


Produced Water Stewardship – Infrastructure, Applications, and Economic Development

NEW MEXICO PRODUCED WATER RESEARCH CONSORTIUM
2023 ANNUAL MEETING
DECEMBER 13-14, 2023 – ALBUQUERQUE

Infrastructure, Scenario. and Socio-economic Working Groups

NM STATE
NEW MEXICO PRODUCED WATER RESEARCH CONSORTIUM

Recent NM Drivers in Produced Water Treatment and Reuse

Gov. Lujan Grisham to establish first-of-its-kind Strategic Water Supply – $500 million investment will leverage advanced market commitments

Dec 5, 2023 | Press Releases

DUBAI — At the 2023 United Nations Climate Change Conference today, Gov. Michelle Lujan Grisham announced a first-of-its-kind strategic water supply to increase drought resilience and advance clean energy production and storage.

The strategic water supply will support the nation's transition to renewable energy by providing resources for water-intensive processes around creating green hydrogen, storing energy produced by wind and solar, and manufacturing electric vehicles, microchips, solar panels, and wind turbines, for example.

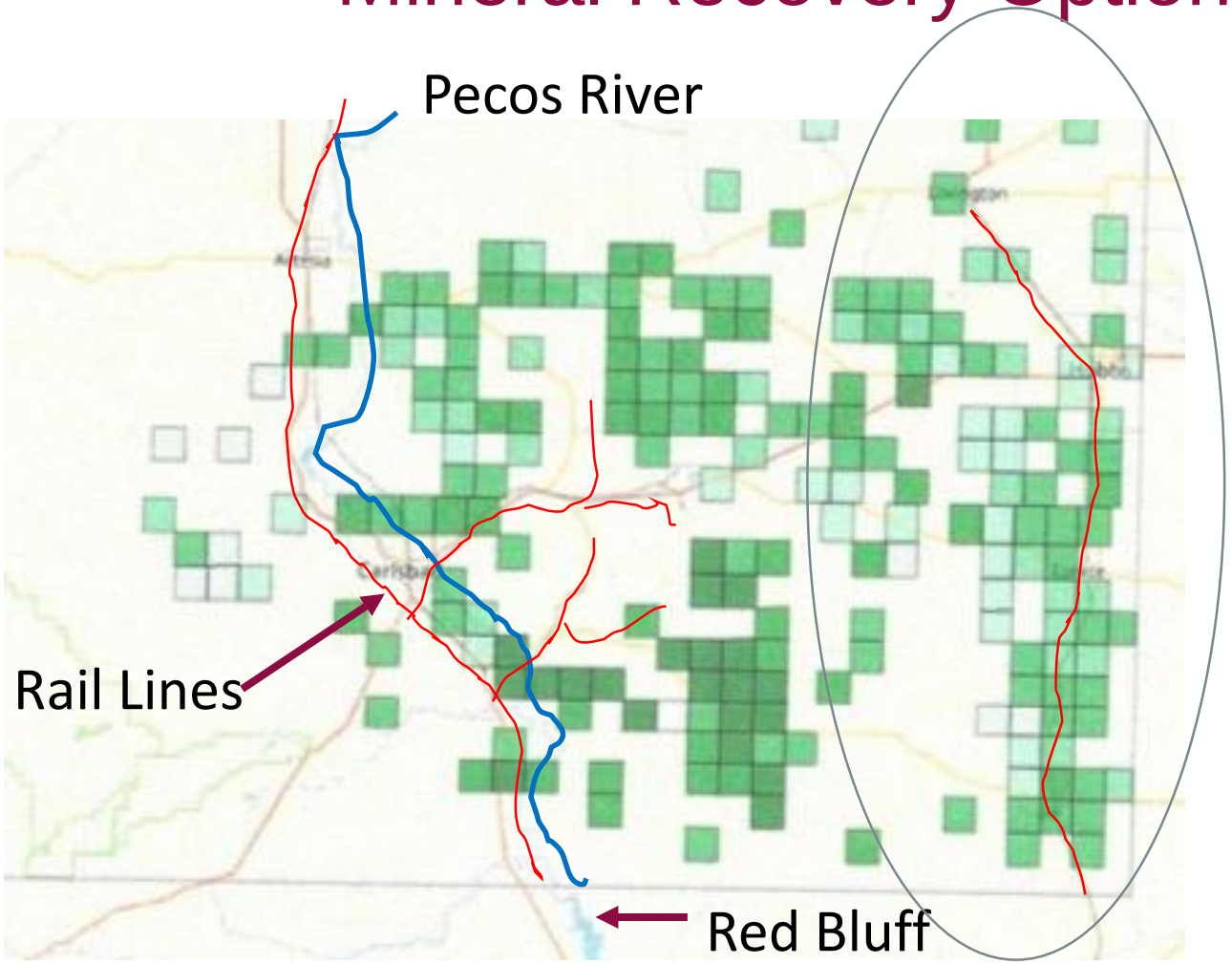
Through a $500 million investment, New Mexico will purchase treated brackish and treated produced water to build the strategic water supply. In early 2024, the New Mexico Environment Department will issue guidance and seek proposals from companies interested in pursuing a contract.

