Wichita's Equus Beds ASR Experience

Brian Meier
Project Manager

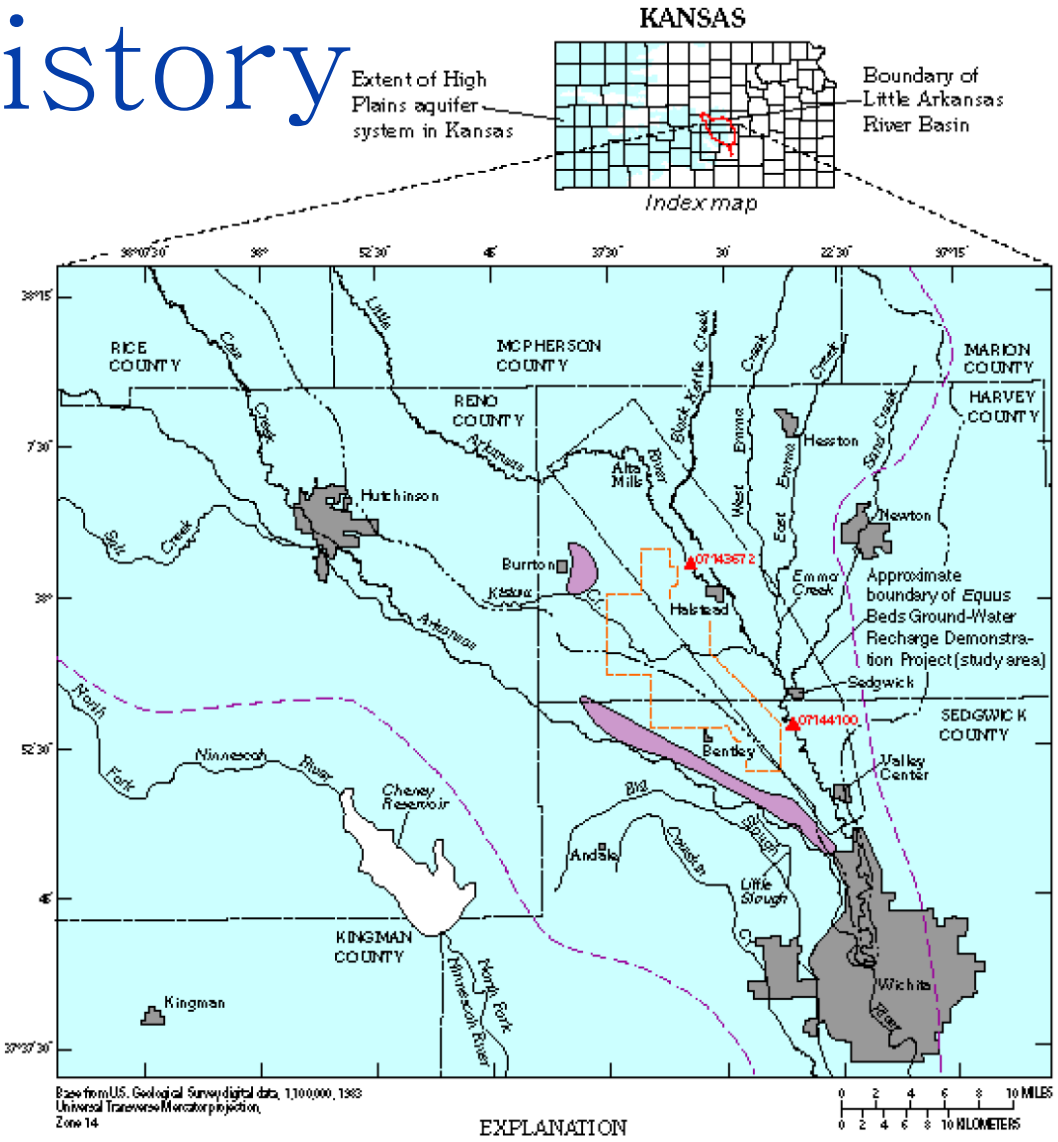
Oklahoma Governor's
Water Conference 2015

Agenda

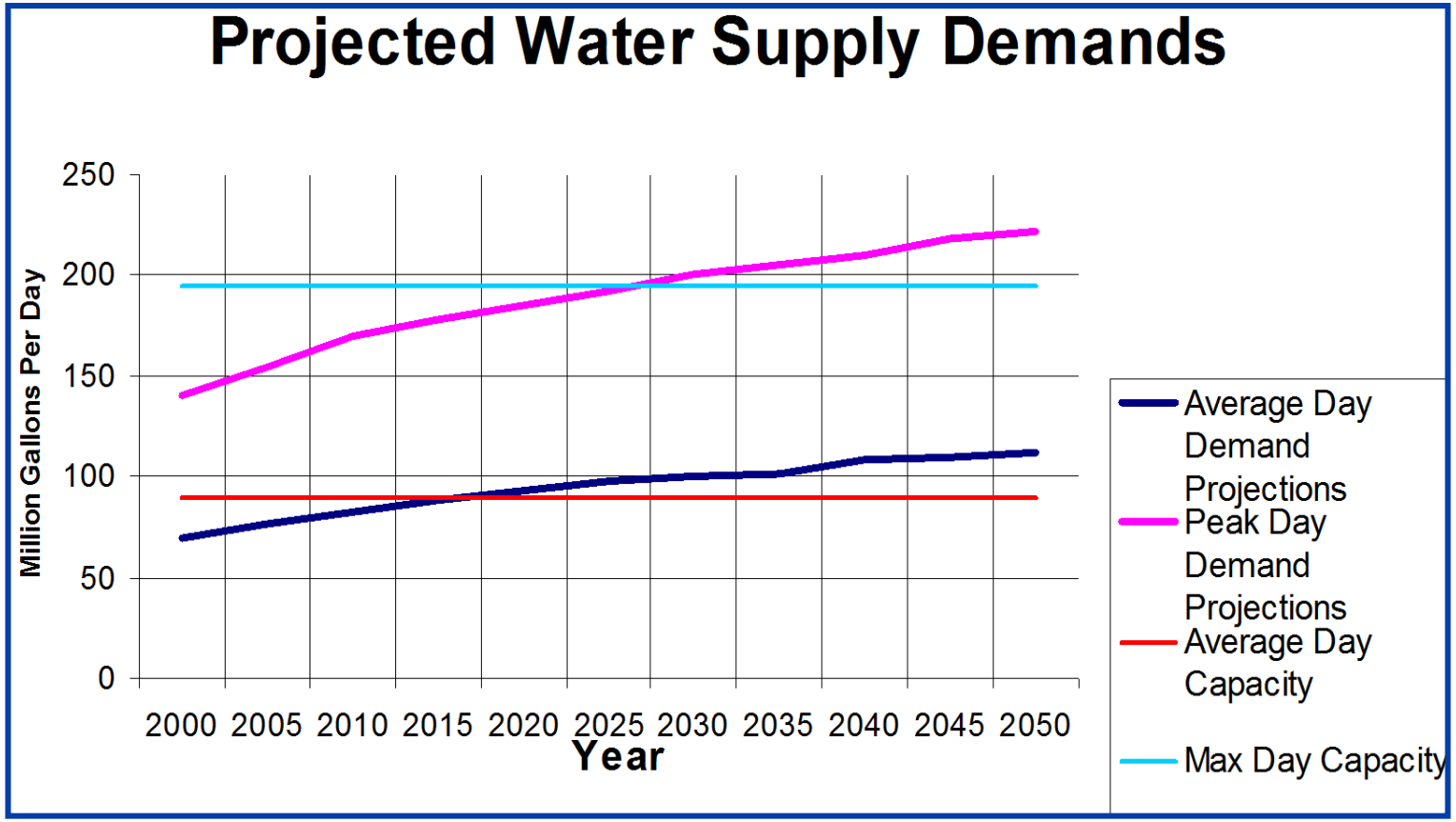
- Brief Program History
- ASR Demonstration Project
- Phase I Overview
- Phase II Overview
  - Wellfield
  - SWTP and Intake
- Results and Continued Work

