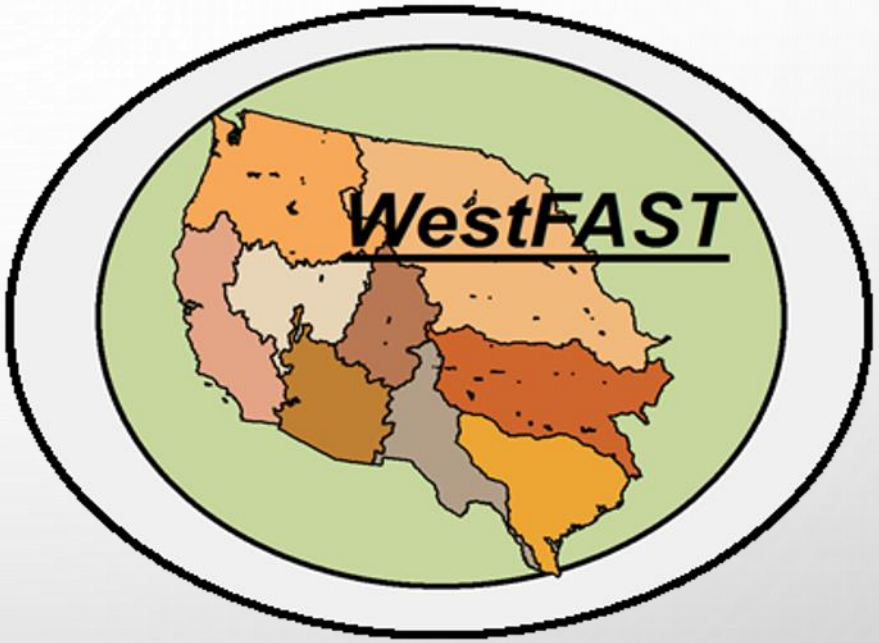
WESTFAST WEBINAR

SALINITY IN THE WESTERN UNITED STATES

DECEMBER 8, 2020, 1PM MOUNTAIN



Texas Water Development Board

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

USGS

Colorado River Basin
SALINITY
CONTROL FORUM

BUREAU OF
RECLAMATION

Zhuping Sheng
Water Resources Engineering Consultant
El Paso, Texas, United States

SALINITY: WHAT? WHERE? HOW?

Rangeland

Point Source

Return Flows

SALINITY – WHAT ARE THE SOURCES

- ROBERT BOYD, BUREAU OF LAND MANAGEMENT

SALINITY – WHAT ARE THE SOURCES?

Natural

- Geologic Formations/Derived Soils
- Atmospheric Deposition
- High TDS Groundwater Discharge
- Halophytic Vegetation

Anthropogenic

- Agricultural Irrigation Return Flows
- Industrial Wastewater Discharges
- Municipal/Domestic Wastewater Discharges
- Stormwater Runoff
- Acid Mine Drainage

SALINITY – WHAT ARE THE IMPACTS

- MARCIE BAINSON, BUREAU OF RECLAMATION

Damages Sectors

- Agricultural
- Residential
- Commercial
- Groundwater
- Utility
- Recycled Water
- Industrial

Agricultural Damages

Crop Production

- Limits type of crop
- Lower yields
- Increases water use and operating & maintenance costs

Crops Impacted

- Head Lettuce, Leaf Lettuce, Romaine Lettuce, Avocado, Strawberry, Nursery, Cut Flowers, Vineyard, Broccoli, Cauliflower, Onions, Cantaloupe, Carrots, Oranges, Tangerines, Lemon/Limes, Grapefruit, Table Grapes, Potatoes, Olives, Honeydews, Tomatoes, Corn, Wheat, Cotton, Barley, Alfalfa Hay, Pasture

Residential Damages

- Accelerates appliance and pipe deterioration, e.g.
  - Water Pipes
  - Water Heaters
  - Faucets
  - Garbage Disposals
  - Clothes Washers
  - Dishwashers
  - Water Softeners

Commercial Damages

- Impacts to:
  - Sanitary Facilities
  - Cooling Facilities
  - Commercial Kitchens
  - Commercial Laundries

Groundwater

- Impacts to:
  - Direct Recharge
  - Indirect Recharge
  - Incidental Recharge

Water Utilities

- Impacts to
  - Treatment Plants
  - Distribution Systems

Recycled Water

- Additional treatment required
- Reuse capability reduced

Industrial Damages

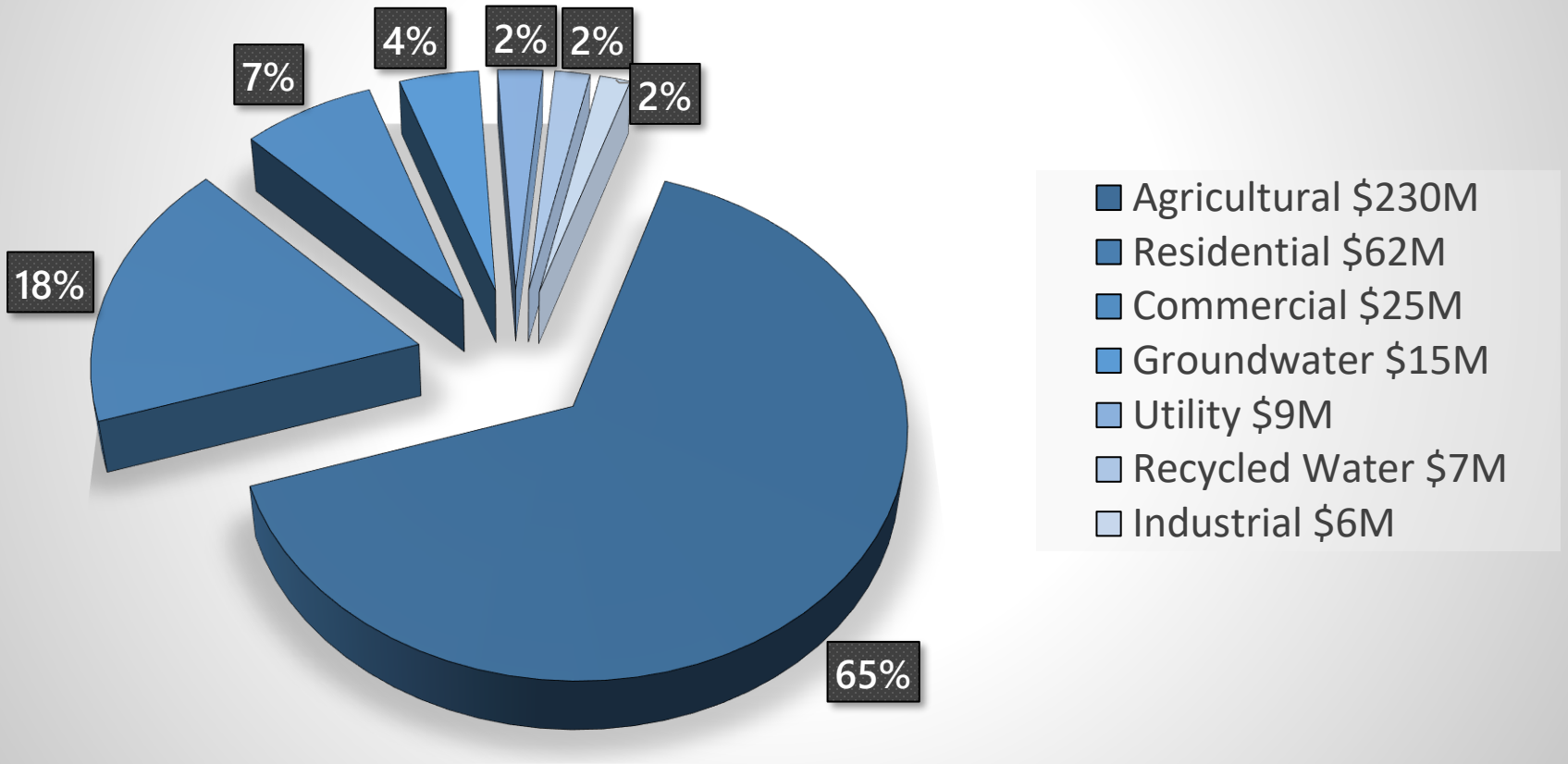
- Accelerates pipe and machinery deterioration
- Additional treatment required for high tech applications
- Impacts to
  - Cooling Towers
  - Boilers

The Salinity Economic Impact Model (SEIM)

The model estimates salinity impacts from the baseline condition (500 mg/L) and then calculates the change in economic impacts when salinity concentrations rise above the baseline condition.

Damages Sectors

2020 Quantified Economic Damages
$354 Million/Year



Overall Salinity Impacts

-Negotiations with Mexico and between states
-Use of water
-Need for cooperation between involved parties
-Meet EPA water quality regulations
-Agriculture and crop yields

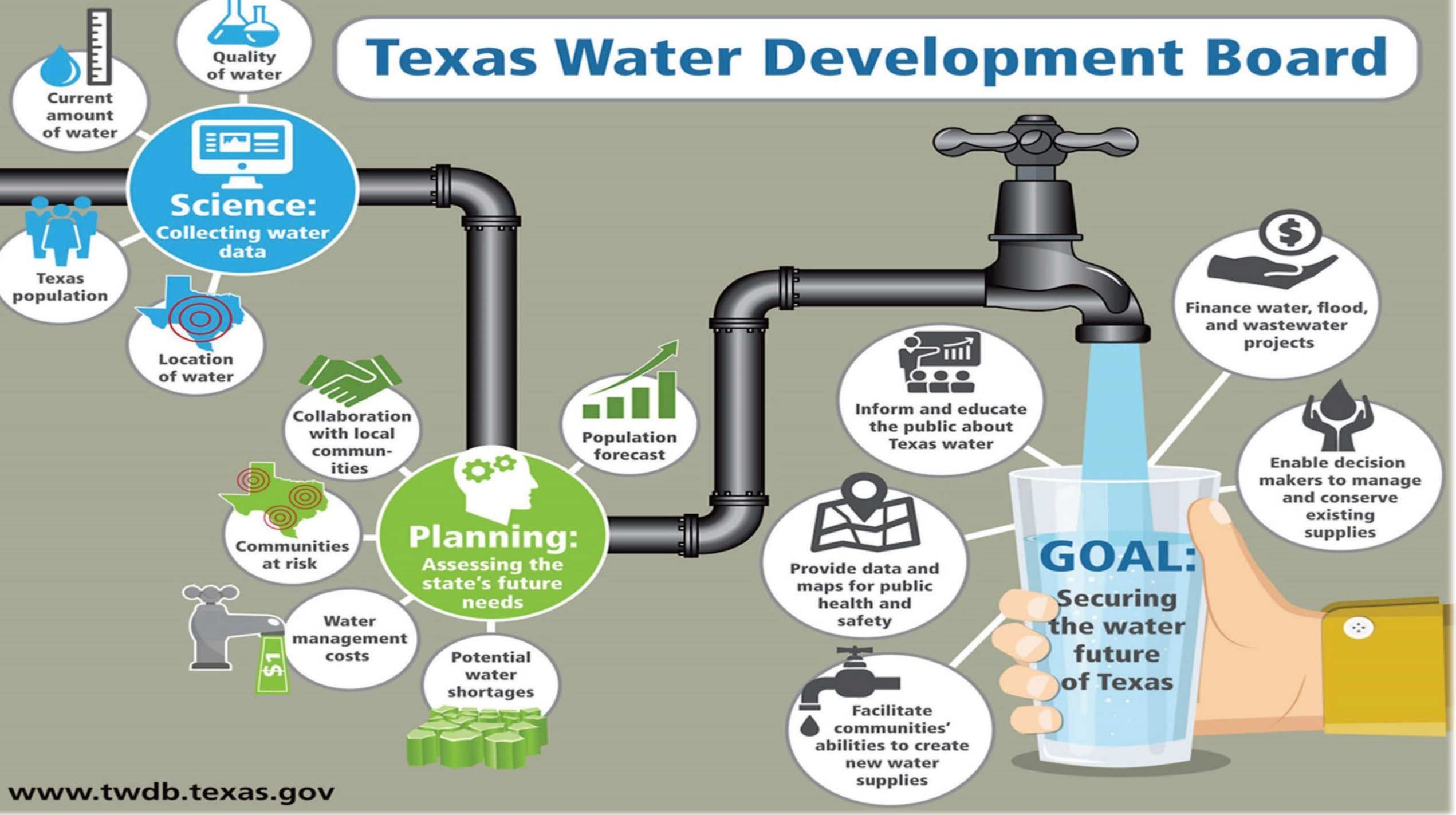
SALINITY – WHERE IS IT A PROBLEM?

TEXAS

Presenter – Erika Mancha, Texas Water Development Board

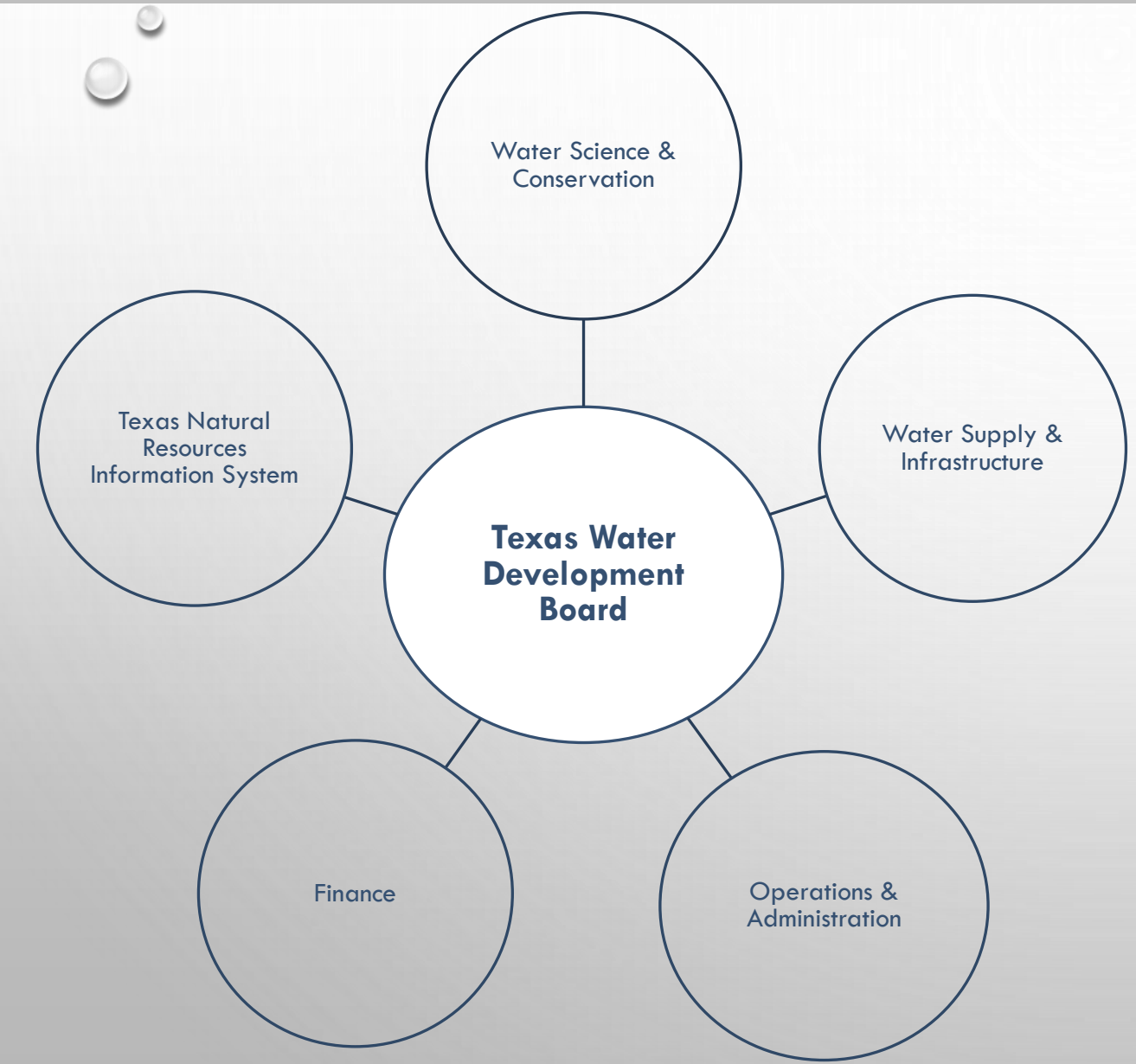
- *Sources of Salinity*
- *Economic Impacts*
- *What are the big questions/needs? E.g. control measures, toolboxes, science gaps*
- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*

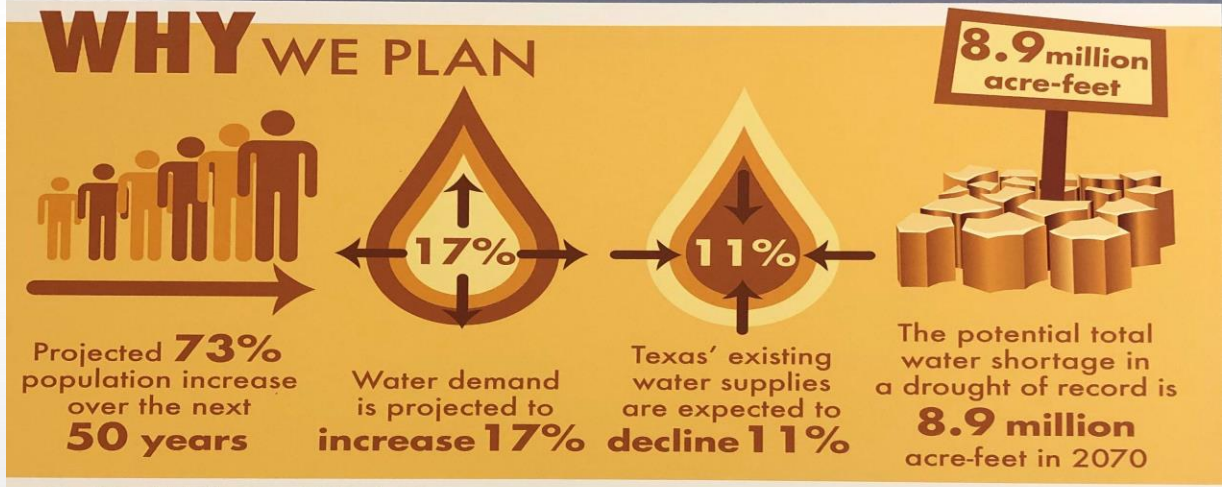
Texas Water Development Board

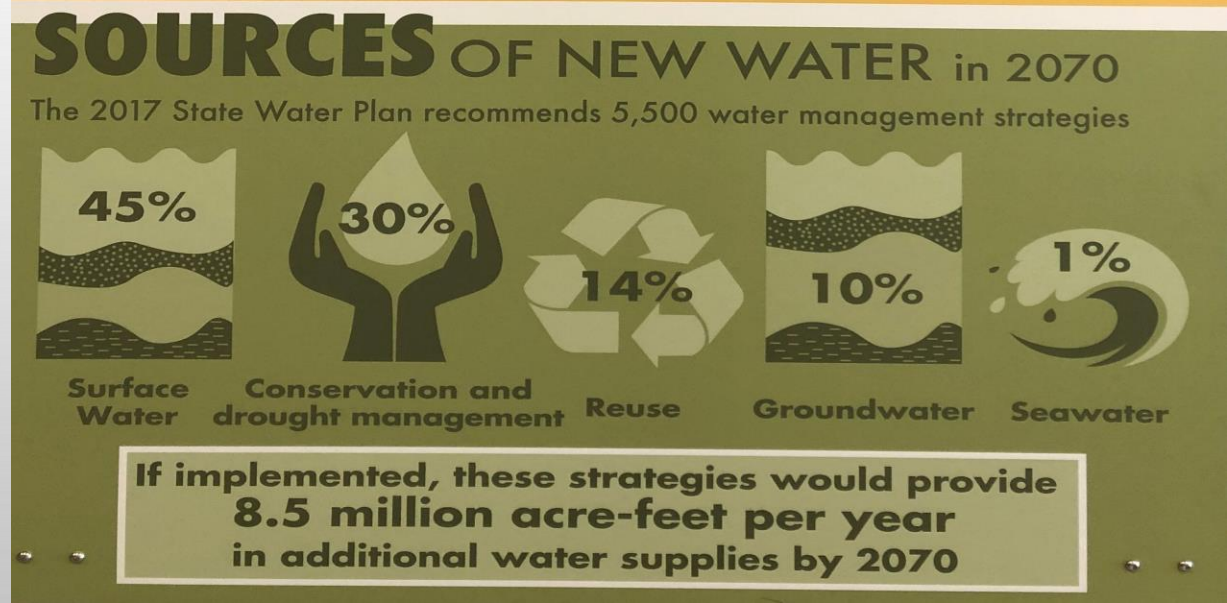


www.twdb.texas.gov

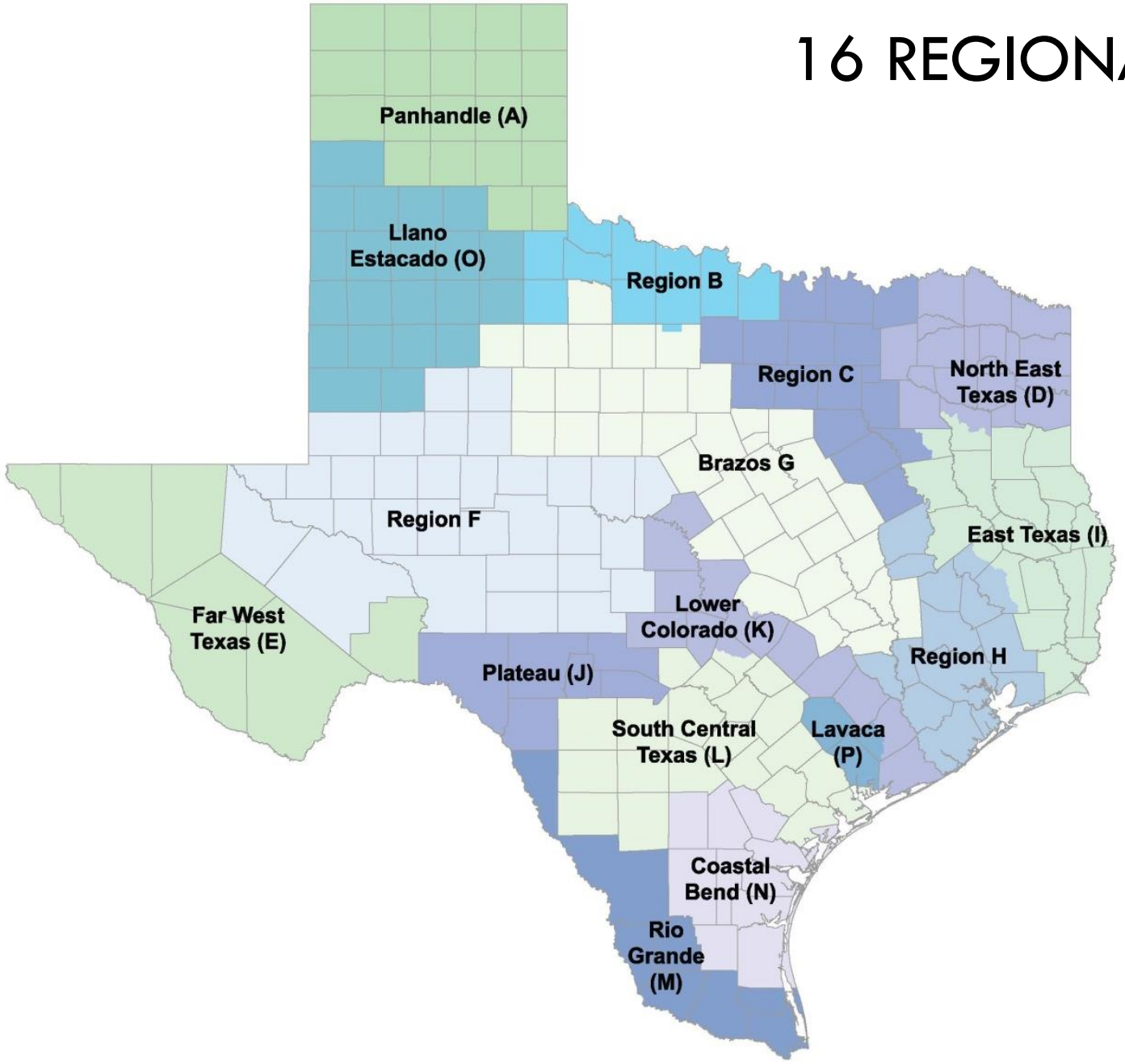
Mission: "To provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas"





