Permian Basin Water Conference
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Emerging Opportunities for Wholesale Produced Water Use and Reuse Markets

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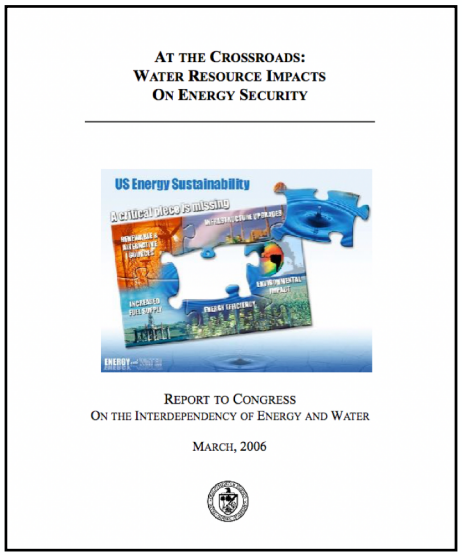
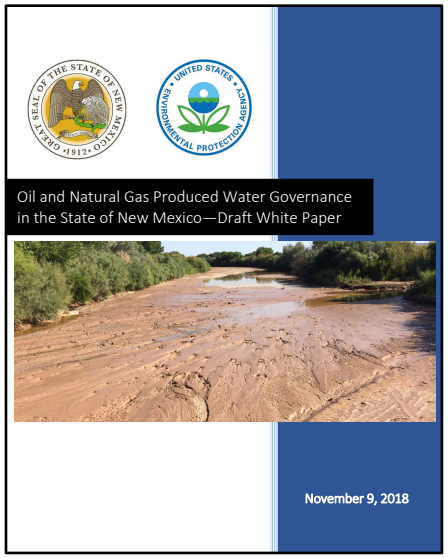
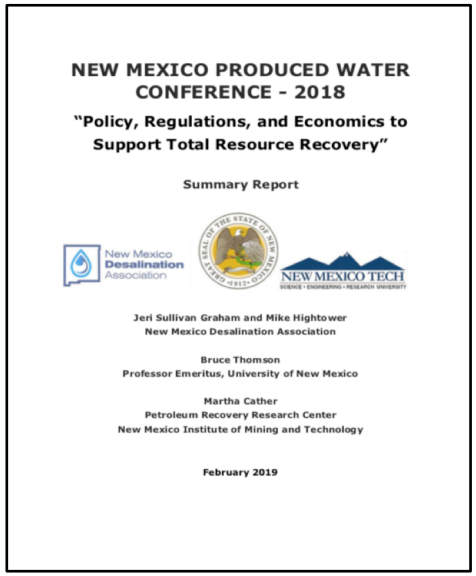
Recent New Mexico Efforts on Produced Water Treatment and Reuse