Program History

- City of Wichita Background Info
  - Largest city in KS
    Pop. 390,000
  - Largest water provider
    125 MGD max.
  - Two main water sources
    Cheney Reservoir
    Equus Beds Aquifer



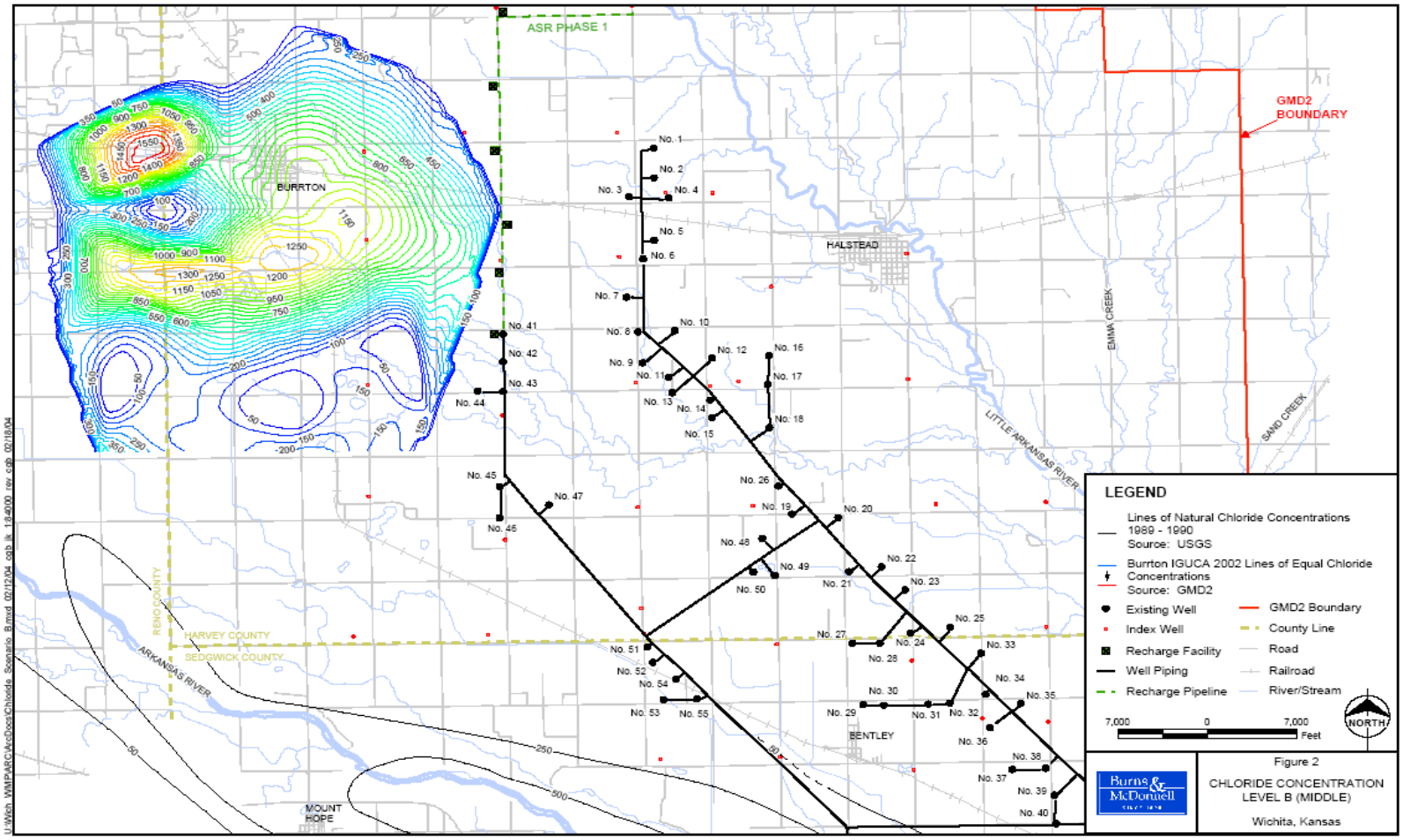
Program History



- City began looking for future water supplies in the 1980s