In September 2023, NMED began drafting the States Ground and Surface **Water** Protection - Supplemental Requirements for **Water Reuse** (20.6.8 NMAC) regulations ……..with a projected hearing date by the WQCC in April 2024.

Infrastructure and Scenario Planning - Major 2023 Efforts

- Help coordinate Society of Petroleum Engineers Conference on produced water treatment and reuse and specifically mineral recovery opportunities (Jan –May 2023)
- Supported TX regulators in getting western state information on current agriculture and surface water discharge standards and ability to treat produced water to those standards (Jan – August 2023)
- Worked with DOE/NETL for NMPWRC to become an Indefinite Delivery Indefinite Quantity (IDIQ) contractor (Apr-Dec 2023)
  - Support DOE modeling and analysis on produced water impacts,
- Worked with OCD on treating produced water for plugging and abandonment operations to accelerate treatment technology commercialization

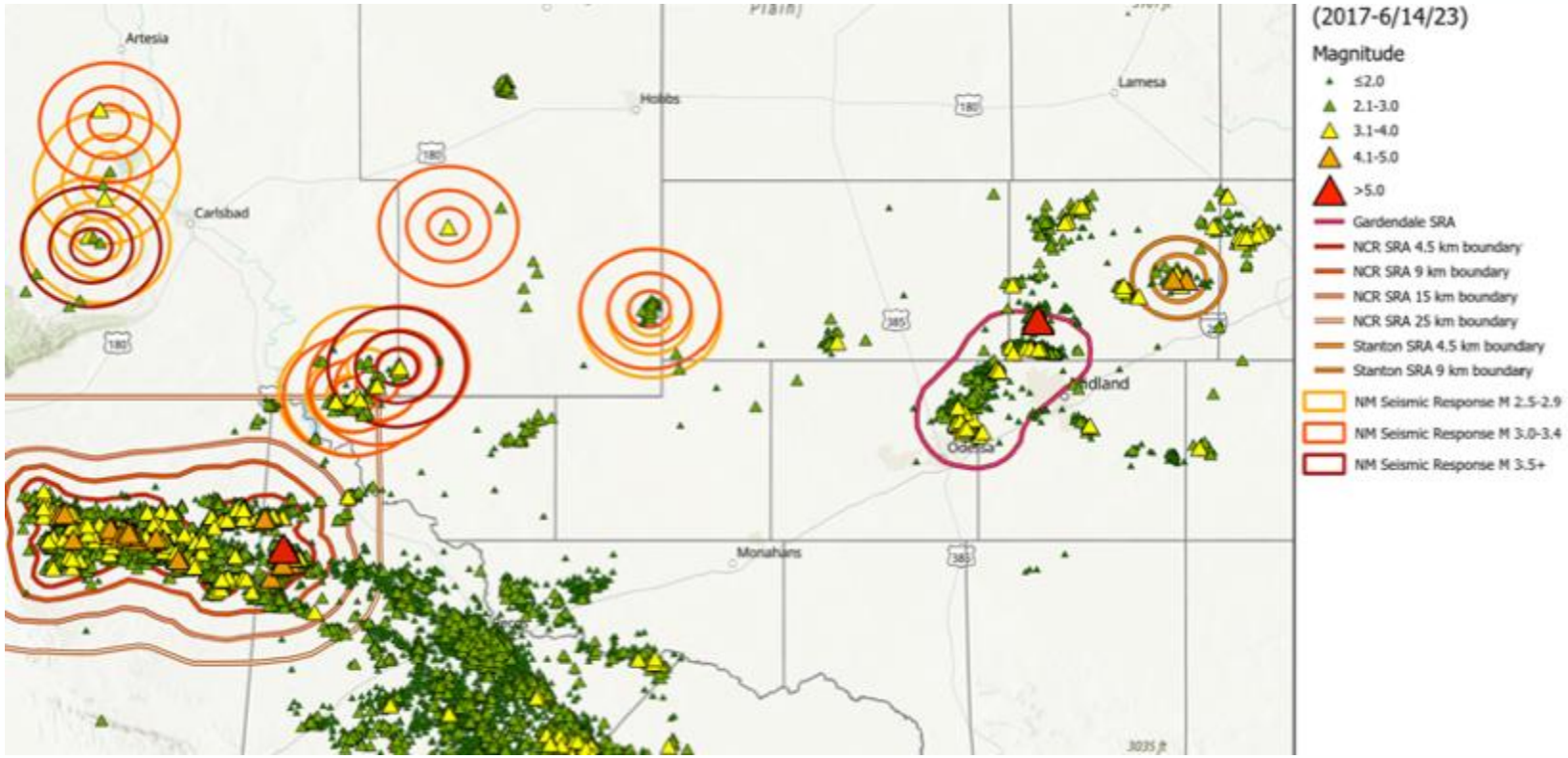
Mineral Recovery Options and Opportunities



