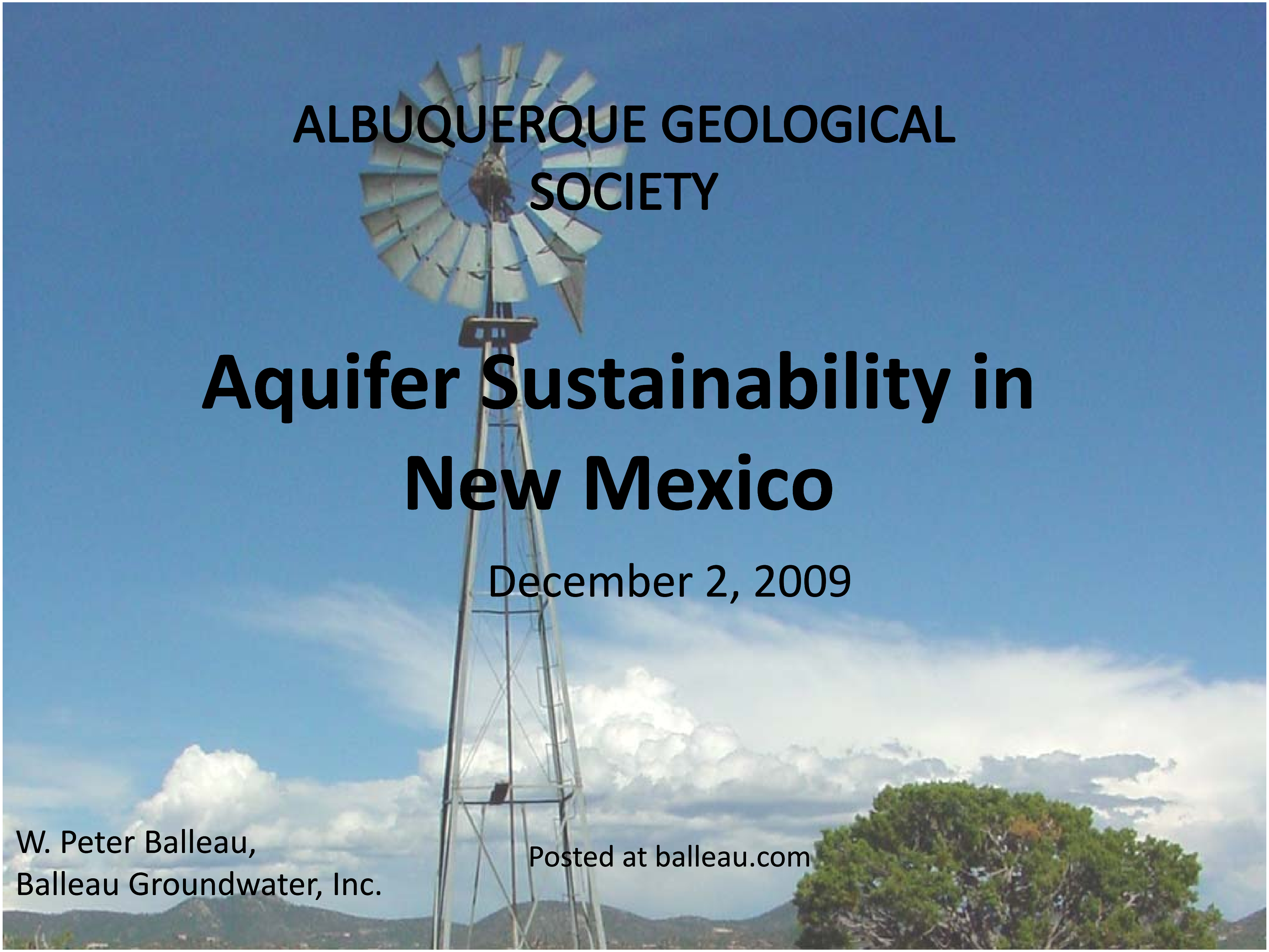


ALBUQUERQUE GEOLOGICAL SOCIETY

Aquifer Sustainability in New Mexico

December 2, 2009

W. Peter Balleau,
Balleau Groundwater, Inc.

Posted at balleau.com

CHALLENGES TO GROUNDWATER RESOURCE DEVELOPMENT

- "The sustainability of groundwater represents one of the major water challenges."

  -3rd World Water Forum (2003)

- "The problem of ground water mining represents a fundamental threat…"

  -World Bank (1999)

- "The country cannot sustain even the current levels of groundwater use…we must act to protect our rivers, springs, wetlands, lakes and estuaries from groundwater pumping."

  -Water Follies (R. Glennon, 2002)

- "Water in the West: Barack Obama and Joe Biden understand that the American West is facing a serious water crisis. In the long run, we do not have enough water to meet the West's fast-growing needs."

  Barackobama.com (2008)

NEW MEXICO AQUIFER DISCHARGE

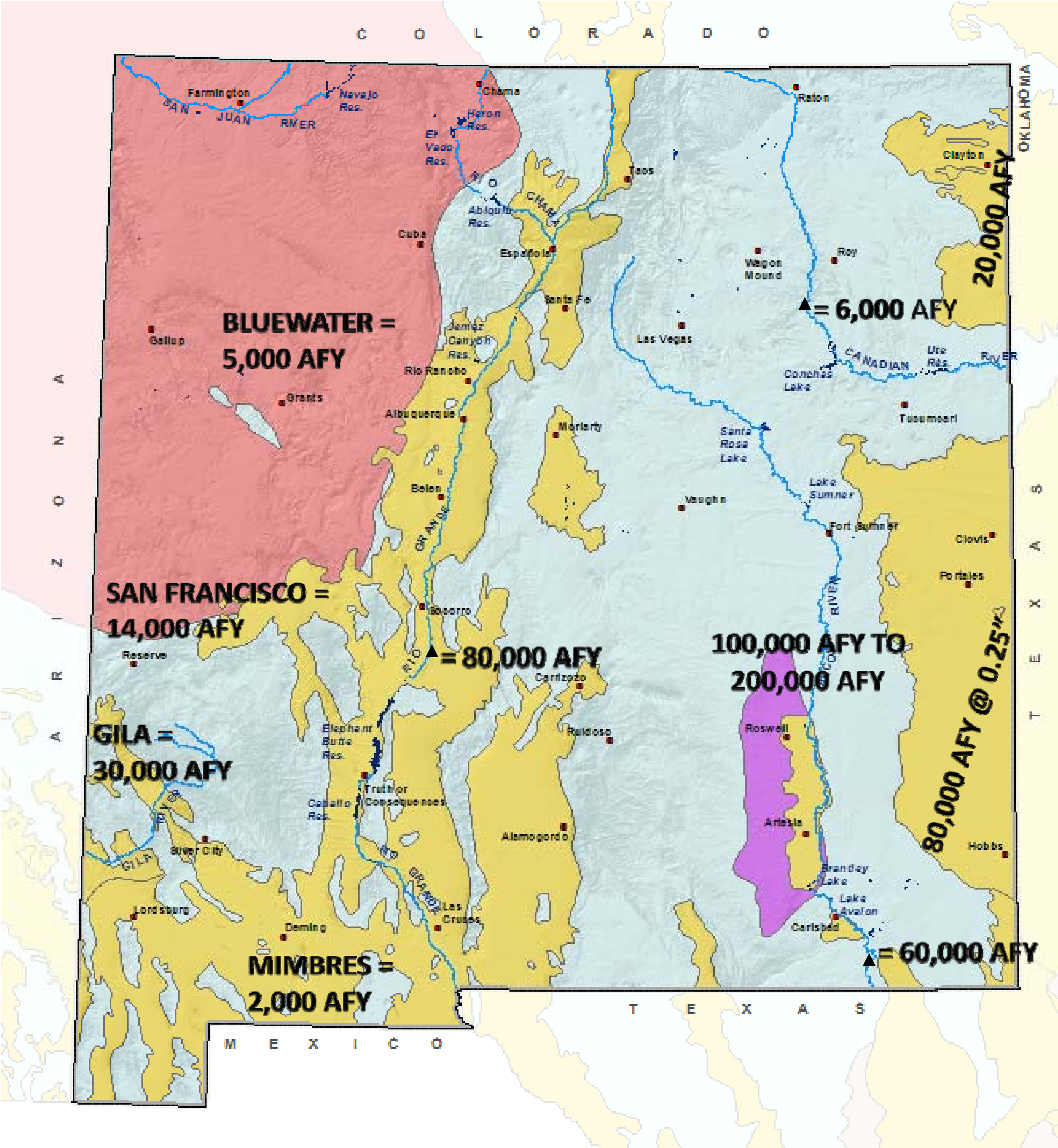
Basin	Dry Season Baseflow (AFY)	Well Withdrawal[1] (AFY)
Canadian River	6,000	66,000
Rio Grande	80,000	695,000
Pecos River	60,000	445,000
Mimbres River	2,000	
San Juan River	6,000	4,000
Gila/San Francisco River	45,000	104,000
High Plains	100,000	525,000
	300,000 AFY (some depleted by wells)	1,800,000 AFY

Will the "committed" depletion erase all baseflow in future?

