GROUNDWATER MONITORING AND ASSESSMENT PROGRAM

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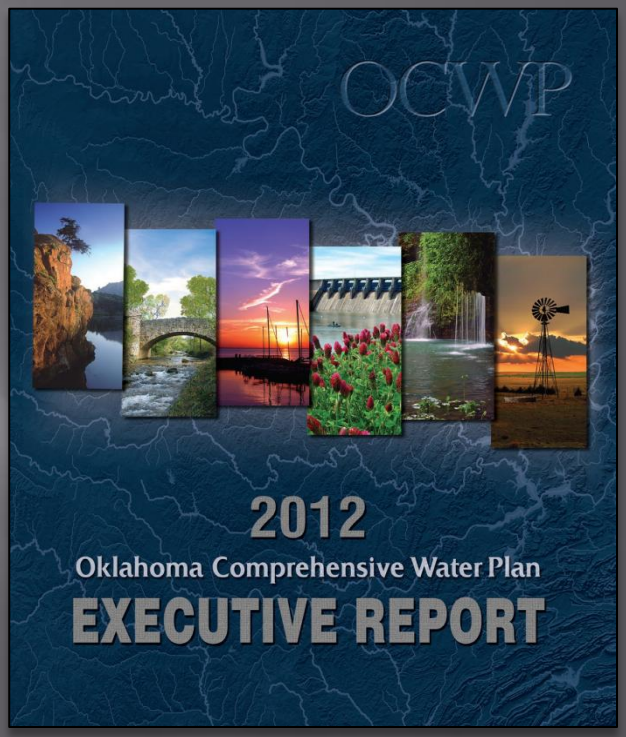
State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

New Statewide Monitoring Initiative

- Made Possible Through Legislative Funding Following Adoption of Oklahoma Comprehensive Water Plan (OCWP) High Priority Recommendations (2012).
- The OCWP cited the lack of baseline groundwater quality data as a weakness in Oklahoma's ability to evaluate future groundwater supplies for beneficial use.



OCWP Recommendations

PRIMARY RECOMMENDATIONS

- Water project & infrastructure funding (81 B)
- Regional planning groups
- Surplus/Excess water
- Instream flows (Bio-Rec)
- State/Tribal water consultation & resolution
- Water conservation
- Water supply reliability
- **Monitoring**

MONITORING RECOMMENDATIONS

- Integration of SW/GW quality monitoring programs.
- Stable funding to support.
  - Gaging
  - BUMP
  - Non-Point Source
  - Point Source (agriculture, mining & oil and gas)
- Creation of an ambient groundwater quality program.
- Fully implement state-wide program for the collection of biological data.

Funding for Monitoring

OCWP funding request was for an additional $2.3 million to enhance the State's Beneficial Use Monitoring Program and to initiate a Groundwater Monitoring & Assessment Program (GMAP).

The Oklahoma Legislature ultimately approved $1.5 million in additional monitoring monies.

Monitoring White Paper

- Reviewed and Incorporated State and National Strategies in Proposal.
- Solicited Comments and Critique from Stakeholder Groups Including:
  - State and Federal Water and Environmental Agencies.
  - Institutions of Higher Education.
  - Representatives of Agriculture, Citizen Groups, Industry, Municipal, and Native American Tribes.
- Held Public and Private Meetings with Interested Stake Holders.

Monitoring Objectives

- Obtain data on current conditions of groundwater levels and quality (baseline).
- Describe the spatial distribution, occurrence and, magnitude…….. over different "seasons."
- Collect long-term data to observe changing conditions over time (trends).

