Insights into Contaminant Occurrence in Public-Supply Wells

Lessons from the USGS Transport of Anthropogenic and Natural Contaminants (TANC) Study, Nationwide and in New Mexico

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USGS

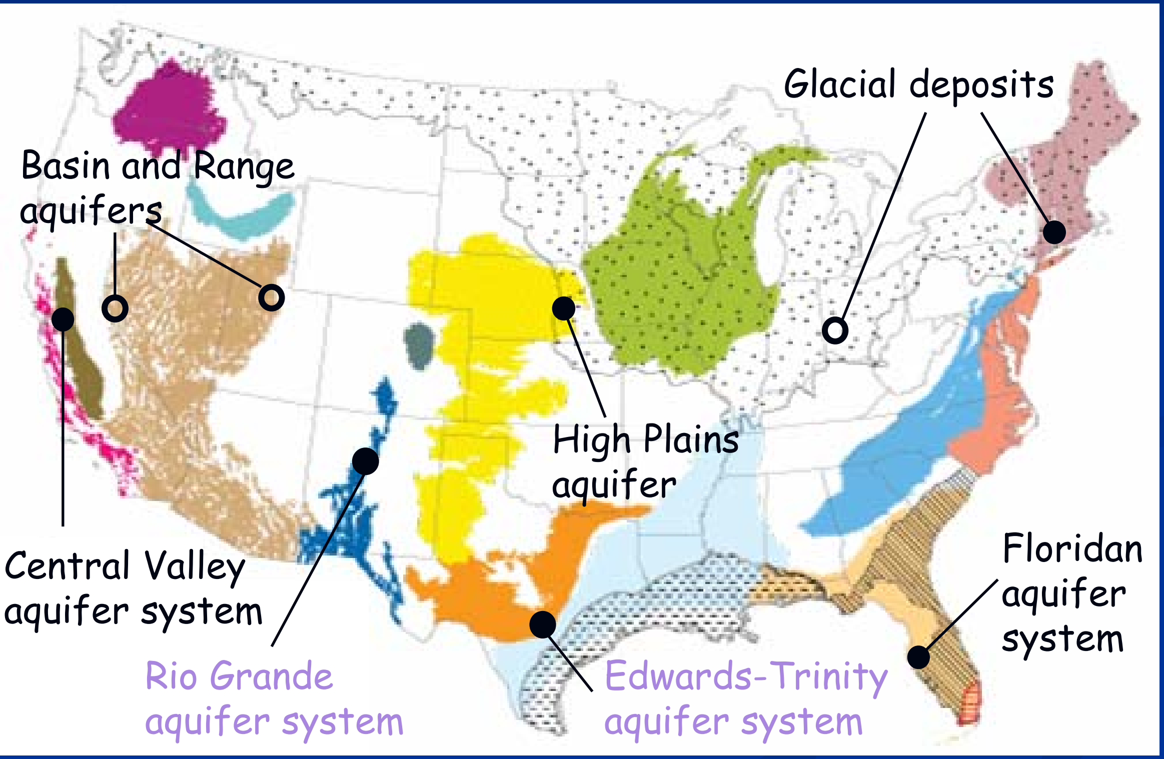
U.S. Department of the Interior
U.S. Geological Survey

TANC General Question

What are the primary

(1) anthropogenic and natural contaminant sources,
(2) aquifer processes, and
(3) well characteristics

that control the transport and transformation of contaminants along flow paths to supply wells in representative water supply aquifers?



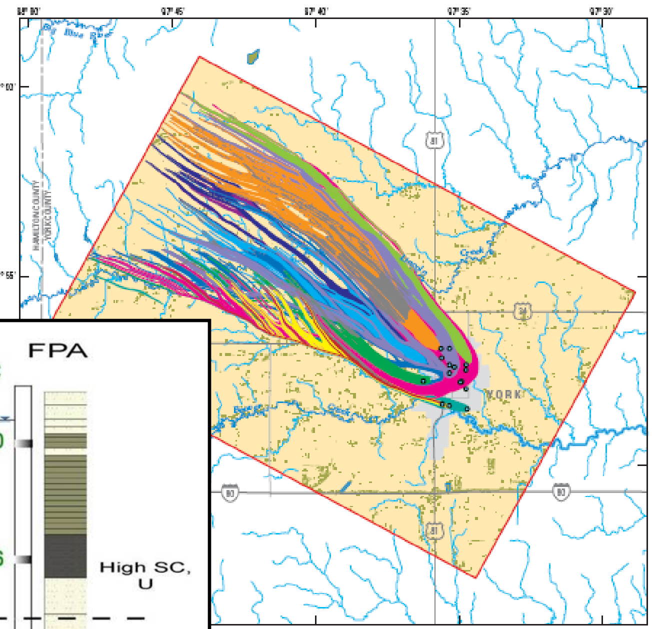
TANC Objectives

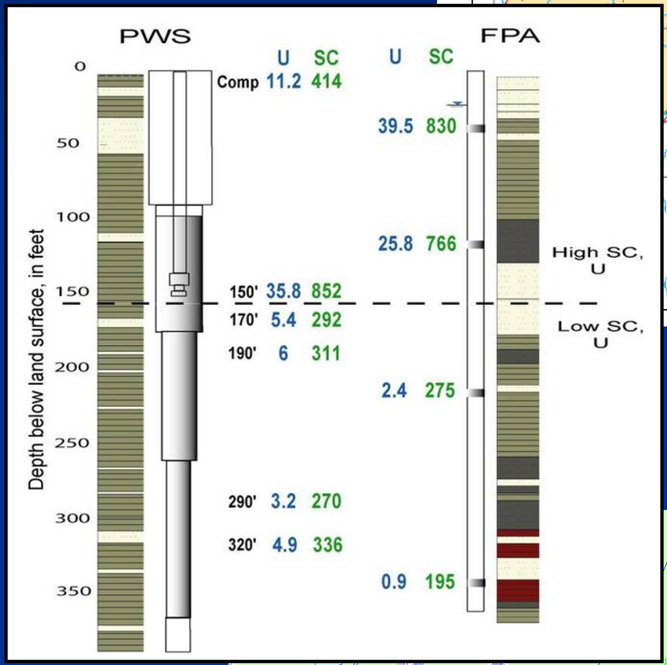
- Identify dominant contaminants and sources of those contaminants in public-supply wells
- Assess effects of natural processes and human activities on contaminant occurrence in public-supply wells
- Identify factors most important to incorporate into public-supply well vulnerability assessments
- Develop simple methods and models for screening public-supply wells for vulnerability
- Increase understanding of potential effects of water-resource development and management decisions

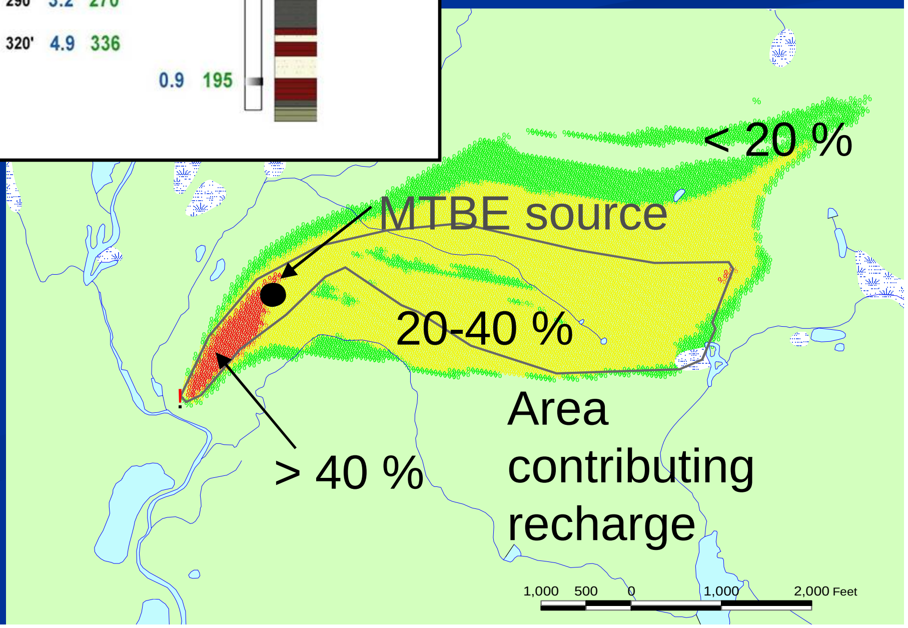
Eberts et al., 2008

TANC Study Approach

- Combines chemical data (new and retrospective) with ground-water-flow modeling to evaluate variables influencing susceptibility and vulnerability
- At regional scale, contributing areas of numerous supply wells are modeled and characterized
- At local scale, a single supply well is studied in great detail (includes depth-dependent sampling, drilling/sampling, local-scale modeling)







