Simulation of Groundwater Flow and Chloride Transport in the *Equus* Beds Aquifer

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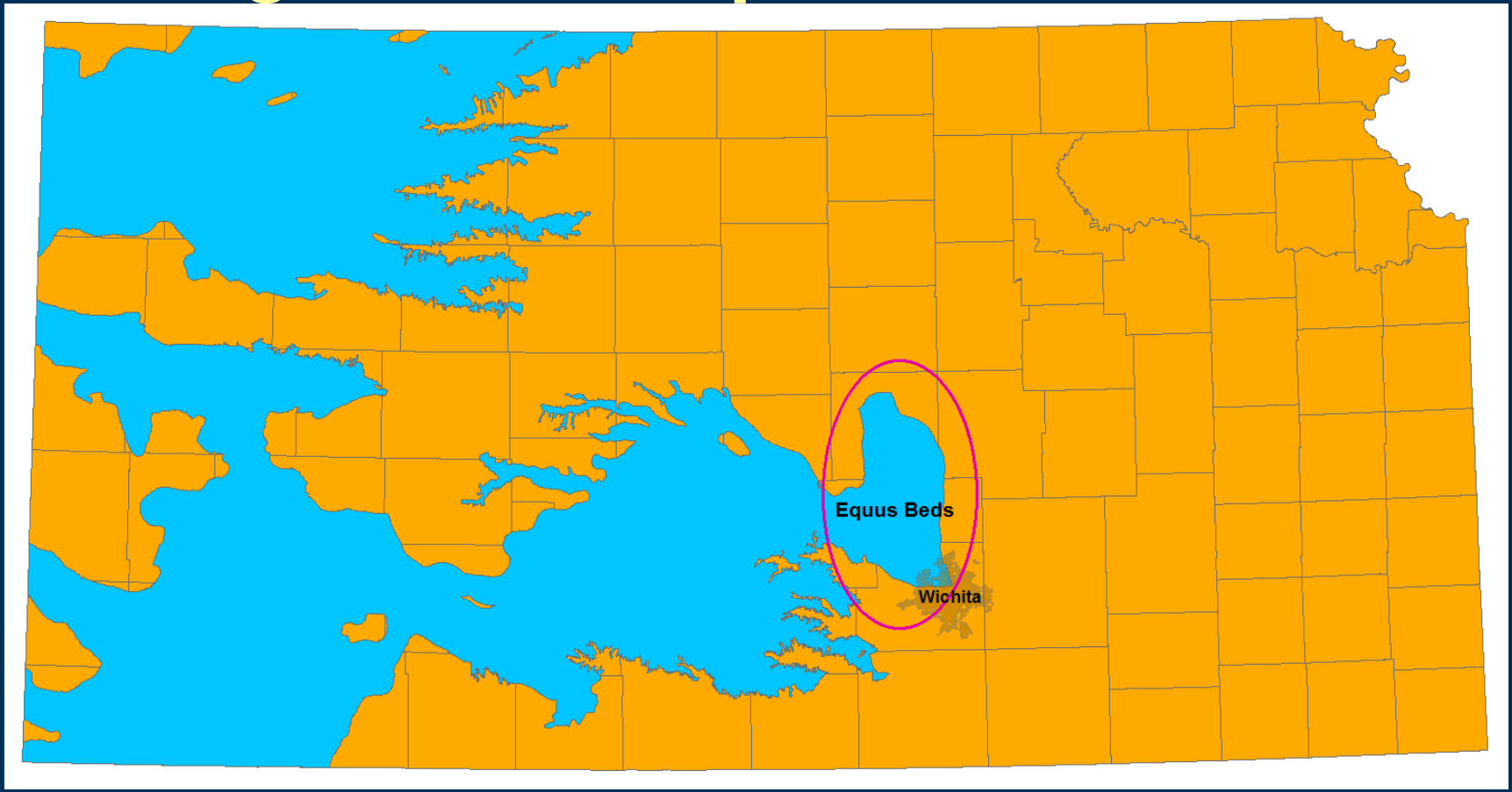
U.S. Geological Survey