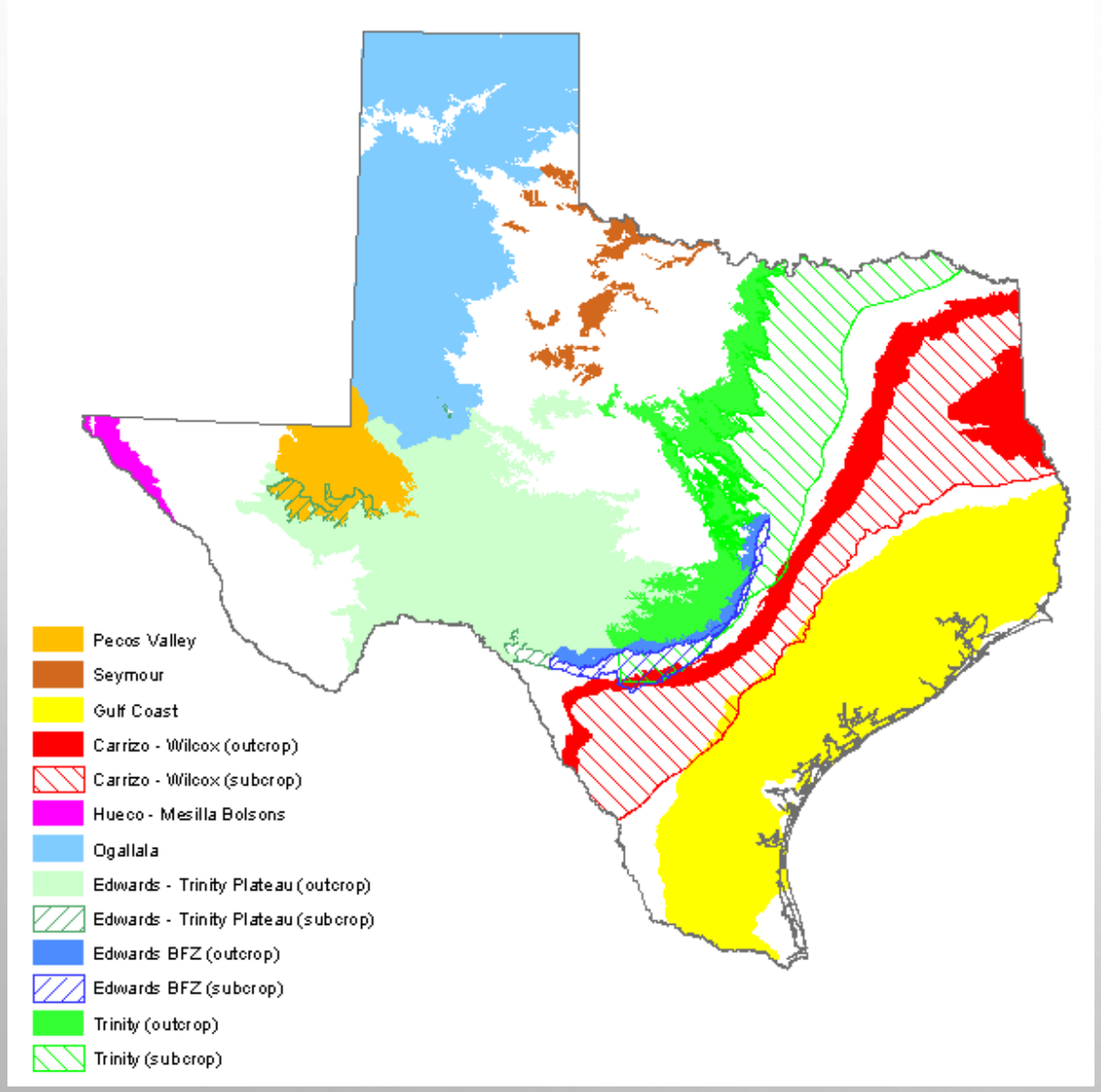


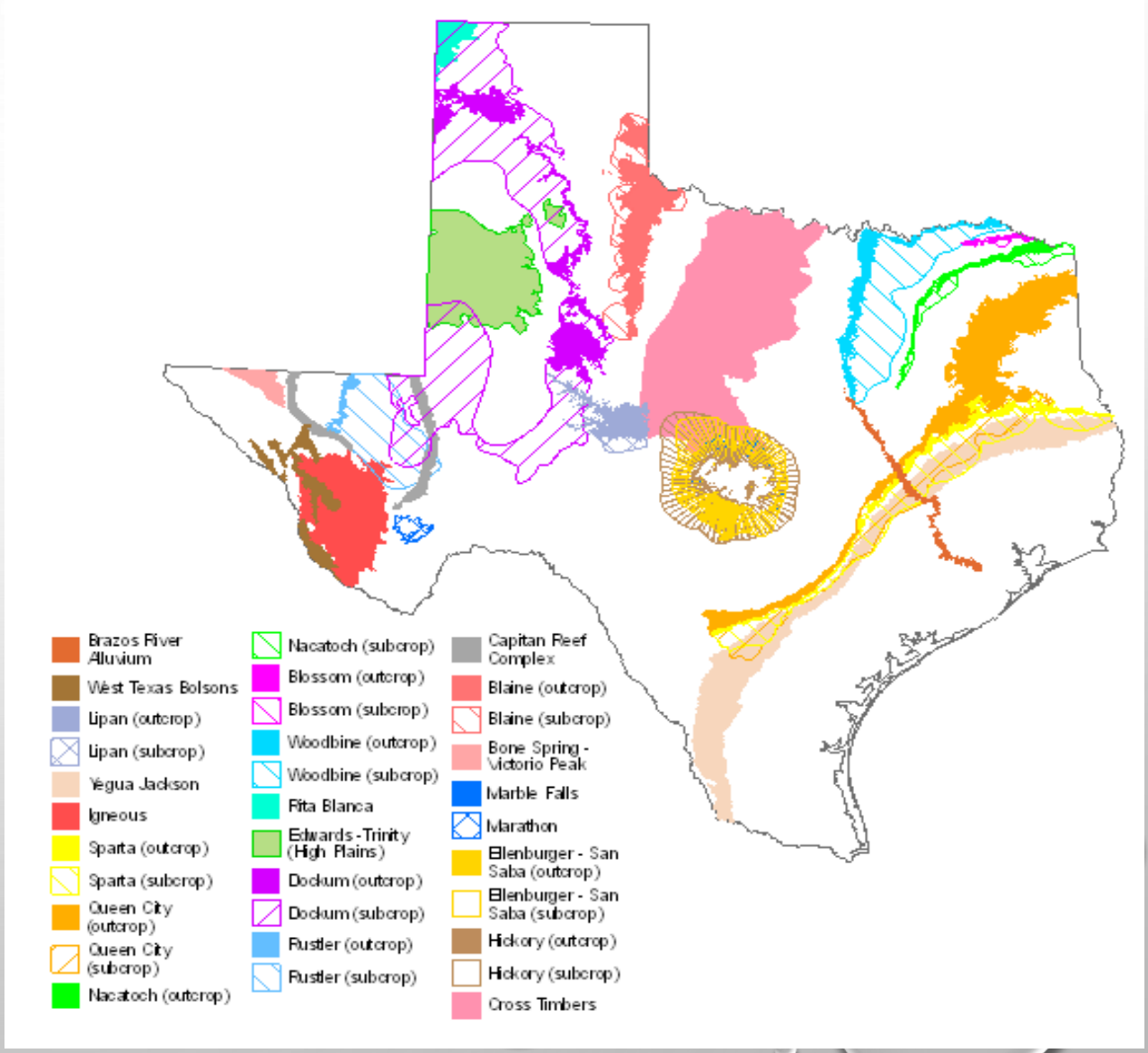
16 REGIONAL WATER PLANNING AREAS



- Bottom-up approach
- State Water Plan every five years
- Working on 2022 State Water Plan

TWDB MAJOR & MINOR AQUIFERS

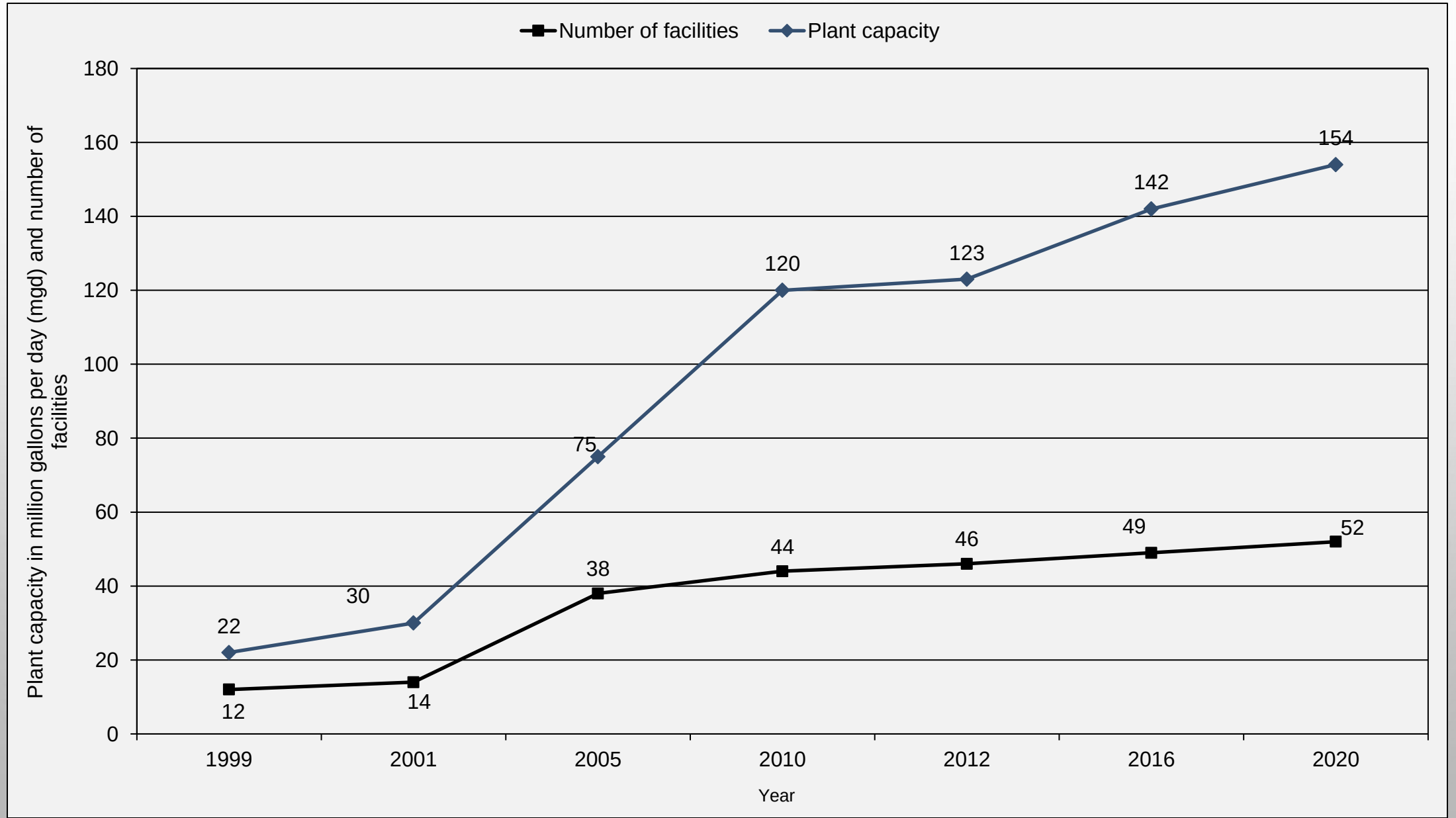




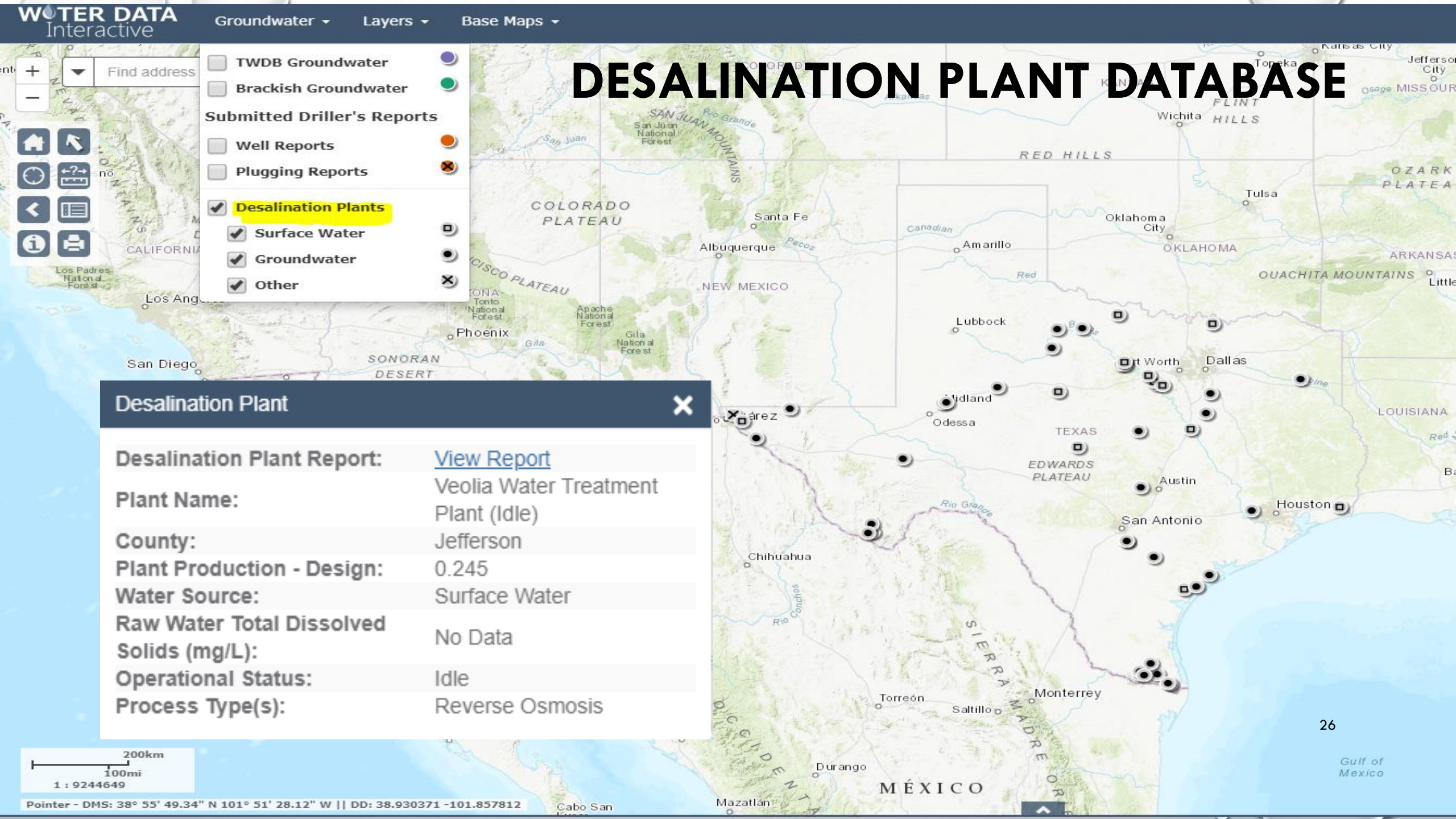
GENERAL SOURCES OF SALINITY

- NATURAL OCCURRING
  - MAXIMUM CONTAMINANT LEVEL FOR TOTAL DISSOLVED SOLIDS (TDS)
    - 500 MG/L IN U.S.
    - 1,000 MG/L IN TEXAS
- SEAWATER INTRUSIONS
- AGRICULTURE RETURN FLOWS
- WASTEWATER RETURN FLOWS
- SALINITY INVERSIONS