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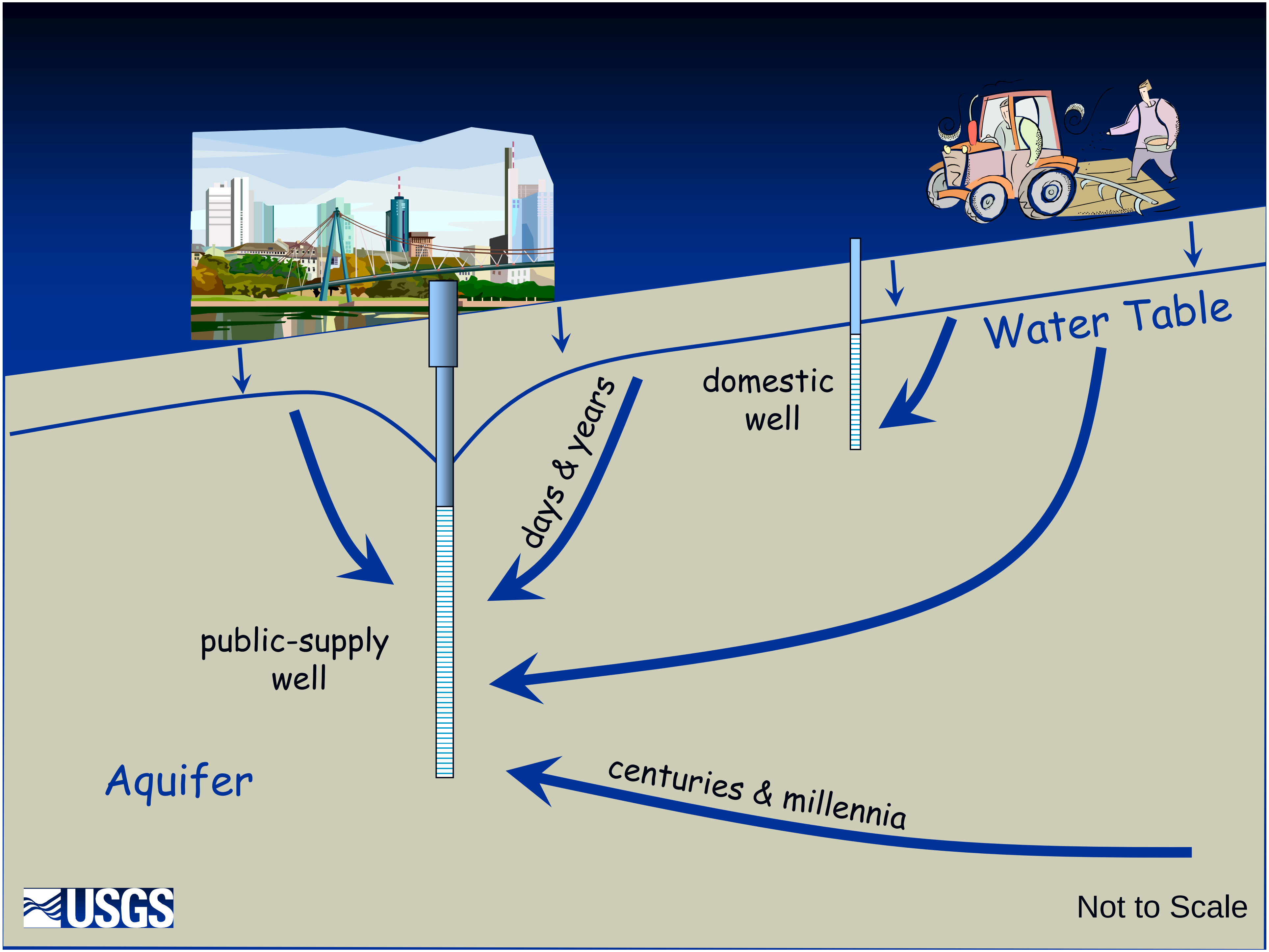
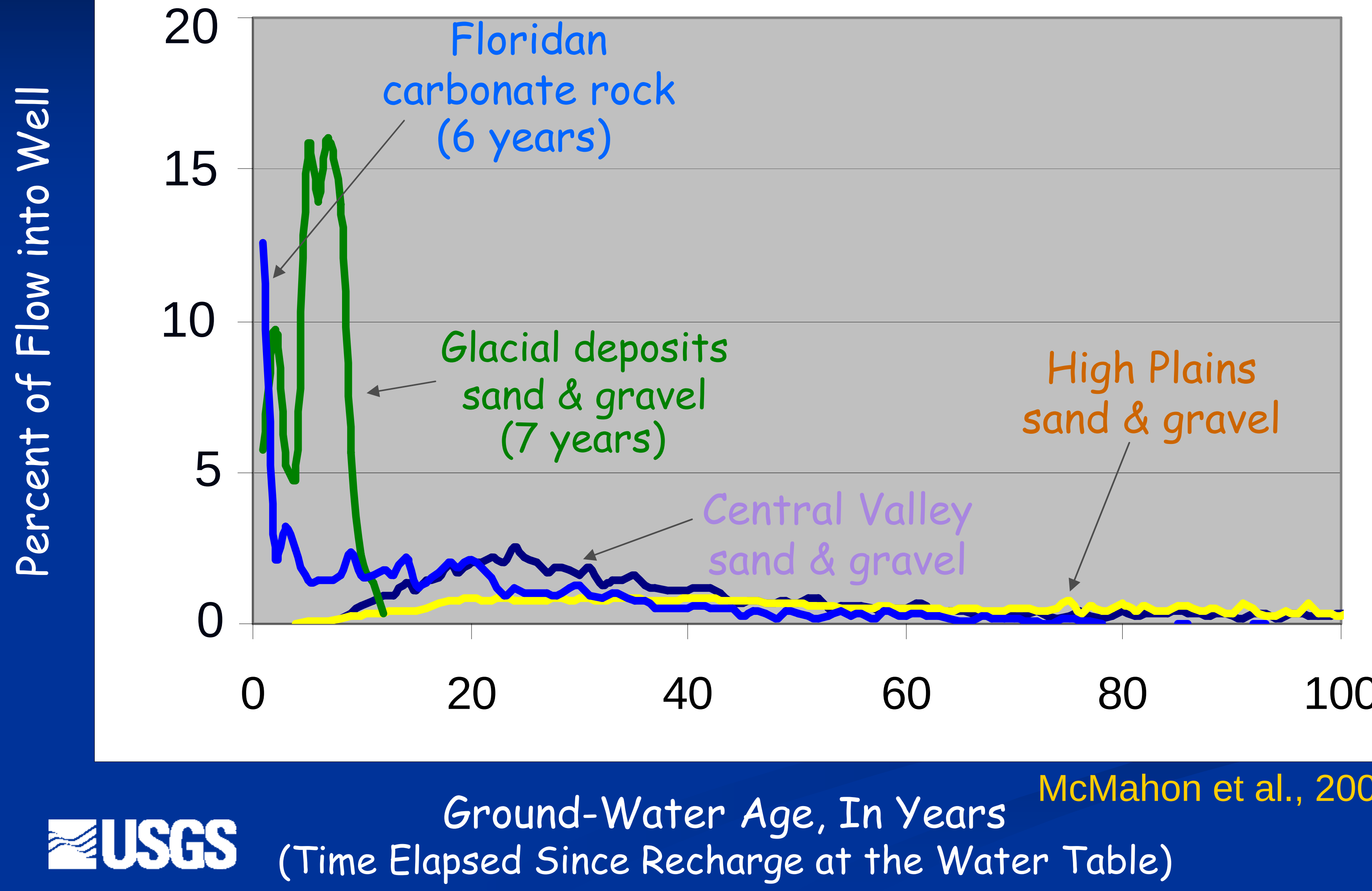
Lessons and Tools from National Case Studies

Three factors are largely responsible for the observed contaminant detections in public-supply wells:

- **Age distribution of water** — *the simultaneous contribution to a well of water that recharged the aquifer at different times in the past*
- **Short-circuit pathways** — *natural or manmade features that allow water to "short-circuit" expected flow paths to a well*
- **Geochemical conditions** — *the general chemistry of the water in the aquifer surrounding a well*



Water Table
domestic well
days & years
public-supply well
Aquifer
centuries & millennia
USGS
Not to Scale