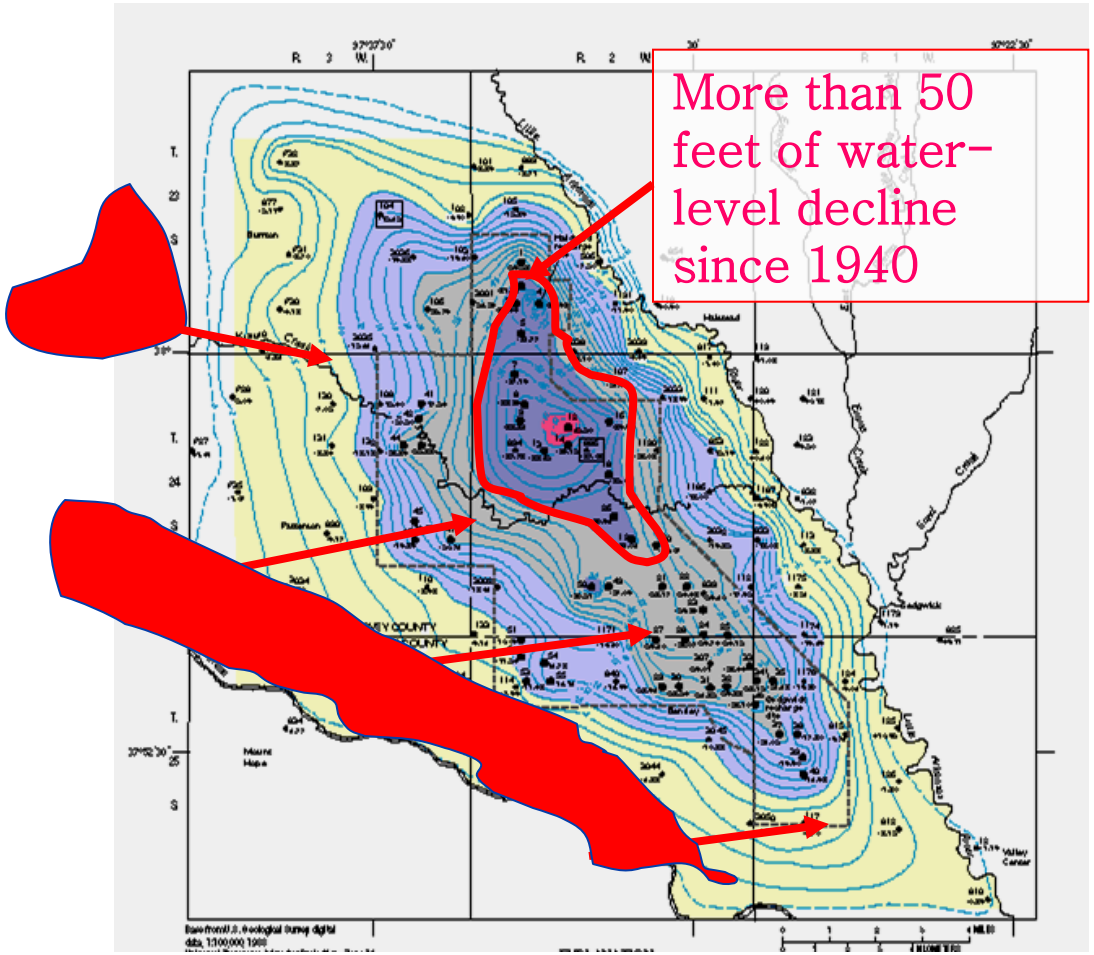
Program History

Chloride Migration Threatens Supply



Program History

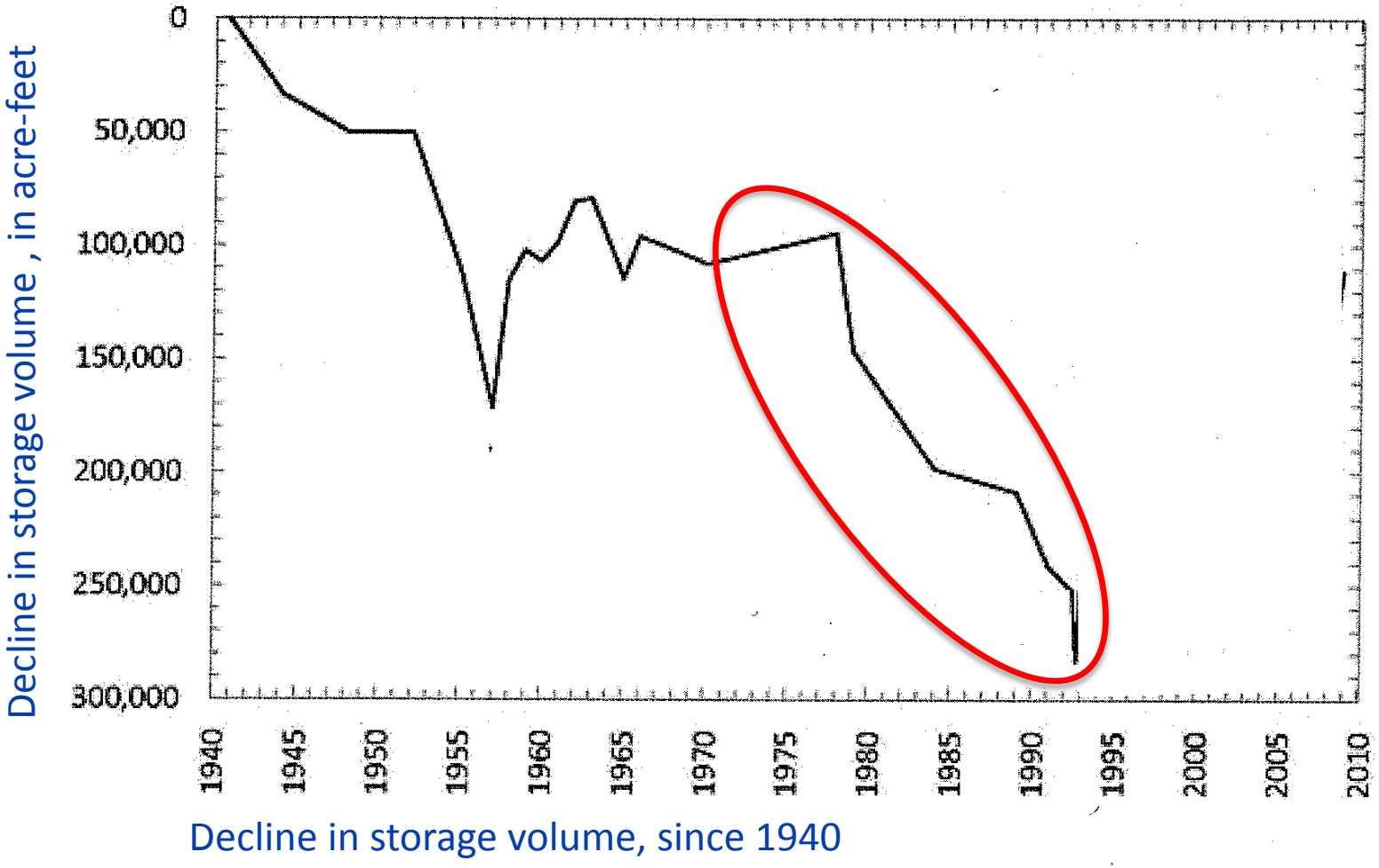
Overuse of the Resource



- Since 1940, agricultural and municipal pumping created a depression encouraging migration of the chloride plumes toward the well field