Spatial Design Considerations

- Number of Wells
- Density of Wells
- Aquifer Type, Lithology, Thickness
- Depth to Water, Stratification of Aquifer
- Surface Water Features
- Land and Water Use
- Groundwater Recharge/Discharge Areas
- Holistic versus Targeted monitoring

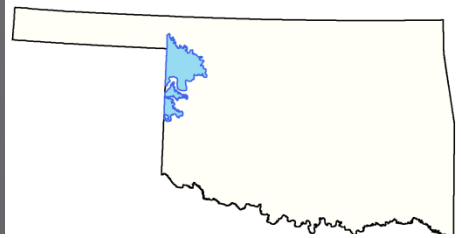
Well Selection & Distribution

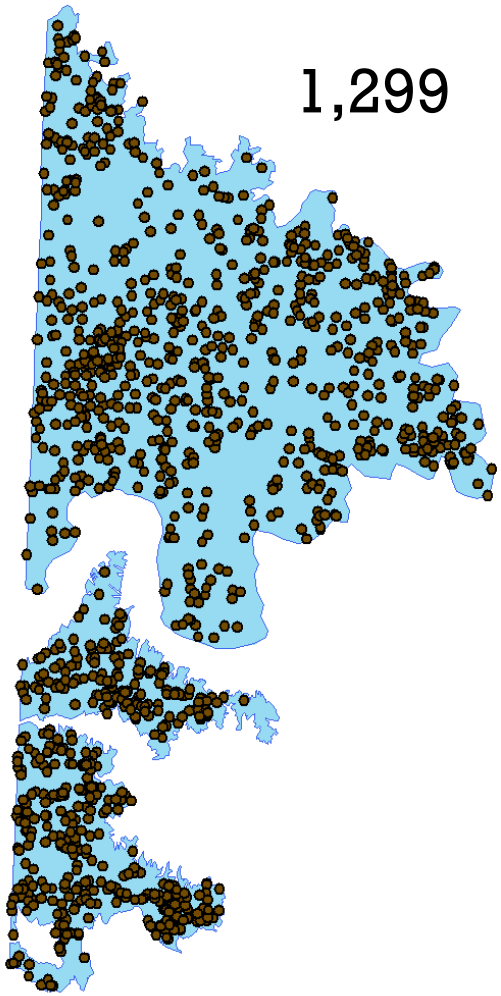
- Stratified by aquifer, randomly selected.
  - Aquifers categorized by areal extent as a determinant on number of wells per given area.

- Well selection probabilities were weighted and assigned based on well density of the surrounding area, enabling a random but spatially balanced population of wells (Olsen's, 2003 Generalized Random Tessellation Stratified survey design).

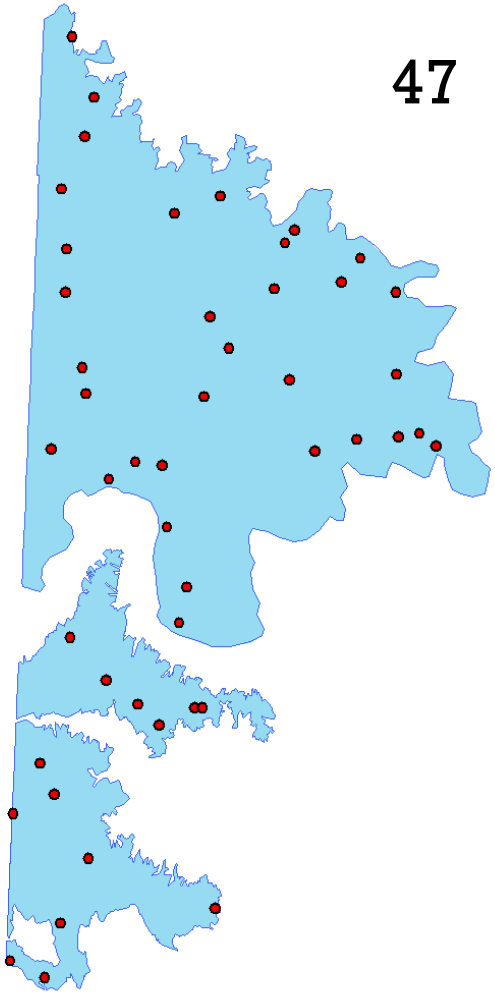
- With this design, statistically valid assumptions may be made about the entire population by measuring the characteristics of a representative subset.