McMahon et al., 2008

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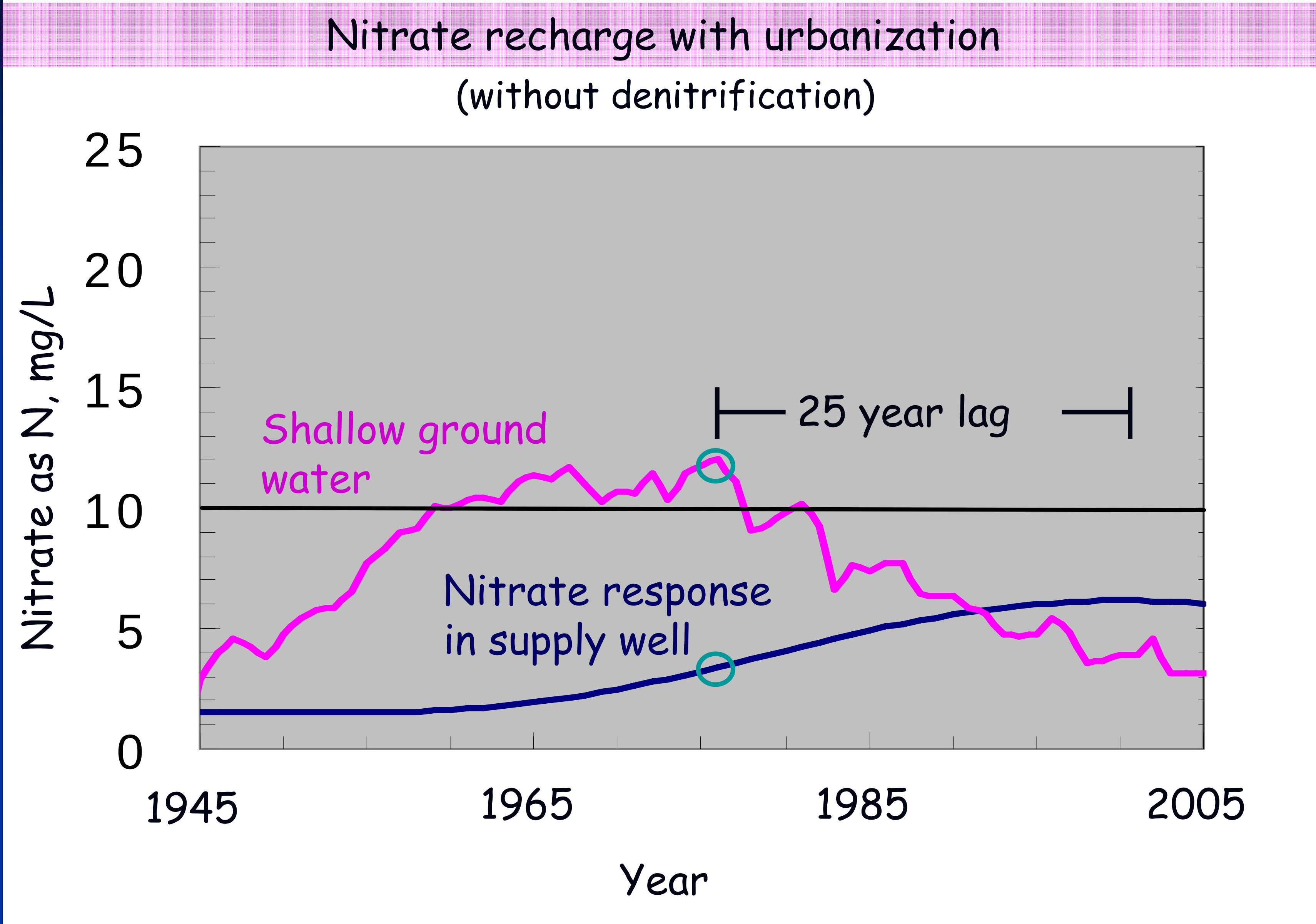
Central Valley sand & gravel public-supply well



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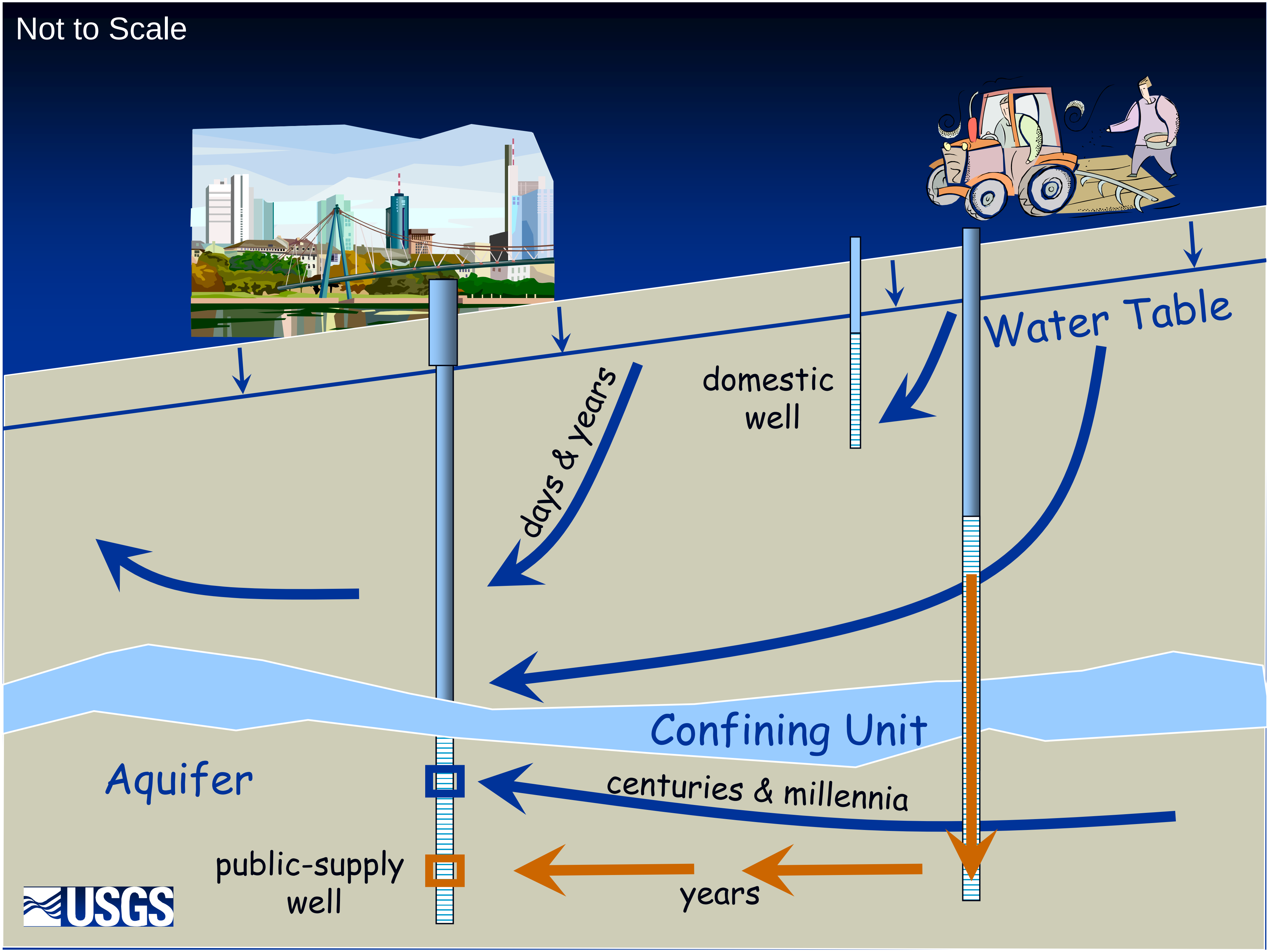
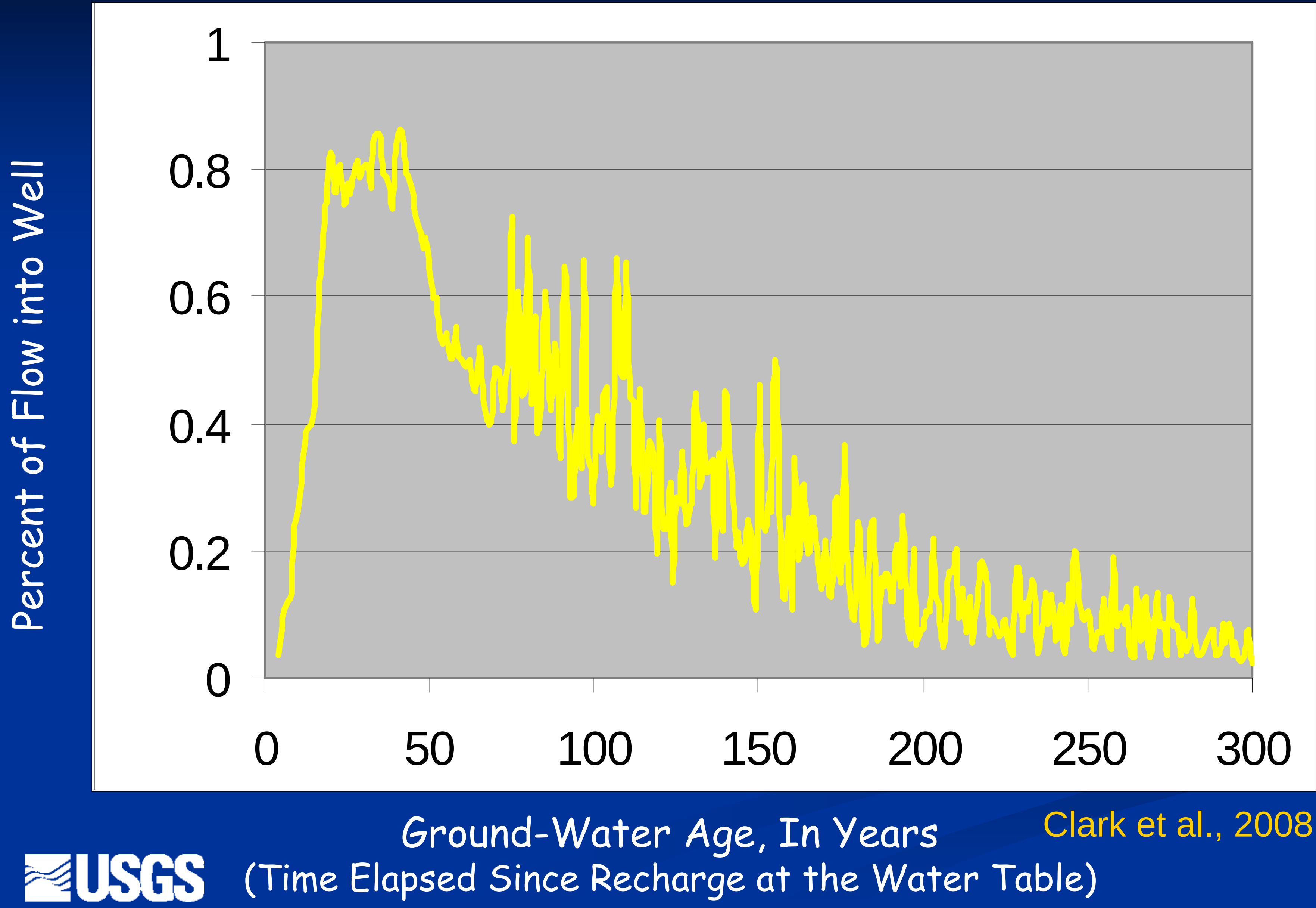
Modified from Burow et al., 2008