Program History

Overuse of the Resource – Municipal & Agriculture



Program History

Integrated Local Water Supply Plan (ILWSP)

- 27 water supply alternatives evaluated
- Approved in 1993 to meet the City's needs through 2050

- Major Recommendations:
  - Change strategy to 60% surface / 40% well water
  - Implement ASR to develop a sustainable groundwater resource

Program History

Challenges of an ASR Project

- Historical/Regulatory Challenges
  - 1st ASR project in Kansas
  - No regulations in place to administer an ASR project
  - Water rights and accounting considerations
  - No regulations in place for Bank Storage Wells

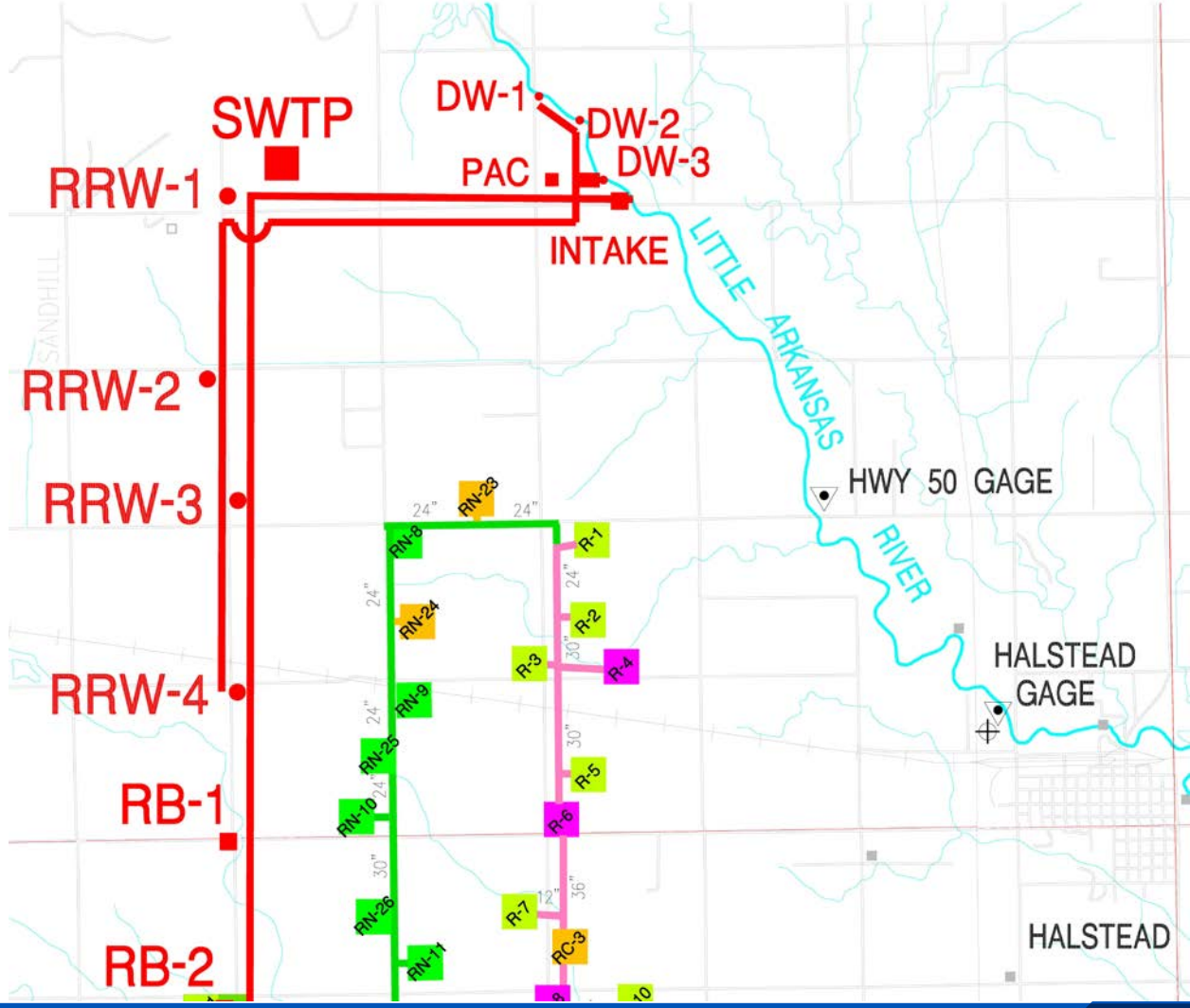
Program History

ASR Demonstration Project

- Activities through Oct. 1999
  - Worked with DWR & GMD2 to develop regulations
  - Evaluated treatment technologies
  - Evaluated recharge techniques
    - Basins
    - Wells
    - Trenches
  - Evaluated water capture techniques
    - Direct SW diversion
    - Bank storage wells
  - Public update meetings
  - Began conceptual design of full-scale recharge and recovery system

ASR Phase I Overview

- 1999–2006
- Developed regulations
- Local, regional, & state involvement
- Public outreach
- Water sources
  - Surface water intake
  - 3 Diversion wells
- Recharge points
  - 4 Recharge wells
  - 2 Recharge basins
- Slow migration of chloride plume



