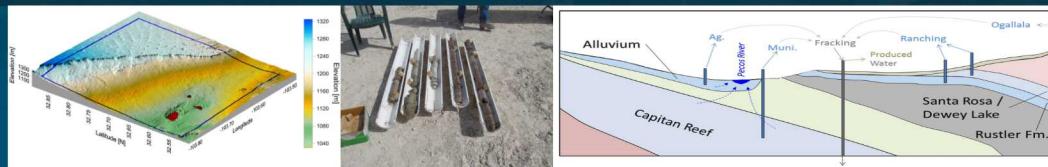


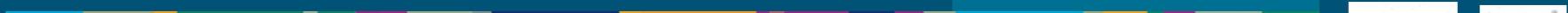
Assessing Risk to Water Resources from Oil and Gas Activities in the San Juan Basin



Animas and San Juan Watersheds Conference
June 19-20, 2019

PRESENTED BY

Thomas Lowry, Sandia National Laboratories



The Project Team

Tom Lowry – Sandia National Laboratories
Owen Lofton – Sandia National Laboratories
Patricia Johnson – Sandia National Laboratories
Dale Bowman – Sandia National Laboratories
Whitney Thomas – BLM Farmington
Dave Herrell – BLM Santa Fe



Introduction

Motivation

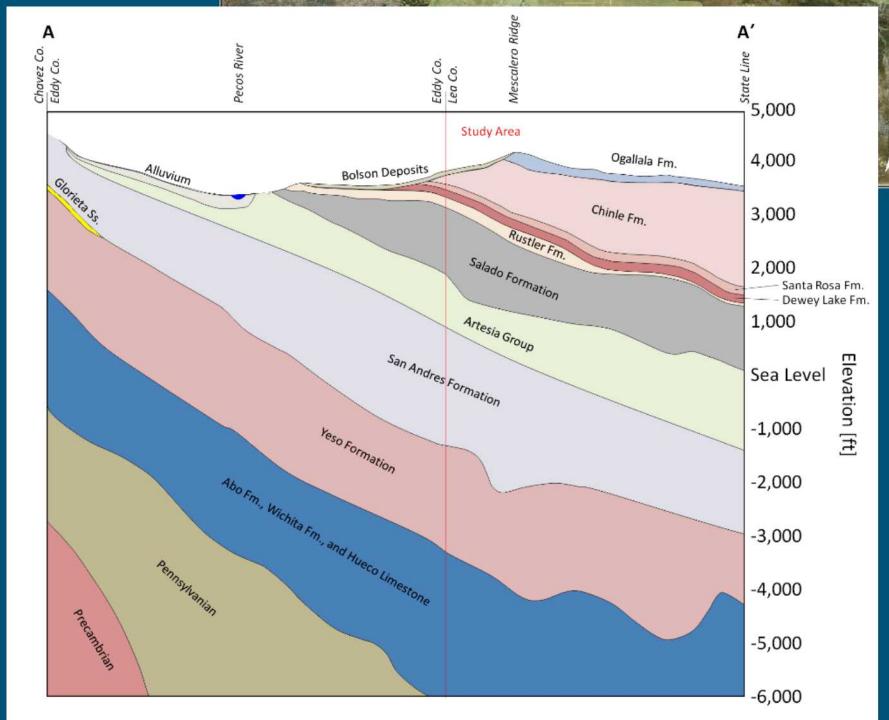
Reasonable Foreseeable Development

Water Resource Studies

- Dewey Lake / Santa Rosa
- Permian Basin

San Juan Basin

- Groundwork
- Issues
- Schedule
- Shameless call for input



Motivation

With the increase in drilling activity and hydraulic fracturing in particular, there is need to insure the regions ability to meet increasing water demands in a manner that is sustainable while also avoiding unintended, localized impacts.

Approach

Use a multi-disciplinary approach to identify and rank potential cumulative impacts of future water demands. Of key importance is understanding the current state of the groundwater system (quality and quantity).

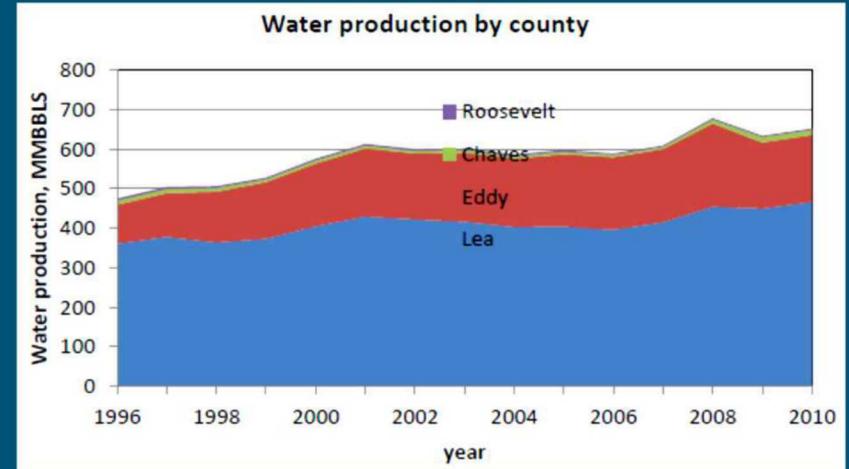
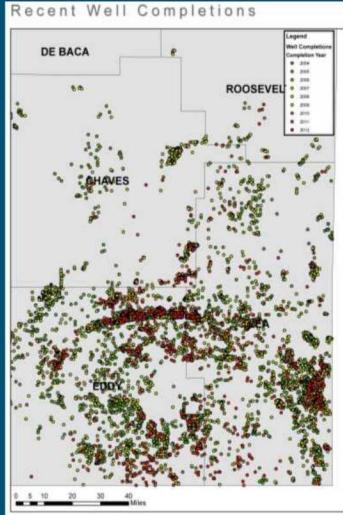
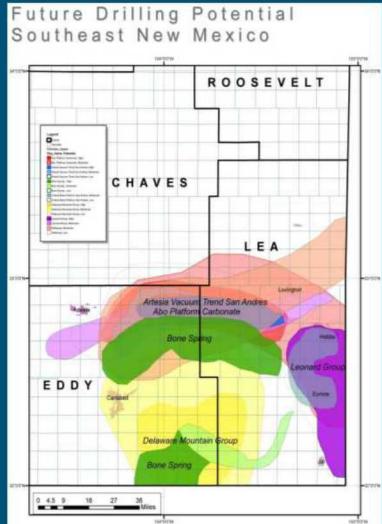
1. Data collection
2. Field verification
3. Field testing and monitoring
4. Modeling??

Reasonable Foreseeable Development (RFD)

Study by Engler et al. (2012, 2013, 2014) to estimate the development of hydrocarbon production in southeast NM (Chaves, Eddy, Lea, and Roosevelt counties) over the next 20 years

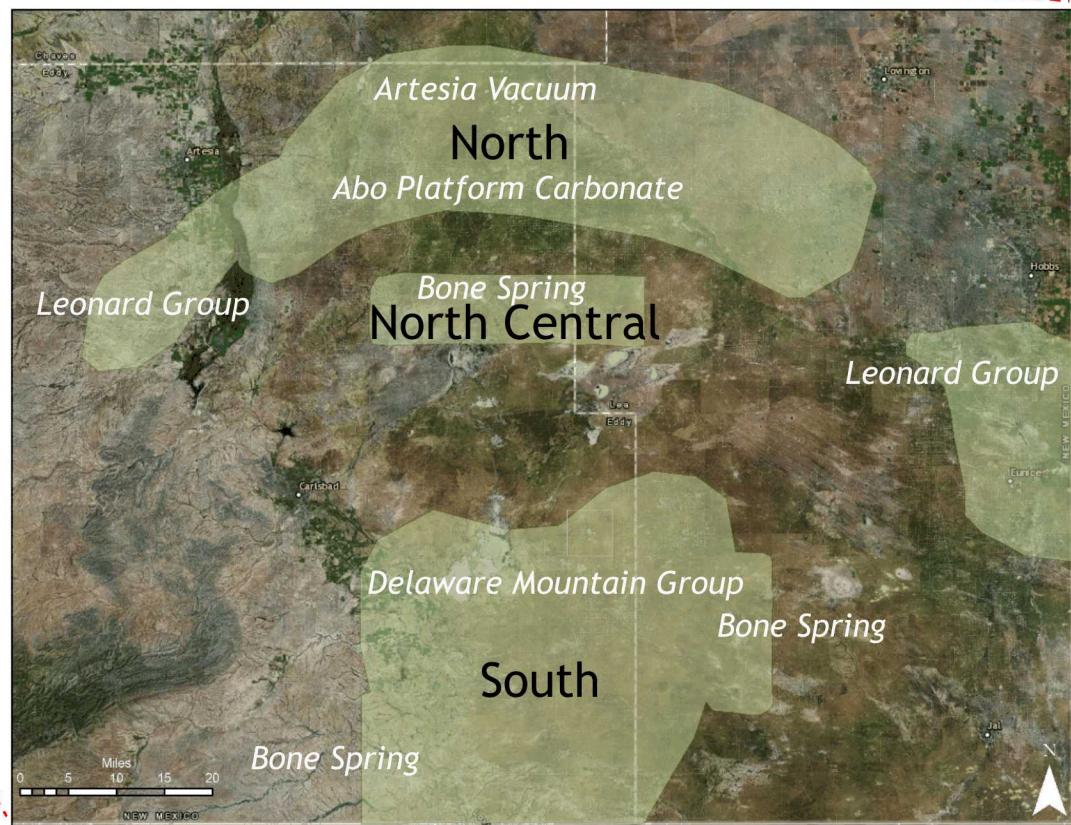
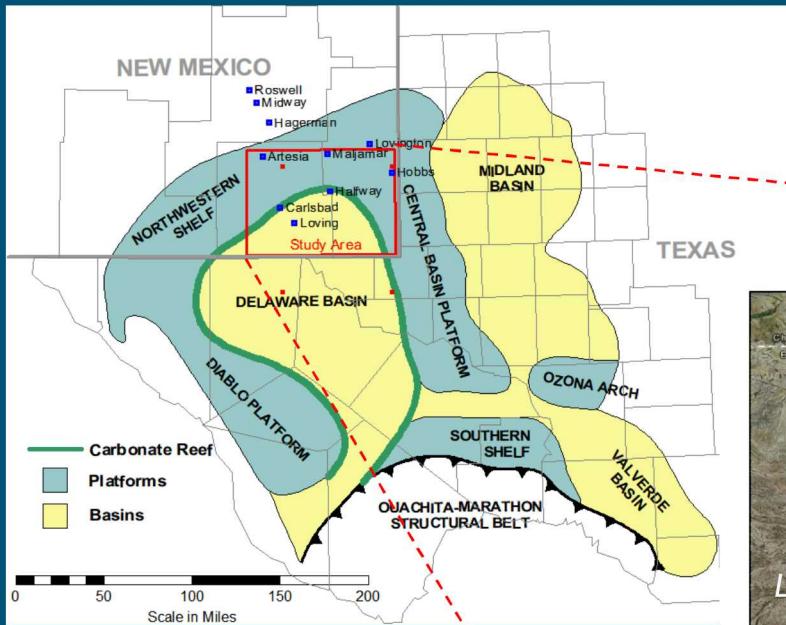
Identified the major oil (16) and gas (10) plays and categorized them into potential areas of 'low', 'moderate', 'high', or 'very high'

Oil production ~800 wells / yr, gas production decreasing, water demand increasing (7.3 AF/well ave.)



Engler T.W., R. Balch, and M. Cather, 2012, *Reasonable Foreseeable Development (RFD) Scenario for the B.L.M New Mexico Pecos District*, Final Report submitted to Jim Stovall, Project Manager Carlsbad Field Office, 55p

PA's and Study Area



Data Collection, Verification, Testing

Inventory of the water users and water sources: Areas of high and very high potential

Identify past studies and/or tests that may pertain to conditions at each site.