Not to Scale
Water Table
domestic well
days & years
Confining Unit
Aquifer
centuries & millennia
public-supply well
years
USGS

High Plains sand & gravel public-supply well



Clark et al., 2008

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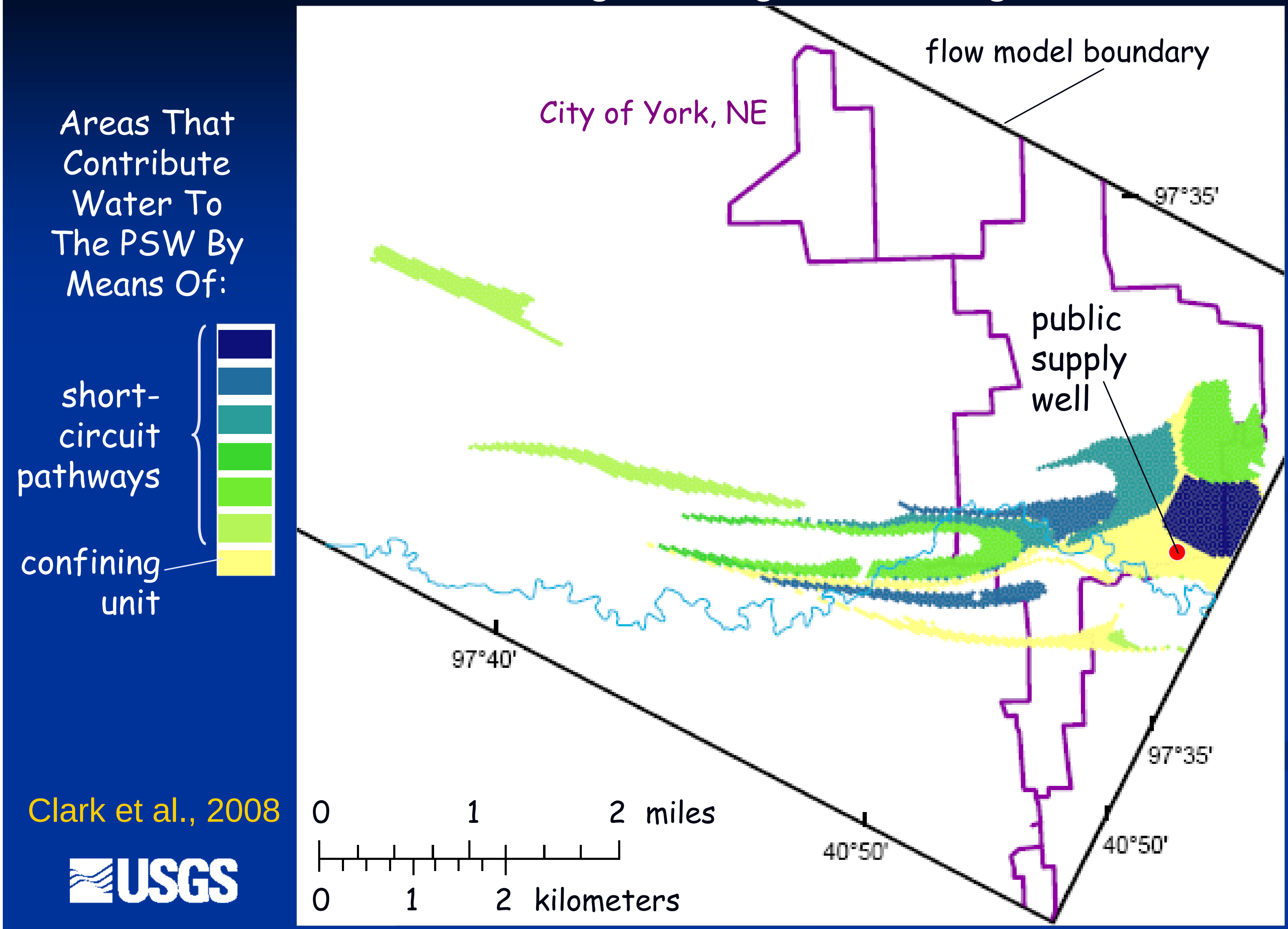
simulated contributing recharge area - High Plains

Areas That Contribute Water To The PSW By Means Of:



Clark et al., 2008

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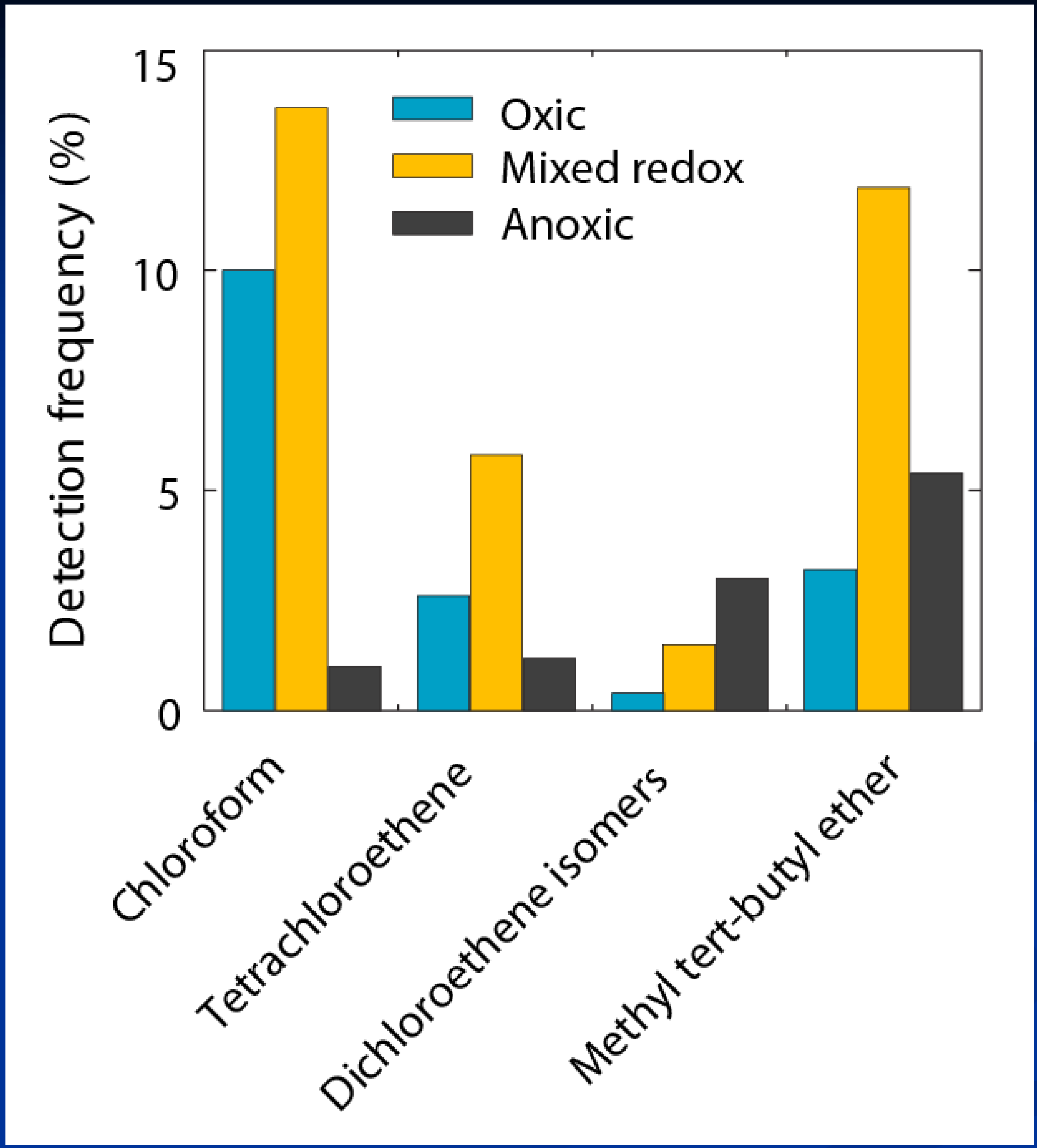

McMahon and Chapelle, 2008

Threshold Concentrations for Identifying Redox Processes in Regional Aquifer Systems

