

Aquifer Storage and Recovery and Managed Aquifer Recharge throughout Texas: Planning for the Future

*Austin Geological Society Meeting
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Introduction

- Surface water reservoirs have historically allowed water to be stored when abundant and then utilized when needed
- While the population of Texas has grown, the availability of surface water storage has not
- In 2019, Texas Legislature directed the Texas Water Development Board (TWDB) to conduct a studies of aquifer storage and recovery (ASR) projects and managed aquifer recharge (AR) projects
- The 2021 Draft State Water plan shows that 11 out of 16 Regional Water Planning Areas have ASR or AR included as recommended Water Management Strategies

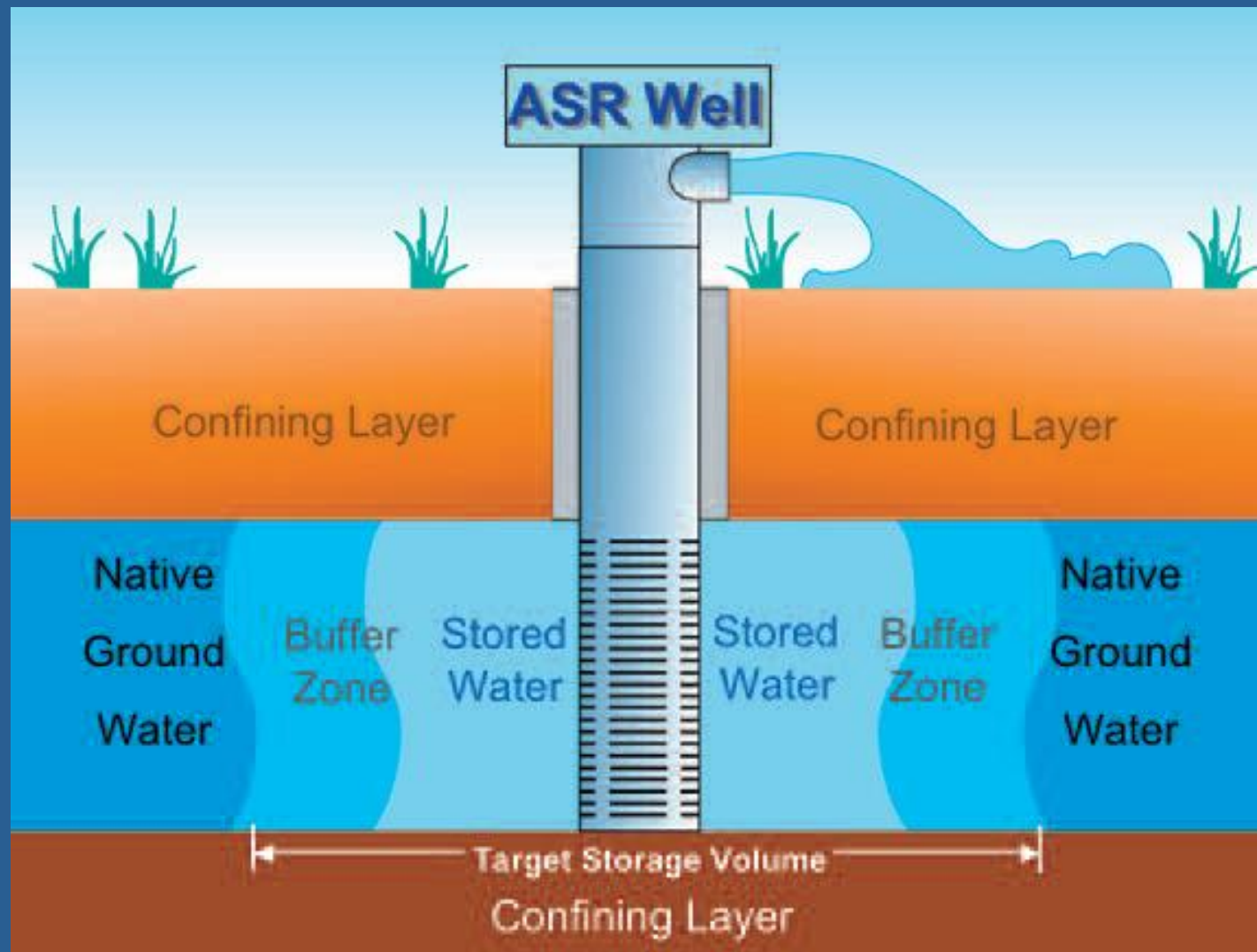
Introduction – House Bill 721

- In 2015, the Texas Legislature appropriated funds and directed the TWDB to provide grant support for demonstration projects and/or feasibility studies increase water availability through innovative storage approaches
- This grant funding supported three recently completed ASR demonstration projects for Corpus Christi, New Braunfels, and Victoria
- In 2019, the Texas Legislature, through House Bill 721, tasked the TWDB with determining the feasibility of using Texas aquifers for ASR and AR.
- This legislation outlined specific analyses to be included in the statewide survey of relative suitability, including considerations for hydrogeological characteristics, the availability of excess water for potential storage, and the current and future water supply needs

Introduction – ASR

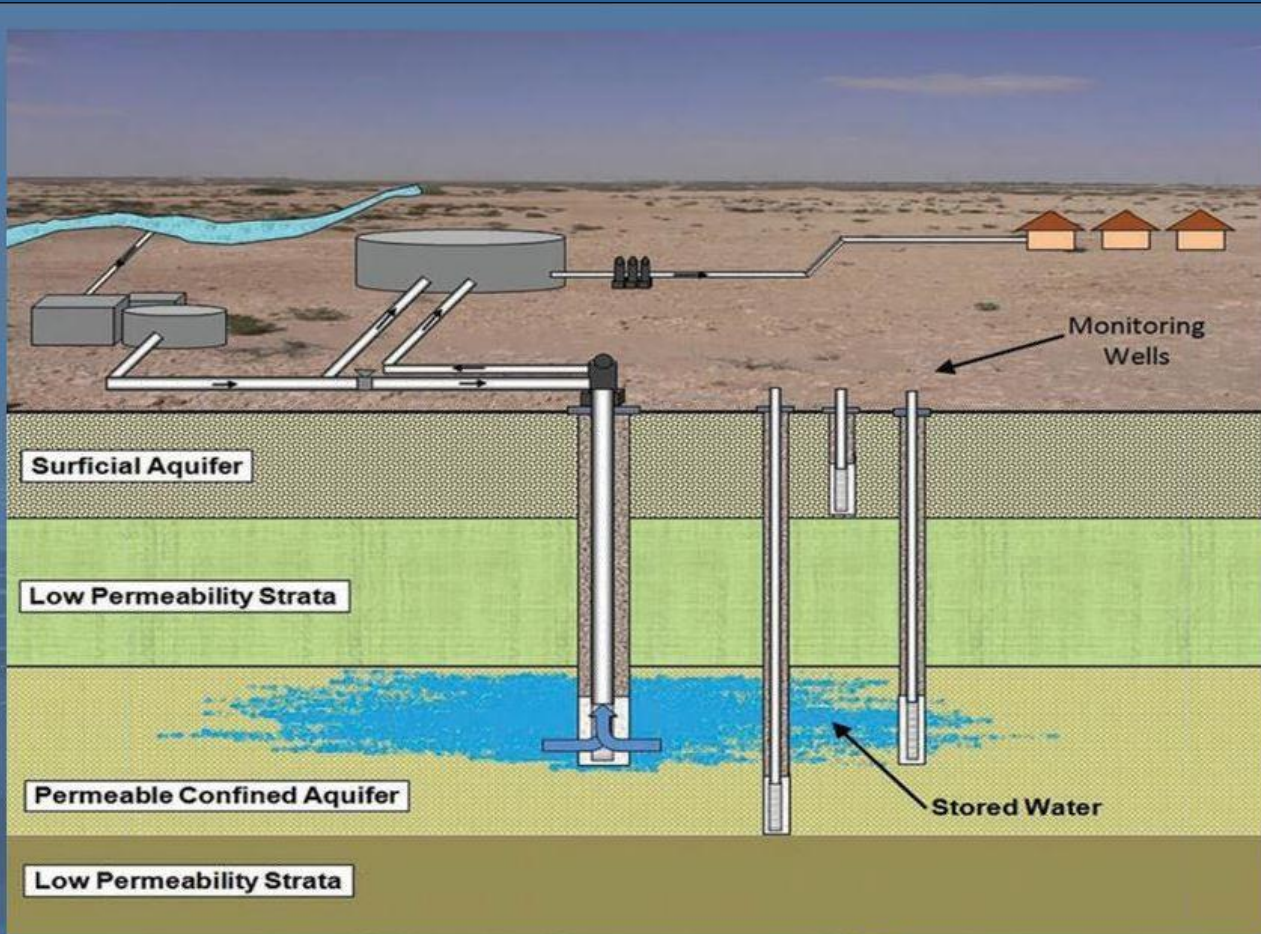
Aquifer Storage and Recovery (ASR)

- Storage of water in an aquifer and recovery of that water for beneficial use
- Source water can be reclaimed, groundwater, or surface water
- The same well to retrieve the water or use another well at different location
- When a different well is used for recovery it is sometimes referred to as Aquifer Storage, Transit, and Recovery (ASTR)



From NGWA

Introduction – ASR



Components of an ASR System

(Intentionally simplified for reference)



ASR Projects usually require

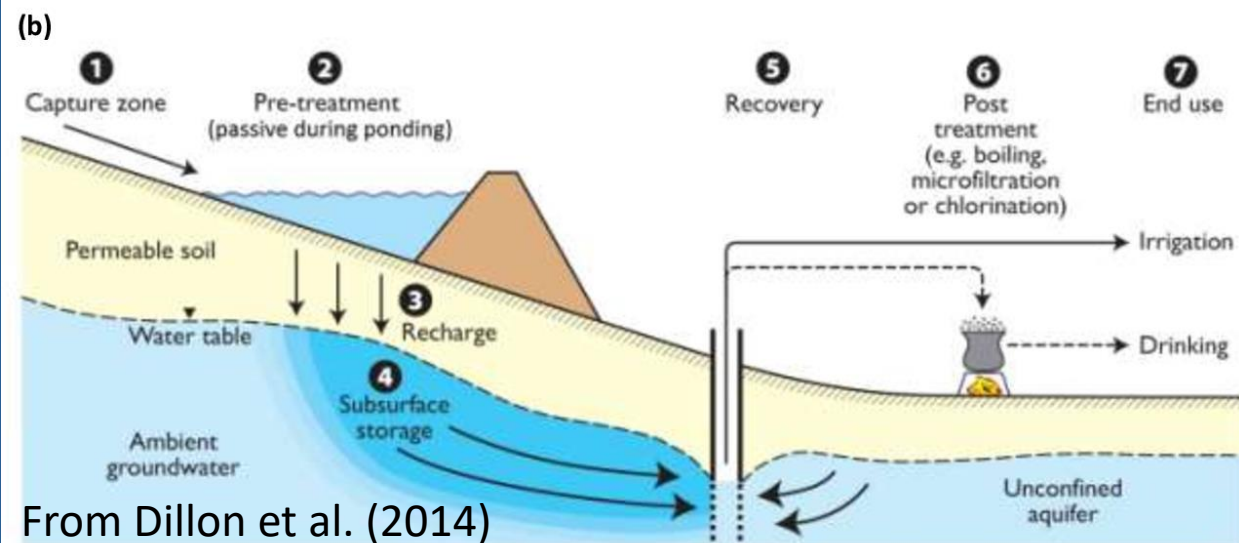
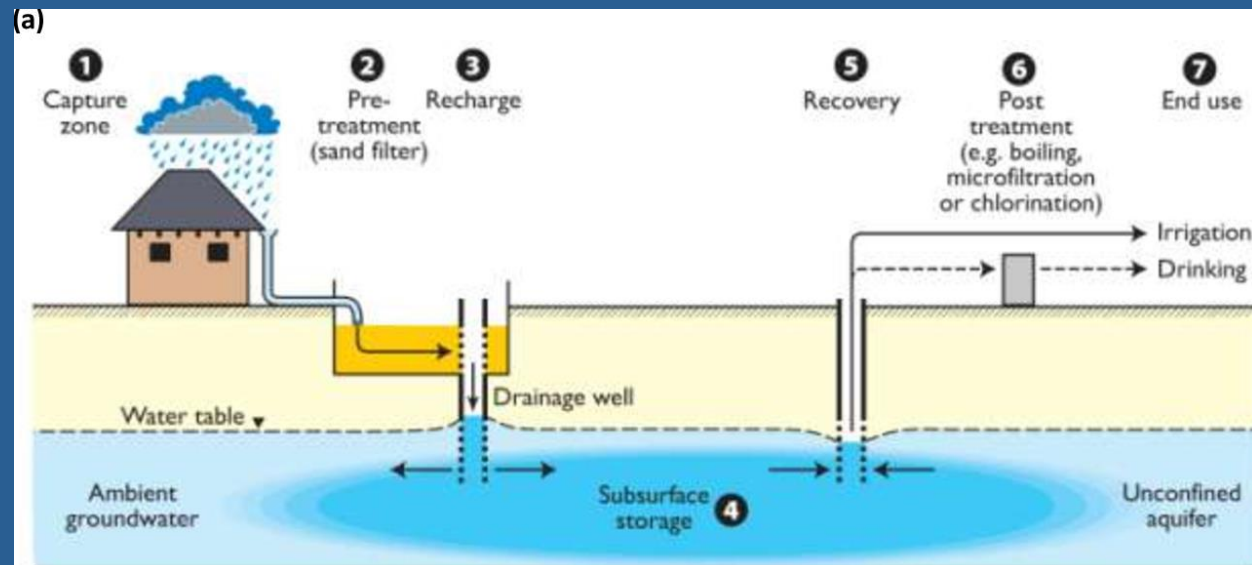
- New water right/permit
- Injected water point source
 - New surface water intakes
 - Diversion and control structures
 - Production wells
- Conveyance/transmission pipelines
- Wells/wellfields
 - Production
 - Injection
 - Recovery
- Water treatment plant
 - Expansions
 - New builds
- Pump stations
- Storage tanks

From NGWA

Introduction – MAR or AR

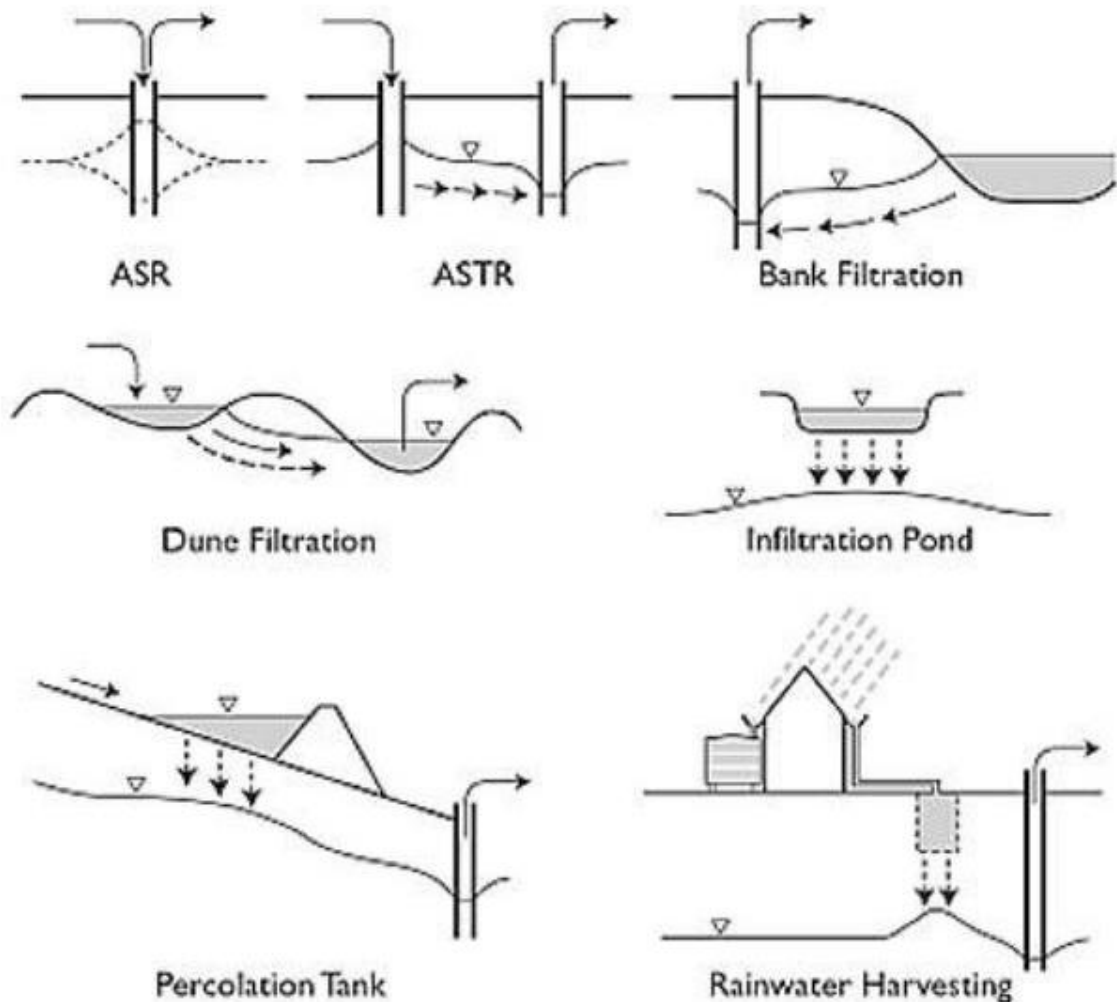
Managed Aquifer Recharge (MAR or AR)

- Intentional recharge of an aquifer without an injection well
- Commonly uses infiltration basins or gravity-fed vadose wells
- Source water can be reclaimed, groundwater, or surface water
- Implementation is often site-specific
- May be done to reduce water level decline; supplement available groundwater; improve water quality; improve spring flows; or mitigate subsidence



From Dillon et al. (2014)