Ogallala Northwest

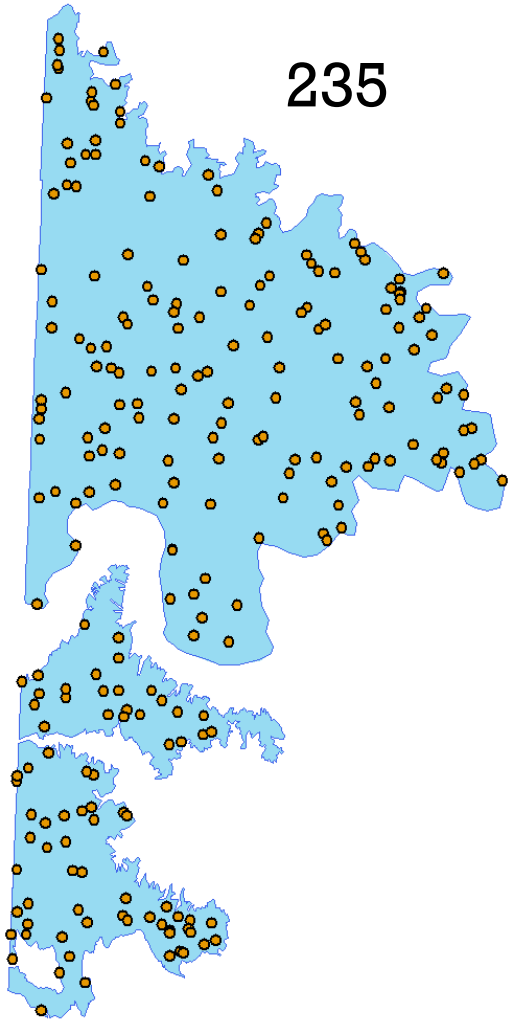




All eligible wells



Sampling sites



Alternate sites


Antelope Hills, Ogallala Aquifer
Roger Mills County, Oklahoma

OKGMAP Network Notes

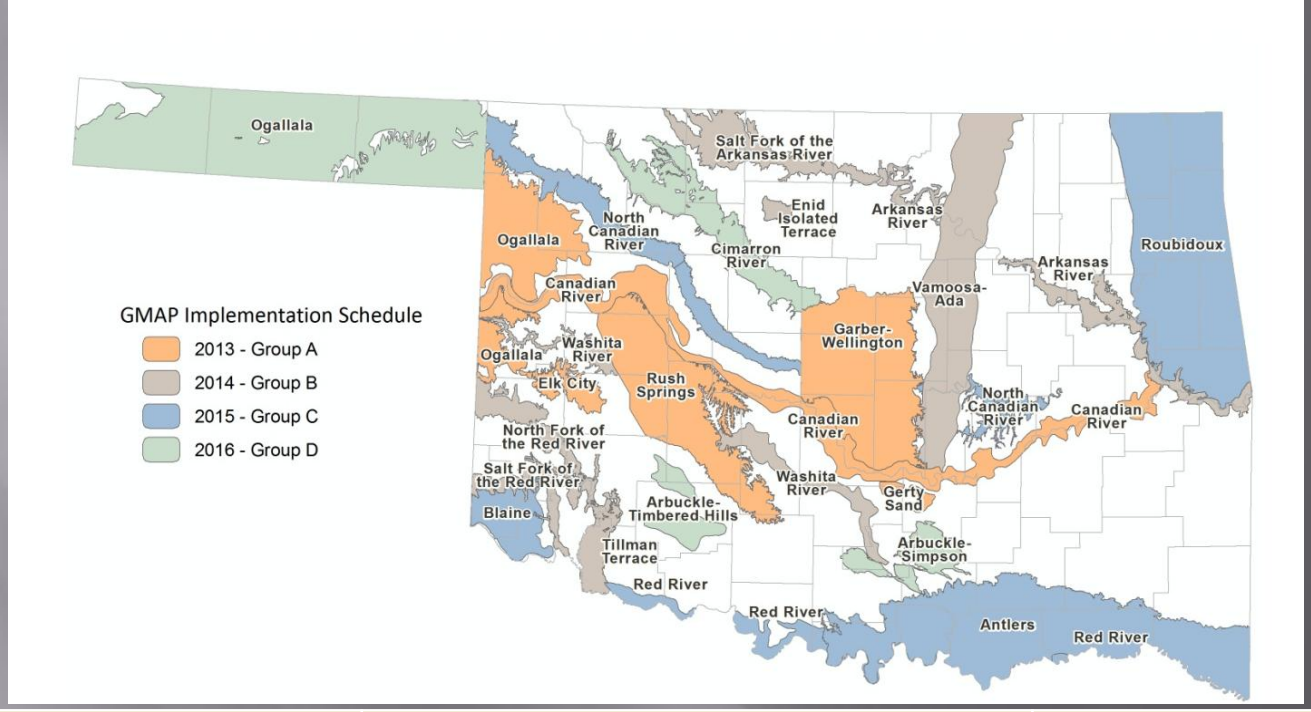
Goal: Minimum of 30 wells per aquifer for water quality monitoring; 25% more for water level measurements