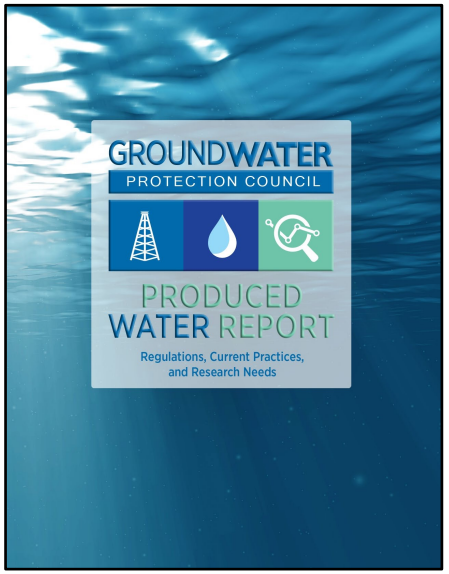
Sandia, Los Alamos, DOE
2004-15



NMED, OSE, EPA 2017-18

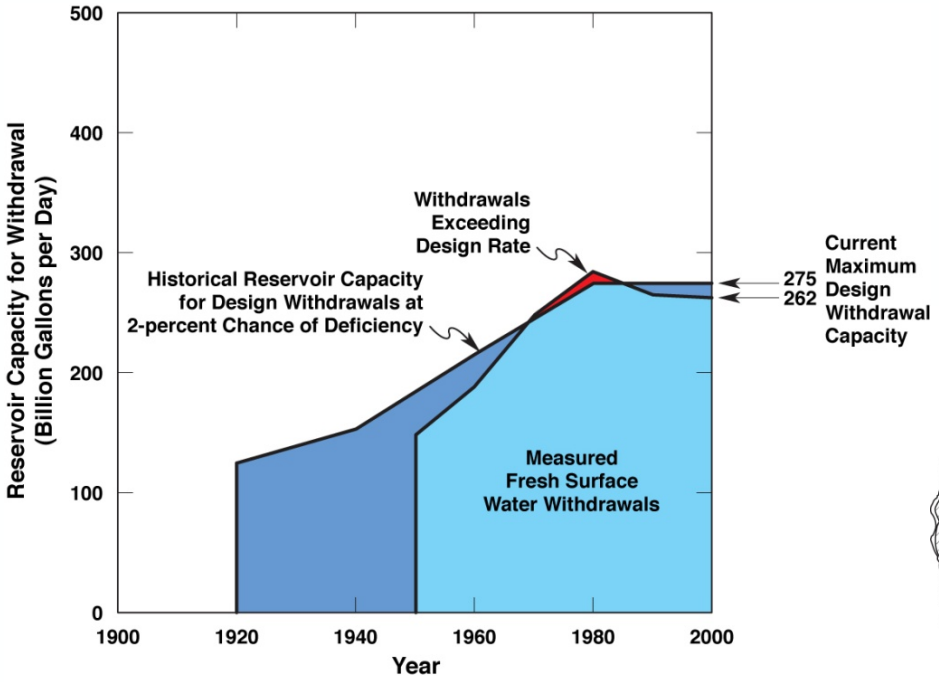


NMED, OSE, EMNRD
2017-19



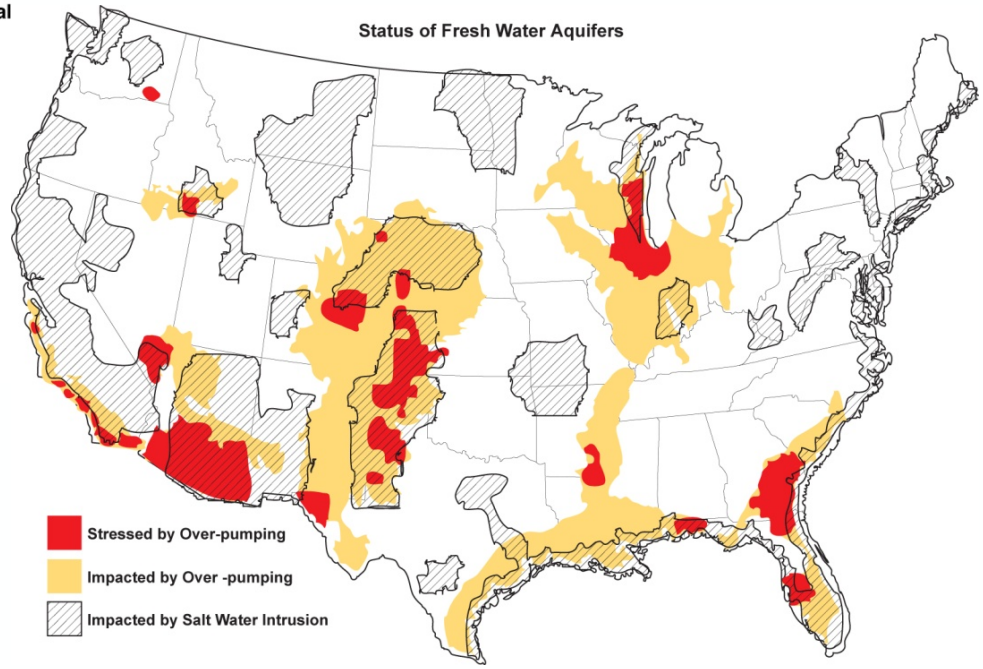
EMNRD 2016-19

Fresh Water Availability Issues Driving Produced Water Reuse



(Based on USGS WSP-2250 1984 and Alley 2007)