DESALINATION GROWTH IN TEXAS

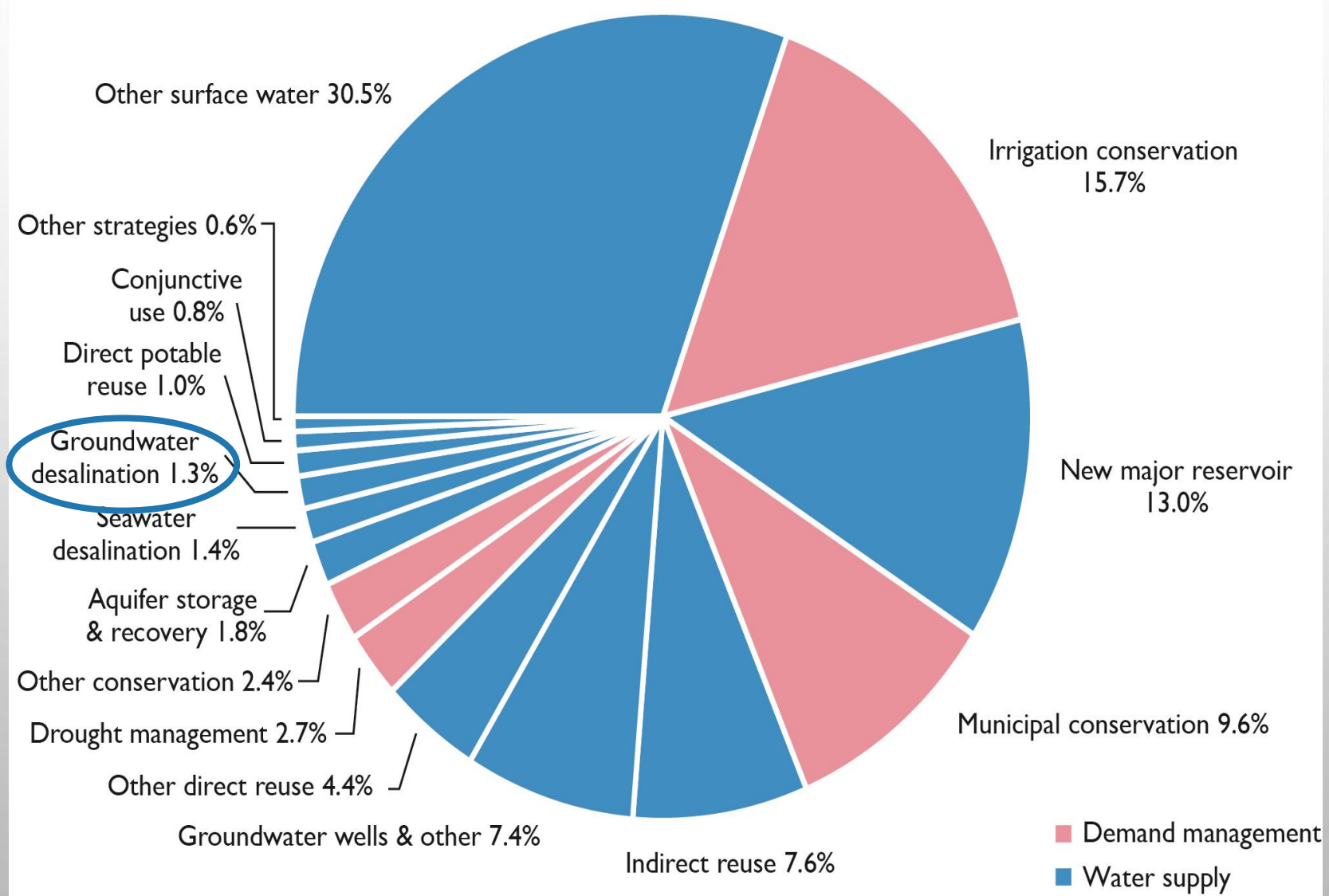


DESALINATION PLANT DATABASE

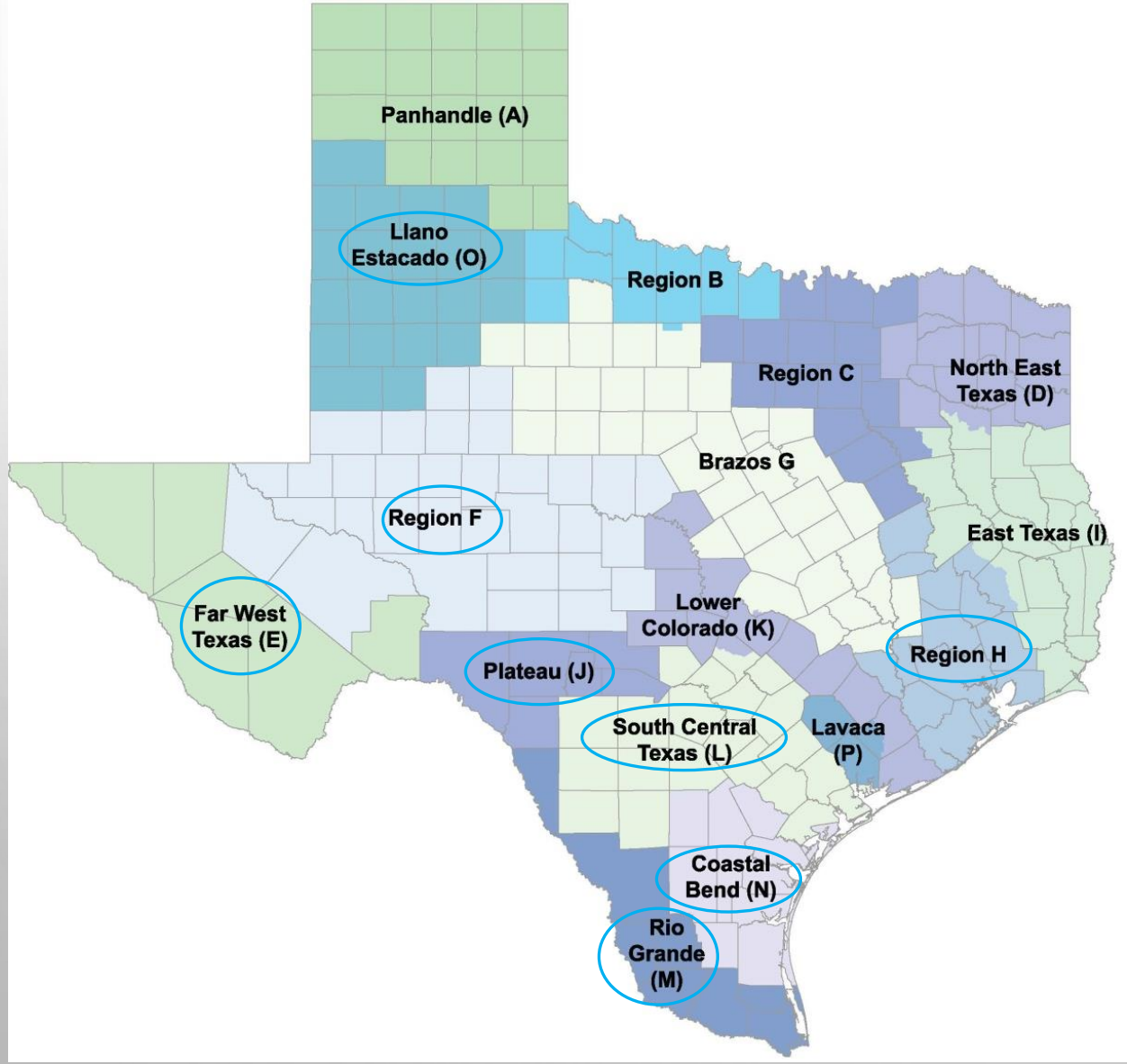


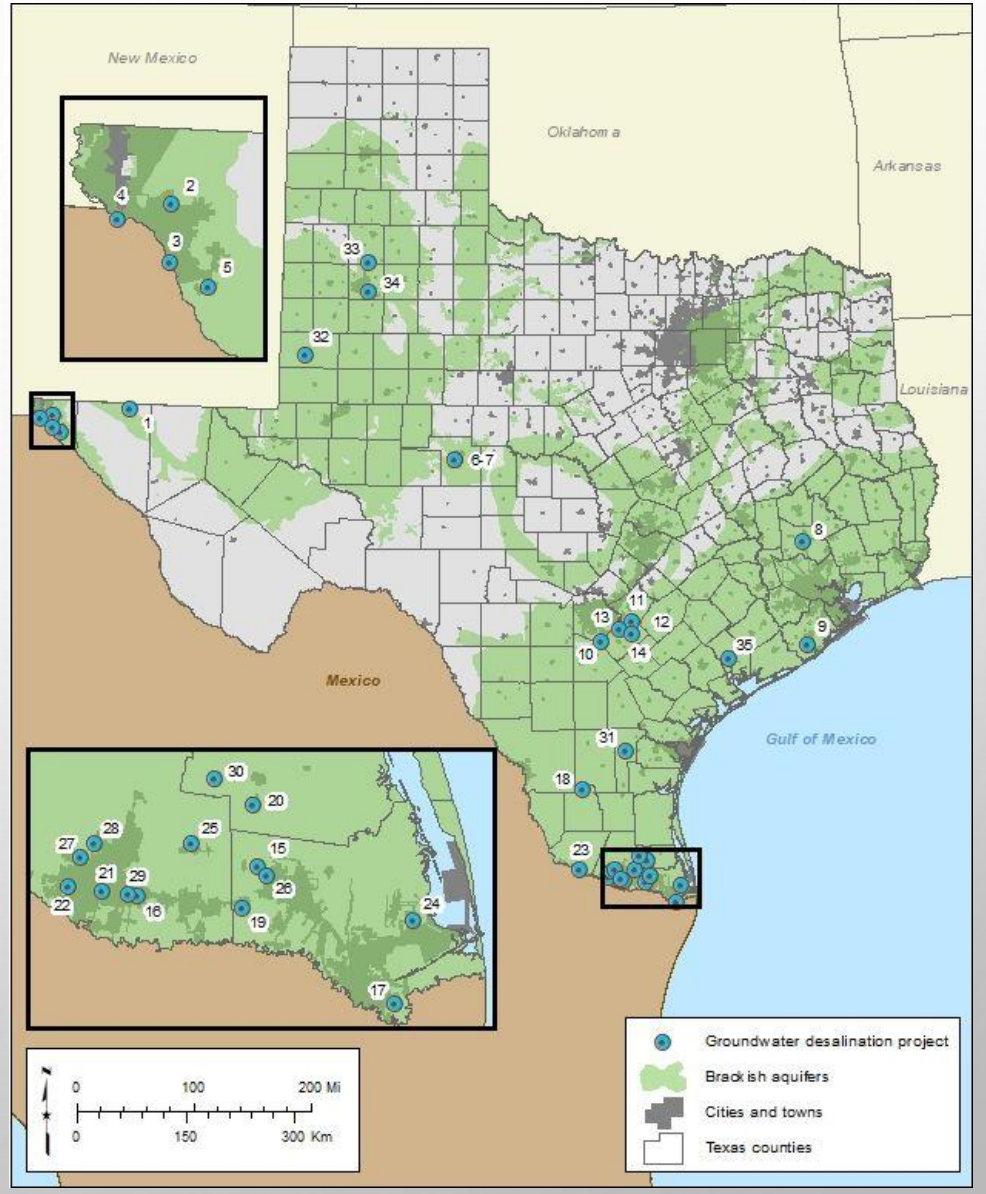
RECOMMENDED WATER MANAGEMENT STRATEGIES BY 2070 IN 2017 STATE WATER PLAN

~111,000 acre –feet/year

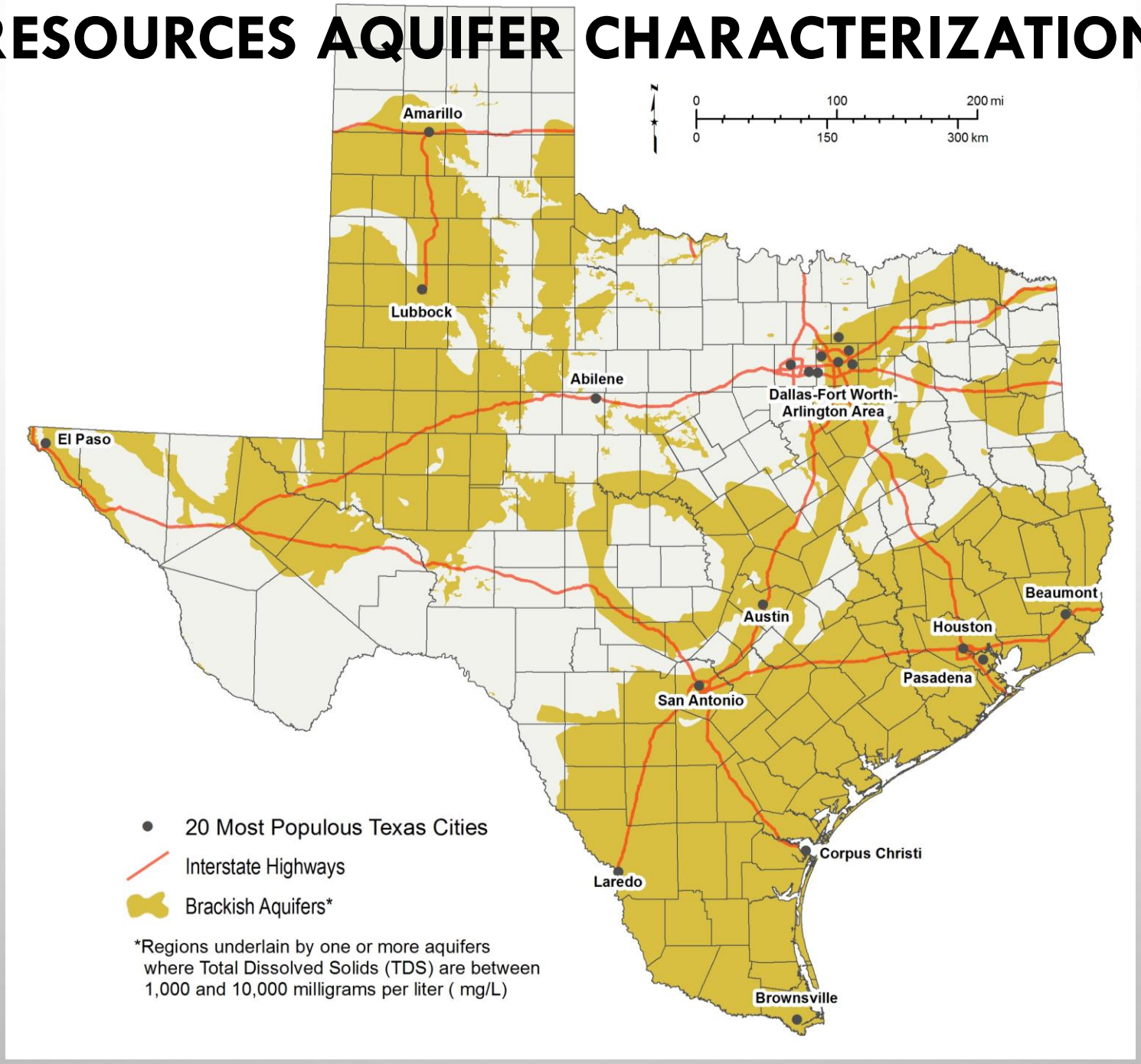


GROUNDWATER DESALINATION RECOMMENDED WATER MANAGEMENT STRATEGIES AND PROJECTS

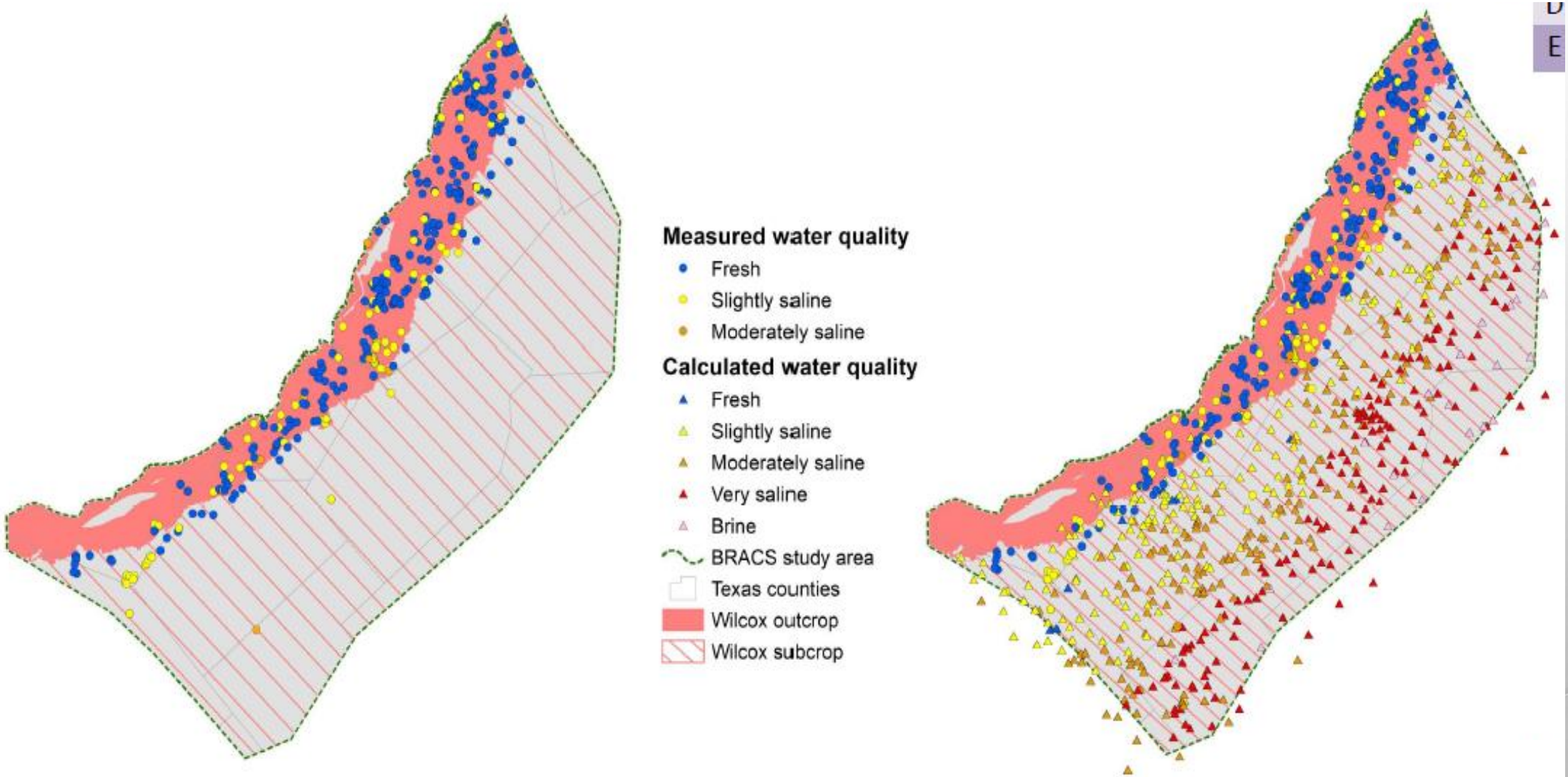


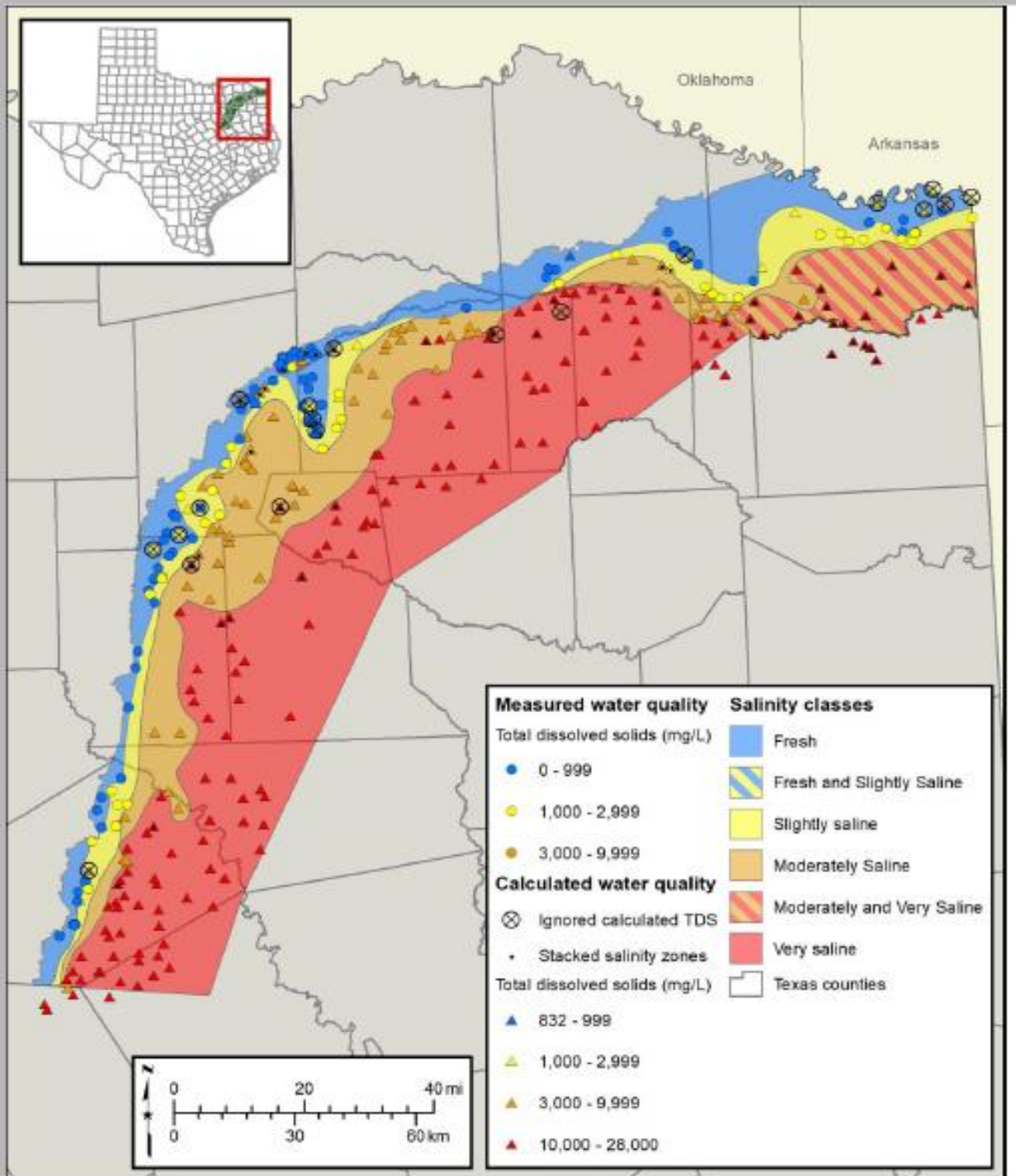


BRACKISH RESOURCES AQUIFER CHARACTERIZATION SYSTEM



MEASURED VS CALCULATED WATER QUALITY DATA

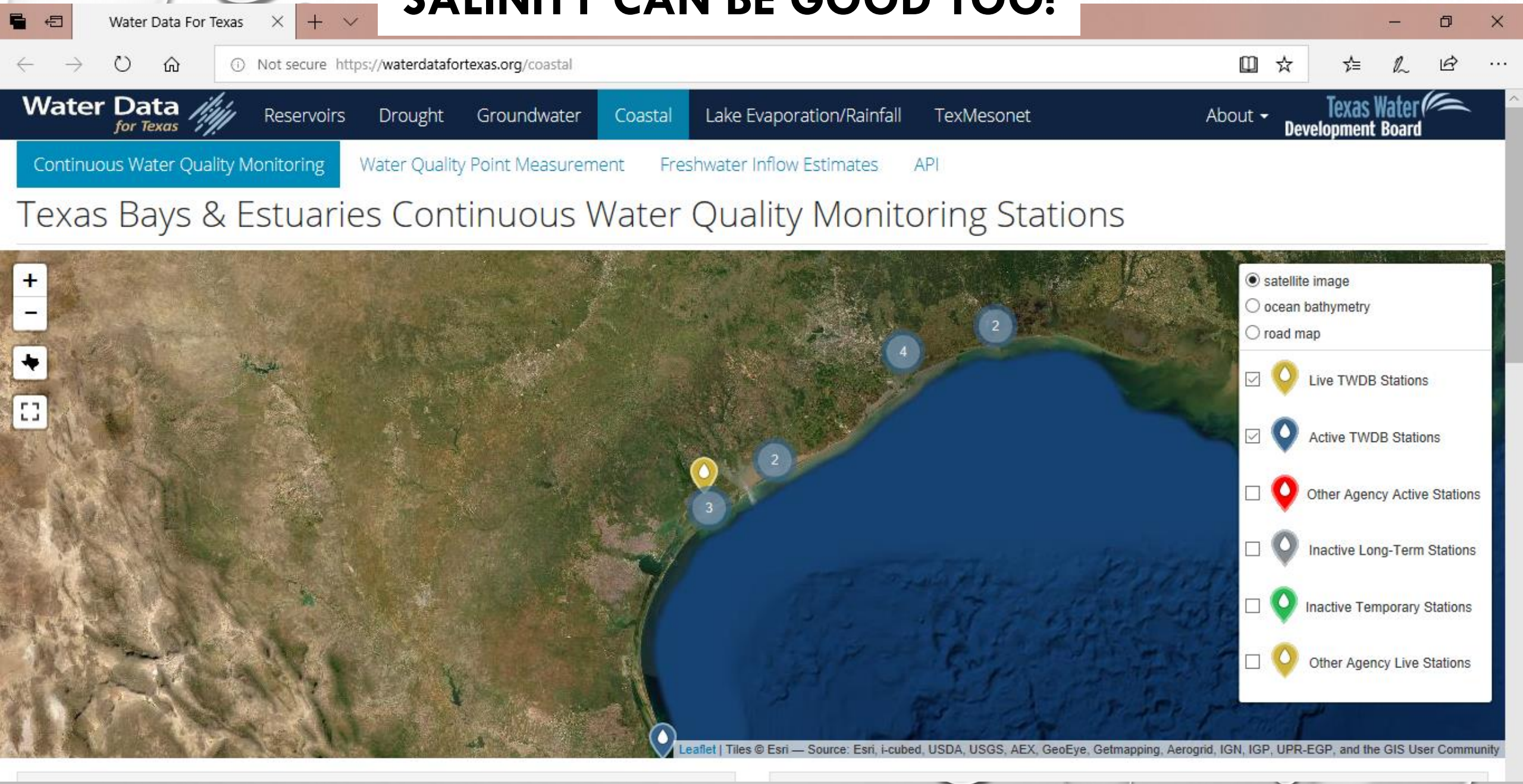




Examples from recently published studies

Salinity class	Volume (acre-feet)
Fresh	2,120,000
Fresh and slightly saline	30,000
Slightly saline	2,040,000
Moderately saline	3,720,000
Moderately and very saline	1,890,000
Very saline	8,190,000
Total	17,990,000

SALINITY CAN BE GOOD TOO!



