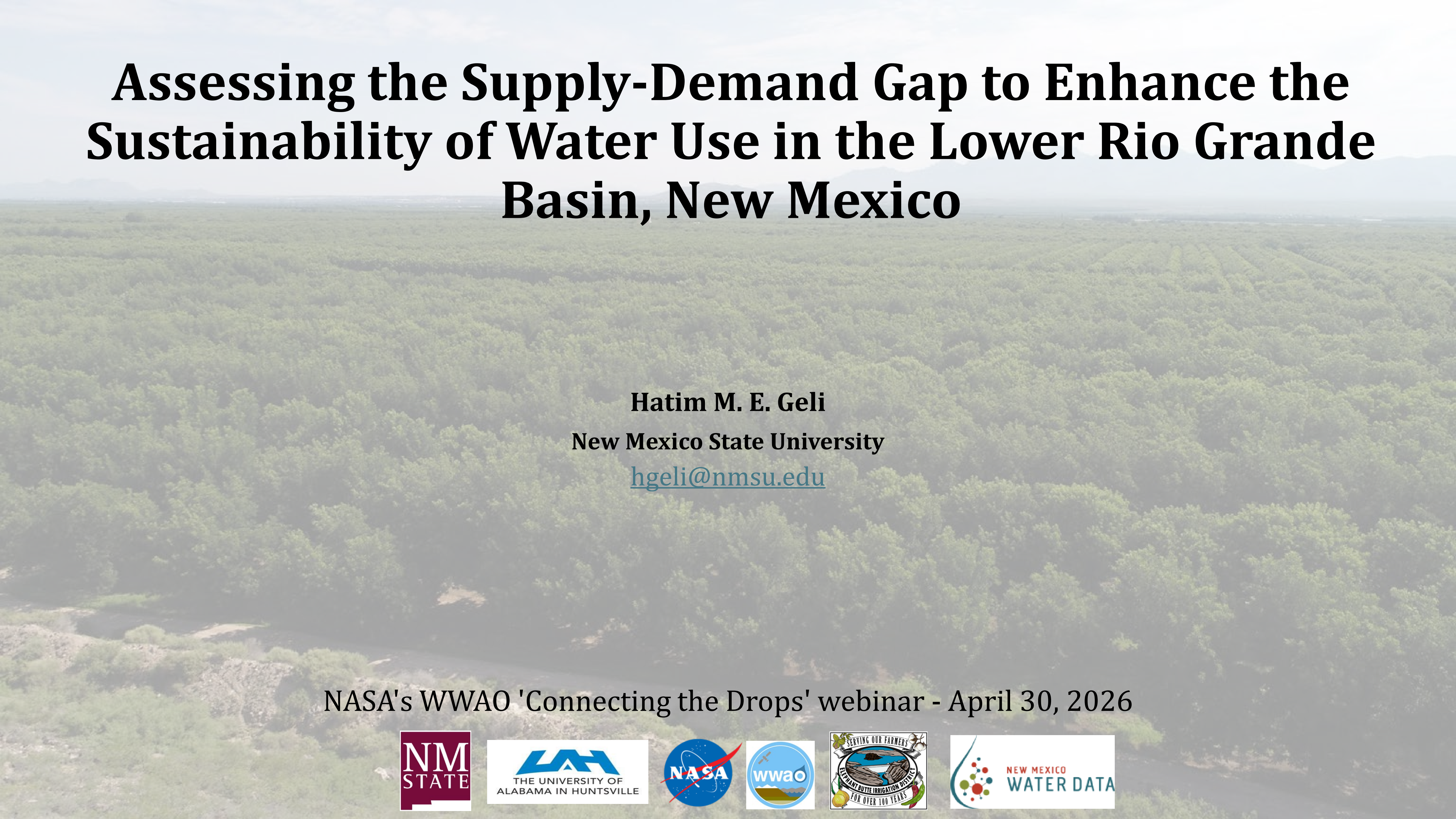

# Assessing the Supply-Demand Gap to Enhance the Sustainability of Water Use in the Lower Rio Grande Basin, New Mexico

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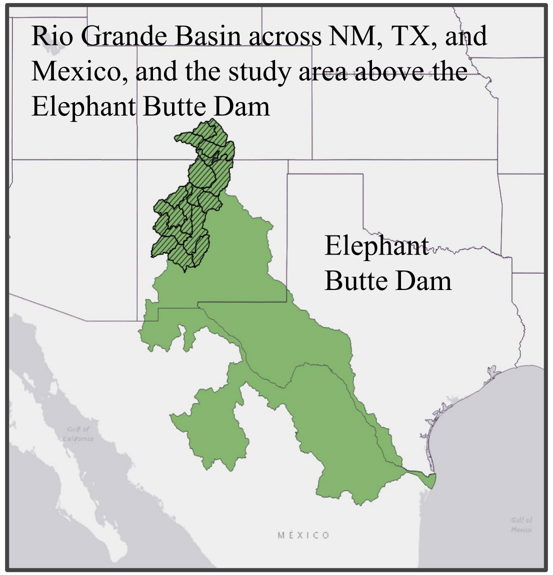
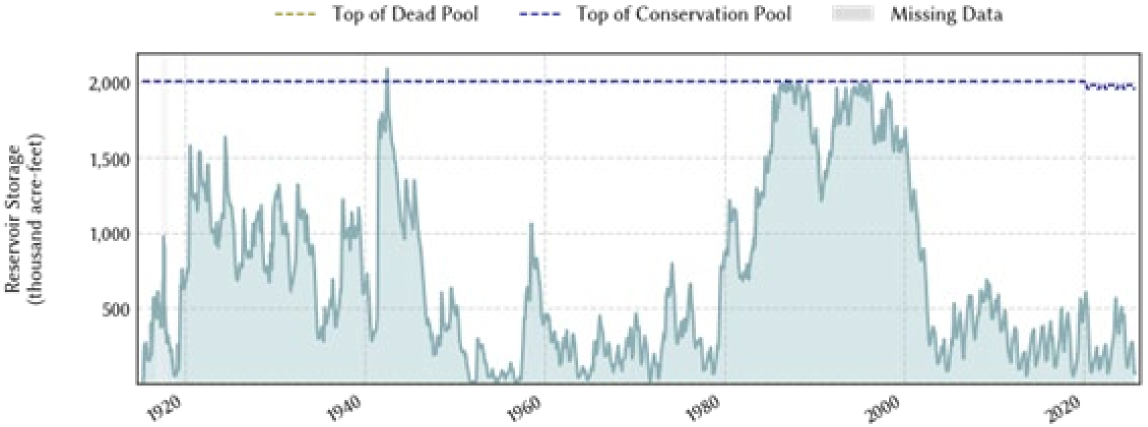
NASA's WWAO 'Connecting the Drops' webinar - April 30, 2026

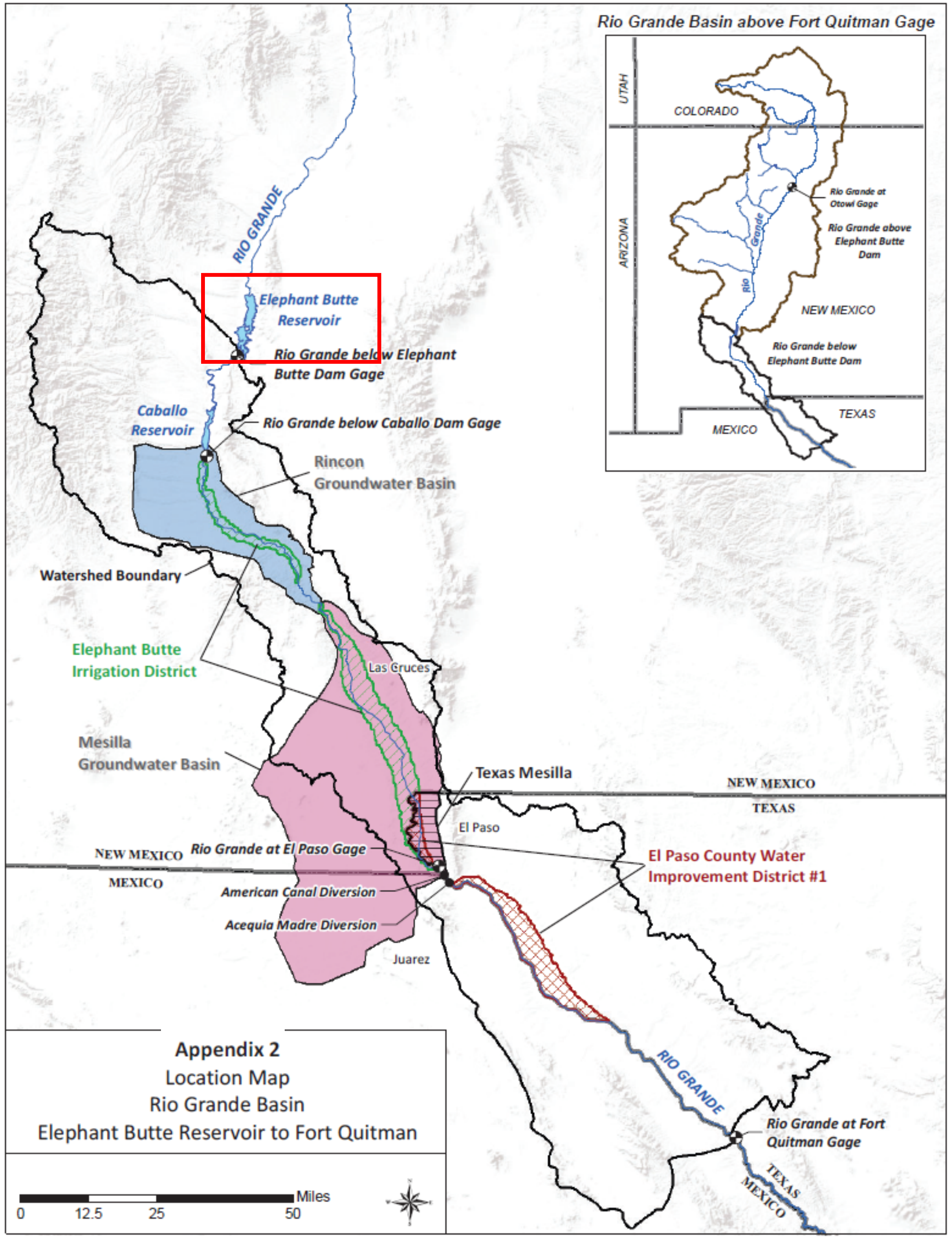
# Background

- The arid-to-semiarid climate, along with frequent droughts, raised concerns about water allocations in the Rio Grande Basin in New Mexico.
- There is an urgent need to understand better and manage this valuable resource to meet urban, agricultural, and environmental water demands.





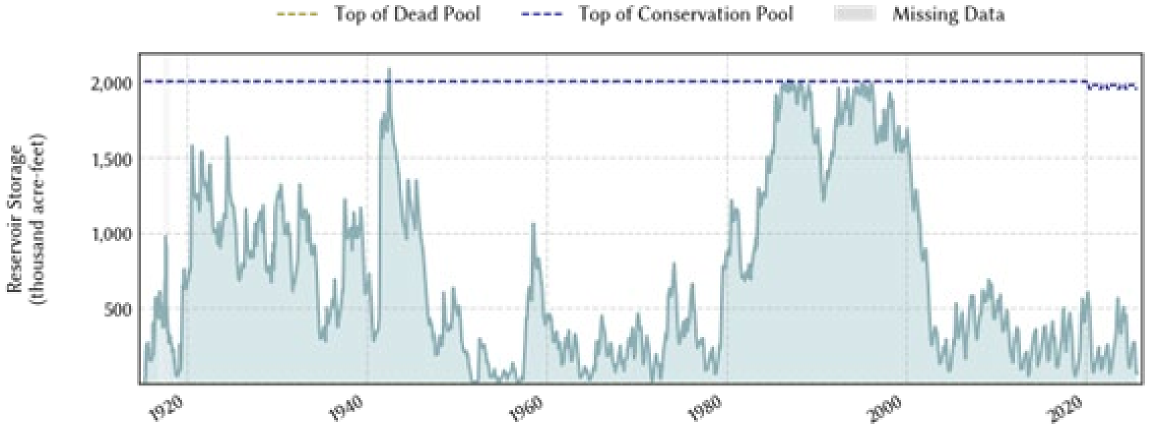
Pecan orchards in southern New Mexico, and Elephant Butte Lake level is at 3.8% full as of September 4, 2025



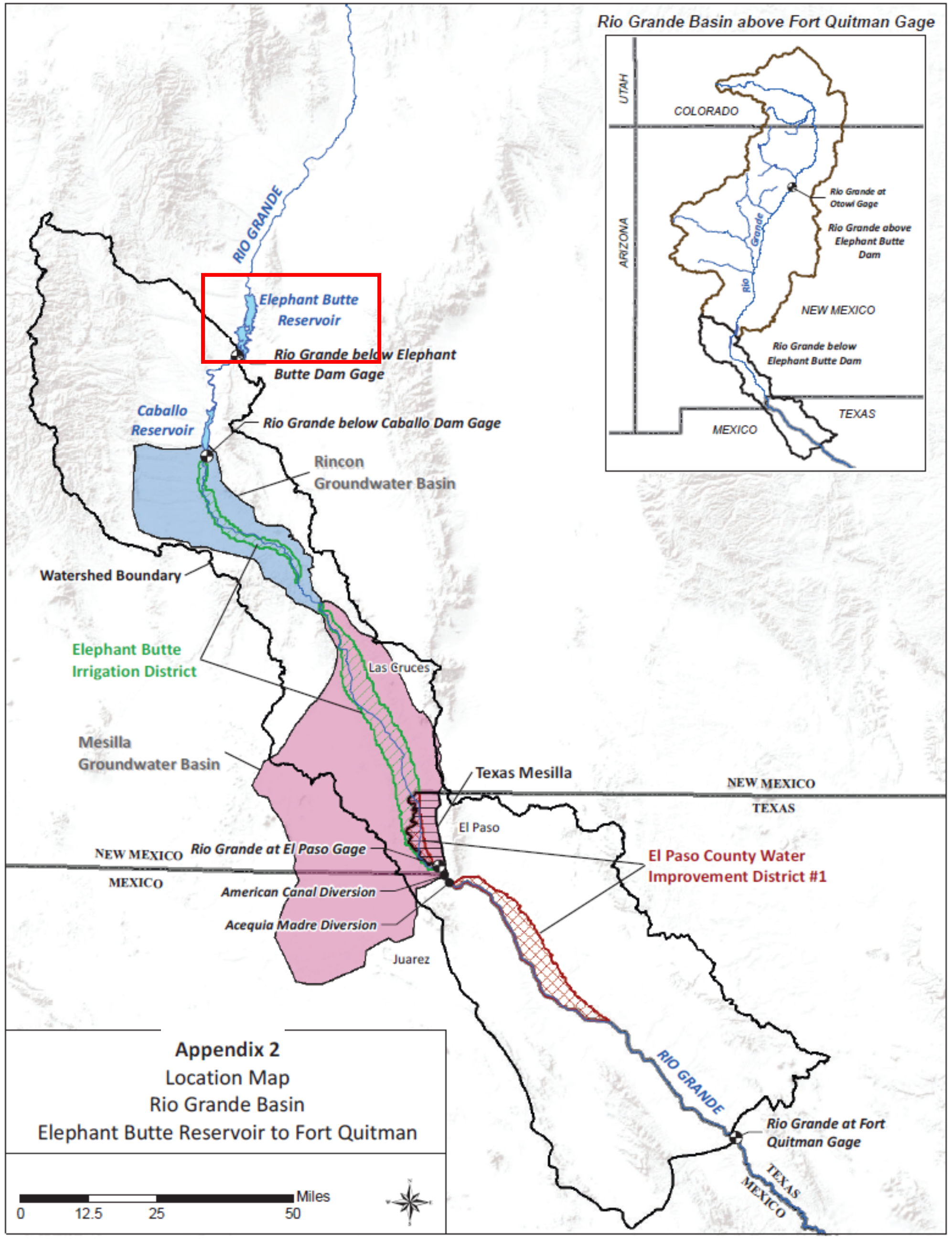
Rio Grande Basin (Elephant Butte Reservoir to Fort Quitman)