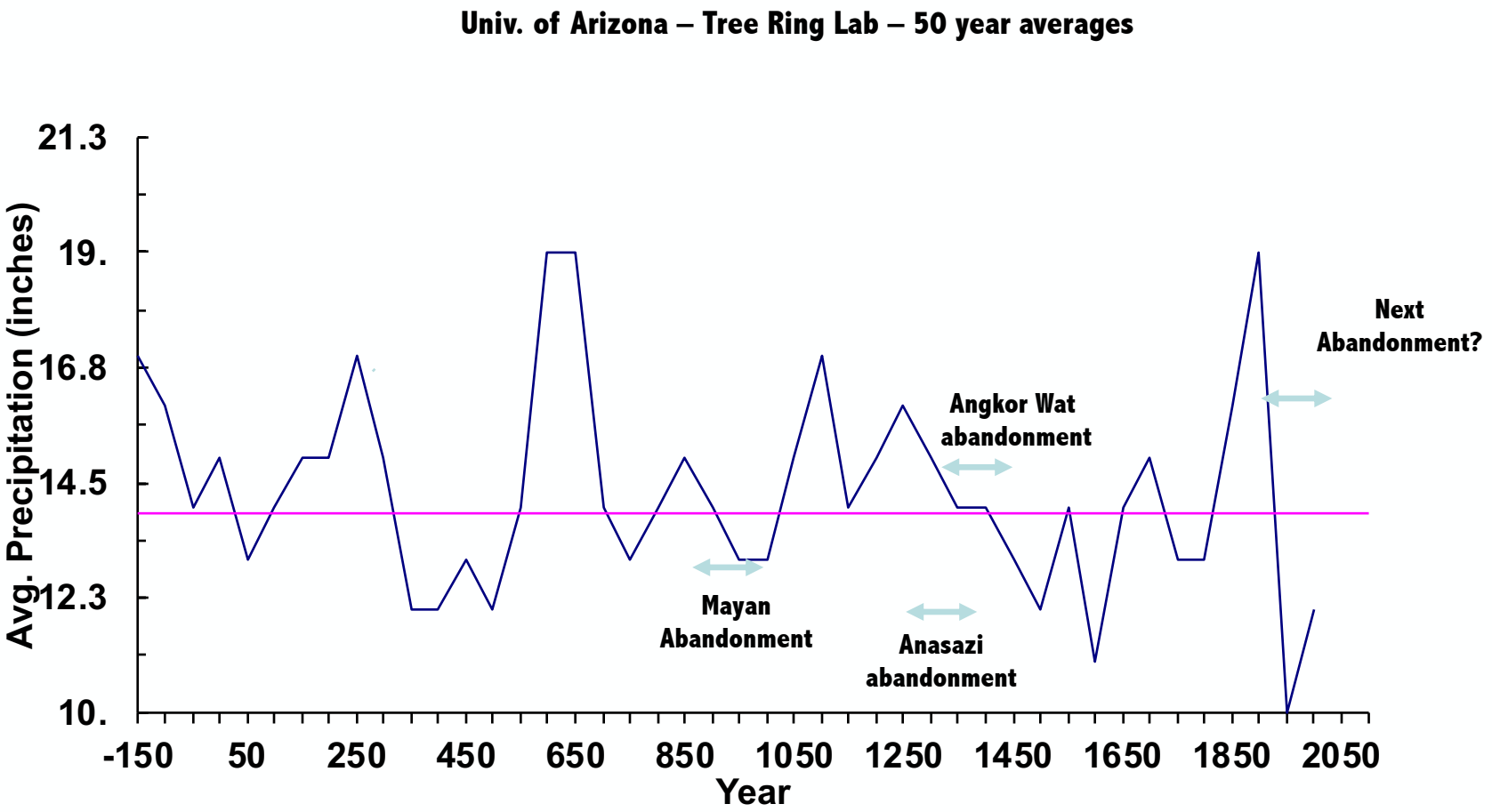
- No new surface water storage capacity since 1980



(Shannon 2007)

- All major groundwater aquifers overstressed

Climate Issues Driving Produced Water Reuse in the Western U.S.



The mid-latitudes are in the 100th year of a 300 yr arid cycle

When Hope was Alive!

Hope, New Mexico 88540,
2020 Population 100

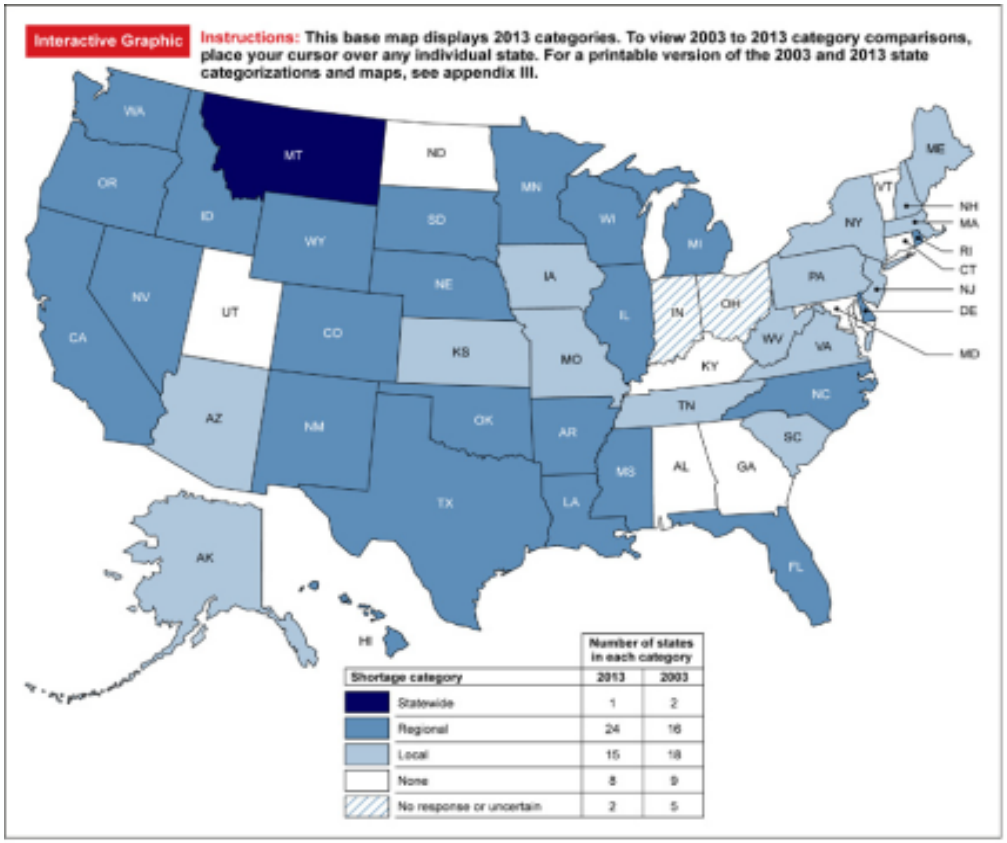
Settled by sheepherders in the 1870s, Hope had 2,000 people when it incorporated in 1910 with a bank, four general stores, three churches, three hotels, two doctors, two barber shops, a saloon, dentists, jewelers, blacksmiths and a newspaper.