Surface Water Intake

Capture Wet Weather Flows Directly from River

Phase I Water Treatment

PAC Pretreatment to Remove Atrazine from Surface Water

- Surface water treatment plant to treat to Drinking Water Standards

ASR Phase I Overview

Bank Storage Wells

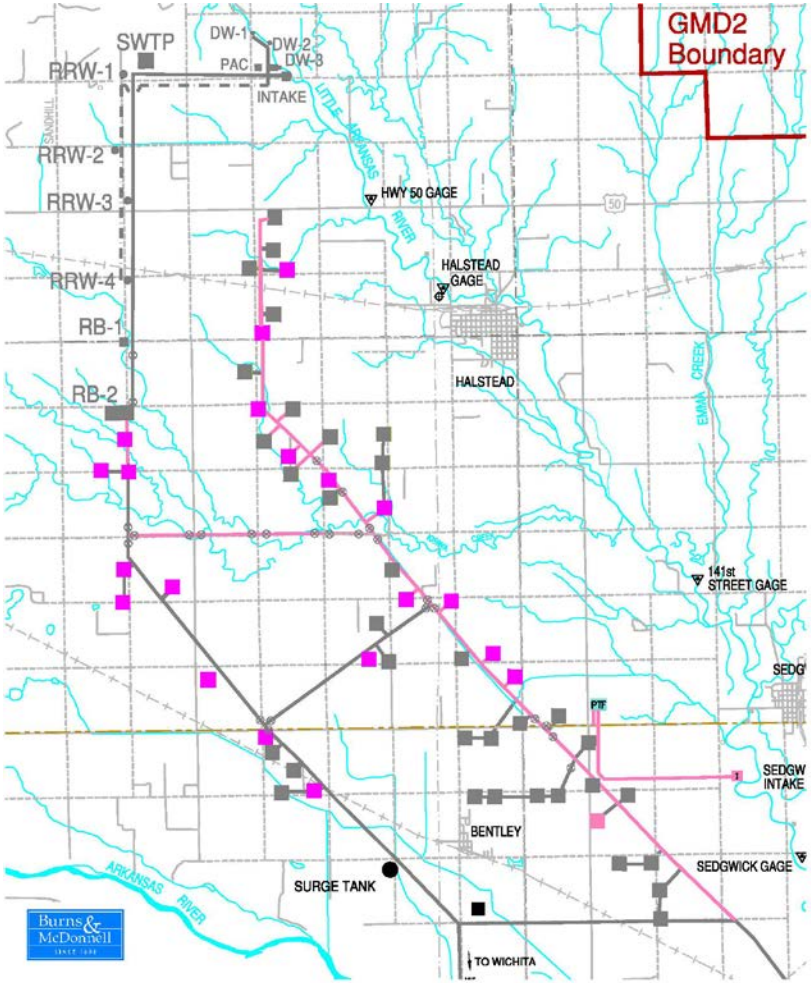
Recharge Basins

Recharge Recovery Wells (RRWs)

ASR Phase II Overview

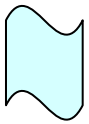
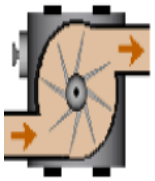
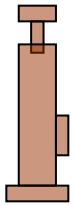
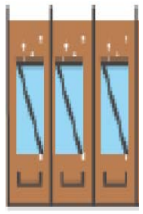
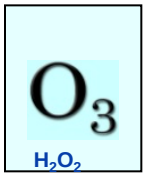
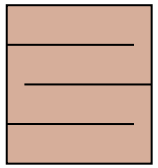
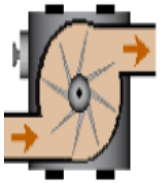
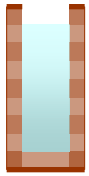
Above-base Flow, Treatment, Aquifer Recharge

- Above-base flow captured at surface water intake
- Treatment at SWTP to Drinking Water Standards
- 30 MGD Capacity
- Recharge to Aquifer
  - 30 RRWs
  - 1 Recharge basin



Phase II Overview – SWTP & Intake

General Process

Little Arkansas River	Intake	Presedimentation	Strainers	Membrane Ultrafiltration	Advanced Oxidation Process	Clearwell	Pump Station	Recharge Wells
								
Divert Water from River	Remove Solids	Remove Solids	Remove Solids, Bacteria, and other small organisms	Inactivate Viruses, remaining bacteria and destroy atrazine	Store Finished Water	Pump to Recharge Wells	Aquifer Recharge	

Phase II Overview – Intake

Divert Water from Little Arkansas River

Little Arkansas River | **Intake** | Presedimentation | Strainers | Membrane Ultrafiltration | Advanced Oxidation Process | Clearwell | Pump Station | Recharge Wells