# Background – *Conti*.

- Involved parties: New Mexico (EBID, OSE – Rio Grande Project), Texas – EPCWID, and Mexico.
- The RGP delivers water to Mexico (international treaty), 60,000 acre-feet, unless there is an extraordinary drought (which is a condition that is not currently defined).
- New Mexico and Texas share surface water at 57% and 43%, respectively.
- EBID delivers water to 90,640 acres of authorized land. About 70,000 acres are currently irrigated.
- Texas has claimed that New Mexico has not met its obligations since the 1940s.
- Texas indicated that New Mexico would need to forfeit 18,300 acre-feet (~ 5.9 billion gallons) of groundwater within a 10-year period



Pecan orchards in southern New Mexico and Elephant Butte Lake level at 3.8% full as of September 4, 2025

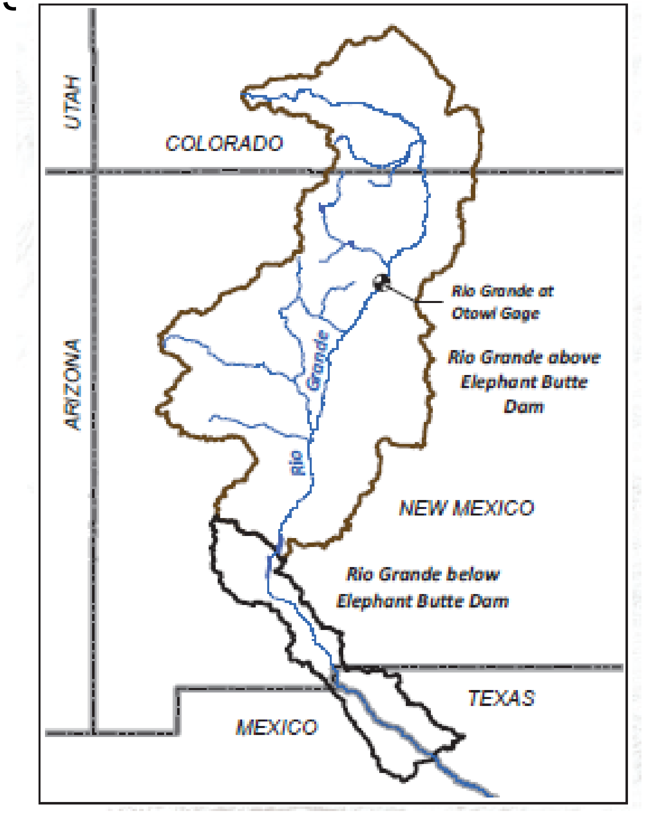


Rio Grande Basin (Elephant Butte Reservoir to Fort Quitman)

# Potential Sustainable Management Options

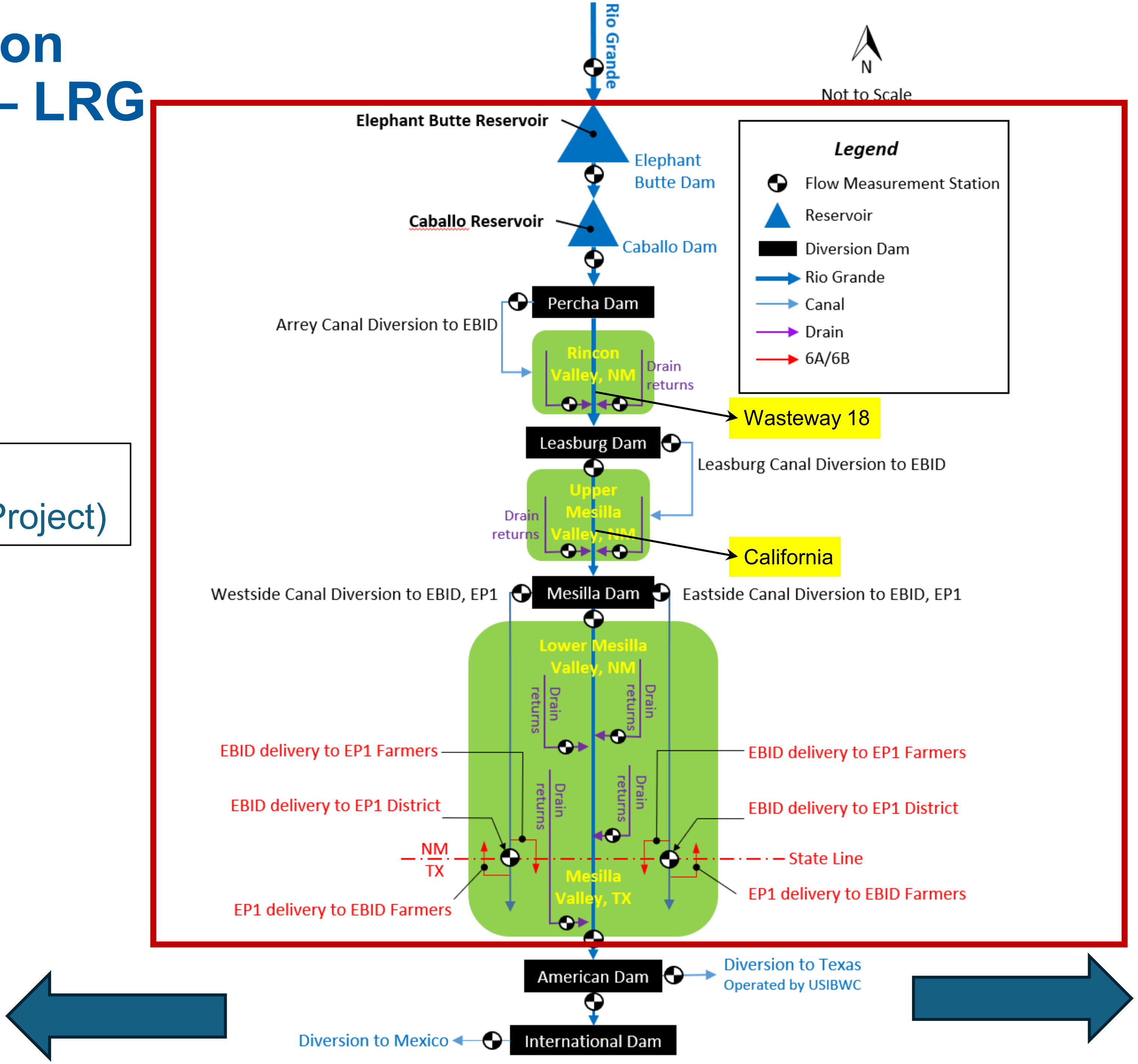
- Evaluating hydrological conditions and responses at the Upper Rio Grande Basin
    - Forecasts for seasonal inflow
    - Alternative land management scenarios
- Evaluating hydrological responses as well as crop/land management practices
    - Prediction of land fallawing and retirement of farms
    - Forecast of monsoonal runoff to estimate system gains

Rio Grande Basin above Fort Quitman Gage



# Water Allocation Components – LRG

New Mexico
(EBID, Rio Grande Project)



Rio Grande

N

Not to Scale

***Legend***

- ⊕ Flow Measurement Station
- ▲ Reservoir
- ▬ Diversion Dam
- → Rio Grande
- → Canal
- → Drain
- → 6A/6B

**Elephant Butte Reservoir**

Elephant Butte Dam

**Caballo Reservoir**

Caballo Dam

Percha Dam

Arrey Canal Diversion to EBID

Rincon Valley, NM

Drain returns

Wasteway 18

Leasburg Dam

Leasburg Canal Diversion to EBID

Upper Mesilla Valley, NM

Drain returns

California

Westside Canal Diversion to EBID, EP1

Mesilla Dam

Eastside Canal Diversion to EBID, EP1

Lower Mesilla Valley, NM

Drain returns

Drain returns

EBID delivery to EP1 Farmers

EBID delivery to EP1 District

EBID delivery to EP1 Farmers

EBID delivery to EP1 District

NM

TX

State Line

EP1 delivery to EBID Farmers

EP1 delivery to EBID Farmers

Mesilla Valley, TX

American Dam

Diversion to Texas
Operated by USIBWC

International Dam

Diversion to Mexico

Mexico

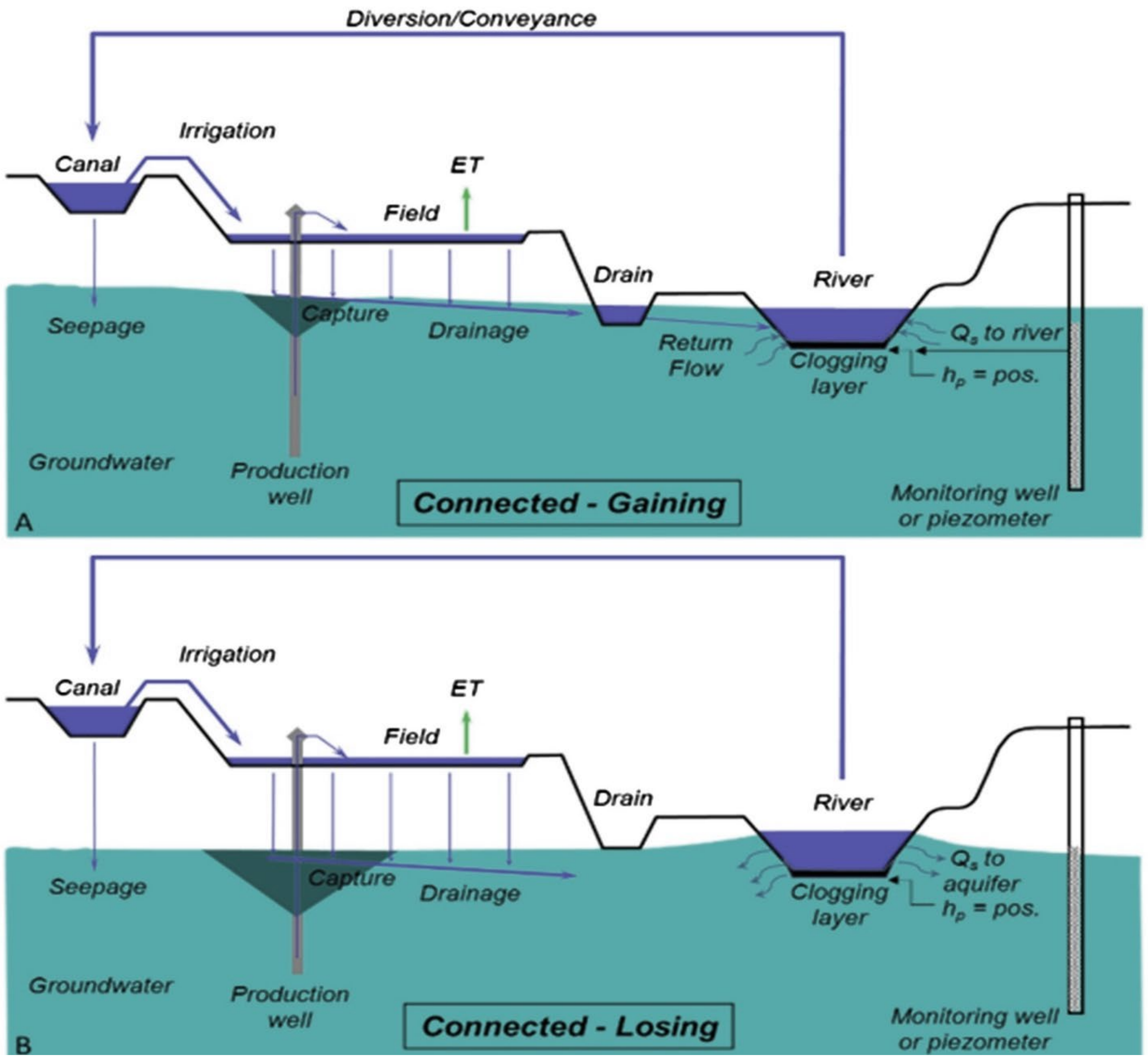
Texas

# Surface and Groundwater Interactions

The connection between surface and groundwater under different flow schemes is as follows:

1. When the river gains water from the alluvial aquifer or drains into it, the system is referred to as a “gaining system” (Figure A). In this case, the aquifer discharges to the river, and the aquifer’s groundwater table is above the riverbed.

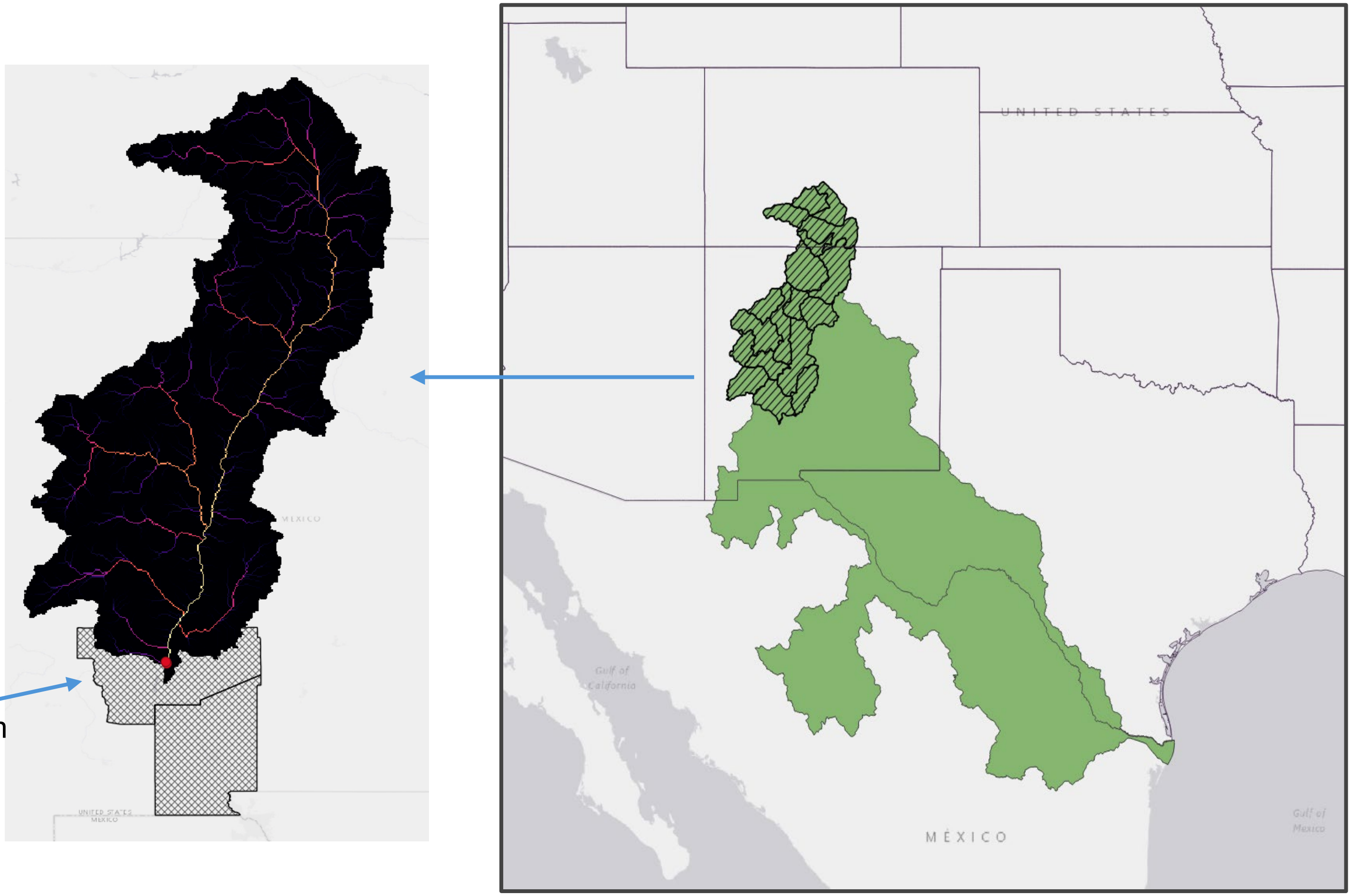
2. In a situation where the river loses or discharges to the alluvial aquifer or the aquifer is recharged by the river, the system is referred to as “losing system” (Figure B), and the riverbed elevation is higher than the groundwater elevation.