In the early 1900s when the river flowed year-round, 20 square miles were in cultivation and orchards produced $200 to $500 per acre. They were served by miles of irrigation ditches .

Hope has been dying since 1912. The biggest reason Hope withered away was because the Peñasco River dried up.

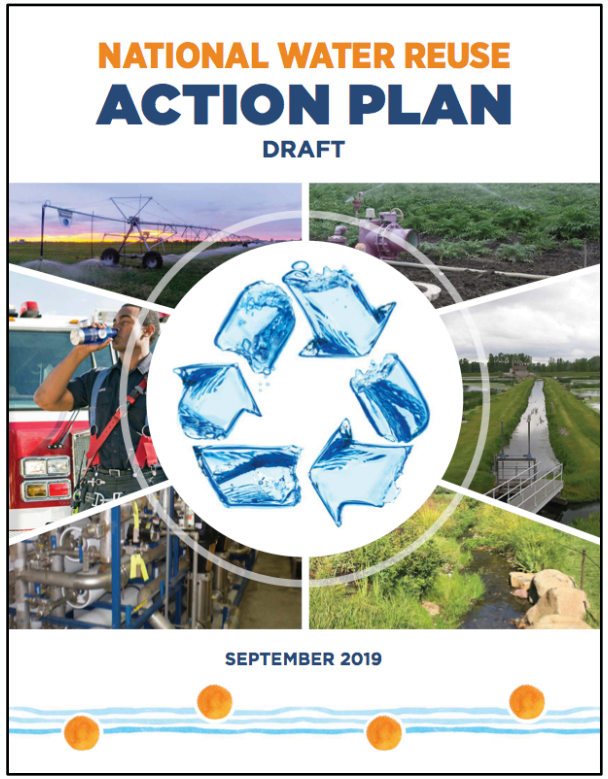
Trends in Fresh Water Resource Limitations and Non-traditional Water Use

GAO 2003 and 2013



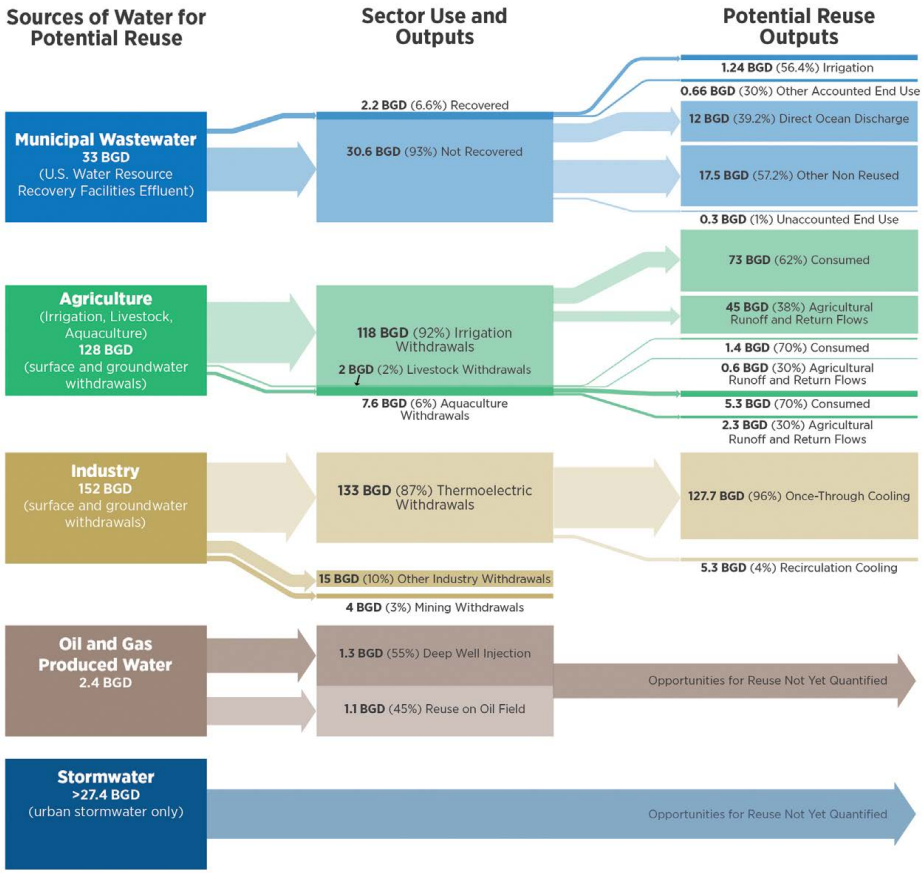
Sources: GAO analysis of state water managers' responses to GAO survey; Map Resources (map).

