



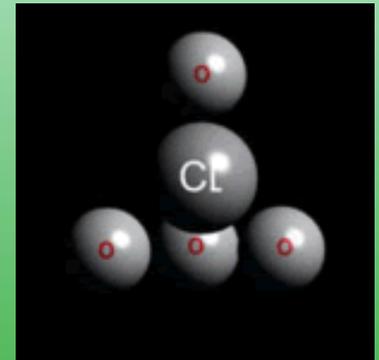
Monitoring perchlorate in shallow ground water in the Central United States

**National Water-Quality Monitoring Council Meeting
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- **Stephen J. Kalkhoff, U.S. Geological Survey, Iowa City, IA.**
 - **Lynne S. Fahlquist, U.S. Geological Survey, Austin, TX.**
 - **W. Andrew Jackson, Texas Tech University, Lubbock, TX.**
 - **Sarah J. Stetson, Colorado School of Mines, Golden, CO.**
 - **Richard B. Wanty, U.S. Geological Survey, Denver, CO.**
 - **Gregory L. Linder, U.S. Geological Survey, Brooks OR**

What is perchlorate?

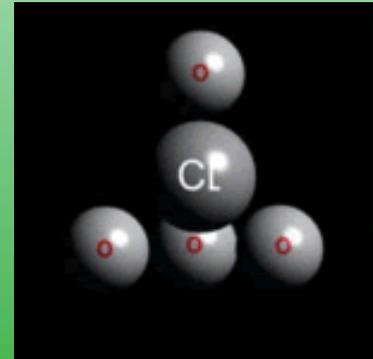
- Perchlorate is both a naturally occurring and man-made chemical.
- Perchlorate a powerful oxidant used in solid rocket fuels by the military and aerospace industry
- Also used in some explosives and flares



Graphic from U.S. EPA

Effects

- **Perchlorate is persistent**
- **High doses of perchlorate can effect normal growth and development of the central nervous system of fetuses and infants.**
- **Is present in public drinking water supplies of over 11 million people at concentrations of at least 4 parts per billion (ppb).**



Graphic from U.S. EPA

Regulations

- **There is no federal drinking water standard for perchlorate**
- **Perchlorate is on the drinking water Contaminant Candidate List**
- **National Academy of Science (NAS) recommended a perchlorate reference dose of 0.0007 mg/kg of body weight (equivalent to a drinking water concentration of about 25 µg/L).**
- **States have set individual standards or goals**

Perchlorate detections known to USEPA as of September, 2004



Perchlorate in selected natural materials and derivative products

(from Orris et al. 2003, USGS OFR 03-314)

Material	Perchlorate concentration (g/kg)
Triple superphosphate	ND
10-10-10 and 10-4-10 fertilizers	ND, ND
Urea	ND
Limestone	ND
Soft rock phosphate ore	ND
Phosphate ores (4)	ND
Potash Ores (3)	0.025, 3.741, 0.042

Atmospheric origin of perchlorate

(from Dasgupta et al, 2005; ES&T, vol. 39)

- **Perchlorate can be formed by a number of atmospheric processes**
 - Formed from chloride aerosol by electrical discharge
 - Exposure of aqueous chloride to high concentrations of ozone
- **Perchlorate was found in rain and snow samples collected in Lubbock,**
 - Detected in 70 percent of samples
 - Concentrations ranged from less than 0.1 to 1.6 ug/L

Objectives

- Determine the occurrence and distribution of perchlorate in shallow ground water the Central United States,
- Determine if there was a relation between the occurrence of perchlorate and agricultural activities



Photo courtesy of USDA NRCS

Study design

- **Concentrate data collection in agricultural areas of Central US**
- **Use data from ongoing USGS investigations**
- **Site selection was not statistically based**
- **Shallow ground-water**
- **Investigate area with gradient of fertilizer use**

Study design--continued

- Use other water chemistry data to understand the occurrence and distribution of perchlorate.
- Compile available spatial information on soils, geology, irrigation, fertilizer, and relate to perchlorate occurrence