Conceptual illustration of surface and groundwater interactions

# Upper Rio Grande Hydrologic Response using VIC

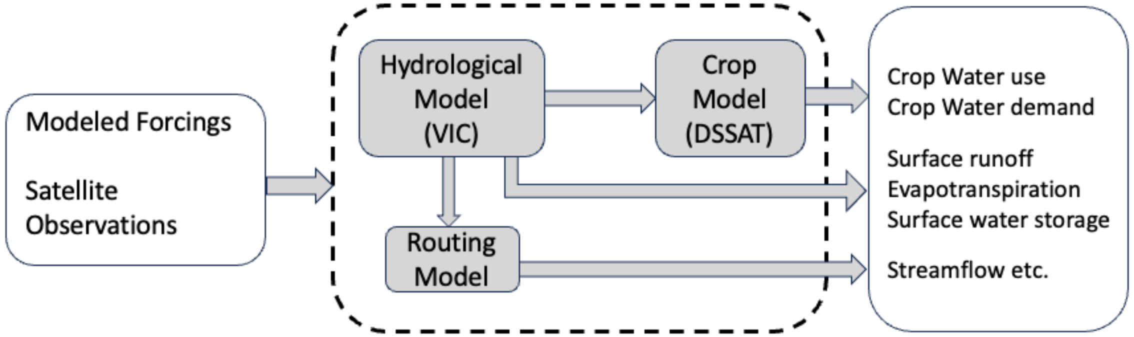
Developing a modeling framework for the RG Basin with short-term (15-day) forecasting capabilities.



Elephant Butte Dam

Rio Grande Basin across NM, TX, and Mexico, and the study area above the Elephant Butte Dam

# RHEAS – Hydrological Model Framework



Modeled Forcings

Satellite Observations

Hydrological Model (VIC)

Crop Model (DSSAT)

Routing Model

Crop Water use
Crop Water demand

Surface runoff
Evapotranspiration
Surface water storage

Streamflow etc.

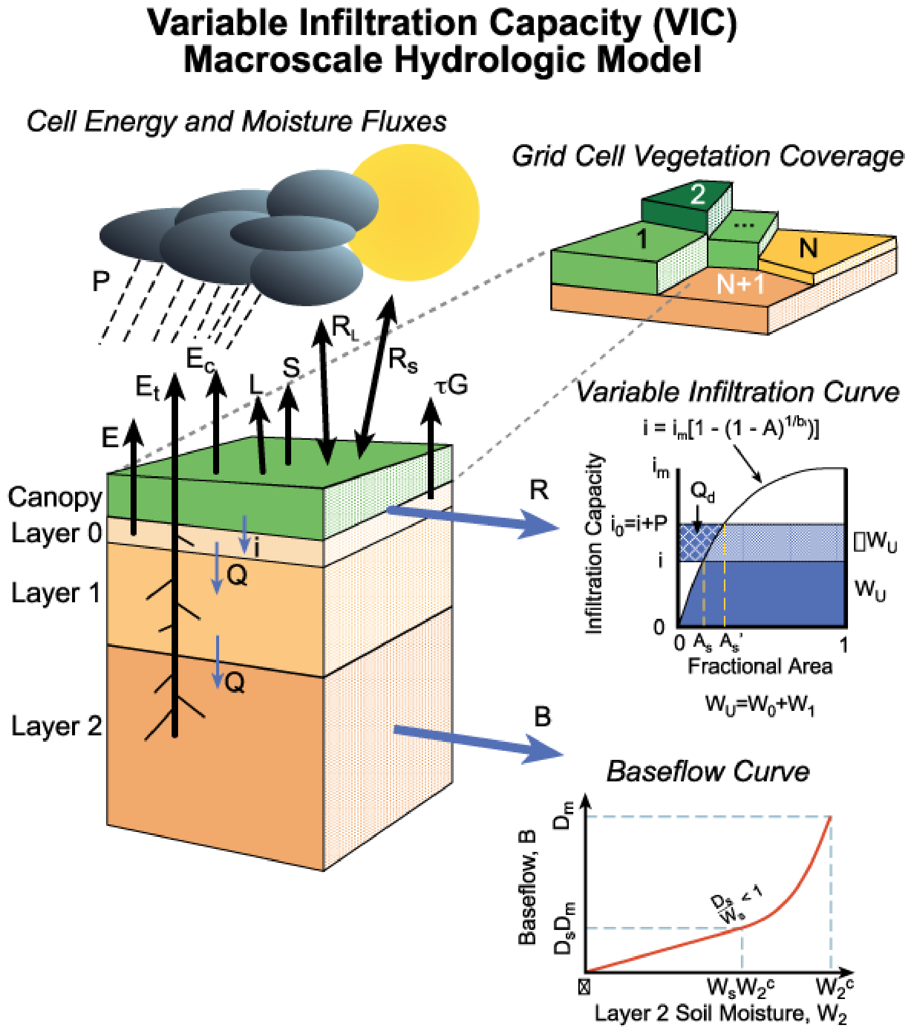
RHEAS Framework (Regional Hydrological Extremes Assessment)

<u>Variable Infiltration Capacity (VIC) Model</u>

- Large-scale hydrologic model (Liang et al, 1994)
- Simulates water & energy storage and fluxes
- Sub-grid variability (vegetation, elevation, infiltration) handled with statistical distribution
- Inputs: meteorological drivers (Precipitation, Air temperature, Wind speed)
- Widely applied across a range of hydro-climatic environments and has also been used to simulate global soil moisture and drought severity

<u>RHEAS VIC</u>

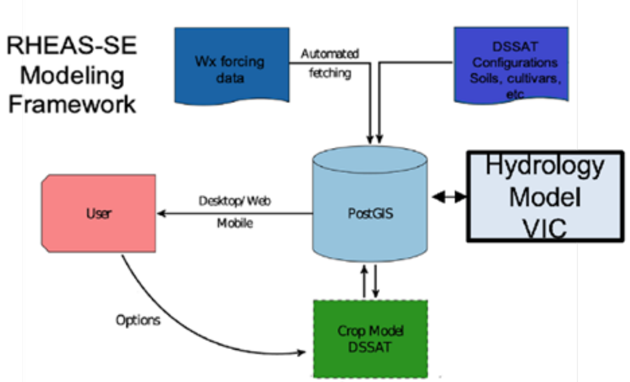
- Globally calibrated
- Globally preprocessed parameter files (snow bands, vegetation etc.)

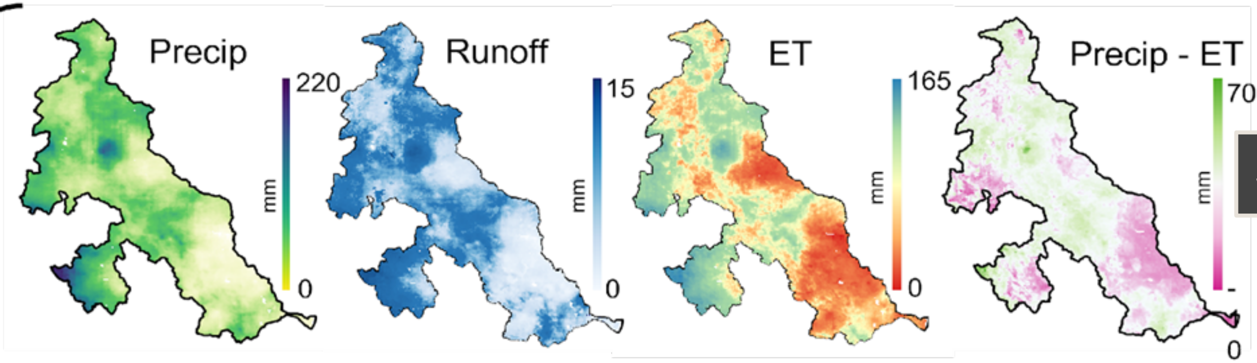


Schematic diagram for VIC model

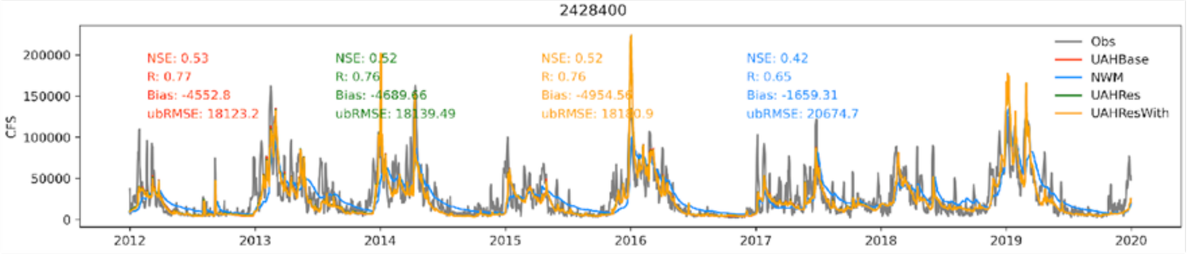
Source: https://vic.readthedocs.io/en/master/Overview/ModelOverview/

# The Modeling Framework





**STEP 1**



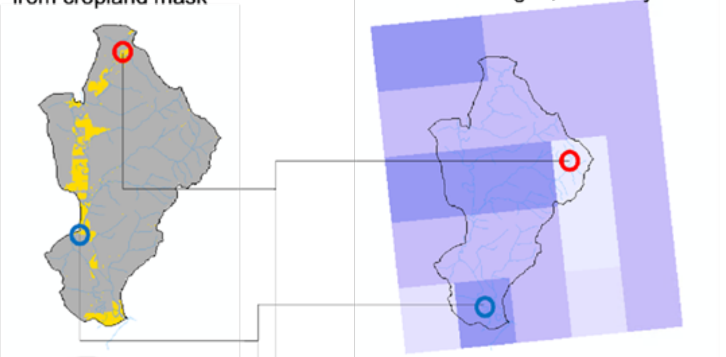
**STEP 2**

Surface Water Availability

The DSSAT Crop model is run stochastically over an AOI (HUC-12), sampling n times ( # of ensembles chosen) over **weather** inputs, **soil**, and **cultivars** randomized over the area

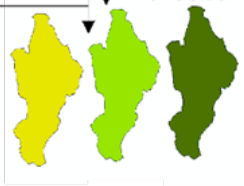
1. Randomly select soils from cropland mask

2. For each selected soils, select weather information from the grid, randomly chosen.



Cultivar - 1
Cultivar - 2
Cultivar - 3
…

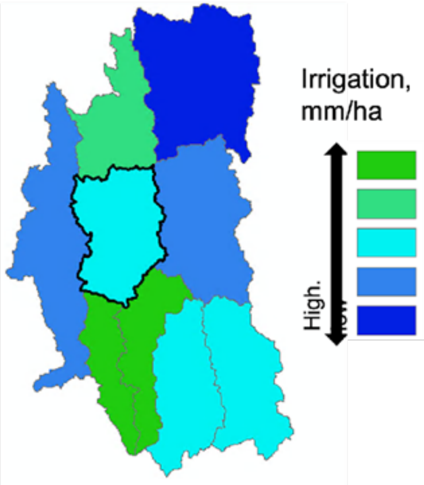
3. Select random cultivar from a curated list

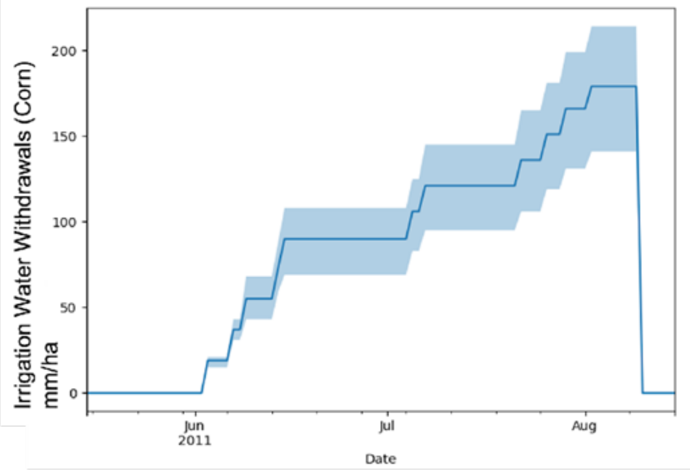


OUTPUT: n number of simulations (and associated stats) of yield, irrigation demand, etc.

**STEP 3**

## Irrigation Demand Statistics @ HUC 12





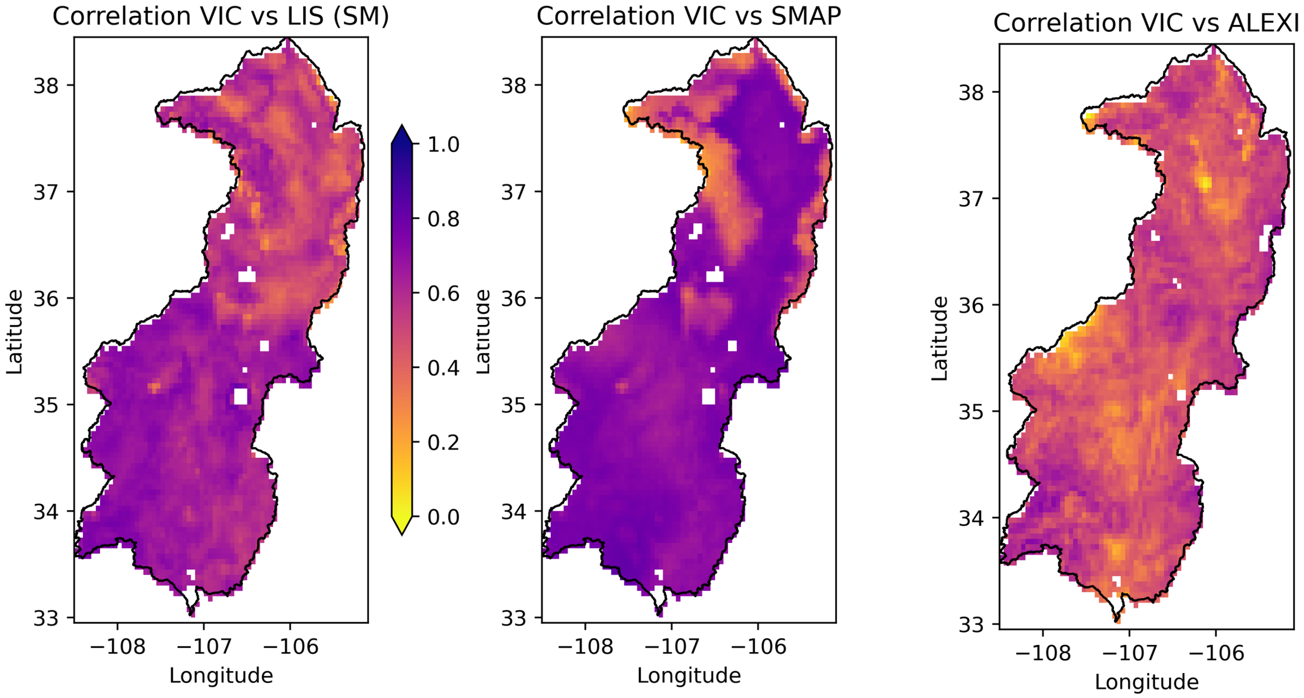
**STEP 4**

# VIC Model Results (Preliminary)

- VIC simulations were developed at 5-km spatial resolution for the 2000-2023 period
- The calibrated model was evaluated for the 2015-2023 period

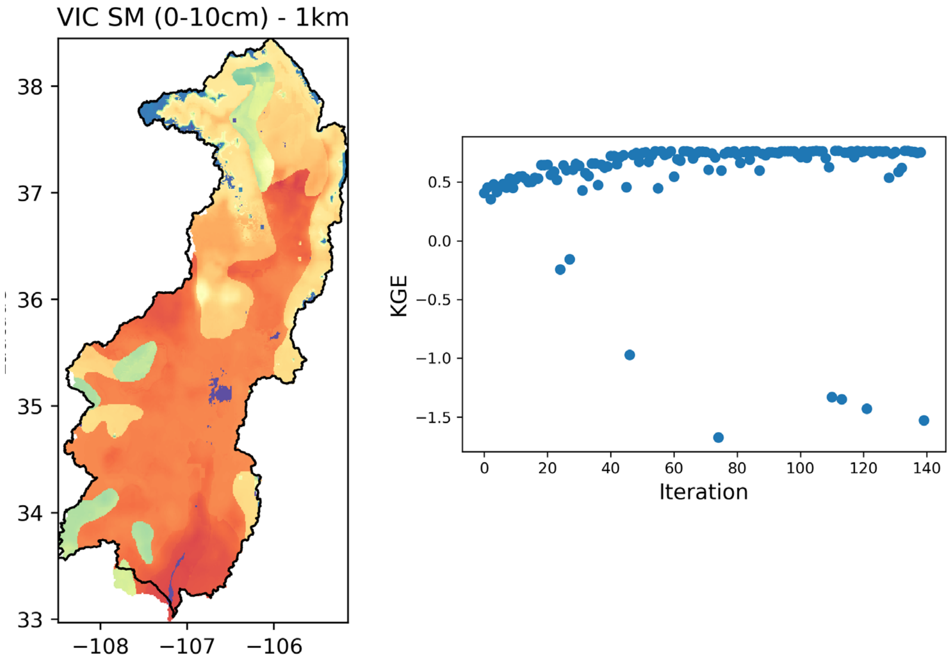
Next Steps:

- Enhance the model resolution from 5 to 1 km
- Further calibrate the model to better simulate the streamflow



Comparison of VIC soil moisture and ET estimates with NASA LIS (SM), SMAP, and ALEXI ET.