NM Permian PW quantity data by ¼ township

- Number of minerals in produced water of economic value – beyond lithium and rare earths
- Transportation infrastructure (rail lines) in place in the Permian to support mineral recovery and sales

Seismicity in the Permian Must Be Addressed
Produced Water Reuse Is Likely the Better Option

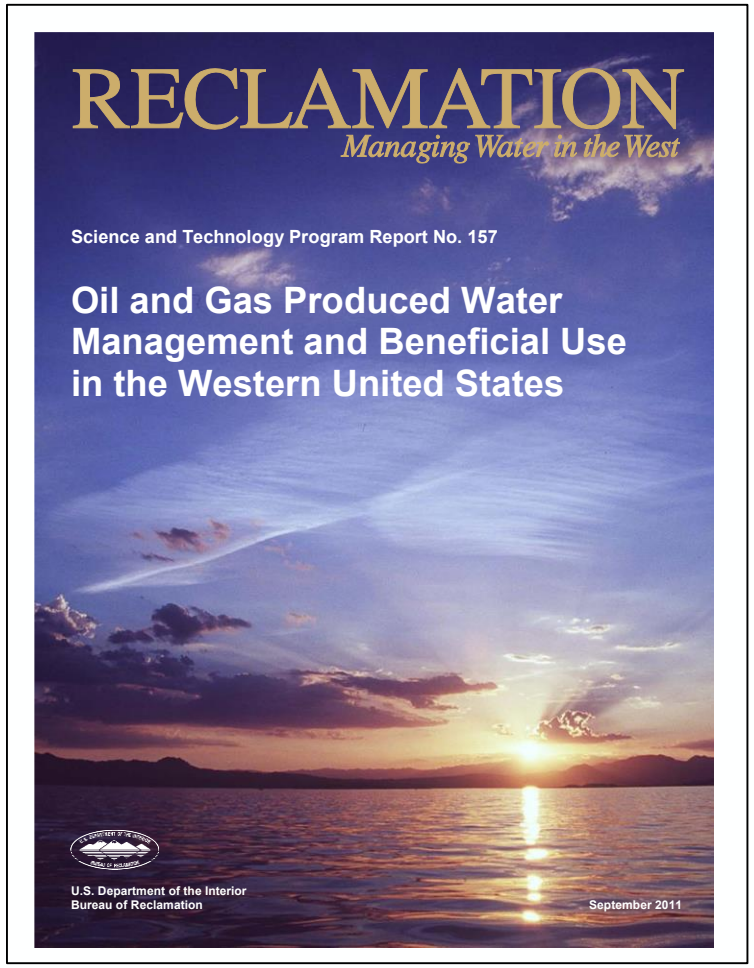


(Capper 2023)

Possible Scenarios:

- Reduce NM produced water disposal in TX by 1 million bbls/day
- Reduce TX produced water disposal by 30% or by 3 million bbls/day
- New disposal areas 50-100 miles away
- Shallow disposal w/more controls (ss, double-cased, lower pressure)
- Treatment and reuse to reduce volumes