Introduction – MAR or AR

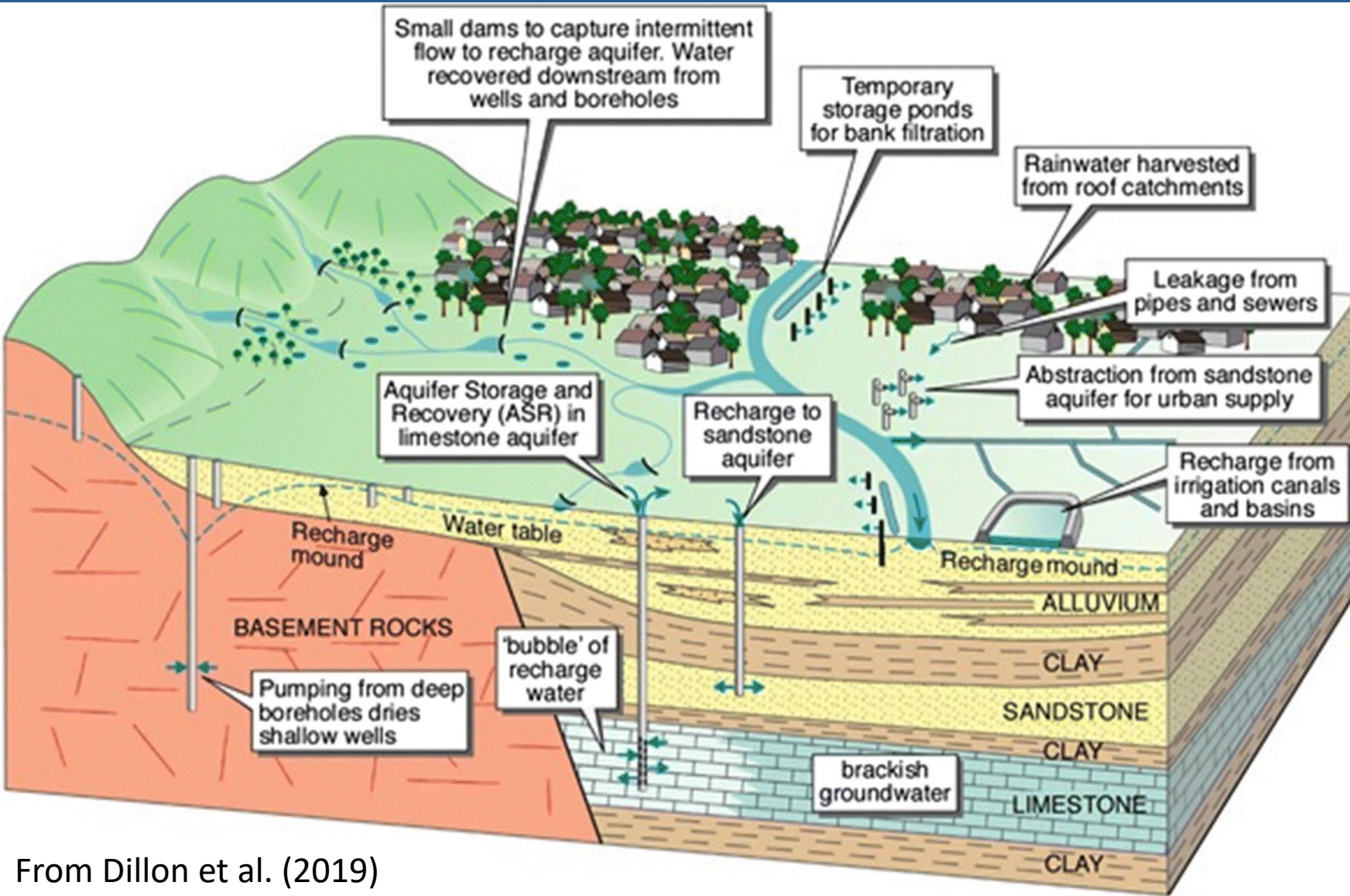


AR Project Forms

- Spreading methods
 - Infiltrations ponds or basins
 - Flooding
 - Ditch or furrow development
 - Irrigation
- Induced bank infiltration
- Channel modification or diversion
 - Recharge dams
 - Sand dams
 - Channel spreading
- Runoff harvesting
 - Barriers
 - Trenches
- Reclaimed water reuse
 - Treatment effluent
 - Wastewater

Most common MAR techniques (Gale and Dillon 2005) ASR: Aquifer Storage and Recovery; ASTR: Aquifer Storage Transfer and Recovery

Introduction (cont.)



Feasibility Studies

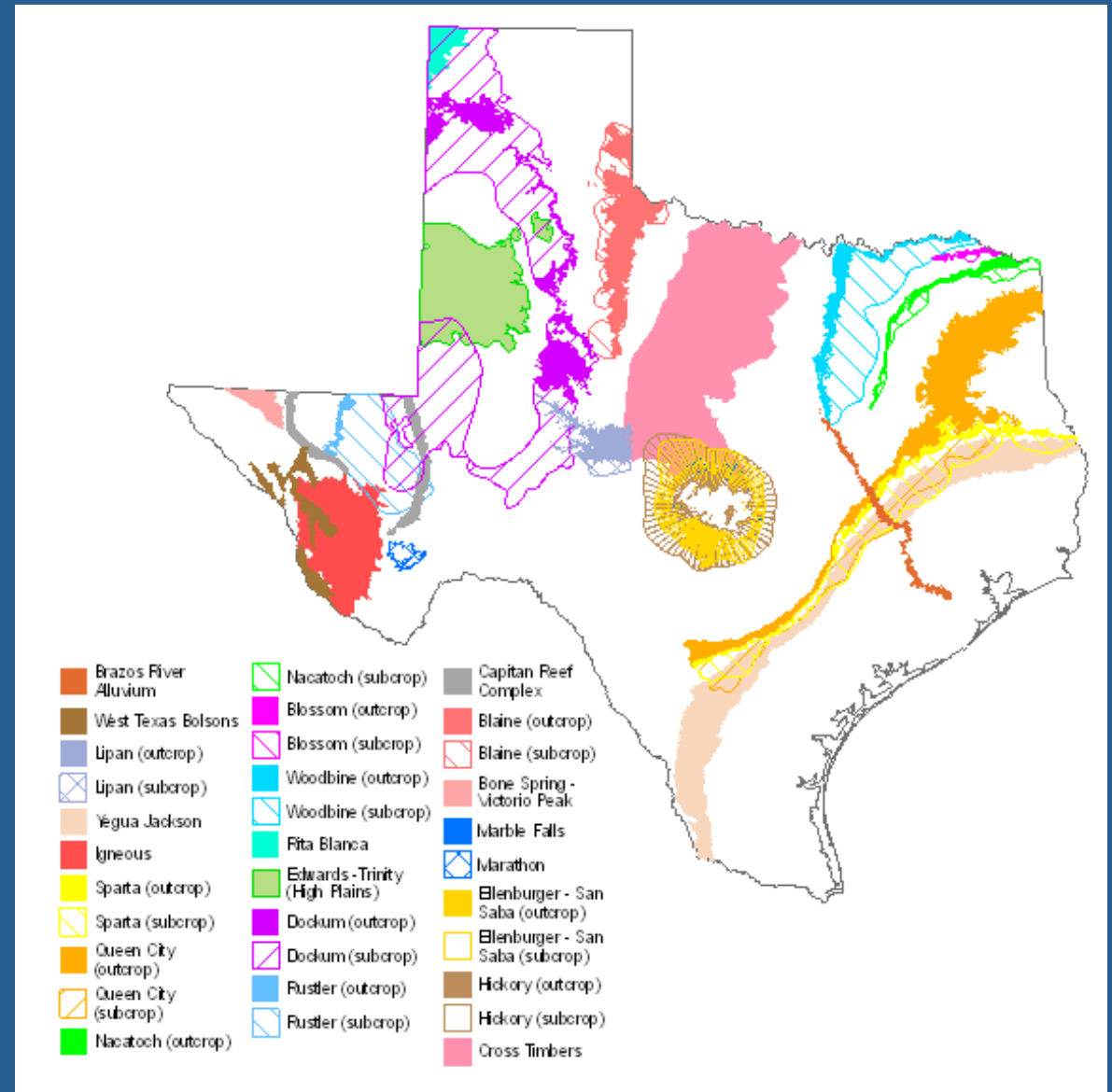
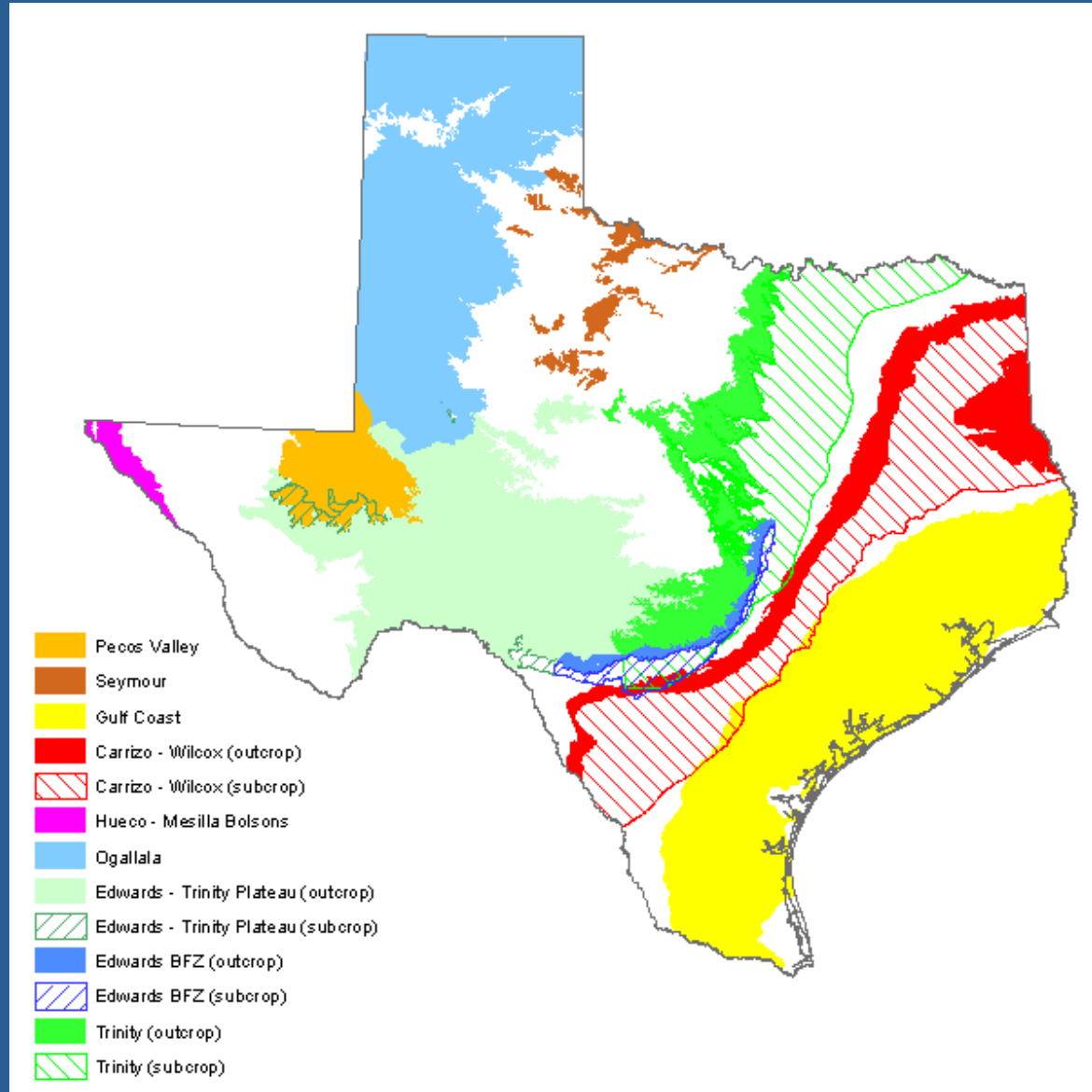
- Hydrologic Characteristics
 - Storage
 - Recharge
 - Recoverability
 - Water Quality
- Excess water
 - Surface Water
 - Reclaimed Water
 - Groundwater
 - Water Quality
- Needs
 - Municipal
 - Industrial
 - Agricultural
 - Environmental

From Dillon et al. (2019)

Implementation of ASR and AR Projects

- Implementation of ASR or AR projects regulated by the Texas Commission on Environmental Quality (TCEQ)
 - <https://www.tceq.texas.gov/>
- All utilities that plan to begin an ASR project must submit an application to TCEQ
 - “Application for Class V Underground Injection Control (UIC) Wells for an Aquifer Storage and Recovery (ASR Project)”
- All utilities that plan to begin an AR project must secure water rights and apply for any necessary discharge permits
 - May include surface water diversion, wastewater discharge, or rainwater harvesting

Implementation (cont.)

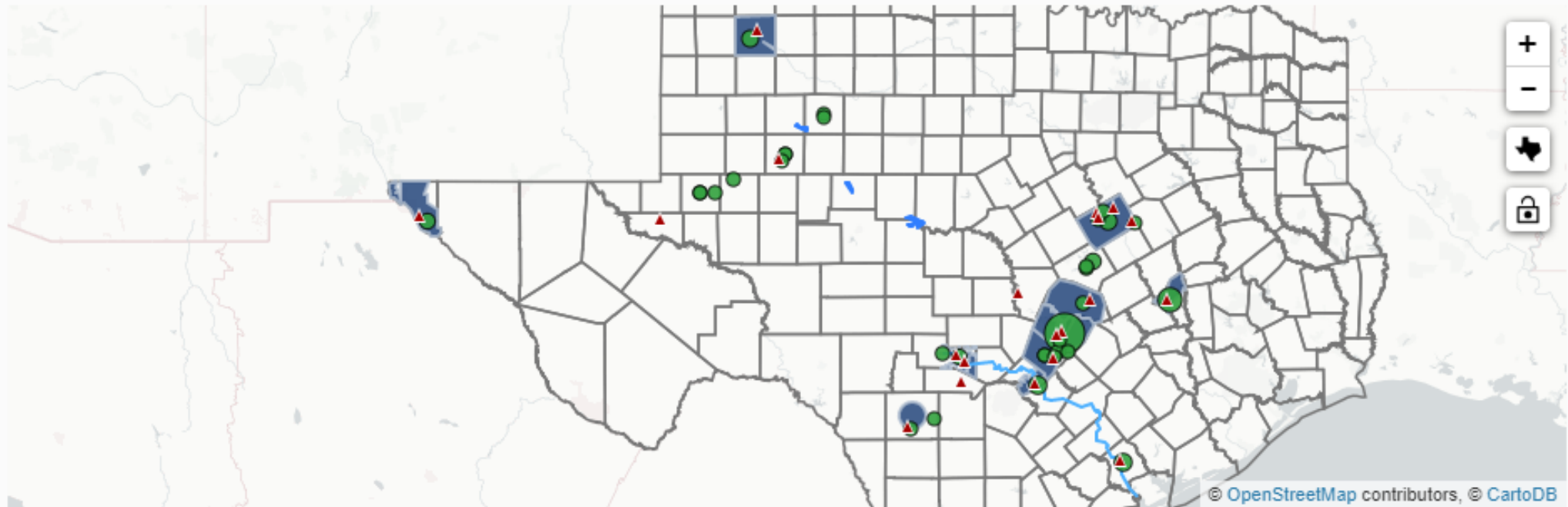


Texas State Water Plan

Data by Planning Decade

Decade: 2020 2030 2040 2050 2060 2070

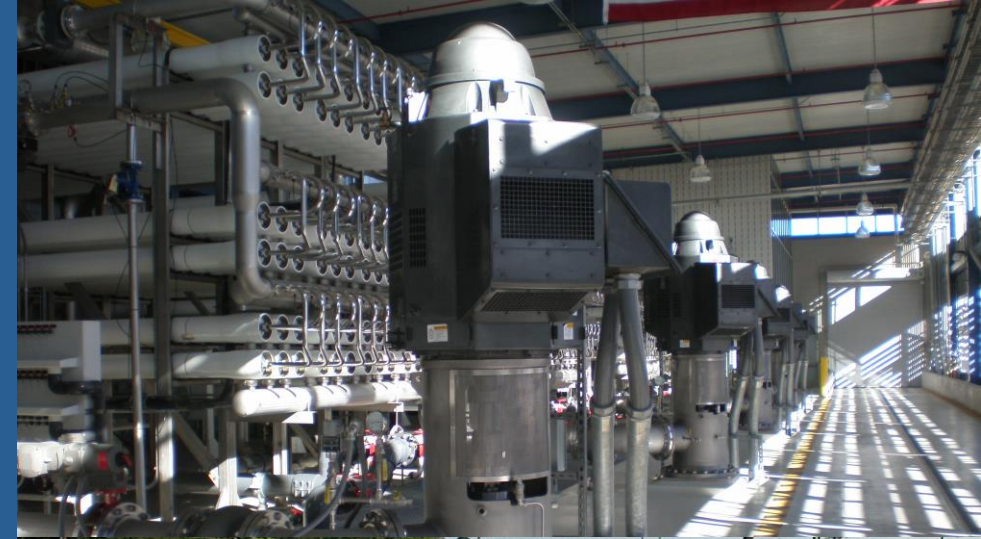
WMS TYPE - AQUIFER STORAGE & RECOVERY
Water User Groups - 2070 - Strategy Supplies (acre-feet/year)



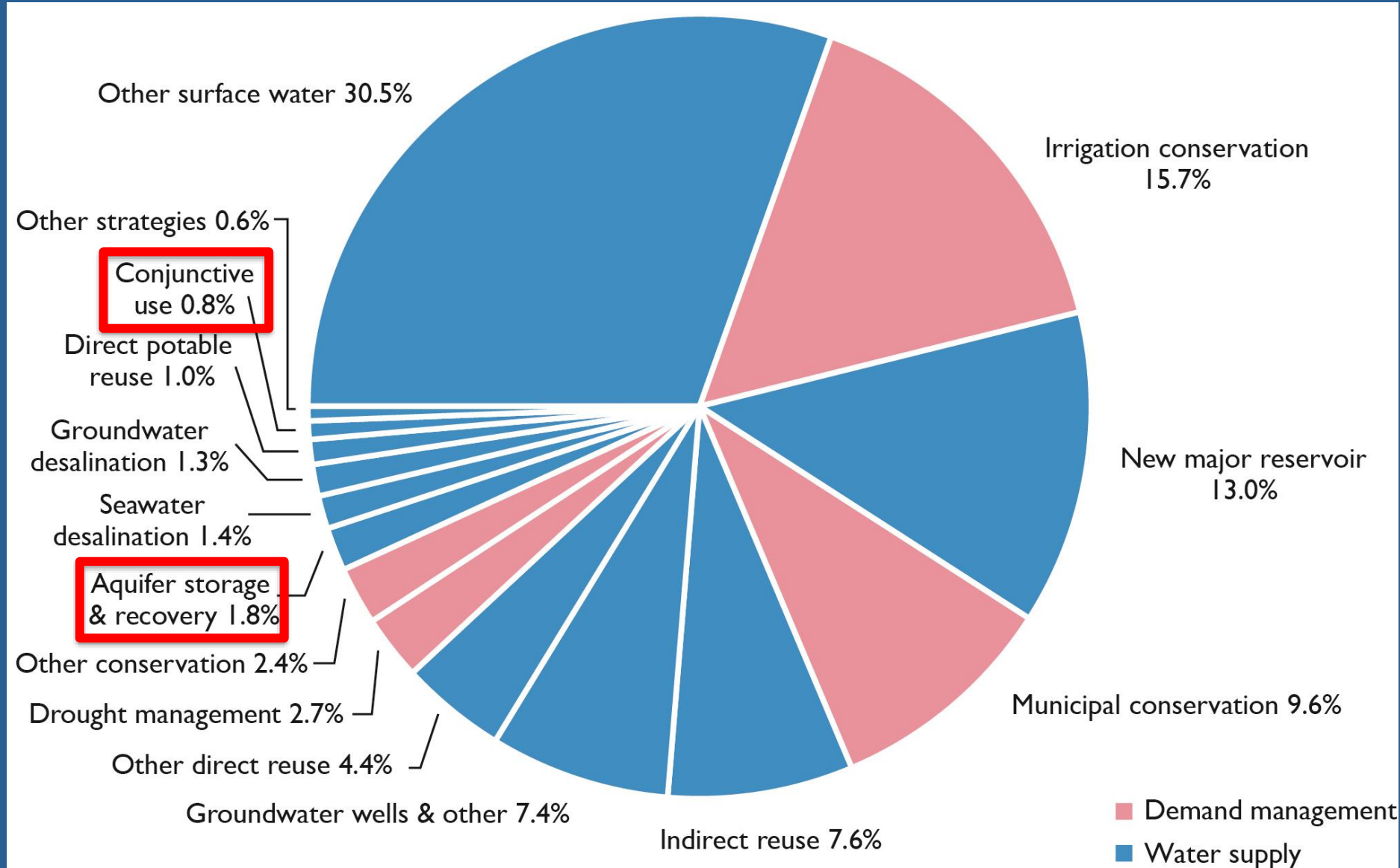
Each water user group is mapped to a single point near its primary location; therefore, an entity with a large or multiple service areas may be displayed outside the specific area being queried. Red triangles indicate capital projects associated with strategy supplies that have been assigned to a Water User Group. [Hide Projects](#)

Texas State Water Plan - WMS

- 2017 SWP
 - **20 ASR and 1 AR projects**
 - 25 ASR and 1 AR recommended WMS
 - 11 ASR and 1 AR alternative WMS
- Projects may include more than one WMS
- ASR and AR accounts for over 53,000 acre-feet per year 2020
- This increases to over 152,000 acre-feet per year by 2070.