SALINITY – WHERE IS IT A PROBLEM?

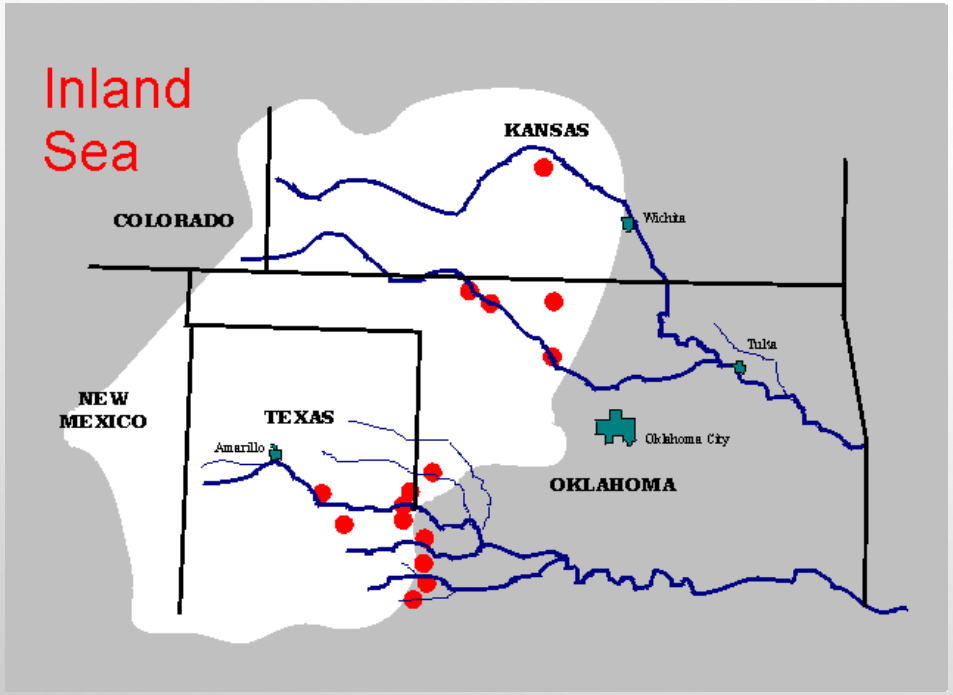
RED RIVER

Presenter – Mike Abate, U.S. Army Corps of Engineers

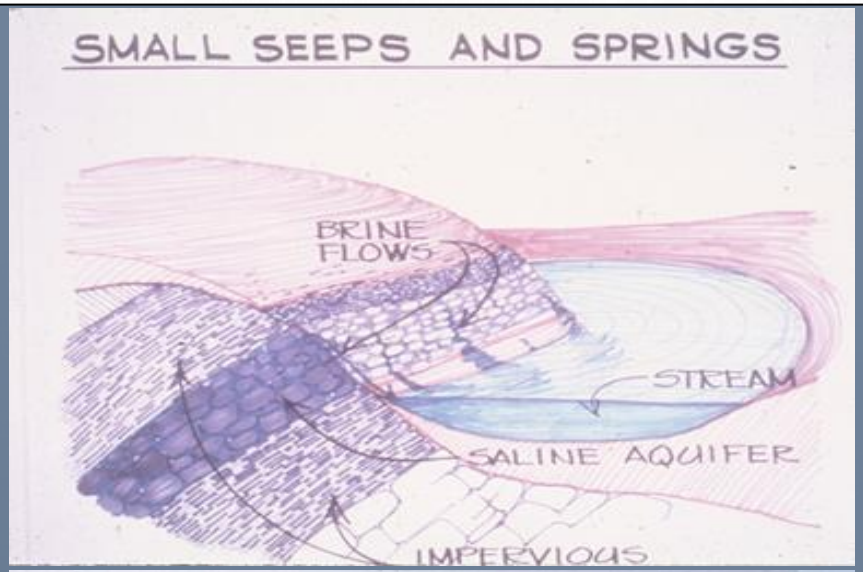
- *Sources of Salinity*
- *Corps of Engineers Control Measures (Planned and Existing)*
- *Economic Impacts*
- *What are the big questions/needs*
- *Major Players*

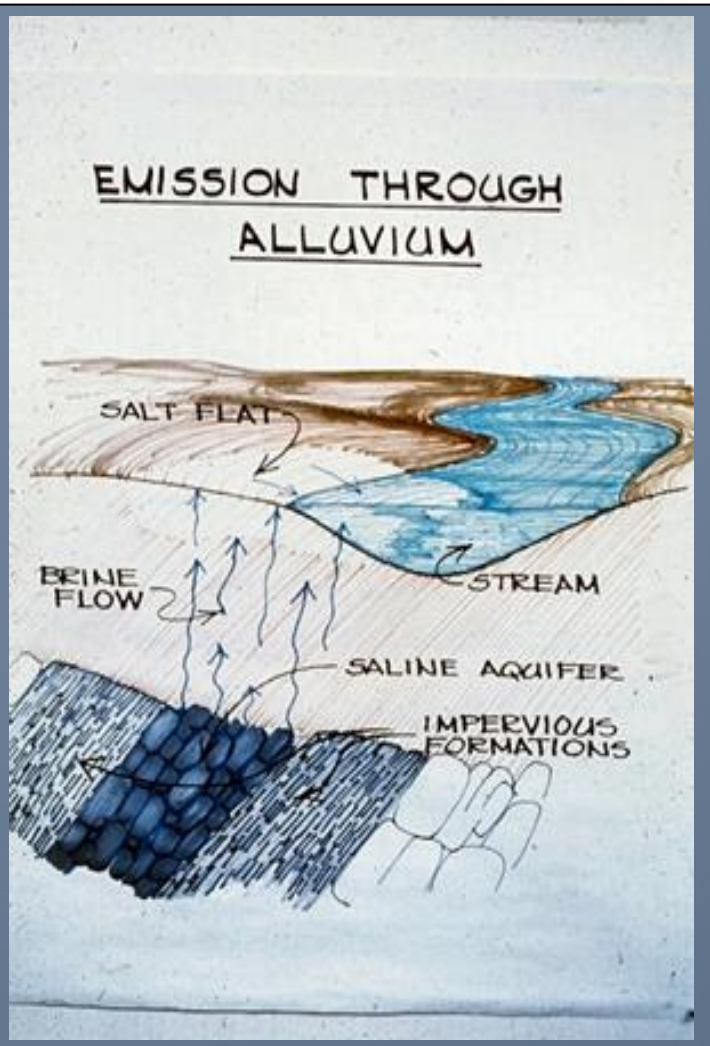
TULSA DISTRICT
US ARMY CORPS OF ENGINEERS

Salt Source Areas

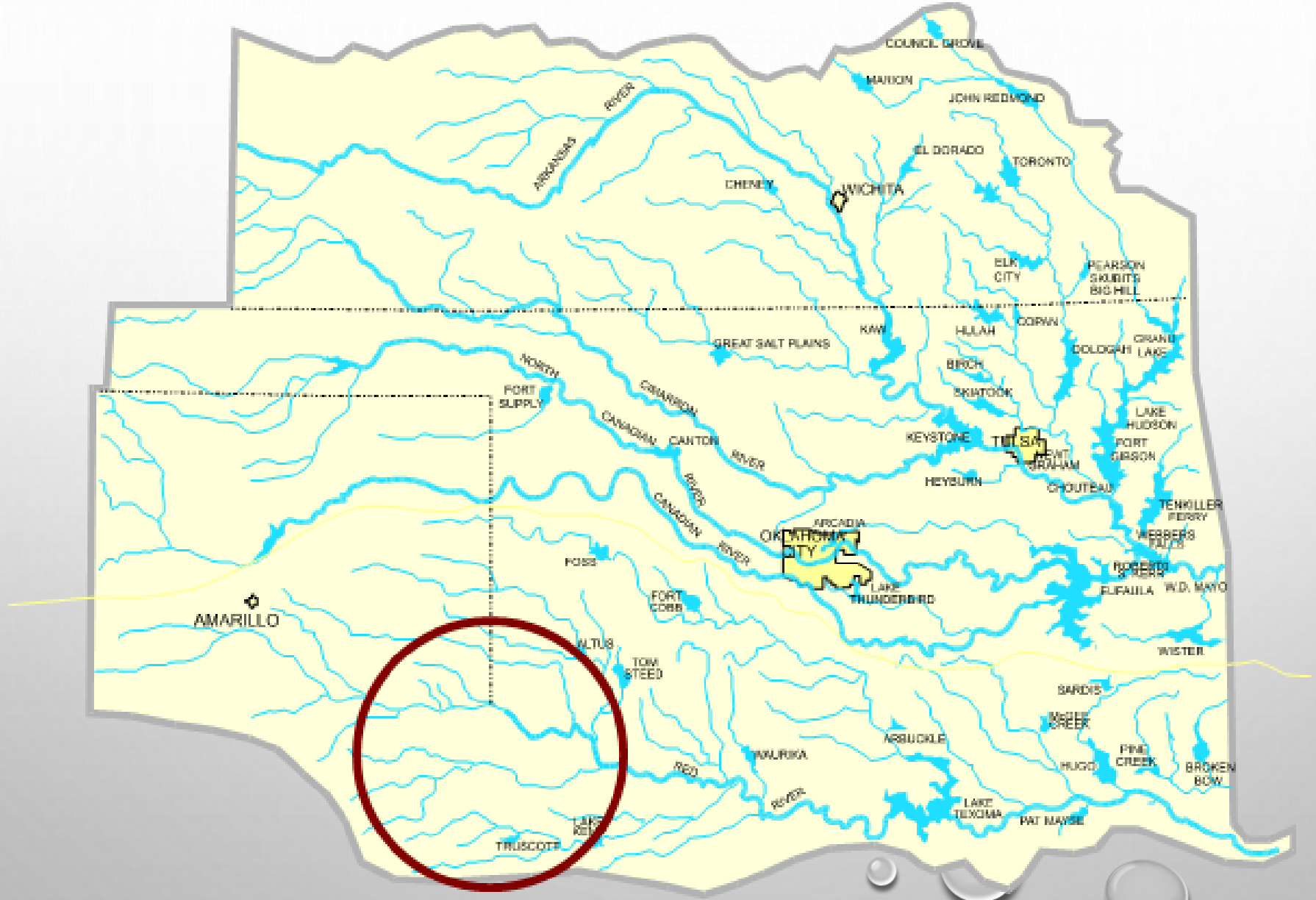


Brine Emission Types



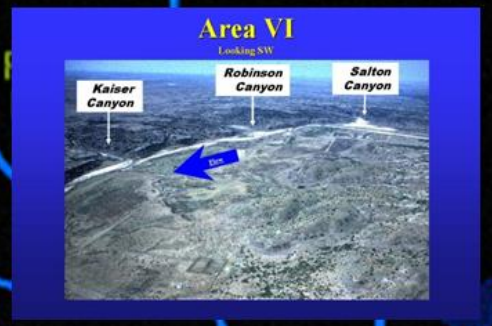


Tulsa District Boundary and RRCCP Location




SALT FORK OF RED RIVER
AREA VI
FISH CREEK
BRINE DAM
RIVER
ELM FORK
TEXAS
PRAIRIE DOG TOWN FORK
AREA XIII
AREA XIV
AREA V
RED
NORTH PEASE
PEASE
AREA IX
MIDDLE PEASE
SOUTH PEASE
RIVER
RIVER
CROWELL
BRINE DAM
AREA VII
AREA X
AREA VIII
TRUSCOTT
BRINE DAM
WICHITA RIVER
CHLORIDE
CONTROL
PLAN

CHLORIDE CONTROL PLAN



SALT FORK OF RED RIVER
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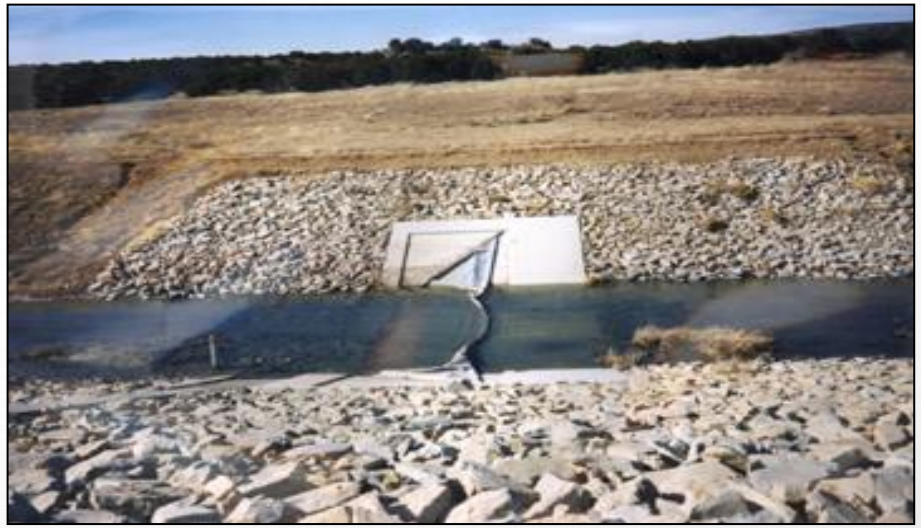
AREA IX
PEASE
MIDDLE PEASE
RIVER
RIVER
CROWELL BRINE DAM
SOUTH PEASE
AREA VII
AREA X
TRUSCOTT BRINE DAM
AREA VIII
WICHITA RIVER

TULSA DISTRICT
US ARMY CORPS OF ENGINEERS

LOW FLOW DIVERSION

Deflated

During periods of high flow after a rain, will allow diluted brines to pass downstream.



Inflated

During low flow periods, brines will be diverted to Brine Containment Facility.


Area VIII
Bateman Pump Station
In operation since 1986

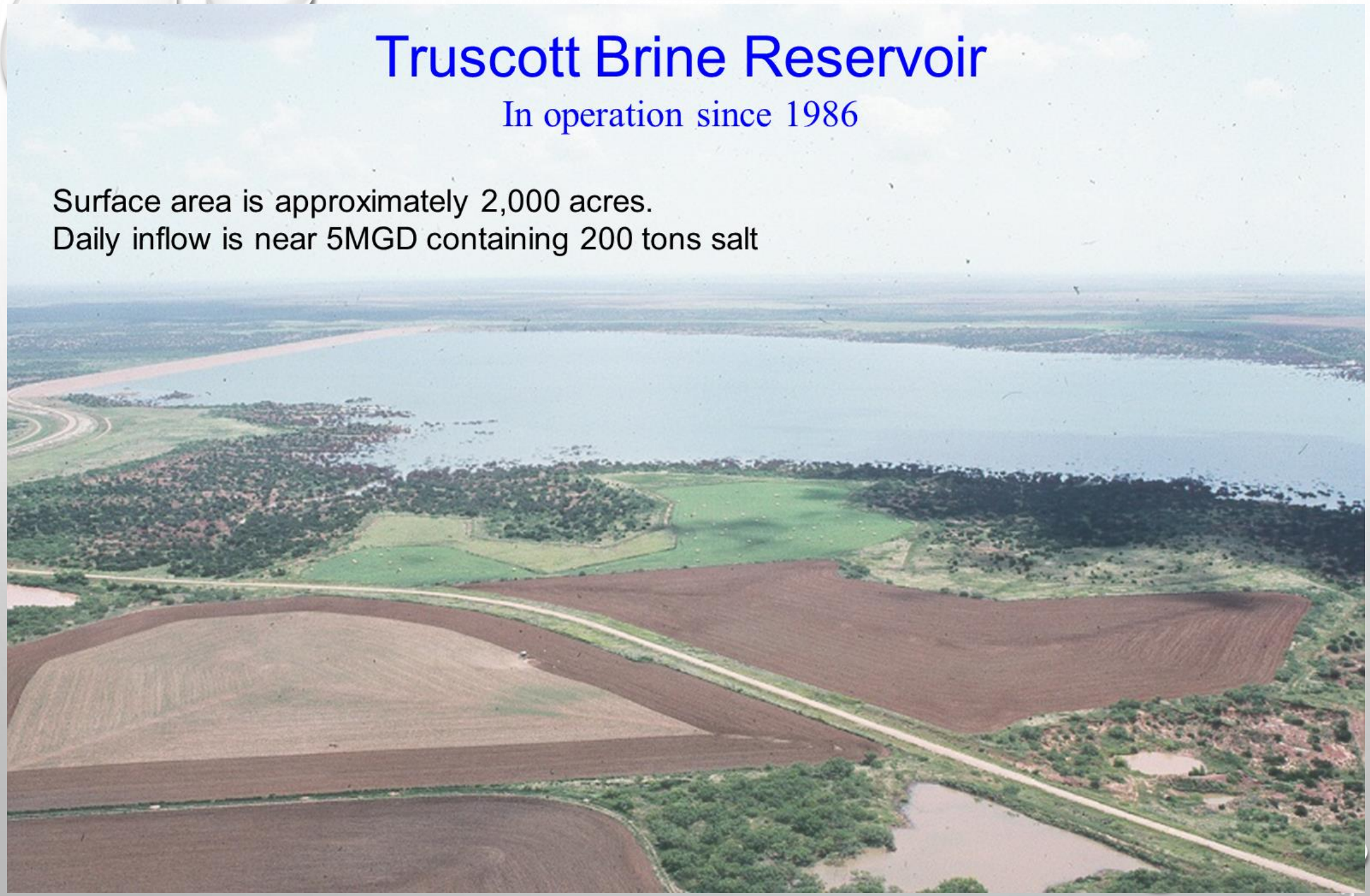
AREA X PUMPHOUSE AND DAM

UNFINISHED

Truscott Brine Reservoir

In operation since 1986

Surface area is approximately 2,000 acres.
Daily inflow is near 5MGD containing 200 tons salt



ECONOMIC IMPACTS/BENEFITS

- IT HAS BEEN ESTIMATED THAT BETWEEN 1960 AND 2006, TEXAS STATE ENTITIES HAVE EXPENDED $385,292,716 ON POLLUTION CONTROL ACTIVITIES IN THE RED RIVER BASIN
- WICHITA RIVER BASIN (AREA VII AND X)
  - FOR THE WICHITA RIVER BASIN PROJECT IN MARCH 2007 PRICES THAT $7.3 MILLION DOLLARS IN BENEFITS ARE NOT REALIZED EACH YEAR BECAUSE OF THE DELAY IN COMPLETION OF WICHITA BASIN FEATURES AREAS VII AND X
- ELM FORK (AREA VI)
  - THE ANNUAL NED BENEFITS CALCULATED FOR EACH OF THE ENTITIES USING WATER FROM LAKE TEXOMA WERE ADDED TOGETHER TO ESTIMATE THE TOTAL ANNUAL NED BENEFITS. THE TOTAL ANNUAL NED BENEFITS IN THE STUDY AREA ARE $3,960,100 ONCE THE FULL BENEFITS OF IMPLEMENTING AREA VI ARE REALIZED.
  - AGRICULTURAL BENEFITS
    - IN THE WITHOUT-CABLE MOUNTAIN RESERVOIR ALTERNATIVE, TOTAL EMPLOYMENT WAS ESTIMATED TO INCREASE BY 88 JOBS AND OUTPUT WAS ESTIMATED TO INCREASE BY $9,864,100
    - IN THE WITH-CABLE MOUNTAIN RESERVOIR ALTERNATIVE, EMPLOYMENT WAS ESTIMATED TO INCREASE BY 156 JOBS AND OUTPUT WAS ESTIMATED TO INCREASE BY $21,656,100

WHAT ARE THE BIG QUESTIONS/NEEDS

- BIGGEST NEED IS FUNDING
  - AREA VI AND AREA X LAST FUNDING (CONSTRUCTION) WAS RECEIVED IN FY 2011
  - AREA VIII (O&M) WAS NOT IN PRESIDENT BUDGET FOR FY2021
    - O&M FUNDING WAS RECEIVED VIA THE FY2020 WORK PLAN
- BIGGEST QUESTION
  - WILL AREA VIII (O&M) BE INCLUDED IN FUR FY2022 PRESIDENT BUDGET
    - WILL WE BE REQUIRED TO DO A DISPOSITION STUDY

MAJOR PLAYERS

Lugert-Altus Irrigation District

SALINITY – WHERE IS IT A PROBLEM?