[1]New Mexico Office of the State Engineer, 2008

DRY SEASON BASEFLOW FROM AQUIFER DISCHARGE

SUM = 300,000 AFY AQUIFER YIELD



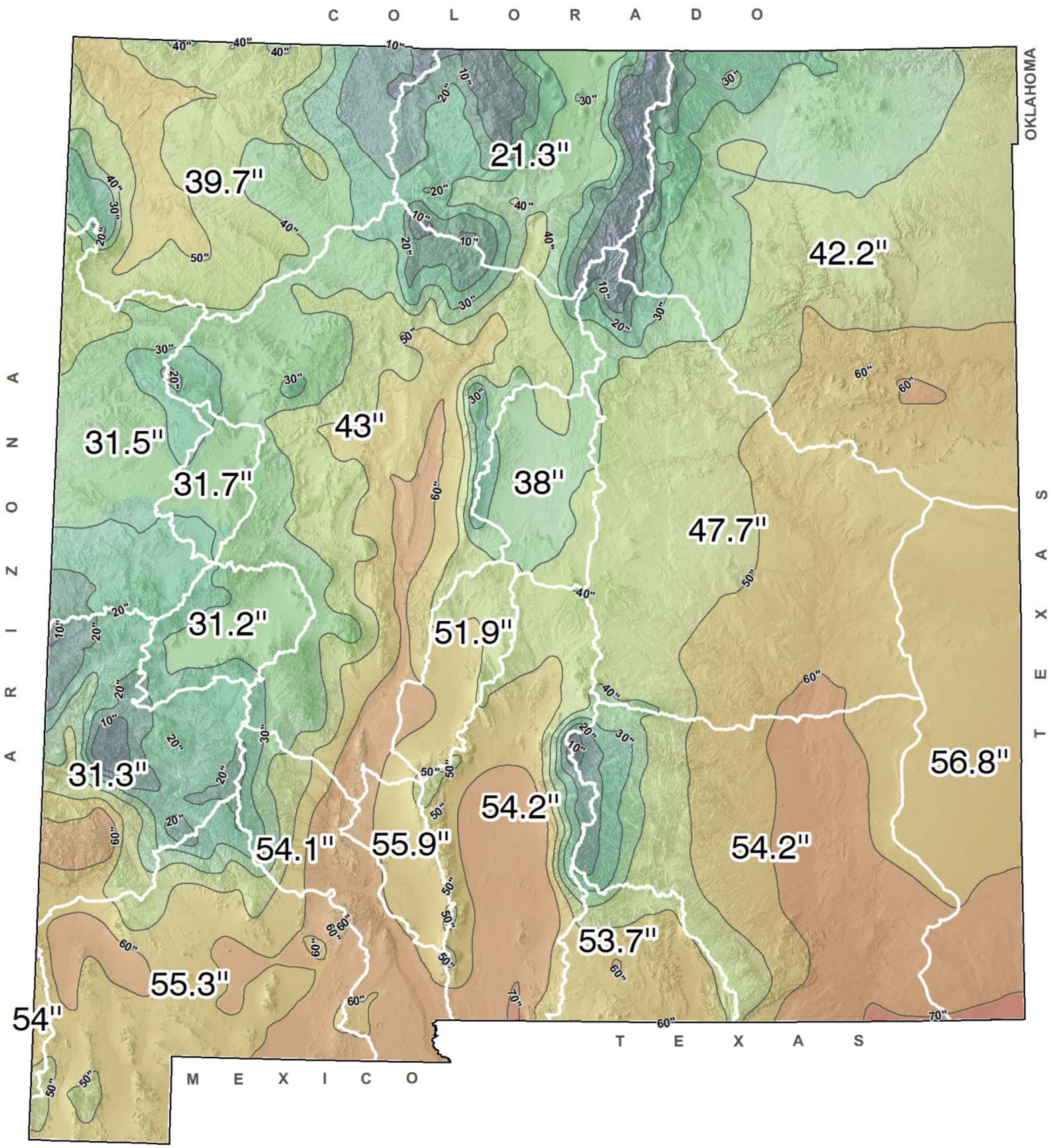
Legend

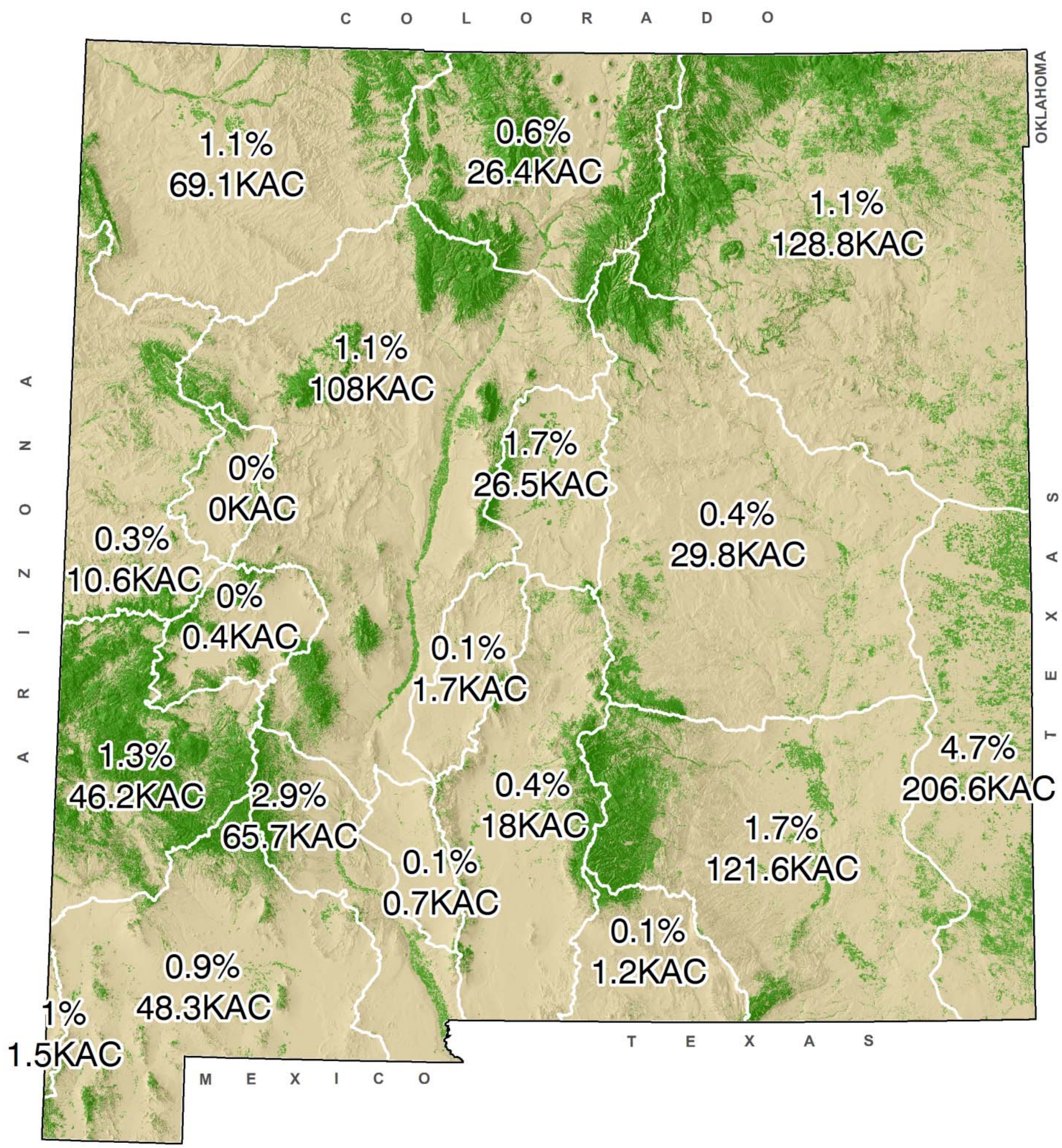
Aquifer Systems

- Basin Fill and Alluvial Aquifers
- San Juan Basin Aquifers (Minor)
- Roswell Basin Artesian Aquifer
- Minor Aquifer Systems