Characterization of the quality and quantity of the groundwater for each aquifer is the objective as opposed to targeting a specific land use or "research" objective.

Blend/incorporate monitoring data available from other state/federal agencies.

Well selection: stratified by aquifer; random and spatially balanced (Olsen, A. R., 2003).

For aquifers where few wells have been drilled, or spatial distribution is uneven, well drilling is a program option.



Group A Aquifers 2013	Water Quality and Water Level	Water Level Only
Canadian	37	11
Elk City	16	4
Garber-Wellington	50	25
Gerty	6	2
Ogallala (NW)	47	13
Rush Springs	72	18
Totals	228	73

Program Monitoring Data Uses

- Technical groundwater studies
- Prioritize water quality protection programs
- Water Supply (all beneficial uses represented)
  - Domestic (private landowner) wells - are unregulated and consequently rarely tested.
  - Public water supply systems (PWS) – Safe Drinking Water Regulatory requirements apply but water quality data derived from wells supplying these systems will be blended to augment and provide a comprehensive assessment.
  - Data from wells used for agriculture, industry, mining and recreation fish and wildlife will also utilized in conjunction with the water supply data.
- Monitoring well placements at waste water lagoons

Program Data Uses Continued

- Establish reference background water quality data and regional-seasonal groundwater level data
- Drought/Water Use (seasonal? long-term?)
- Beneficial Use (water supply planning)
- Municipal Growth (what lies beyond their current boundaries?)
- Marketing The Resource to Industry (how much? of what quality?)
- Education and Public Outreach

Groundwater Level Changes

Aquifer	Wells	2011-2012 (1 year)	2012-2013 (1 year)	2008-2013 (5 year)	2003-2013 (10 year)	Period of Record (19--2013)
Arkansas River	6	0.46	-1.84	-0.45	-4.59	-0.74
North Can.	29	-1.05	-2.11	-4.91	-3.95	0.82
Cimarron River	38	-2.81	-1.92	-6.76	-6.31	-3.61
Canadian River	10	-3.12	1.20	-5.50	-6.25	-3.46
N Fork Red R.	34	-2.15	-1.80	-5.40	-5.92	-1.13
Red River	4	-2.12	-1.18	-3.26	-3.21	-2.53
Salt Fork Ark.	18	-1.25	-1.33	-5.65	-2.14	-6.22
Washita River	6	0.28	-3.19	-4.30	-7.35	-6.15
Enid Terrace	9	-1.67	-1.71	-3.86	-4.37	2.27
Ada-Vamoosa	3	-3.02	-1.96	-11.21	-7.99	-1.21
Antlers	14	-0.11	-1.61	-3.09	-4.95	-3.56
Arbuckle	11	3.15	-8.71	-8.08	-10.56	-14.94
Blaine	15	-10.74	-6.36	-16.54	-18.61	-14.65
Elk City	6	-0.97	-1.33			
GWellington	22	-0.8	-3.45	-6.82	-7.88	-7.82
Rush Springs	70	-1.82	-1.59	-4.00	-3.82	1.81
OG-NW	47	-1.57	-0.45	-3.74	-2.90	1.86
OG-Panhandle	124	-3.25	-2.11	-8.38	-12.39	-20.21

GW Quantity Program Enhancements

- Number of Wells (doubling in capacity from historical network)
- Distribution of Wells (spatially representative)
- Frequency of Manual (taped) Measurements
- Deployment of Continuous Level Recorders
- Mapping
- Reporting