EPA 2020



Major Sources of Waste Waters and Potential Reuse Volumes

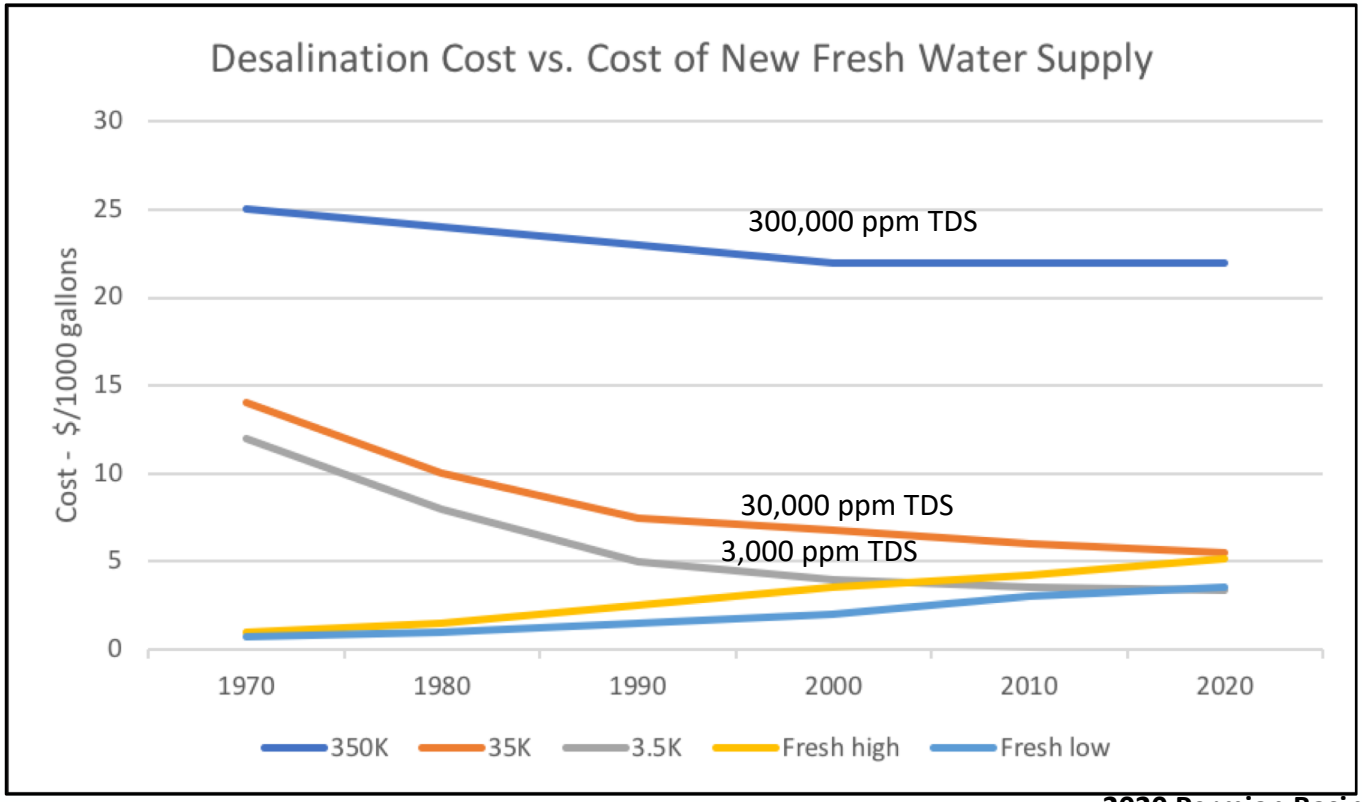
- Clear potential to reclaim more of nation's waste waters
- Sources of water for potential reuse:
  - 33 BGD - Municipal wastewater
  - 128 BGD - Agriculture
  - 152 BGD - Industry
  - 2.4 BGD - Oil and gas produced water
  - >27.4 BGD – Stormwater



New Mexico was identified with the GWPC by the EPA to the lead the WRAP effort on research for treated produced water reuse outside the oil and gas sector

Decreasing Treatment/Increasing Fresh Water Costs

(EWRI Hightower 2018)



2000 Permian Basin Avg. Produced Water Disposal costs $2/1000 gal

2020 Permian Basin Avg. Produced Water Disposal costs $20-50/1000 gal

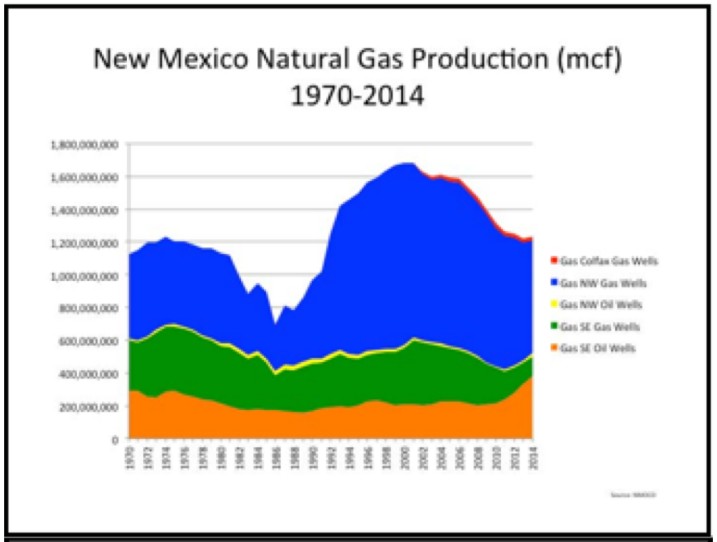
Marginal cost of water treatment is are driving the "One Water Concept"