Photo from U.S. Geological Survey

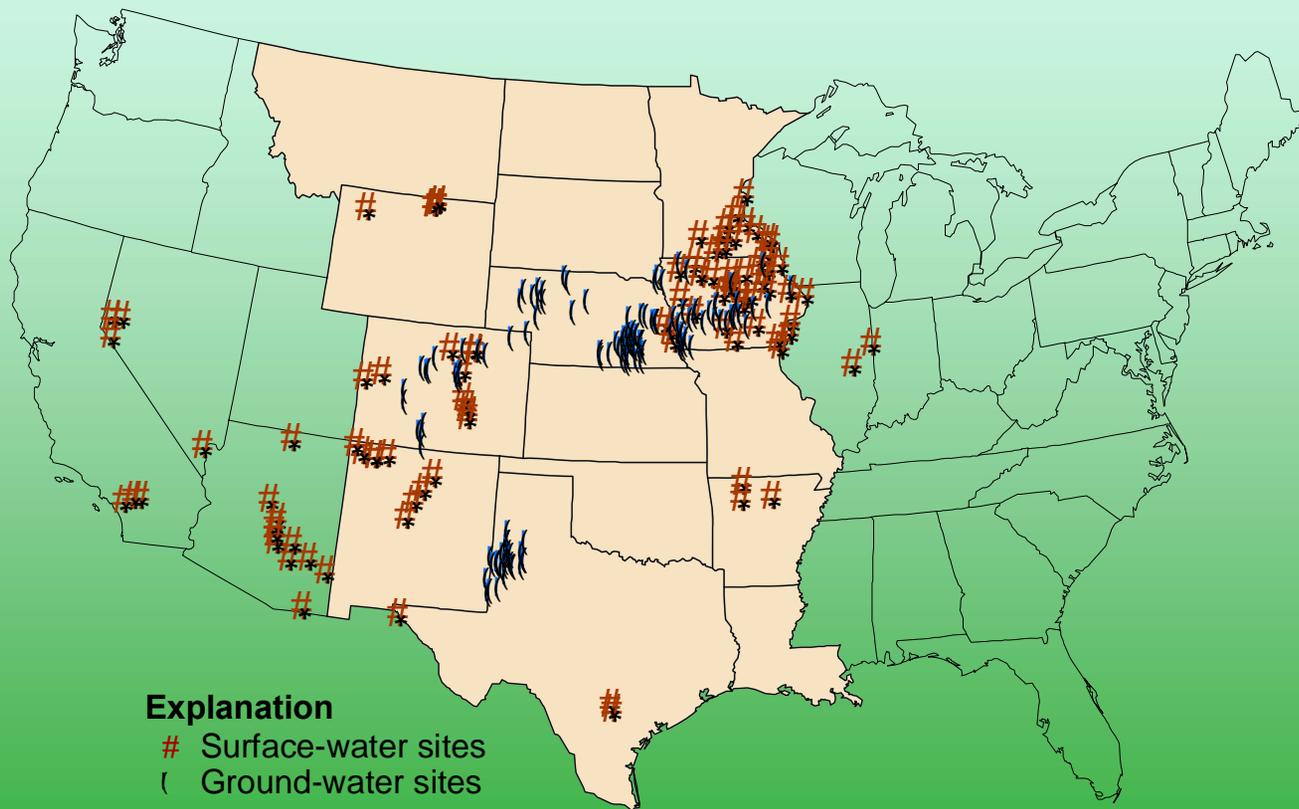
Cooperating agencies and programs --Federal

Agency	Program	Study unit or state
USGS	NAWQA trend	ACAD,CAZB, CNBR,EIWA, HPGW,NVBR, RIOG, SCTX, SOCA, SPLT, TRIN, UCOL,UMIS, YELL
	NAWQA ACT	CNBR
	NAWQA TANC	CNBR
USEPA	Landscape indicators (LIPS)	Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin

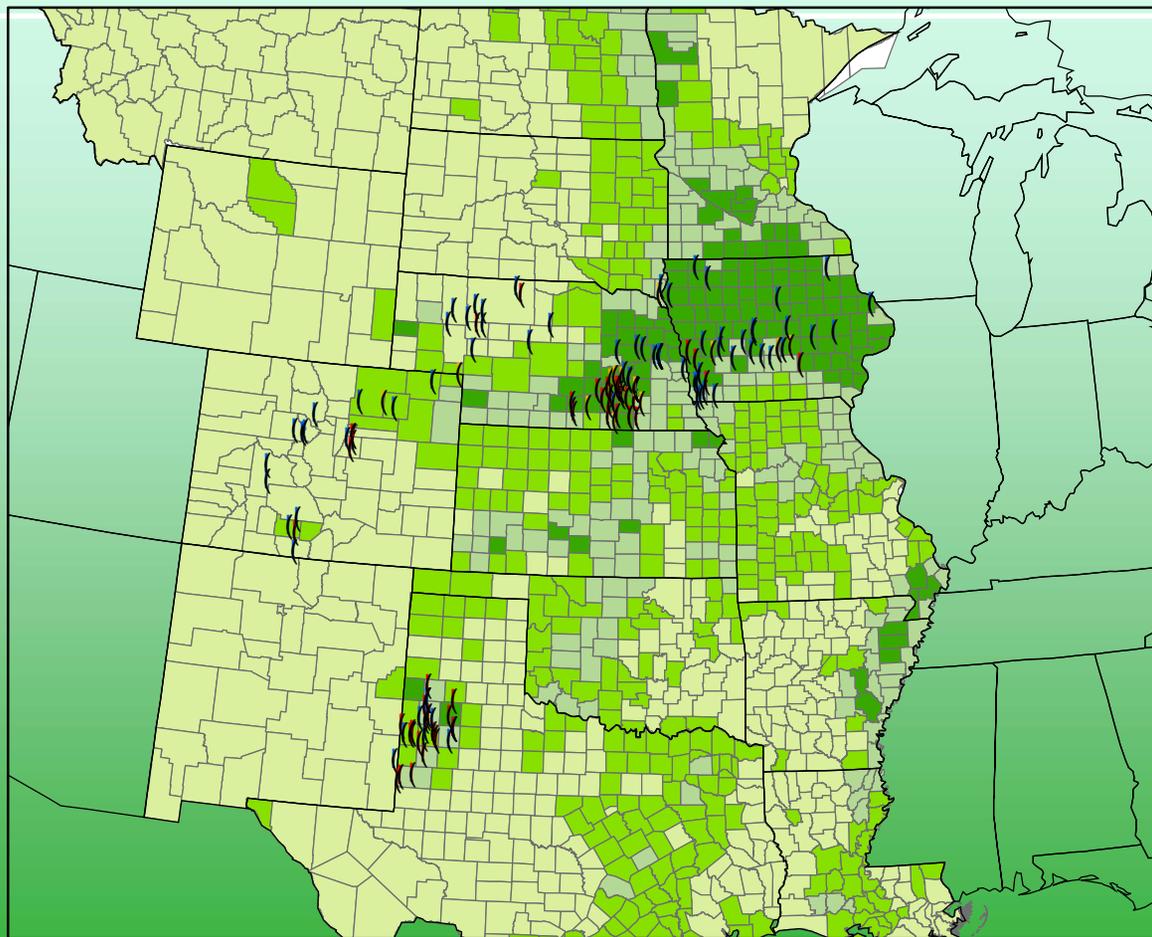
Cooperating agencies and programs -- Coop

Program	State
Arizona Department of Environmental Quality	Arizona
New Mexico basic data network	New Mexico
Tongue River Surface-Water-Quality Monitoring Network-	Wyoming
Iowa Ground-Water Monitoring Network	Iowa
City of Seward	Nebraska

Sites sampled for perchlorate



Shallow ground water

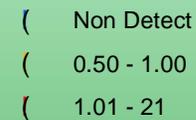


Explanation

Nitrogen application rate (in tons per square mile)



Perchlorate concentration (in micrograms per liter)