Texas State Water Plan - WMS



Texas State Water Plan - WMS

ID	Project sponsor	Source Water Type
1	Brazos River Authority	surface water (SW)
2	Canadian River Municipal Authority	SW/GW
3	City of Austin	surface water (SW)
4	City of Bandera	surface water (SW)
5	City of Bryan	groundwater (GW)
6	City of Buda, Hays County, and others	groundwater (GW)
7	City of Buda, Hays County, and others	groundwater (GW)
8	City of College Station	Reclaimed (R)
9	City of Kerrville	surface water (SW)
10	City of Lubbock	SW/GW
11	City of New Braunfels	surface water (SW)
12	City of Uvalde	groundwater (GW)
13	City of Victoria	surface water (SW)
14	City of Waco	surface water (SW)
16	Colorado River Municipal Water District	SW/GW
18	Kerr County	surface water (SW)
19	Lavaca Navidad River Authority	surface water (SW)
20	Lower Valley Water District	Reclaimed (R)
21	El Paso Water Utilities	surface water (SW)
22	Guadalupe-Blanco River Authority	surface water (SW)

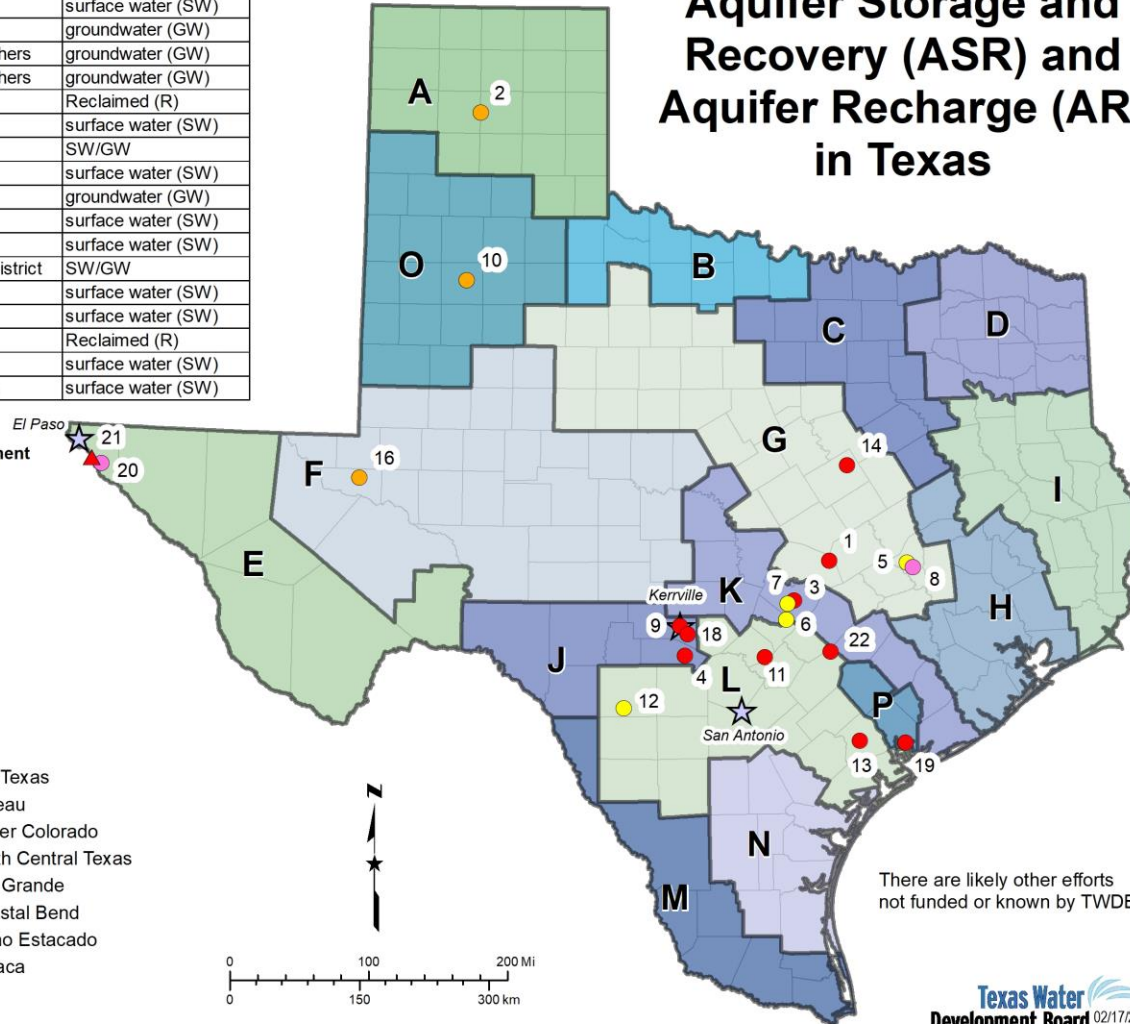
Aquifer Storage and Recovery (ASR) and Aquifer Recharge (AR) in Texas

2017 Recommended Water Management Strategy Projects

- ▲ AR, SW
- ASR, SW
- ASR, GW
- ASR, R
- ASR, SW/GW
- ☆ Operating Facilities

Regional Water Planning Areas

- A - Panhandle
- B - Region B
- C - Region C
- D - North East Texas
- E - Far West Texas
- F - Region F
- G - Brazos G
- H - Region H
- I - East Texas
- J - Plateau
- K - Lower Colorado
- L - South Central Texas
- M - Rio Grande
- N - Coastal Bend
- O - Llano Estacado
- P - Lavaca



There are likely other efforts not funded or known by TWDB.

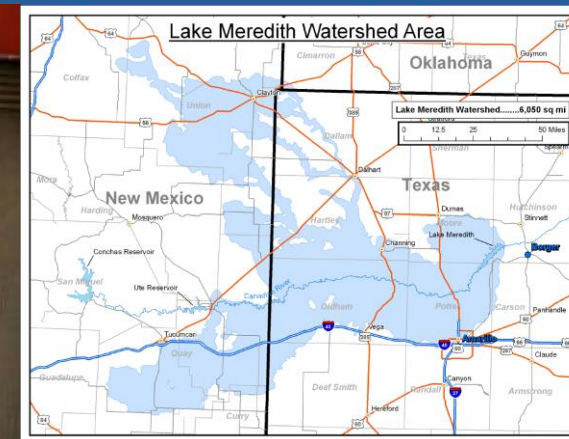
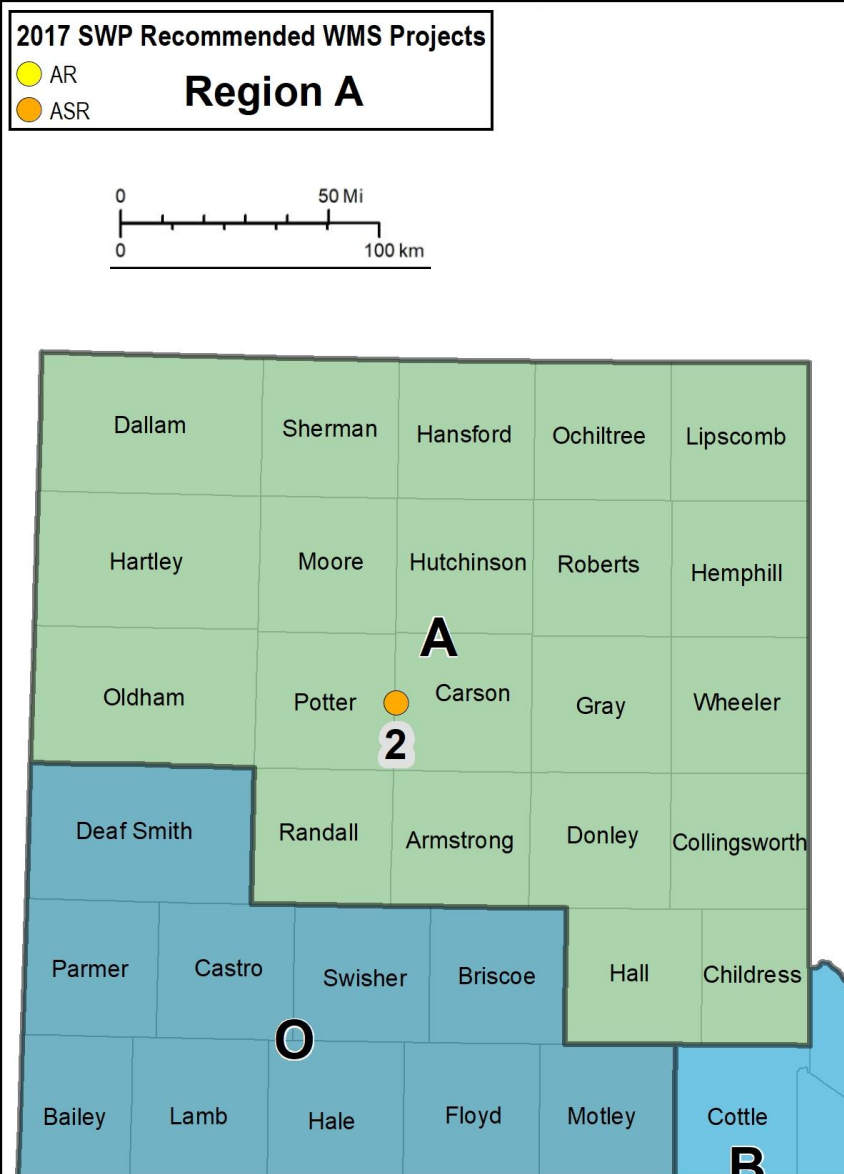
Texas Water Development Board 02/17/2020



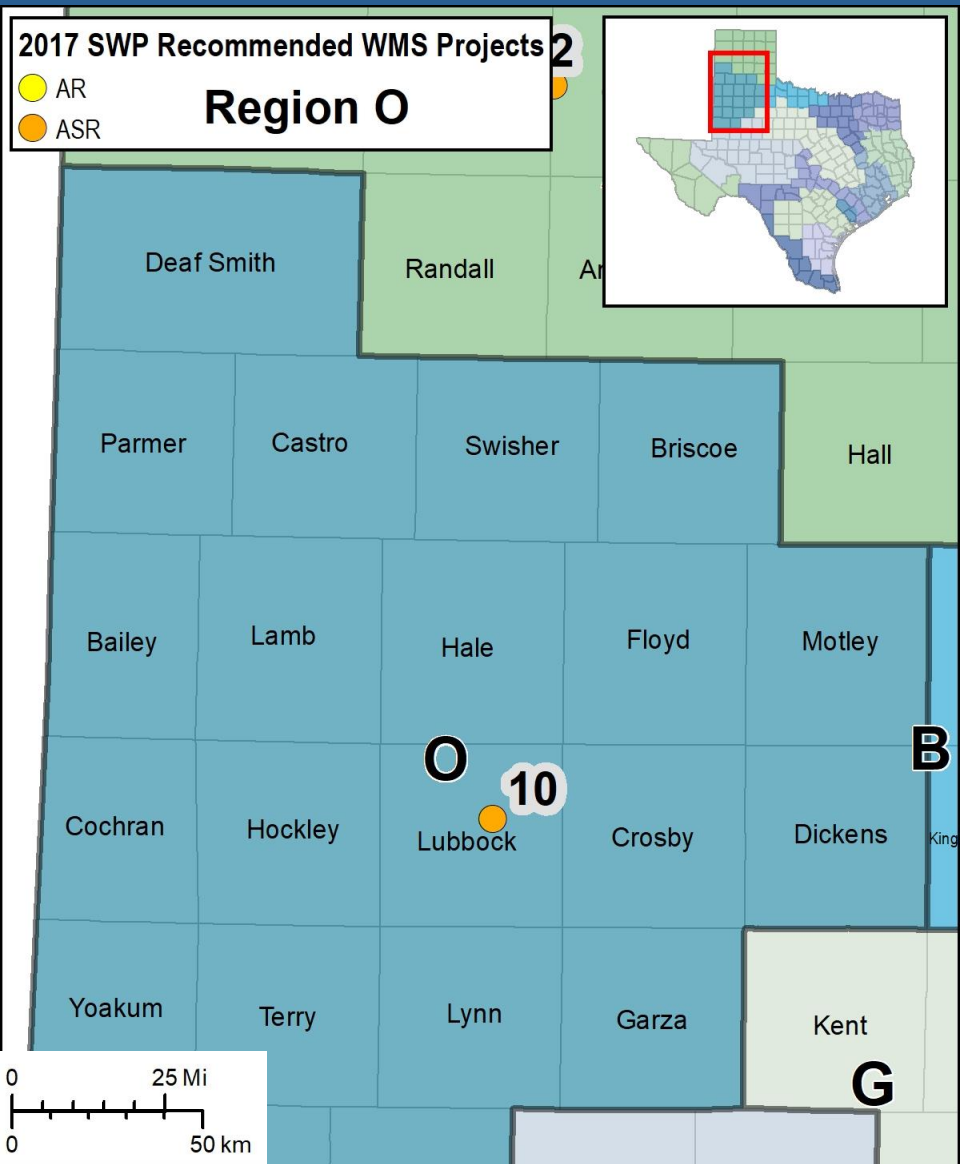
ASR-MAR – Region A and O

2/10 Canadian River Municipal Water Authority

- Source water: SW and GW
- Target Aquifer: Ogallala Aquifer
- Volume estimate: 16,400 acre-ft/year
- Cost: \$67,649,300
- Notes: Evaluation of 11 member city's PWS wells for ASR retrofit and construction of combined infrastructure. Available water from CRMWA's sources (Lake Meredith or Robert County Well Field) would be treated and stored by the member cities for future use by utilizing primarily existing well fields and infrastructure.

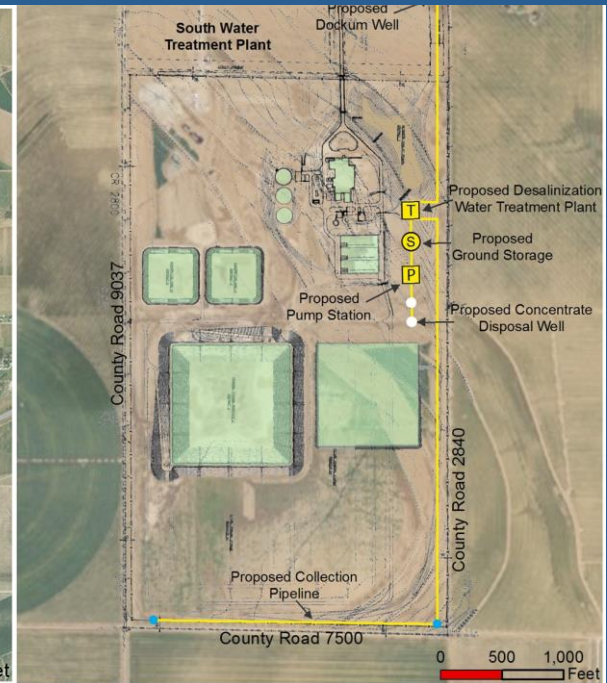
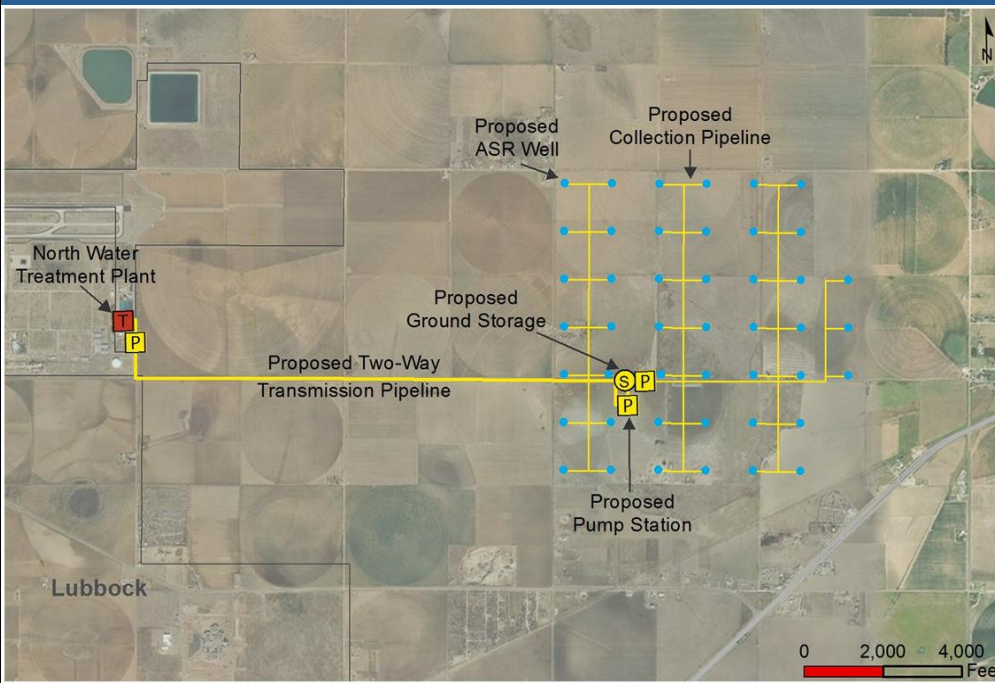