Redox Process	Water Quality Criteria (mg/L) O_2	NO_3^--N	Mn^{2+}	Fe^{2+}	SO_4^{2-}	Comments
Oxic						
O_2 reduction	≥0.5	—	<0.05	<0.1	—	—
Suboxic						
—	<0.5	<0.5	<0.05	<0.1	—	Further definition of redox processes not possible
Anoxic						
NO_3^- reduction	<0.5	≥0.5	<0.05	<0.1	—	—
Mn(IV) reduction	<0.5	<0.5	≥0.05	<0.1	—	—
Fe(III)/SO_4^{2-} reduction	<0.5	<0.5	—	≥0.1	≥0.5	—
Methanogenesis	<0.5	<0.5	—	≥0.1	<0.5	—
Mixed						
—	—	—	—	—	—	Criteria for more than one redox process are met

McMahon and Chapelle, 2008

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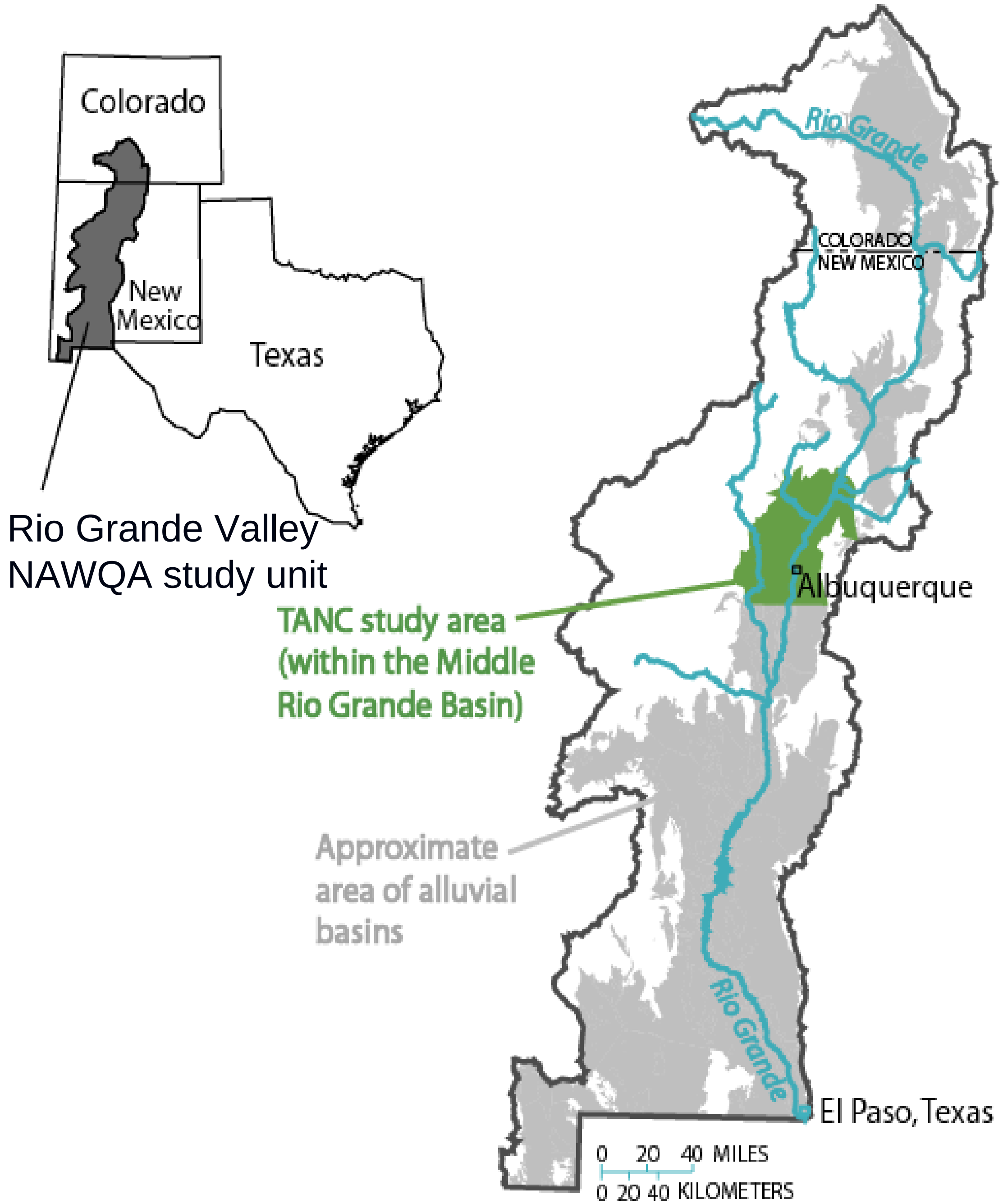
Rio Grande TANC Study Area: the Middle Rio Grande Basin

- Includes the most populous area of NM
- Was the subject of an intense 6-year study of hydrogeology in the late 1990s



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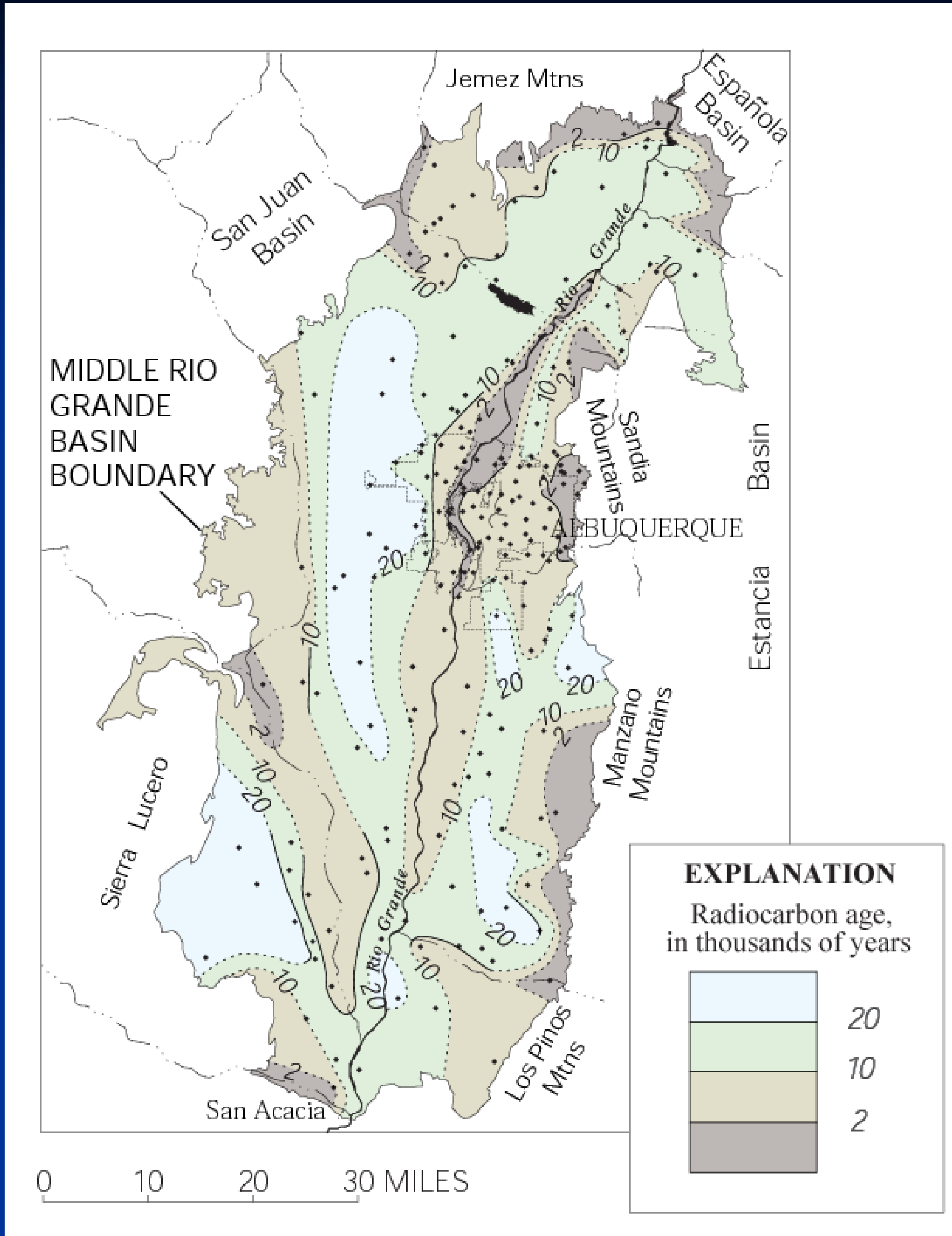