Verify the data

- Contact and work with each water user to access their well(s)

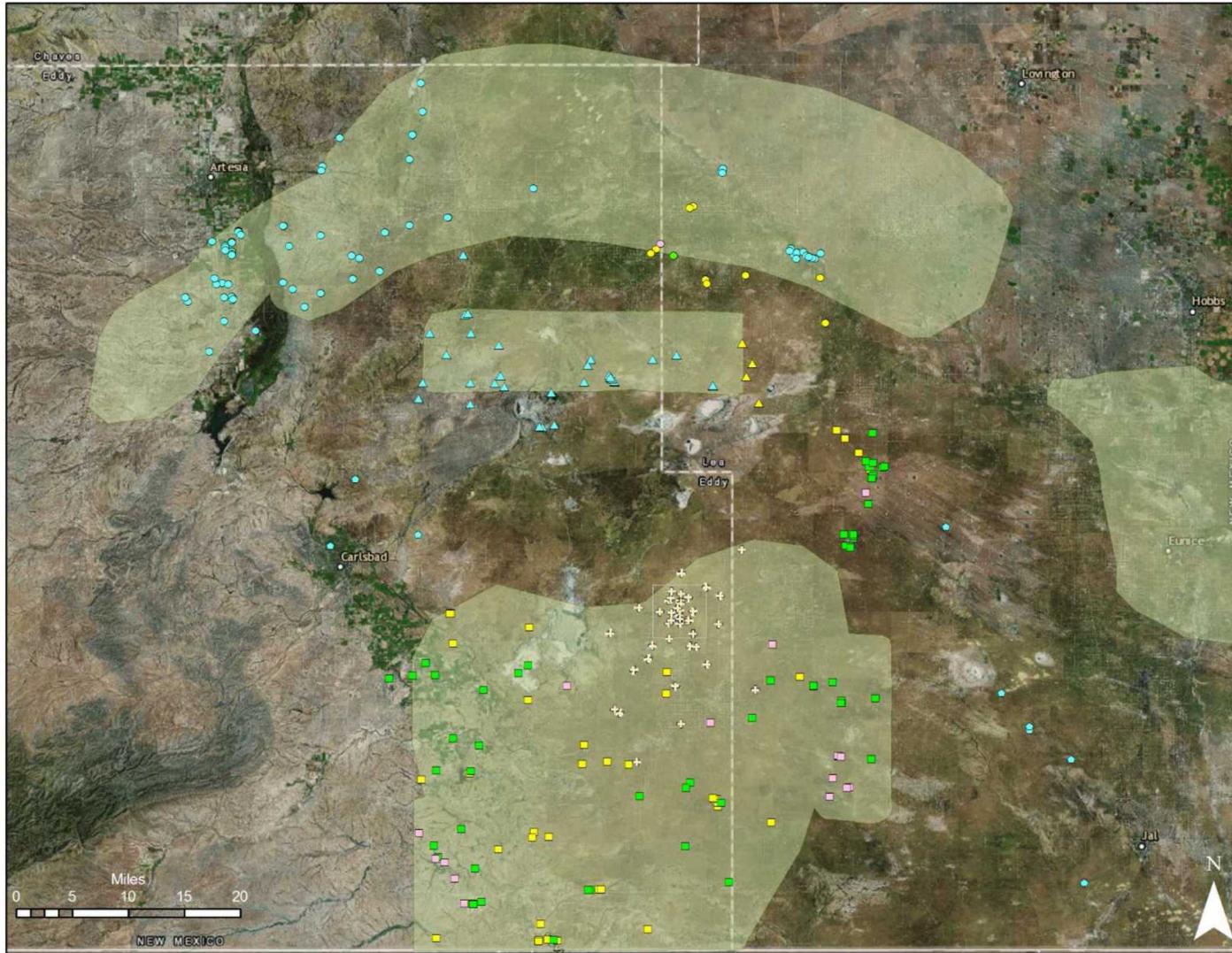
Field Testing and Sampling

- Measured and Verified: GPS coordinates, surface elevation, well diameter, distance to top of casing depth to water, total depth
- Sampled: Cations/anions, pH, conductivity, trace metals

Established current baseline from which future changes can be compared to and provide hydrogeologic parameters to the model.



Data Collection, Verification, Testing



Working with Private Well Owners

Dear XXXXXXXX,

May 24, 2016

On behalf of the Bureau of Land Management (BLM), Sandia National Laboratories (Sandia) is conducting a study to assess the sustainability of water resources in Eddy, Lea, and Chavez Counties. The demand for water is increasing proportionally with the recent increase in hydraulic fracturing and the BLM would like to better understand the sustainability of these practices on federal land given the limitations on water in our arid region.

As part of this study Sandia will be collecting field data on water wells in your area that includes depth to water, overall depth, water quality, and the primary purpose of the well. This information will be compiled into a database and utilized to develop a model that can predict impacts on the regional water supply in correlation with changes in oil and gas production.

You are receiving this letter because one or more wells on your property have been identified as candidates for field data collection. We are asking landowners to participate in our study by granting Sandia access to their wells for the purposes of gathering the various measurements. In return for allowing access, participating landowners will receive a comprehensive report documenting the current status and state of each of their wells. To preserve your anonymity the information will be assigned a generic identification number that will be used in documents released to the public.

The value of this study is greatly dependent on the quality and quantity of information gathered in the field so we hope you will support us as we attempt to find a balance between development and preserving our water resources.

By signing this letter, the Landowner agrees to allow Sandia access to their well(s) for the purposes of measuring water level and total well depth and to collect water samples that will be analyzed for general geochemistry and metals profiling. A copy of the water quality report and the water level data will be supplied to the landowner.



Figure 42 Wallen Fed. No. 9 East



Figure 38 Windmill No. 2 West



Figure 56 (House Well) North

was to define the Dewey Lake and Santa Rosa aquifers to aid the BLM with on-going and gas permitting informing environmental to BLM Lea Study for the Santa Rosa Fo Report - SANI more inform study).

Before field conducted, i generated usi query of the Office of the

Results of Well Survey and Water Quality Analysis BLM Dewey Lake Study XXXXXX Geographic Area Wells Lea County, New Mexico

dual report is tiered from a former acted by Sandia National Laboratories was an effort to assist the Bureau of

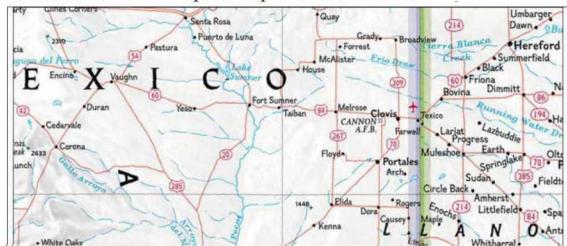
agement (BLM) sing ground water a BLM, State and 1ds, targeting the ce and Santa Rosa aring formations model boundary the agency. The tent of that work

etter define the Dewey Lake and Santa Rosa

aquifers to aid the BLM with on-going and gas permitting

informing environmental to BLM Lea Study for the Santa Rosa Fo Report - SANI more inform study).

geographic area names were selected based on the landowner or grazing permittee's name. This specific report is confined to the



Hall Environmental Analysis Laboratory, Inc.

Client: Sandia National Labs	Client Sample ID: CP-1330-20141202
Project: BLM-DL	Collection Date: 12/2/2014 9:50:00 AM
Lab ID: 1412226-001	Matrix: AQUEOUS
Analyses	Result
EPA METHOD 300.0: ANIONS	RL Qual Units
Fluoride	0.10 mg/L
Chloride	32.0 mg/L
Bromide	0.18 mg/L
Phosphorus, Orthophosphate (As P)	ND mg/L
Sulfate	190.0 mg/L
Nitrate+Nitrite as N	ND mg/L
EPA METHOD 6010B: DISSOLVED METALS	DF Date Analyzed
Calcium	8.0 mg/L
Magnesium	4.9 mg/L
Potassium	1.6 mg/L
Sodium	210.0 mg/L
SM2510B: SPECIFIC CONDUCTANCE	Batch
Conductivity	1000.0010 µmhos/cm
SM4500-H+B: PH	Analyst: JRR
pH	8.43 1.68 pH units
SM320B: ALKALINITY	Analyst: JRR
Bicarbonate (As CaCO ₃)	240.0 mg/L CaCO ₃
Carbonate (As CaCO ₃)	4.9 mg/L CaCO ₃
Total Alkalinity (as CaCO ₃)	240.0 mg/L CaCO ₃
SM2540C MOD: TOTAL DISSOLVED SOLIDS	Analyst: KS
Total Dissolved Solids	636.0020 mg/L