GW Quality Program Improvements

- Groundwater quality data baseline monitoring within Oklahoma's major aquifers
- Groundwater quality trend monitoring within each of Oklahoma's major aquifers
- Groundwater quality assessments that focus on the resource as opposed to a regulatory purpose

Network When Fully Implemented

Long-term monitoring of Oklahoma's Major Aquifers

Water Quantity

- 1,068 wells in the main Baseline Network
- 530 of those wells in the long-term Trend Network

Water Quality

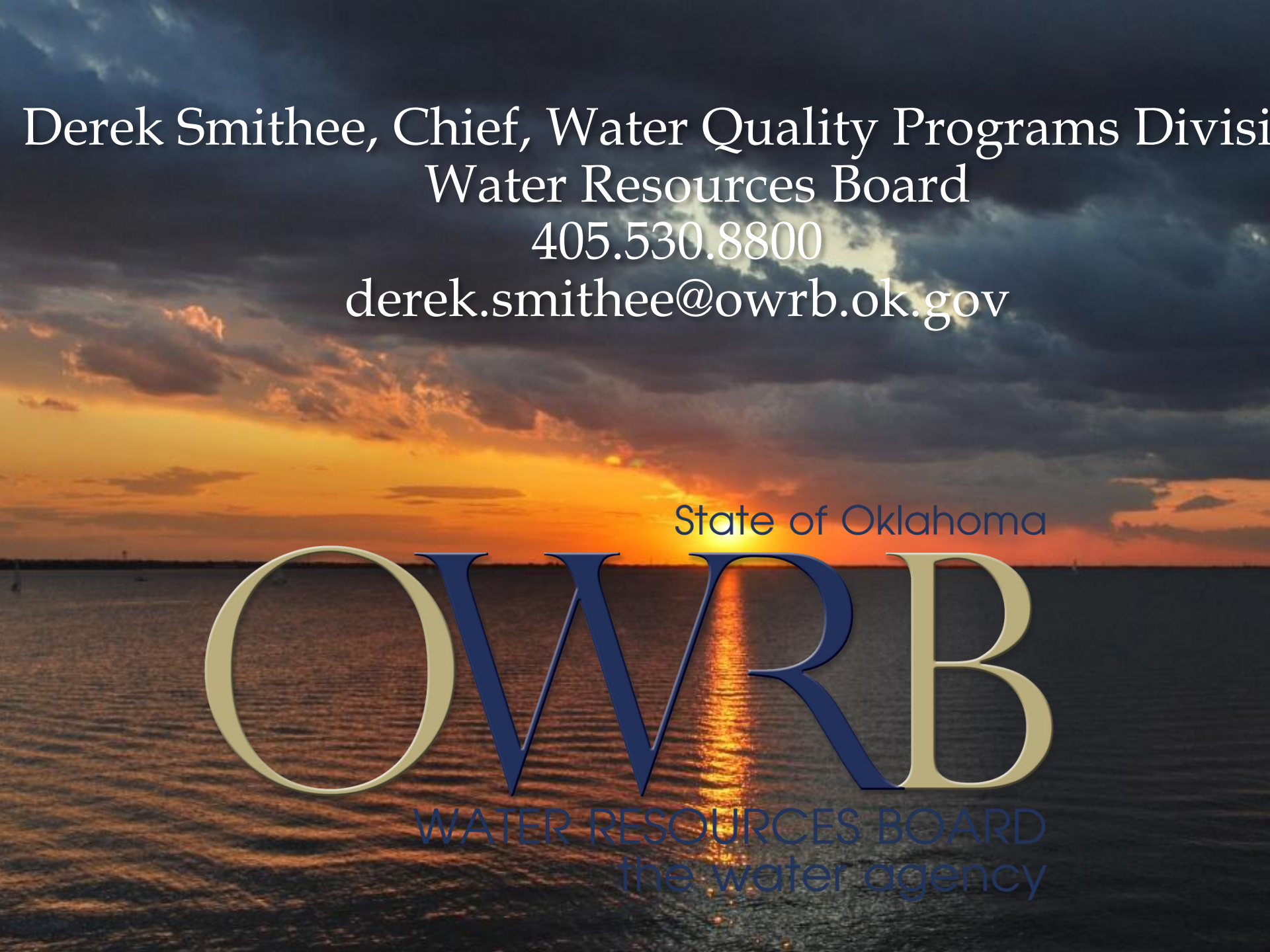
- 700 wells in the main Baseline Network
- 140 of those wells in the long-term Trend Network