Presentation overview

- Background information
  - Study area
  - Wichita ASR project
- Model construction
- Modeling applications:
  - Artificial recharge credit accounting
  - Chloride transport

High Plains Aquifer in Kansas



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Equus Beds water use

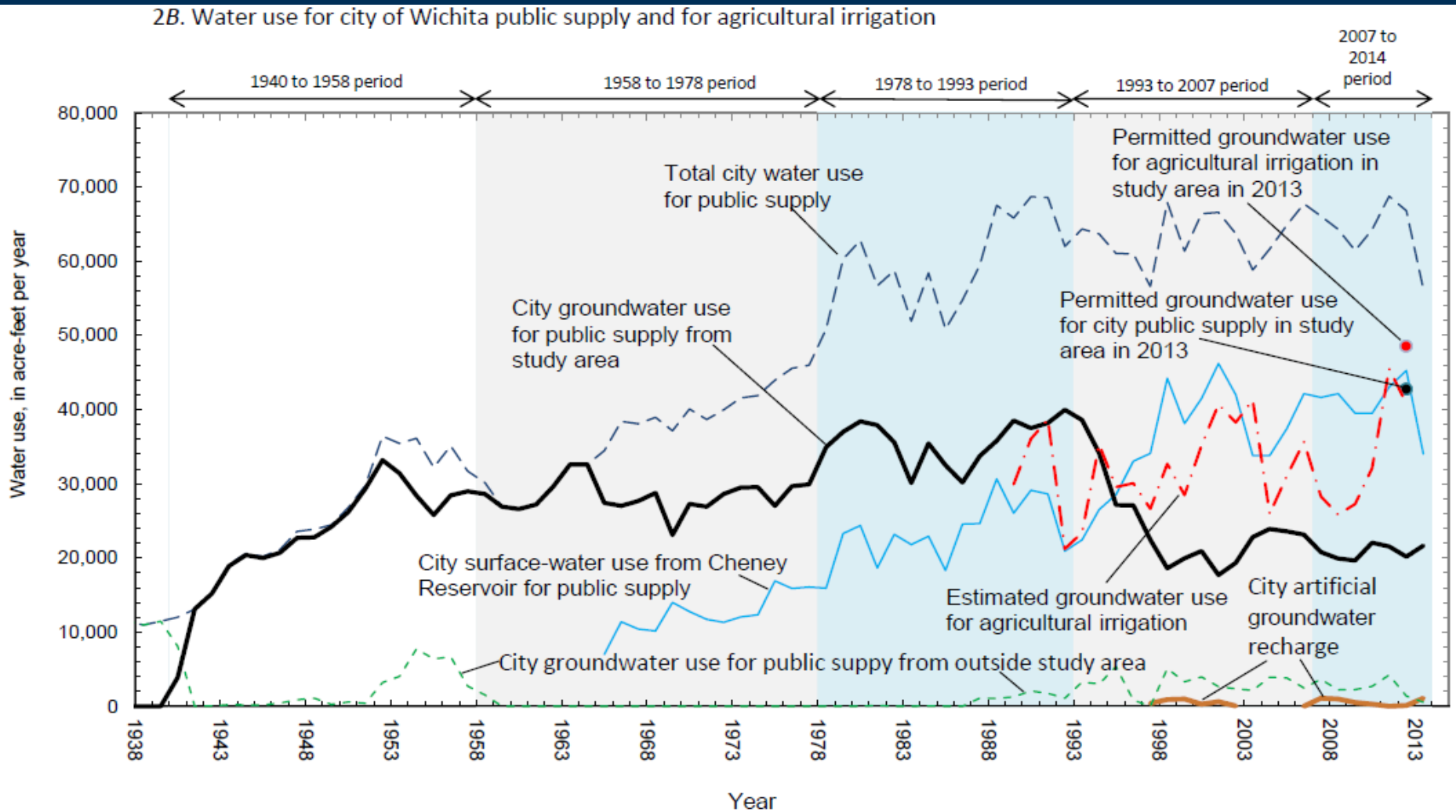
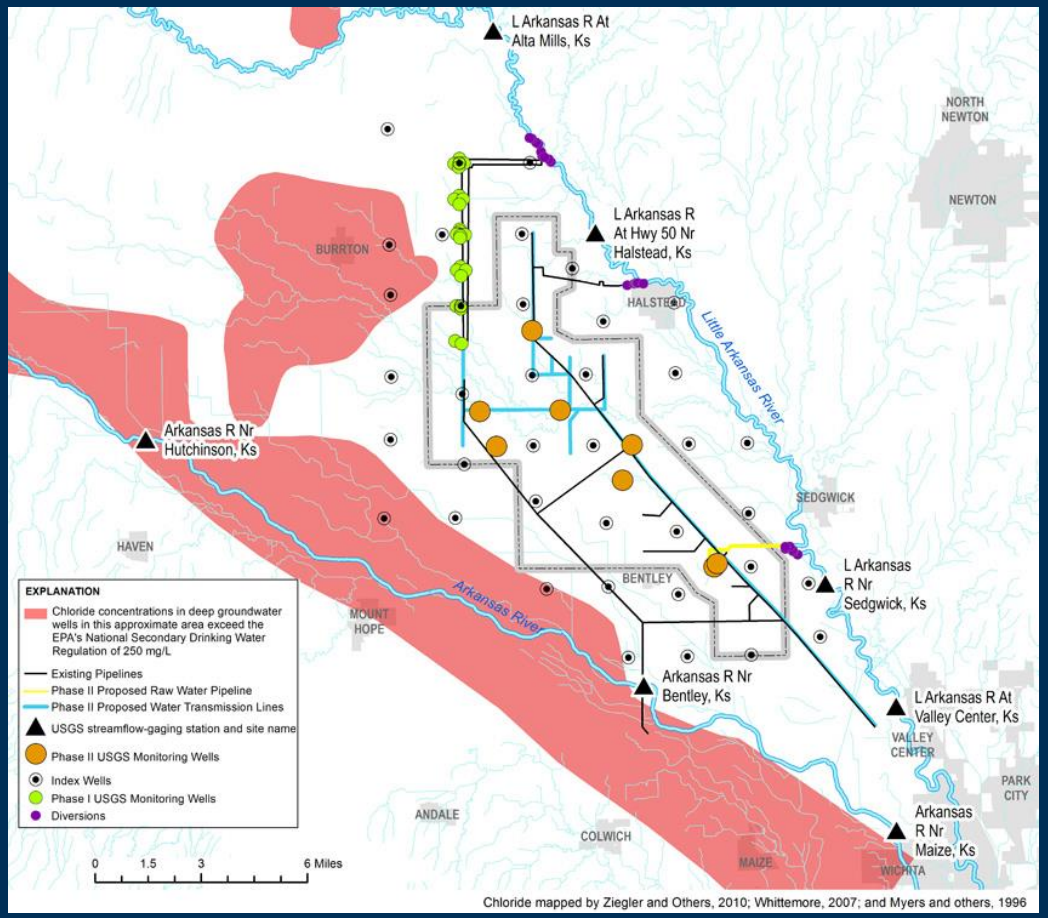