Received Date: 12/4/2014 9:00:00 AM

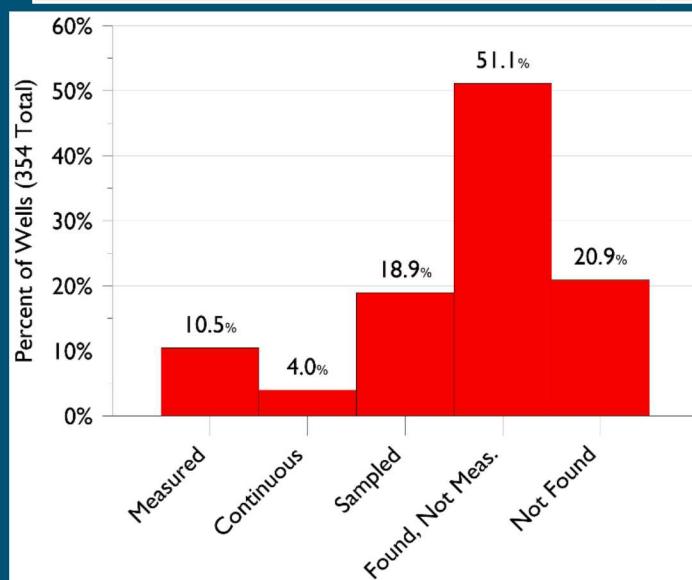
Analytical Report

Lab Order 141226

Date Reported: 12/19/2014

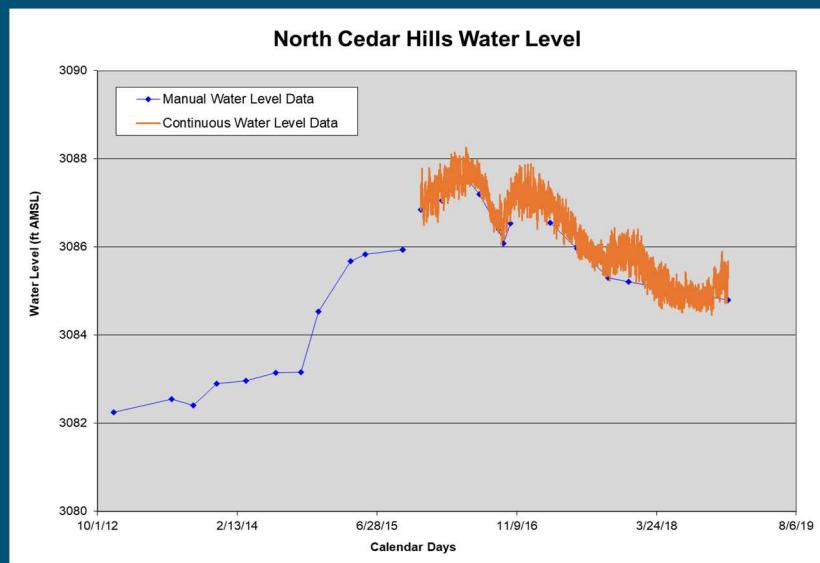
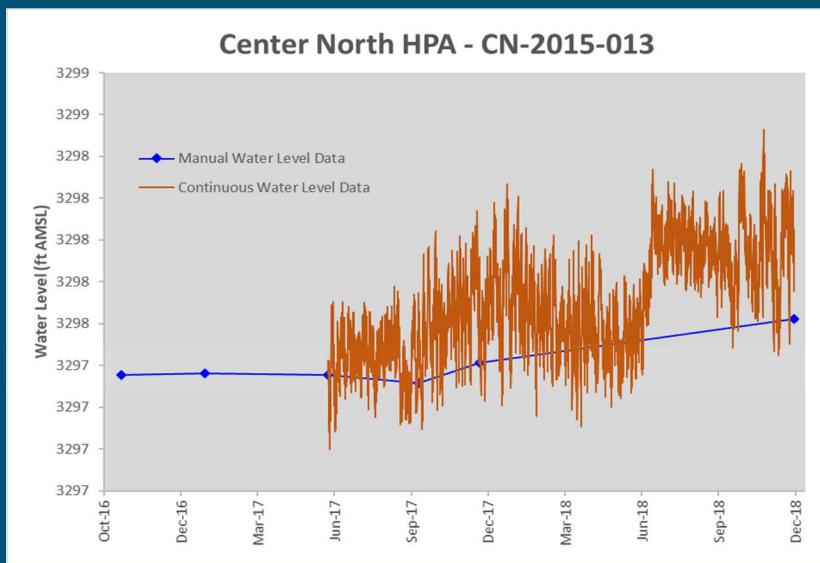
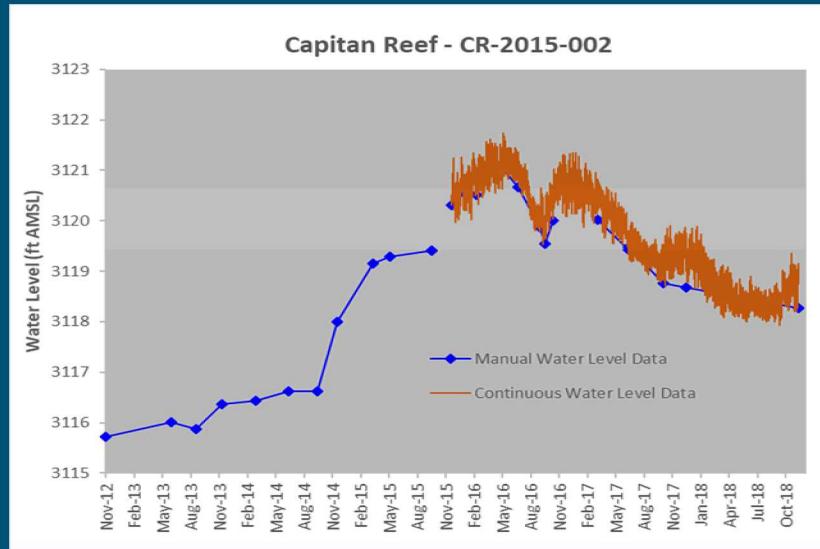
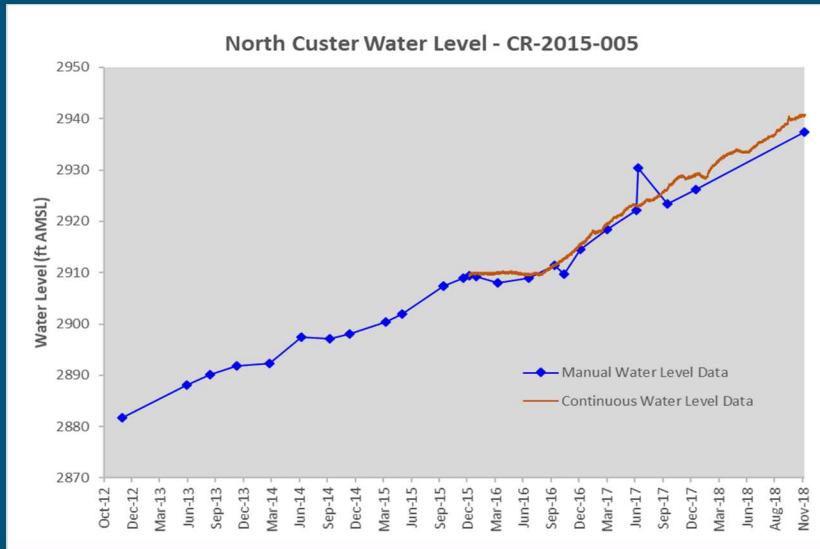
Data Collection, Verification, Testing

	North	N Central	South	Capitan	Total
Total	127	60	158	9	354
Measured	7	10	16	4	37
Continuous	3	2	5	4	14
Sampled	19	11	30	7	67
Found, Not Measurable	70	24	86	1	181
Not Found	28	17	29	0	74



Most of the wells (72%) were either not found or not measurable

Continuous Measurements



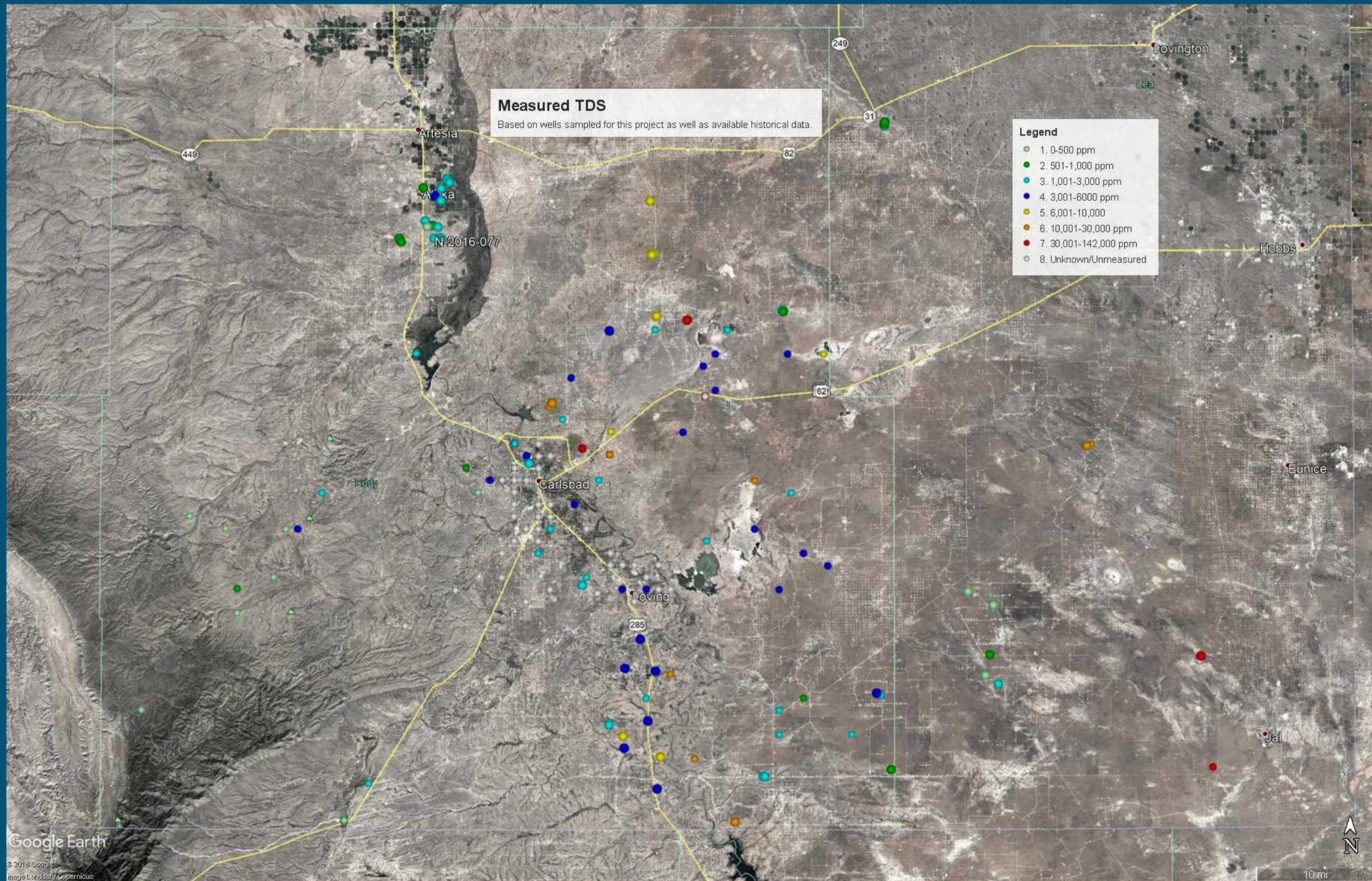
Water Chemistry

- Water samples on ~27% of wells identified/accessible
- Looked at cation/anion balance and other water quality indicators

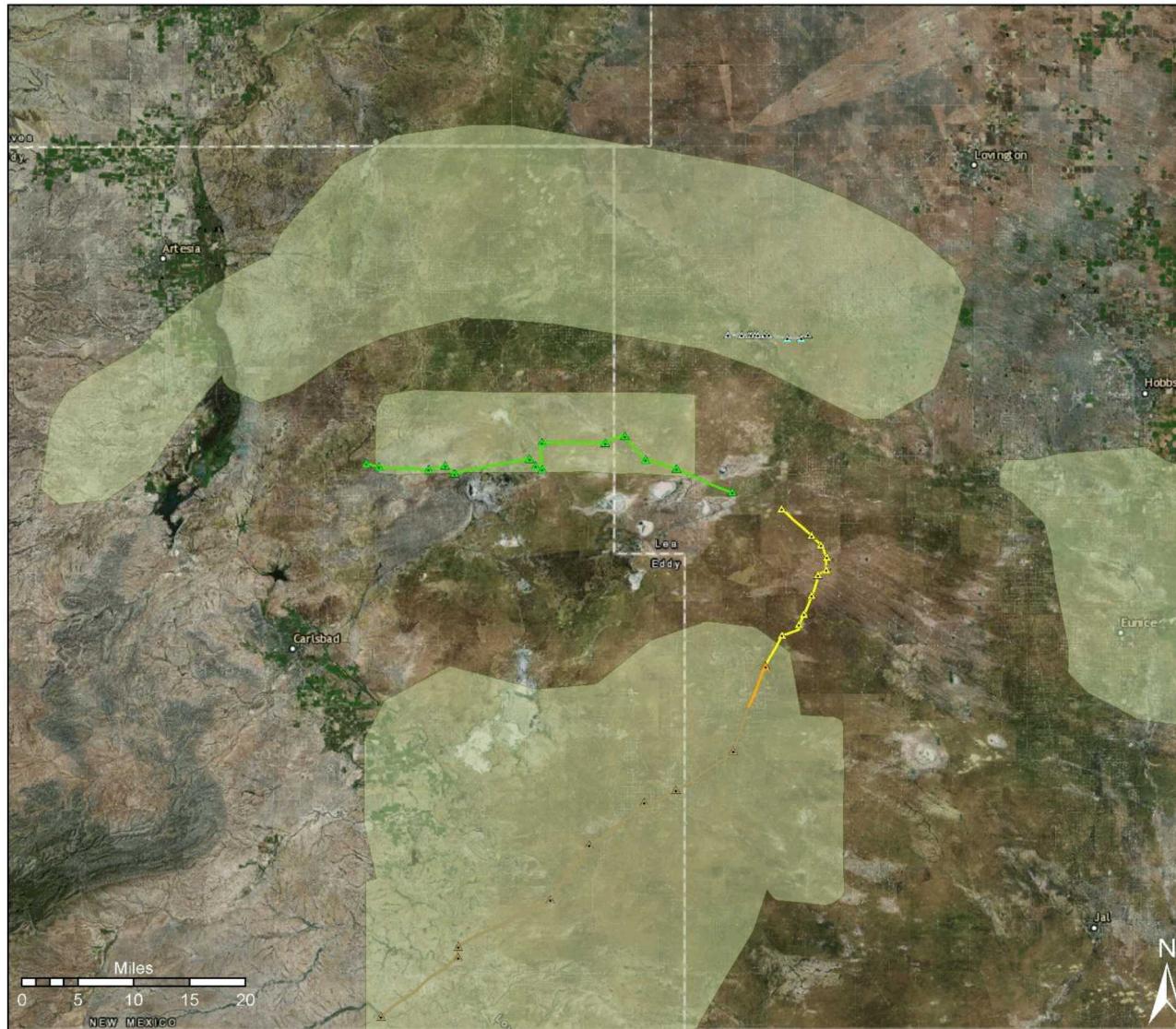
pH	Magnesium (Mg_2^+)	Sulfate (SO_4^{2-})
Specific Conductance	Sodium (Na^+)	Fluoride (F^-)
Total Dissolved Solids (TDS)	Potassium (K^+)	Nitrate (NO_3^-)
Calcium (Ca_2^+)	Bicarbonate (HCO_3^-)	Nitrite (NO_2^-)
Chloride (Cl^-)	Carbonate (CO_3^-)	

- Some wells also sampled for 17 trace metals

Water Chemistry



Cross-Sections



Cross-Section Locations

- South Area X-Section
- North-Central Area (N-S) X-Section
- Mescalero Ridge South X-Section
- North-Central Area (W-E) X-Section
- BLM High Potential Areas