MOISTURE DEFICIT AND AVERAGES FOR MAJOR BASINS

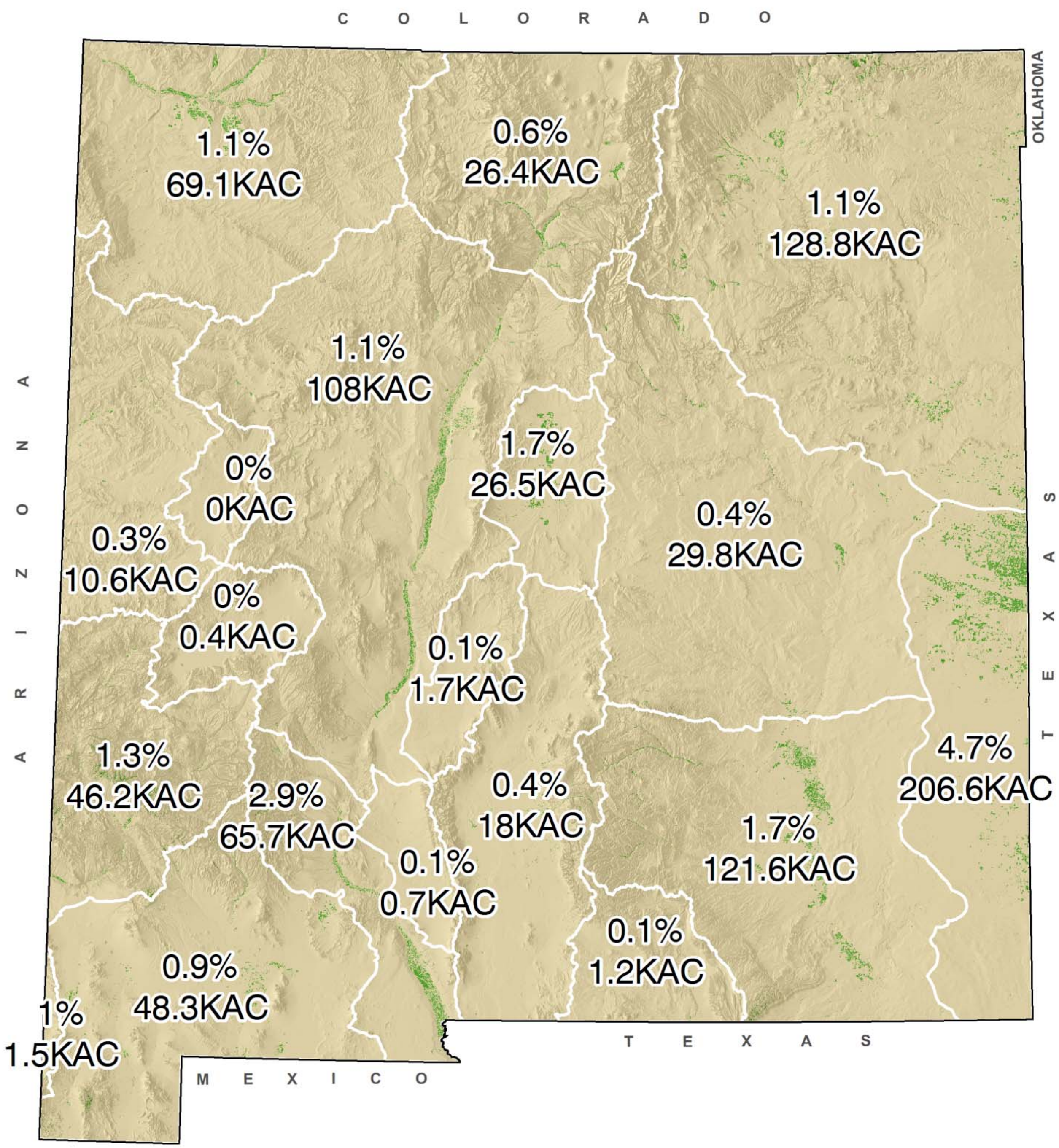
Lake Evaporation Minus Precipitation





LANDSAT GREENNESS OF MAJOR BASINS

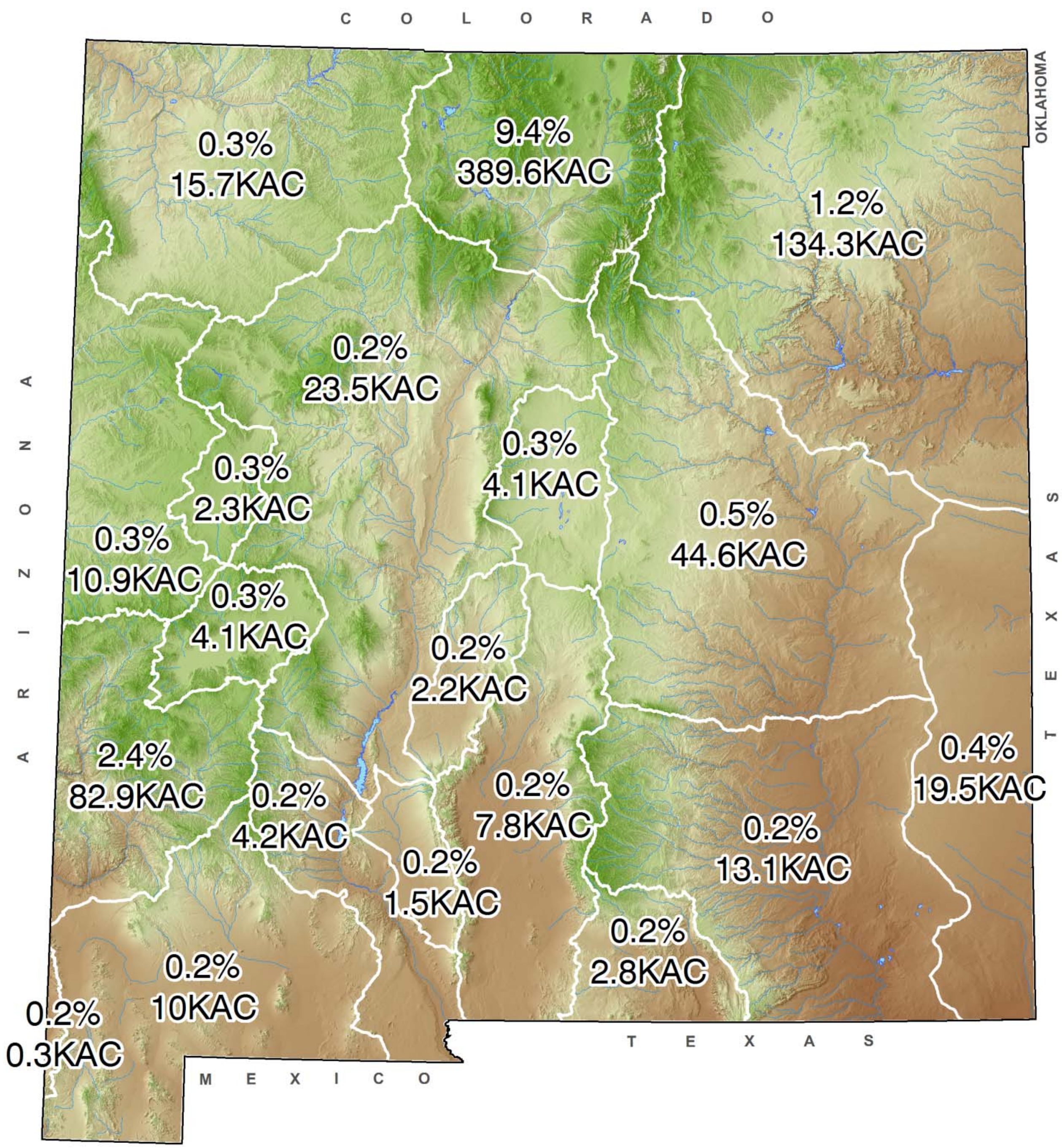
Green zones in Mountains consume "green" water



LANDSAT GREENNESS BELOW MOUNTAIN FRONT AND PERCENT COVERAGE OF MAJOR BASINS

Irrigated valleys and urban areas consume "blue" water

Permit needed to divert and use

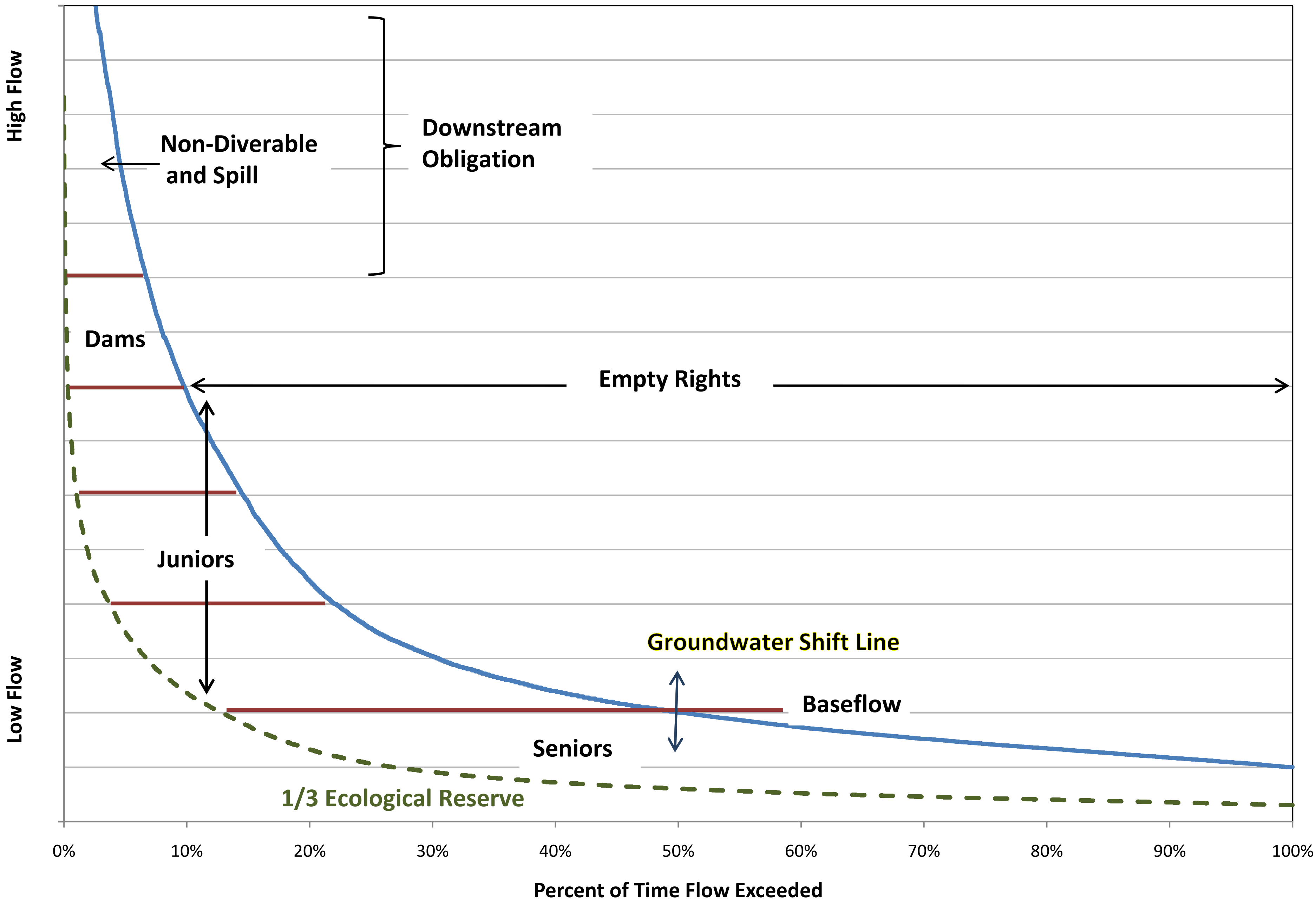


LOCAL
RUNOFF DIVIDED BY MOISTURE DEFICIT FOR MAJOR BASINS

Runoff = 2 MAFY
MD = 289 MAFY
Serves < 1% of State MD

773 KAC at Full Supply

HYDROGRAPH CATEGORIES FOR SUSTAINABILITY ANALYSIS



"GOOD STATUS" BASIN INDEX OF SUSTAINABLE SUPPLY

- Local basin runoff (blue water) adjusted for:
  - a) downstream obligation (nil to large)
  - b) ecological water (reserve ~one-third of hydrograph)
  - c) any upstream deliveries to local basin
  - d) non-divertable flood flows discharged
  - e) salt balance in view of outflows (except closed basins)
  - f) import or export, if any

= Basin Supply for development of fully-watered lands (positive or negative)

- Basin Supply ÷ basin PE = Index of basin area that can be sustainably developed
  - a) Index > 1.0 means basin exports unused water
  - b) 0 < Index < 1.0 sustainable acreage is a corresponding fraction of basin area
  - c) Index negative means unsustainable condition

HOW DOES GROUNDWATER FIT INTO BASIN YIELD?