Year 1 GMAP Results for Group A Aquifers (March-October 2013)

- Rush Springs Aquifer Pilot Demonstration (March)
- 228 wells from Group A aquifers sampled (August-October 2013)
- 1,000^{+} groundwater levels obtained from 800^{+} wells
- 1,600^{+} citizen/entity contacts to secure access private property to sample/collect measurements
- New data base development in progress; public domain access anticipated in FY15

Decisions don't *require* data

But *GOOD* decisions do!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GMAP Laboratory and Field Parameters

Laboratory Analytical	Laboratory Analytical	Field Data
Nutrients-Filtered mg/L	*Metals-Filtered ug/L*	*Purge Parameters*
Total P	Aluminum	Dissolved Oxygen mg/L
N-Ammonia	Barium	Temperature °C
Nitrate+Nitrite	Beryllium	Specific Conductance uS/cm
Minerals-Filtered mg/L	Cadmium	pH
Chloride	Cobalt	*Field Chemistry mg/L*
Bromide	Chromium	Total Alkalnity, CACO3
Flouroide	Copper	Total Hardness, CACO3
Sodium	Mercuy	*Hydrologic Data*
Sulfate	Molybdenum	Depth to Water (feet)
Silica	Nickel	Flow Rate (gpm)
TDS (Unfiltered)	Lead	*Location Data*
Specific Conductance uS/cm	Thalium	X, Y Coordinates, Dec. Degrees
Hardness	Uranium	Altitude (ft., mean sea level)
Macronutrients-Filtered mg/L	Vanadium	
Calcium	Zinc	
Magnesium	*Metalloids-Filtered ug/L*	
Potassium	Anitmony	
Micronutrients-Filtered mg/L	Arsenic	
Boron	*Non-Metals-Filtered ug/L*	
Iron	Selenium	
Manganese	**Total Analytical Costs = $987.95**	

Network Wells (Selection Criteria)

- Construction record that describes lithology, screen interval, & total depth.
- Completed in at least 75% of the aquifer.
- Avoidance of the use of stock-agriculture wells or point source monitoring wells.
- Only wells from the "shallow" part of the aquifer were included as potential candidates for the baseline networks, i.e. G-W, (where there are significant hydro-geologic differences with depth).

Network Types

- Baseline Network Implementation
  - Groups of 4-7 aquifers per year (July-September) beginning in 2013 (completed by 2016)
  - Continuous water level recorders will be installed in 2-4 wells per aquifer with a primary purpose to monitor for drought and seasonal changes.
- Trend/Seasonal Network Implementation
  - Groups of 4-7 aquifers per year; two periods: May-June and October-November, beginning 2014
- Surveillance (Synoptic) Network Implementation (first survey 2017)
  - Once every 5th year; reconstitute baseline networks for re-verification of condition and to assess program needs and direction related to parametric coverage, measurement frequencies, network IMP challenges, purpose, etc.)

Oklahoma Groundwater "Facts"

- Oklahoma aquifers store ~ 386 million A.F. of GW.
- Groundwater use accounts for……..
- 350,000 Oklahomans rely on domestic wells.
- On a hot summer day……
- Groundwater is private property (domestic use is unregulated). Non-domestic use requires a permit.
- Licensed well drilling firms protect groundwater from potential sources of pollution by adhering to minimum construction standards.

Geospatial Analysis

GIS Analysis was used to determine:

- **Applicable wells**
  - **Based on pre-defined conditions, that included well depth, screened interval, vertical stratification, etc.**
- **Intersect applicable wells with major aquifers.**
- **Primary & oversample selections are generated for each aquifer.**
  - **The primary and oversample wells by design blends random selection with spatial balance.**