Phase II Overview – Intake

Remove Solids

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

Pump Station

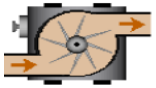
Recharge Wells

Phase II Overview – SWTP

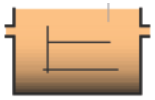
Remove Solids

Little Arkansas River

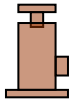
Intake



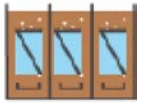
Presedimentation



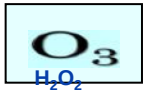
Strainers



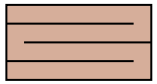
Membrane Ultrafiltration



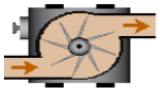
Advanced Oxidation Process



Clearwell



Pump Station



Recharge Wells

Phase II Overview – SWTP

Phase II Overview – SWTP

Remove Solids, Bacteria, and Other Small Organisms

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

Pump Station

Recharge Wells

Phase II Overview – SWTP

Inactivate Viruses, Remaining Bacteria & Destroy Atrazine

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

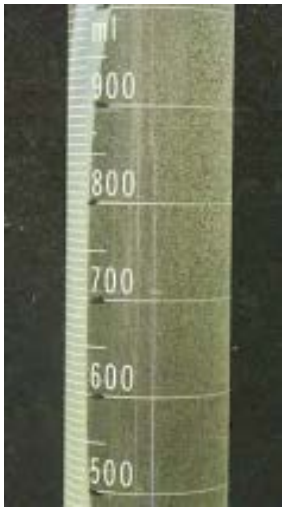
Pump Station

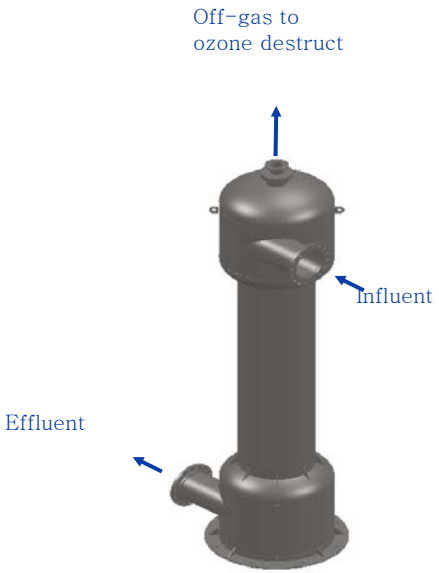
Recharge Wells

Phase II Overview – SWTP

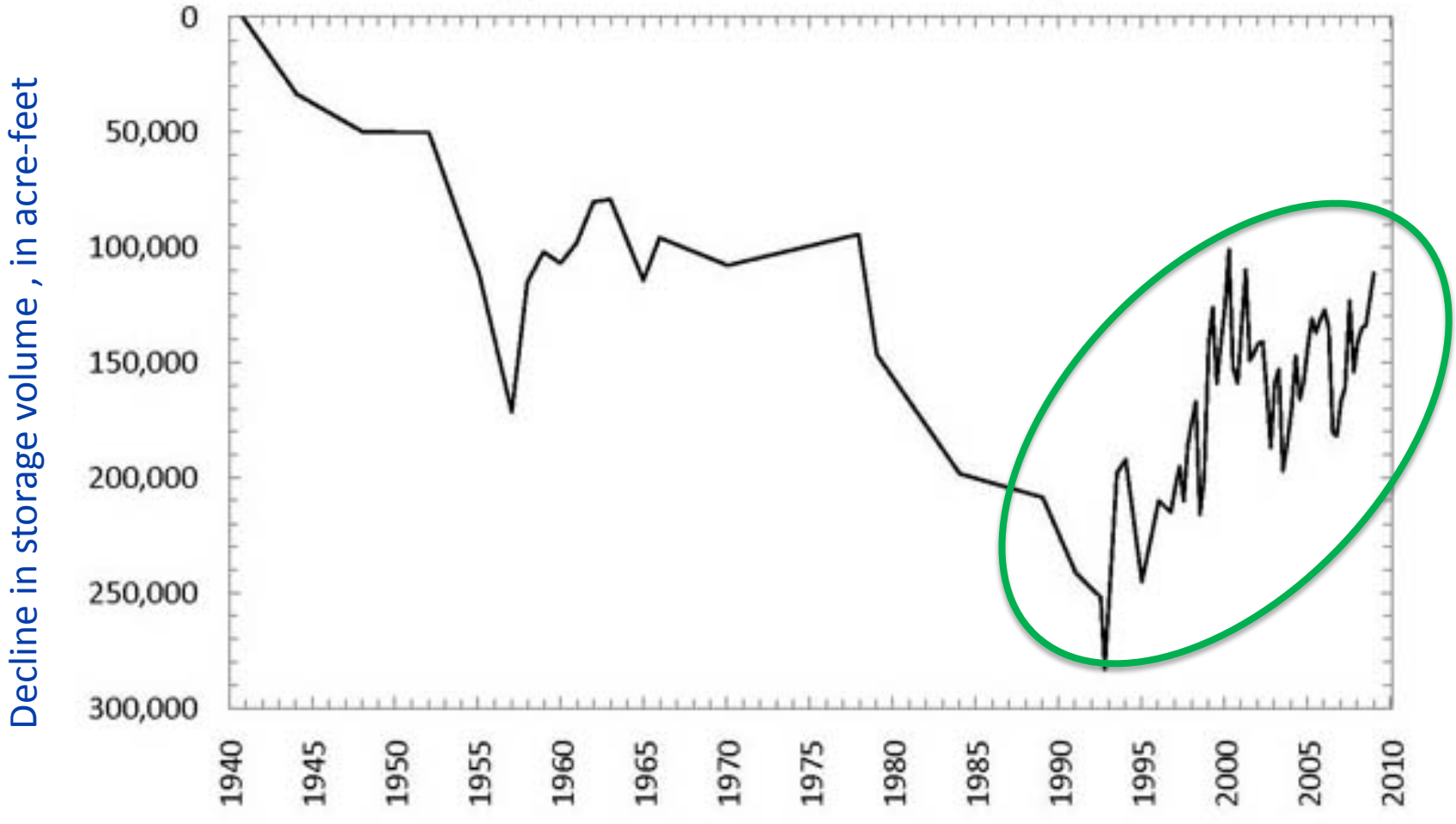
Major Treatment Processes – AOP

- Degasifiers
  - Untransferred oxygen/ozone
  - Slow separation due to very small bubbles
  - 2-Phase Flow Concerns





ILWSP Plan & ASR Results



Future Phases of Wichita ASR

- Additional recharge/recovery wells
- Bank storage sells
- Continued administrative review and modification
- Continued optimization of plant and well operations

Wichita ASR Today

- ASR Phase One and Two constructed
- To date – more than two billion gallons (over 6,100 AF) have been recharged
- Continue to evaluate projected demands and utilization of all water resources
- Continued review and discussion of regulatory framework


BURNS McDONNELL
SM

Recharge Recovery Wells (RRWs)

- Recharge Diversion Well Water in the Aquifer & Form Hydraulic Barrier from Chloride Plumes

RIVER DIVERSION WELL

Capture Bank Storage Water From the Aquifer

RECHARGE BASIN

Recharge Surface and Diversion Well Water in the Aquifer & Form Hydraulic Barrier from Chloride Plumes

Phase II Overview – SWTP & Intake

Goals

- Solids/sediment removal
- Atrazine removal
- Mitigation of bromate formation
- Treated to potable water standards
- Treatment Goals

Raw Water

Parameter	Max
Turb (NTU)	1000
Atrazine (ug/L)	20
Bromide (mg/L)	0.3
TOC (mg/L)	20

Membrane Goals

Recovery (%)	90.0
Max. Net Flux (gfd)	39.5
Turbidity (NTU)	<1

AOP Goals

Parameter	Influent	Effluent
pH	7	6 to 9
Atrazine (ug/L)	20	<3
Bromide (mg/L)	0.3	N/A
Bromate (mg/L)	N/A	<0.01
Virus Inactivation	4-Log Reduction	

Finished Water

Parameter	Max
Turb (NTU)	<1
Atrazine (ug/L)	<3
Bromate (ug/L)	<10
Crypto	2-log
Giardia	3-log
Virus	4-log

Phase II Overview – Intake

Divert Water from Little Arkansas River

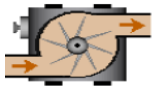
Little Arkansas River | **Intake** | Presedimentation | Strainers | Membrane Ultrafiltration | Advanced Oxidation Process | Clearwell | Pump Station | Recharge Wells

Phase II Overview – Intake

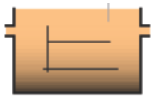
Remove Solids

Little Arkansas River

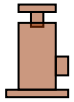
Intake



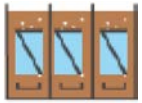
Presedimentation



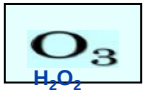
Strainers



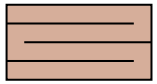
Membrane Ultrafiltration



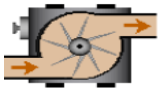
Advanced Oxidation Process



Clearwell



Pump Station



Recharge Wells

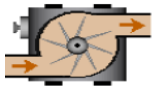
Phase II Overview – SWTP

Phase II Overview – SWTP

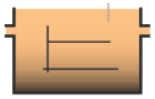
Remove Solids

Little Arkansas River

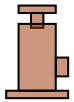
Intake



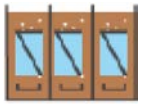
Presedimentation



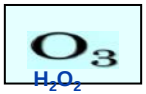
Strainers



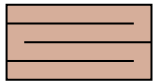
Membrane Ultrafiltration



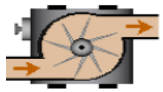
Advanced Oxidation Process



Clearwell



Pump Station



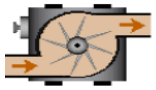
Recharge Wells

Phase II Overview – SWTP

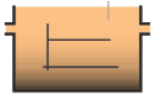
Remove Solids, Bacteria, and other small organisms