"…water will only be available from (aquifer) storage for an interim period before effects of the groundwater withdrawal are fully transmitted to the river." (Reynolds to Water Law Study Committee, letter, September 1, 1983)

"Transitional Storage" defined in: Water for Nevada, 1971

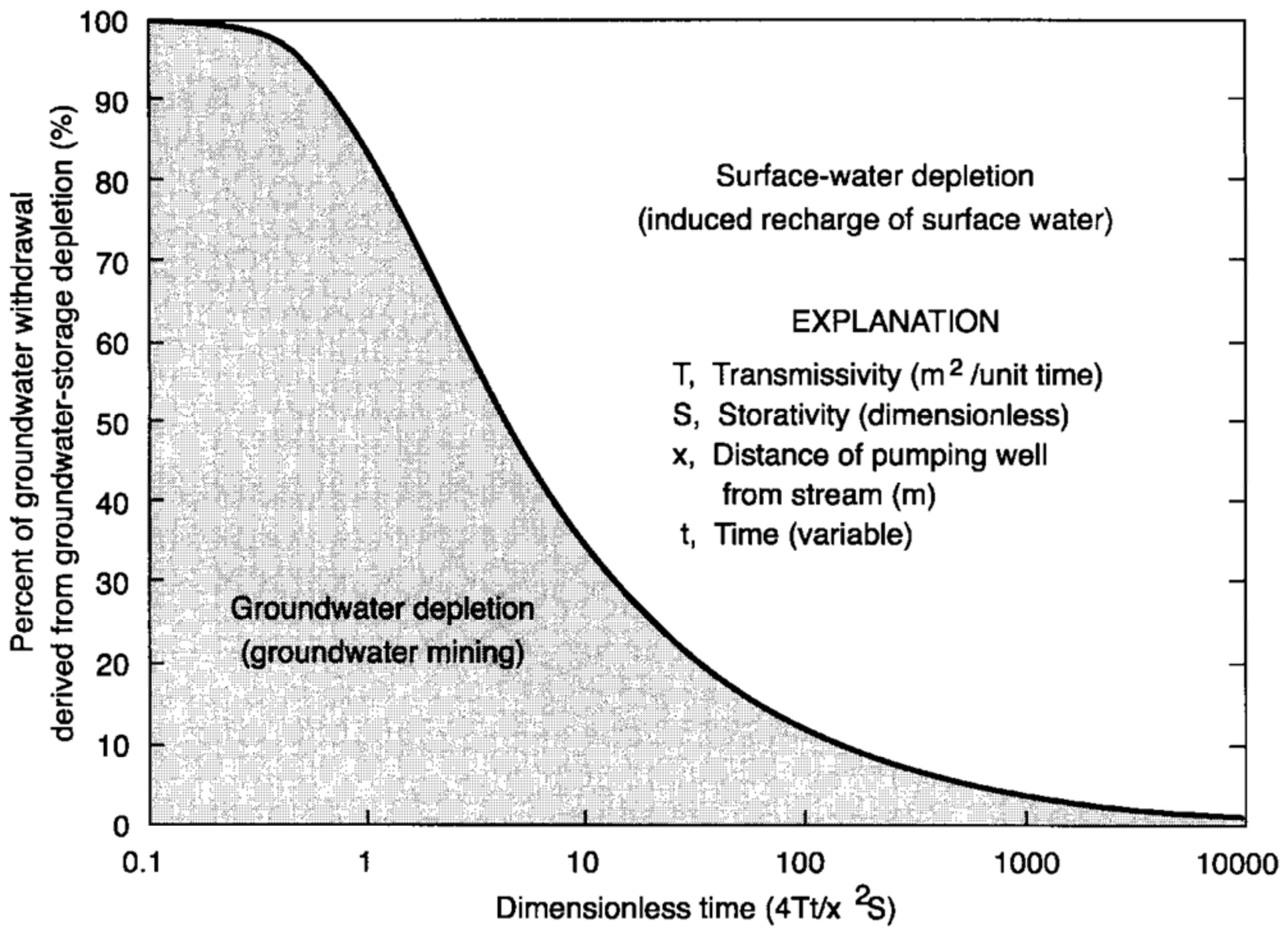
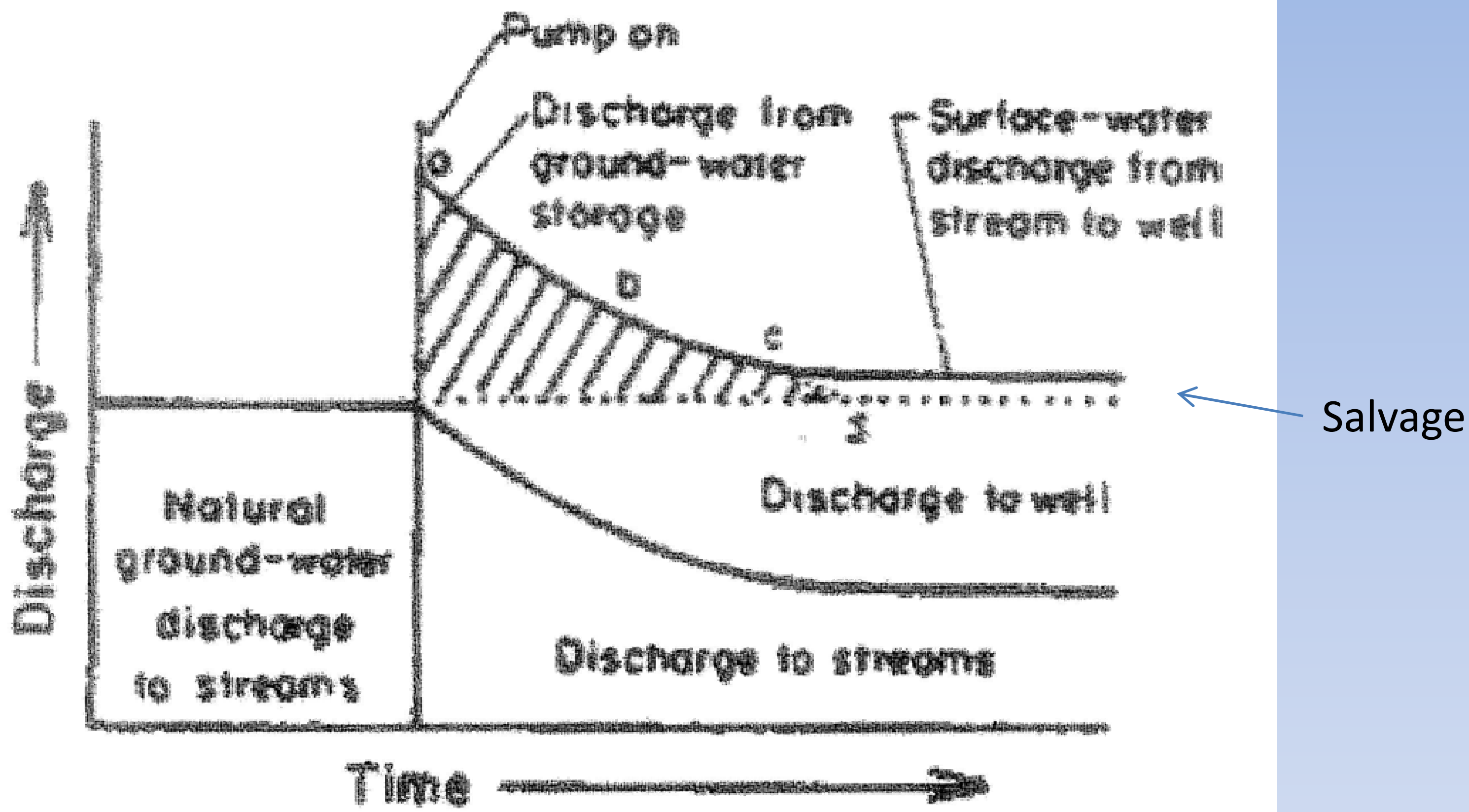
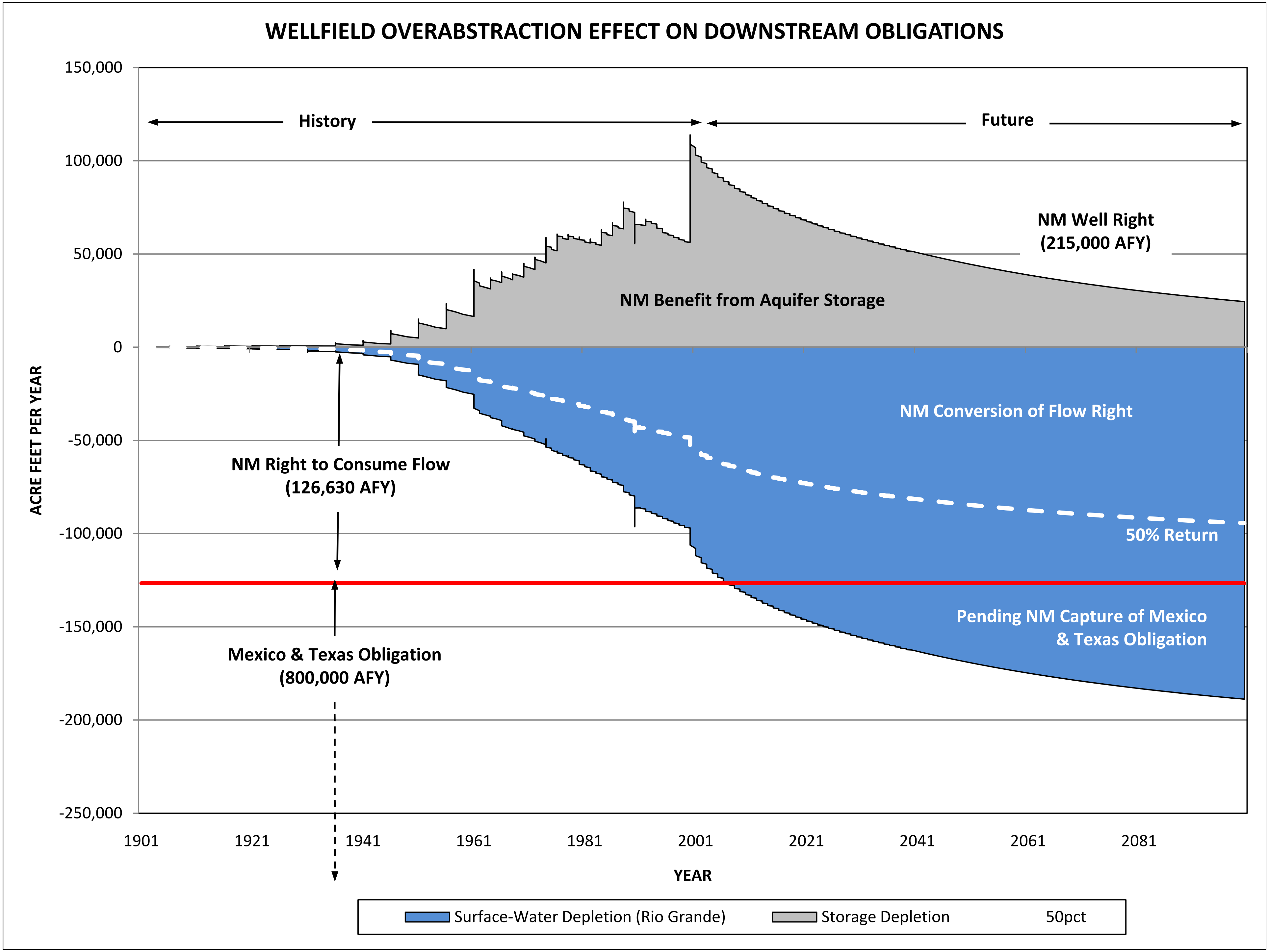