North HPA - Mescalero Ridge W to E

West

East

30-025-29898
GRN
ref elev: 3983 ft amsl
T18S R33E sec 09

30-025-30311
GRN
ref elev: 3996 ft amsl
T18S R33E sec 10

30-025-25012
GR/acoustic
ref elev: 4000 ft amsl
T18S R33E sec 10

30-025-29698
GRN
ref elev: 4009 ft amsl
T18S R33E sec 11

30-025-29422
GRN
ref elev: 4015 ft amsl
T18S R33E sec 11

30-025-29368
GRN
ref elev: 4010 ft amsl
T18S R33E sec 11

30-025-2915
GRN
ref elev: 4028 ft amsl
T18S R33E sec 11

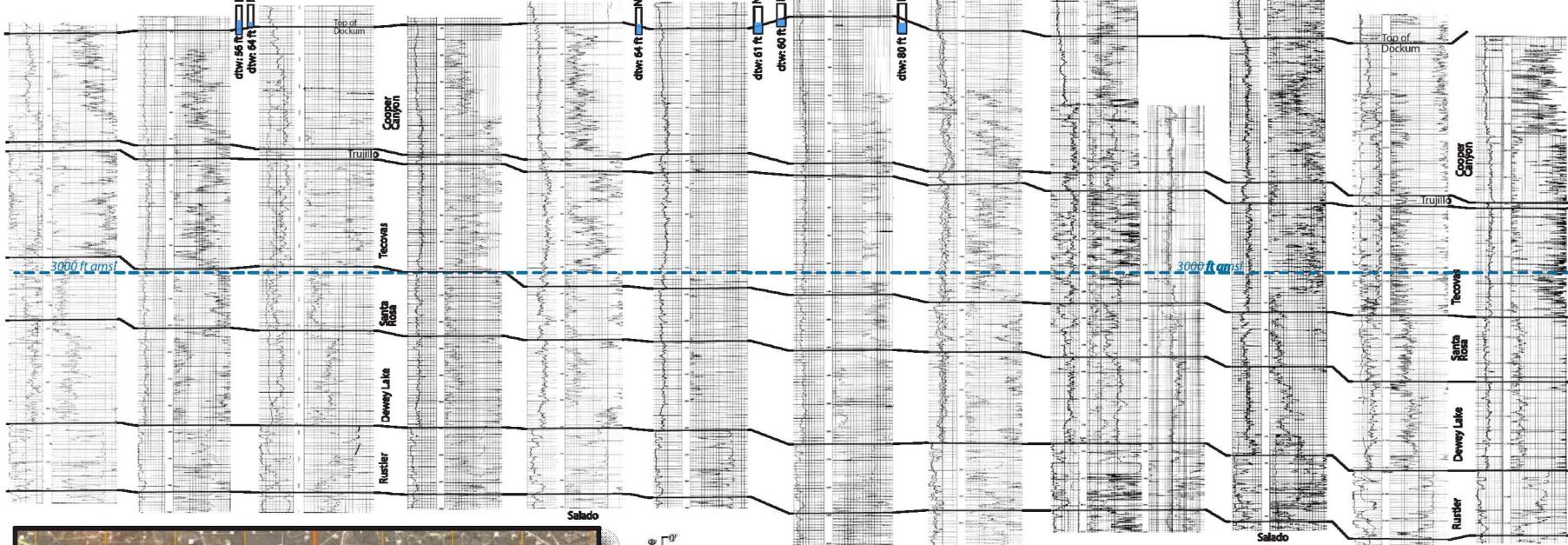
30-025-28700
GRN
ref elev: 4056 ft amsl
T18S R33E sec 12

30-025-28575
GRN/density/resistivity
ref elev: 4124 ft amsl
T18S R33E sec 12

30-025-28285
GRN
ref elev: 4083 ft amsl
T18S R34E sec 08

30-025-27432
GRN
ref elev: 4068 ft amsl
T18S R34E sec 09

30-025-28865
GRN
ref elev: 4055 ft amsl
T18S R34E sec 09



Mescalero Ridge South
West-East Geophysical Log Cross-section
All logs are placed relative to mean sea level (reference line is 3000 ft amsl)
Nearby water wells are projected into the log cross-section where depth and water level data are available
Logs are not placed horizontally to scale

Explanation

GR - gamma ray

GRN - gamma ray/neutron log

formation contact

standard reference elevation

N-2016-xoc: water well identifier

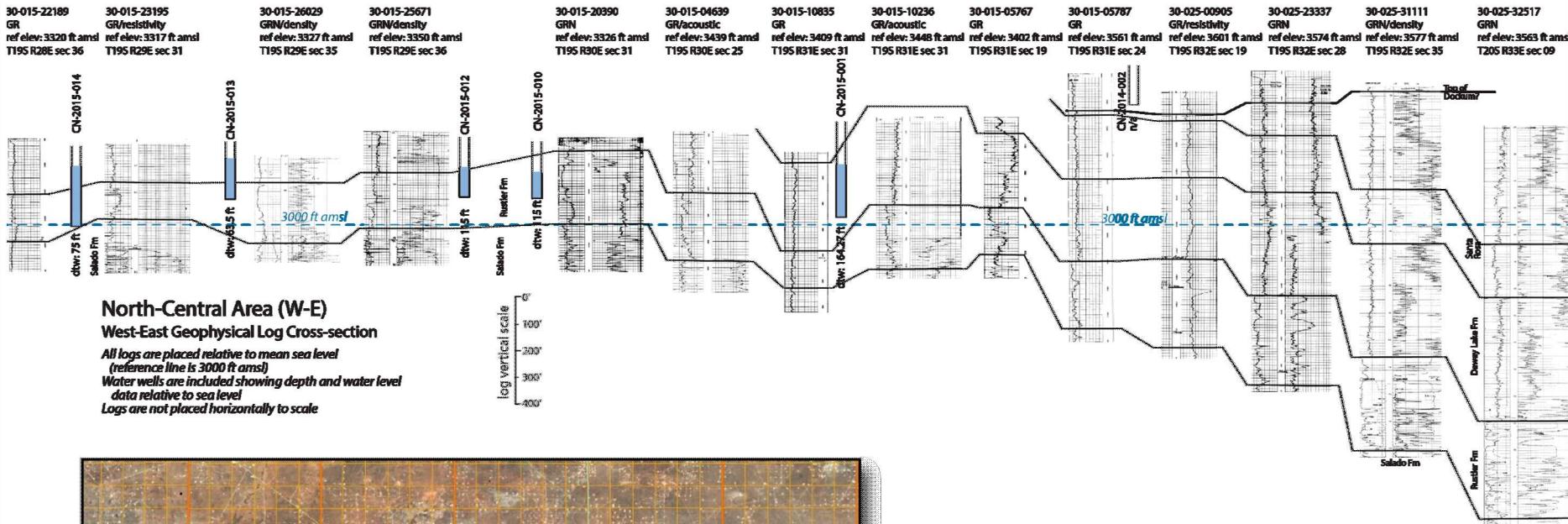
dtw: depth to water in ft

well diagram, at reference elevation with scaled dtw in blue

North-Central HPA - W to E

West

East



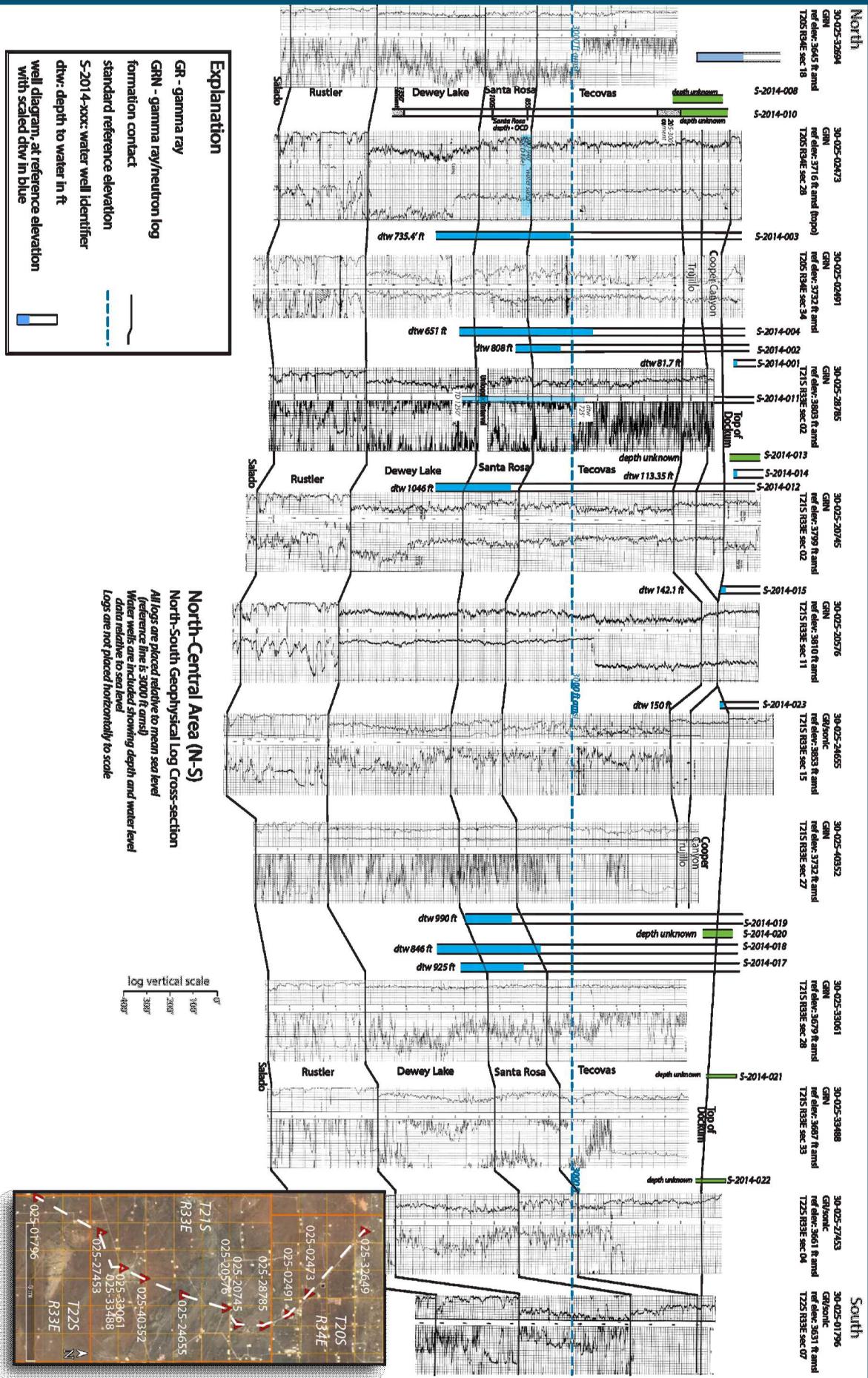
North-Central Area (W-E)
West-East Geophysical Log Cross-section
All logs are placed relative to mean sea level
(reference line is 3000 ft amsl)
Water wells are included showing depth and water level
data relative to sea level
Logs are not placed horizontally to scale