ARKANSAS RIVER

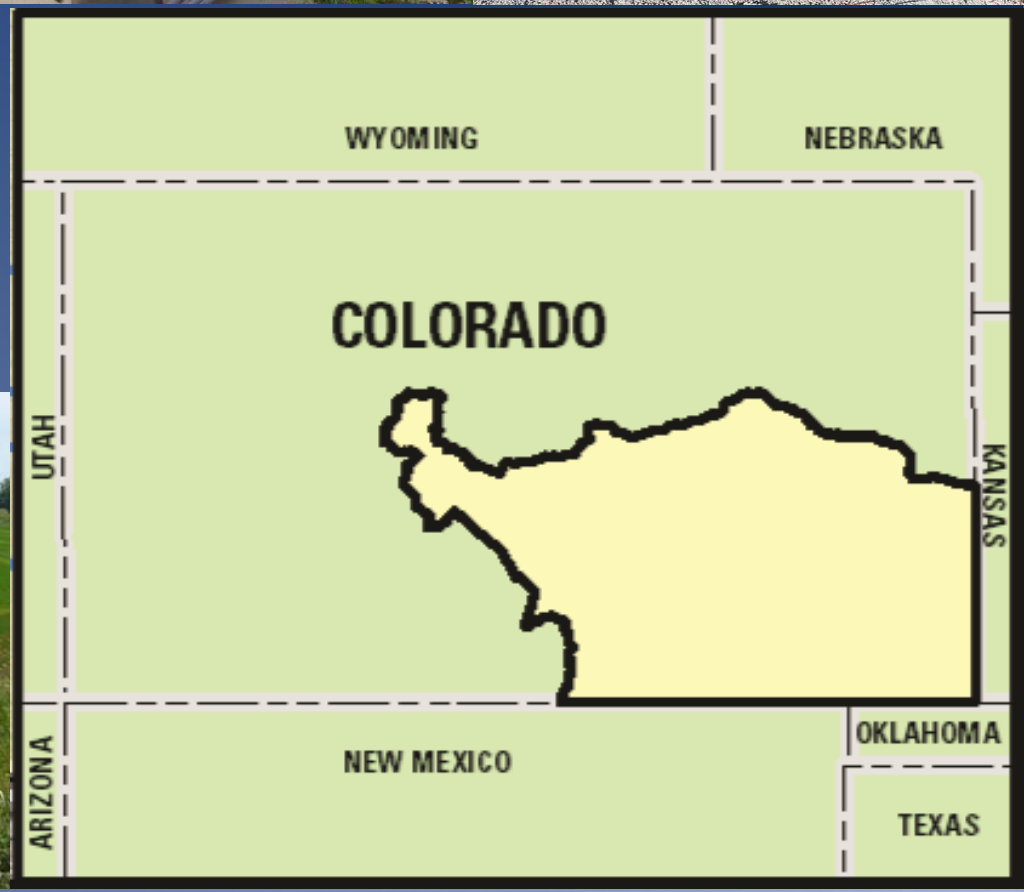
Presenter – Carleton Bern, U.S. Geological Survey

- *Sources of Salinity*
- *Economic Impacts*
- *What are the big questions/needs? E.g. control measures, toolboxes, science gaps*
- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*




WestFAST Presentation
Salinity in the Arkansas River Basin

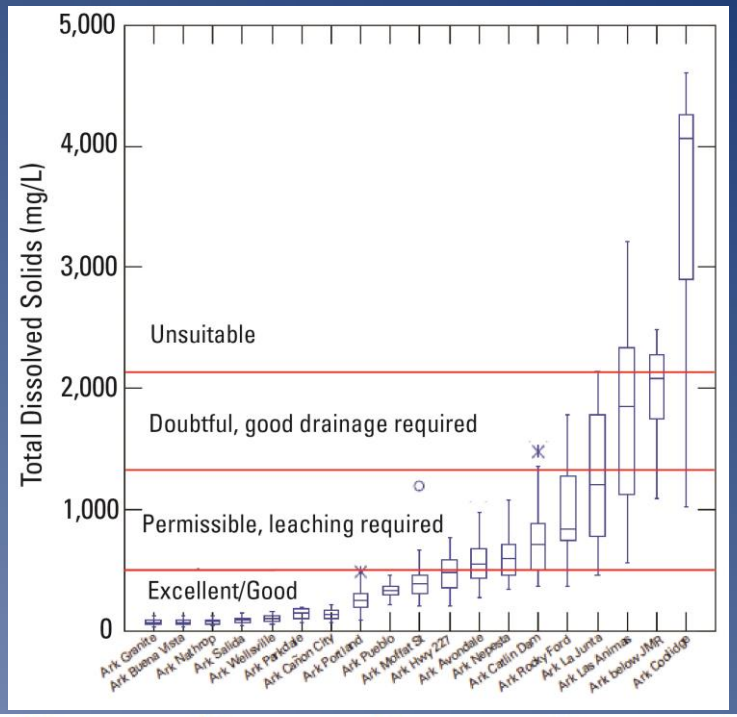
Carleton Bern, Ph.D.
U.S. Geological Survey,
Colorado Water Science Center