Fig. 9 Transition from reliance upon groundwater storage to induced recharge of surface water. (Adapted from Balleau 1988)

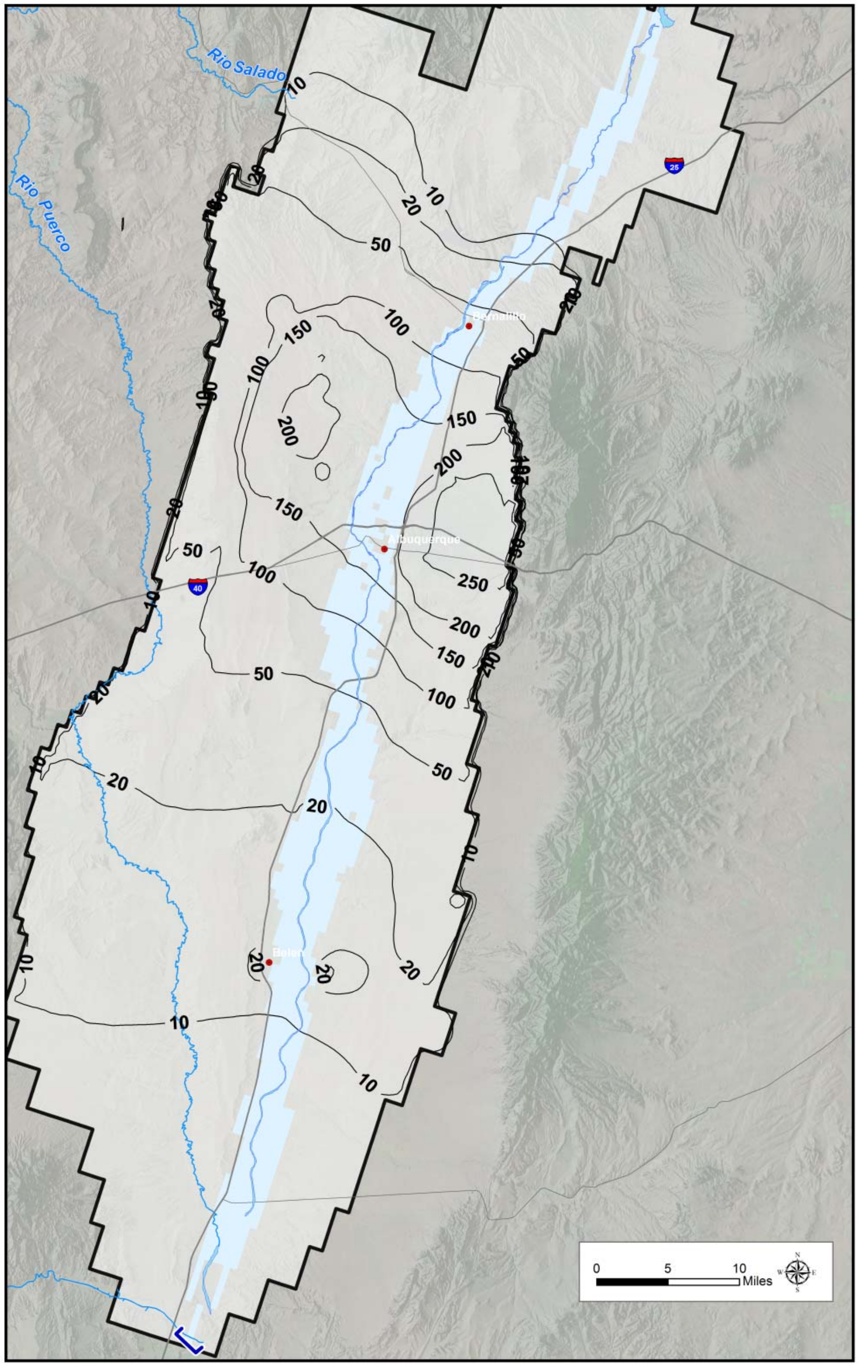
Adapted from: Sophocleous, M., (2002) Interactions Between Groundwater and Surface Water: the State of the Science. Hydrogeology Journal 10:52–67.



Adapted from Figure 5 of Summers, W.K., 1985, Conceptualization of Ground-Water Flow Systems and the Design of Monitoring Programs, SME Preprint 85-365



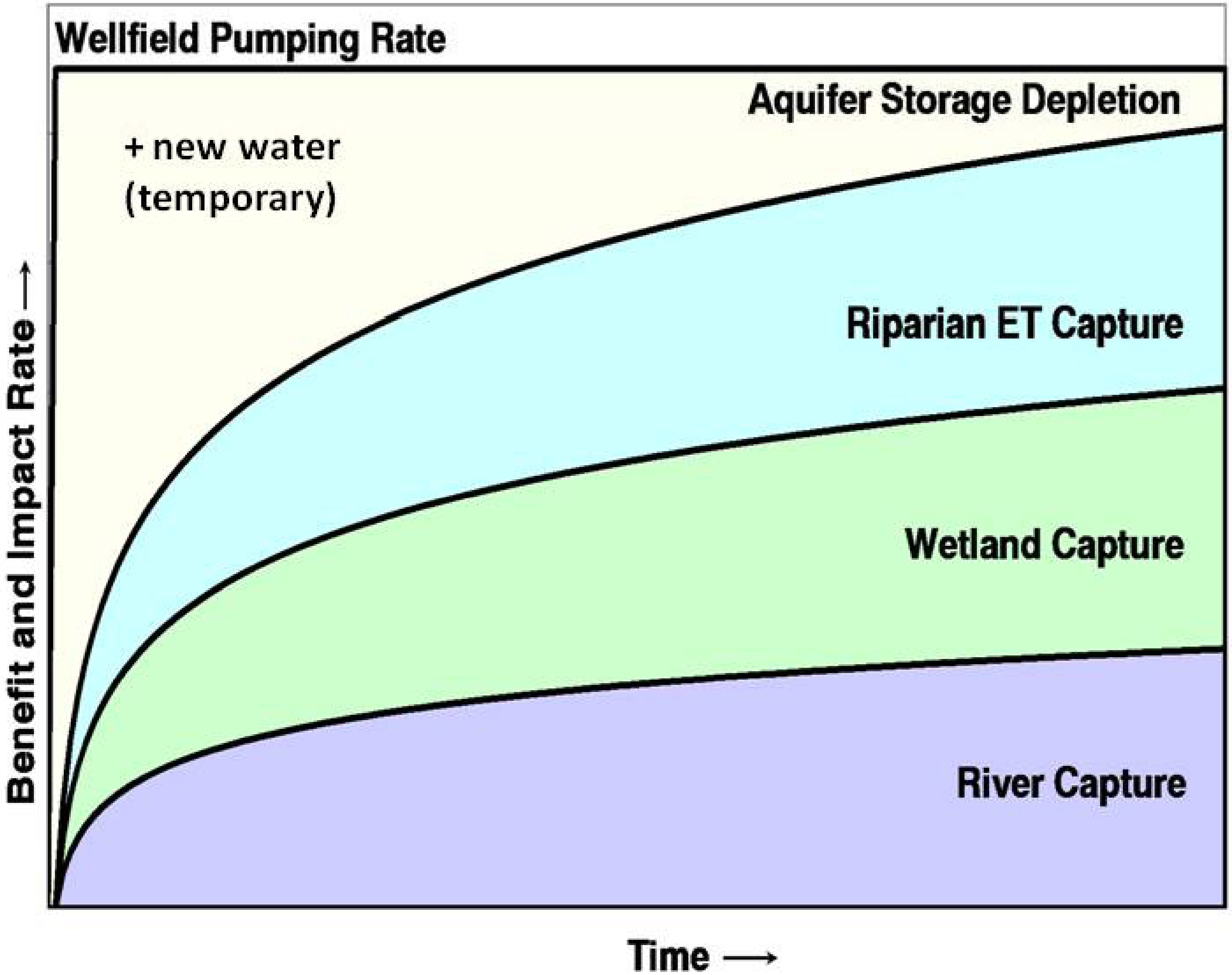
WELLFIELD OVERABSTRACTION EFFECT ON DOWNSTREAM OBLIGATIONS
History
Future
NM Well Right
(215,000 AFY)
NM Benefit from Aquifer Storage
NM Conversion of Flow Right
50% Return
NM Right to Consume Flow
(126,630 AFY)
Pending NM Capture of Mexico
& Texas Obligation
Mexico & Texas Obligation
(800,000 AFY)
ACRE FEET PER YEAR
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
-250,000
1901
1921
1941
1961
1981
2001
2021
2041
2061
2081
YEAR
Surface-Water Depletion (Rio Grande)
Storage Depletion
50pct