Bureau of Reclamation – Changes in Western Irrigation Science

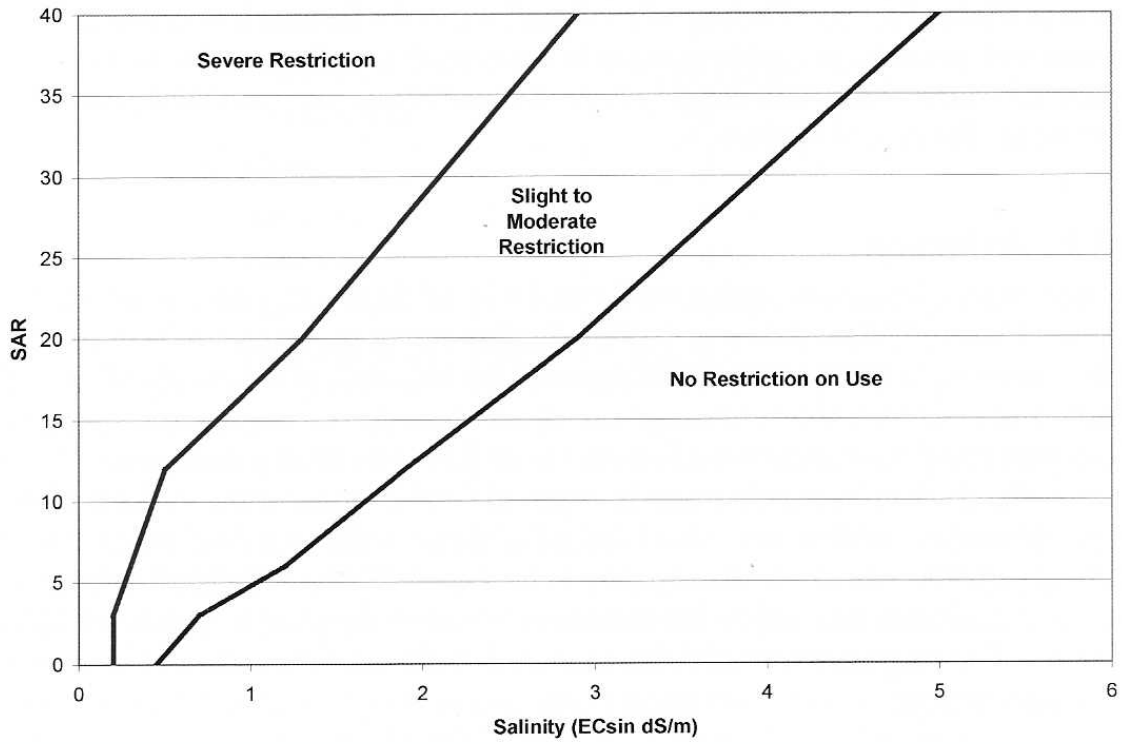


BOR Report 157, 2011

Current science on agricultural, livestock, and wildlife ecological considerations

- TDS/Electrical conductivity (Ec)
- Sodium Adsorption Ratio (SAR)
- Important individual constituents
  - boron,
  - selenium,
  - ammonia,
  - metals,
  - chlorides,
  - pH,
  - organics
  - NORM

Movement to Soil and Plant Chemistry-based Irrigation Criteria Since the 1990's in Western States



- Historical classification
  - Class 1 <700 ppm TDS, <60% Na, B<0.5
  - Class 2 2000 ppm TDS, 60-75% Na, B<2.0
  - Class 3 >2000 ppm TDS, 75% Na, B~2
- Modern focus is on Sodium Absorption Ratio (SAR)

  $SAR = Na^{+}/((1/2(Ca^{2+} + Mg^{2+}))^{1/2}$
  where concentrations are expressed as milliequivalents per liter.
- Takes into consideration western alkaline and sandy soils and waters

Seeing Changes in Agricultural Water Quality Standards

Table 9. Constituent limits for irrigation water (adapted from Rowe and Abdel-Magid, 1995)

Constituent	Long-term Use (mg/L)	Short-term Use (mg/L)
Aluminum (Al)	5	20
Arsenic (As)	0.1	2
Beryllium (Be)	0.1	0.5
Boron (B)	0.75	2
Cadmium (Cd)	0.01	0.05
Chromium (Cr)	0.1	1
Cobalt (Co)	0.05	5
Copper (Cu)	0.2	5
Fluoride (F)	1	15
Iron (Fe)	5	20
Lead (Pb)	5	10
Lithium (Li)	2.5	2.5
Manganese (Mn)	0.2	10
Molybdenum (Mo)	0.01	0.05
Nickel (Ni)	0.2	2
Selenium (Se)	0.02	0.02
Vanadium (V)	0.1	1
Zinc (Zn)	2	10

Table 8. Crop tolerance to boron in irrigation water

Tolerance Level	Range of Boron Concentration	Crops
Very Sensitive	< 0.5 mg/L	Lemon, blackberry
Sensitive	0.5–0.75 mg/L	Avocado, grapefruit, orange, apricot, peach, cherry, plum, persimmon, fig, grape, walnut, pecan, cowpea, onion
Sensitive	0.75–1.0 mg/L	Garlic, sweet potato, wheat barley, sunflower, mung bean, sesame, lupine, strawberry, jerusalem artichoke, kidney bean, lima bean, peanut
Sensitive	1.0–2.0 mg/L	Red pepper, pea, carrot, radish, potato, cucumber
Moderately tolerant	2.0–4.0 mg/L	Lettuce, cabbage, celery, turnip, kentucky bluegrass, oats, maize, artichoke, tobacco, mustard, sweet clover, squash, muskmelon
Tolerant	4.0–6.0 mg/L	Sorghum, tomato, alfalfa, purple vetch, parsley, red beet, sugarbeet
Very tolerant	60–15.0 mg/L	Cotton, asparagus

pH -6.5-8.4
Chlorides < 100 mg/L
Nitrates – 10 to 45 mg/L

From BOR Report 157, 2011

Quality of Thermal Treatment of Permian Produced Water

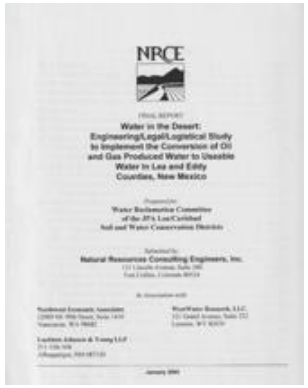
Constituent	Feed (ppm)	Distillate (ppm)
TDS	126,000	350+/-150
TPH	75+/-70	11+/-3
Ammonia	~400	46
Fe	1	0
Mn	0.36	0.004
Na	38162	102
Ca	4554	7
Mg	751	1.5
K	647	0.9
Ba	6.6	0.9