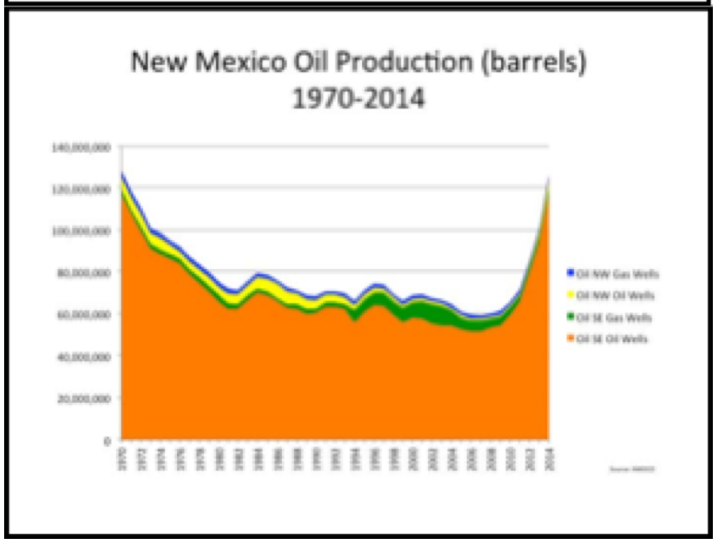
NM 2019 Produced Water Act, HB 546

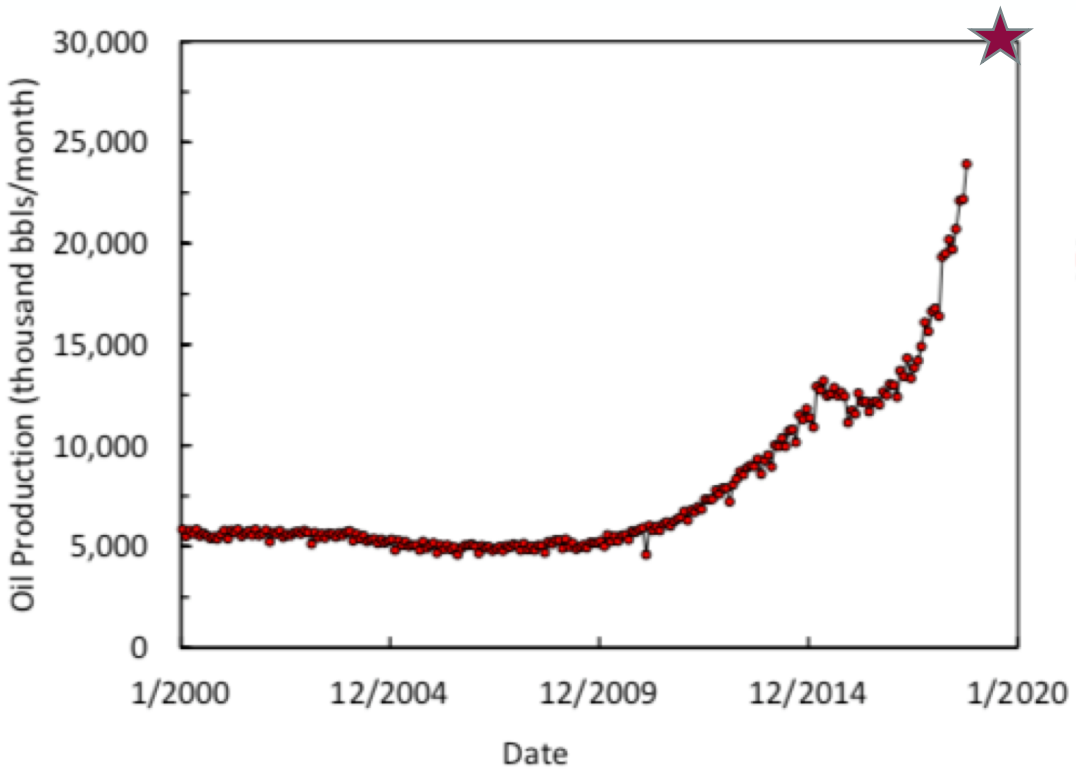
- Through the Act, statutory and regulatory authority for the reuse of produced water was modified:
  - Reuse inside oil and gas sector remains under the Oil Conservation Division (OCD) of the NM EMNRD,
  - **Reuse outside the oil and gas sector, was designated to the NM Environment Department (NMED).**
- The Act encourages produced water reuse outside oil and gas to:
  - enhance fresh water sustainability,
  - reduce or eliminate fresh water use in the oil and gas sector,
  - support new economic development opportunities,
  - maintain public and environmental health and safety.