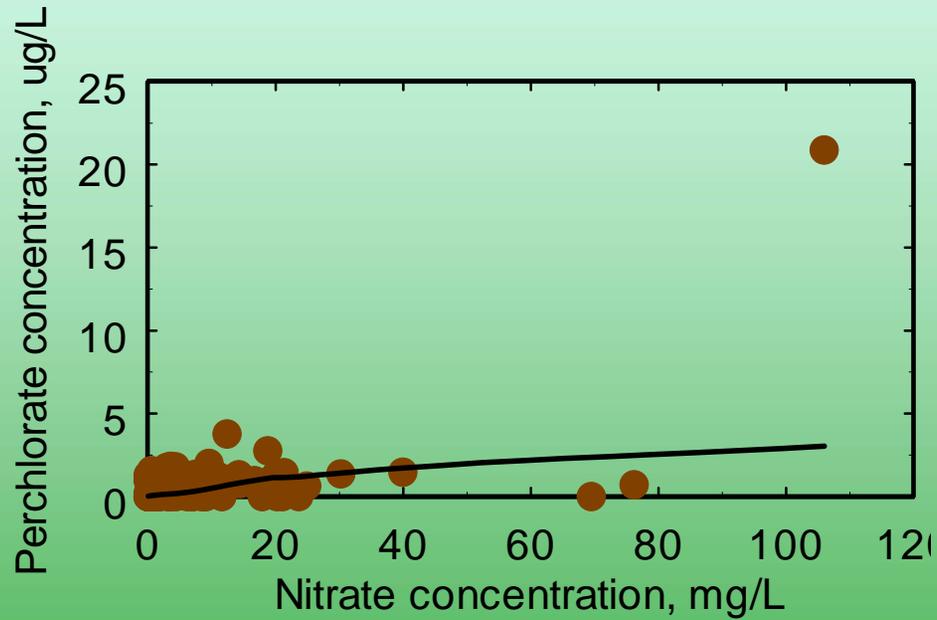


Perchlorate occurrence

Constituent	North-central US	South-central US
	Average values	
Well depth, in feet	81	165
Conductance, in microSiemens per centimeter	711	1460
Perchlorate detection rate, in percent	38	69
Perchlorate concentration, in micrograms per Liter	.87	4.6

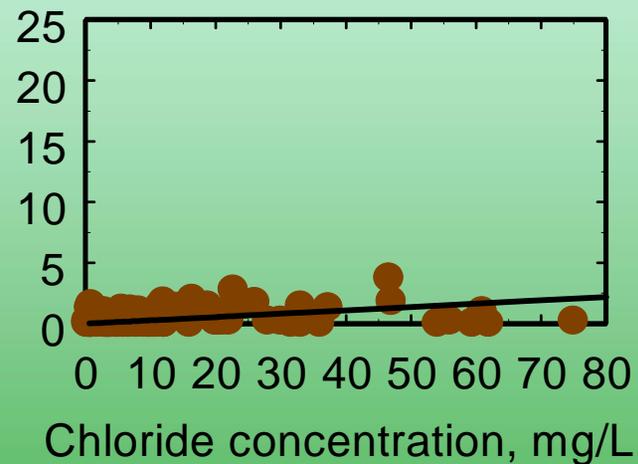
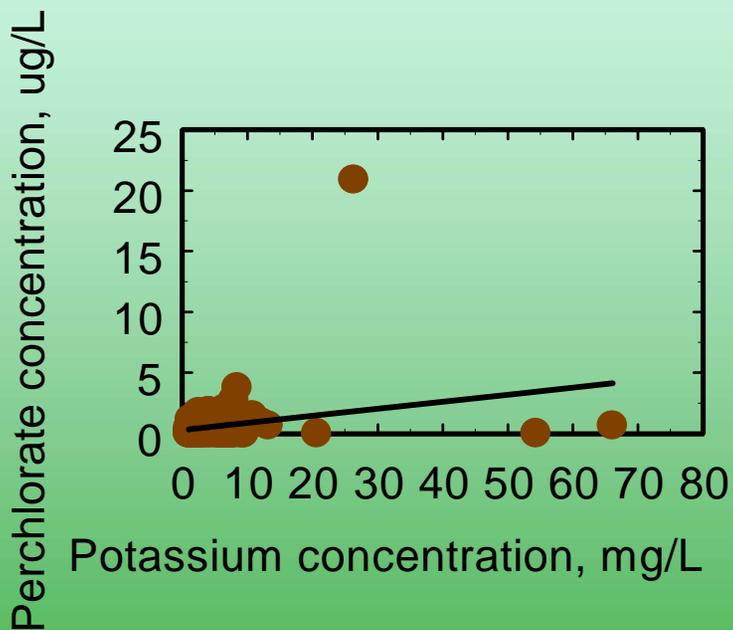
Relation to agricultural intensity