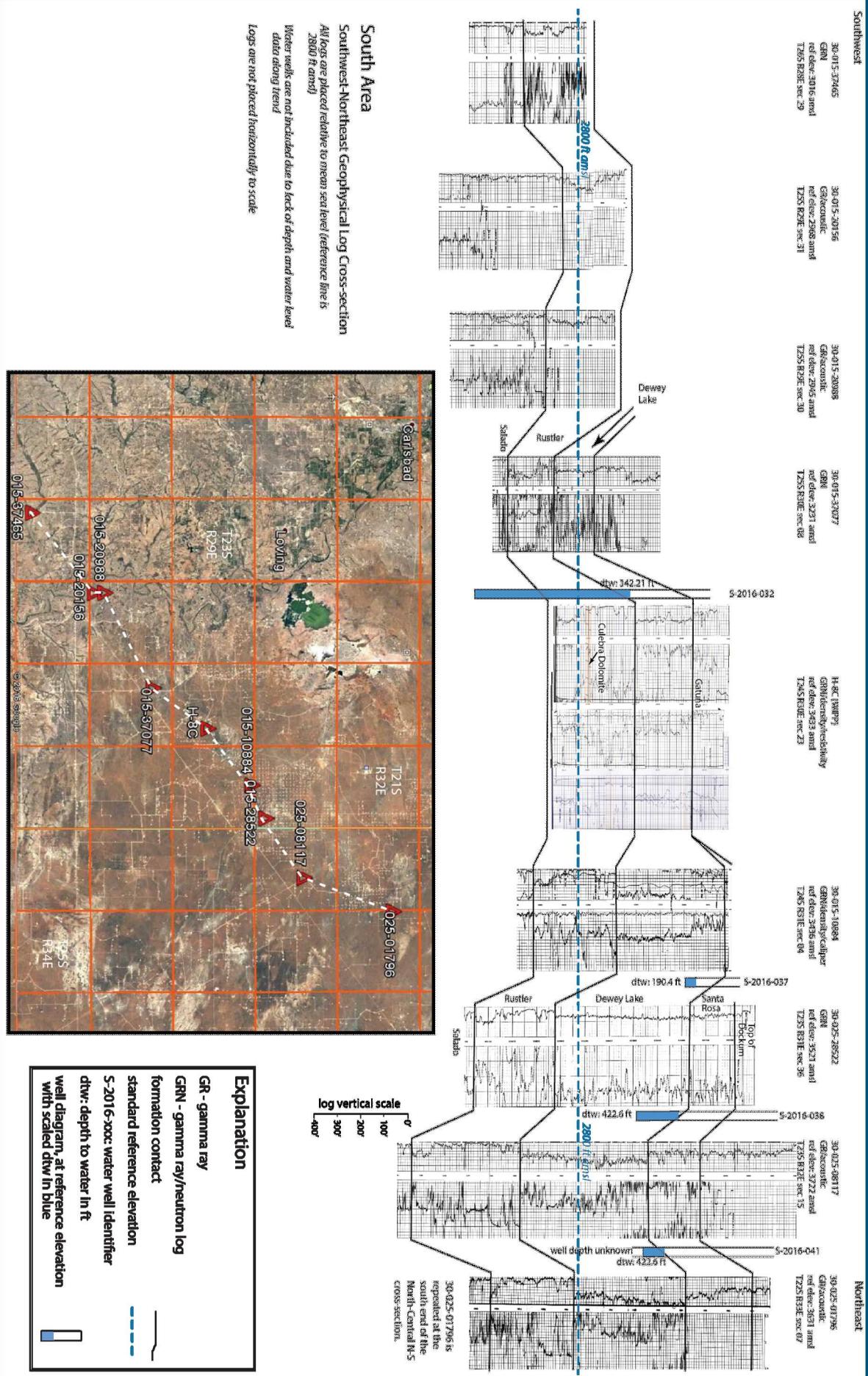
Explanation

GR - gamma ray
GRN - gamma ray/neutron log
formation contact
standard reference elevation
CN-201x-xoc: water well identifier
dtw: depth to water in ft
well diagram, at reference elevation
with scaled dtw in blue

North-Central HPA - N to S



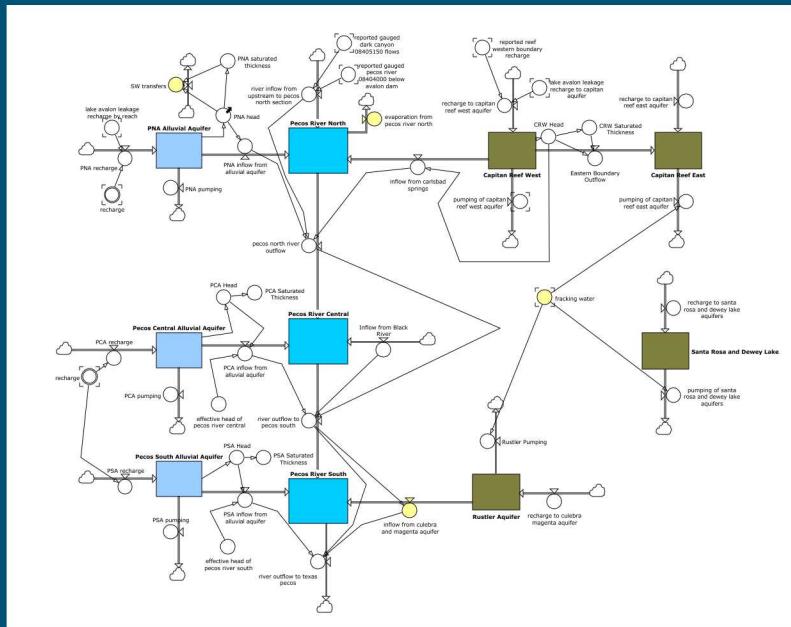
South HPA – SW to NE



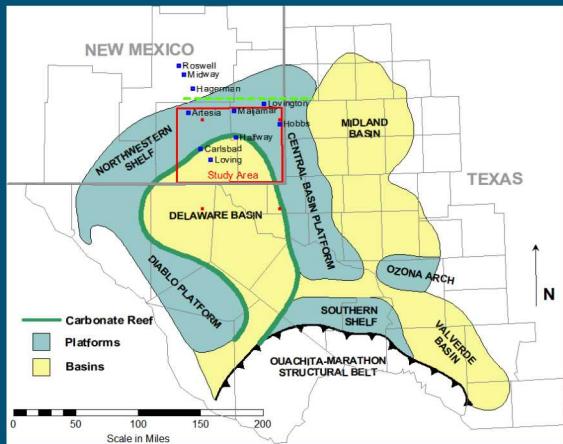
Modeling

System Dynamics Modeling – Develop a system dynamics (SD) simulation tool to simulate water availability over a range of different future scenarios as identified in the RFD.

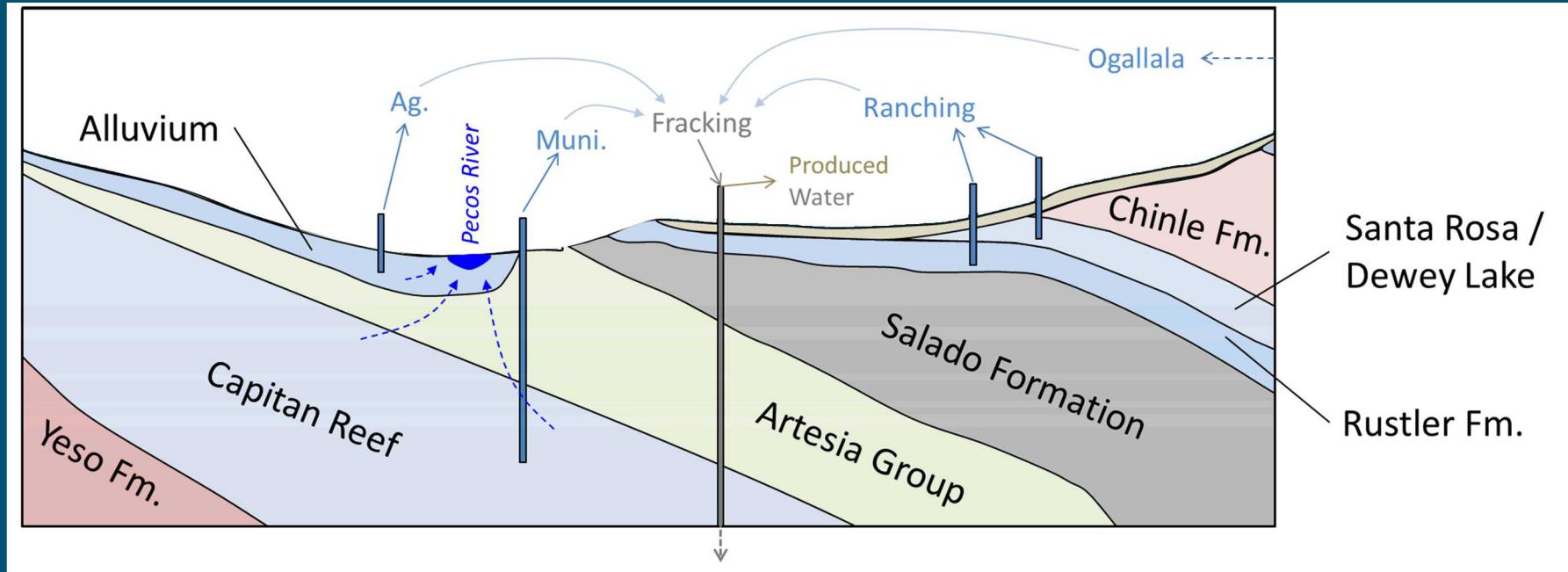
- Table-top player
- Simulate the increase in drilling activity and water demand relative to each formation and water source to identify the areas/users/formations that are most vulnerable and to estimate the risk to water quantity and quality.
- Provide decision makers with a tool to assess localized, cumulative impacts.



Conceptual Model

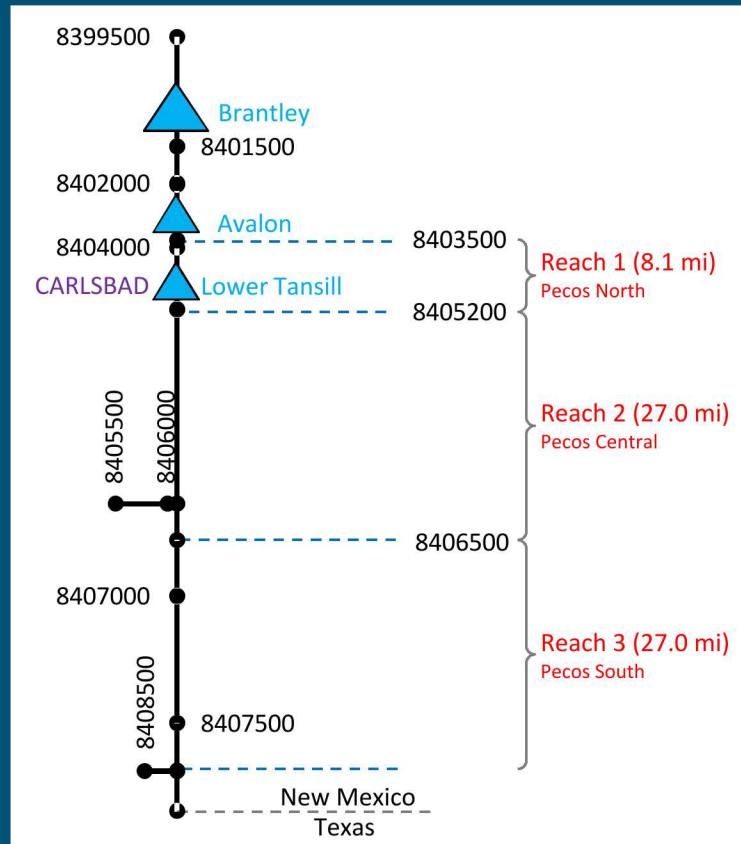
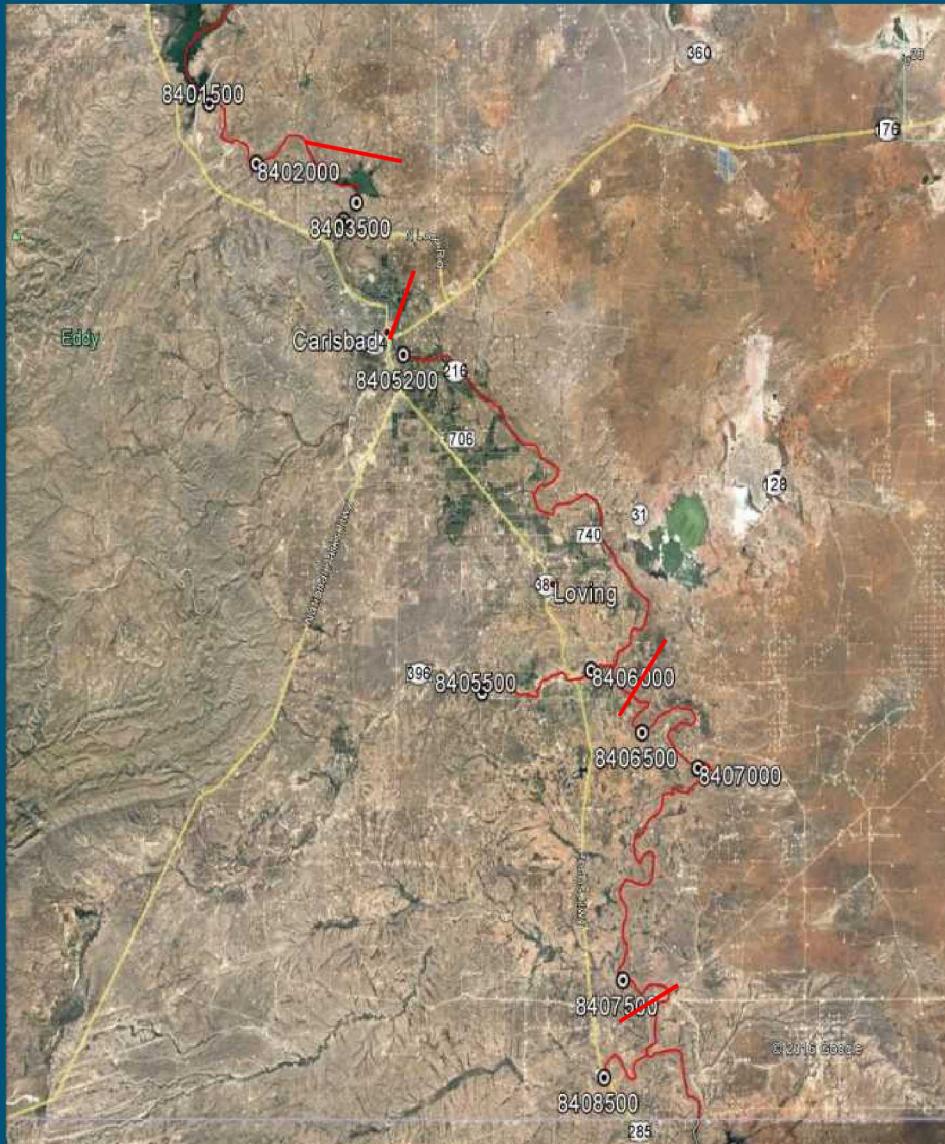