Little Arkansas River

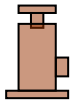
Intake



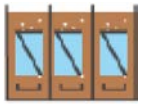
Presedimentation



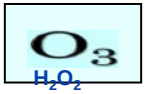
Strainers



Membrane Ultrafiltration

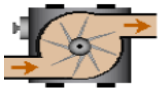


Advanced Oxidation Process



Clearwell

Pump Station

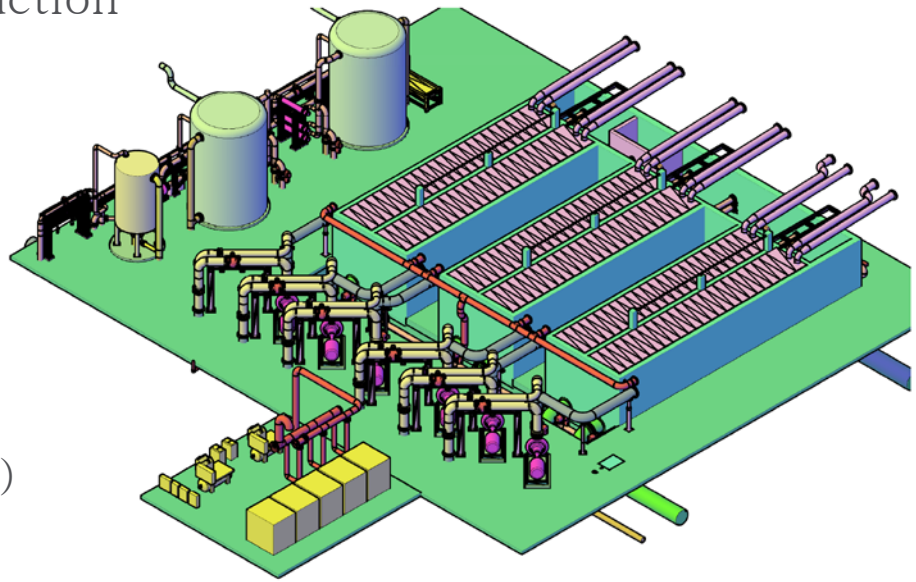


Recharge Wells

Phase II Overview – SWTP & Intake

Major Treatment Processes – Membranes

- Ultrafiltration, GE Zenon Zee-Weed 500d, 0.04 micron
- Membranes are submerged, under suction
- 6 Trains
- 7 Cassettes/Train
- 36 Modules/Cassette
- = ~2 million total fibers
- 1,140,480 ft^2 total surface area
- Cleaning is critical
  - Sodium hypochlorite cleaning (organics)
  - Citric acid cleaning (inorganics)
  - Air scour
  - Backpulsing
  - Long-term storage for intermittent operations



Phase II Overview – SWTP & Intake

Major Treatment Processes – Membranes

- Permeate Pumps

Phase II Overview – SWTP

Inactivate Viruses, remaining bacteria & destroy atrazine

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

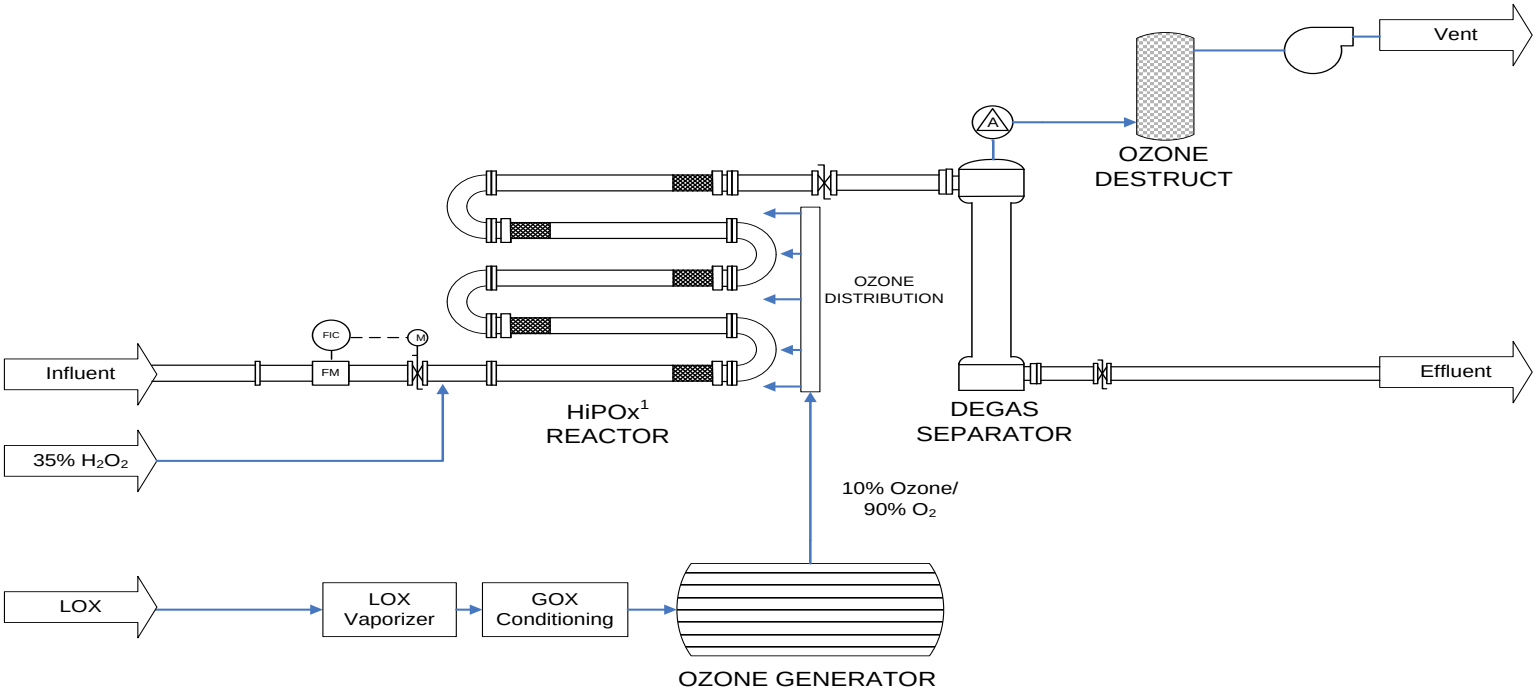
Pump Station

Recharge Wells

Phase II Overview – SWTP

Major Treatment Processes – AOP

- Advanced Oxidation Process
- Ozone and Hydrogen Peroxide (Per-ozone)