Figure 2B.--Water use for city of Wichita public supply and for agricultural irrigation, 1938 to 2014 (modified from Hansen and Aucott , 2010). Data from Wichita Water Department ([1959]), Stramel (1956, 1967), Gerald T. Blain (written commun., city of Wichita,1997), Megan Schmeltz (written commun., city of Wichita, 2009), and Kansas Department of Agriculture, Division of Water Resources (unpublished data, 2014).



http://ks.water.usgs.gov/equus-beds-recharge

- Burrton plume caused by disposal of salt water from oil/gas production into pits in 1920s-1940s
- Brine disposal about 1.9 million tons of salt (~1 million tons of chloride)
- Burrton contamination area about 30 mi^2 (>250 mg/L Cl) and about 200 ft thick

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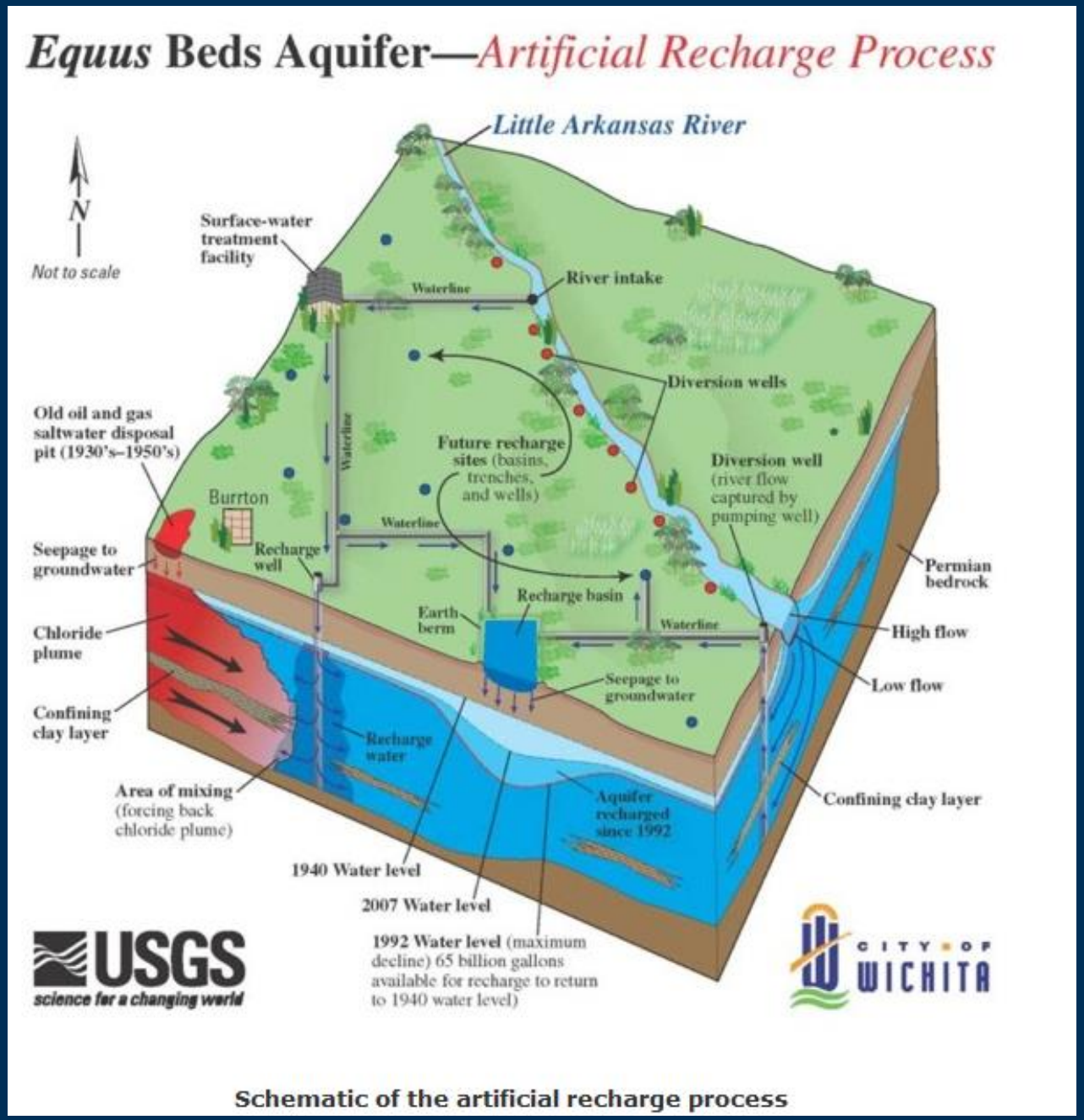