Reproduced from Summers, 1972

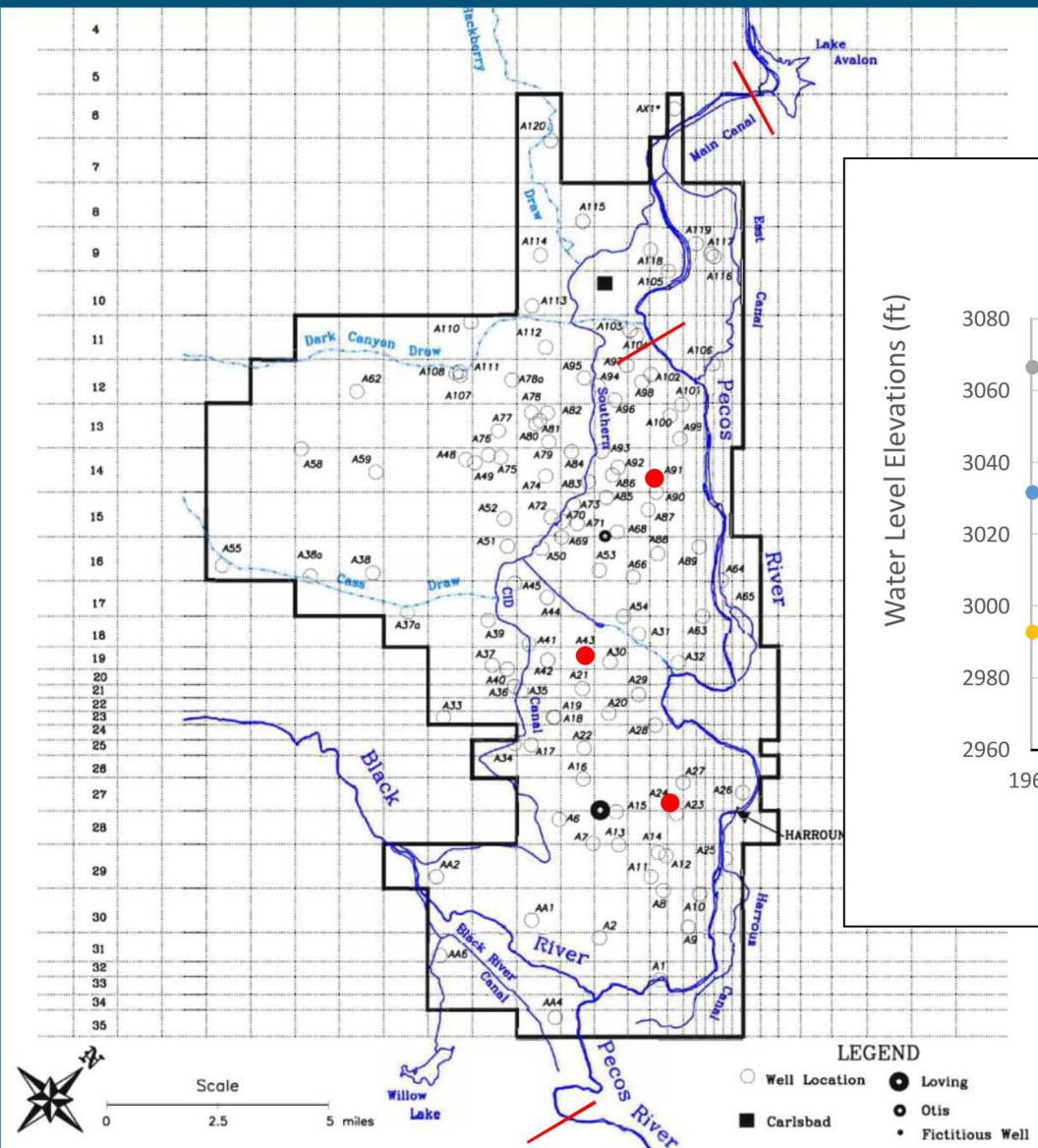


Summers, W.K., 1972, Geology and regional hydrology of the Pecos river basin, New Mexico, Open File Report #37, New Mexico Water Resources Institute, New Mexico State University, Las Cruces, New Mexico, 393 p.

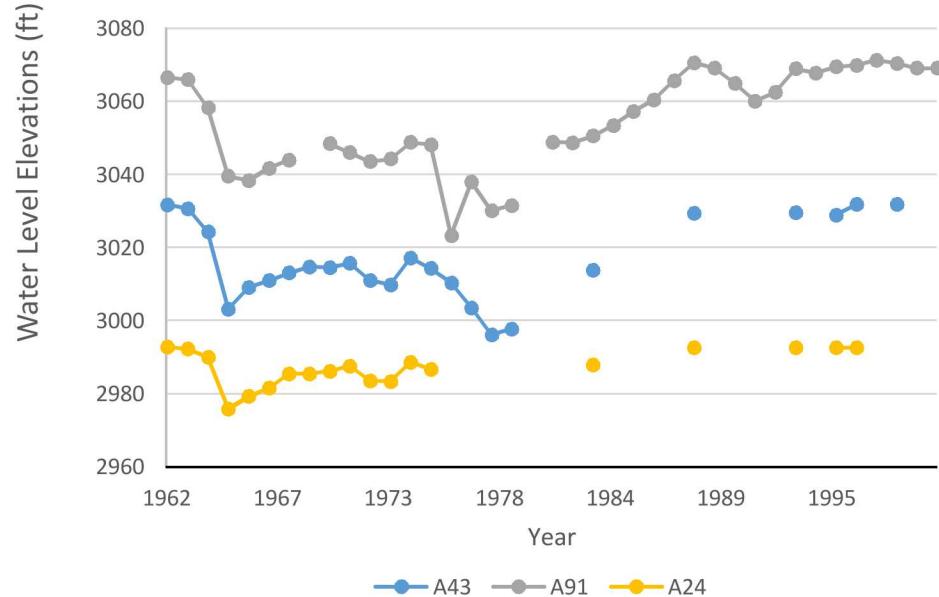
Conceptual Model



Numerical Model



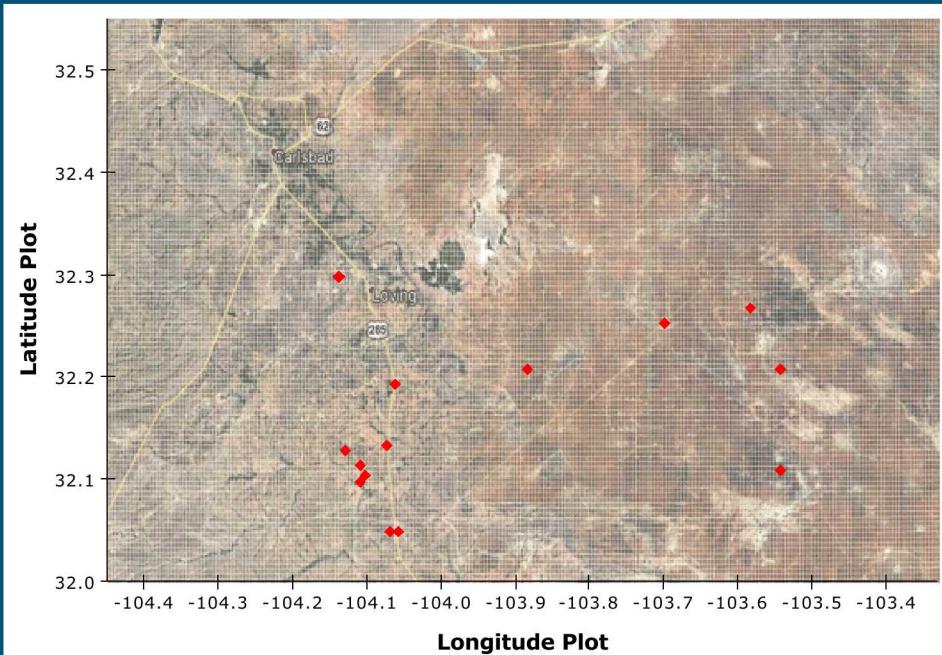
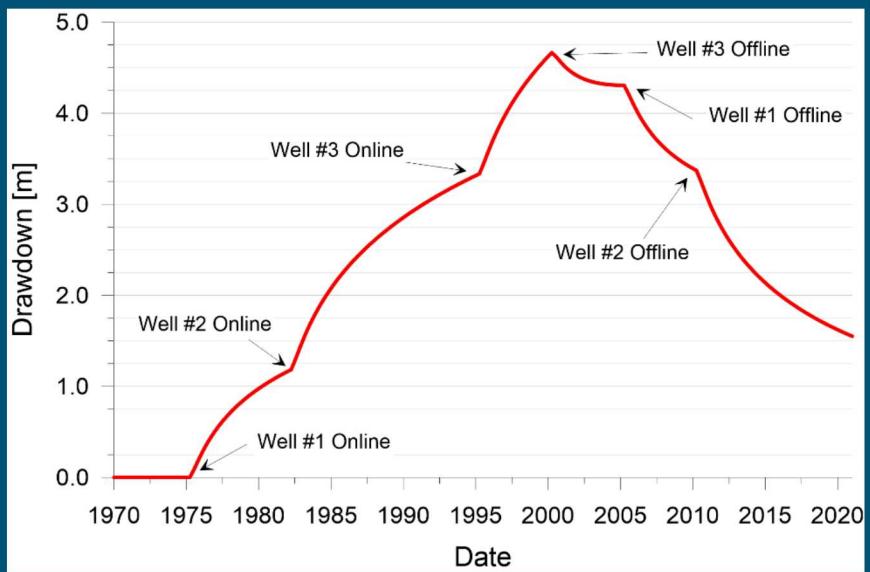
Observed Hydrographs for 3 Wells Near Pecos River in Study Area