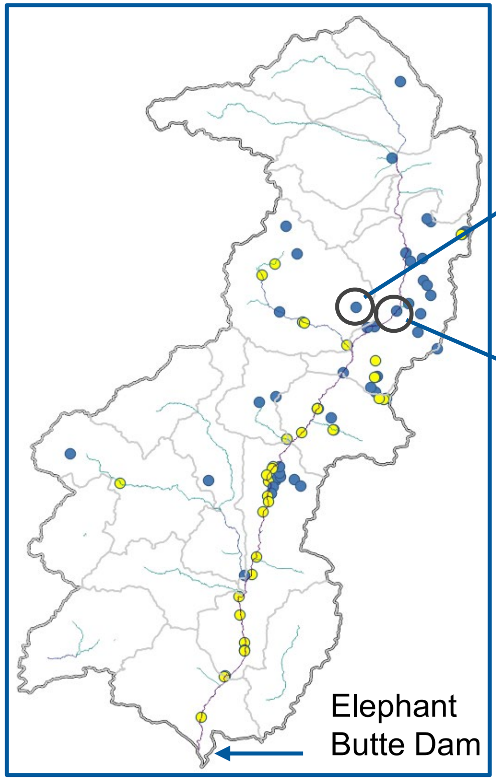
| | Bias | RMSD | R |
|---|---|---|---|
| VIC/LIS (SM) | 0.05 | 0.07 | 0.60 |
| VIC/SMAP | -0.01 | 0.05 | 0.68 |
| VIC/ALEXI | 2.89 | 3.15 | 0.47 |



VIC soil moisture estimates for the top 10 cm and Kling-Gupta Efficiency (KGE) of the model calibration at 1 km.

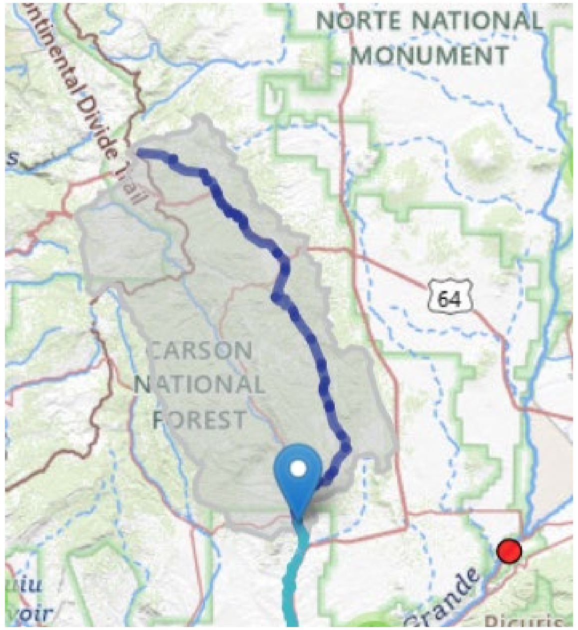
# VIC Model Results (Preliminary)

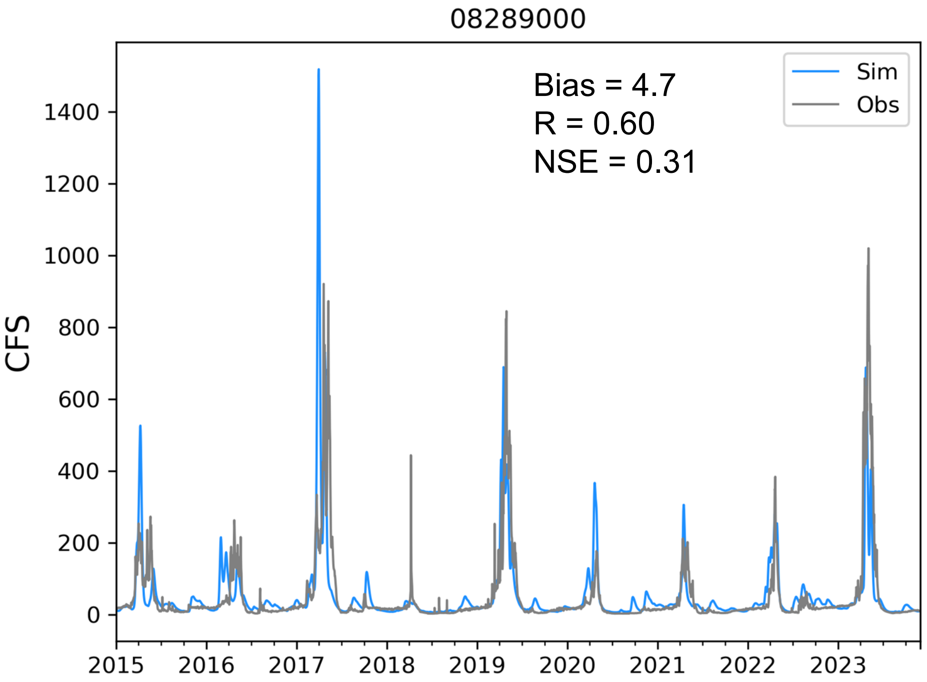
- VIC calibration results at USGS site 08289000 with ~1100 km$^2$ watershed are from 2005-2015
- Calibrated model evaluation for the 2015-2023 at USGS site 08263500

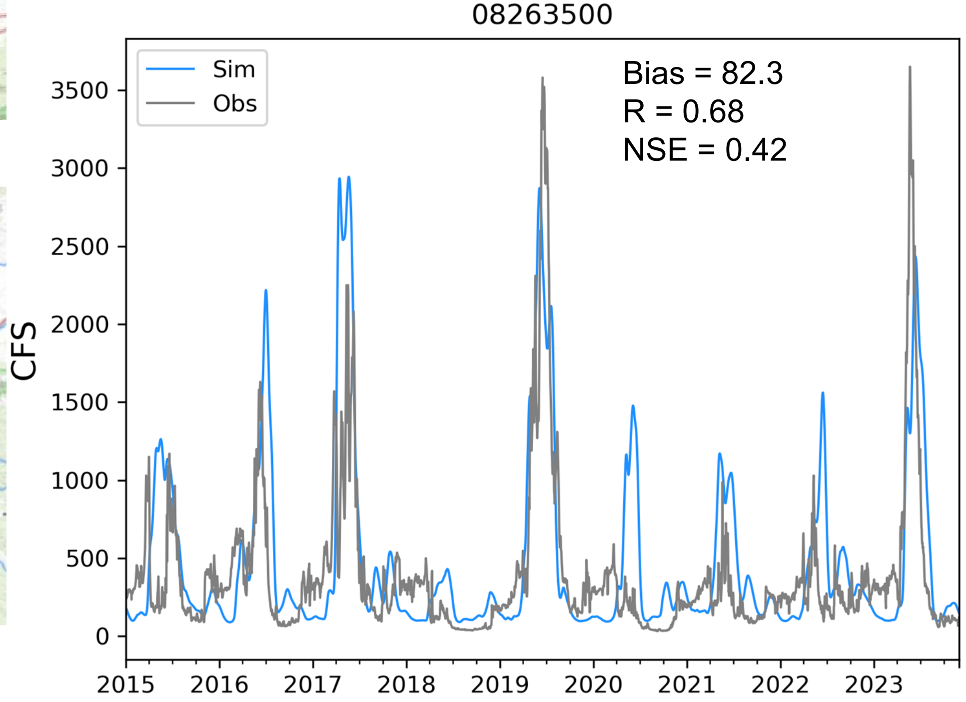


USGS 08289000

USGS 08263500

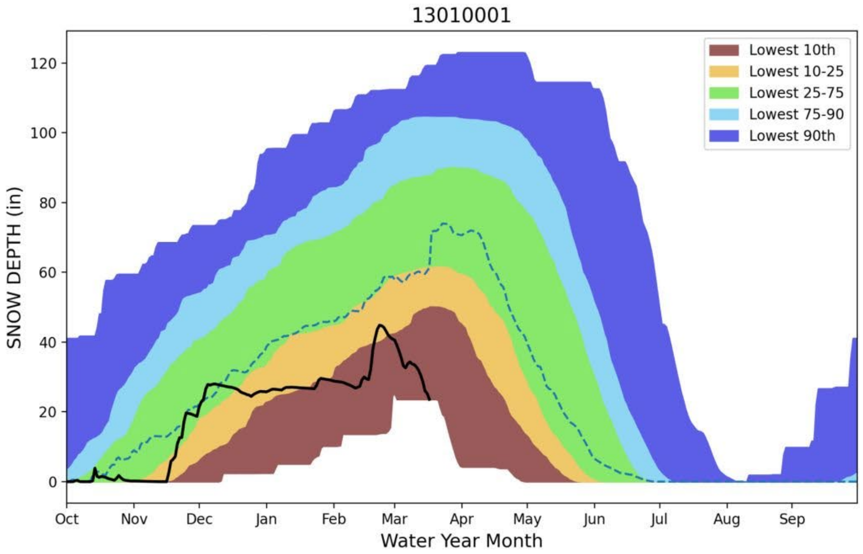


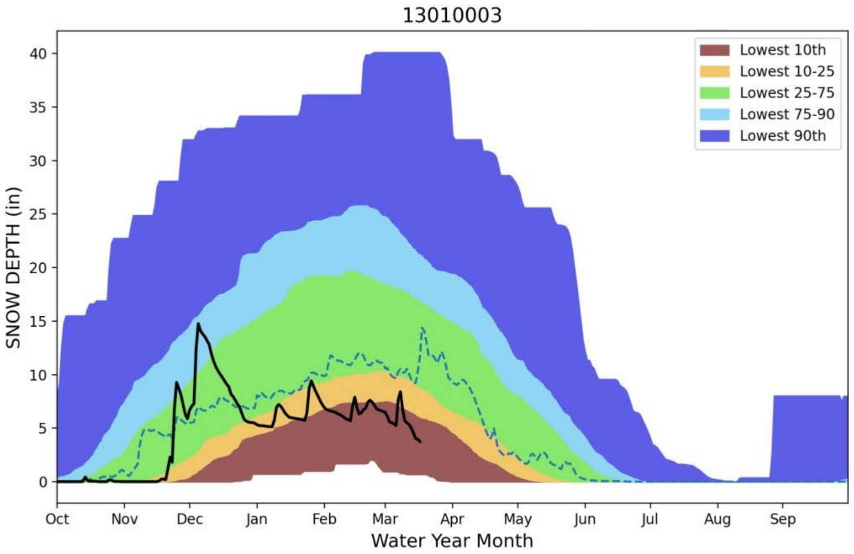




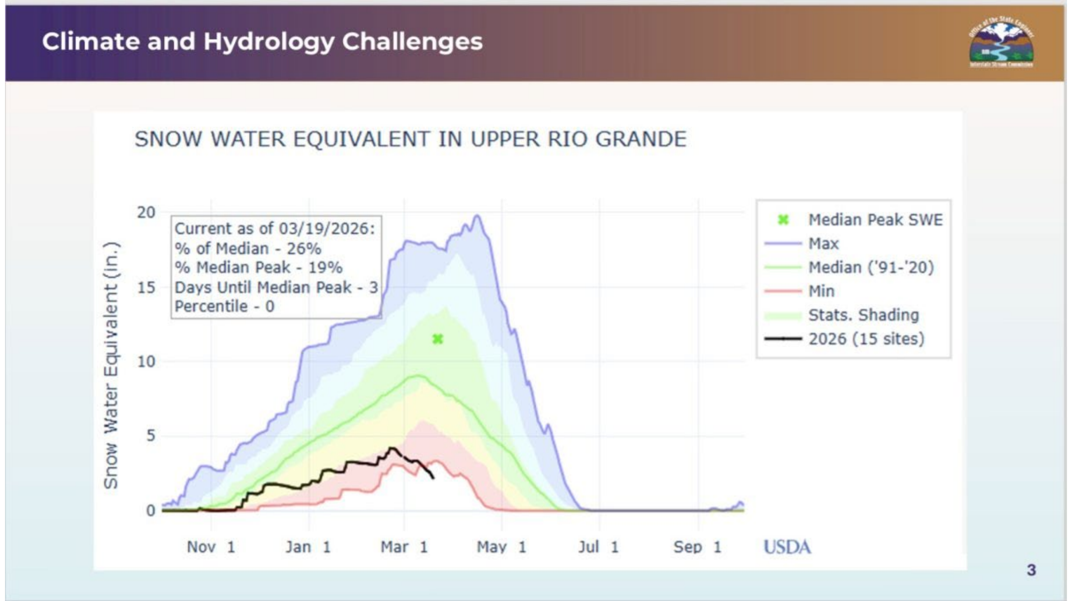
Upper and middle RGB with USGS gages (with natural flows)

# VIC Snow Depth Estimates





[Recent VIC Results]