ASR-MAR – Region A and O

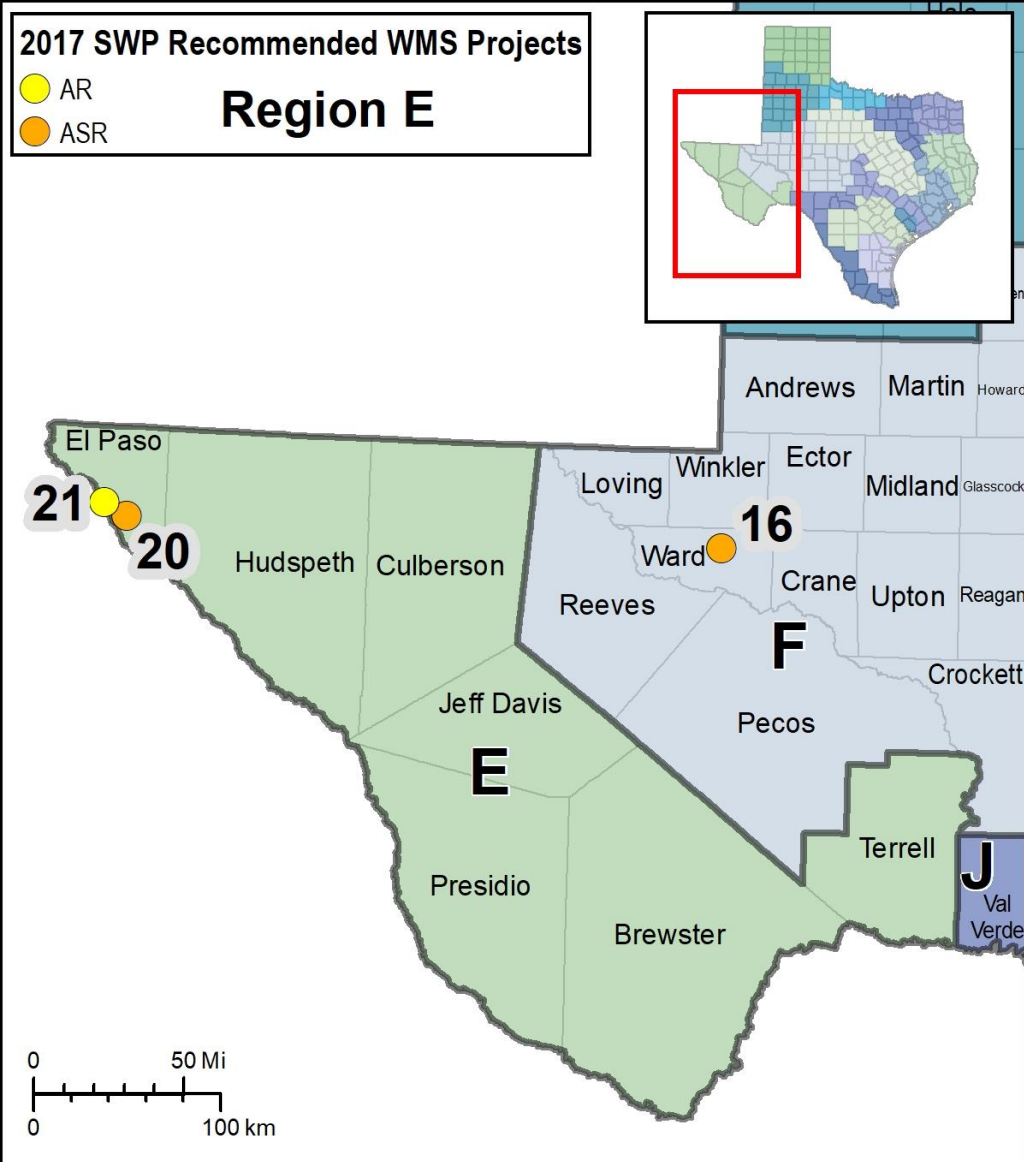


10 City of Lubbock ASR

- Source water: mixed, SW-GW
- Target Aquifer: Ogallala Aquifer
- Volume estimate: 6,090 AF/year
- Cost: \$62,345,000
- Notes: 45 ASR wells, assuming 20% loss to nearby wells



ASR-MAR – Region E



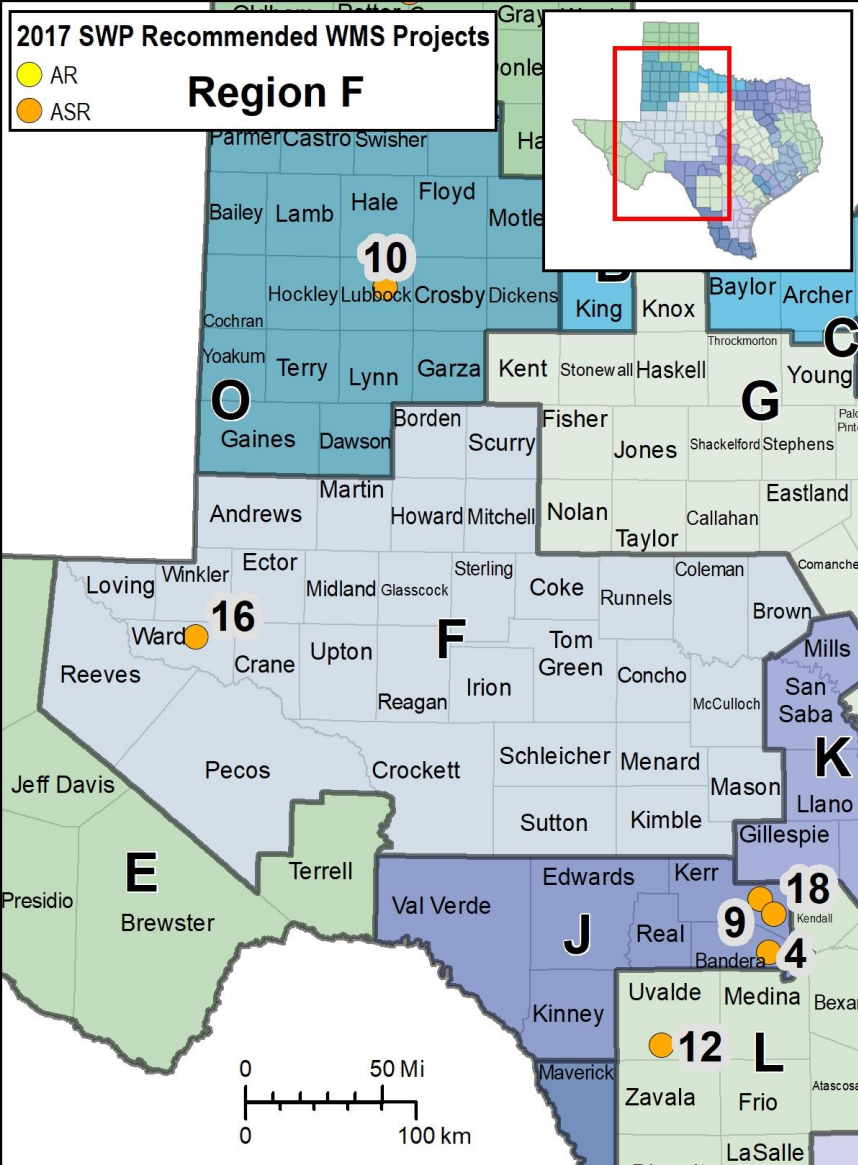
20 Lower Valley Water District Proposed AR

- Source: mixed, SW and R
- Target Aquifer: Hueco-Bolson Aquifer
- Volume estimate: 3,808 acre-ft/year
- Cost: \$18,108,000
- Notes: Project would create AR basins to store water purchased from EPWU. Would include production wells for later recovery

21 El Paso Water Utilities AR

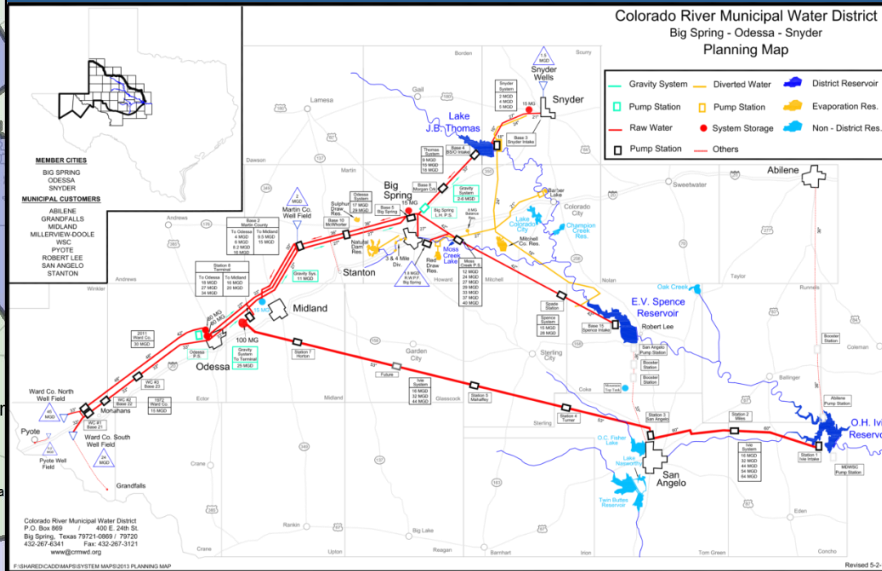
- Source water: SW
- Target Aquifer: Hueco Bolson Aquifer
- Volume estimate: 6,500 acre-ft/year
- Cost: \$1,806,000
- Notes: Project is an expansion of the existing AR basins using water from EPWU's Fred Hervey Reclamation Plant.

ASR-MAR – Region F

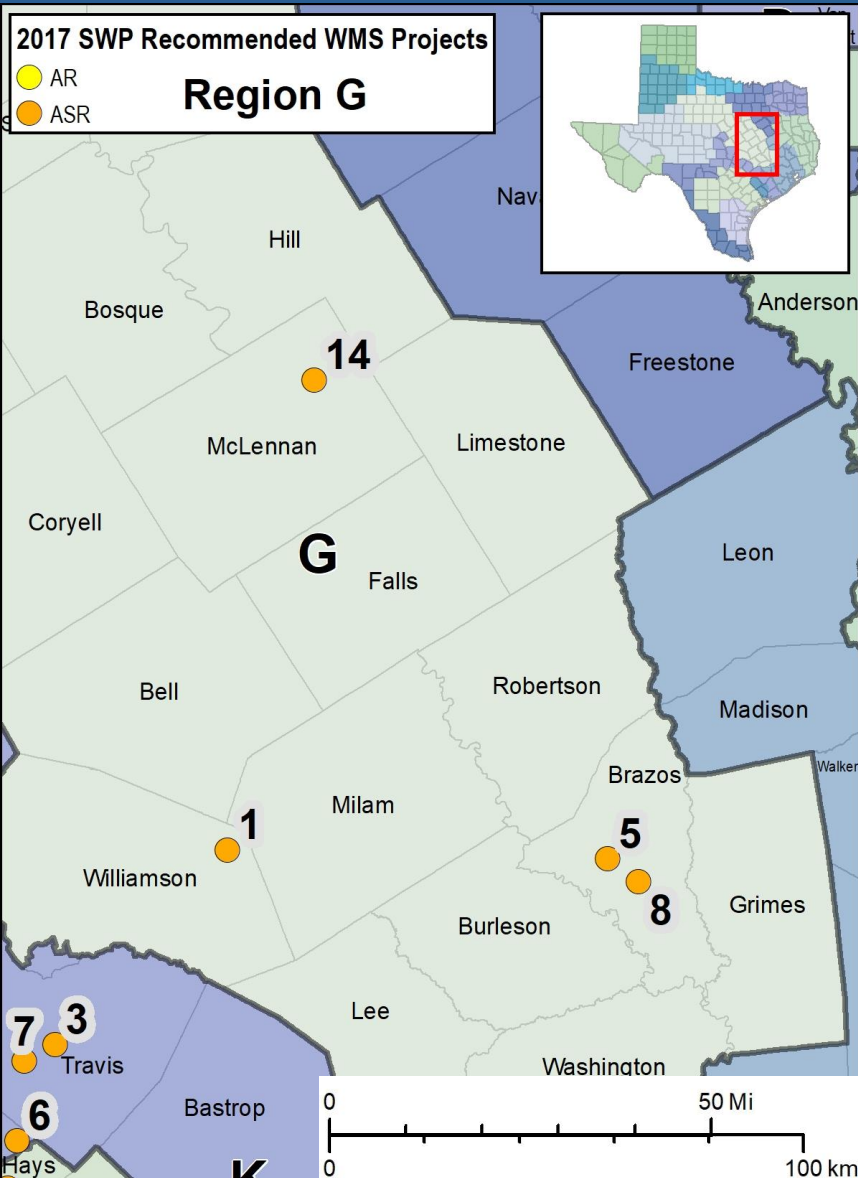


16 - Colorado River Municipal Water District ASR

- Source water: mixed, SW-GW
- Target Aquifer: Pecos Valley Aquifer
- Volume estimate: 5,000 acre-ft/year
- Cost: \$10,184,000
- Notes: During periods of above inflow in the Colorado River Basin (winter), unutilized surface water would be treated and stored in CRMWD's existing well field



ASR-MAR – Region G



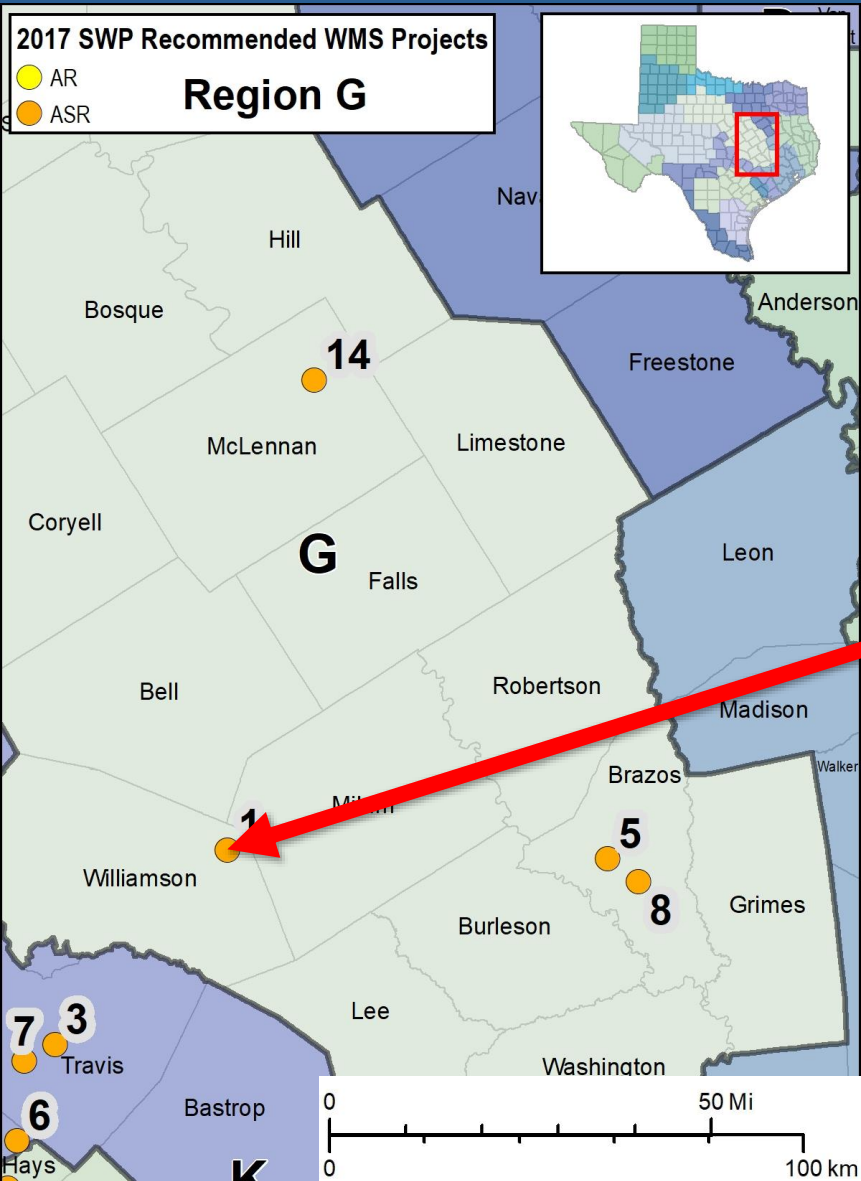
1 Brazos River Authority

- Source water: SW
- Target Aquifer: Lower Trinity Aquifer
- Volume estimate: 9,677 acre-ft/year
- Cost: \$99,820,000
- Notes: Water from Lake Granger would be stored in the Lower Trinity Aquifer for later recovery. Project would include 5 ASR wells & 10 recovery wells.

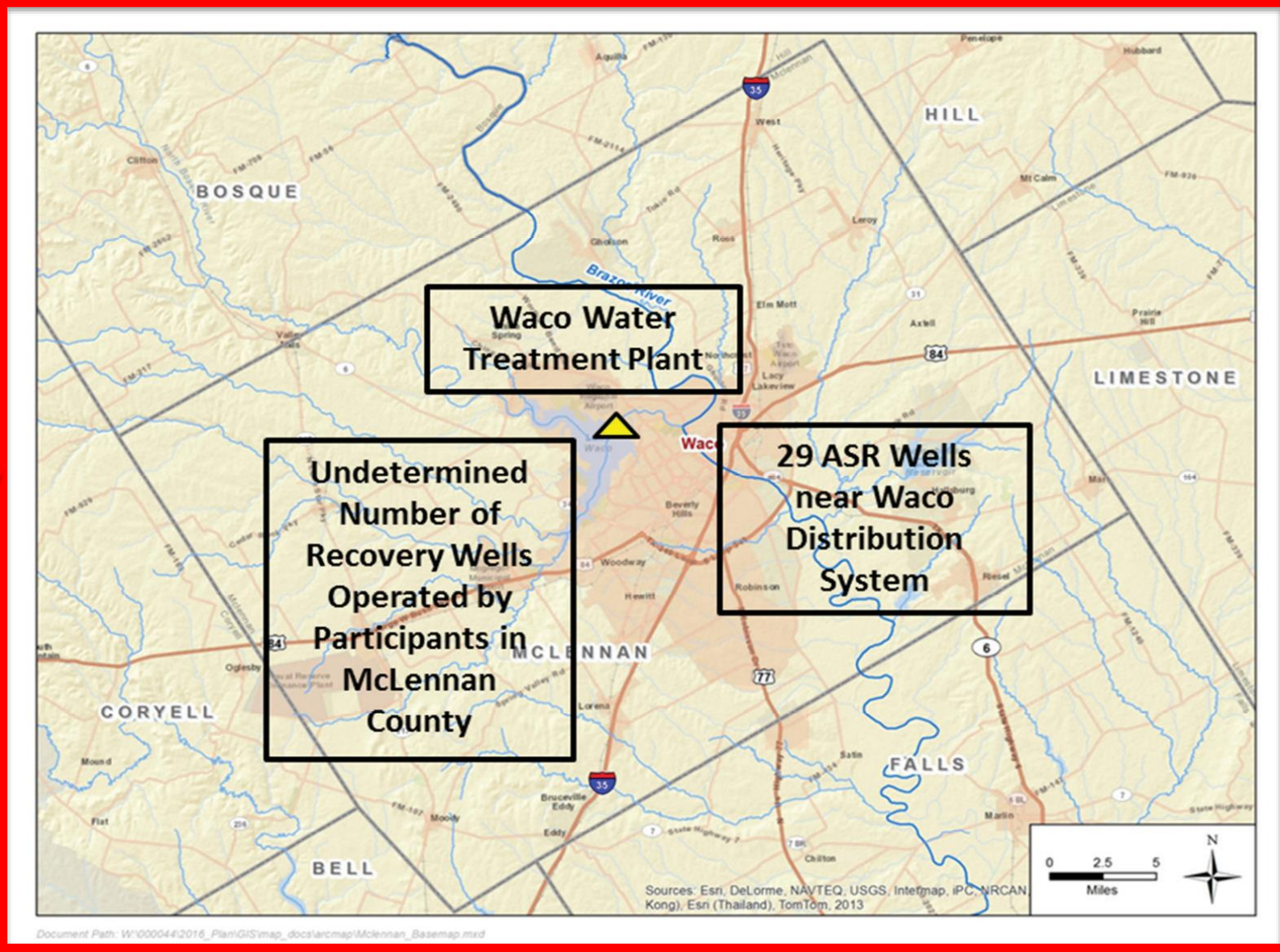
14 City of Waco

- Source water: SW
- Target Aquifer: Trinity Aquifer
- Volume estimate: 8,000 acre-ft/year
- Cost: \$56,542,000
- Other: 4 conjunctive WMS. Water from Lake Waco would be stored in the Trinity aquifer and recovered down gradient by local users