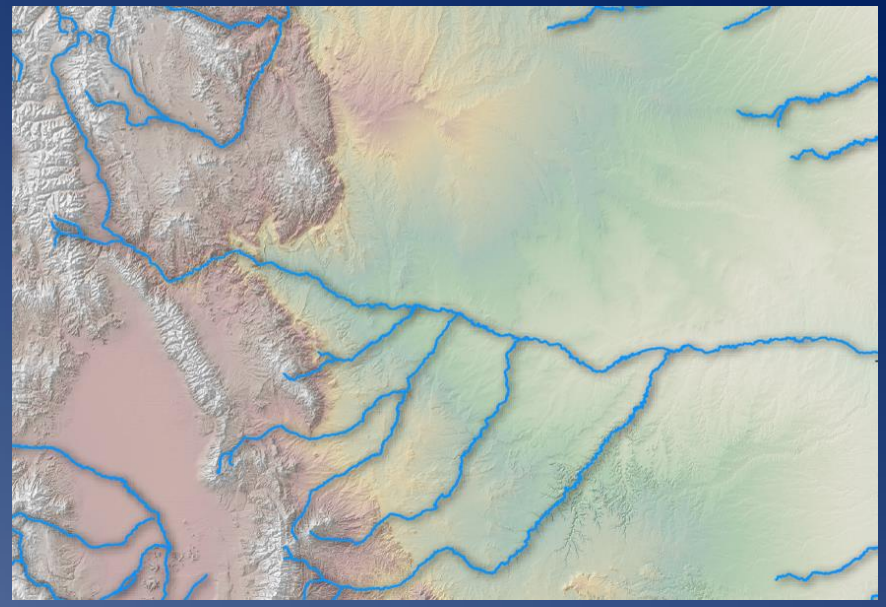


USGS

Sources of salinity

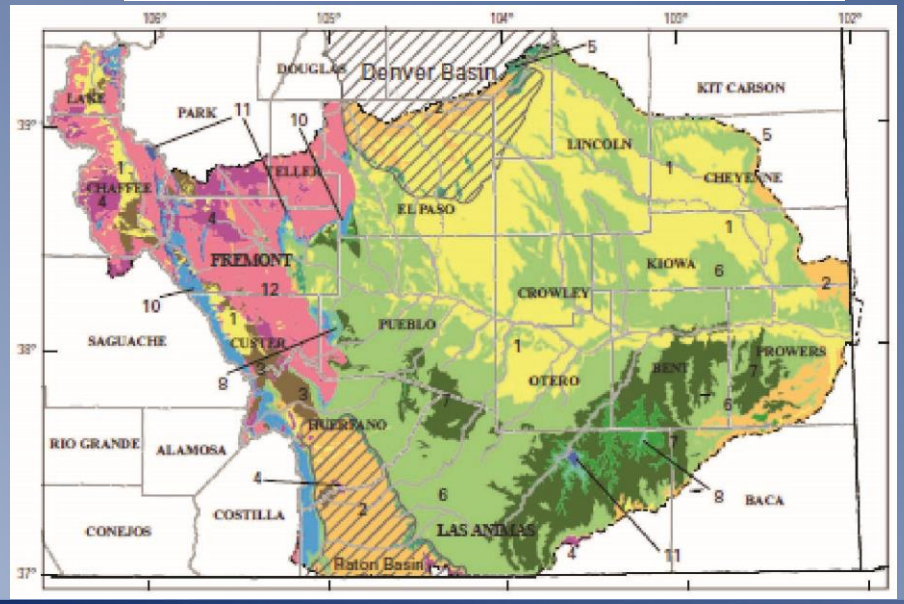
. . . and uranium and selenium

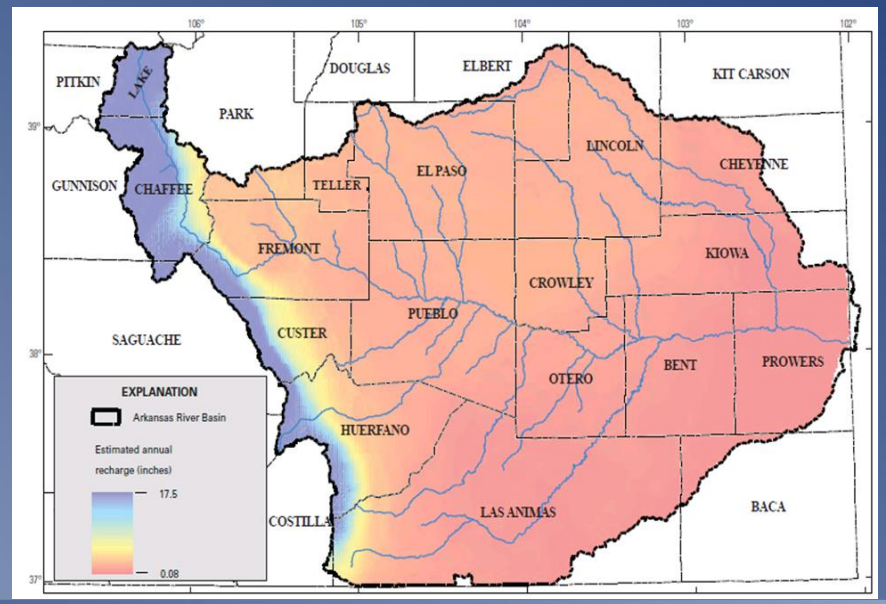




Topography

Geology

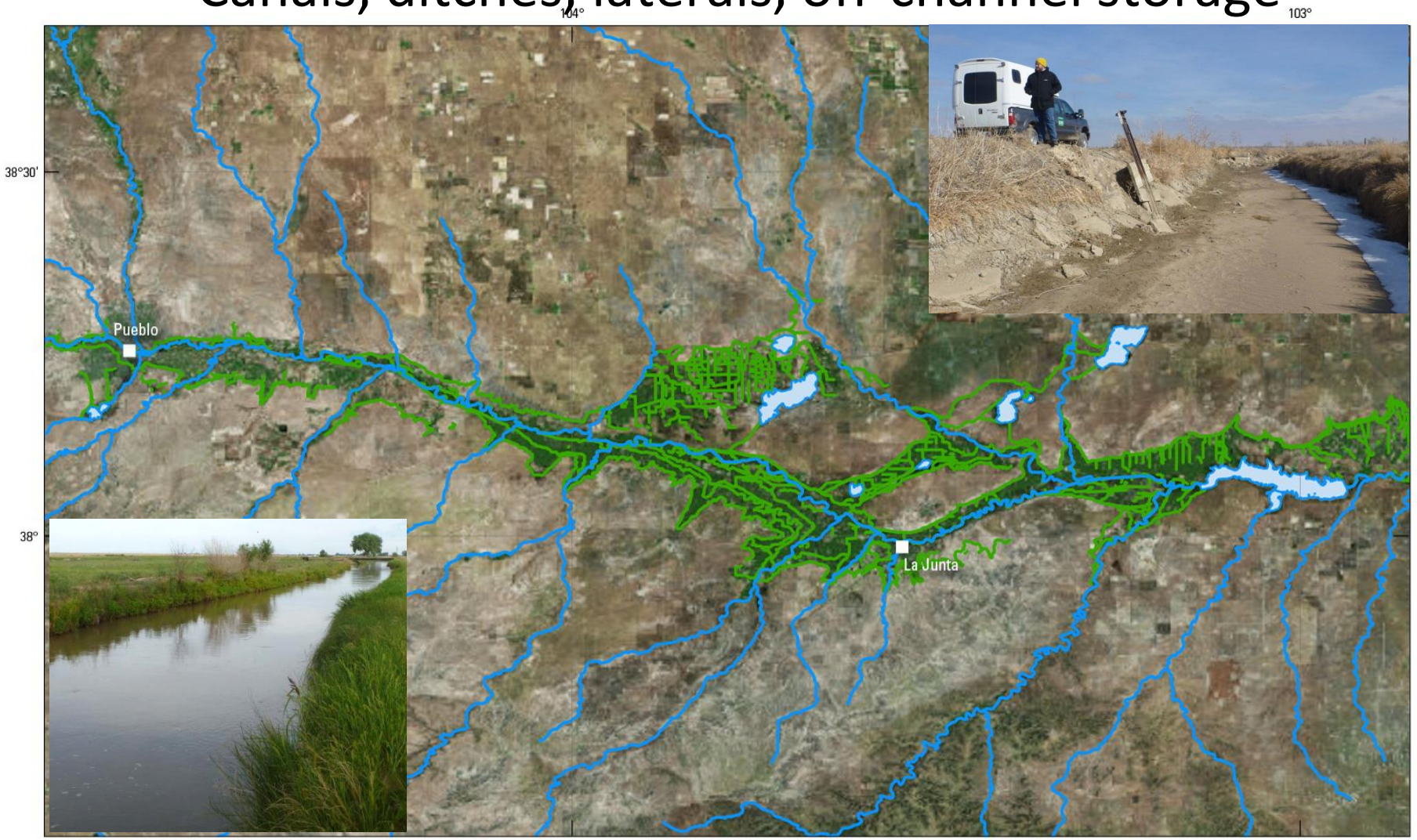




Climate

Sources of salinity

Canals, ditches, laterals, off-channel storage

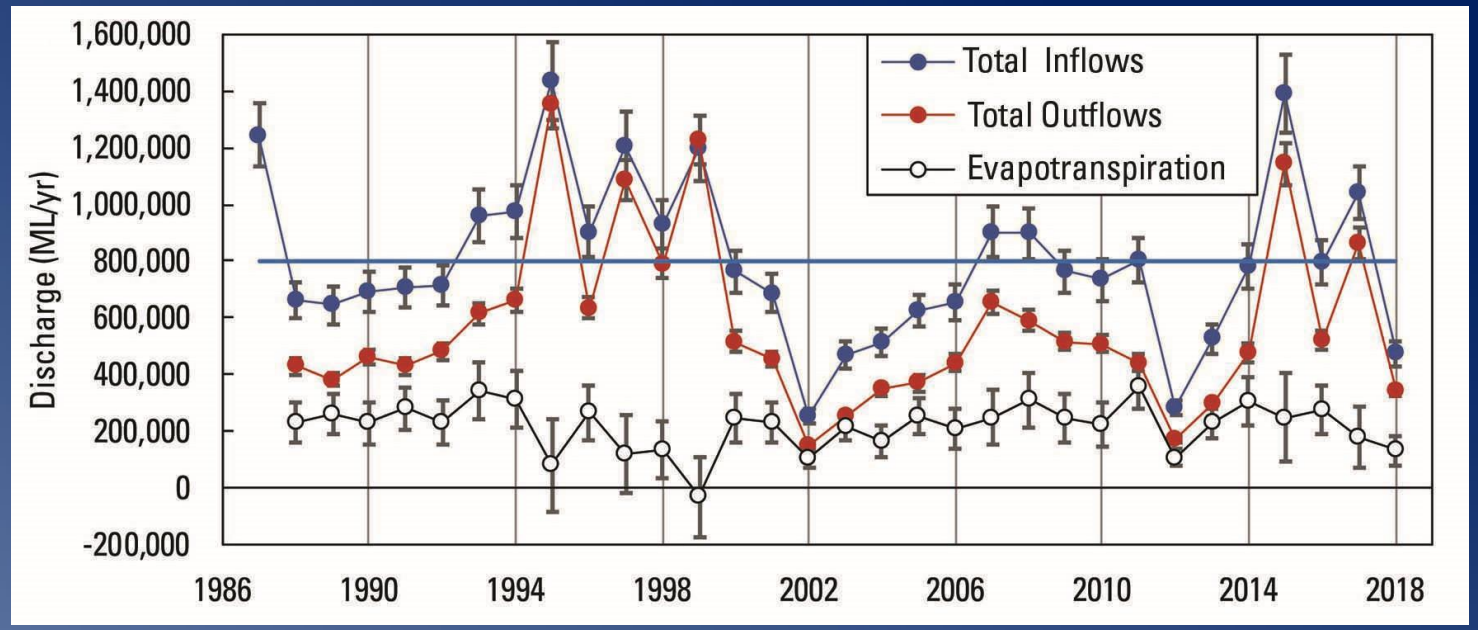


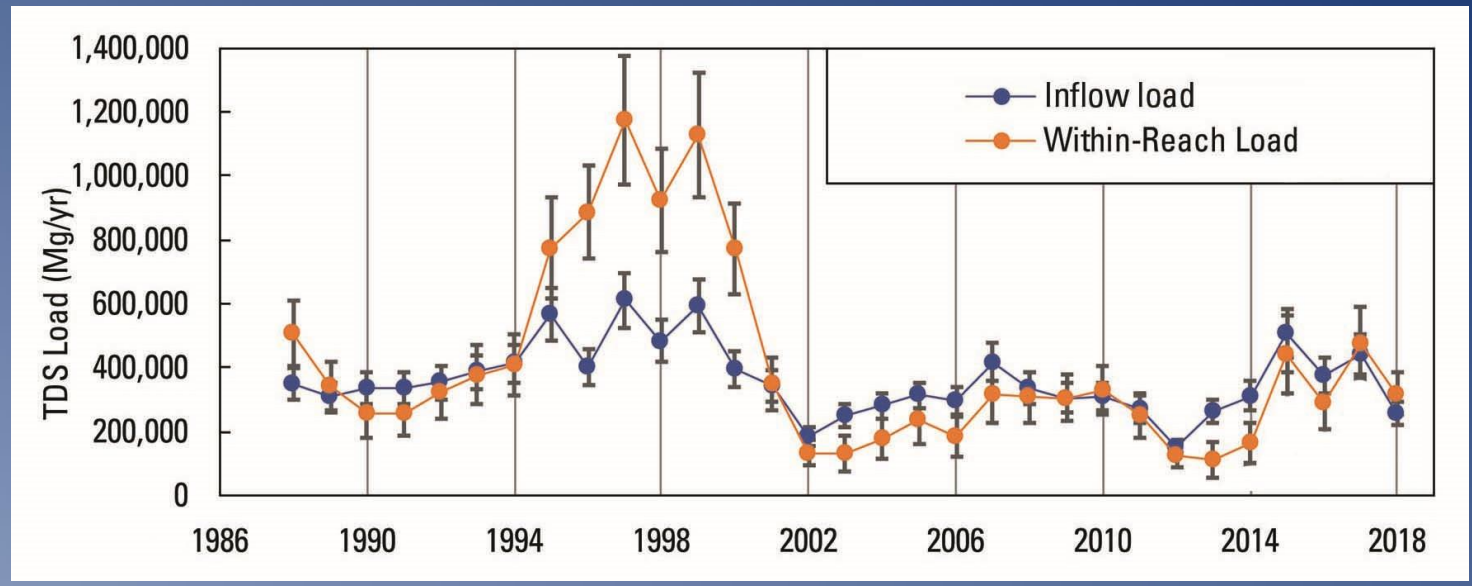
Seepage losses from canals range 10-37%

Sources of salinity

Year to year variation

Discharge (streamflow) and Total Dissolved Solids Loads

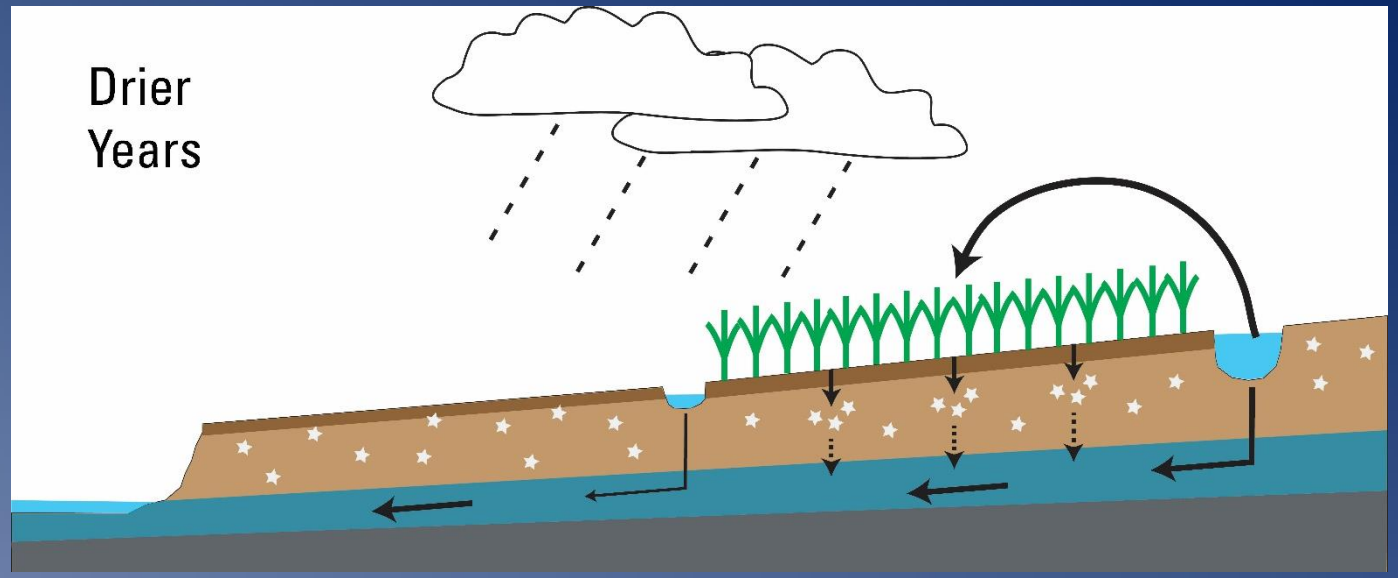




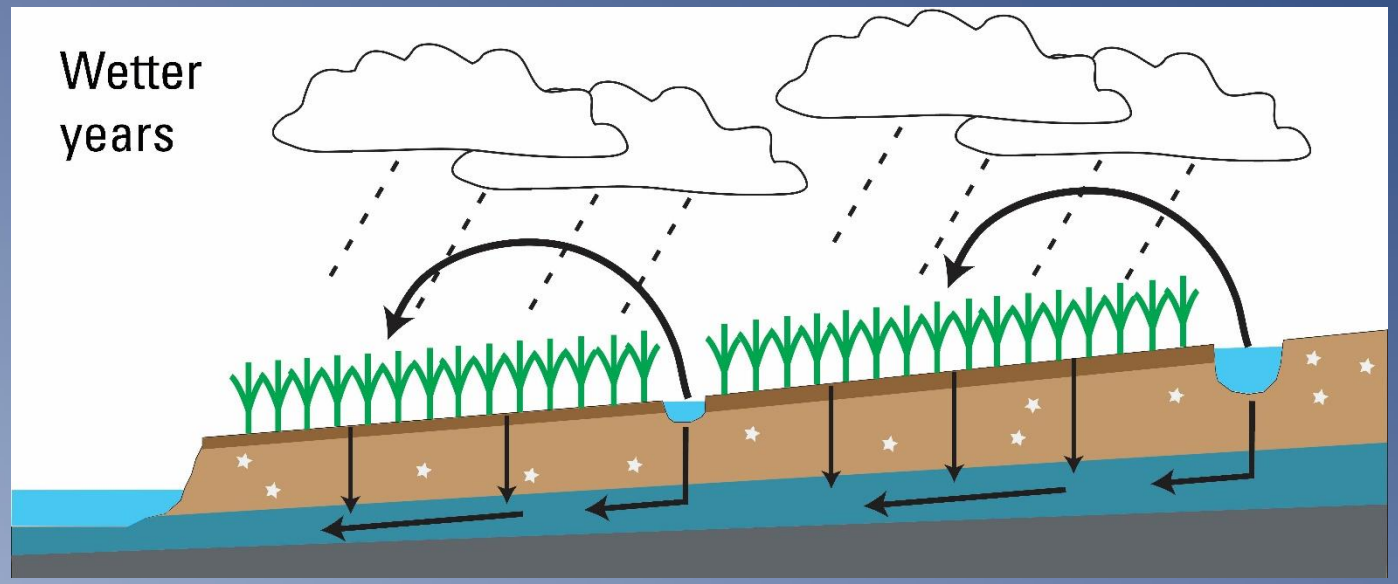
Bern, C.R., Holmberg, M., Kisfalusi, Z., 2020. Salt flushing, salt storage, and controls on selenium and uranium: A 31-year mass-balance analysis of an irrigated, semiarid valley. Journal of the American Water Resources Association: https://doi.org/10.1111/1752-1688.12841

USGS

Sources of salinity



Salt storage

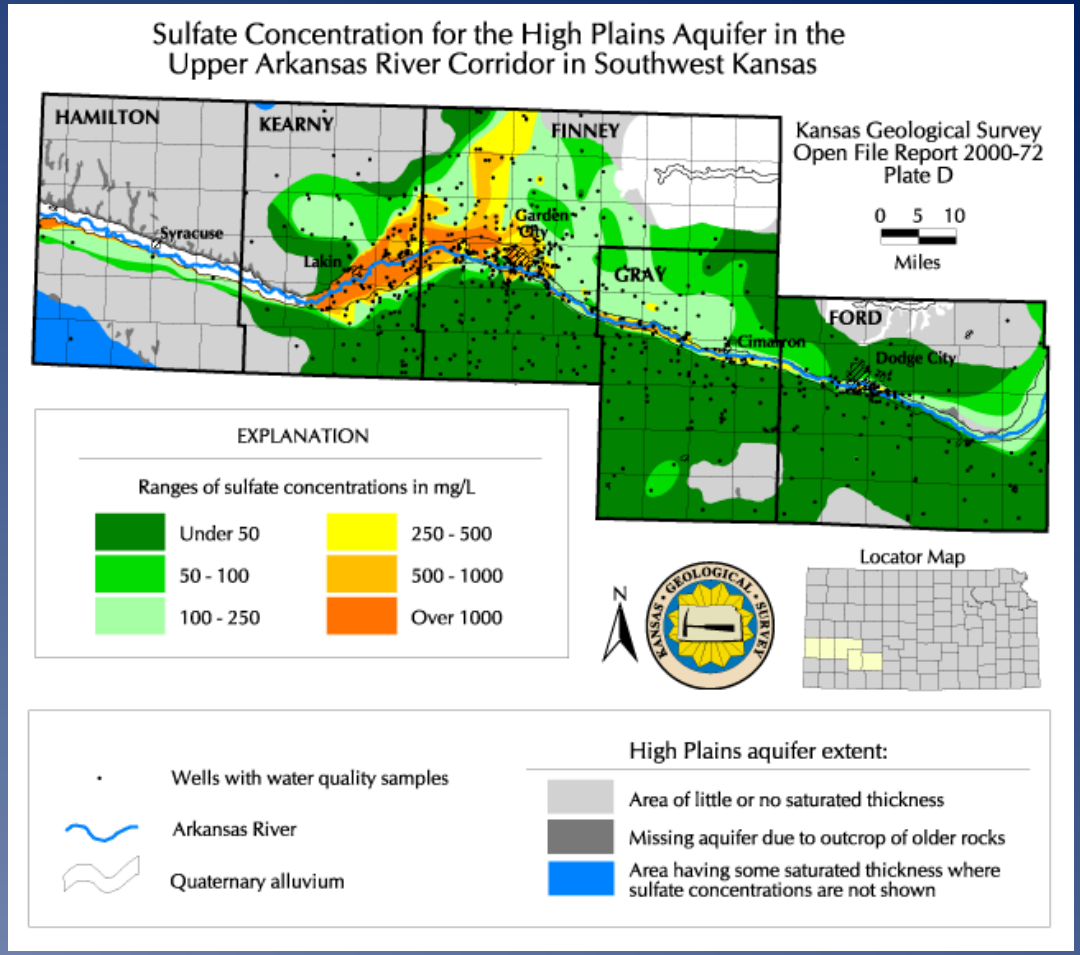


Salt flushing

Economic impacts

Water quality challenges of the lower Arkansas River

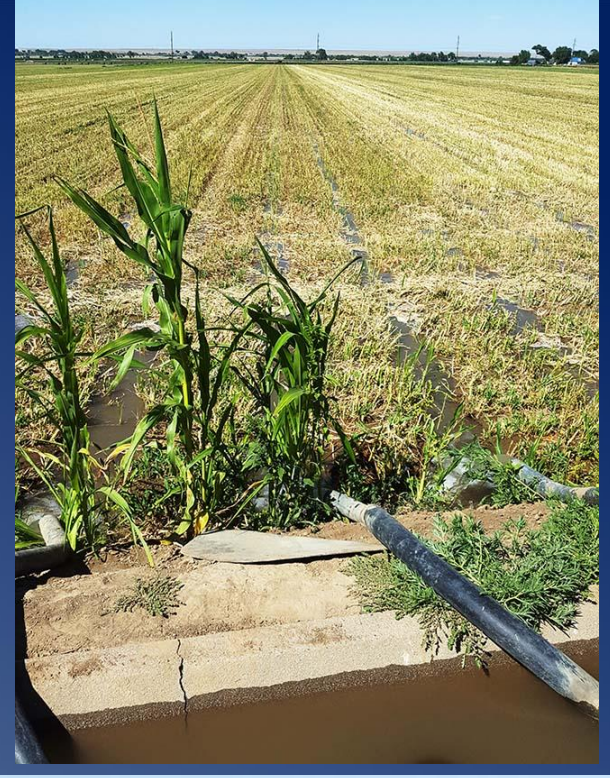
- **Salinity**
  - ~6-17% reduction in crop yields in Colorado
  - Larger reductions in crop yields in Kansas
  - Saline water infiltrates the High Plains aquifer
- **Selenium**
  - Exceeds 4.6 µg/L chronic wildlife toxicity standard
  - Compliance issues.
- **Uranium**
  - Exceeds 30 µg/L drinking water standard
  - High water treatment costs for small towns



USGS

Control Measures/ Tool Boxes

- Conversion from furrow to sprinkler and drip irrigation
- Lining of canals and laterals
- Polyacrylamide application to canals
- Lease fallow/transfer of water rights
- Arkansas Valley Conduit ($564 million to move 7,500 af/year for municipal use)



What are the big questions/needs? E.g. science gaps

How much does conversion to sprinkler irrigation reduce salinity?

Permanent reduction? Or delayed delivery?

Irrigation vs. canal seepage contributions to river salinity?

Flushing pattern similar or different east of John Martin Reservoir?

Who are the major players? Who's engaged in addressing the issue? What are the challenges of working together?

Non-Federal Players

Water conservancy districts

Municipalities that hold water rights

Canal companies

Colorado State University

Southeastern Water Conservancy District

SALINITY – WHERE IS IT A PROBLEM?

RIO GRANDE

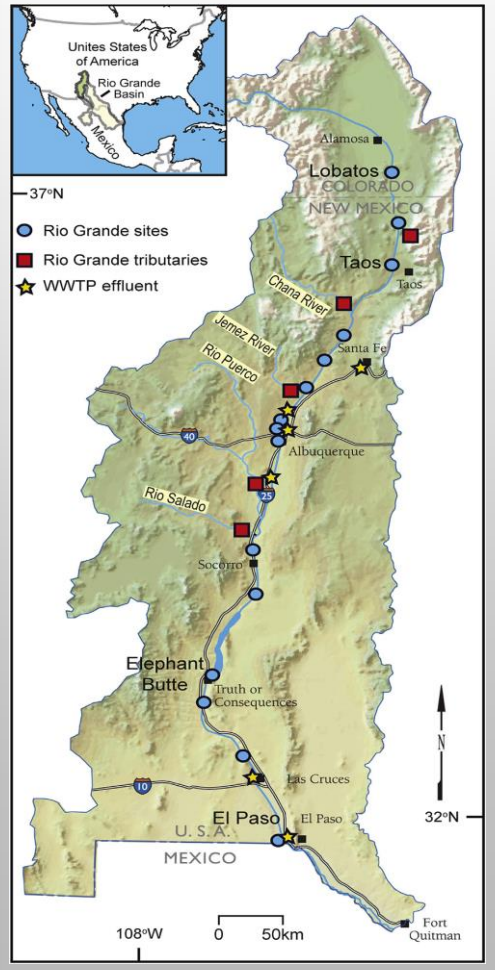
Presenter – Zhuping Sheng, Sheng Engineering

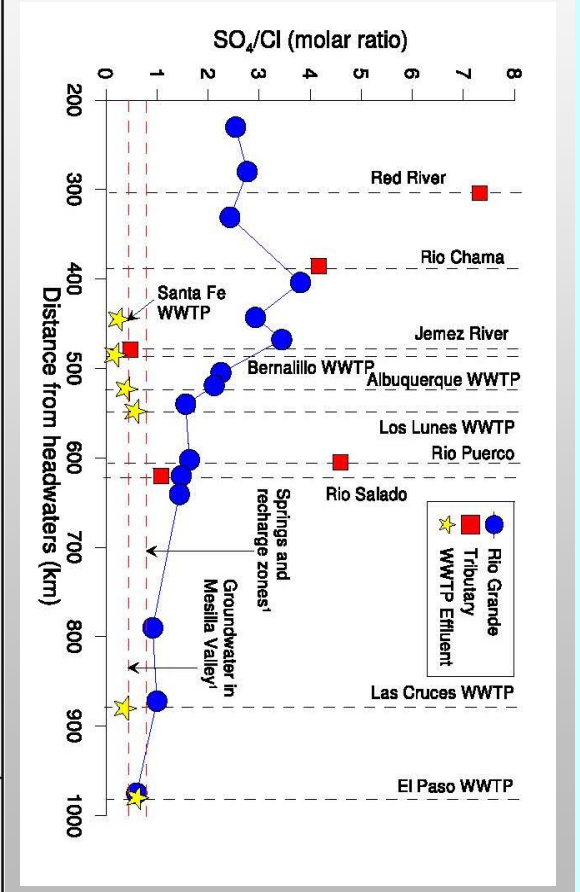
- *Sources of Salinity*
- *Economic Impacts*
- *What are the big questions/needs? E.g. control measures, toolboxes, science gaps*
- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*

RIO GRANDE

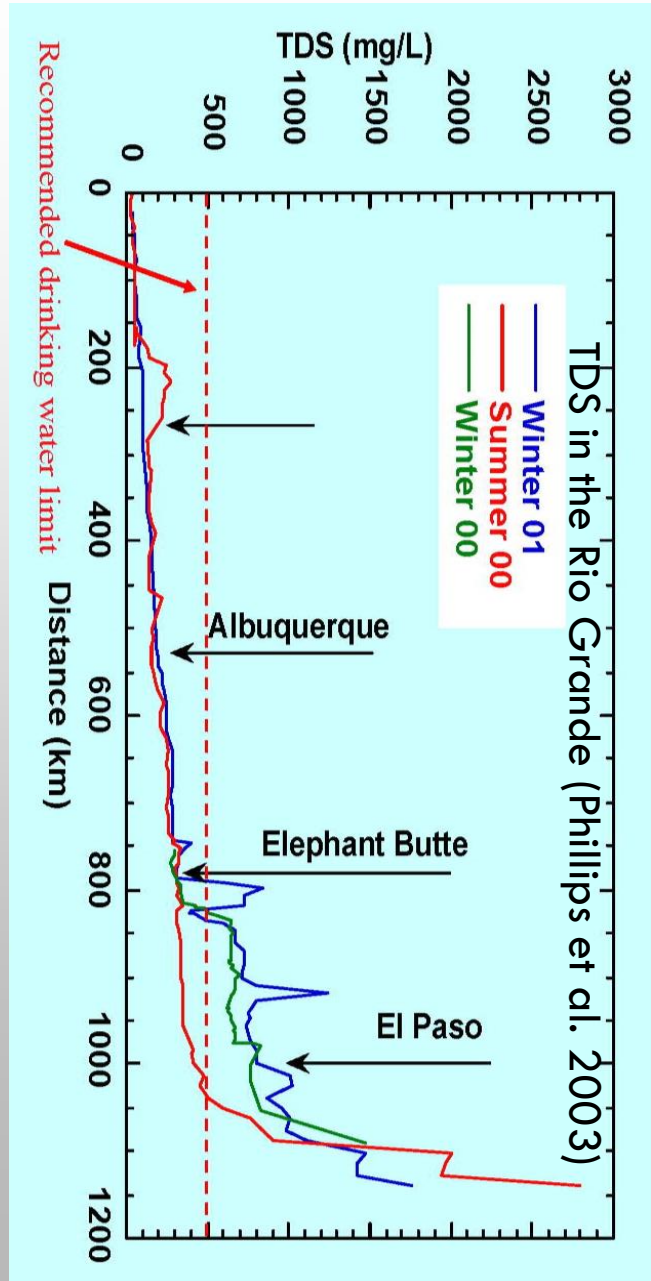
SALINITY – WHERE IS IT A PROBLEM?

Sources of Salinity (1)





Borrok and Engle 2014

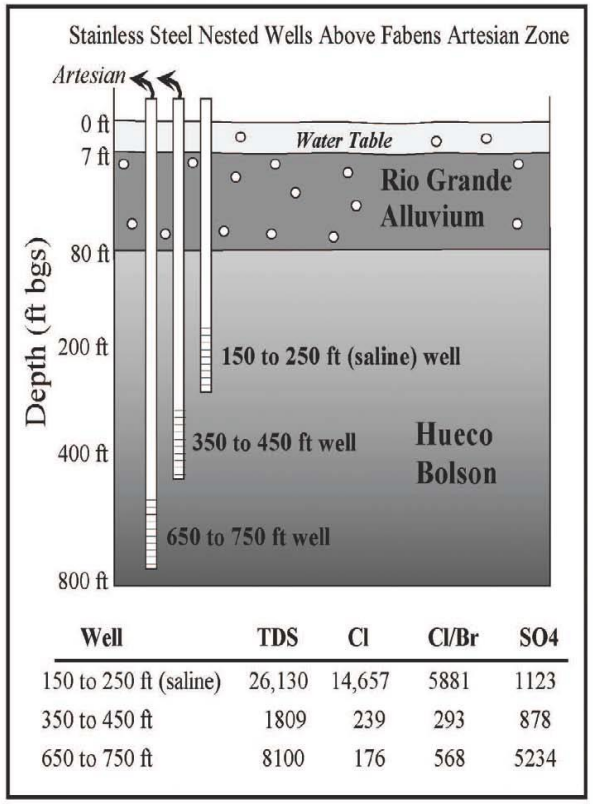


TDS in the Rio Grande (Phillips et al. 2003)

RIO GRANDE

SALINITY – WHERE IS IT A PROBLEM?