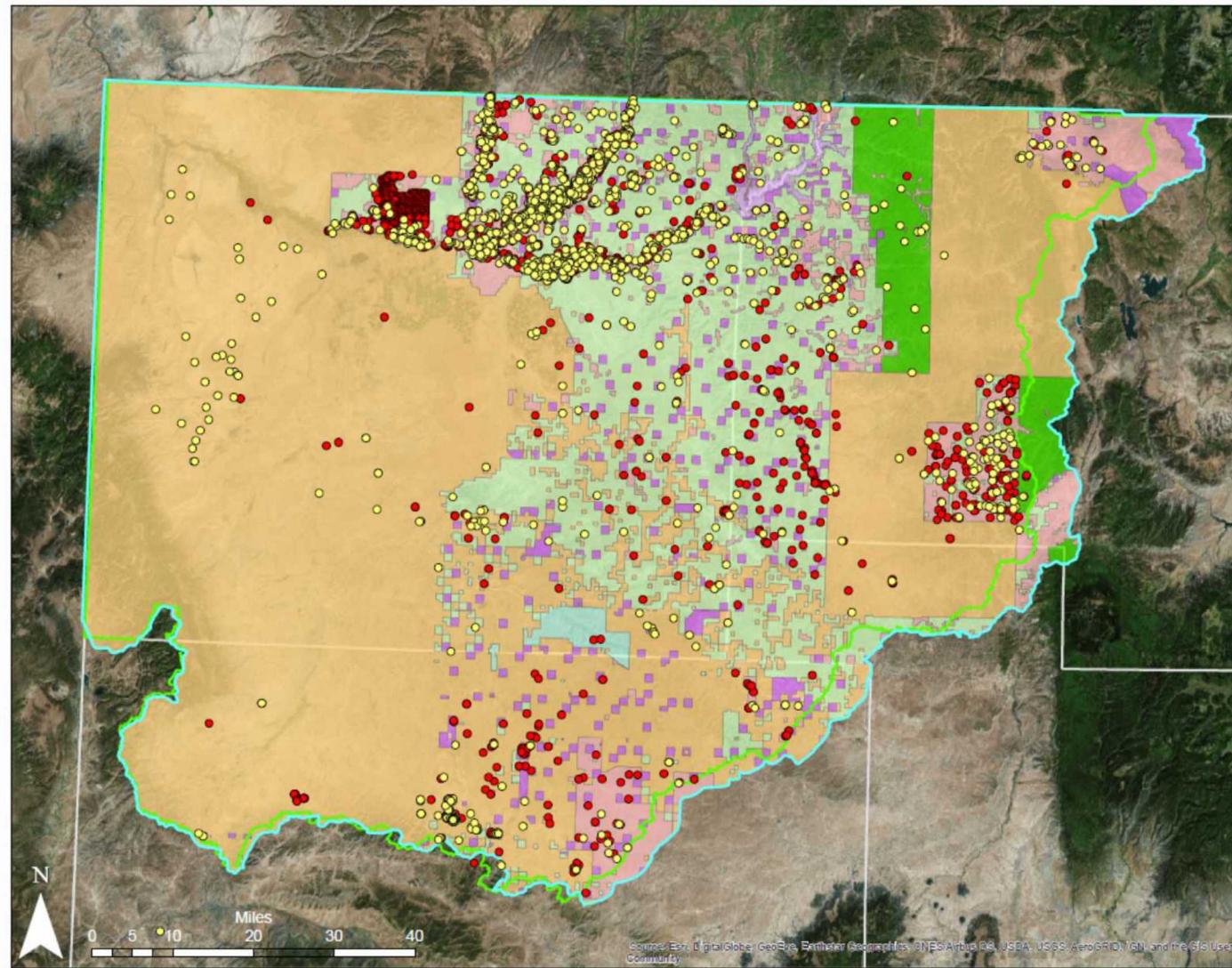
Localized Impacts

Domain split into 1/200th degree grid (~360 m)

Mean aquifer dynamics, T, S, pumping rate



San Juan Basin

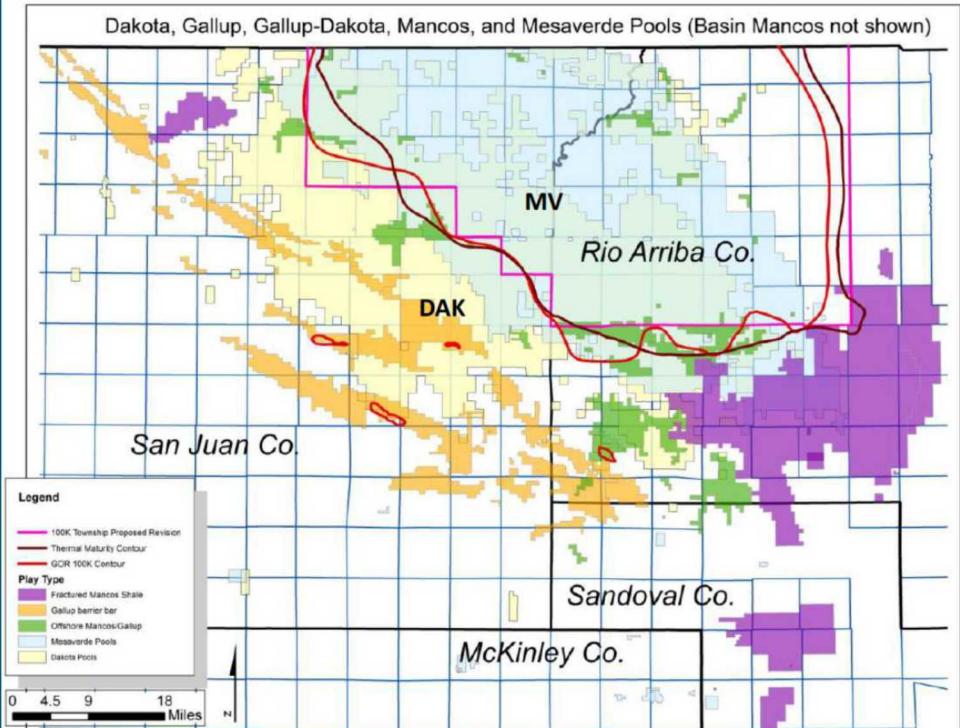
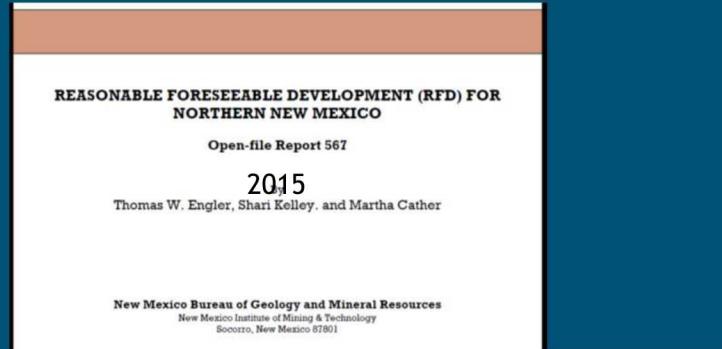


NMOSE Wells Identified in San Juan SW Basin

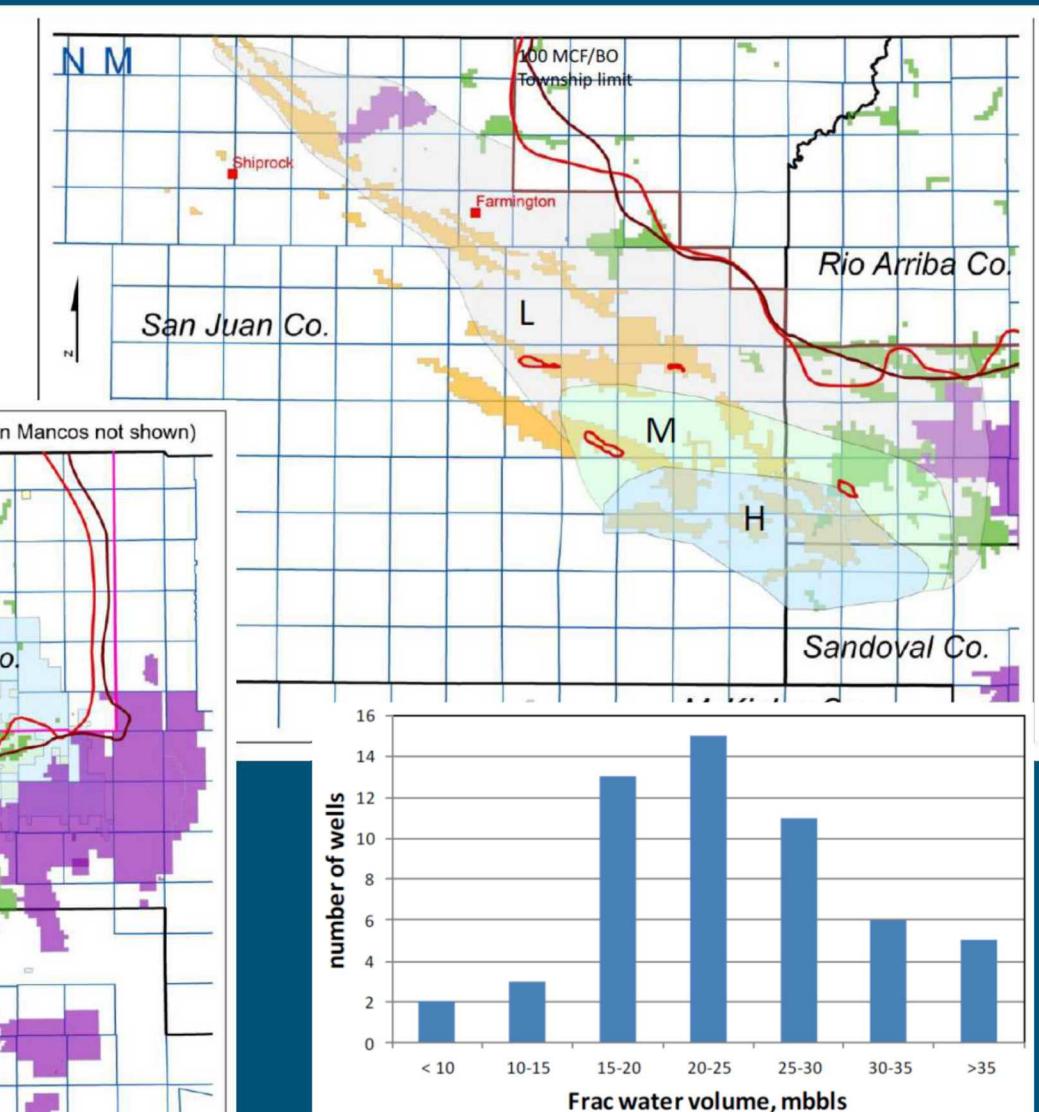
WATERS Database Results	
Well Type	
●	Meter Attached
●	Well Log Not Received
○	Well Log Received
■	San Juan Surface Water Basin
■	San Juan Groundwater Basin
Land Ownership	
■	Bureau of Land Mgmt
■	Bureau of Rec
■	Forest Service
■	Pueblo/Tribal
■	National Park Service
■	Private
■	State
■	State Game and Fish
■	County Boundaries

Past Work

Oil Potential Map



Mancos Gas Potential



Water Use Distribution (3.13 AF/well ave.)

Past Work

HYDROLOGIC ASSESSMENT OF OIL AND GAS RESOURCE DEVELOPMENT OF THE MANCOS SHALE IN THE SAN JUAN BASIN, NEW MEXICO

Open-file Report 566

By
 Shari Kelley, Thomas Engler, Martha Cather,
 Kathryn Pokorny, Cheng-Heng Yang, Ethan Mamer,
 Gretchen Hoffman, Joe Wilch, Peggy Johnson,
 and Kate Zeigler

New Mexico Bureau Geology & Mineral Resources
 New Mexico Institute of Mining & Technology
 Socorro, New Mexico 87801