This regulatory transition is an emerging trend in the oil and gas sector – OK, TX, CA

Produced Water Production Driving Reuse in NM

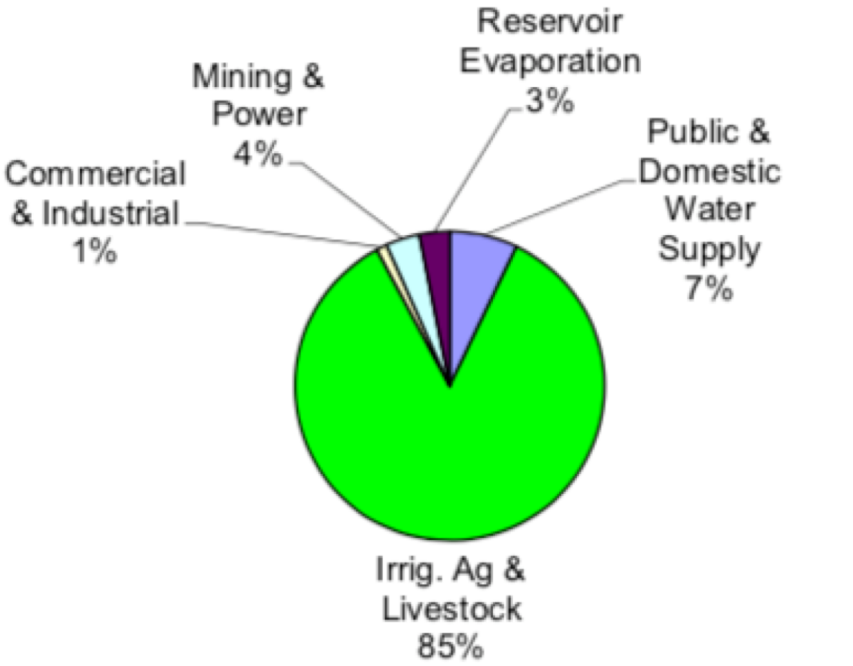




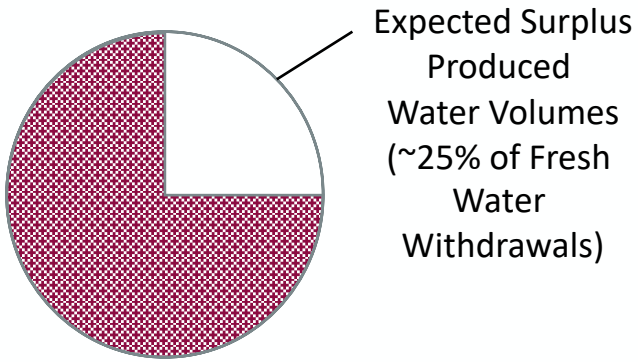


Average 4-5 bbls of produced water/ barrel of oil
~4 million bbls produced water/day (3 ABQ's)

Economic Impact Of Produced Water Reuse



Annual Fresh Water Withdrawal



Surplus expected to be ~1 B bbls/yr (2-3 M bbls/day)

Projected Produced Water Surplus

Socioeconomic Benefits of Produced Water Reuse

Element	Value
Oil production value	$6-8 B
Gas production value	$5-7 B
General Fund direct revenues	$2 B
General Fund	$1B
Capital Outlay	$.4-.5 B
Taxes to local government	$.5 B
Percent of Budget from Oil and Gas Revenues	30%

(NM LFC Finance Facts, 2018)

Supporting state economic growth and societal benefits

Cost/Benefit	Range of Values
Price of Oil (WTI)	$55.00
Price of Recycled Water per barrel	$0.50 - $7.00
Marginal Cost of Production & Taxes	$20 - $25
Marginal Cost of Water Disposal per barrel	$0.50 - $2.25
Marginal Cost of Transportation	$0.00 - $9.00
Marginal Cost of Recycling	$1.00 - $16.00
Marginal Private Value of Recycled Water	$0.25 - $1.75
Marginal Social Value of Recycled Water	$0.48 - $51.24

(Chermak & Patrick, 2018)

Local Produced Water Treatment Challenges

- Produced water quality varies by depth, location
  (10,000 mg/L to > 300,000 mg/L)
- Often Na, Ca, Cl, and SO4, high scaling
- Can contain hazardous constituents such as: Ra, Ba, Sr, U, heavy metals, organics,
- Fracking chemicals –
  Water and sand –99% to 99.5% by volume
  Friction reducer, Biocide, Surfactants,
  Thickeners, Scale and Corrosion inhibitors, and
  other trace chemicals
- Surface storage
- Concentrate management and disposal issues and costs – solid, hazardous, radioactive, or mixed waste