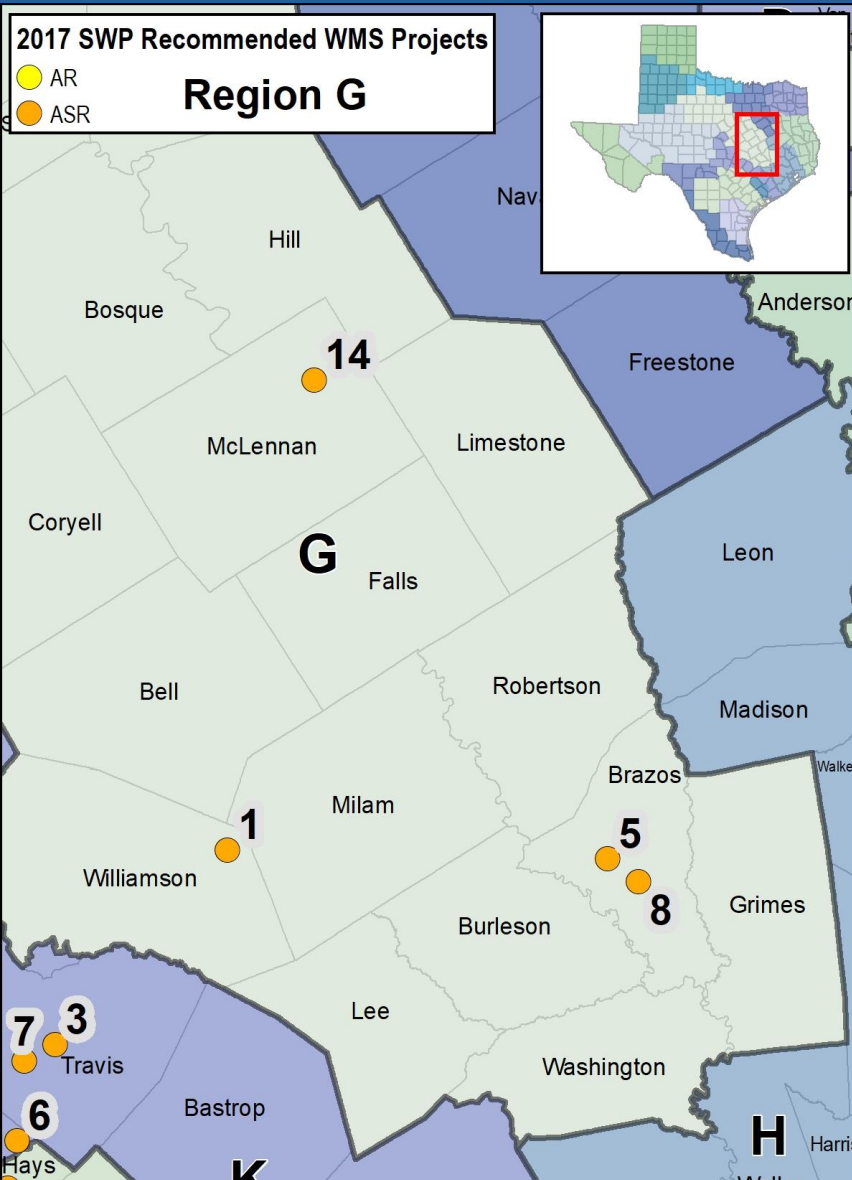
ASR-MAR – Region G



ASR-MAR – Region G



ASR-MAR – Region G (cont.)



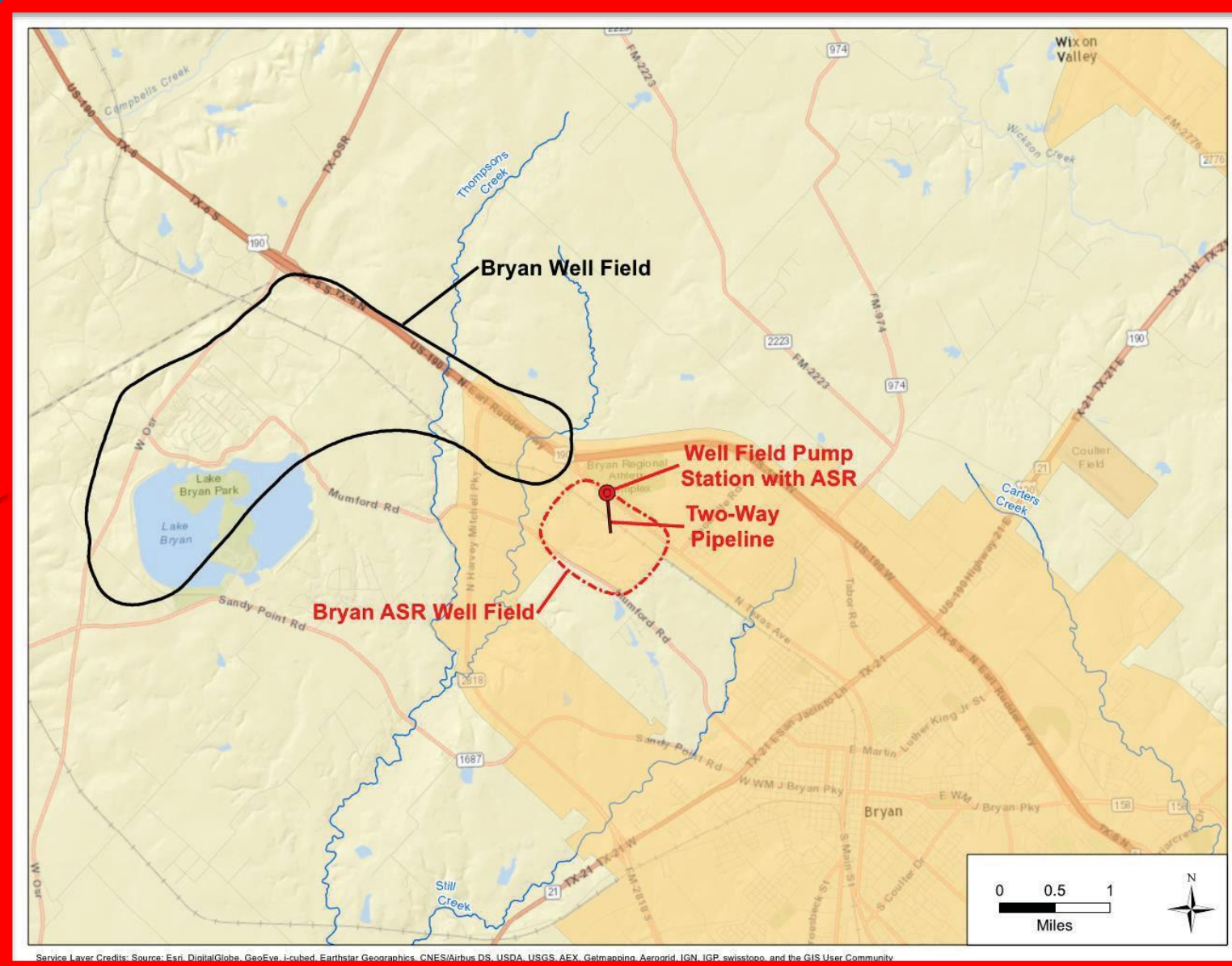
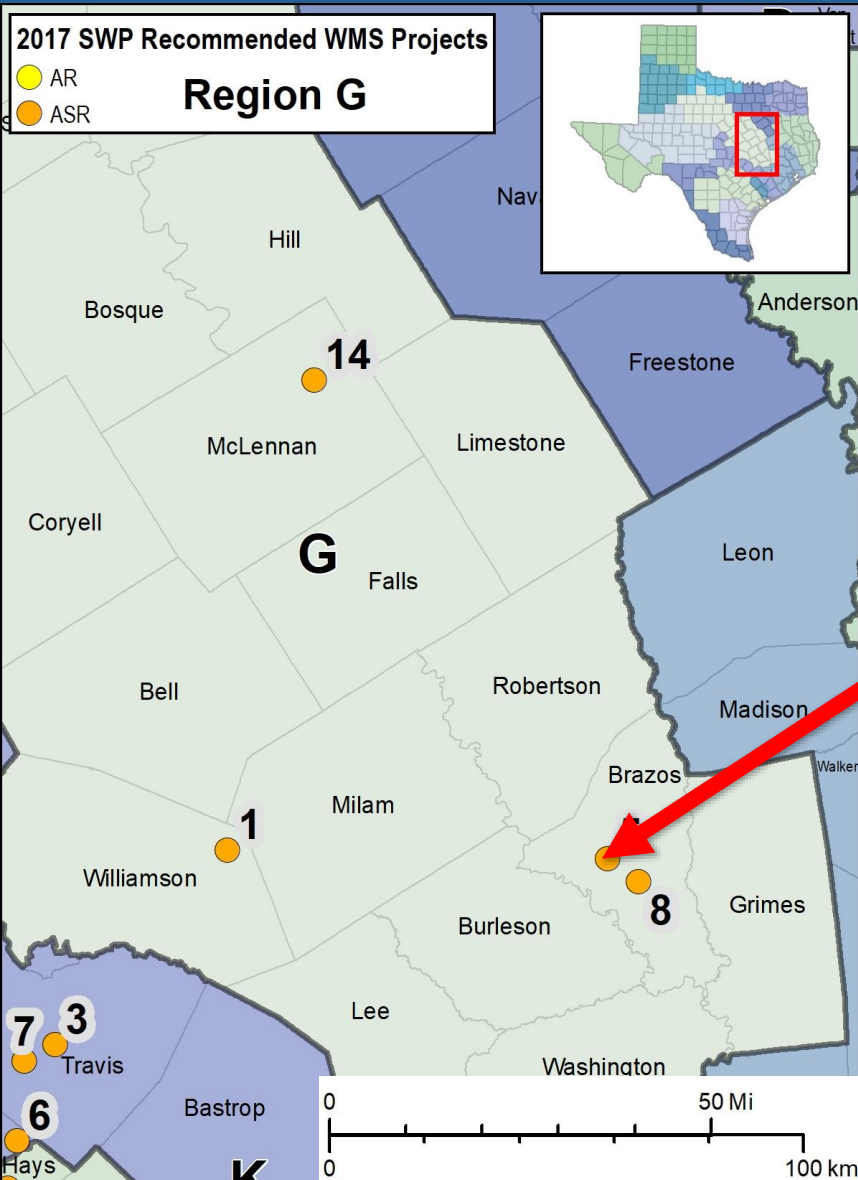
5 City of Bryan

- Source water: GW
- Target Aquifer: Carrizo-Wilcox Aquifer (115 deg F)
- Volume estimate: 19,839 AF/year
- Cost: \$57,328,000
- Notes: ASR pilot project completed using retrofitted production well. Recovered water requires cooling

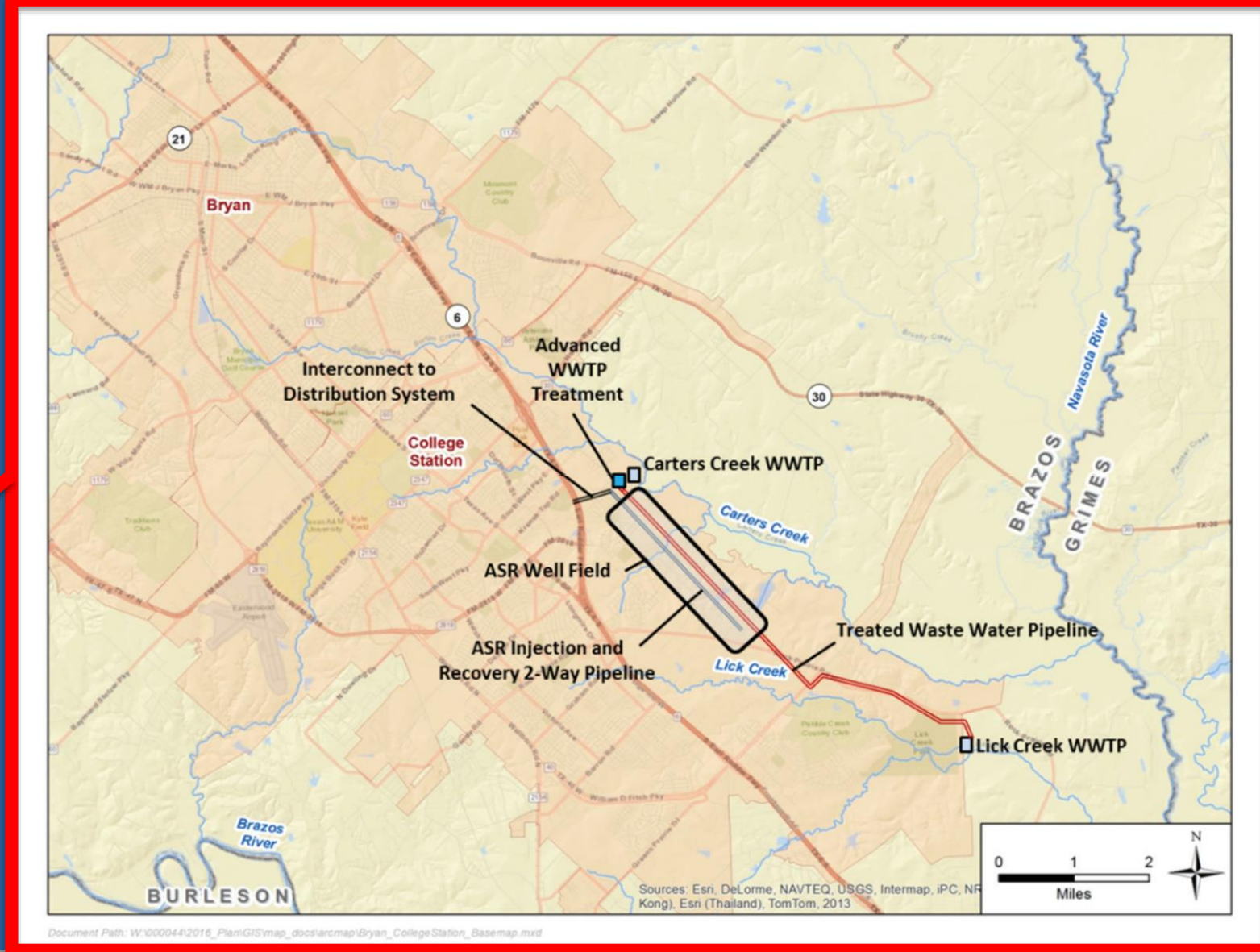
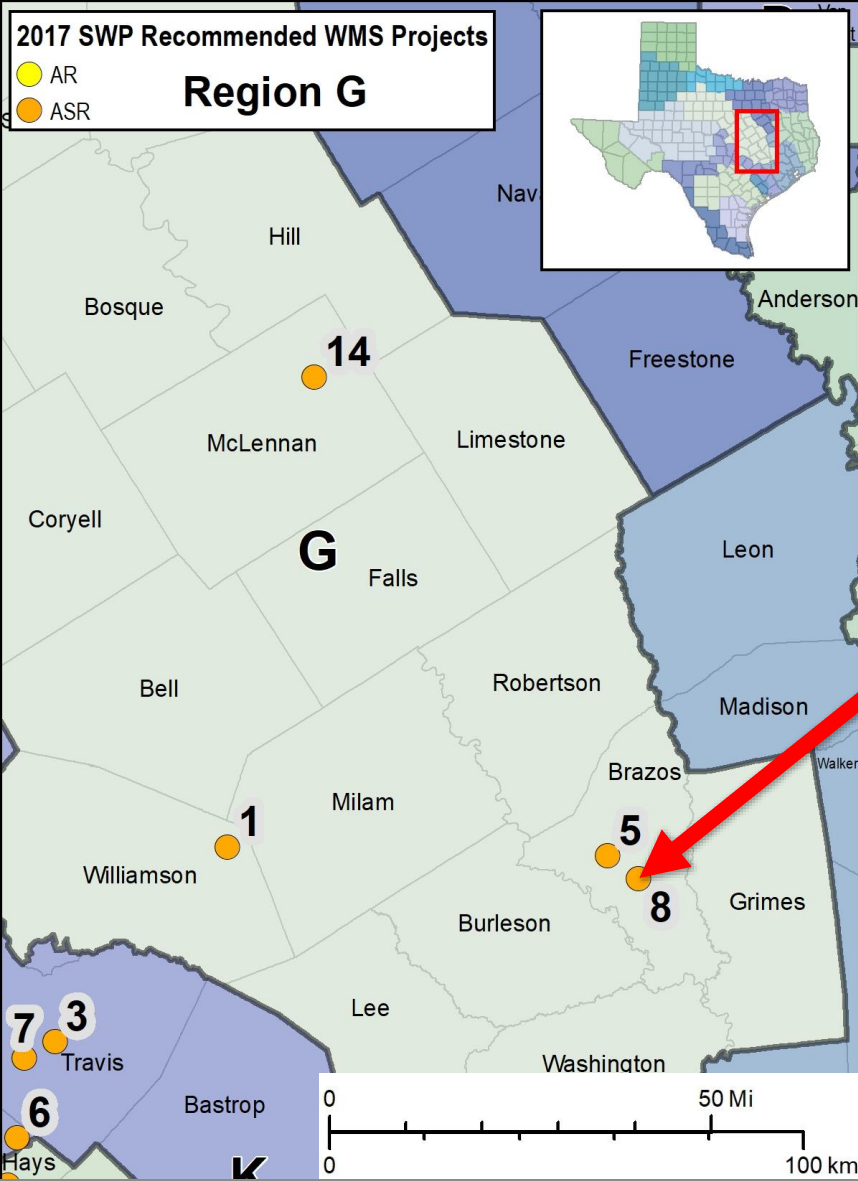
8 City of College Station

- Source water: R
- Target Aquifer: Queen City - Sparta Aquifer
- Volume estimate: 2,800 AF/year
- Cost: \$63,850,000
- Notes: Reclaimed water from College Station's RO WTP would be treated and stored for later recovery. One of only two primarily reclaimed water projects in the SWP