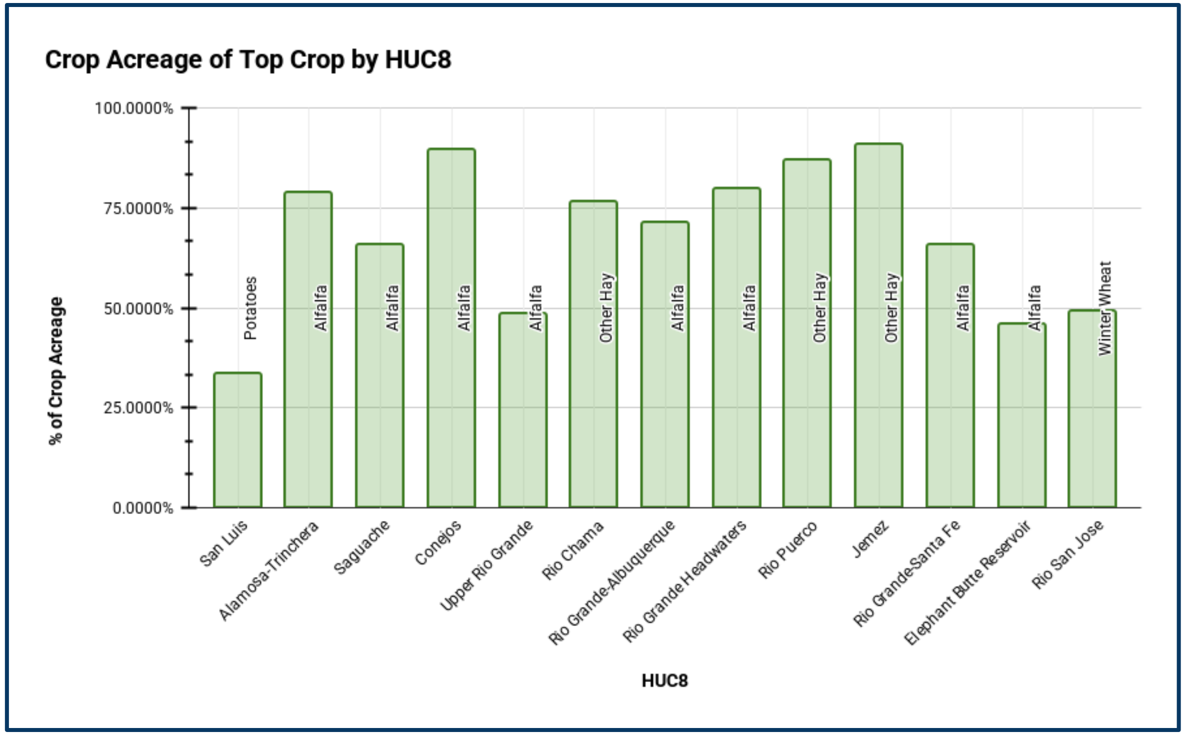


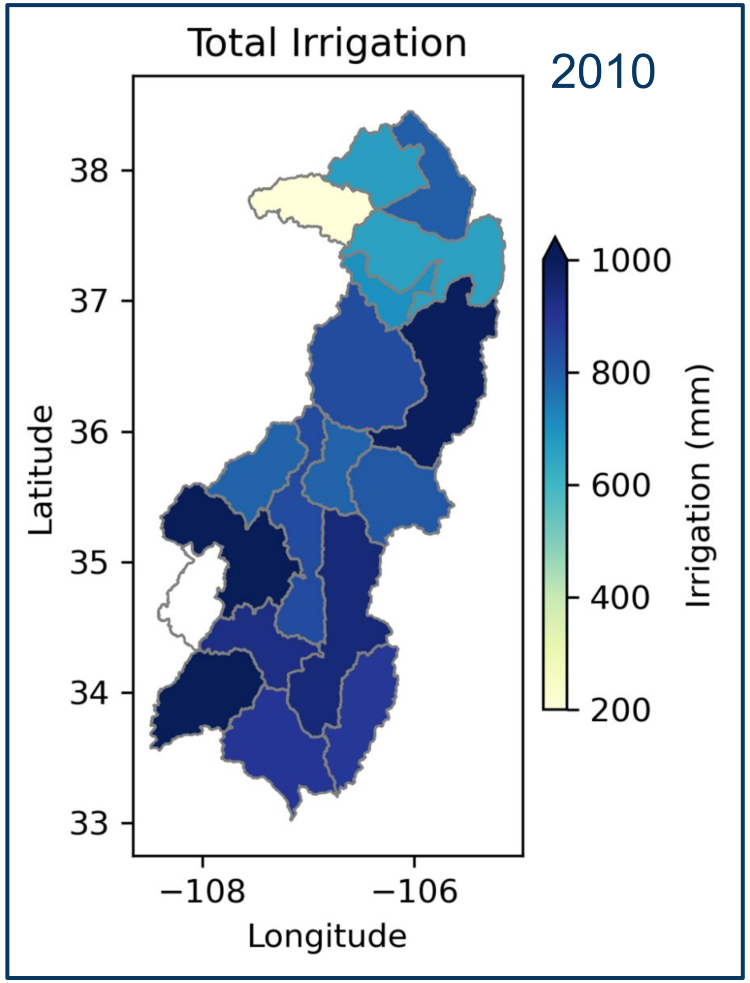
**Climate and Hydrology Challenges**

https://sierracountycitizen.org/what-you-need-to-know-march-22-2026-climate-change-overuse-send-the-middle-rio-grande-into-dire-situation/

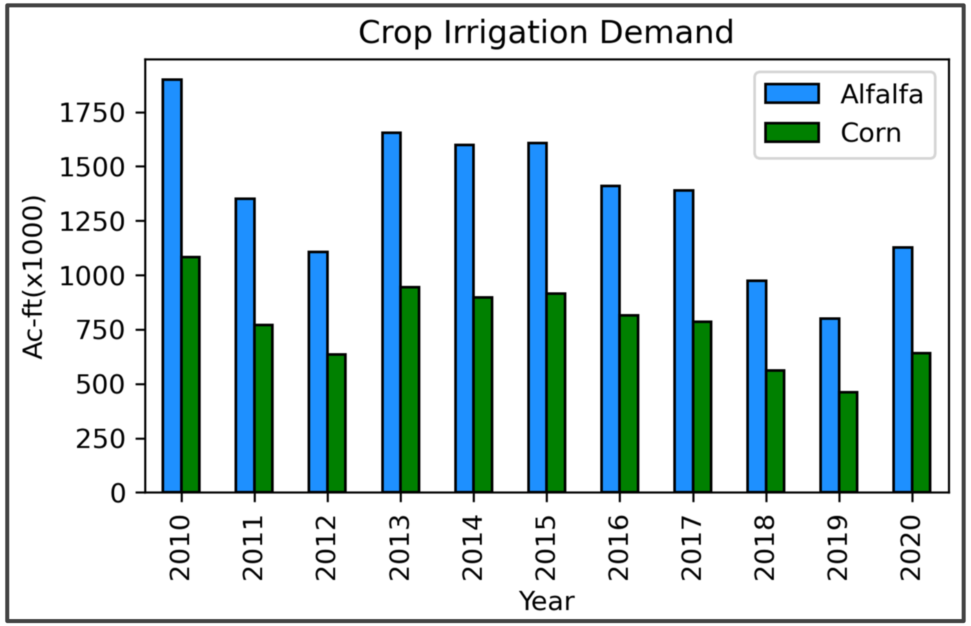
# Crop Management Scenarios

- Alfalfa is by far the dominant crop in the Upper RGB HUC 8 basins with agriculture, and, along with pecans, it is the most water-intensive crop in the basin (Samimi et al., 2023).
- Other Hay/Non-Alfalfa class from the USDA's Cropland Data Layer has a similar irrigation demand as alfalfa. When combined, these crops comprise 56.9% of the total agricultural land in the domain.





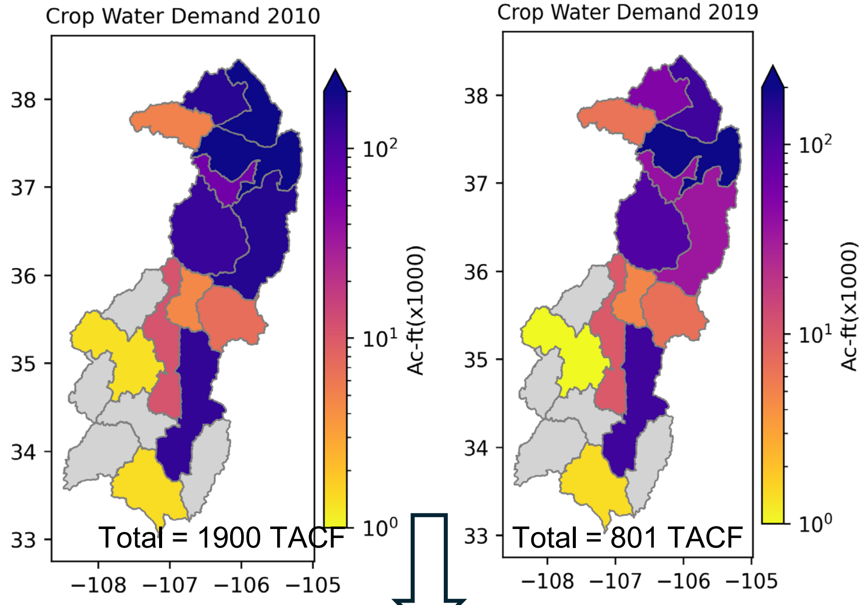
# Crop Management Scenarios



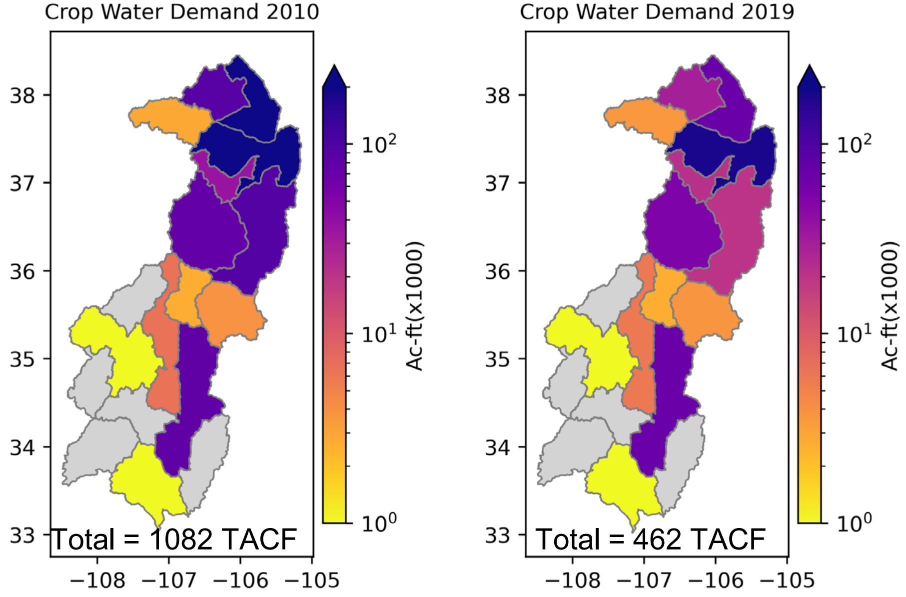
Alternate Scenarios:

- Nearly 40% less irrigation water demand when Alfalfa is replaced by drought-resistant corn
- If half of Alfalfa is replaced with corn, it will require ~ 30% less water
- If we reduce the cropping area by 20%, the water needed will also go down by roughly that amount.
- If we reduce the crop area by 20% and replace Alfalfa with corn, water need can be reduced by more 50% compared to the current condition.