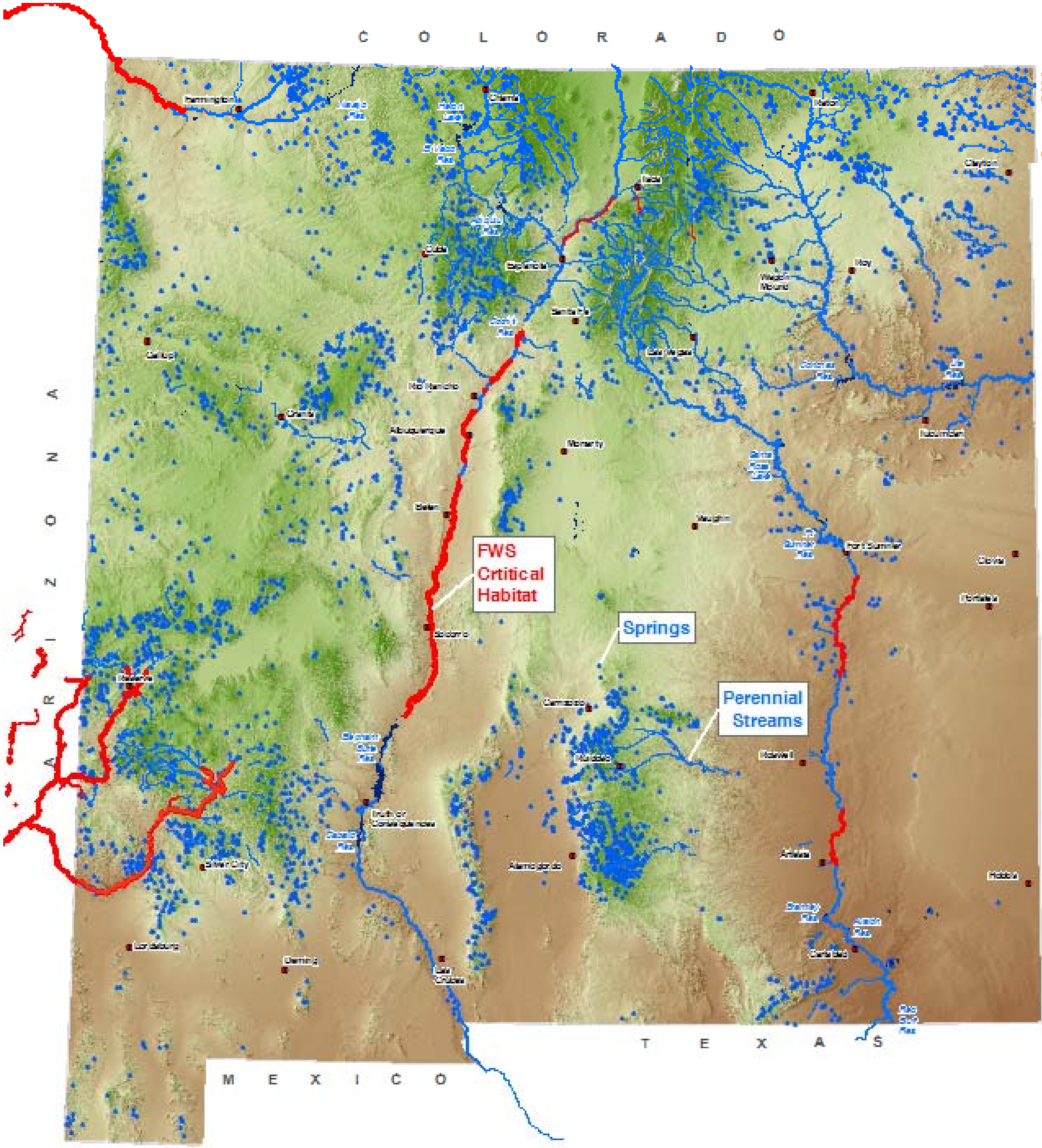
ALBUQUERQUE BASIN EQUILIBRIUM WITH 215,000 AFY PUMPING

Is this condition sustainable in view of hydrology, ecology, and downstream obligations?

THE GROUNDWATER IMPACT PROBLEM



How much to be reserved for ecological waters and downstream obligations, or taken for economic use?



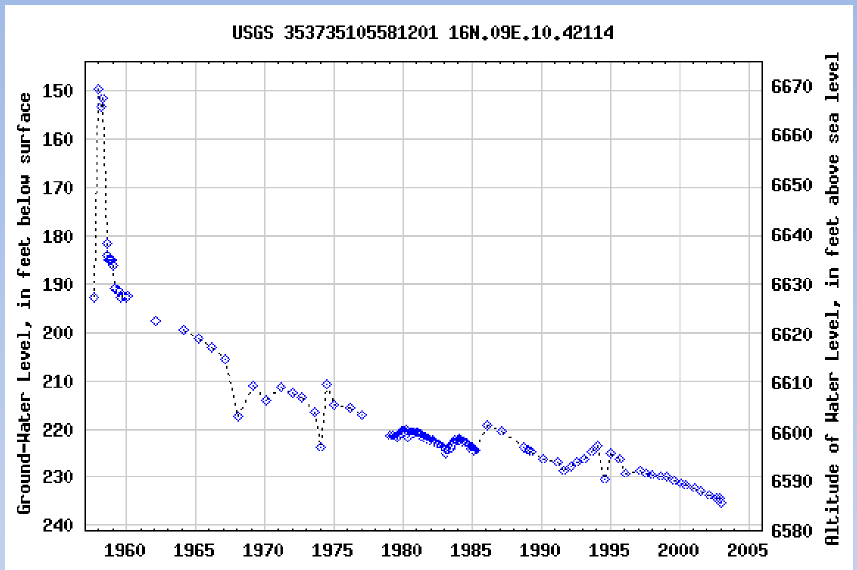
ECOLOGICAL WATERS

>5700 Miles of Perennial Streams

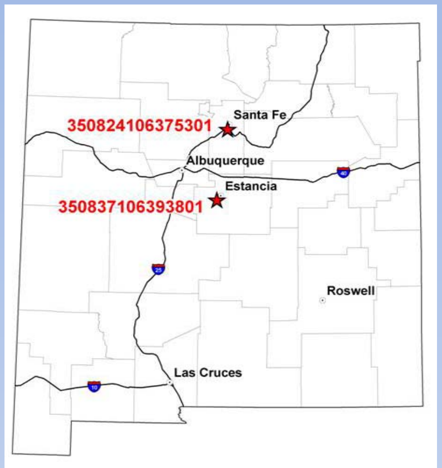
> 4600 Springs

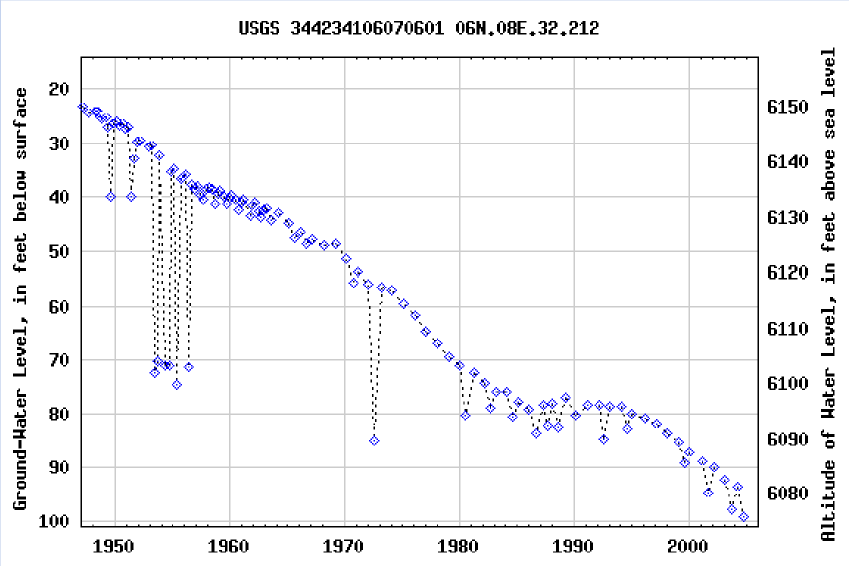
An Estimated 100,000 to 200,000 AFY Riparian Loss