Constituent	Feed (ppm)	Distillate (ppm)
Sr	1348	3.3
Al	0,14	0.006
Li	32	0.005
Zn	0.04	0.02
Pb	0	0.006
HCO3	120	200
SO4	270	10
Cl	72300	160
Si	17	0.10
PO4	3.7	2.90

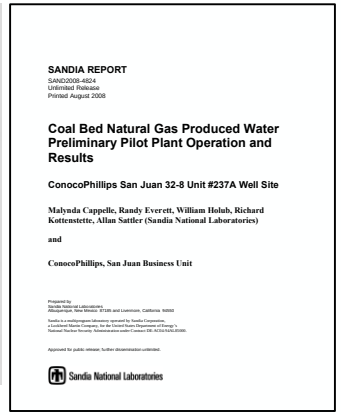
Average of real-time hourly data during a one-month test series

Pilot Treated Produced Water Reuse in Rangeland Restoration

- Conoco Phillips/Sandia/NMSU Ag Research Center 2004-2008
  - BLM research permit with OCD
  - Treated 25,000 ppm TDS produced water with pre-treatment and RO - then blended with produced water to get 2,000 ppm -12,000 ppm
  - 6 tons/ac CO2 sequestration
  - Sprinkler and water cannon irrigation on several acres
  - 3-4 acre-inches per year to supplement rainfall
  - 6,000 ppm TDS blended PW had best growth
- Based on SAR ag water quality requirements for western soil (alkaline) adapted range grasses


NRCE

Water in the Desert:
Engineering/Legal/Logistical Study
to Implement the Conversion of Oil
and Gas Produced Water to Useable
Water in Lea and Eddy
Counties, New Mexico


SANDIA REPORT
SAND2008-4824
Unlimited Release
Printed August 2008

Coal Bed Natural Gas Produced Water
Preliminary Pilot Plant Operation and
Results

ConocoPhillips San Juan 32-8 Unit #237A Well Site

Malynda Cappelle, Randy Everett, William Holub, Richard
Kottenstette, Allan Sattler (Sandia National Laboratories)

and

ConocoPhillips, San Juan Business Unit

Sandia National Laboratories

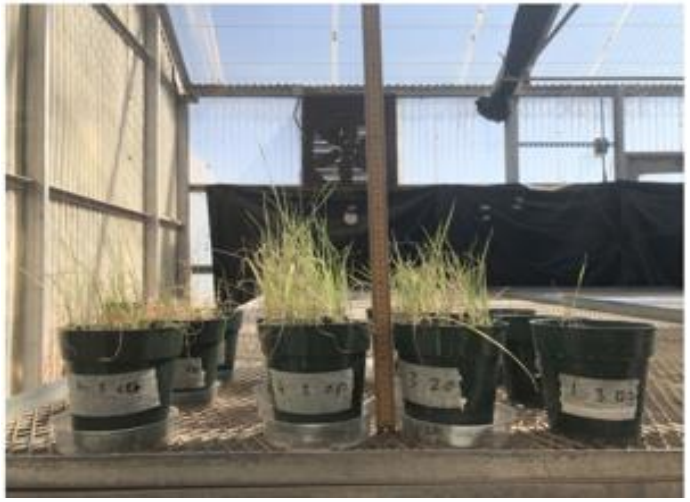
Green House Ag Studies with Produced Water

- Treated vs diluted water results can be significant
- Constituent ratios and soils are important
- Always identify waters – e.g.
  - Diluted PW (1400 ppm)
  - Tap water (400 ppm)
  - Treated PW(250 ppm)
  - Raw PW (8500 ppm)
- Coordinated with ag agencies (NRCS)