**Current** Condition using Alfalfa as proxy

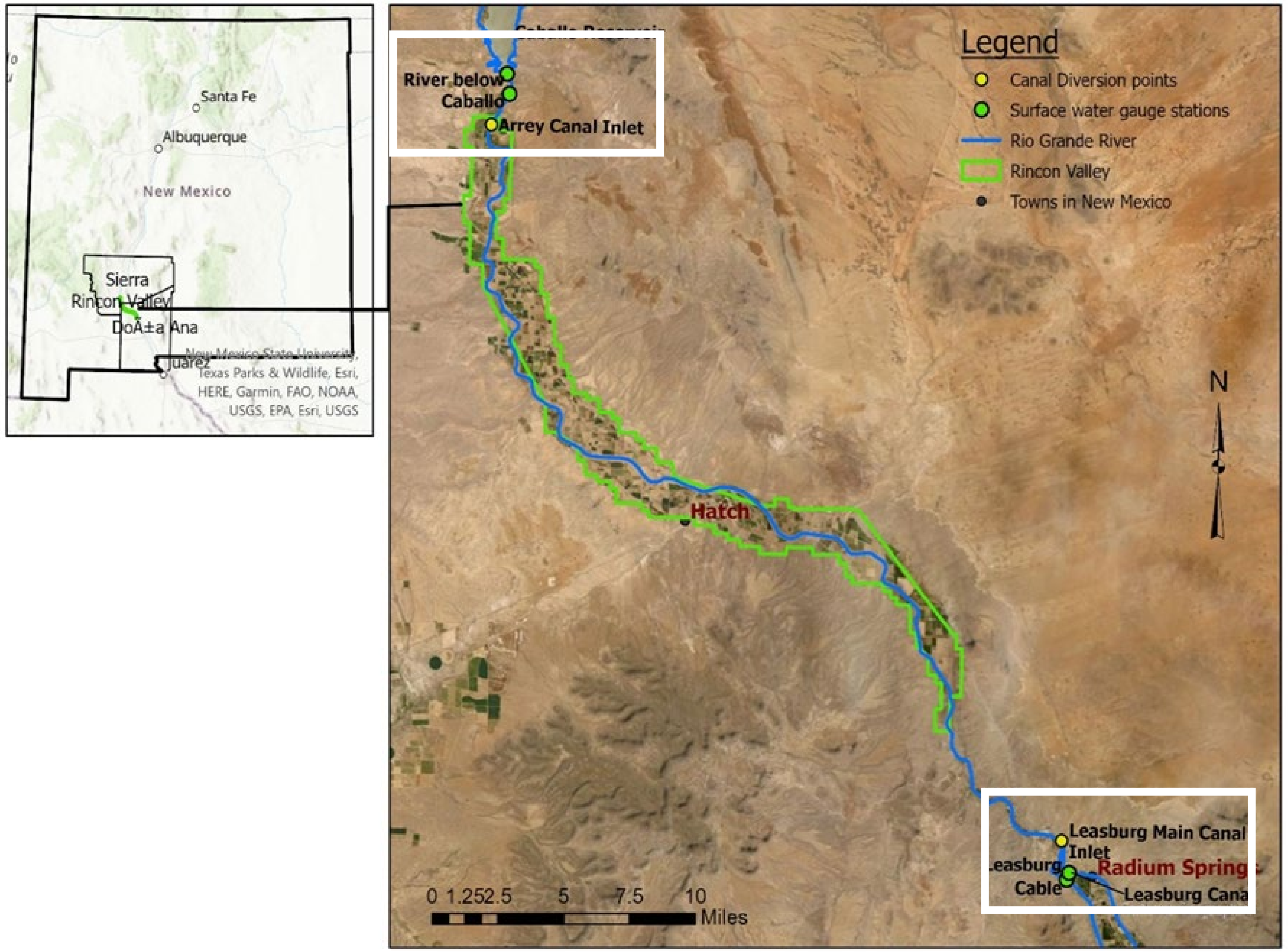


**Alternate** scenario: all Alfalfa is replaced by Corn

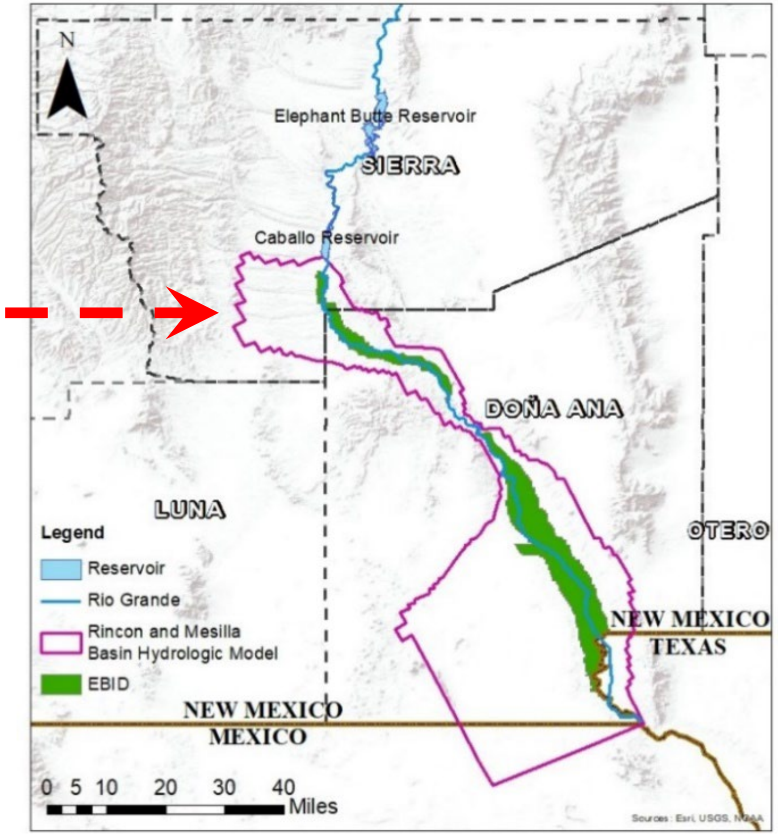


# Lower Rio Grande

## Rincon Valley

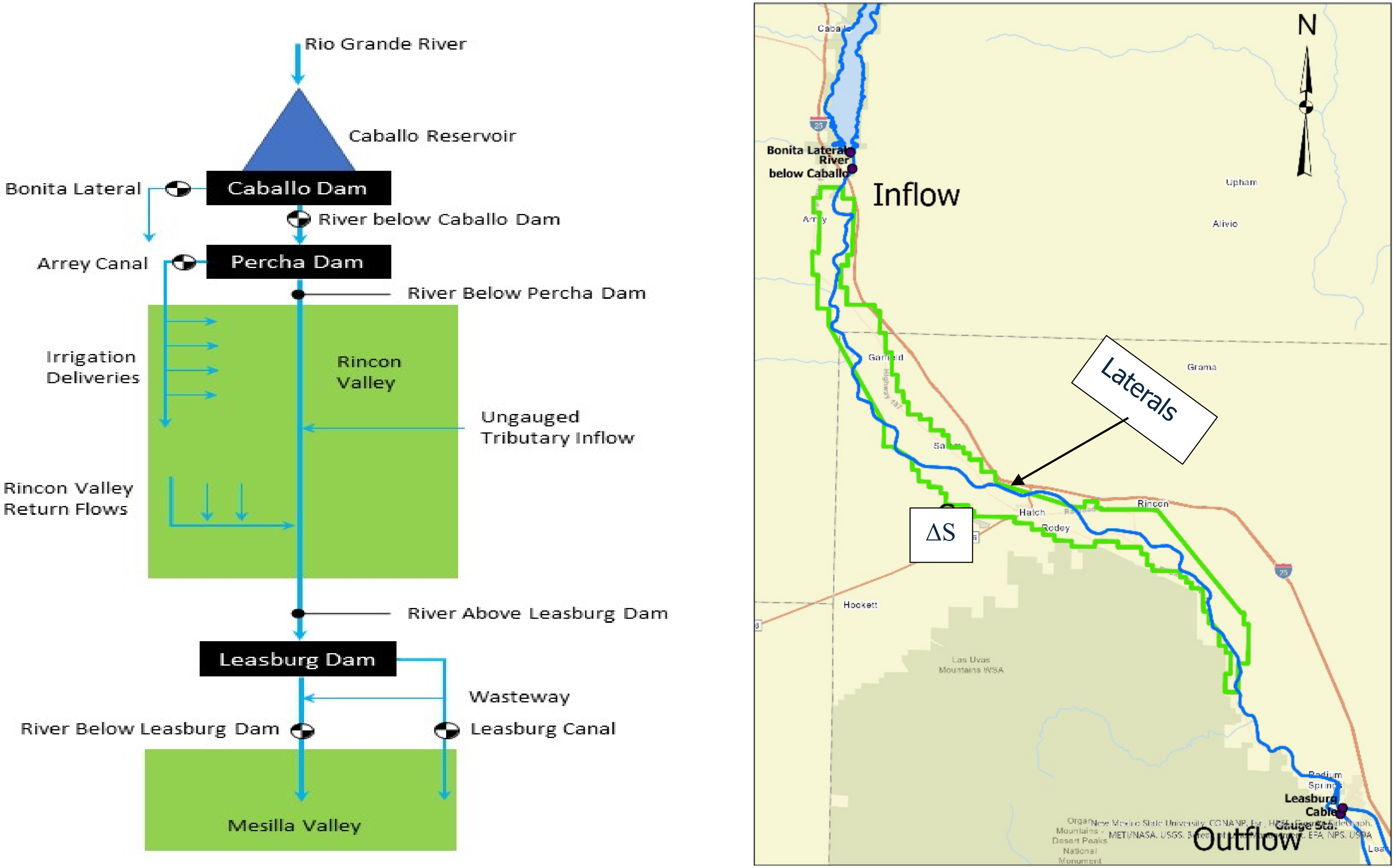


Rincon Valley from Caballo Dam up to Leasburg Dam



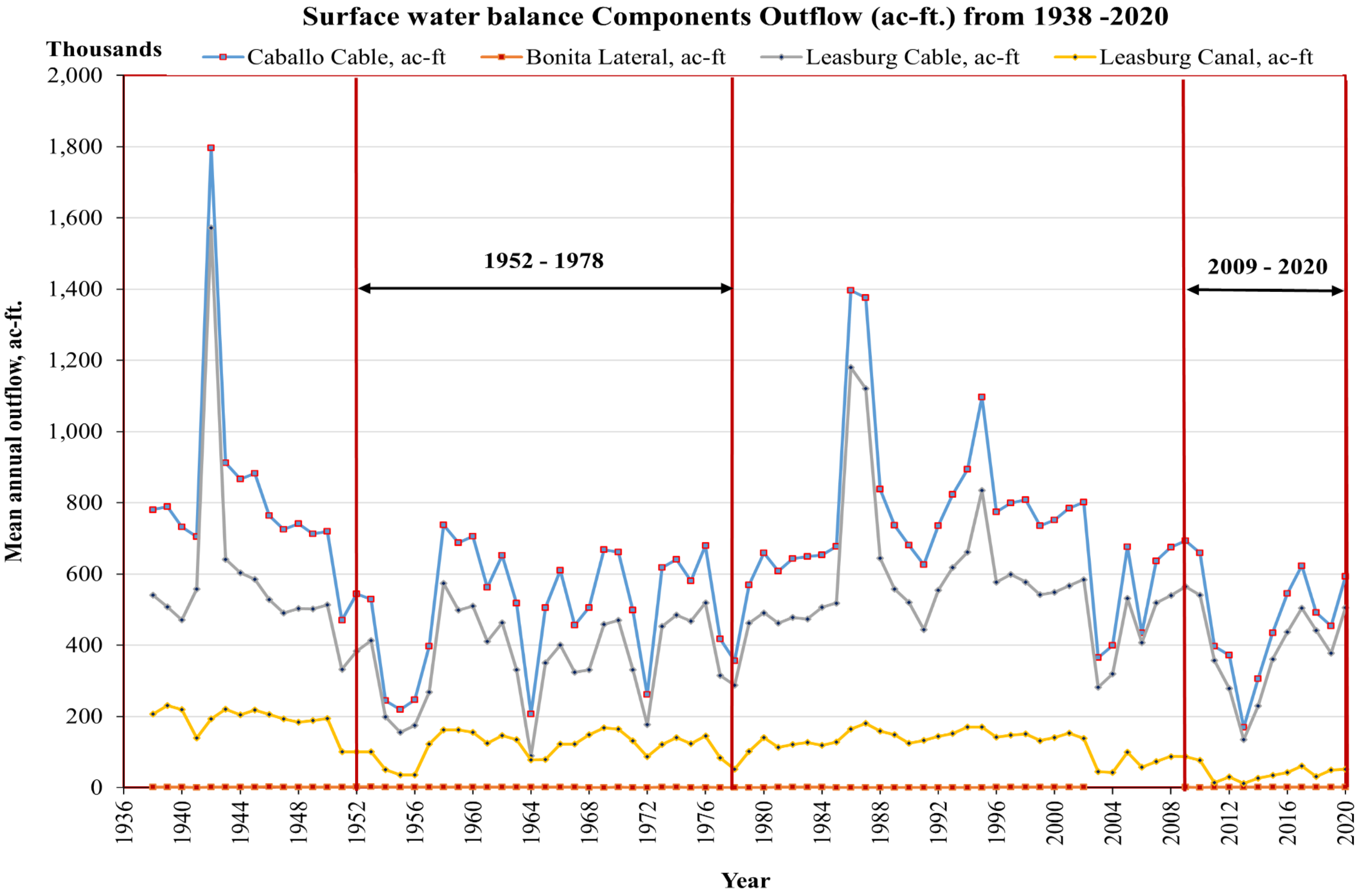
The Rio Grande Project encompasses New Mexico, Texas, and Mexico.

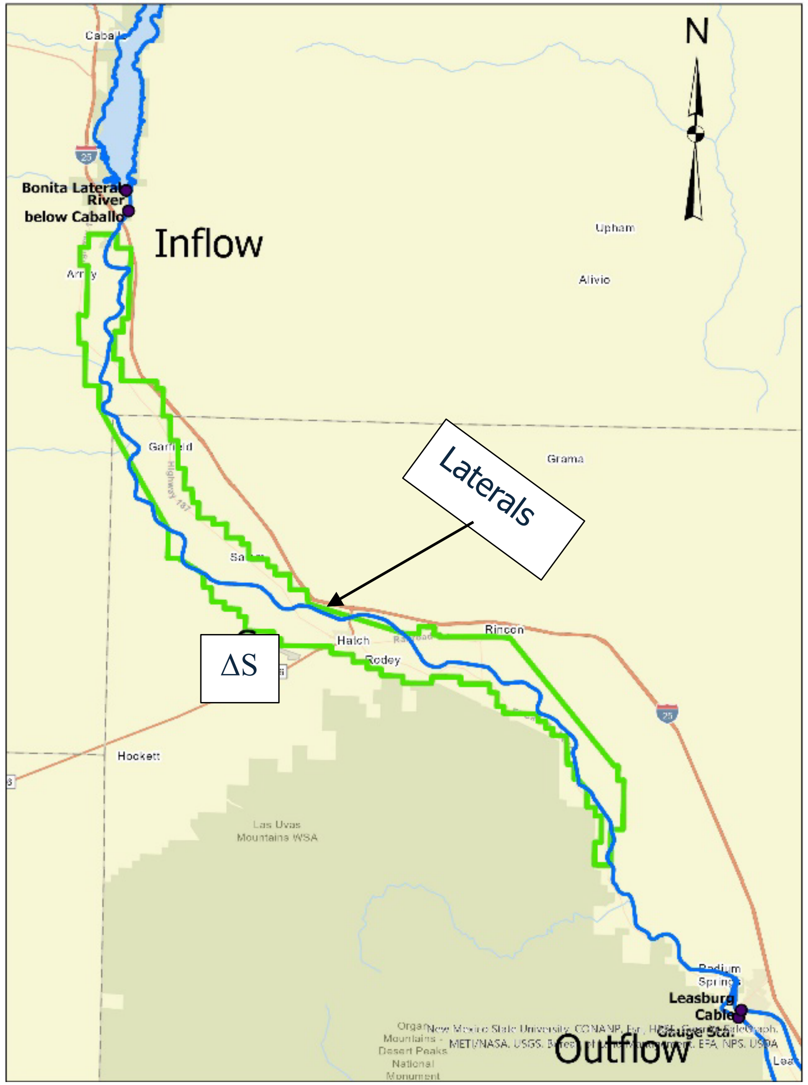
# Rincon Valley Hydrological System schematic diagram



A schematic diagram of the hydrological system of the Rincon Valley

# Surface Water inflow and outflow observations



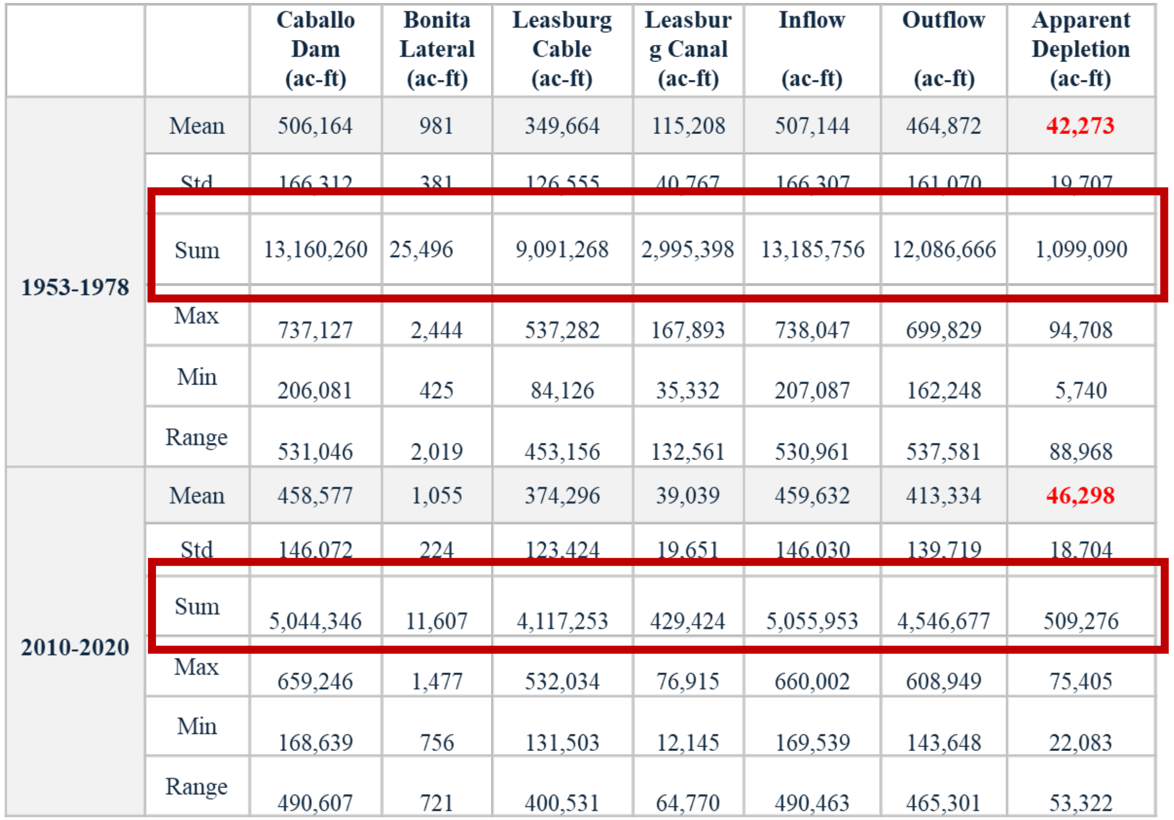


Average annual flow rate (ac-ft.) of surface water balance components in the Rincon Valley, from 1938 through 2020.

# Surface Water Apparent Depletion

- A total of 37 years (1953 – 1978 and 2010 – 2020) was used to estimate the surface water and groundwater depletions in the Rincon Valley.
- The total surface water depletion for the early and recent drought periods was **1,099,090 ac-ft** and **509,276 ac-ft**, respectively.
- During the early drought years, considerable depletion was estimated, with the largest value in 1966 (94,708 ac-ft), equivalent to about 5.89% of total surface water depletion in the Rincon Valley for this study.
- Similarly, during the recent drought years, the largest surface water depletion occurred in 2017 (75,405 ac-ft.), accounting for 4.69% of the total surface water depletion in this study.
- However, the mean of these drought periods indicates that the recent drought is experiencing greater surface water depletion than the early drought.

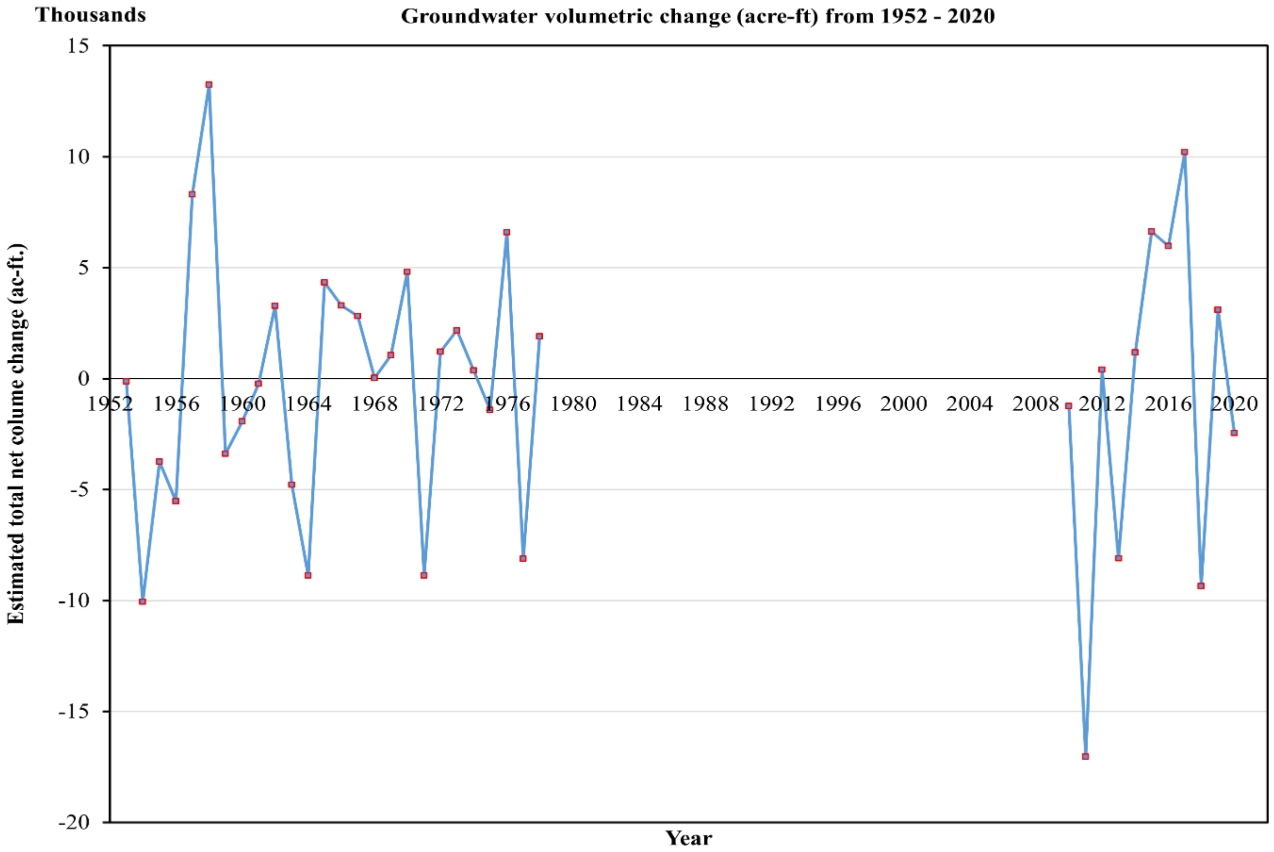
Summary of surface water balance components