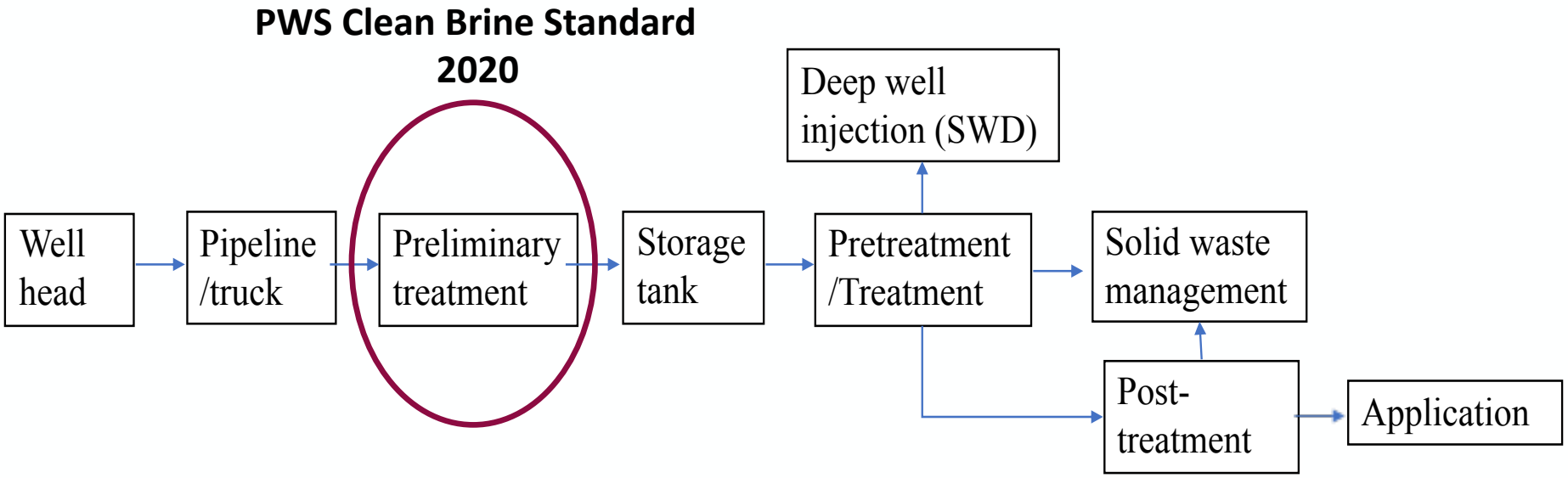
REQUIRES SAFE TRANSPORTATION, HANDLING, TREATMENT, STORAGE, AND RESIDUALS MANAGEMENT

Common Water Quality Requirements for Various Applications

Produced Water Quality (ppm) TDS	Application	Common Water Quality Requirements (ppm) TDS	Typical Treatment Process
Conventional 10K to 50K 50%<35K	Drinking	500-600	Chemical/membrane/thermal
	Aquifer Storage & Recovery	300-5,000	Chemical/membrane/thermal
	Agriculture and livestock	Class 1 <700, <60% Na, B<0.5 Class 2 2000, 60-75% Na, B<2.0 Class 3 >2000, 75% Na, B~2	Chemical/membrane/thermal
Unconventional 60K to 300K 30%<100K	Rangeland	4,000 – 10,000	Chemical/membrane/thermal
	Surface Flow	600-2000	Chemical/membrane/thermal
	Mineral Recovery	>100,000 (no discharge)	Chemical/thermal
	Road Construction	Up to 100,000	Chemical/membrane/thermal

Clean Brine Standard Changes the Landscape on Produced Water Reuse

Pre-treatment **Treatment** **Post-treatment** **Disposal**



Improve reuse options to reduce fresh/brackish water use in drilling and fracking

Water recovery for wholesale and fit-for-purpose uses

Mineral and resource recovery

Waste and seismicity reduction

Clean Brine Standard Benefits for Produced Water Reuse

- Preliminary treatment standards will drive compatibility of different produced waters
  - Enables the ability to mix or share produced water without chemical or biological fouling or sludge formation, reduce air emissions and organic residuals, etc.
- Establishes a general baseline water quality to reduce pre-treatment and treatment variability
- Increases treatment economies of scale to 10-15 MGD plants, utilizing common industry and midstream produced water infrastructure capabilities
- Often good access to high volume waste disposal capacity
- Support basic (wholesale) quality indices for reuse inside or outside oil and gas sector

Potential Wholesale Produced Water Quality Metric

Application	Common Water Quality Requirements (ppm) TDS
Drinking	500-600
Cooling Water	1,000-2,000
Process Water	500-1,000
Pumped Hydro	3,000-10,000
Rangeland Restoration	4,000 – 10,000
Surface Flow	600-2000
Mineral Recovery	>100K (no discharge)
Road Constr.	Up to 100,000
Average Wholesale Index	3000-4000

Produced Water Sharing and Treatment to Wholesale Index Reuse Benefits

- Provides baseline water quality for-fit-for-purpose uses
- Easier treatment, less local infrastructure needs
- Provides flexibility of uses with ability to blend
- Reduce local community/user technical and environmental risks
- Increase options and accelerate implementation

0.25 Mgd desalination system