North Central United States

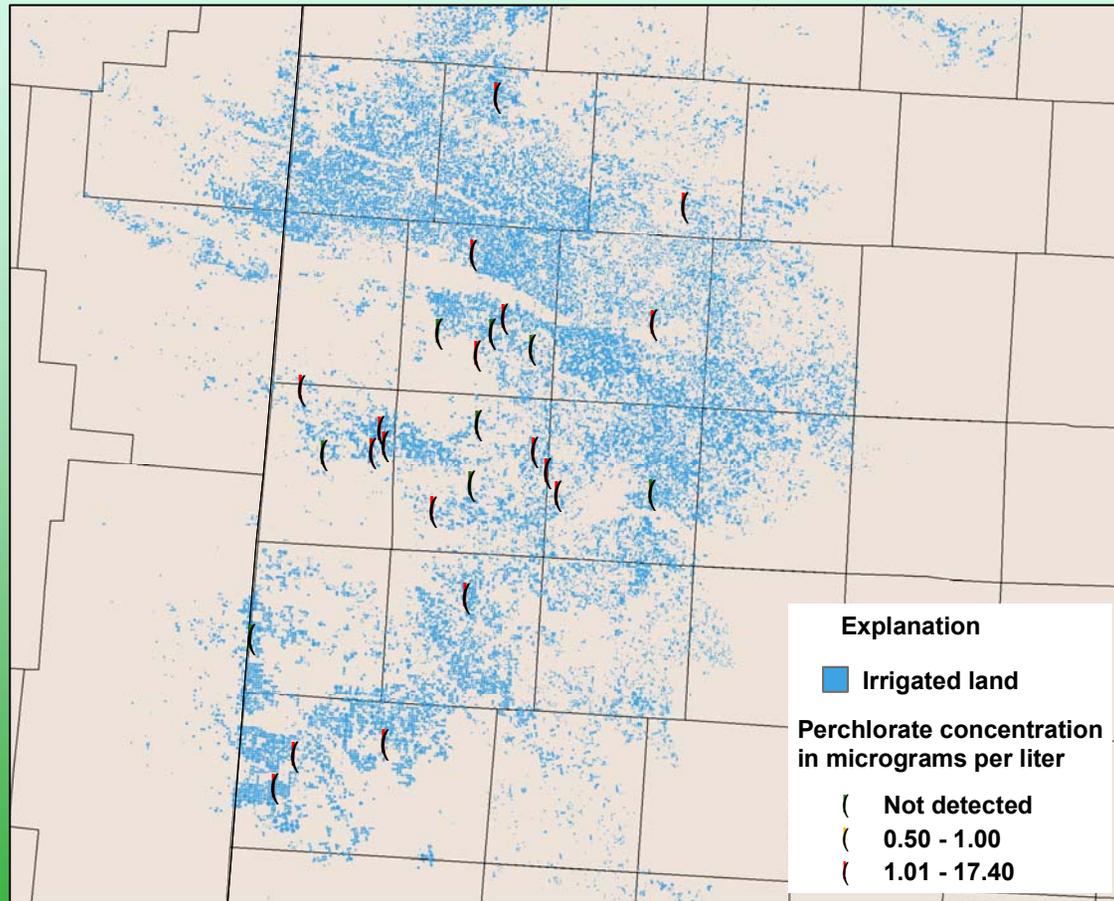


Relation to agricultural intensity

North Central United States -- continued



Perchlorate in ground water in relation to irrigation Texas

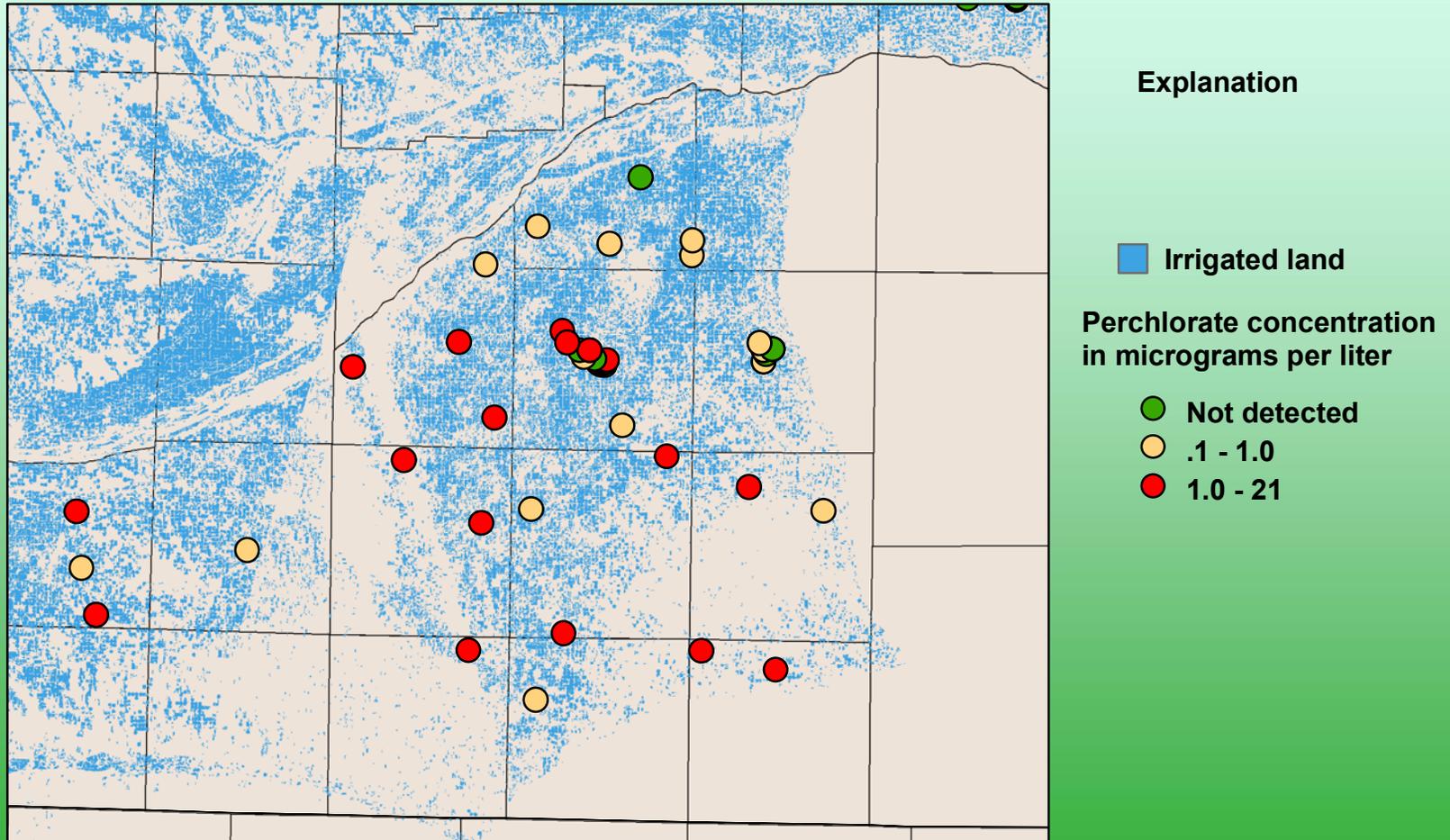


0 10 20 30 40 50 Miles
[Scale bar]



Irrigated land from Qi and others, 2002

Perchlorate in ground water in relation to irrigation Nebraska



0 5 10 20 30 40 Miles

Irrigated land from Qi and others, 2002

Summary and conclusions

- Perchlorate is commonly present at low concentrations in shallow ground water in agricultural areas of north-central and south-central United States
- Occurrence related to irrigation

Perchlorate level micrograms per liter (ppb)	Percent of wells
0.50	44
1.0	32
6.0	7
18	.6
25	0

Summary and conclusions--continued

- **Use of existing USGS monitoring networks was critical for successful completion of perchlorate monitoring**

Additional information

- Stetson and others, 2006, **Stability of low levels of perchlorate in drinking water and natural water samples**: Analytica Chimica Acta, Articles in press
- Rajagopalan and others, 2006, **Widespread presence of naturally occurring perchlorate in high plains of Texas and New Mexico**: Environmental Science and Technology,
- Plummer and others, 2006, **Perchlorate in Pleistocene and Holocene groundwater in north-central New Mexico**: Environmental Science and Technology, vol. 40, no. 6, pp. 1757-1763
- Dasgupta, and others, 2005, **The origin of naturally occurring perchlorate: The role of atmospheric processes**: Environmental Science and Technology, vol. 39, no. 6, pp. 1569-1575
- Bohlke and others, 2005, **Perchlorate isotope forensics**: Analytical Chemistry, vol. 77, no. 23, pp. 7838-7842.