Schematic of the artificial recharge process

- Chloride from Burrton and Arkansas River
- Agriculture and city pumpage can increase the velocity of chloride movement and declines in water levels
- Artificial recharge will slow chloride movement and increase available water

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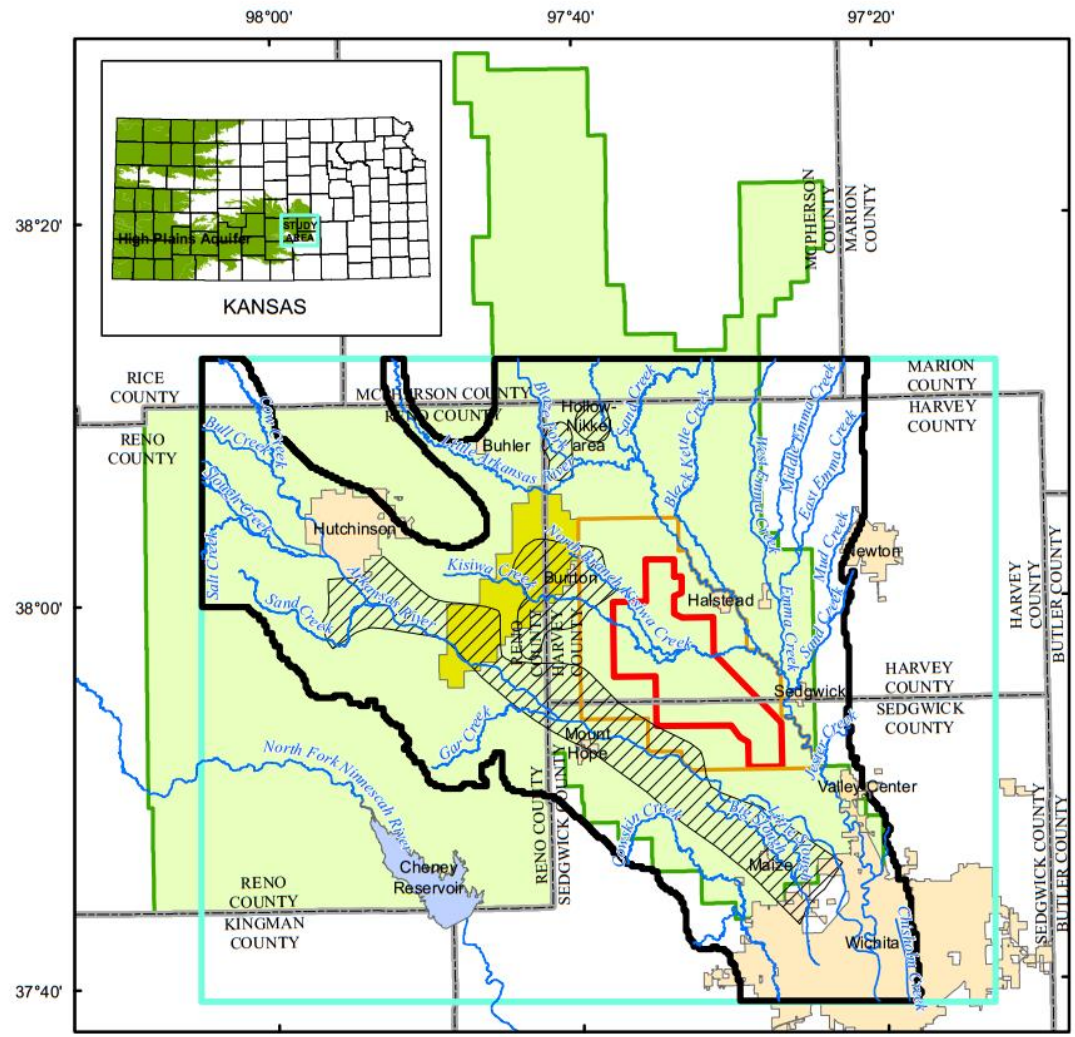
Model construction