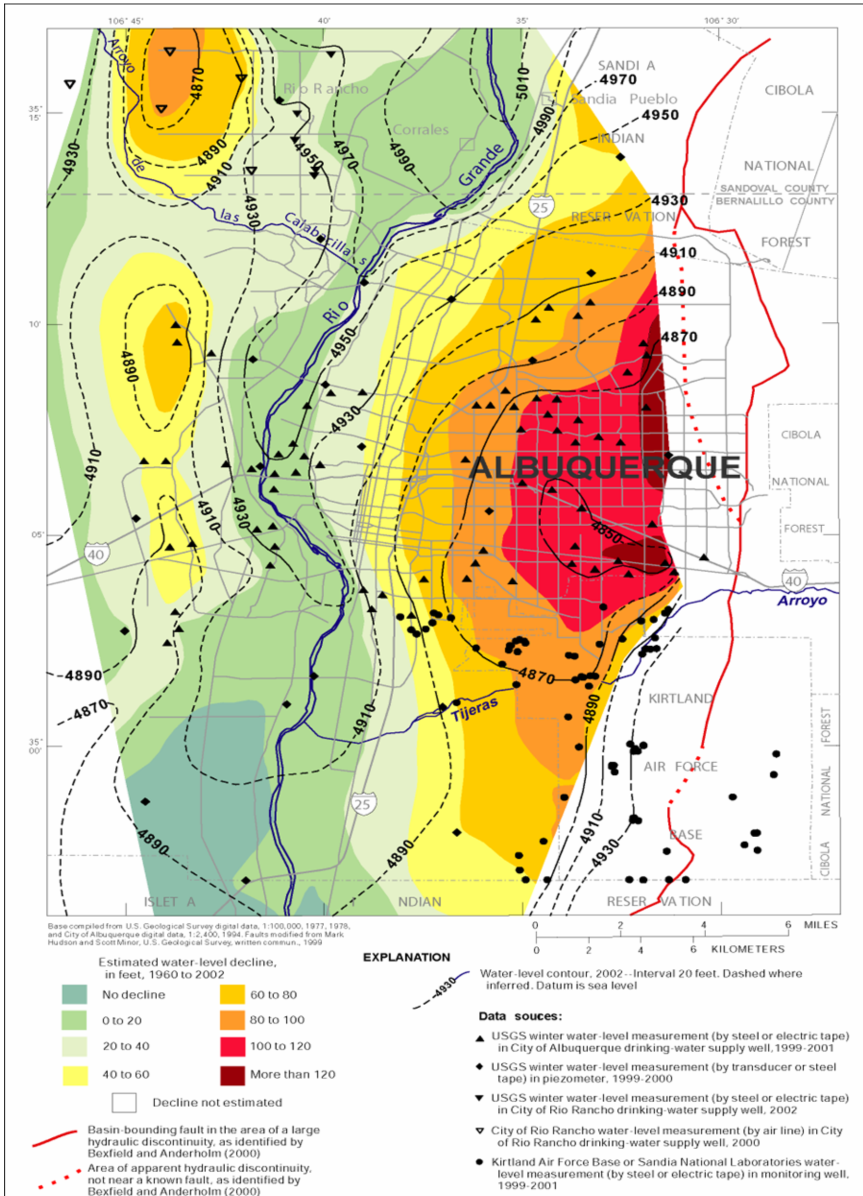
Unique Features of the MRGB

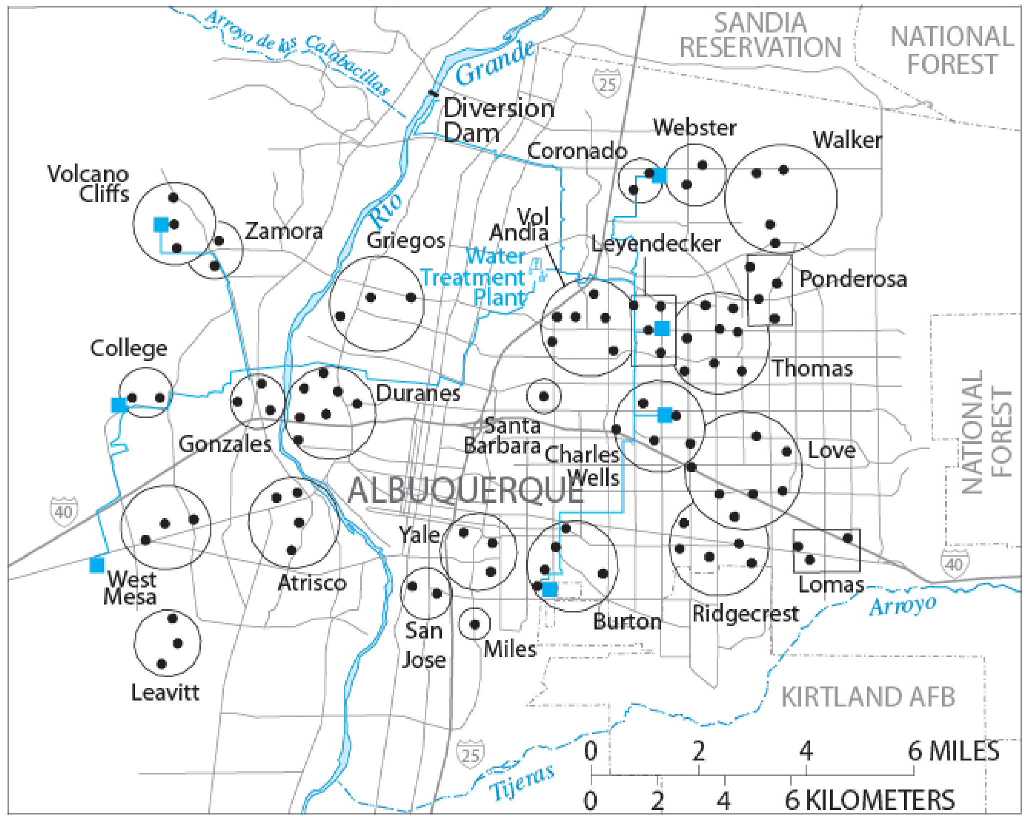
- "Recent" recharge is very small and limited in spatial extent because little areal recharge of precipitation
- Most ground water in the upper part of the aquifer is ~2,000 to 20,000 years old
- However, CFCs are detected near the water table and even in deep production wells (up to 2,000 ft deep) across much of the ABQ area

Plummer and others, 2004

More Unique Features

- Historical pumping for public supply (primarily by Albuquerque) has resulted in substantial water-level declines
- In 2009, Albuquerque begins using surface water from the Rio Grande as the primary source of drinking water





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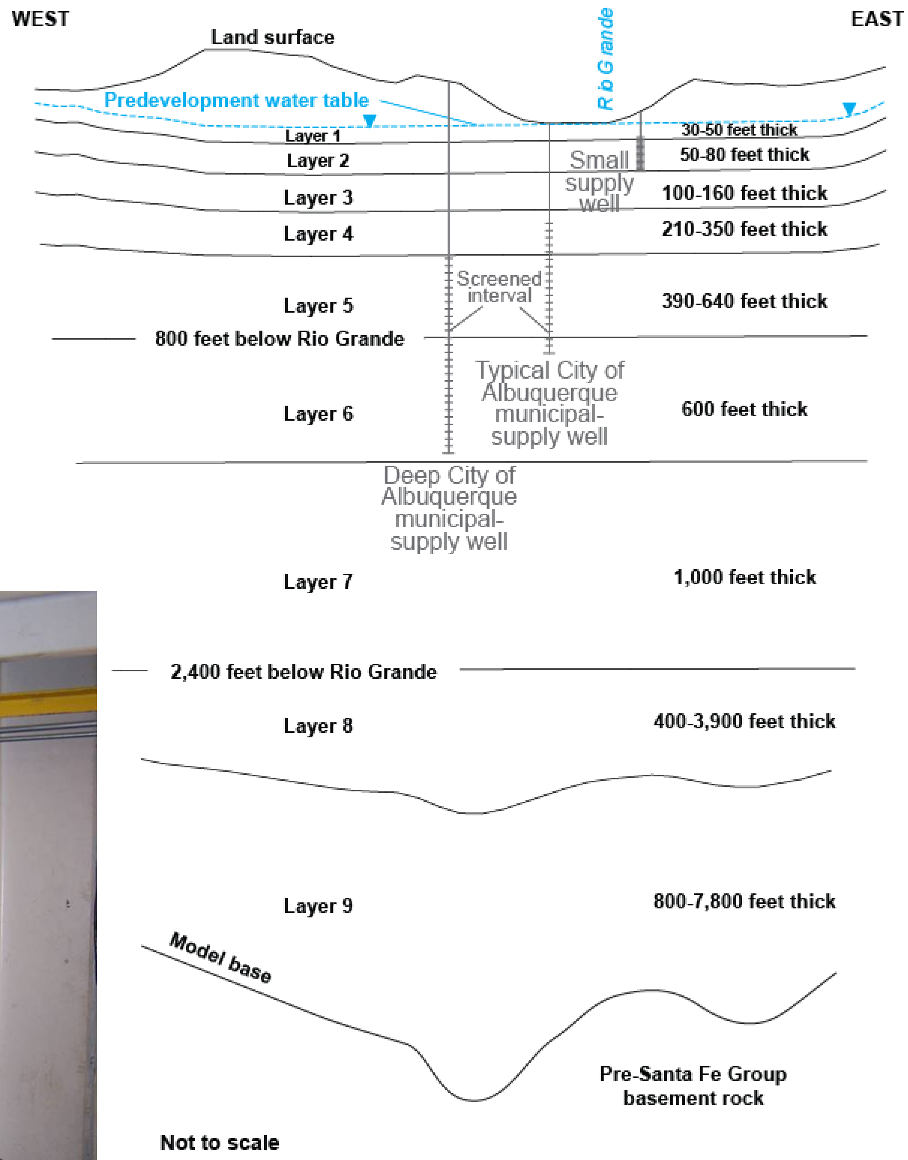
Supply Wells