November 2014

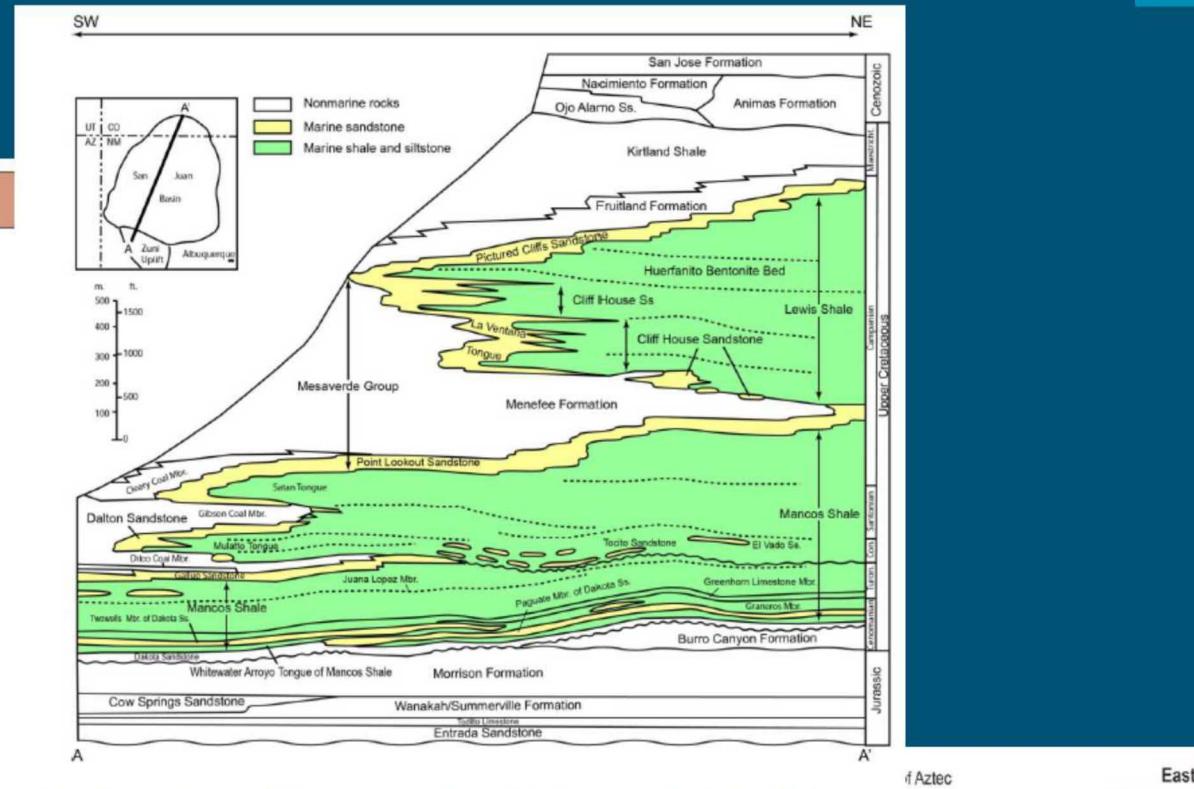
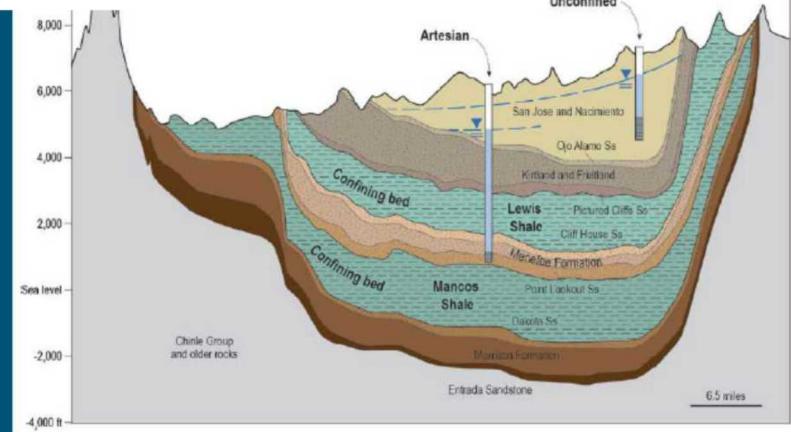


Figure 3—Stratigraphy of the Jurassic, Cretaceous, and Cenozoic rocks in the San Juan Basin.
 Modified from Molenaar (1977, 1989).



Past Work

Spatial Distribution of GW Water Rights

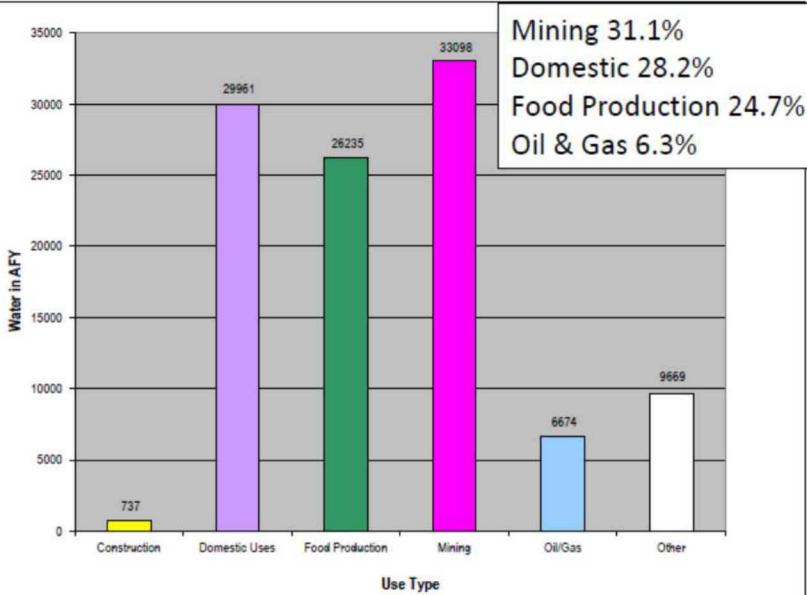
HYDROLOGIC ASSESSMENT OF OIL AND GAS RESOURCE DEVELOPMENT OF THE MANCOS SHALE IN THE SAN JUAN BASIN, NEW MEXICO

Open-file Report 566

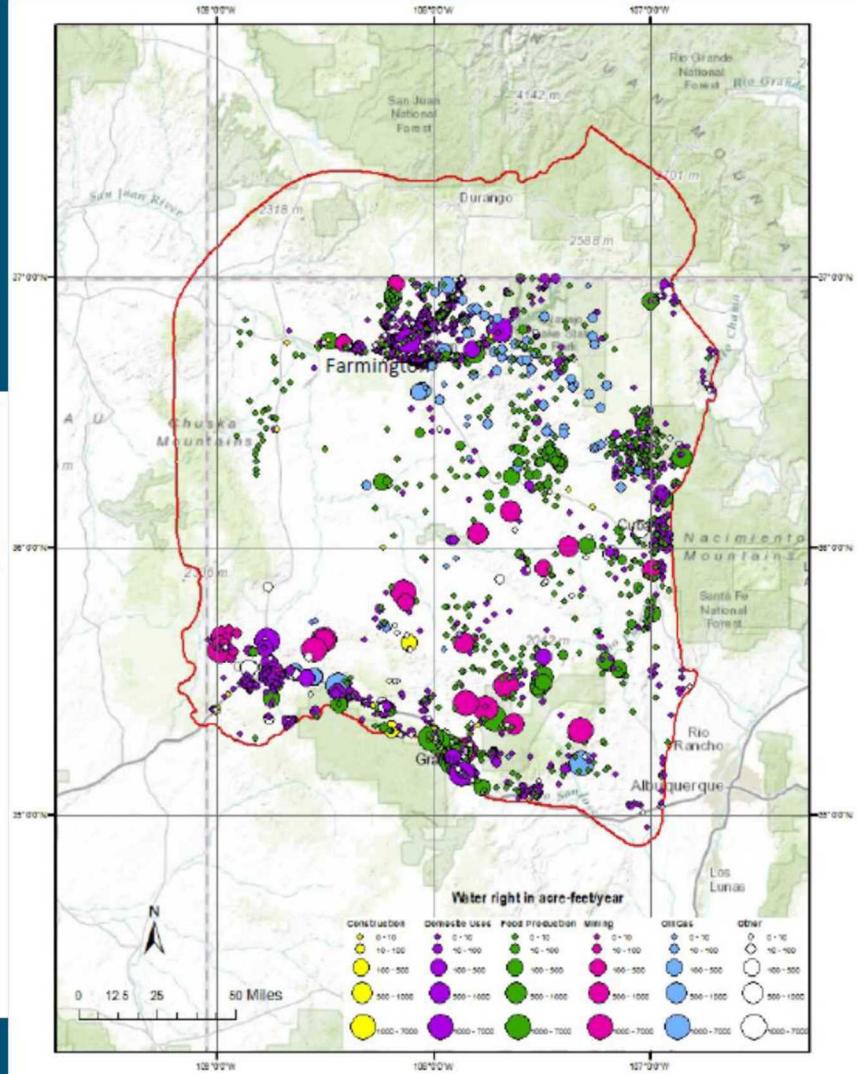
By

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Gretchen Hoffman, Joe Wilch, Peggy Johnson,
and Kate Zeigler

New Mexico Bureau Geology & Mineral Resources
New Mexico Institute of Mining & Technology
Socorro, New Mexico 87801



GW Water Right Usage



Questions for This Project

Field Work

- Where, what, how often?

Modeling

- Systems model? (Decision support?)
- Basin-scale flow model?
- Other?

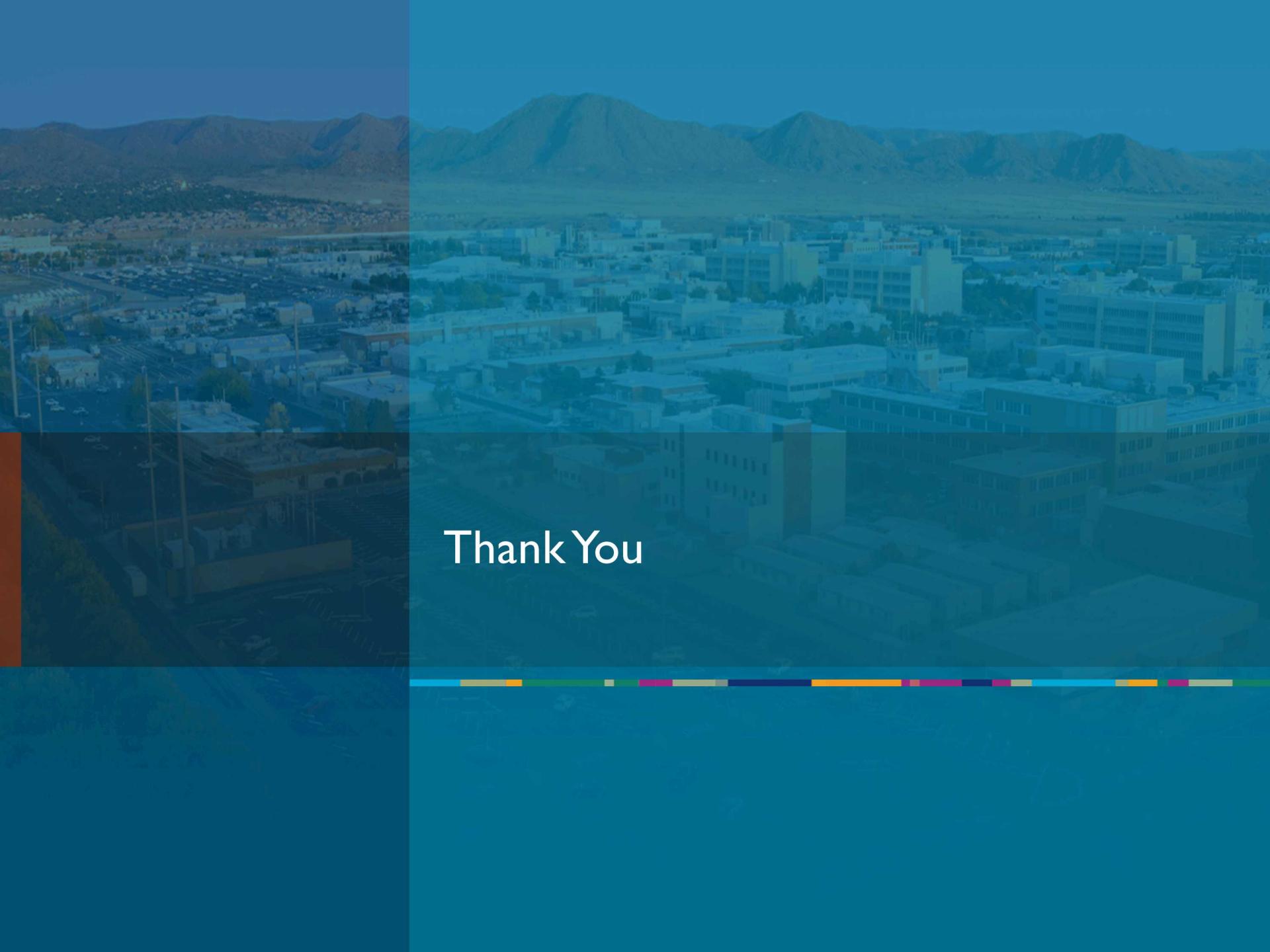
Monitoring

- Periodic vs continuous
- Locations
- Who manages it?

Data Repository

How to not be redundant? Collaboration with other agencies (USGS, OSE, etc.)

Benefits to BLM / Farmington Office / Nation



Thank You