- MODFLOW used for flow model (Kelly and others, 2013)
- SEAWAT used for solute transport
- 1,844 square mile model area
- 369,346 active cells, 400 ft by 400 ft
- Three layers



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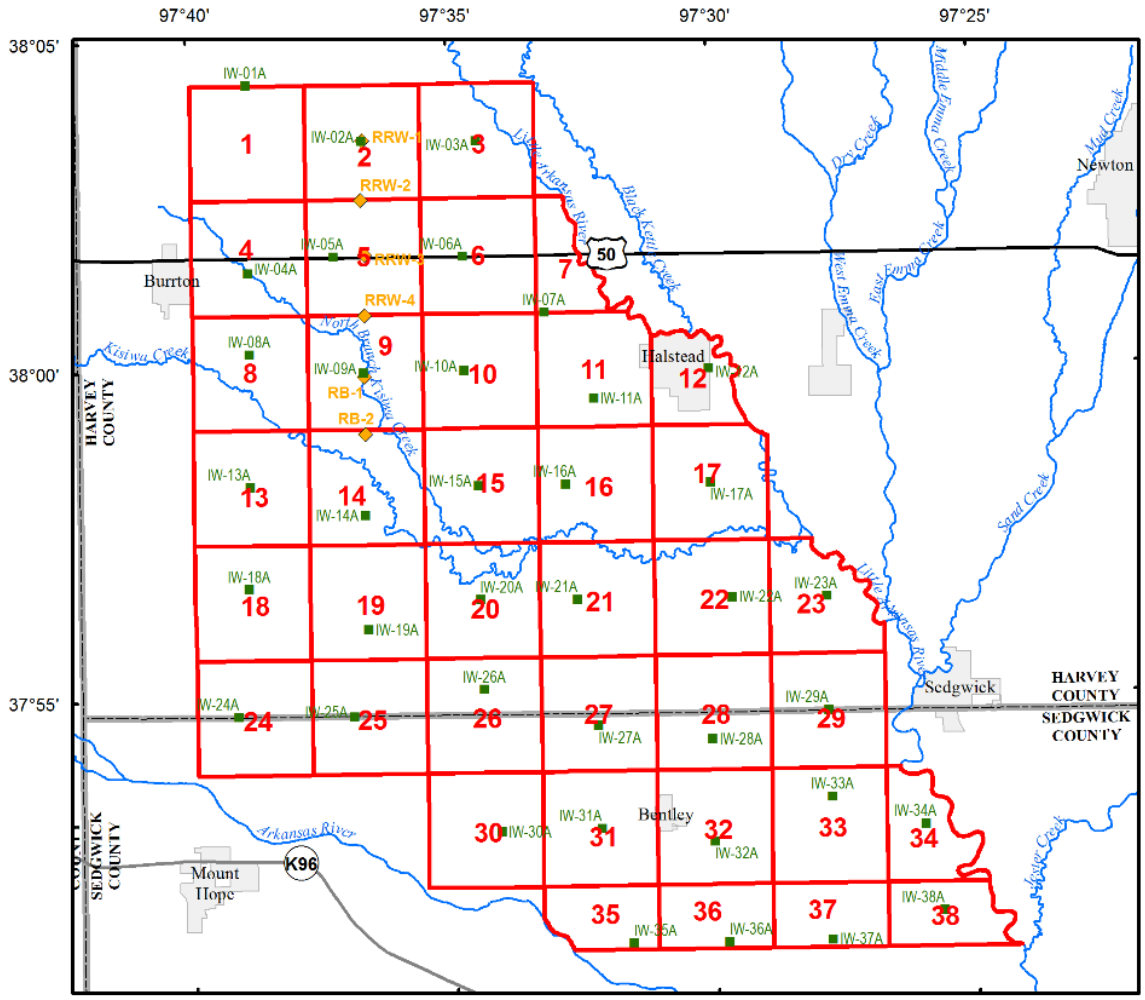
ASR Credits

- Wichita accounts for the artificially recharged water and reports to the state to receive credits that can be withdrawn later.