| | | Caballo Dam (ac-ft) | Bonita Lateral (ac-ft) | Leasburg Cable (ac-ft) | Leasburg Canal (ac-ft) | Inflow (ac-ft) | Outflow (ac-ft) | Apparent Depletion (ac-ft) |
|---|---|---|---|---|---|---|---|---|
| **1953-1978** | Mean | 506,164 | 981 | 349,664 | 115,208 | 507,144 | 464,872 | **42,273** |
| | Std | 166,312 | 381 | 126,555 | 40,767 | 166,307 | 161,070 | 19,707 |
| | Sum | 13,160,260 | 25,496 | 9,091,268 | 2,995,398 | 13,185,756 | 12,086,666 | 1,099,090 |
| | Max | 737,127 | 2,444 | 537,282 | 167,893 | 738,047 | 699,829 | 94,708 |
| | Min | 206,081 | 425 | 84,126 | 35,332 | 207,087 | 162,248 | 5,740 |
| | Range | 531,046 | 2,019 | 453,156 | 132,561 | 530,961 | 537,581 | 88,968 |
| **2010-2020** | Mean | 458,577 | 1,055 | 374,296 | 39,039 | 459,632 | 413,334 | **46,298** |
| | Std | 146,072 | 224 | 123,424 | 19,651 | 146,030 | 139,719 | 18,704 |
| | Sum | 5,044,346 | 11,607 | 4,117,253 | 429,424 | 5,055,953 | 4,546,677 | 509,276 |
| | Max | 659,246 | 1,477 | 532,034 | 76,915 | 660,002 | 608,949 | 75,405 |
| | Min | 168,639 | 756 | 131,503 | 12,145 | 169,539 | 143,648 | 22,083 |
| | Range | 490,607 | 721 | 400,531 | 64,770 | 490,463 | 465,301 | 53,322 |

# Groundwater Apparent Depletion

- The largest net annual groundwater loss and gain are (10,055.89 ac-ft) and 13,245.07 ac-ft. During the early drought years of 1954 and 1958, respectively.
- The largest net annual groundwater recharge(gain) and discharge(loss) of 10,214.39 ac-ft and 17,050.54 ac-ft. was observed in 2017 and 2011, respectively.



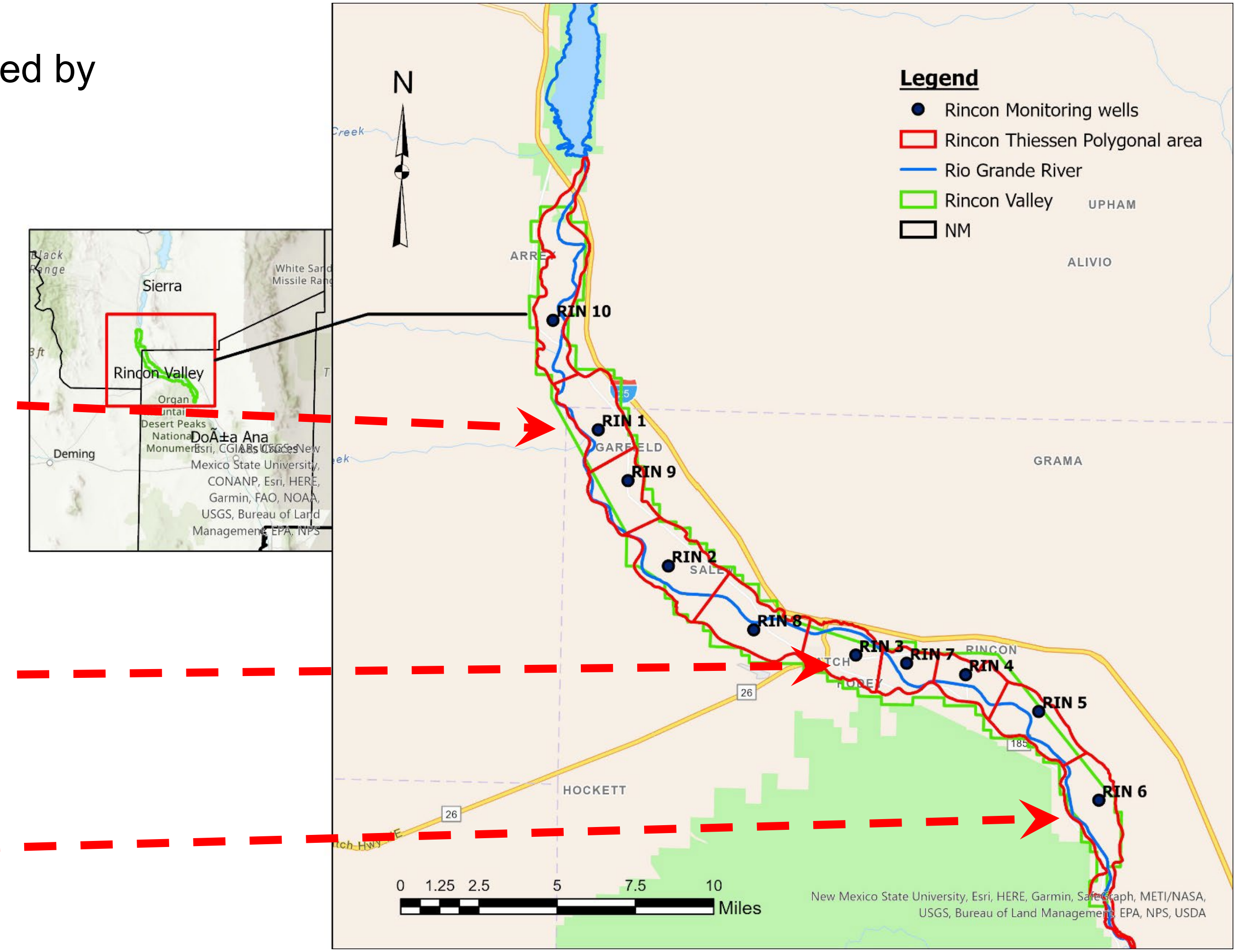
Annual estimated volume change (ac-ft.) from 1953 -1978 for the early drought years and 2010 – 2020 for the recent drought years.

# Groundwater Monitoring Wells

- There are 13 monitoring wells along Rincon Valley.
- In 2009, the original 10 monitoring wells were replaced by these 13 new wells.

Groundwater monitoring Wells in Rincon Valley

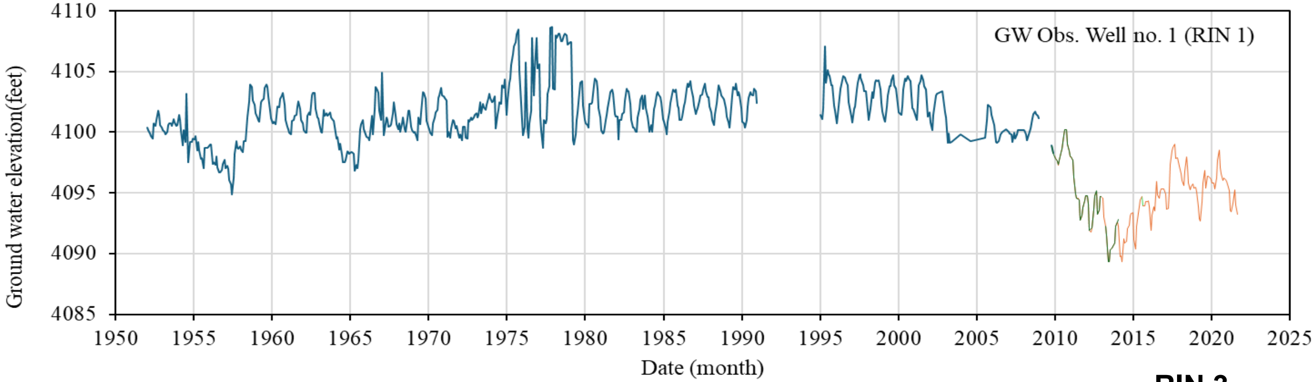
| Monitoring Wells | Thiessen Polygon Area (acre) | Latitude | Longitude |
|---|---|---|---|
| **Rin 10** | 4,158.72 | 32°49′ 12.95″ | 107°18′ 27.83″ |
| **Rin 1** | 2,911.59 | 32°46′ 11.81″ | 107°16′ 54.02″ |
| **Rin 9** | 2,263.10 | 32°44′ 48.14″ | 107°15′ 52.92″ |
| **Rin 2** | 3,502.87 | 32°42′ 27.62″ | 107°14′ 30.02″ |
| **Rin 8** | 3,425.74 | 32°40′ 44.21″ | 107°11′ 38.64″ |
| **Rin 3** | 2,555.68 | 32°40′ 05.20″ | 107°08′ 16.89″ |
| **Rin 7** | 1,460.68 | 32°39′ 53.37″ | 107°06′ 36.21″ |
| **Rin 4** | 1,784.42 | 32°39′ 35.05″ | 107°04′ 39.95″ |
| **Rin 5** | 2,573.86 | 32°38′ 36.80″ | 107°02′ 13.31″ |
| **Rin 6** | 3,427.67 | 32°36′ 10.70″ | 107°00′ 11.99″ |
| **Mean** | **2,806.43** | | |
| **Sum** | **28,064.33** | | |
| **Std dev.** | **797.62** | | |

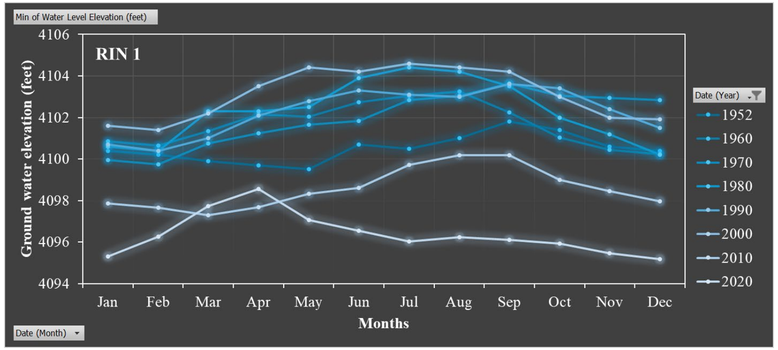


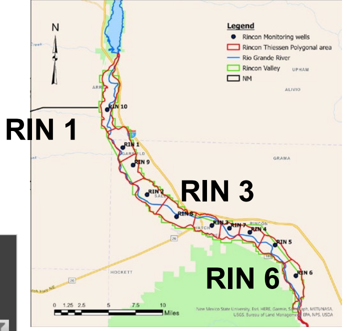
The location of 10 monitoring wells in the Rincon Valley

# Groundwater Levels Observations

**RIN 1**

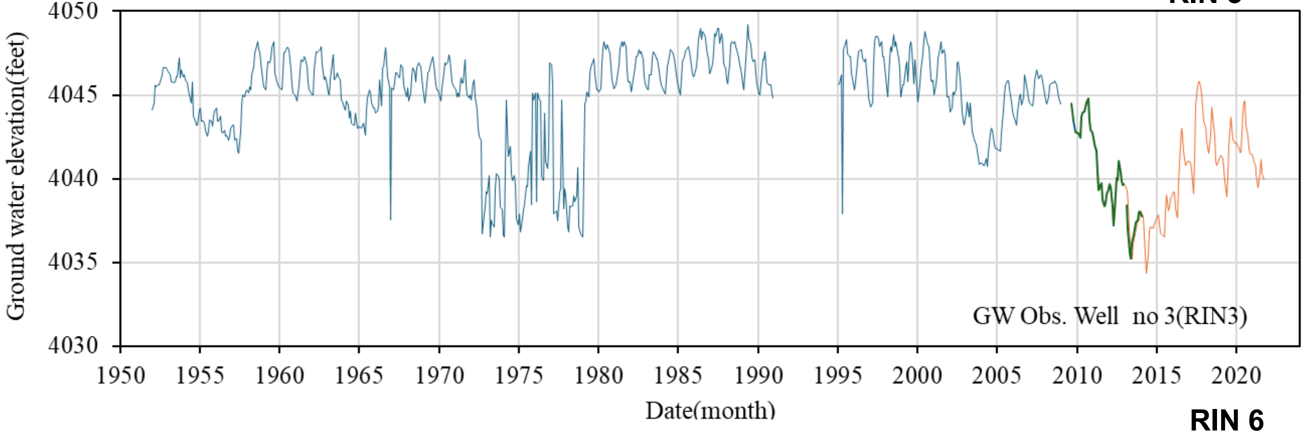


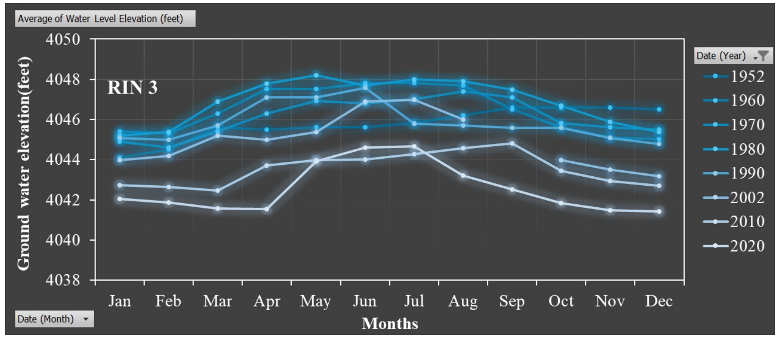




Groundwater elevations during **July** dropped from 4104.6 to 4096.03 ft (2000 -2020) with a drop of **8.57 feet**

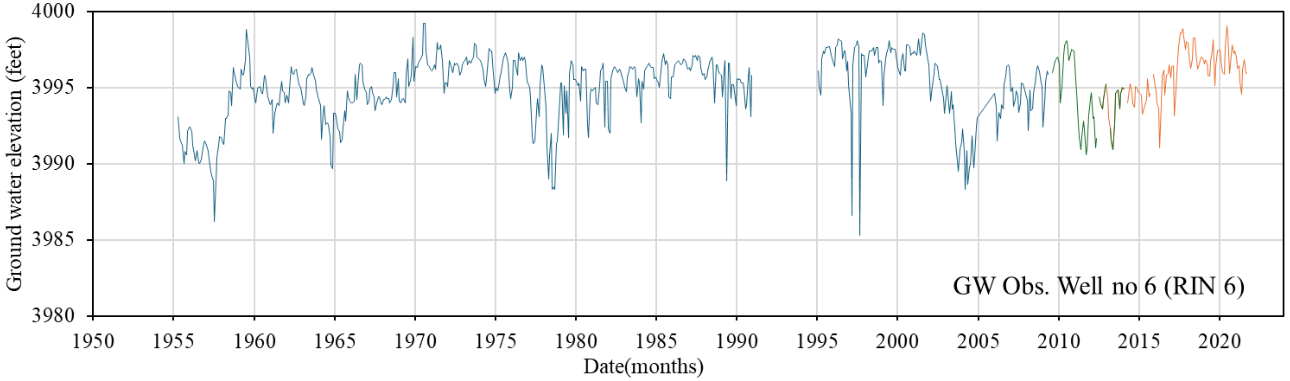
**RIN 3**

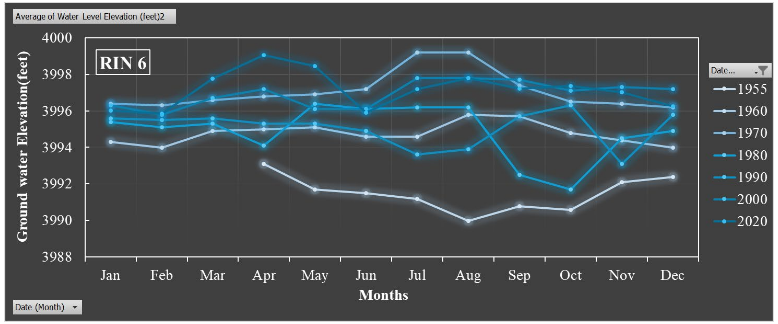




Groundwater elevations during **July** dropped from 4047.99 to 4044.65 ft (1980 – 2020) with a drop of **3.34 feet**