Western Wheat grass

Alfalfa

Meadow Brome grass



Russian Wildrye

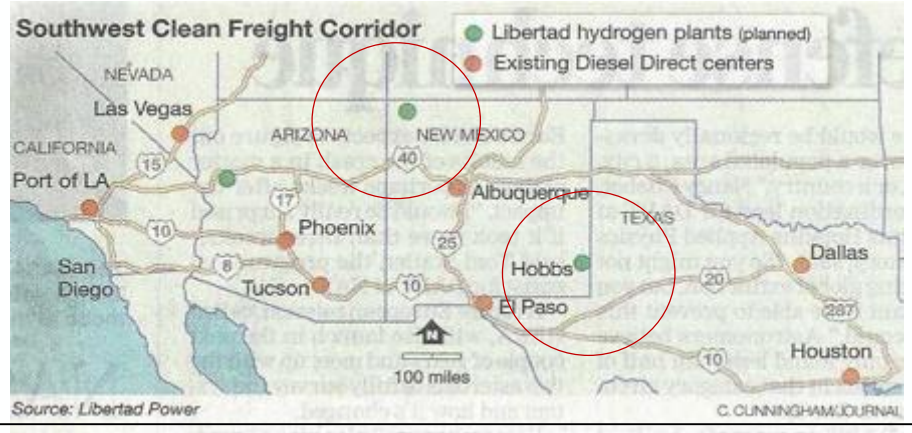
Federal Funding for Produced Water Treatment and Reuse

- Expand produced water treatment and recycling in NM with OCD using federal P&A funding
  - Treatment to create fresh water for drilling and cementing and 10# brine for closing - ~$2- 3/bbl, 100-200 bbls/day per drill rig, 5-6 drill rigs
  - At least 1700 in old fields, but access to SWD, power, appropriate quality, etc.
- Provides an opportunity to collect lots of treatment data – accelerate technology operational data
- Appropriate scale for pilot-testing of combined pre-treatment and treatment trains
- Pre-cursor to longer-term need to potentially eliminate fresh water use in drilling and fracking

Socio-economic Working Group - Major 2023 Efforts

- Supported the Western Inter-State Hydrogen Hub (WISHH) on the use of produced water for hydrogen production in the West (Nov 2022 – May 2023)
  - Provided information on brackish and produced water availability and benefits to support hydrogen development in the west
  - Supported the adoption of the Consortium developed Socio-economic model as the system dynamic framework for estimating ESG and EEEJ benefits
- Participated with producers, water midstreams, and consultants on a DOE proposal using PARETO for regional produced water disposal, treatment, infrastructure, and socio-economic optimization and design in SE NM.
- Worked with communities on the economic development opportunities in establishing local Produced Water Authorities in NM (Jun – Dec 2023)

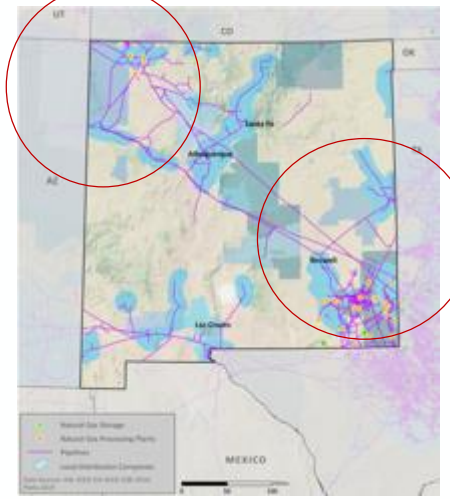
Produced Water Treatment Reuse Industrial Opportunities



The Roosevelt Project

A New Deal for Employment, Energy and Environment

2 of 3 gas pipelines to CA



- Intersection of all 3 US Electric- Grids
- Lowest levelized cost of wind and solar
- SWD, EOR, pipelines, lots of natural gas

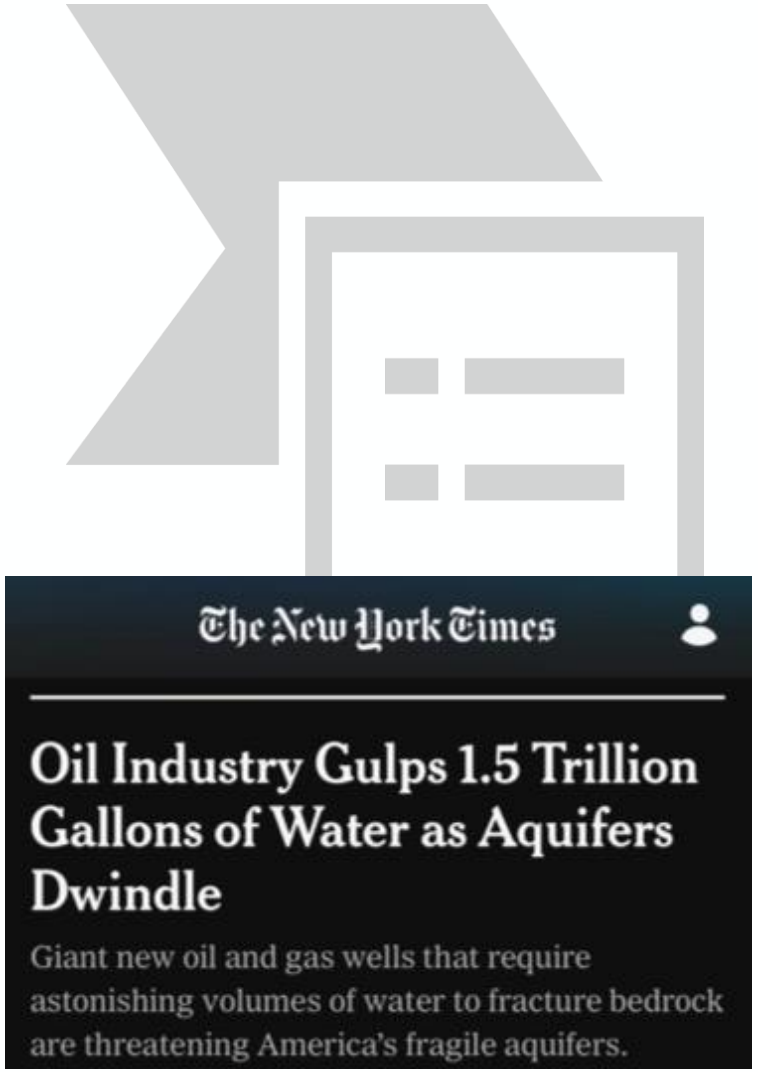
NMED Priorities – No Discharge/Closed Loop