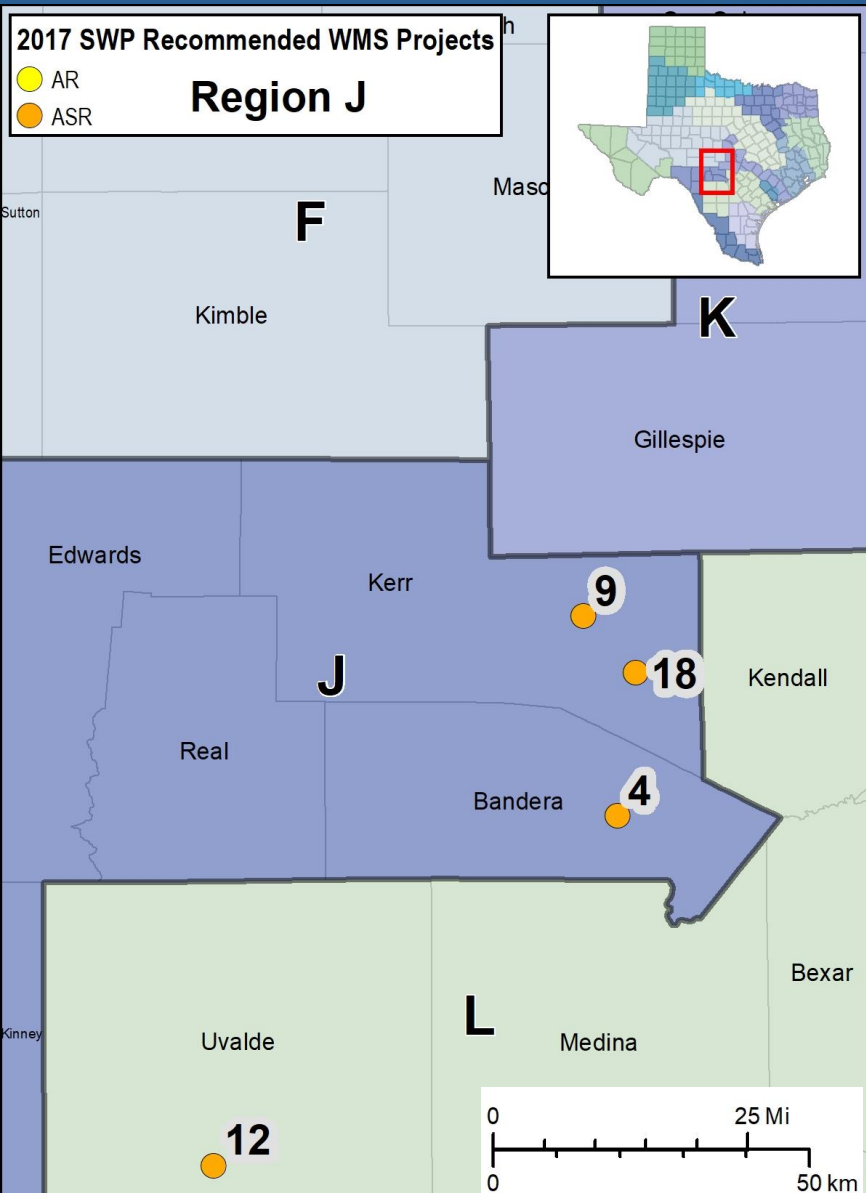
ASR-MAR – Region G



ASR-MAR – Region G

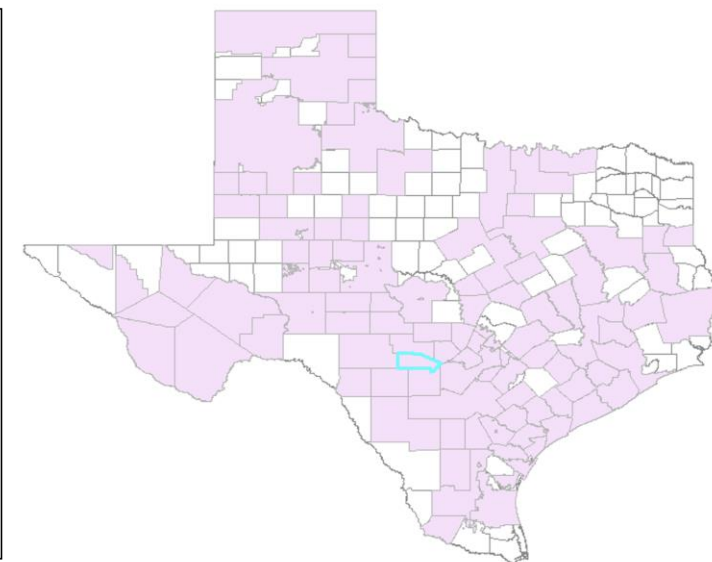
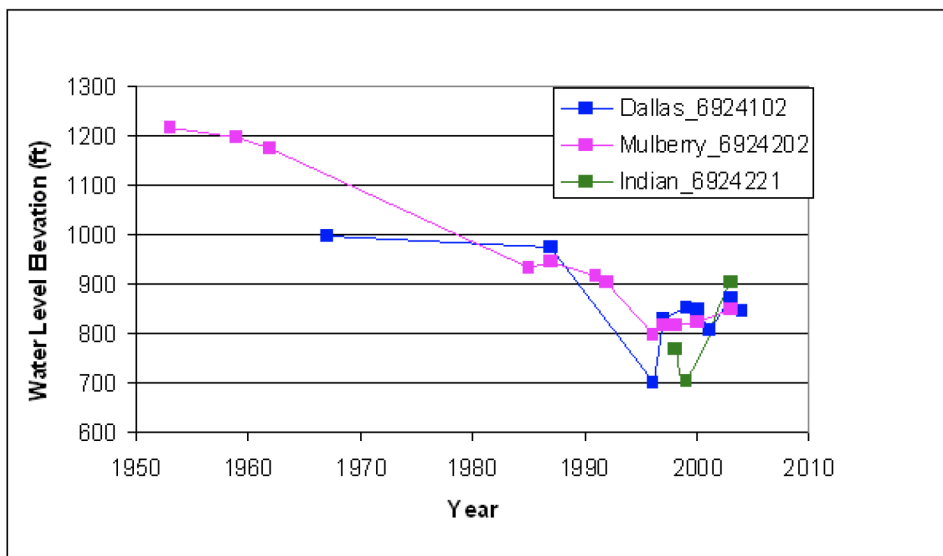


ASR-MAR – Region J

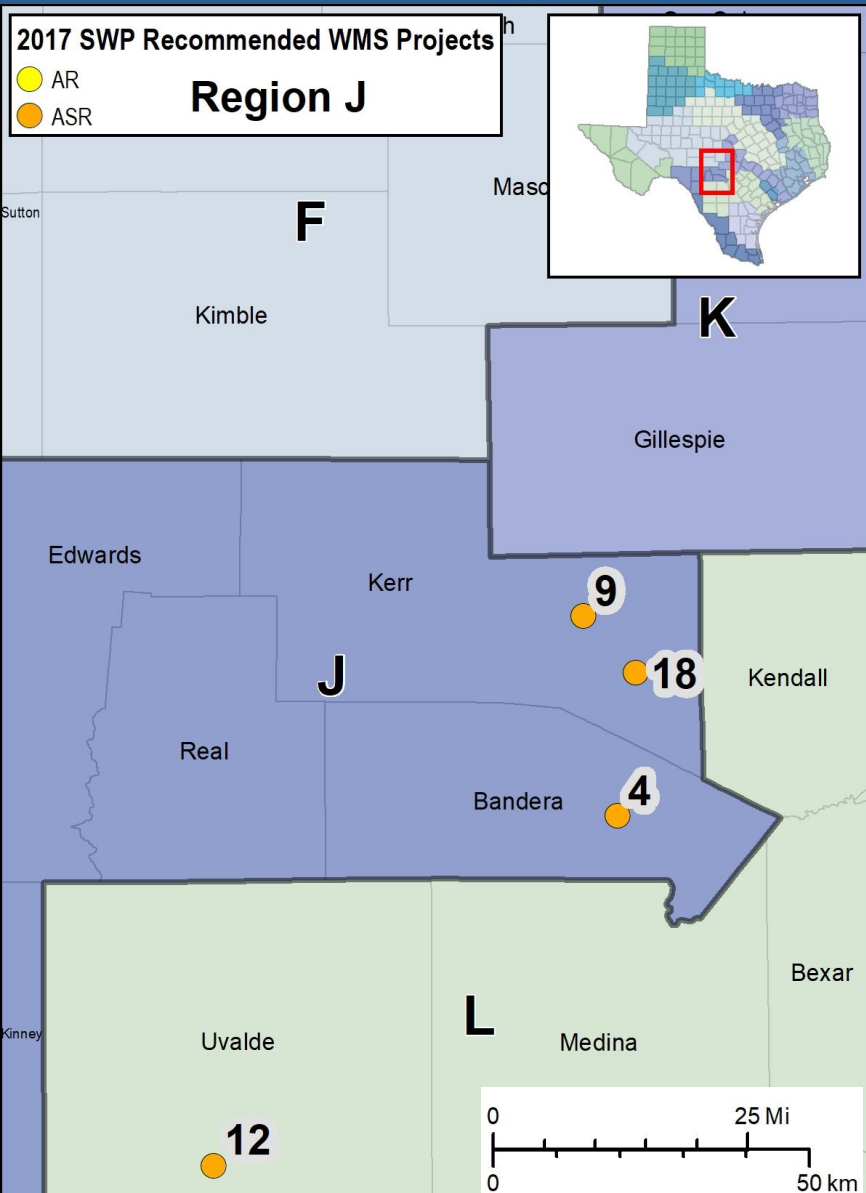


4 City of Bandera

- Source water: SW
- Target Aquifer: Lower Trinity Aquifer
- Volume estimate: 500-1,500 AF/year
- Cost: \$29,450,000
- Notes: Plan includes 2 ASR wells. Project would have the dual benefit of storing water for later recovery and mitigating flood erosion south of the city.



ASR-MAR – Region J



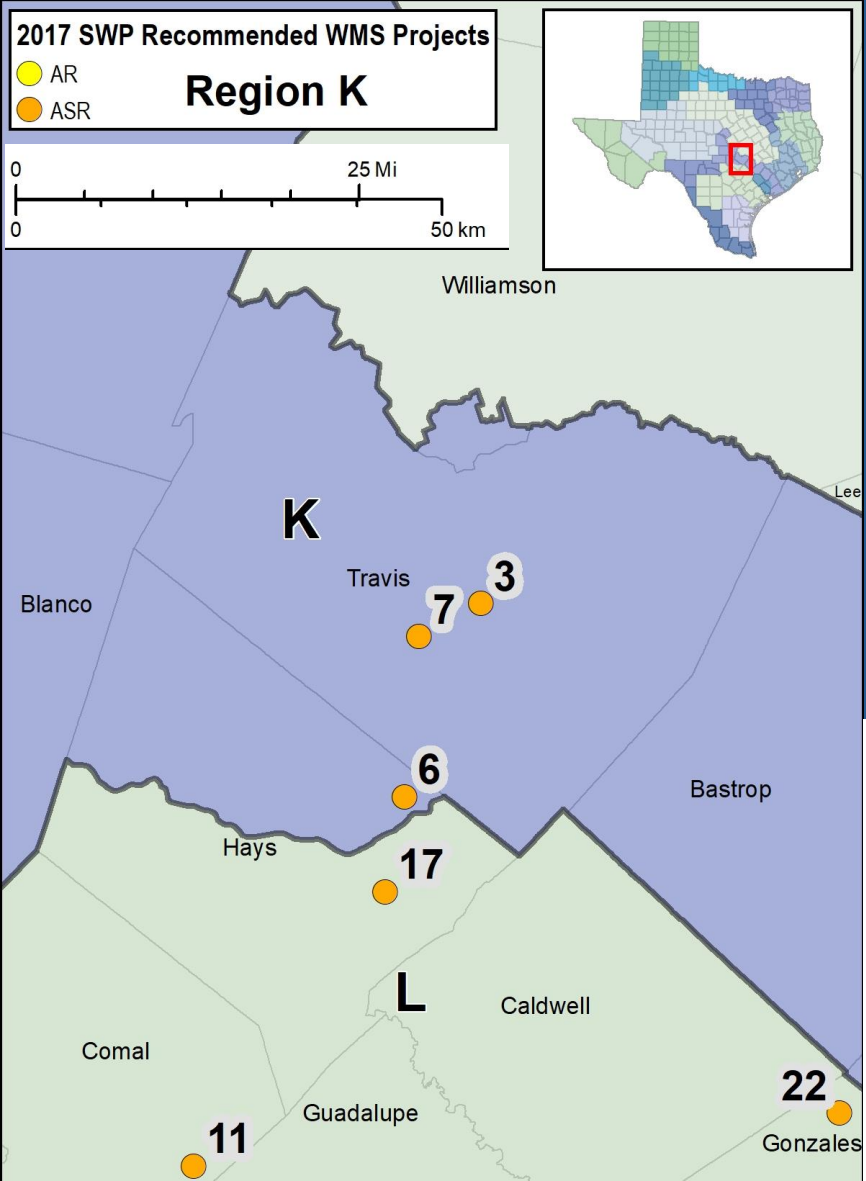
9 City of Kerrville

- Source water: SW
- Target Aquifer: lower Trinity Aquifer
- Volume estimate: 3,360 AF/year
- Cost: \$11,543,000
- Notes: Expansion of existing ASR project. Two ASR wells are planned for drilling, bringing total to 4 ASR wells

18 Kerr County

- Source water: SW
- Target Aquifer: lower Trinity Aquifer
- Volume estimate: 1,124 AF/year
- Cost: \$1,258,000
- Notes: 2 WMS, paired with a new WTP (+\$25,581,000)

ASR-MAR – Region K



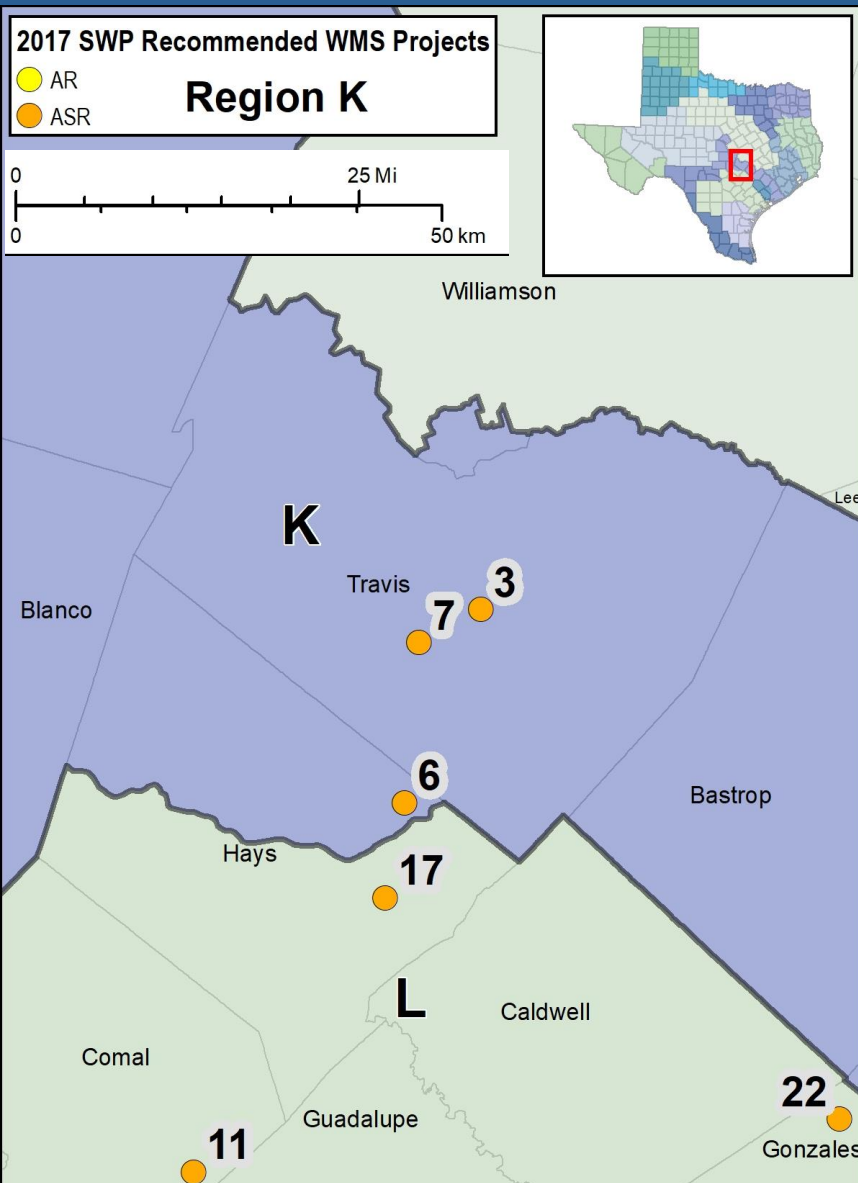
3 City of Austin

- Source water: SW/R
- Target Aquifer: Carrizo-Wilcox Aquifer
- Volume estimate: 5,048 AF/year
- Cost: \$312,316,000
- Notes: River diversion and 9 ASR wells in Bastrop County. Colorado River water under the City’s existing water rights. Additionally, treated effluent from the Walnut Creek Wastewater Treatment Plant (WWTP) is one of the water sources to be considered

Table 5-32: City of Austin Aquifer Storage and Recovery Project Yields

Water Management Strategies (ac-ft/yr)					
2020	2030	2040	2050	2060	2070
10,000	25,000	25,000	50,000	50,000	50,000

ASR-MAR – Region K



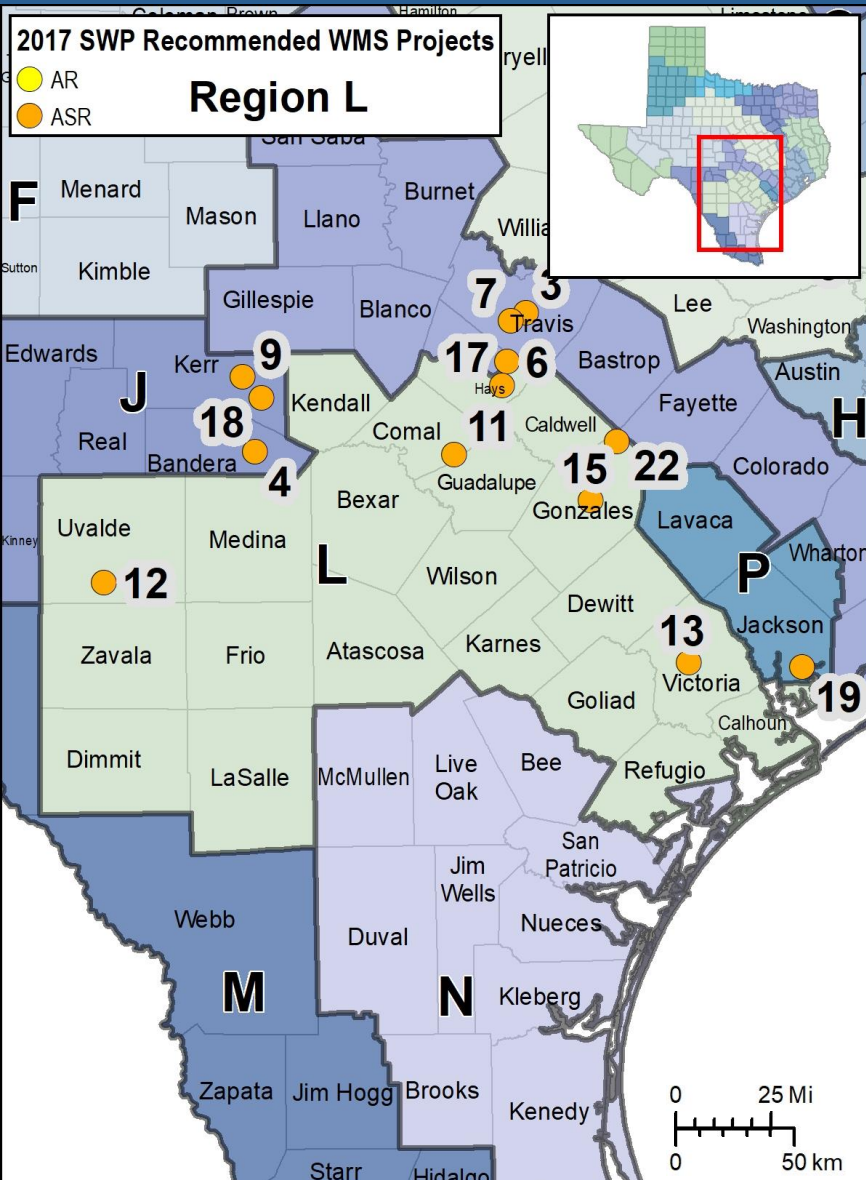
6 Buda-Hays Co.-Mountain City-Sunset Valley