**RIN 6**

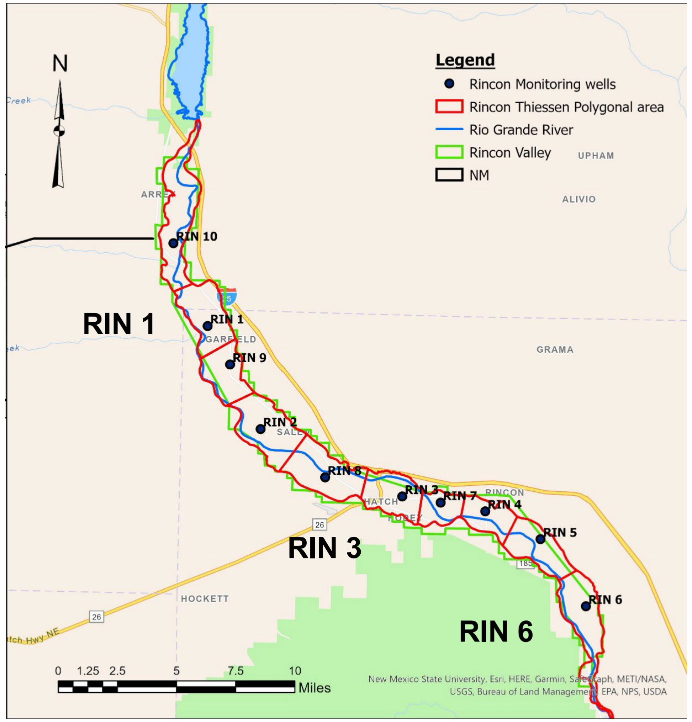




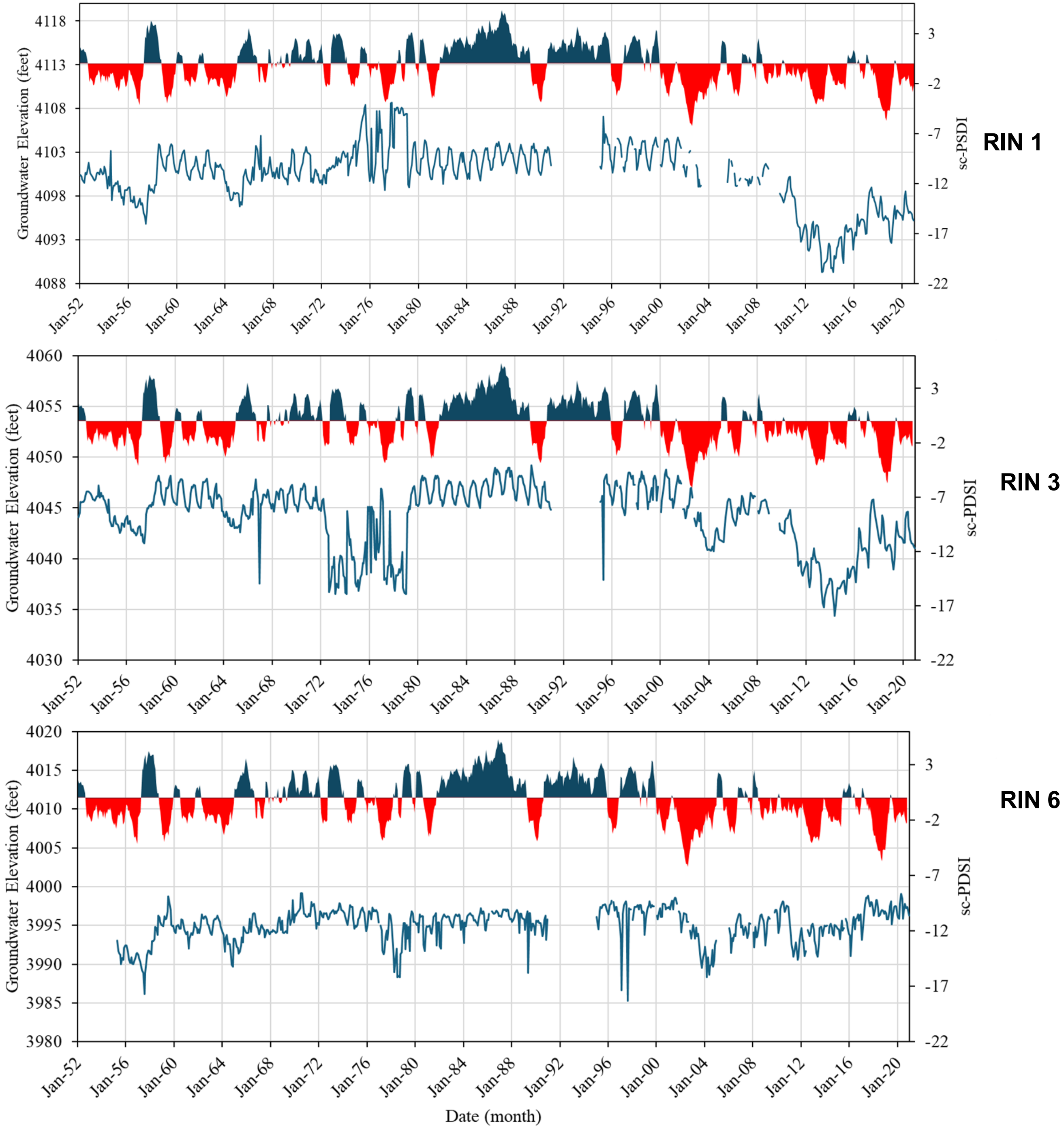
Groundwater elevations during **July** increased from 3991.19 to 3999.19 ft (1955 – 1970) with an increase of **8 feet**

# Drought and Groundwater Levels

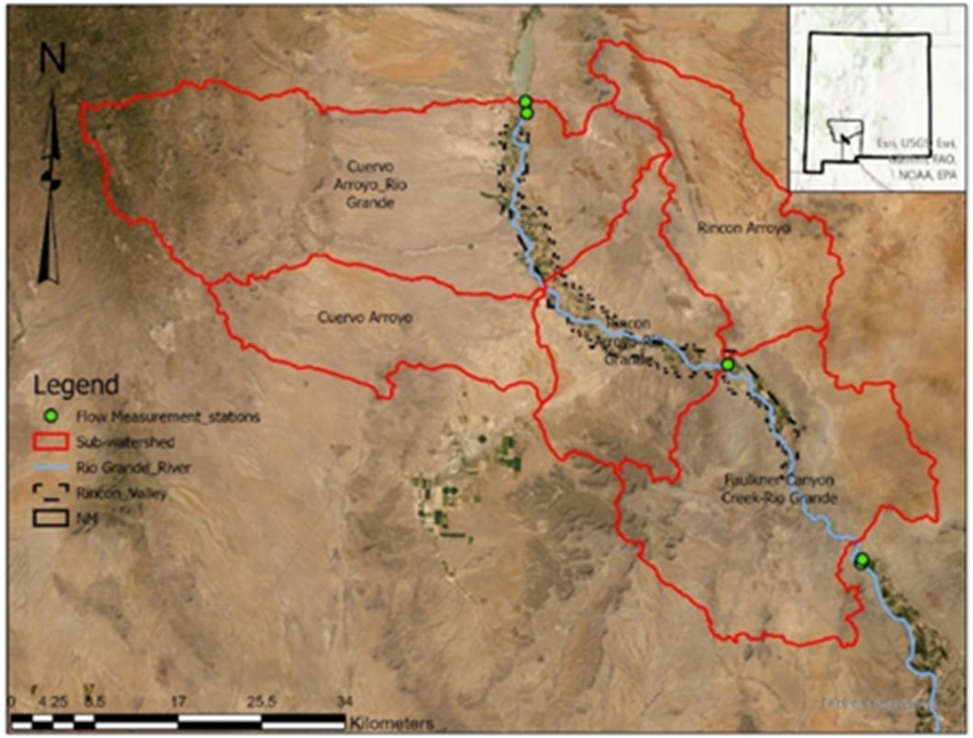
- Self-calibrated PDSI drought was used to identify drought events in the headwaters.
- RIN 1 and RIN 3 show a strong response to drought, especially in recent years.
- RIN 6, however, shows less response.



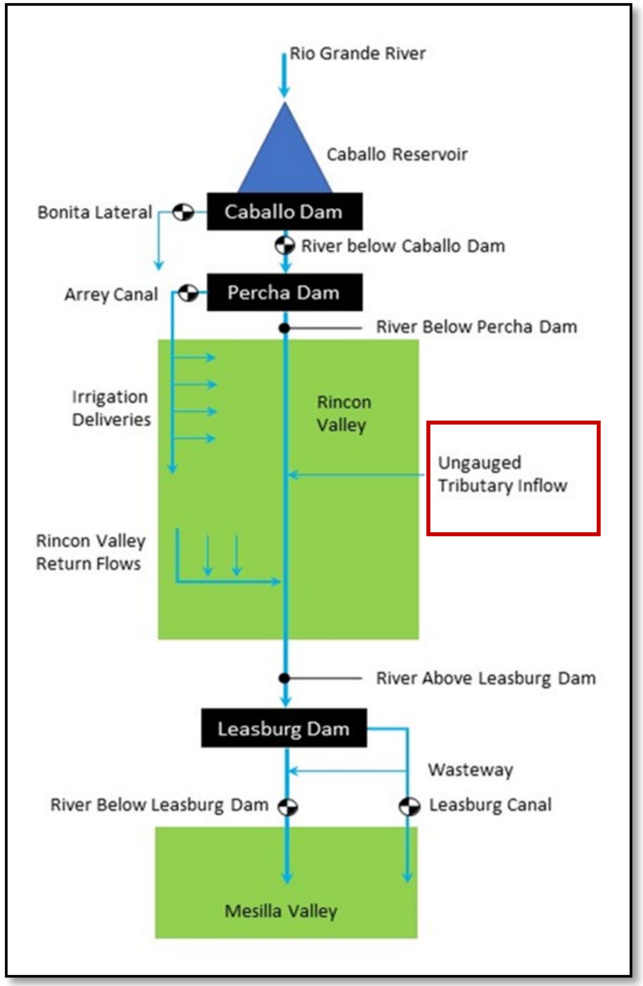
Groundwater elevations compared to drought events based on self-calibrated PDSI



# Missed Opportunities - Accounting for Local Precipitation



Sub-watersheds that contribute to surface water inflows through precipitation events include Rincon Arroyo, Rincon Arroyo-Rio Grande, Cuervo Arroyo, Cuervo Arroyo-Rio Grande, and Faulkner Canyon Creek, with a total estimated area of 158 acres.

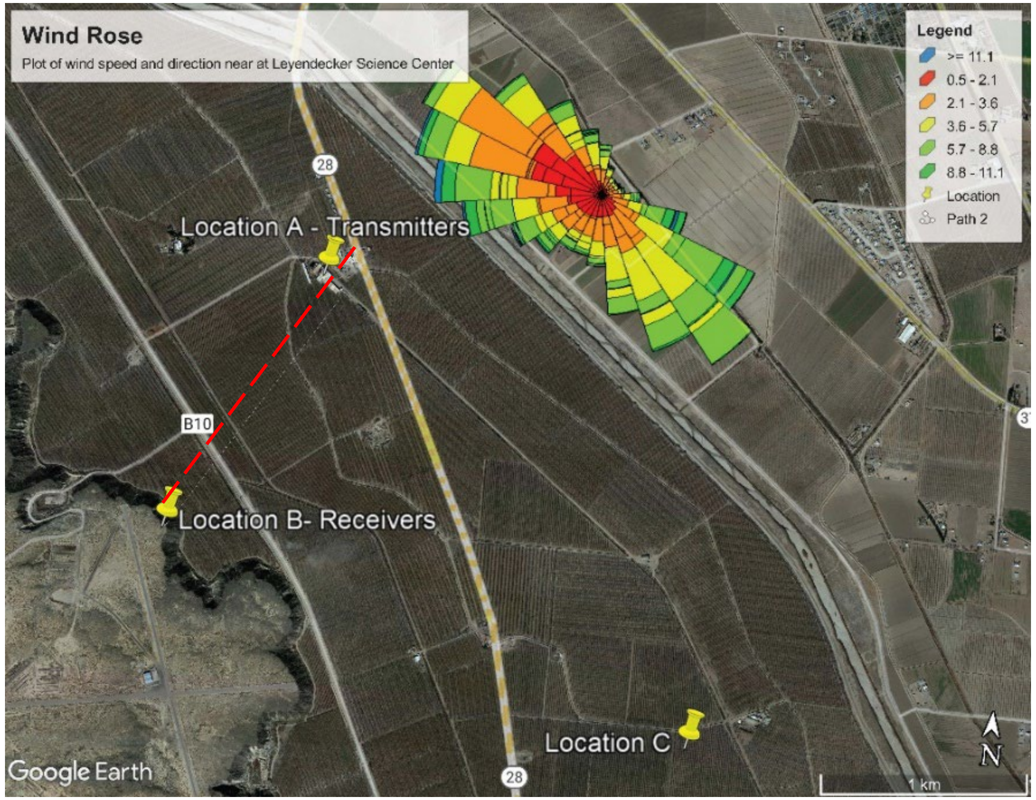


The hydrologic system of Rincon Valley

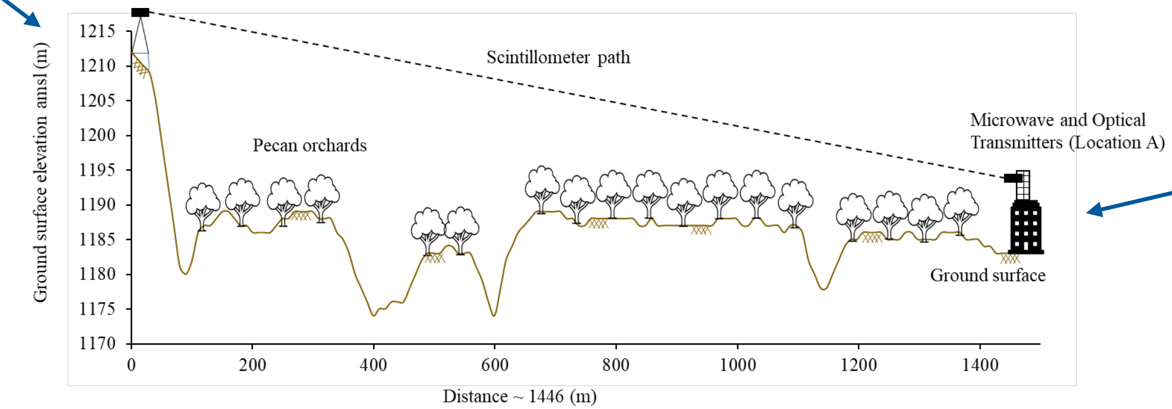
- Stormwater runoff/inflow into the Rio Grande from ungauged arroyos is not accounted for and can appear as spikes in downstream streamflow in the valley.
- There are no reliable measurements of stormwater inflows from arroyos across the valley.
- There can be significant rainfall events that need to be accounted for.

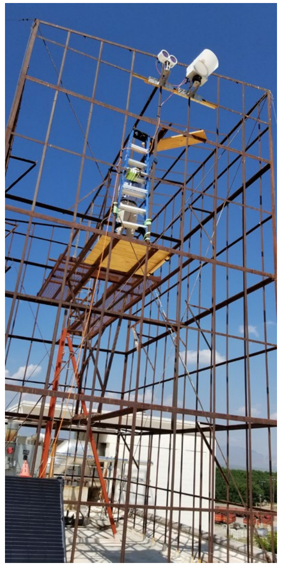
# ET Measurement

- Limited ET observation over agricultural fields urged the need to develop sites to collect data
- A microwave and optical scintillometer is being used to collect latent heat flux and sensible heat flux.



Location B - Receiver





Location A - Transmitter

Scintillometer-based ET measurement site in southern New Mexico, over a pecan orchard.

# Thank you


Credit: Phil King

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