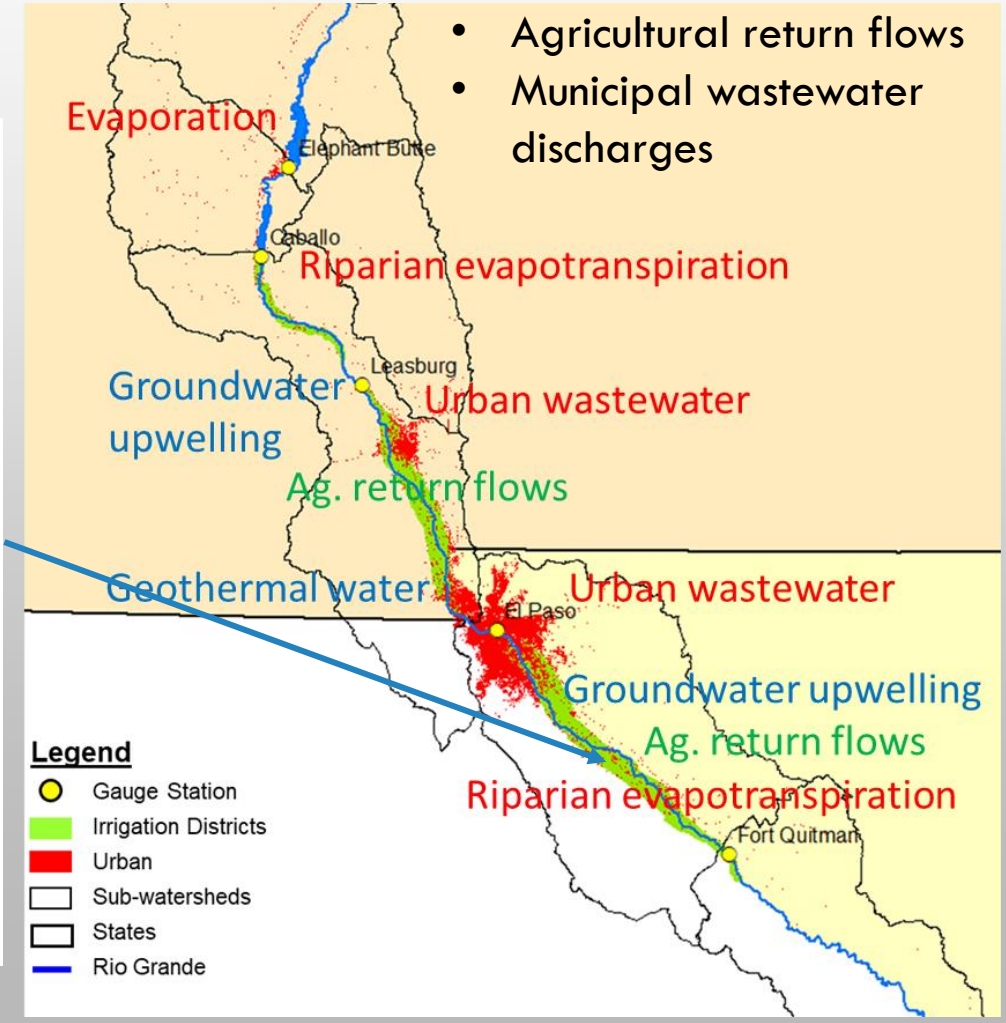
Sources of Salinity (2)



Well	TDS	Cl	Cl/Br	SO4
150 to 250 ft (saline)	26,130	14,657	5881	1123
350 to 450 ft	1809	239	293	878
650 to 750 ft	8100	176	568	5234

Hibbs and Merino, 2006

- Groundwater upwelling
- Evaporation of two reservoirs
- Agricultural return flows
- Municipal wastewater discharges



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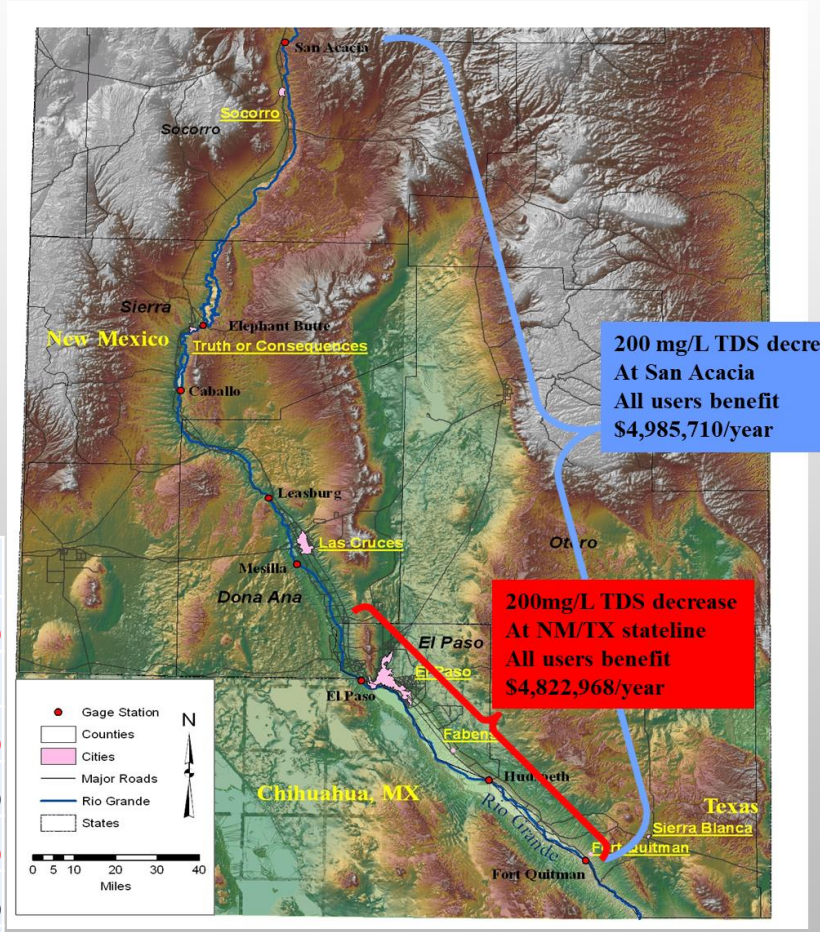
SALINITY – WHERE IS IT A PROBLEM?

Economic Impacts

- *Damages: ag. Vs. urban*
- *Benefits by lowering TDS (200 mg/L)*

Type of Use	Damage	Percent
Agricultural	$ 2,424,935	24%
Urban - El Paso County		
Residential	$ 4,301,050	42%
Landscape	$ 1,187,516	12%
Commercial/Other	$ 1,761,402	17%
Industrial/Large Users	$ 343,903	3%
Treatment Plants	$ 134,844	1%
Total	$ 10,153,650	100%



Michelsen et al. 2009

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SALINITY – WHERE IS IT A PROBLEM?

What are the big questions/needs? E.g. control measures, toolboxes, science gaps

Texas A&M AgriLife Research

- Brackish water: a resource
- Impacts of salinity on water availability
- Salinity control (planning vs. implementing)
  - Source of salts (natural vs. human)
  - Removal of salts from the water, advance in technology: desalination & concentrate management
  - Live with it, salt tolerant crops/leaching

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SALINITY – WHERE IS IT A PROBLEM?

- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*

The Albuquerque Journal

Control & management efforts:
Both centralized (coalition) vs. decentralized (farmers)

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SALINITY – WHERE IS IT A PROBLEM?

Rio Grande Salinity Management Coalition

Rio Grande Compact Commission
- Texas Commissioner
- New Mexico Commissioner
- Colorado Commissioner

State Water Management Agencies
- TCEQ & TWDB
- NMISC & NMED
- CO DWR

Local Water Utilities and Irrigation Districts
- El Paso Water Utilities
- Las Cruces Utilities Department
- EBID
- EPCWID#1
- HCCRD#1

University Research Organizations
- NMSU-NMWRRI
- TAMU – Agriife Research
- UTEP-CERM

Other State and Federal Agencies
- NMDA
- USBR
- USGS - New Mexico and Texas Water Science Centers

SALINITY – WHERE IS IT A PROBLEM?

COLORADO RIVER

Presenter – Don Barnett, Colorado River Basin Salinity Control Forum

- *Sources of Salinity*
- *Economic Impacts*
- *What are the big questions/needs? E.g. control measures, toolboxes, science gaps*
- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*

The "Great [illegible]"

Facts/Results:

The Colorado River Basin Salinity Control Program…

- reduced the annual salt load by about 1.2M tons
- reduced the downstream concentration 100 mg/L
- reduced <u>quantified</u> damages by approximately $300 million annually
- $50/ton

- had an annual salt load of 9-10 million tons

Colorado River Basin SALINITY CONTROL FORUM

Colorado River Basin Salinity Control Program

- Sources of Salinity
- Economic Impacts
- Big Questions/Needs
- Major Players/How do they Function Together

Colorado River Basin SALINITY CONTROL FORUM

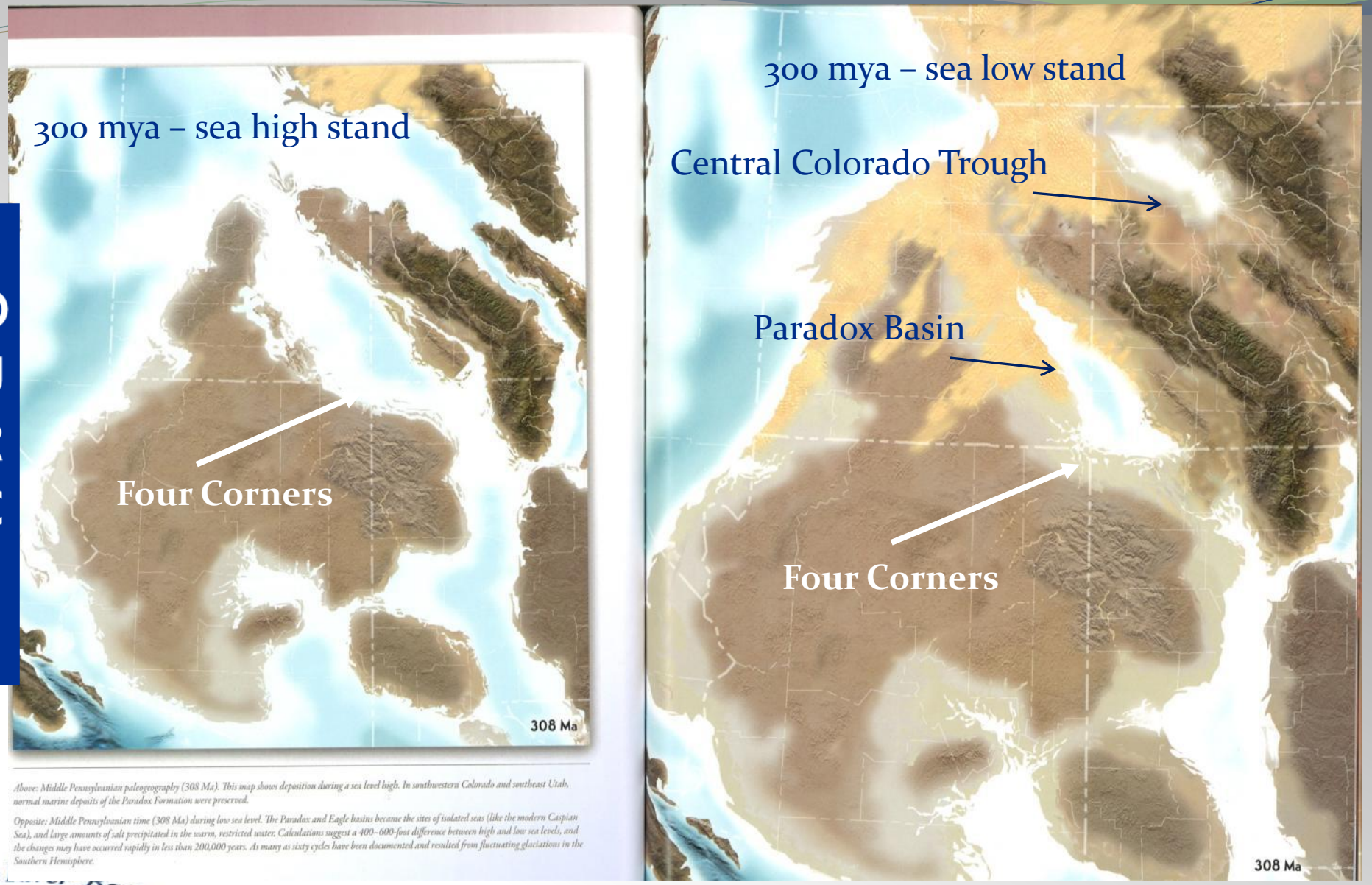
SOURCES

About 300 mya – formation of Pangea super continent

(paleogeographic map from Blakey and Ranney, 2008)

Colorado River Basin SALINITY CONTROL FORUM

SOURCES



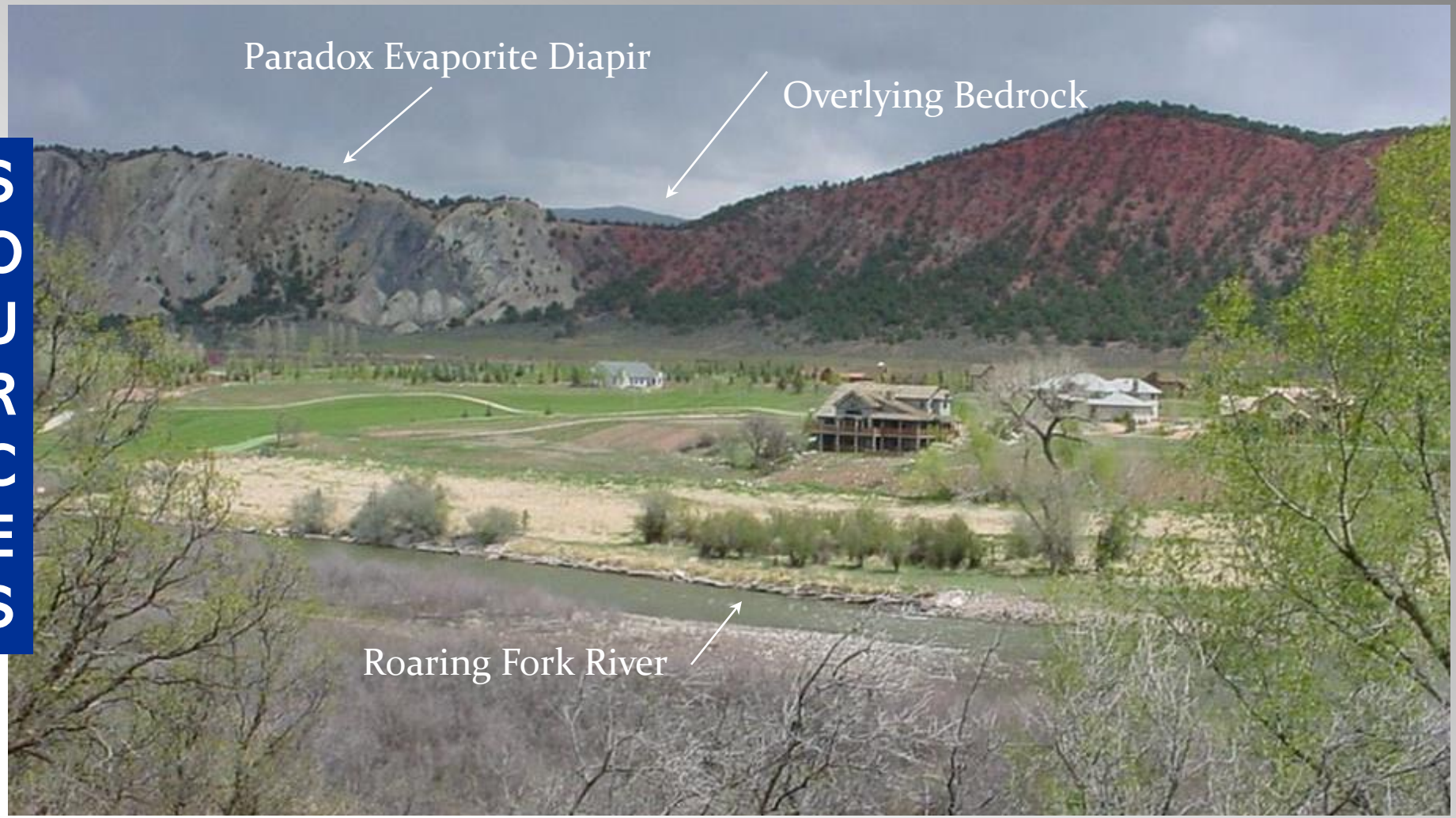
Above: Middle Pennsylvanian paleogeography (308 Ma). This map shows deposition during a sea level high. In southwestern Colorado and southeast Utah, normal marine deposits of the Paradox Formation were preserved.

Opposite: Middle Pennsylvanian time (308 Ma) during low sea level. The Paradox and Eagle basins became the sites of isolated seas (like the modern Caspian Sea), and large amounts of salt precipitated in the warm, restricted water. Calculations suggest a 400–600-foot difference between high and low sea levels, and the changes may have occurred rapidly in less than 200,000 years. As many as sixty cycles have been documented and resulted from fluctuating glaciations in the Southern Hemisphere.

Colorado River Basin SALINITY CONTROL FORUM

(Paleogeographic map from Blakey and Ranney, 2008)

SOURCES



Colorado River Basin SALINITY CONTROL FORUM

Above Glenwood Springs, Colorado

SOURCES

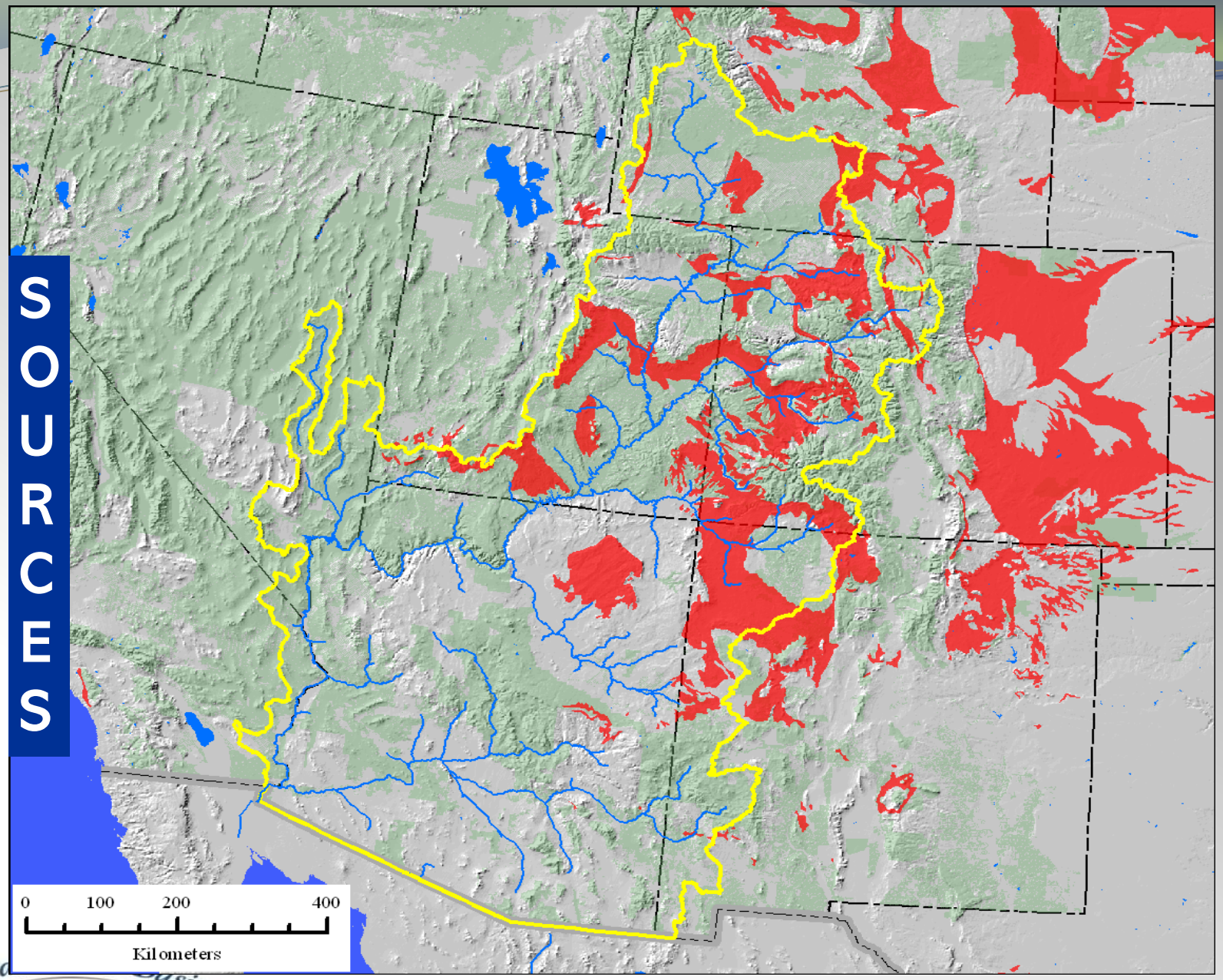

About 100 mya – transgression of Western Interior Seaway
Western Interior Seaway
Deposition of 1000's of feet of salty marine shale