- Greenhouses, industrial cooling, refineries
- Concentrate recovery or disposal to SWD

Energy Sector Options

- Blue and Green Hydrogen – transportation fuel, mix with natural gas in pipelines, hydrogen combined cycle – energy reliability
- Orphaned wells - plugging and abandonment, thousands
- Pumped-hydro – energy storage to balance renewables – NW and SE NM

NM Produced Water Authority Opportunities



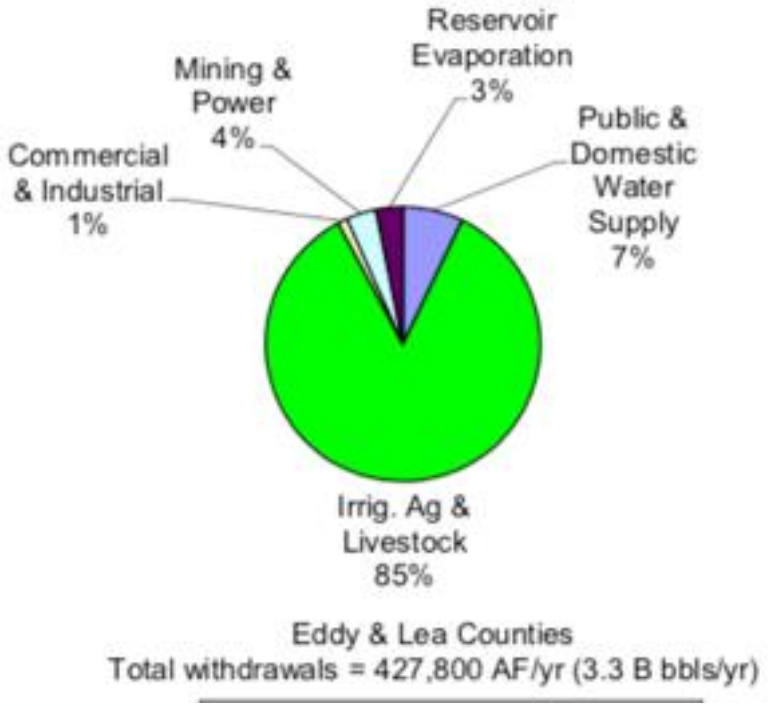
- Cooperative multi-government water development and management authority
- Limited liability (risk limitations)
- Does not require state approval
- Ability to support public/private water treatment and use infrastructure
- Supports local fresh water sustainability and encourages local economic development
- Similar successful industrial water development authority in Texas
- Applicable to both Permian and San Juan Basins
- Improves industry ESG score
- Supported by the NM Chamber of Commerce