REGIONAL TREND EXAMPLE

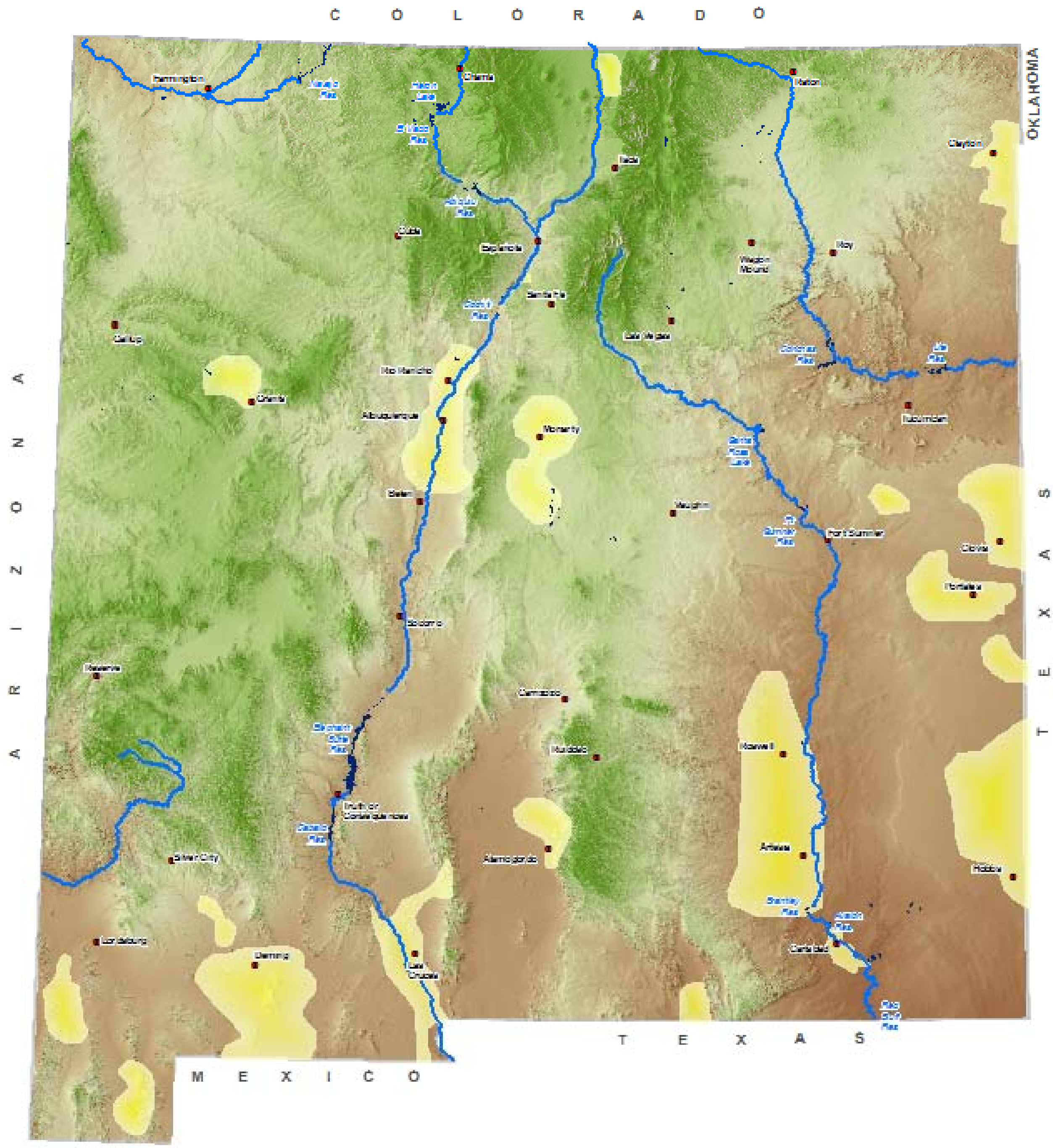


SANTA FE





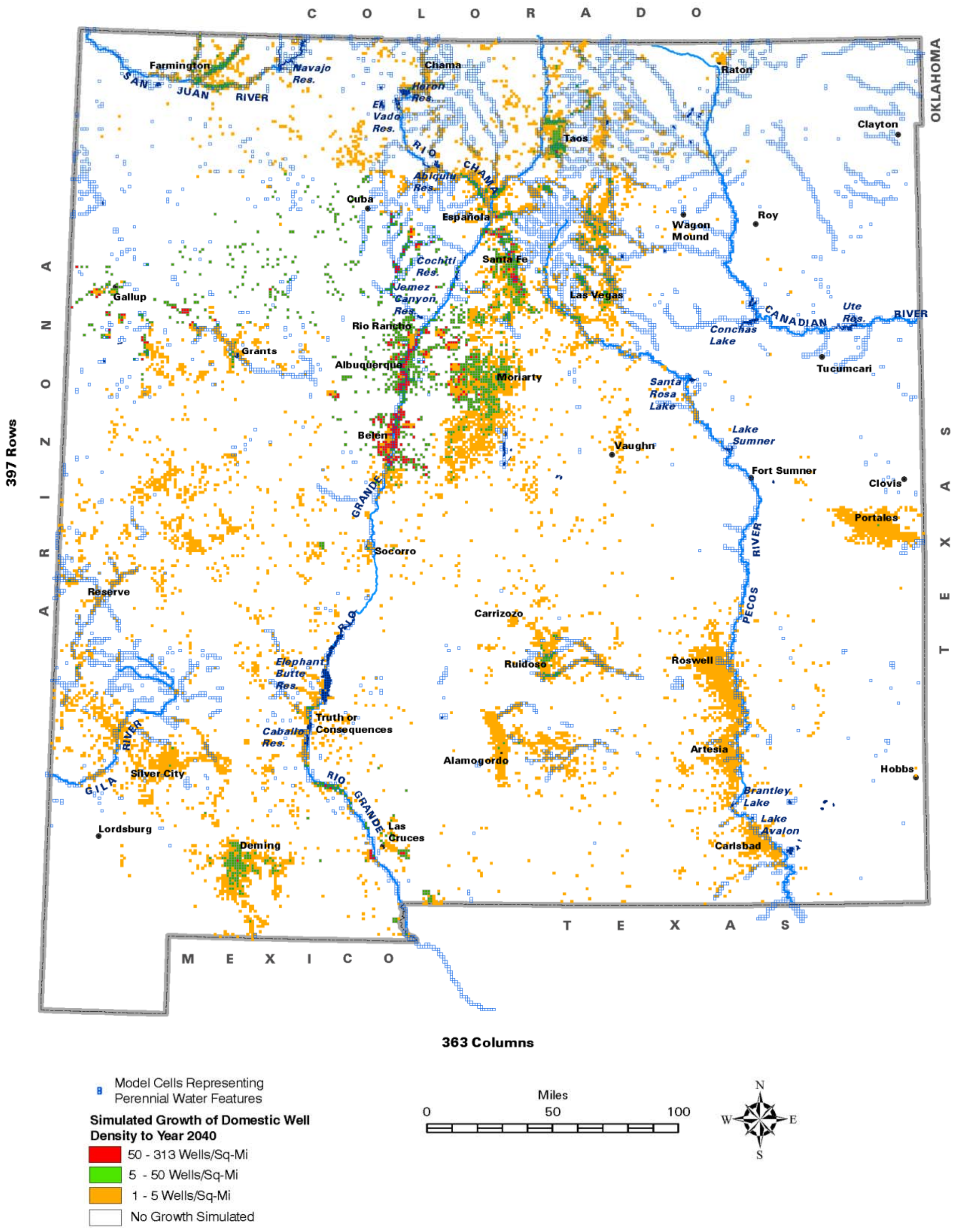
ESTANCIA



AREAS OF AQUIFER DRAWDOWN

Adapted from: USGS, 1972, New Mexico State Water Plan: Map Showing Observed Changes of Ground-Water Level and Hydrographs of Selected Wells in New Mexico.

STATEWIDE MODEL GRID AND WELL DENSITY



AQUIFER SOURCES STATEWIDE PERCENT OF PUMPING

	Year	
	2000	2040
Surface Water Depletion	28%	33%
Aquifer Storage Depletion	72%	67%

Note: Time to equilibrium (0% storage, 100% surface) is typically 100 to 1,000 years in New Mexico aquifers

“GOOD STATUS” AQUIFER INDEX OF INTERIM SUPPLY

- Major aquifer volume in storage to desired depth (say 100 feet) for use in the intended period (say 100 years) adjusted for capture of ET and flood waters

= Interim Supply for term development

- Aquifer Interim Supply ÷ basin PE = Index of basin area than can be developed for interim

Note: ET salvage, ecological conditions at the water table, capture of rejected recharge in wetlands, and induced recharge of flood waters are best managed by groundwater operations, rather than surface-water operations.

