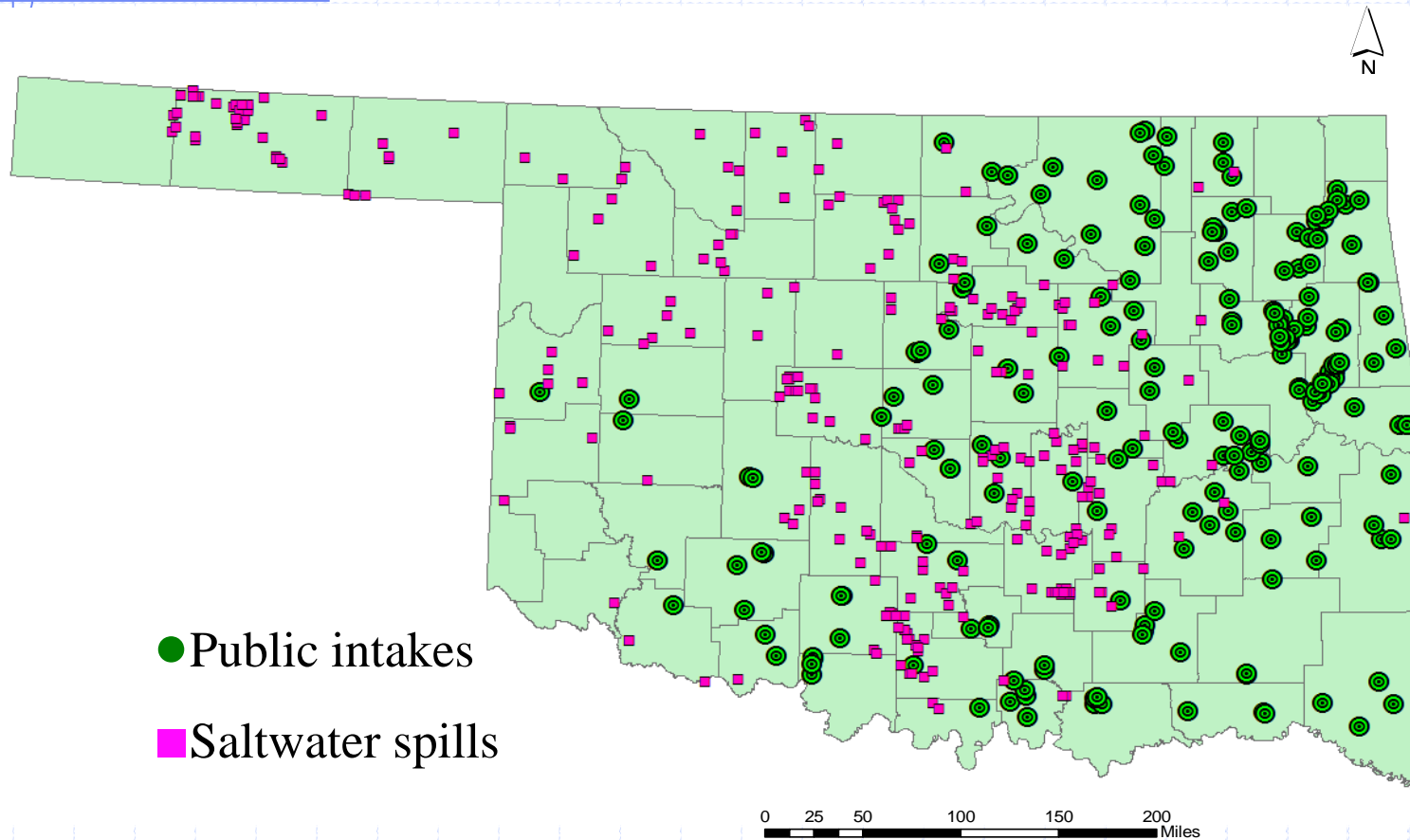
- DEQ mapped 168 surface water intakes that are actively feeding into public water supply systems.
- Locations were obtained directly from the DEQ.
- Distance from the 333 saltwater spills was then determined.



<http://oklahomawatch.wpengine.netdna-cdn.com/files/2013/03/Photo-1-Exposed-Intake-Valves.jpg>

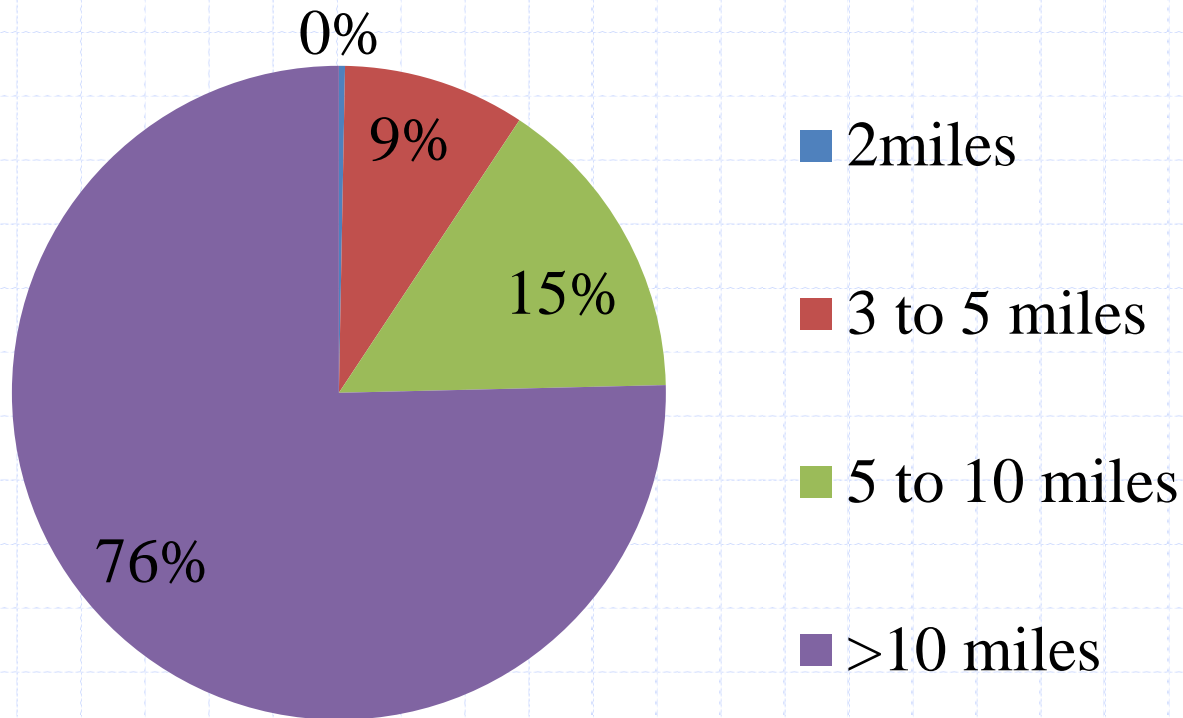


# Saltwater spills vs PWS



# Saltwater – PWS results

**Distance of Saltwater spills to PWS**



# Overall Results

- Over the one year period of May 2012 to May 2013, 2,078 incidents were reported by the OCC.
- Two water wells may have been impacted by new drilling activities, while six other wells were probably impacted by old production or abandoned wells.
- 24% of the 333 reported salt water spills occurred over high vulnerability aquifers.
- The shortest distance of a water spill to a PWS surface intake was two miles. 76% of saltwater spills were more than 10 miles from a PWS.