- "The Model will provide an accounting of the water that resides in each cell and the amount that moves between each cell and out of the basin storage area." - KDA-DWR order on ASR project



Base modified from U.S. Geological Survey
1:100,000-scaled digital data, 2005
Universal Transverse Mercator projection
Zone 14
Horizontal coordinate information is referenced to the
North American Datum of 1983 (NAD83)

0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS

EXPLANATION

22 **Basin storage area (BSA) -- shows index cells and cell numbers**

Index monitoring well

Phase 1 recharge site

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Phase 1 recharge

	2007	2008	2007 through 2008
Artificial recharge (acre-feet)	1121	978	2099
Model calculated storage change in BSA (acre-feet)	973	634	1607
Percent of recharge retained in BSA	87	65	77

Chloride-transport simulations

- Chloride-transport model was added to the existing calibrated flow model.
- Simulated chloride transport from 1990 through 2008.
- Hypothetical scenarios tested include removing all pumping, doubling Wichita pumping from the well field, decreased agricultural pumping, and increased artificial recharge.

Chloride-transport model report and animations

- Follow this link to view the report and/or download video files showing simulated chloride transport in the Equus Beds from 1990 through 2008:

  http://pubs.usgs.gov/of/2014/1162/

Effects of hypothetical scenarios

- Average simulated speed from 1990-2008 of the Burrton plume under actual pumping and artificial recharge conditions was about 0.8 feet/day.
- Doubling Wichita pumping from well field increased rate of Burrton plume migration to about 1.2 feet/day.
- Increasing phase 1 artificial recharge by 2,300 acre-feet/year slowed the plume to about 0.7 feet/day.
- If all pumping is removed, the Burrton chloride plume continues to move about 0.7 feet/day

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Next steps and potential model applications:

- Update all data through 2013+
- Recalibrate model
- Identify (and fill) data-collection needs
- Test additional scenarios
- Artificial recharge accounting
- Optimization of artificial recharge and pumping sites and rates
- Testing strategies for dealing with the plume, such as pumping from the plume

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Questions?

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For more information

http://ks.water.usgs.gov/equus-beds-recharge

Klager, B.J., Kelly, B.P., and Ziegler, A.C., 2014, Preliminary simulation of chloride transport in the *Equus* Beds aquifer and simulated effects of well pumping and artificial recharge on groundwater flow and chloride transport near the city of Wichita, Kansas, 1990 through 2008: U.S. Geological Survey Open-File Report 2014–1162, 76 p., http://dx.doi.org/10.3133/ofr20141162

Selected publications:

- Burrton Task force report and DWR Chief Engineer order issued on June 1, 1984. https://agriculture.ks.gov/docs/default-source/igucas/burrton198406.pdf?sfvrsn=2 and correctional order issued on July 24, 1984 https://agriculture.ks.gov/docs/default-source/igucas/burrtoncorrection198407.pdf?sfvrsn=2
- Klager, B.J., Kelly, B.P., and Ziegler, A.C., 2014, Preliminary simulation of chloride transport in the Equus Beds aquifer and simulated effects of well pumping and artificial recharge on groundwater flow and chloride transport near the city of Wichita, Kansas, 1990 through 2008: U.S. Geological Survey Open-File Report 2014–1162, 76 p., http://dx.doi.org/10.3133/ofr20141162
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- Hansen, C.V., Lanning-Rush, J.L., Ziegler, A.C., 2013, Revised shallow and deep water-level and storage-volume changes in the Equus Beds Aquifer near Wichita, Kansas, predevelopment to 1993: U.S. Geological Survey Scientific Investigations Report 2013-5170, 18 p.
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