- Source water: GW
- Target Aquifer: Middle Trinity Aquifer
- Volume estimate: 1,144 AF/year
- Cost: \$13,000,000
- Notes: Excess water only drawn during non-drought years. Project would include a new WTP and over one mile of new pipeline

7 Buda-Hays Co.-Creedmoor-Maha WSC

- Source water: GW/R
- Target Aquifer: Saline Edwards BFZ
- Volume estimate: 1,000 AF/year
- Cost: \$15,000,000
- Notes: Saline portion of the Edwards has higher residence time. Recovered water might need desalination. Multiple candidates for source water

ASR-MAR – Region L



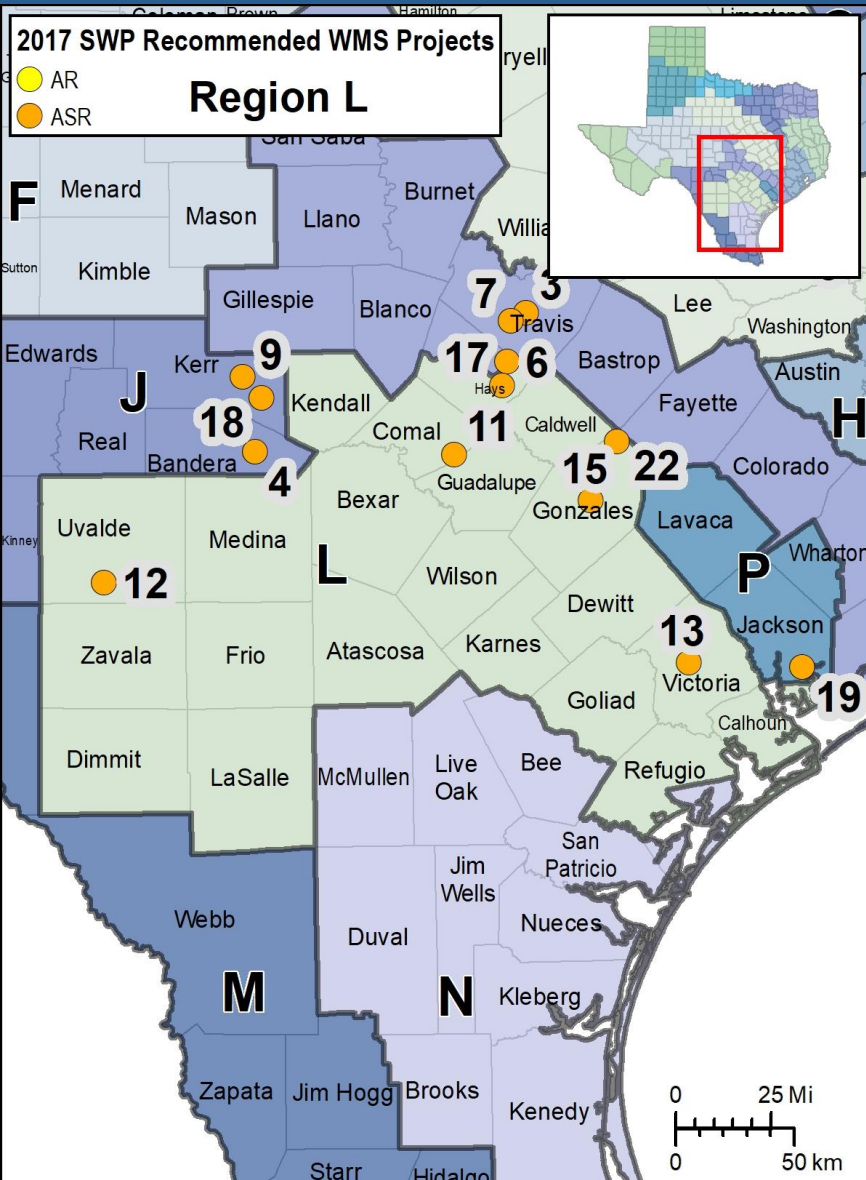
11 City of New Braunfels

- Source water: SW, but could add GW
- Target Aquifer: Lower Trinity Aquifer
- Volume estimate: 8,300 AF/year
- Cost: \$26,269,000
- Notes: Pilot study completed. Project will defer construction of a second water treatment plant and help meet seasonal demands

12 City of Uvalde

- Source water: GW
- Target Aquifer: Carrizo Aquifer (Zavala County)
- Volume estimate: 758 to 4,000 AF/year
- Cost: \$ 32,405,000
- Notes: Project to be done in conjunction with new wells in the Austin Chalk and Buda Limestone. Do to MAG limitations the supply will likely be limited to 1,155 acre-ft per year

ASR-MAR – Region L



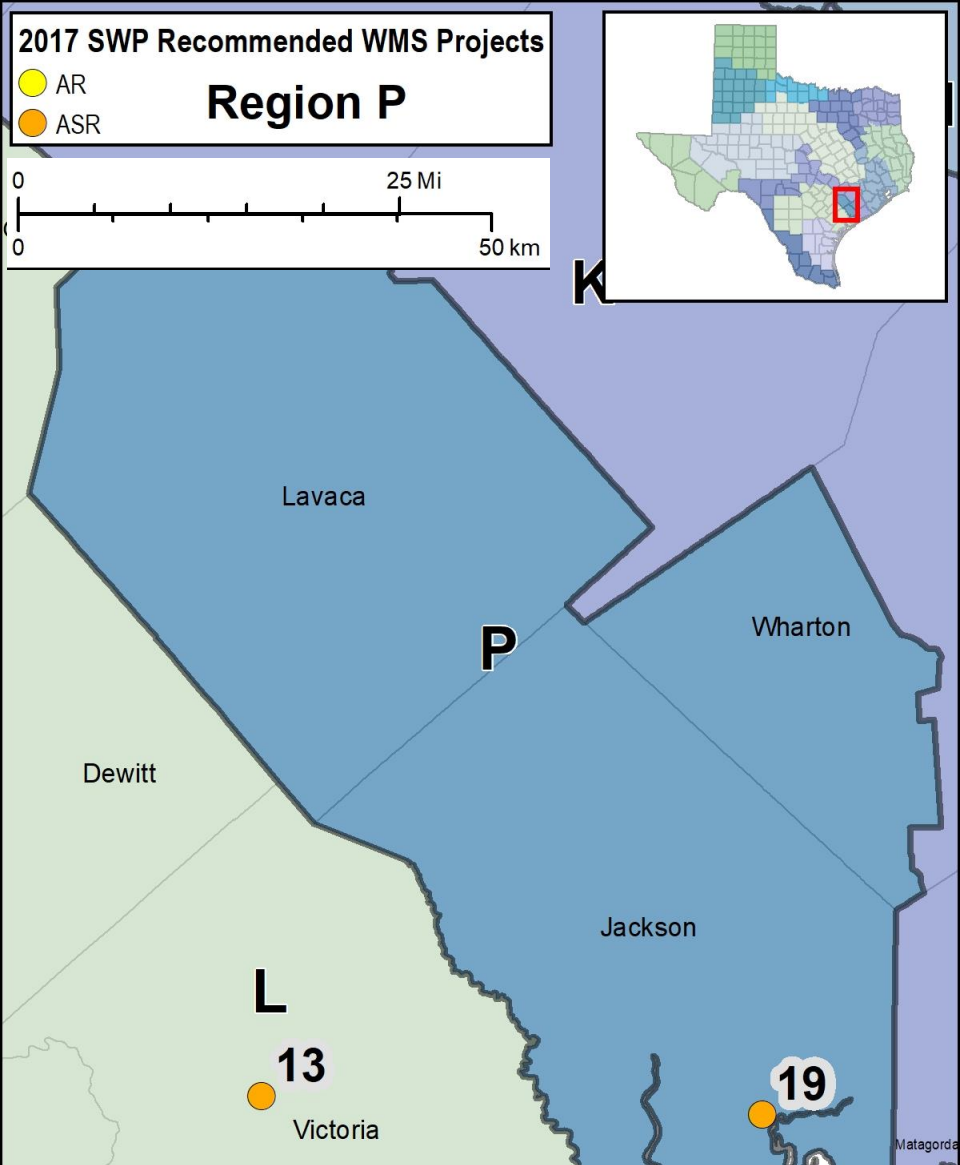
13 City of Victoria

- Source water: SW
- Target Aquifer: Gulf Coast Aquifer
- Volume estimate: 7,900 AF/year
- Cost: \$ 21,100,000
- Notes: Pilot study completed and a retrofitted well has been tested. Complete project could include 10 new ASR wells and 6 retrofits

22 Guadalupe-Blanco River Authority Conjunctive Use

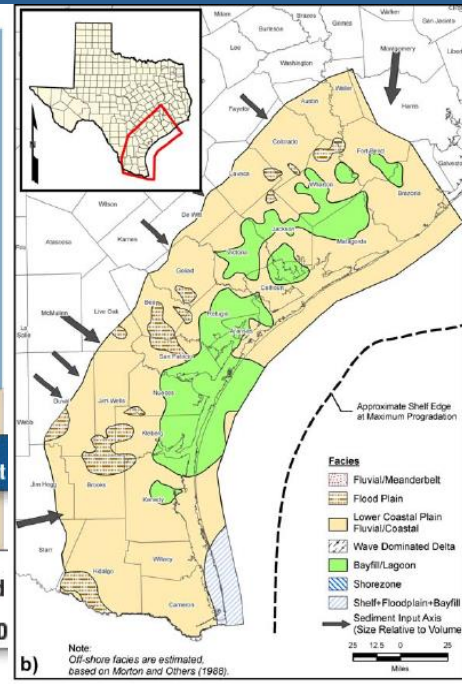
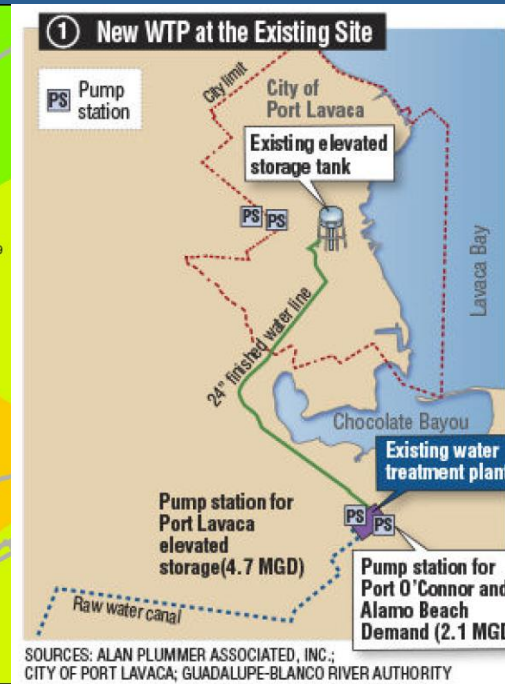
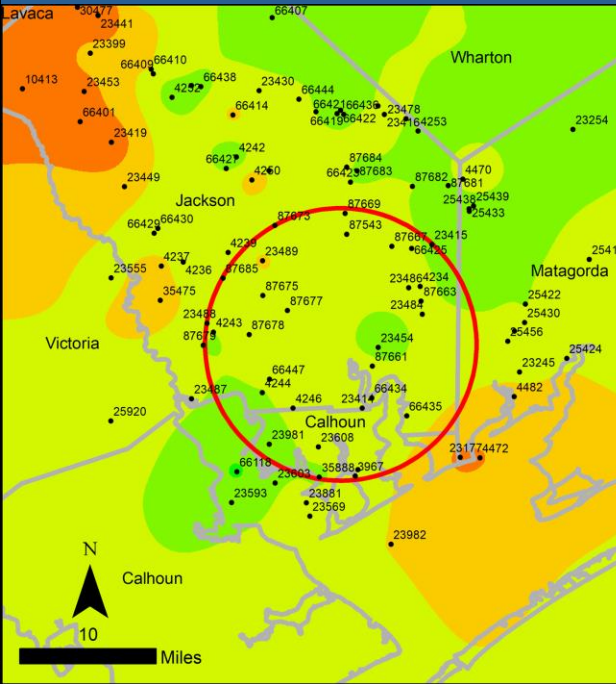
- Source water: SW
- Target Aquifer: Carrizo Aquifer
- Volume estimate: 42,000 AF/year
- Cost: \$700,897,000
- Notes: Added via a SWP amendment to replace old #15 & #17

ASR-MAR – Region P



19 - Lavaca Navidad River Authority

- Source water: SW
- Target Aquifer: Gulf Coast Aquifer
- Volume estimate: 14,163 AF/year
- Project Cost: \$130,169,000
- Notes: Feasibility study completed in conjunction with Victoria



ASR-AR – New for 2021 Draft State Water Plan

Region C

- Interest in large-scale ASR project using SW
- Potential region-wide strategy that benefits multiple major water providers, not an official recommended strategy
- Early stages of planning

Region D

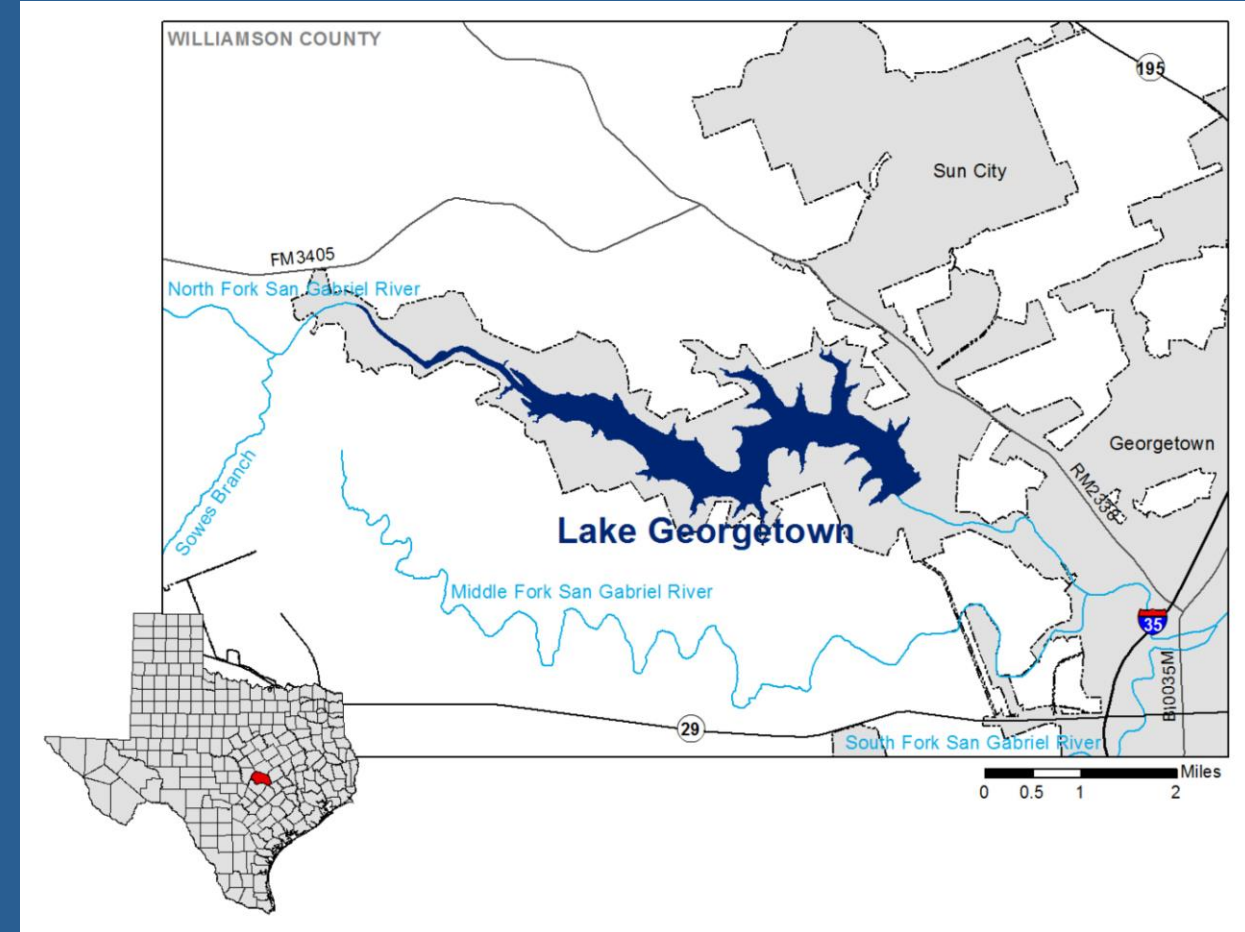
- Tarrant Regional Water District ASR Pilot Project

Region G

- Lake Georgetown ASR Project
- Bell County ASR Project
- Both new projects sponsored by the Brazos River Authority