SOURCES

Grand Valley, Colorado

Colorado River Basin SALINITY CONTROL FORUM

SOURCES



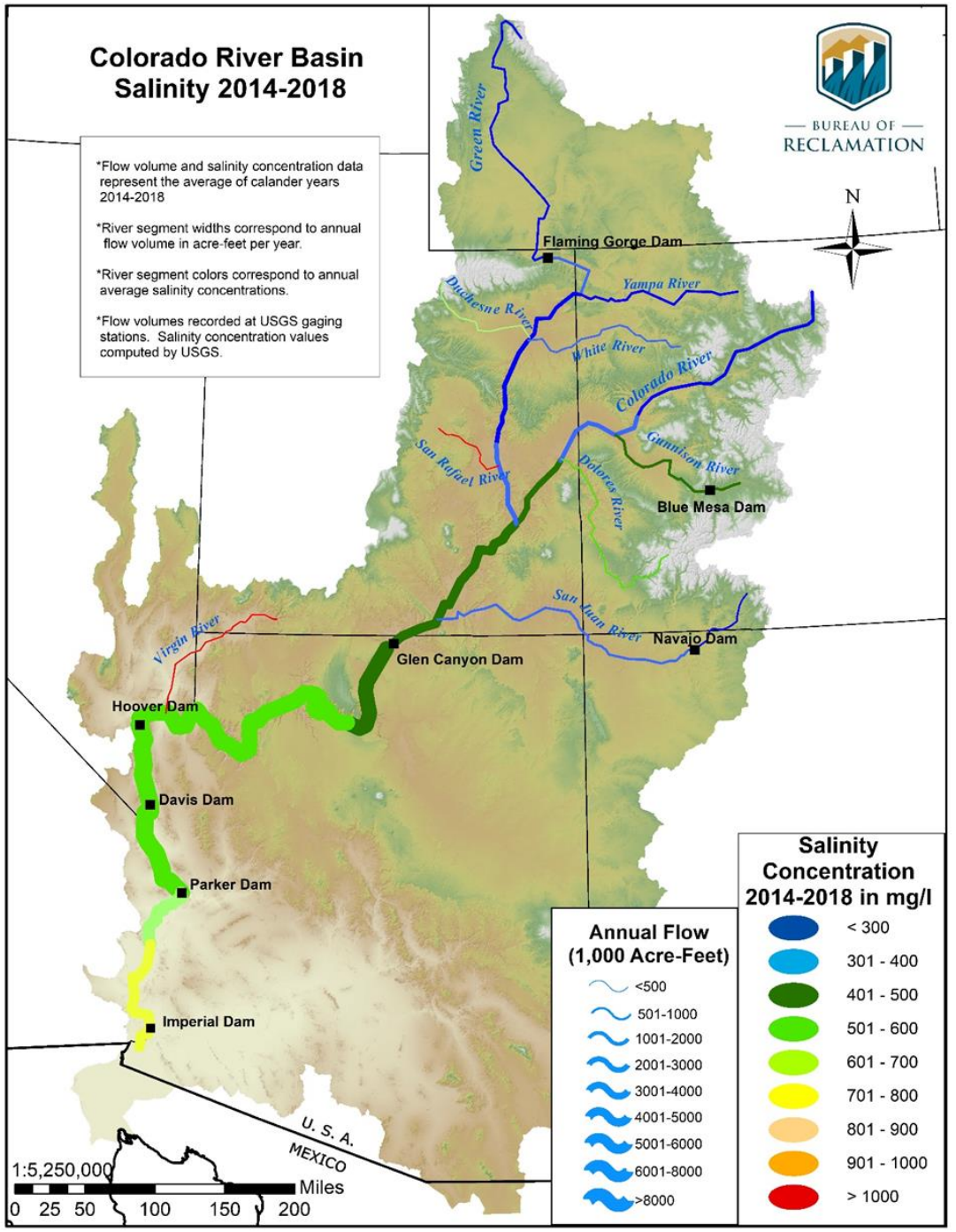
Colorado River Basin

Mancos Shale

Colorado River Basin
SALINITY CONTROL FORUM

SOURCES

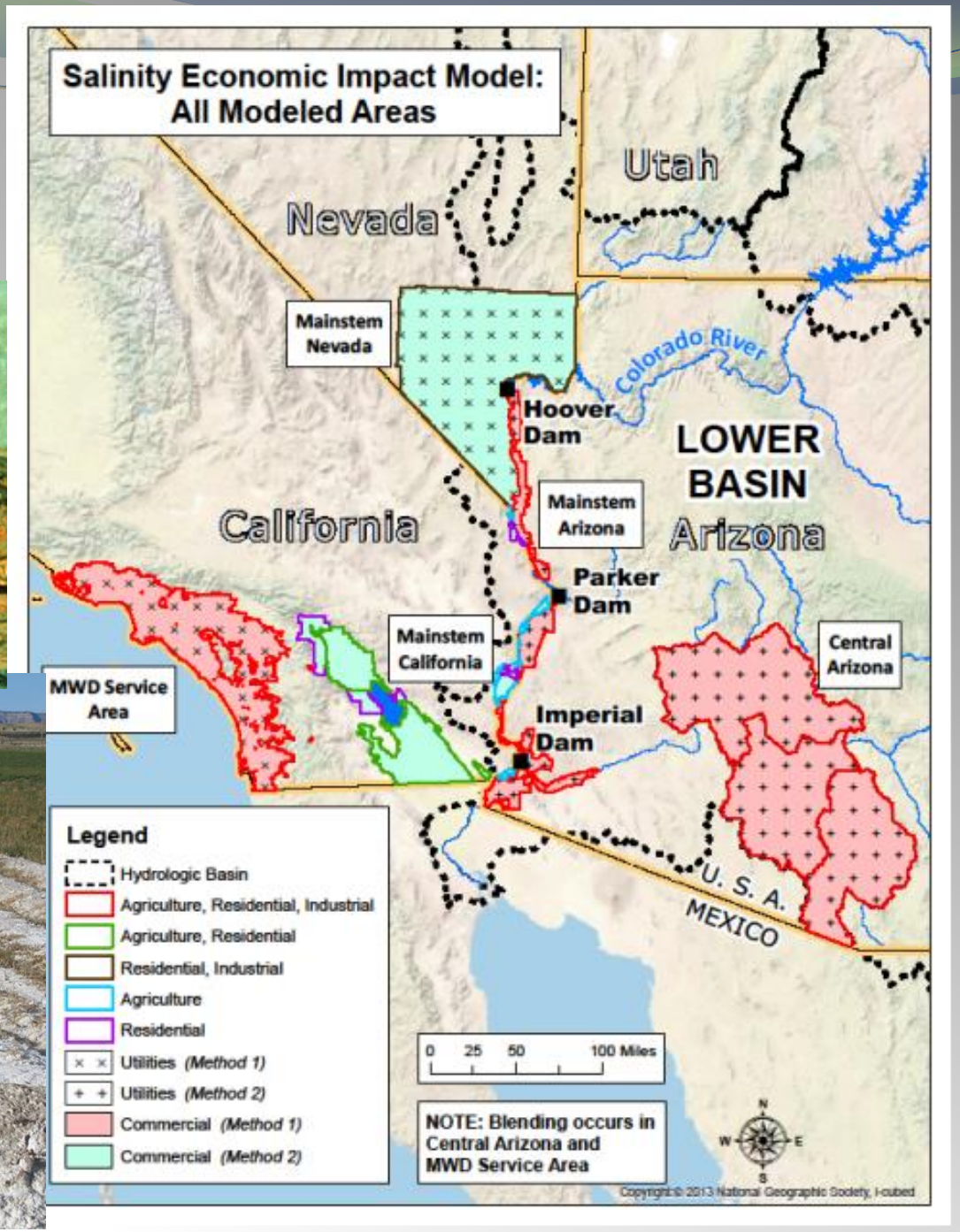
The Colorado River's salinity concentration increases from about **50 mg/L to 800 mg/L** as it flows from its headwaters to the lowest diversion in the United States



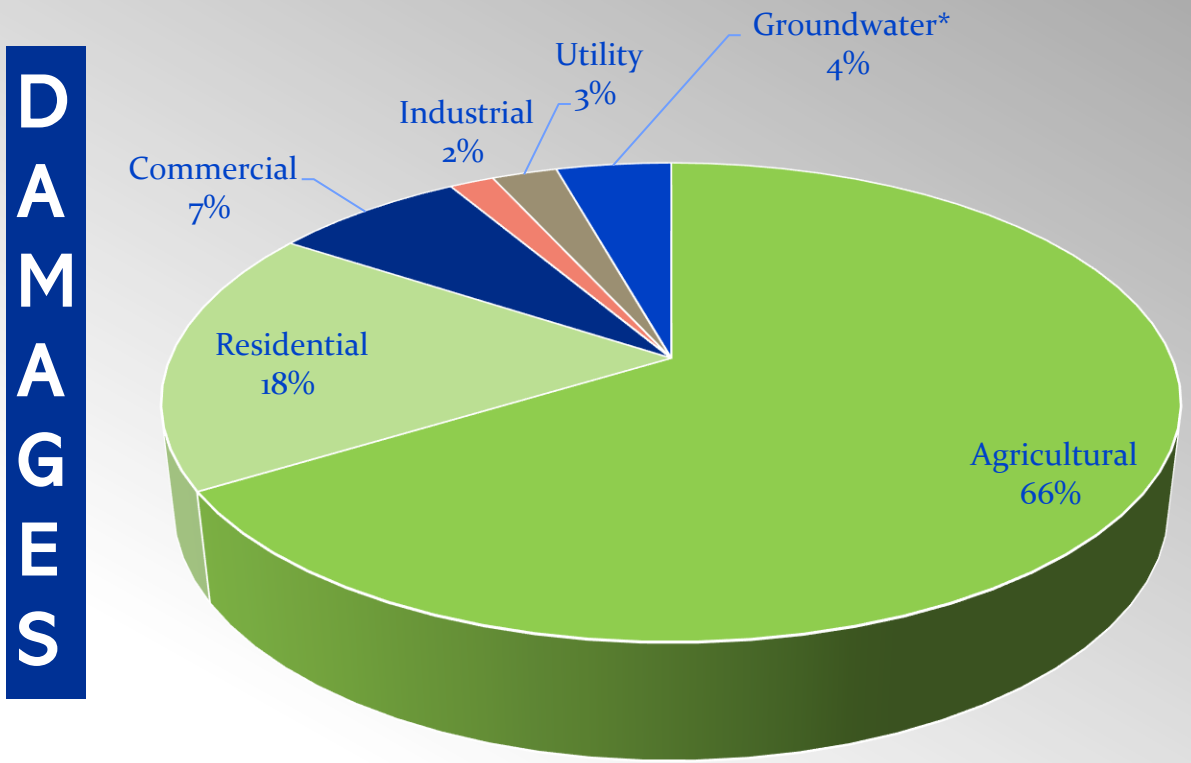
Colorado River Basin SALINITY CONTROL FORUM

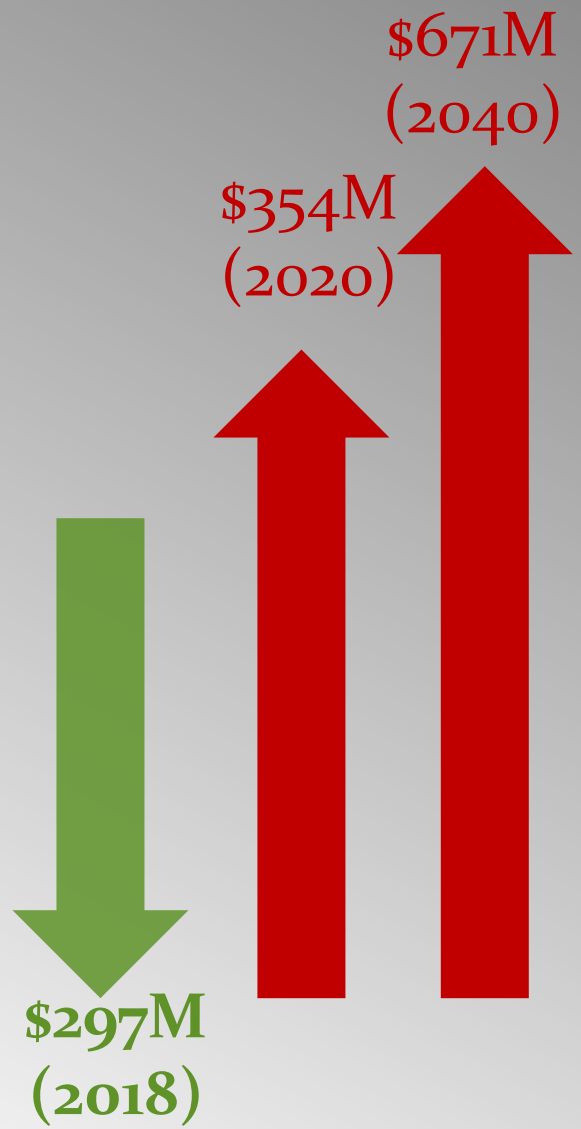
Salinity Damages

DAMAGES



Quantified Salinity Damages by Sector





Colorado River Basin
SALINITY
CONTROL FORUM

Annually!

NRCS Reclamation

NEEDS

BLM

NEEDS

Colorado River Basin Salinity Control Forum

Paradox Valley Unit (PVU)

NEEDS

deep
injection well

brine

shallow collection wells

Colorado River Basin
SALINITY
CONTROL FORUM

Program Needs

NEEDS

- Good on-farm and off-farm projects
- Continued funding
- Better understand salinity loading on rangelands
- Advances in desalinization technologies
- Better determine how salinity control fits with other priorities in the Colorado River Basin

Colorado River Basin SALINITY CONTROL FORUM

Program Coordina

Governors

PLAYERS

Colorado River Basin Salinity Control Advisory Council

Colorado River Basin SALINITY CONTROL FORUM

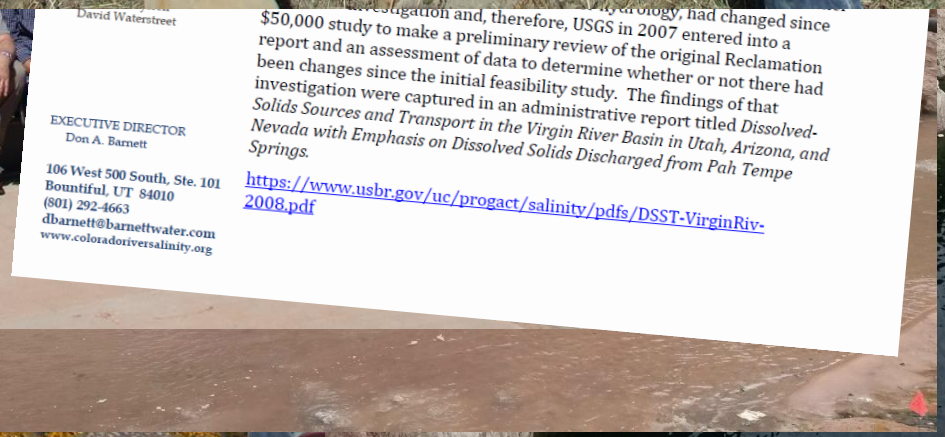
Work Group

USDA

NRCS

USGS science for a changing world

Colorado River Basin SALINITY CONTROL FORUM



David Waterstreet

EXECUTIVE DIRECTOR
Don A. Barnett

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...investigation and, therefore, USGS in 2007 entered into a $50,000 study to make a preliminary review of the original Reclamation report and an assessment of data to determine whether or not there had been changes since the initial feasibility study. The findings of that investigation were captured in an administrative report titled *Dissolved-Solids Sources and Transport in the Virgin River Basin in Utah, Arizona, and Nevada with Emphasis on Dissolved Solids Discharged from Pah Tempe Springs.*

https://www.usbr.gov/uc/progact/salinity/pdfs/DSST-VirginRiv-2008.pdf

Colorado
SAL
CONTRO

Success!

Colorado River Basin
SALINITY
CONTROL FORUM

News and Announcements

At its meeting on June 3, 2020, the Forum approved its *2020 Review, Water Quality Standards for Salinity, Colorado River System*. .

The Forum has released a Program Video and Trailer which provide an overview of the Colorado River Basin Salinity Control Program.

Welcome to the Colorado River Basin Salinity Control Forum Website

Recognizing the rapidly increasing salinity concentration in the Lower Colorado River and its impact on water users, the Colorado River Basin States came together in 1973 and organized the Colorado River Basin Salinity Control Forum (Forum). In 1974, in coordination with the Department of the Interior and the U.S. State Department, the Forum worked with Congress in the passage of the Colorado River Basin Salinity Control Act (Act). Title I of the Act deals with the United States' salinity commitments to Mexico. Title II of the Act creates the Colorado River Basin Salinity Control Program (Program) which focuses on improving the water quality of the Colorado River to U.S. users above Imperial Dam.

Since implementation of the Program, measures have been put in place which now reduce the annual salt load of the Colorado River by more than 1.2 million tons. The salinity concentration at Hoover, Parker and Imperial Dams has been reduced by about 100 mg/L. However, even with these efforts the *quantified* damages to U.S. users are still approximately $354 million per year. Damages are projected to increase to $671 million per year by 2040 if the Program does not continue to be aggressively implemented.

Colorado River Basin Salinity Control Forum
106 W. 500 S. Suite 101 Bountiful, Utah 84010
(801) 292-4663

Website by Rich Keeler

Colorado River Basin SALINITY CONTROL FORUM

www.ColoradoRiverSalinity.org

SALINITY – WHERE IS IT A PROBLEM?

CENTRAL VALLEY, CA

Presenter – Dr. Daniel Deeds, Bureau of Reclamation

- *Sources of Salinity*
- *Economic Impacts*
- *What are the big questions/needs? E.g. control measures, toolboxes, science gaps*
- *Who are the major players? Are control efforts centralized or decentralized? Who's engaged in addressing salinity control? Do the parties work together? Are there challenges with working together?*

Central Valley Overview

Agricultural Significance

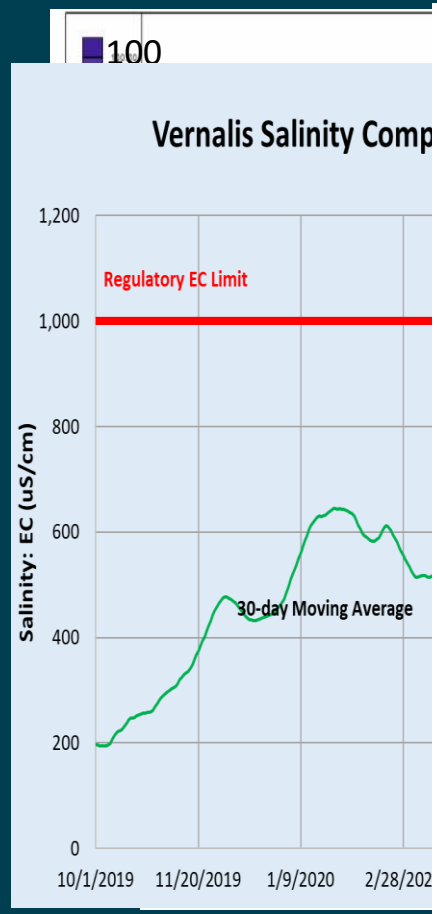
- ~3% of US farmland, produces 11% of US Ag output (by value, 2018).
- $40B/yr.
- Produces ¼ of the US's food

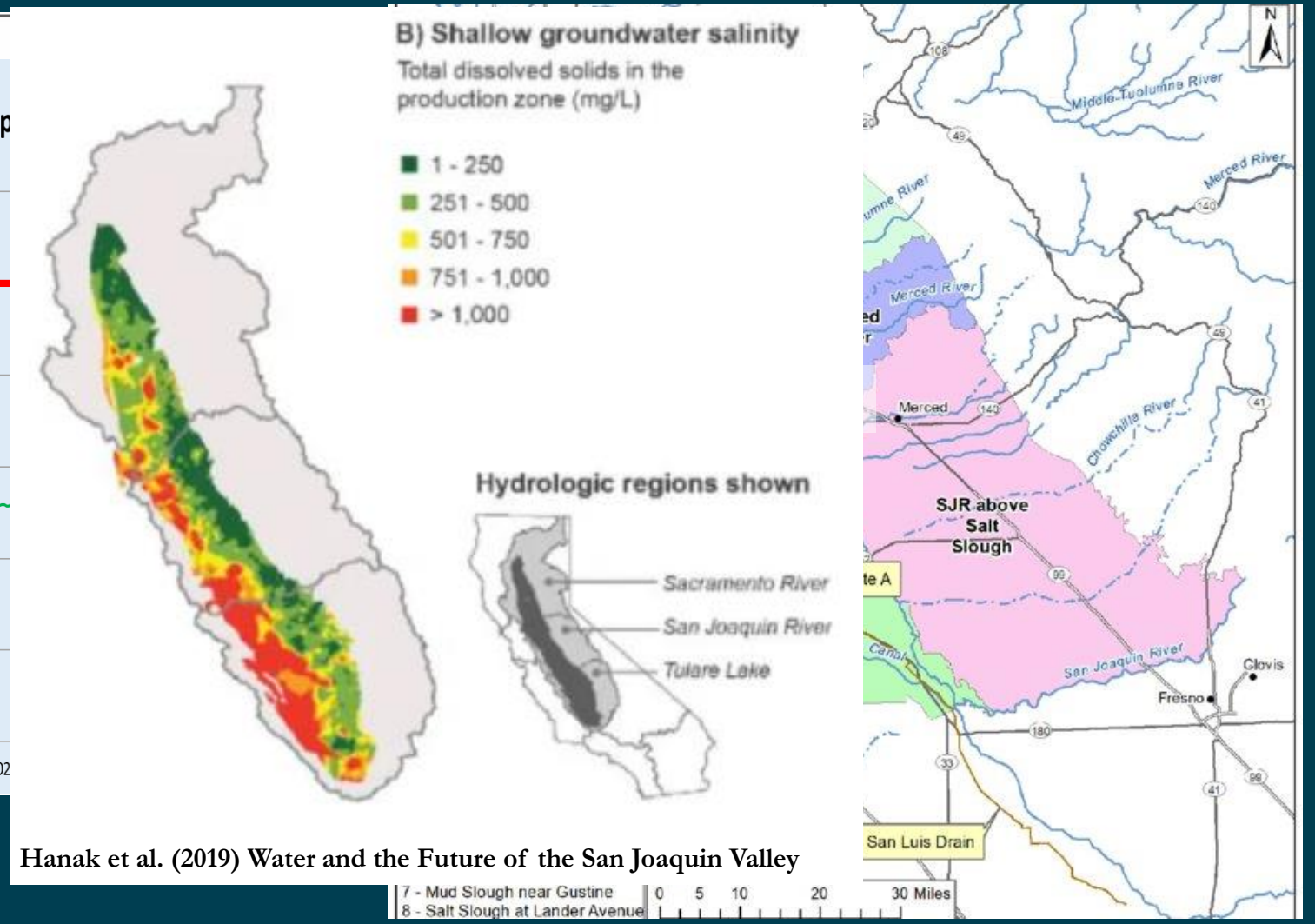
Hydrology

- Sierra Nevada precipitation flows to SF Bay mainly by Sacramento River (N) and San Joaquin River (S)
- Delta water exported by SWP (CA), CVP (USBR) to San Joaquin Basin and SoCal
- Tulare Basin – water in, not out

https://ca.water.usgs.gov/projects/central-valley/about-central-valley.html
https://www.cdfa.ca.gov/statistics, https://www.nass.usda.gov

CV Salt Problems: What, where, who?





Hanak et al. (2019) Water and the Future of the San Joaquin Valley

Conceptual Model For SALINITY IN THE CENTRAL VALLEY AND SACRAMENTO-SAN JOAQUIN DELTA (2007); CDFA

Economic Impacts

- Reduced crop yields
- Salt/drainage management
- Land Retirement/Fallowing
- Reminder - $40B/yr Ag production in Central Valley (2018)
- Comparing Futures for the Sacramento-San Joaquin Delta (Public Policy Institue of California, 2008)
  - $350M per year annual costs by 2030
- The Economic Impacts of Central Valley Salinity (UC Davis, 2009)
  - $1B - $1.5 B per year in 2030
  - 27,000 – 53,000 jobs lost by 2030

Policy Changes in the Future

- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)
  - Stakeholder-led effort to reduce salinity in the Central Valley
  - Central Valley Regional Water Board – Salt and Nitrate Control Program
    - Next 10 years – the "Prioritization and Optimization" (P&O) study
    - Assess salt loads to the region; best salt management practices
    - Both surface and groundwater

- Sustainable Groundwater Management Act (SGMA)
  - California Law, Stakeholder-led effort to combat Central Valley subsidence/groundwater overdrafting
  - Does include water quality, taking backseat to water quantity
  - (Ground)Water management = more surface water, or land retirement
  - Surface water ≈ fully allocated
  - Water and Agriculture in the San Joaquin Valley (Central California Business Review, 2020)
    - Without more surface water, 1M acres of land retired, $6B/yr lost in farm revenue

QUESTIONS

PRESENTERS

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