Phase II Overview – SWTP

Major Treatment Processes – AOP

- Destroys atrazine while limiting bromate formation

AOP REACTION PROCESS

Destruction of Atrazine

$$Organics \xrightarrow{OH^-} Intermediates \xrightarrow{OH^-} CO_2 + H_2O$$

Production of Hydroxyl Radicals using Hydrogen Peroxide and Ozone (35% H_2O_2 and 10% O_3/90% O_2)

$$O_3 + 0.5H_2O_2 \longrightarrow OH^{\bullet} + 1.5O_2$$

Bromate Formation

$$Br^- + O_3 \longrightarrow {}^-OBr + O_2 \xrightarrow{O_3} BrO_2^- \xrightarrow{O_3} BrO_3^-$$

(limit –OBr Formation)

$${}^-OBr + H_2O_2 \longrightarrow Br^- + H_2O + O_2$$

(revert –OBr back to Bromide)

–OBr = hypobromide

Phase II Overview – SWTP

Major Treatment Processes - AOP

- Ozone Generator (4,100 PPD)

Phase II Overview – SWTP

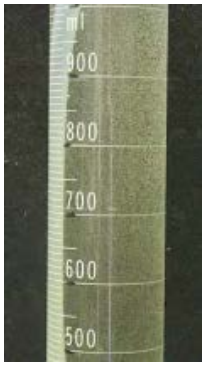
Major Treatment Processes - AOP

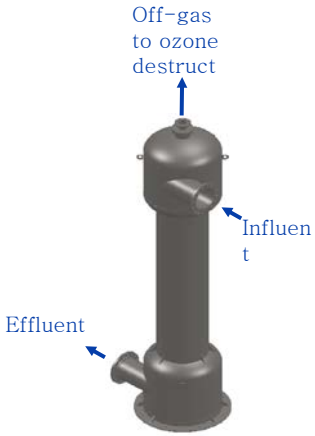
- Ozone Destruct (Thermal/Catalytic)

Phase II Overview – SWTP

Major Treatment Processes – AOP

- Degasifiers
  - Untransferred oxygen/ozone
  - Slow separation due to very small bubbles
  - 2-Phase Flow Concerns





Phase II Overview – SWTP

Finished Water Storage

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

Pump Station

Recharge Wells

Phase II Overview – SWTP

Transfer Water to Aquifer

Little Arkansas River

Intake

Presedimentation

Strainers

Membrane Ultrafiltration

Advanced Oxidation Process

O_3

H_2O_2

Clearwell

Pump Station

Recharge Wells

Phase II Overview – Recharge

RRW Drilling

Phase II Overview – Recharge

RRW Construction

Phase II Overview – Recharge

30 RRWs Added

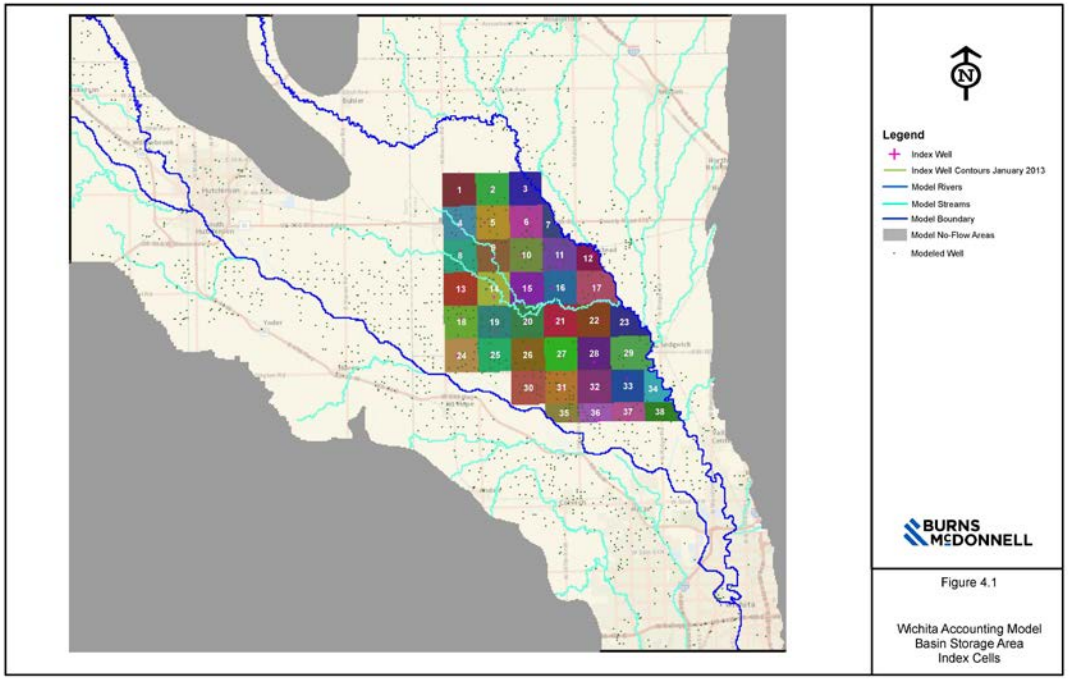
- 30 MGD Tested Production Rate
- 46.4 MGD Tested Recharge Rate
  - Varies with water level

Phase II Overview – Recharge

Recharge Basin 36

Continued Work

1991 – Present



- Process Startup & Operations
  - Why Ty isn't here today
- Process Optimization
  - AOP dosages drastically reduced
  - Membrane cleaning optimization
  - Recharge well modifications, maintenance and optimization
- Continued Enhancement Evaluation
- Regulatory Modifications
- Annual Groundwater Modeling & Recharge Accounting

Successes

- 1997 KCA Public Works Award – Demonstration Project
- 1999 ACEC Engineering Excellence Award – Demonstration Project
- 1999 MO-CEC Excellence Award – Demonstration Project
- 2000 KSPE Achievement Award – Demonstration Project
- 2000 Wichita SPE Achievement Award – Concept Design
- 2011 DBIA Best Project Award – Phase II SWTP & Intake
- 2012 AGC Award of Honor – Phase II SWTP & Intake
- 2015 ACEC National Recognition Award – Phase II SWTP & Intake
- 2015 Global Water Intelligence Award Finalist – Phase II