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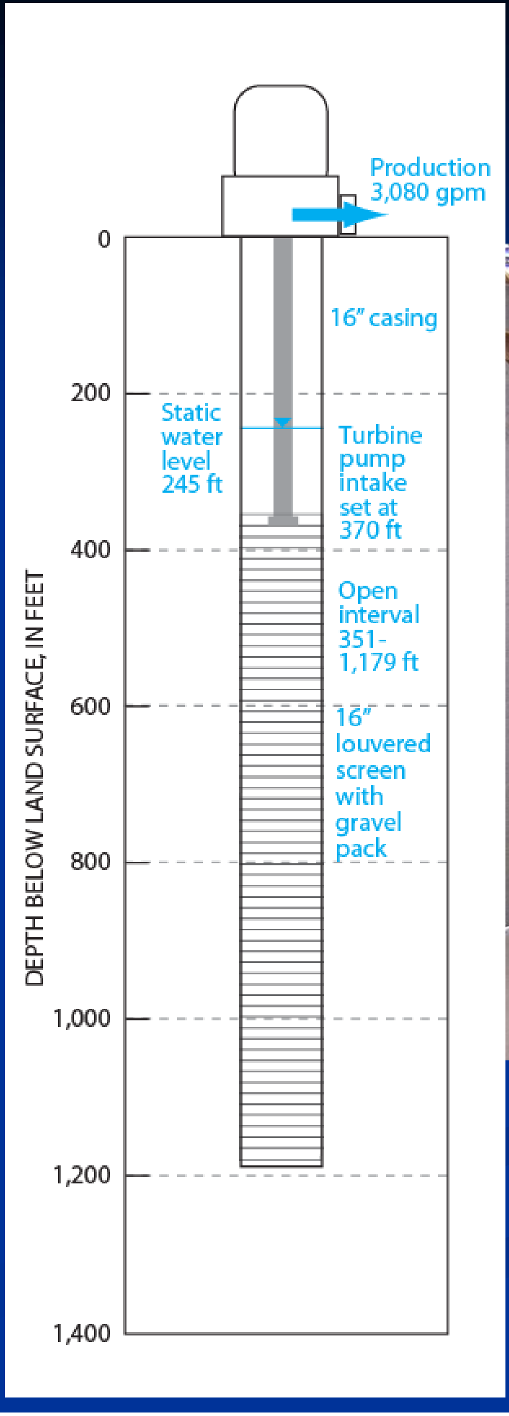
Supply Well for Local Albuquerque TANC Study

- Concentrations of naturally-occurring arsenic fluctuate around the drinking-water standard of 10 ppb
- Sporadic TCE, cis-1,2-DCE, MTBE detections at concentrations of about E0.05 ppb or less



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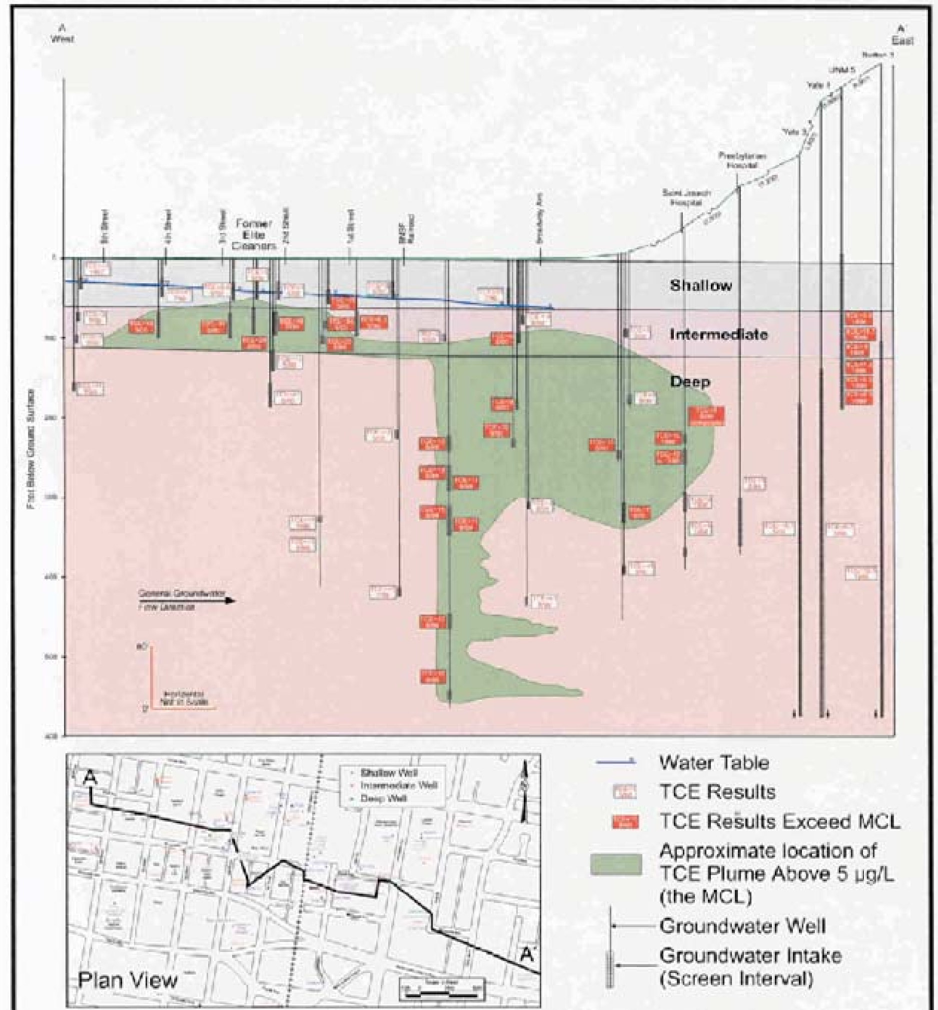