Region H

- San Jacinto River Authority Aquifer Storage and Recovery

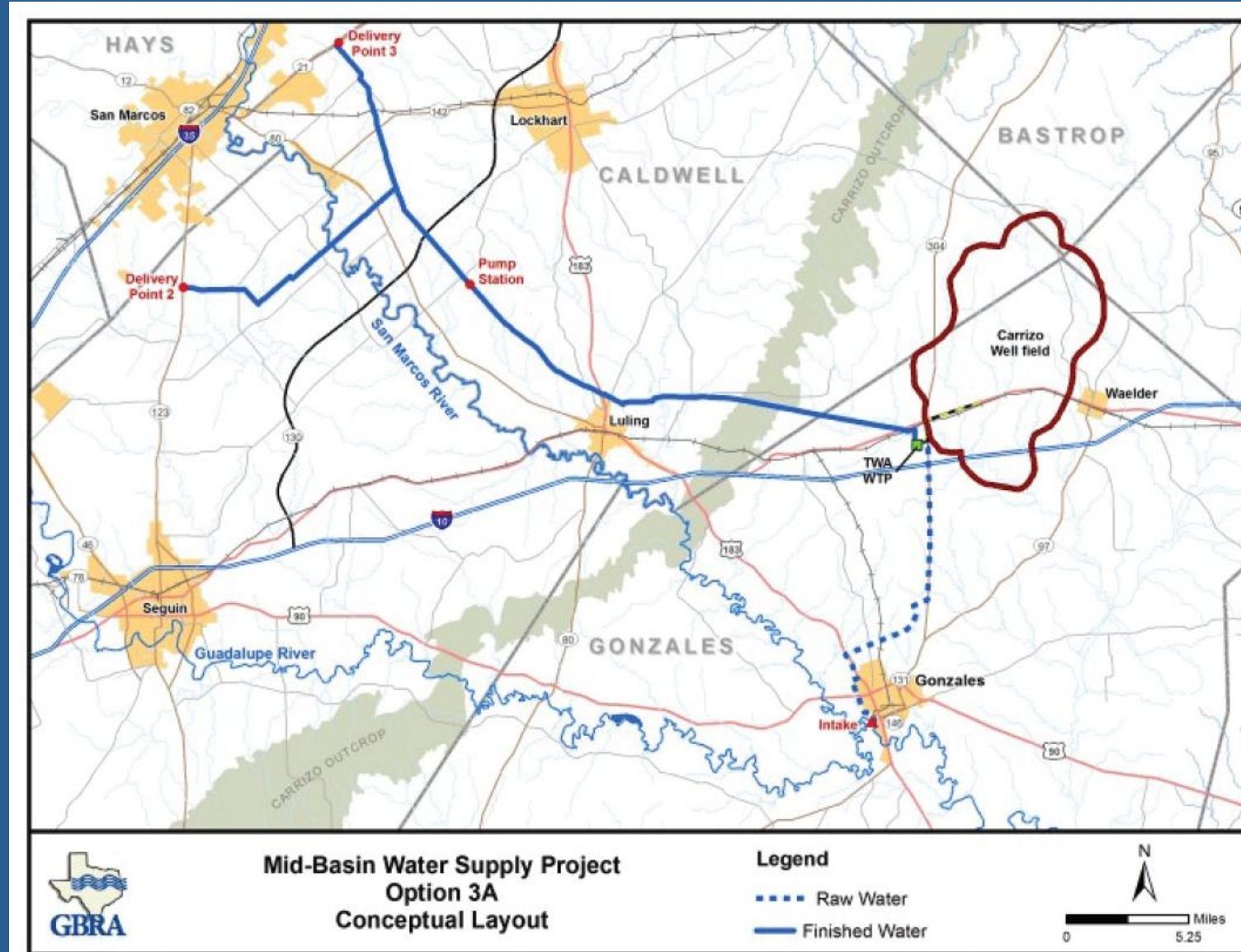


Current Projects



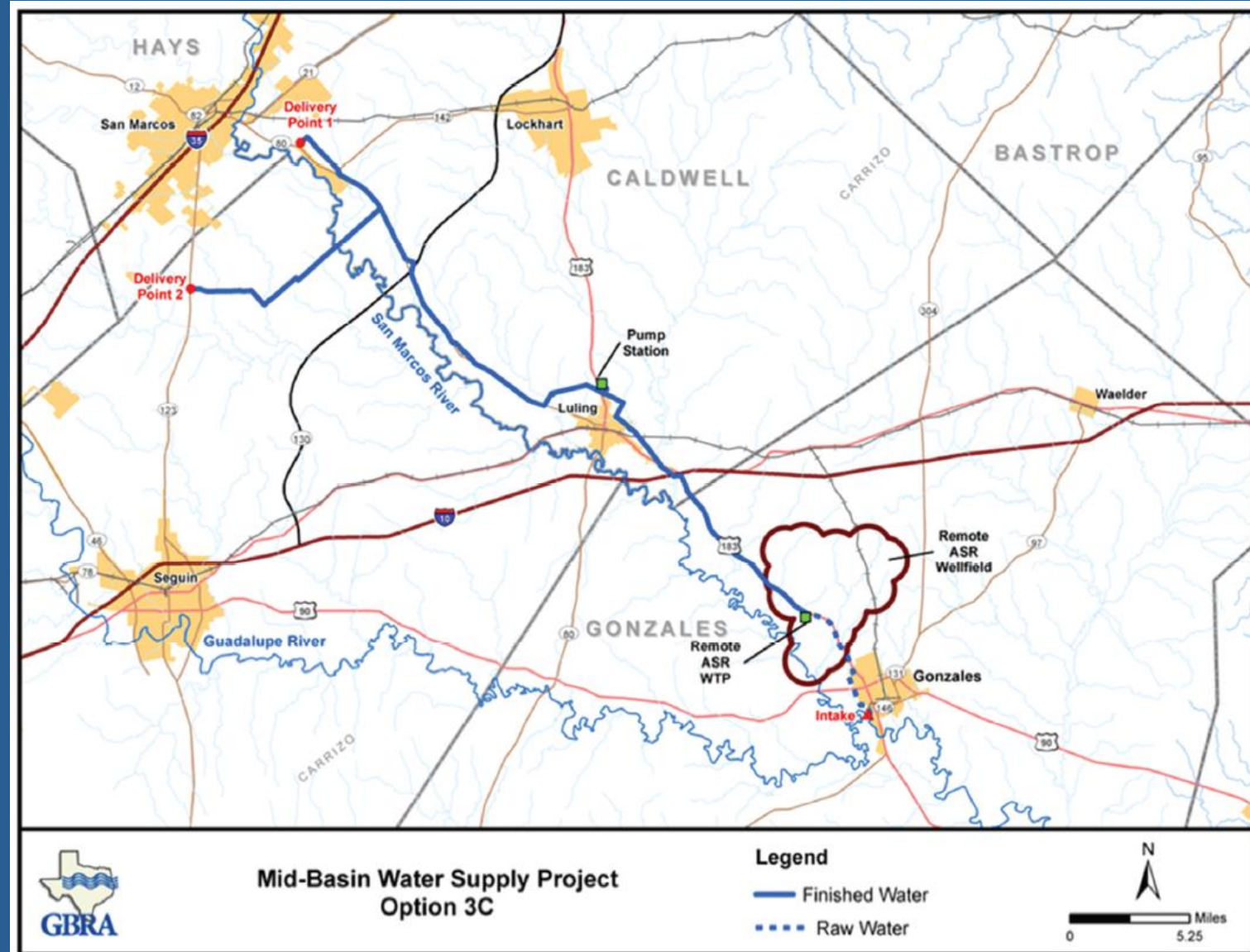
Current Projects – Guadalupe-Blanco River Authority ASR

- GBRA Midbasin Water Supply Project
 - Surface water from Guadalupe River and groundwater from Carrizo Aquifer
 - Conjunctive use project involving groundwater production and ASR
 - Stored water and groundwater will be used to meet demand when surface water does not.



Current Projects – Guadalupe-Blanco River Authority ASR

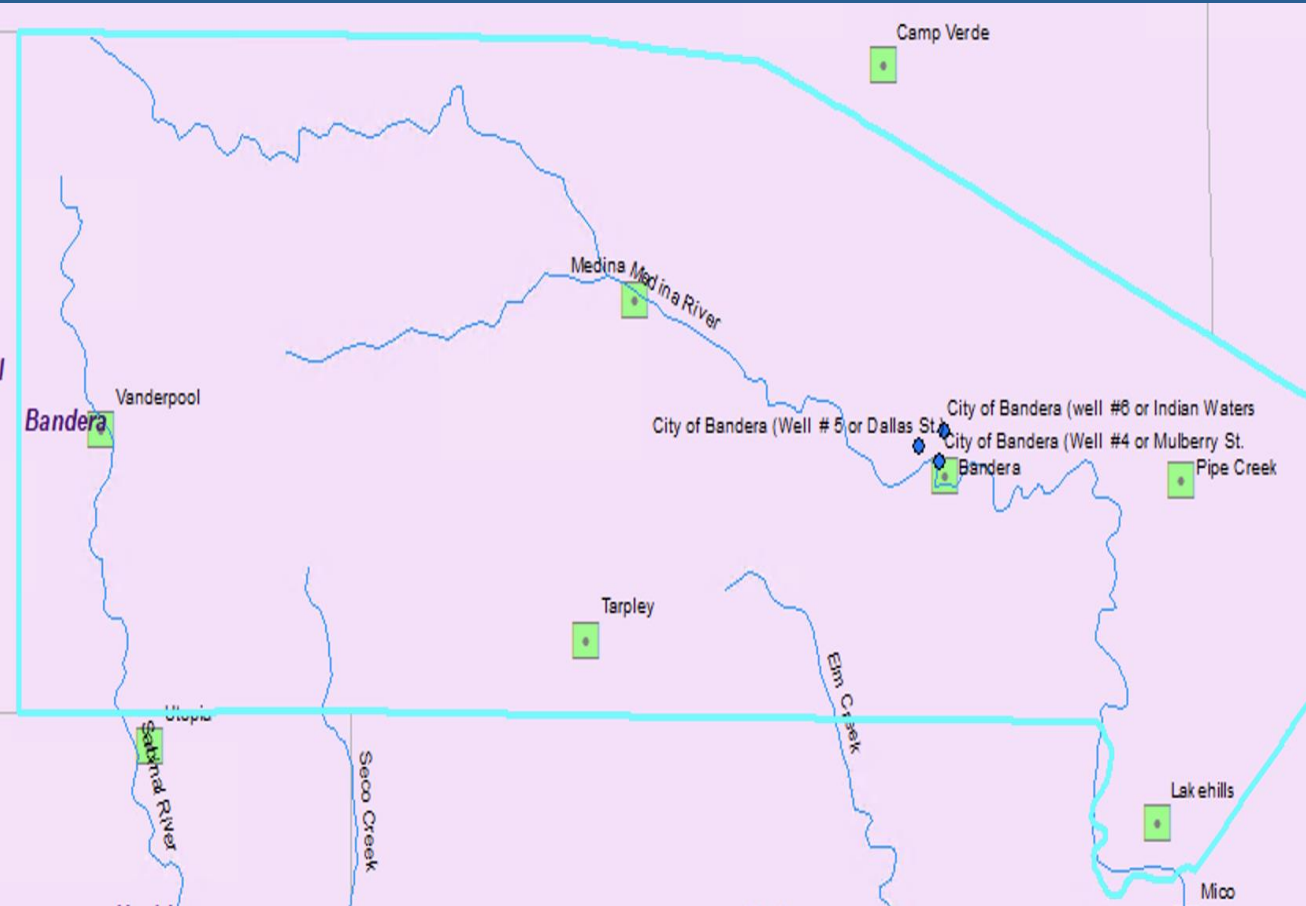
- GBRA Midbasin Water Supply Project
 - Surface water from Guadalupe River and groundwater from Carrizo Aquifer
 - Conjunctive use project involving groundwater production and ASR
 - Stored water and groundwater will be used to meet demand when surface water does not.



Current Projects – GBRA ASR (cont.)

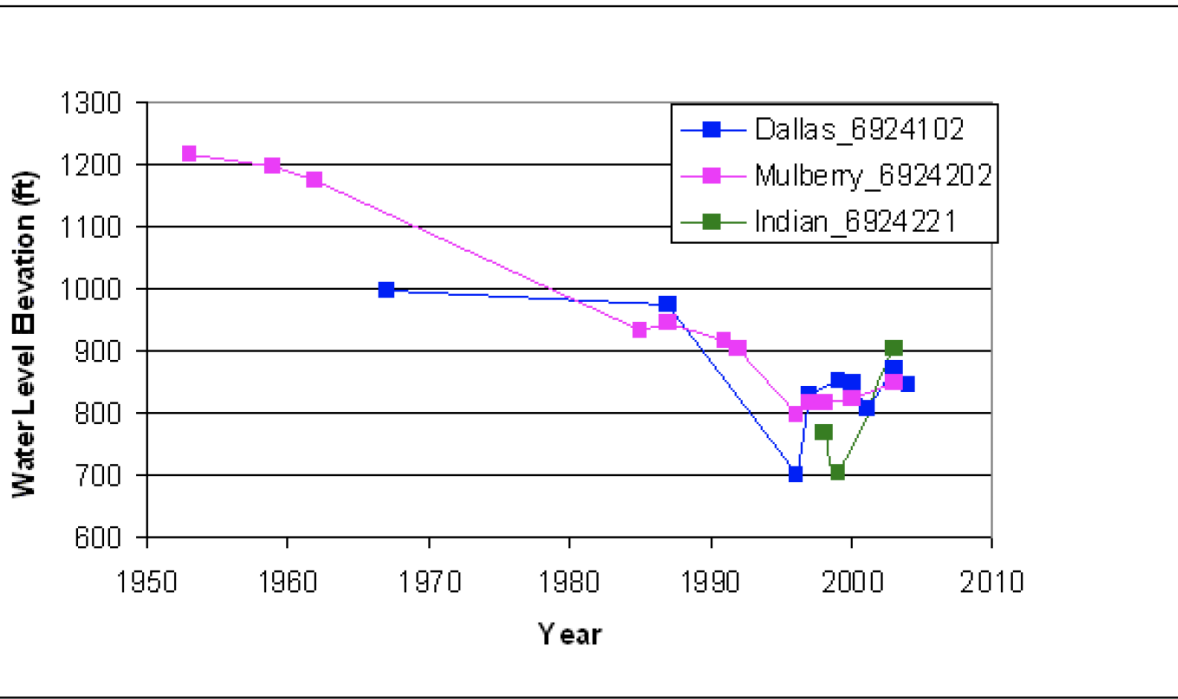
- **Phase 1 – Groundwater development**
 - Carrizo Groundwater Supply Project
 - 15,000 acre-feet from new Carrizo well field
 - Contract for drilling is currently being bid
 - Online by summer 2023
 - Project started in 2019 with SWIFT funding from TWDB
- **Phase 2 – Surface water ASR**
 - 25,000 acre-feet planned
 - Proposed locations in RWP are tentative
 - Well field location could be in northern half of Gonzales county
 - GBRA is currently securing surface water rights and expects TCEQ permit to be issued later this month

Current Projects – City of Bandera ASR



Stratigraphic Unit		Hydrologic Unit	Approx. Maximum Thickness (feet)	Character of Rocks	Water-Bearing Properties
Glen Rose Limestone	upper member	Upper Trinity	500	Alternating resistant and non-resistant beds of blue shale, nodular marl, and impure fossiliferous limestone. Also contains two distinct evaporite zones.	Yields very small to small quantities of relatively highly mineralized water.
	lower member	Middle Trinity	320	Massive, fossiliferous limestone grading upward into thin beds of limestone, dolomite, marl, and shale. Numerous caves and reefs occur in the lower portion of the member.	Yields small to moderate quantities of fresh to slightly saline water.
Travis Peak Formation	Hensell Sand Member Bexar Shale Member		300	Red to gray clay, silt, sand, conglomerate, and thin limestone beds grading downward into silty dolomite, marl, calcareous shale, and shaly limestone.	
	Cow Creek Limestone Member		90	Massive, fossiliferous, white to gray, argillaceous to dolomitic limestone with local thinly bedded layers of sand, shale, and lignite.	
	Hammett Shale Member		80	Dark blue to gray, fossiliferous, calcareous and dolomitic shale with thinly interbedded layers of limestone and sand.	Not known to yield water.
	Sligo Limestone Member Hosston Sand Member	Lower Trinity	120	Sandy dolomitic limestone.	Yields small to large quantities of fresh to slightly saline water.
		350	Red and white conglomerate, sandstone, claystone, shale, dolomite, and limestone.		

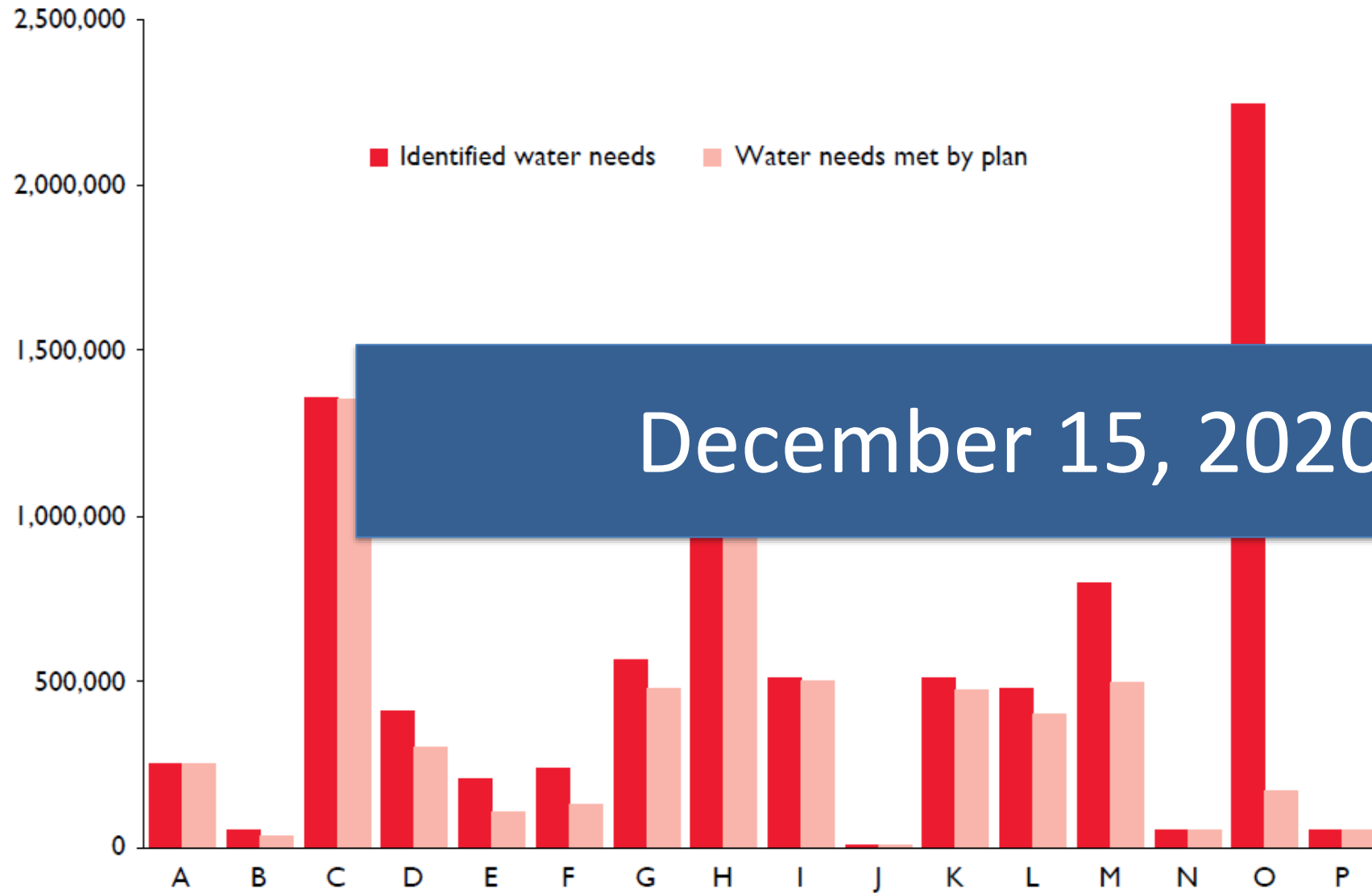
Current Projects – City of Bandera ASR (cont.)



- Feasibility study shows declining water levels and increasing need over the next decades
- Treatment facility:
 - 6.7 mgd projected capacity
 - Provide 500 acre-feet/year in 2040. Increase to 1,500 acre-feet/year by 2060
- ASR:
 - For excess distributed for direct demand
 - Using existing public supply well initially
 - Potencial future plan: Two new Lower Trinity ASR wells

Name in report	BRACS ID	SWN	Owner
Dallas	88432	6924102	City of Bandera (Well # 5 or Dallas St.)
Mulberry	88433	6924202	City of Bandera (Well #4 or Mulberry St.)
Indian	88434	6924221	City of Bandera (well #6 or Indian Waters)

Statewide ASR-AR Survey



December 15, 2020

Texas Water Development Board

Statement of Qualifications
 Services to Conduct a Statewide Survey of Aquifer Suitability for Aquifer Storage and Recovery Projects or Aquifer Recharge Projects
 D No. 580-20-RFQ0005
 Texas Water Development Board
 December 12, 2019

HR In association with:

INTERA
 GEOLOGICAL ENGINEERING SOLUTIONS

COLLIER CONSULTING

GSA GeoSystems Analysis, Inc.
 Innovative Solutions

BUREAU OF ECONOMIC GEOLOGY

Cooper Consulting

Floodace

Conclusions

- ASR and AR projects allow water to be stored in the subsurface during wet periods of time for later recovery or for improving aquifer conditions
- Texas has many areas suitable for ASR or AR projects with appropriate hydrogeological conditions, excess water sources, and a need for water supplies
- These projects will play an increasingly important role as Texas' population continues to grow
- The TWDB will continue to work with local water producers to conduct high-quality aquifer characterization studies and assist in the development of these projects

Thank You

Contact Information

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<http://www.twdb.texas.gov/innovativewater/index.asp>

2017 State Water Plan:

<http://www.twdb.texas.gov/waterplanning/swp/2017/index.asp>



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