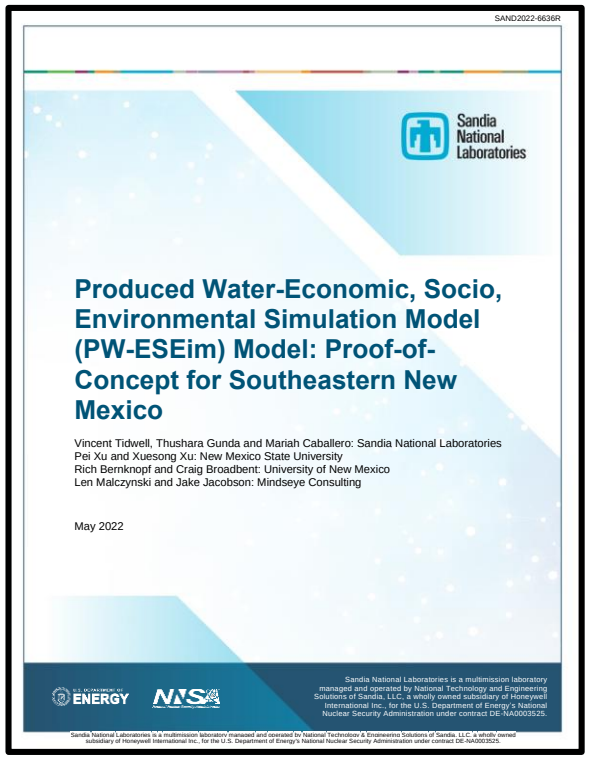
New Water Supplies are a Major Economic Opportunity

- NM is 49th in fresh water availability

	AZ	NM
Water supply:	7 M acft/yr	2 M acft/yr
GDP:	$300 B/yr	$100 B/yr
Ag use:	~72%	~75%
M&I use:	~25%	~25%
Population:	7 M	2 M

GDP is linear with water availability, 200,000 acft/yr of treated produced water could add 10% or $10 B/yr to NM economy. (Consistent with the Consortium's socio-economic model - 2021)




SAND2022-6636R

Sandia National Laboratories

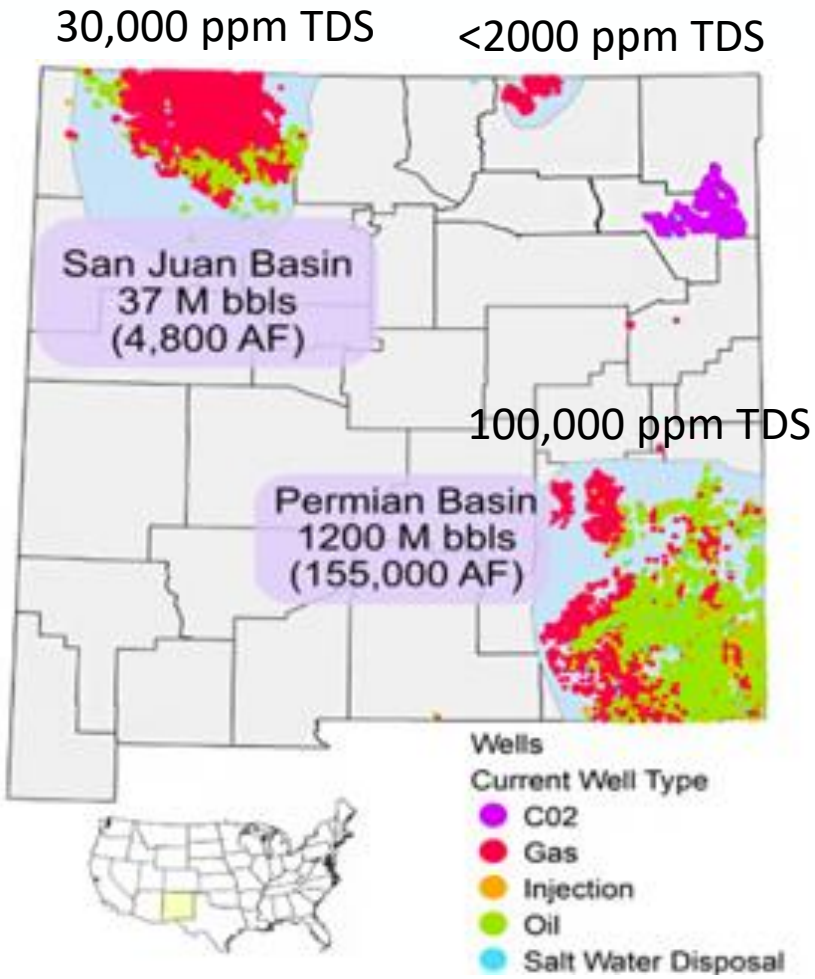
Produced Water-Economic, Socio, Environmental Simulation Model (PW-ESEim) Model: Proof-of-Concept for Southeastern New Mexico

Vincent Tidwell, Thushara Gunda and Mariah Caballero: Sandia National Laboratories
Pei Xu and Xuesong Xu: New Mexico State University
Rich Bernknopf and Craig Broadbent: University of New Mexico
Len Malczynski and Jake Jacobson: Mindseye Consulting

May 2022

Infrastructure, Economic Development 2024 Program Plan

- Combine Infrastructure and Application, and Socio-economic Working Groups for better coordination
- Facilitate treatment technology implementation
  - Integrate NM initiatives with regional produced water authorities
  - Work with OCD with federal funding to create technology markets and cost performance data
  - Team with Co, Tx, and Az on transboundary efforts, projects, and data collection



NMWRRI 2021