Figure 3
Schematic Cross-Section of TCE Plume at the Fruit Avenue Plume Site

Contaminant Pathways and Short Circuits

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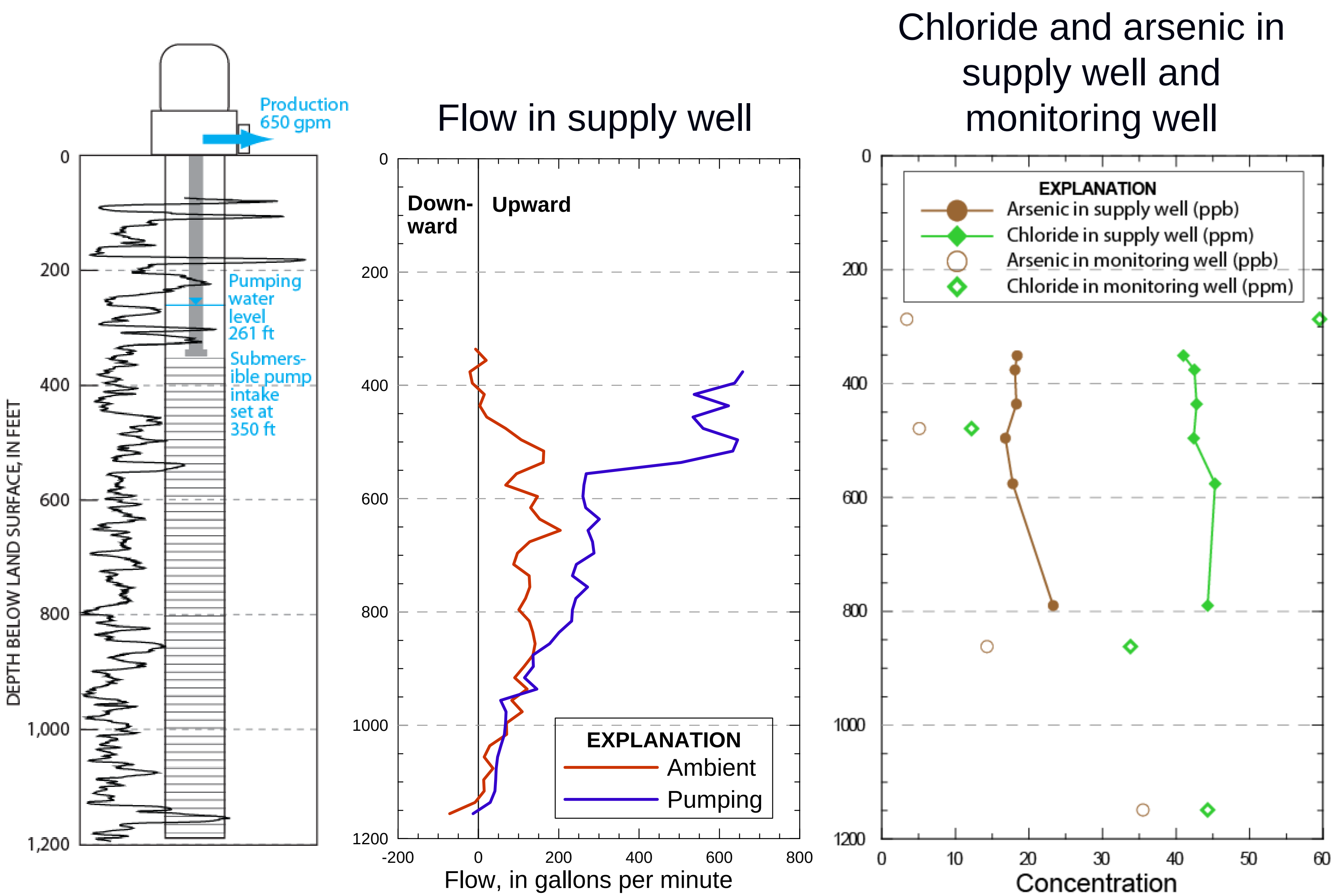
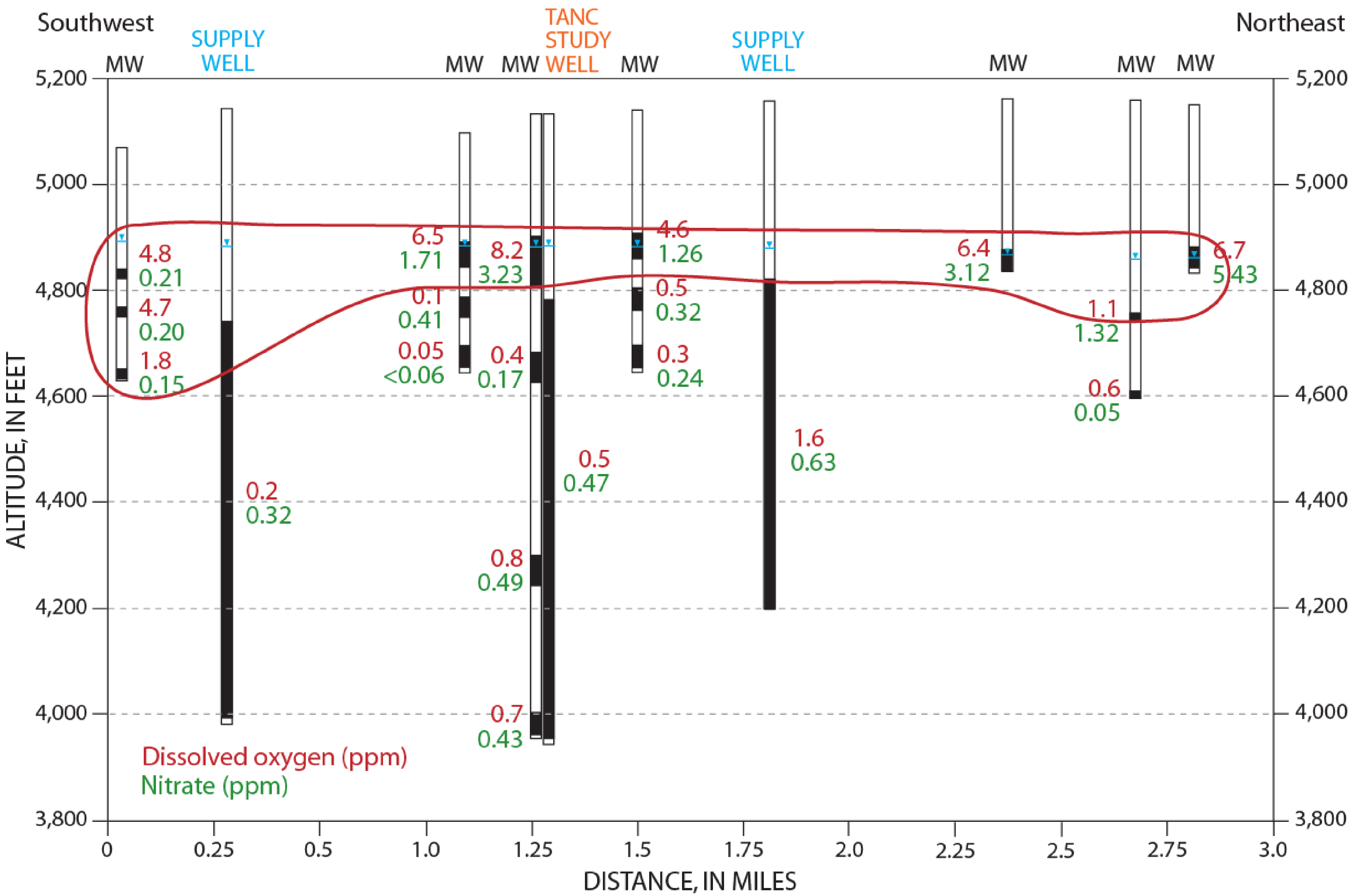
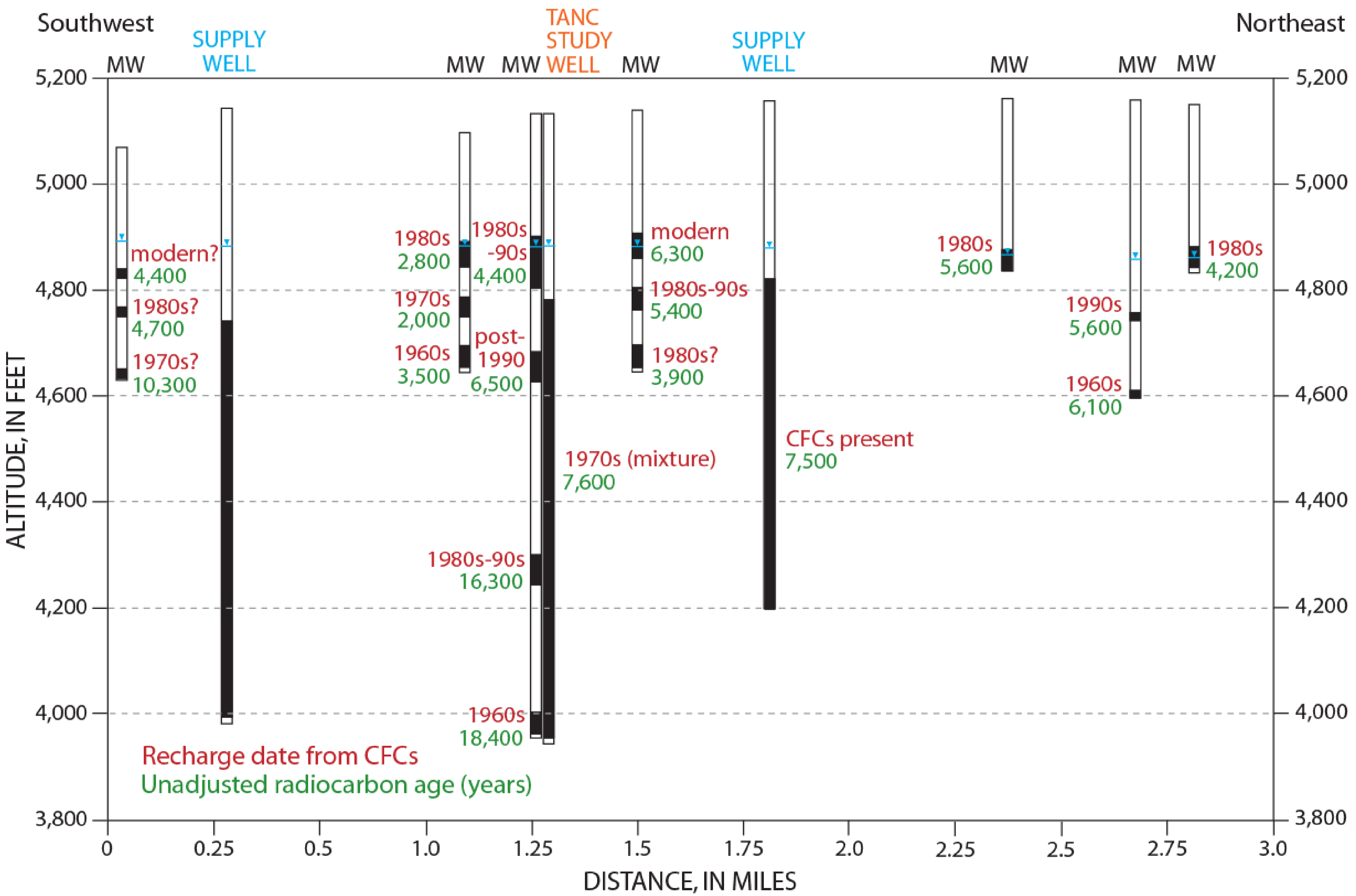
Flow through the Wellbore of the Supply Well



Redox Conditions



Age Distribution of Water



Summary

- Three factors are largely responsible for observed contaminant detections in public-supply wells:
  - (1) Age distribution of water
  - (2) Short-circuit pathways
  - (3) Geochemical conditions
- Aquifer use itself can alter the relative importance of these factors and influence water quality
- The Albuquerque case study is confirming and providing additional insight into the importance of these factors

TANC team members are currently in the process of preparing a USGS Circular and other papers describing lessons learned and illustrating tools and approaches for investigating the above factors in various hydrologic settings

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For More Information

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http://oh.water.usgs.gov/tanc/NAWQATANC.htm