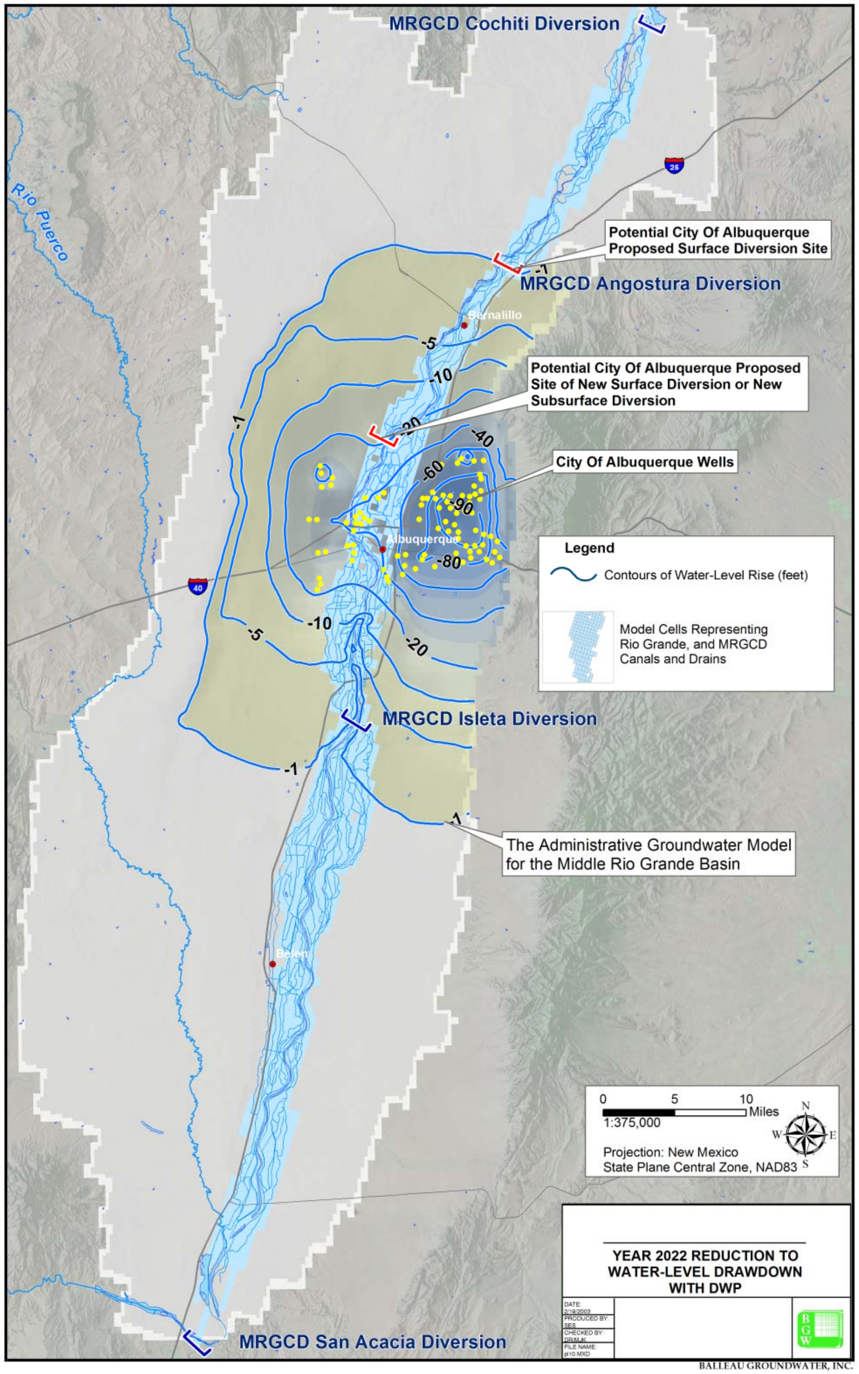
AQUIFER RESTORATION

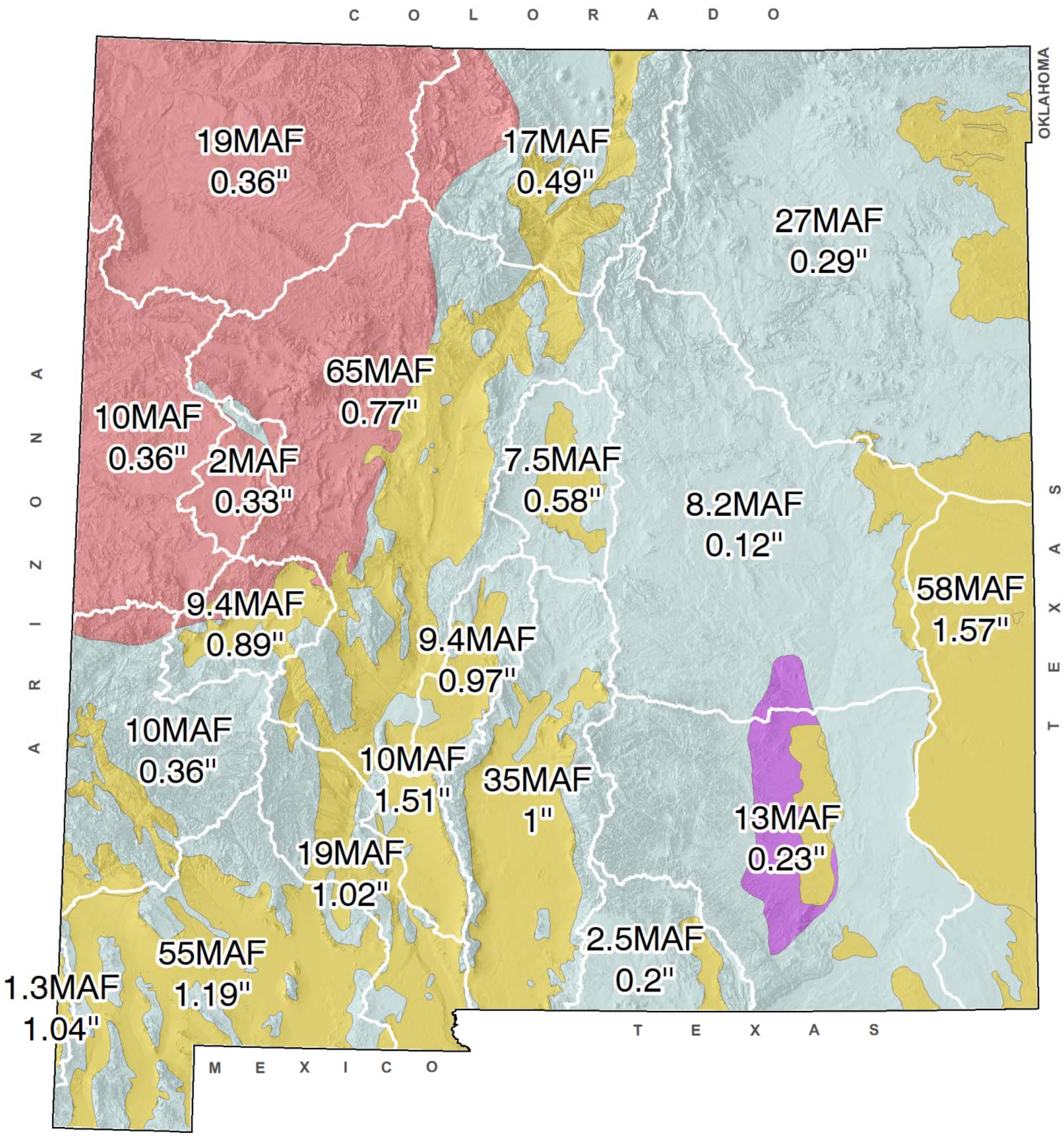
<u>Question</u>: After the interim period, can sustainable water be taken from the stream, or only from wells?
<u>Answer</u>: Wells, until sources such as non-divertible flood flows and ET salvage refill the aquifer space.

- Wells can be more effective surface diversions than are canals of limited capacity. By creating aquifer space to be recharged, previously unmanaged ET losses, non-divertible flood flows and surface reservoir spills, can be retained for basin use.

Note: The 2.5 million AF depleted from Albuquerque Basin aquifer storage is comparable to the volume spilled from Elephant Butte.

Drinking Water Project in OSE Administrative Model Places 252,000 AF from River into Aquifer Storage



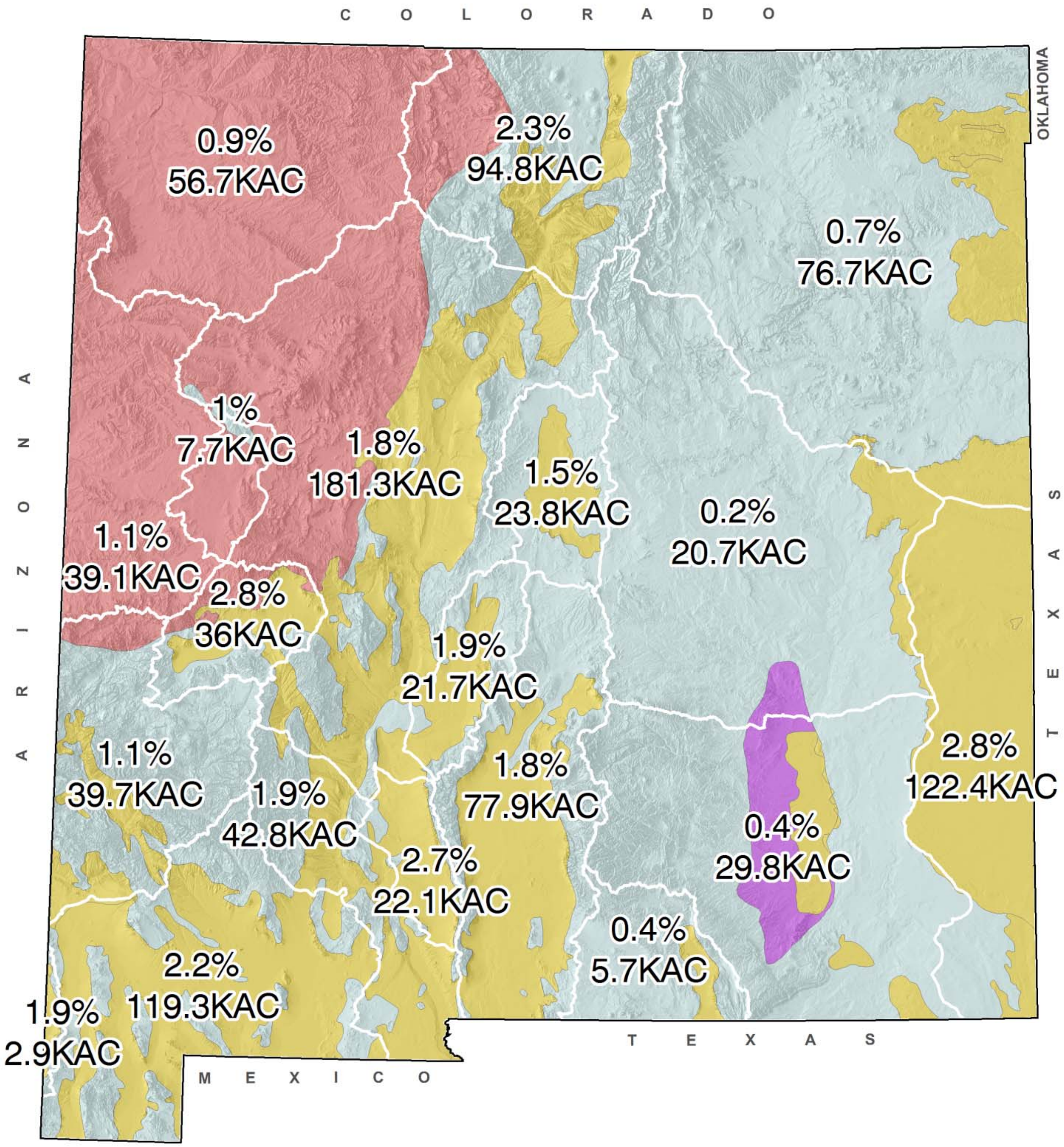


MAJOR AQUIFER STORAGE TO 100 FT AND INCHES PER YEAR OVER 100 YEARS

SUM=378.3 MAF = 210 years at 1.8 MAFY current Q

Legend

- Basin Fill and Alluvual Aquifers
- San Juan Basin Aquifers
- Roswell Basin Artesian Aquifer
- Local Aqufer Systems



BASIN AREA THAT CAN BE DEVELOPED FROM TRANSITIONAL STORAGE

Aquifer index and approximate area served for interim period

SUM = 1000 KAC term GW
v.
773 KAC SW

SUSTAINABLE GROUNDWATER

- Creates a managed, desirable groundwater condition regarding levels and chemistry.
- The “available groundwater resource” is the amount that also achieves ecological objectives (European Water Directive 2000).
- Administering water rights does not result in ecologically sustainable groundwater development. Permitted water use is about half the water loss in New Mexico basins.
- The benefits of groundwater storage development need not be abandoned in the name of “sustainability”.

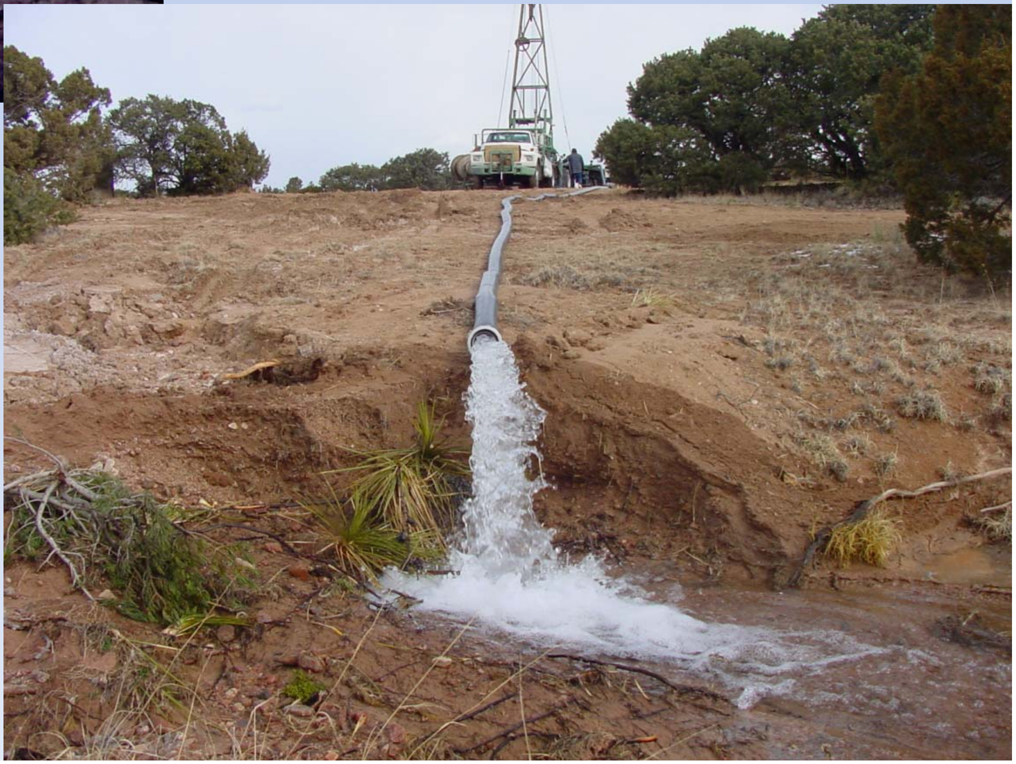
Conclusion

- New Mexico generates sufficient “blue” water (2 MAFY) to sustain aquifer development at today’s level of consumptive use.

- The 3.95 MAFY of Statewide use, half surface and half groundwater, (OSE Tech Report 52) at 50% CU is sustainable. Groundwater can expand the level of today’s use for beyond 100 years.

- An integrated water-accounting model of the state with serviceable aquifer/stream relationships is lacking, but the need is ripe for use in planning.

Yemen ranked as “most overexploited aquifers”
-World Bank



New Mexico
still sustainable

"Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. It is a prerequisite to the realization of all other human rights".

(U.N. Committee on Economic Cultural and Social Rights)