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"A MODELING PERSPECTIVE ON THE TRANSBOUNDARY NATURE OF THE ALLENDE – PIEDRAS NEGRAS AQUIFER"

BY

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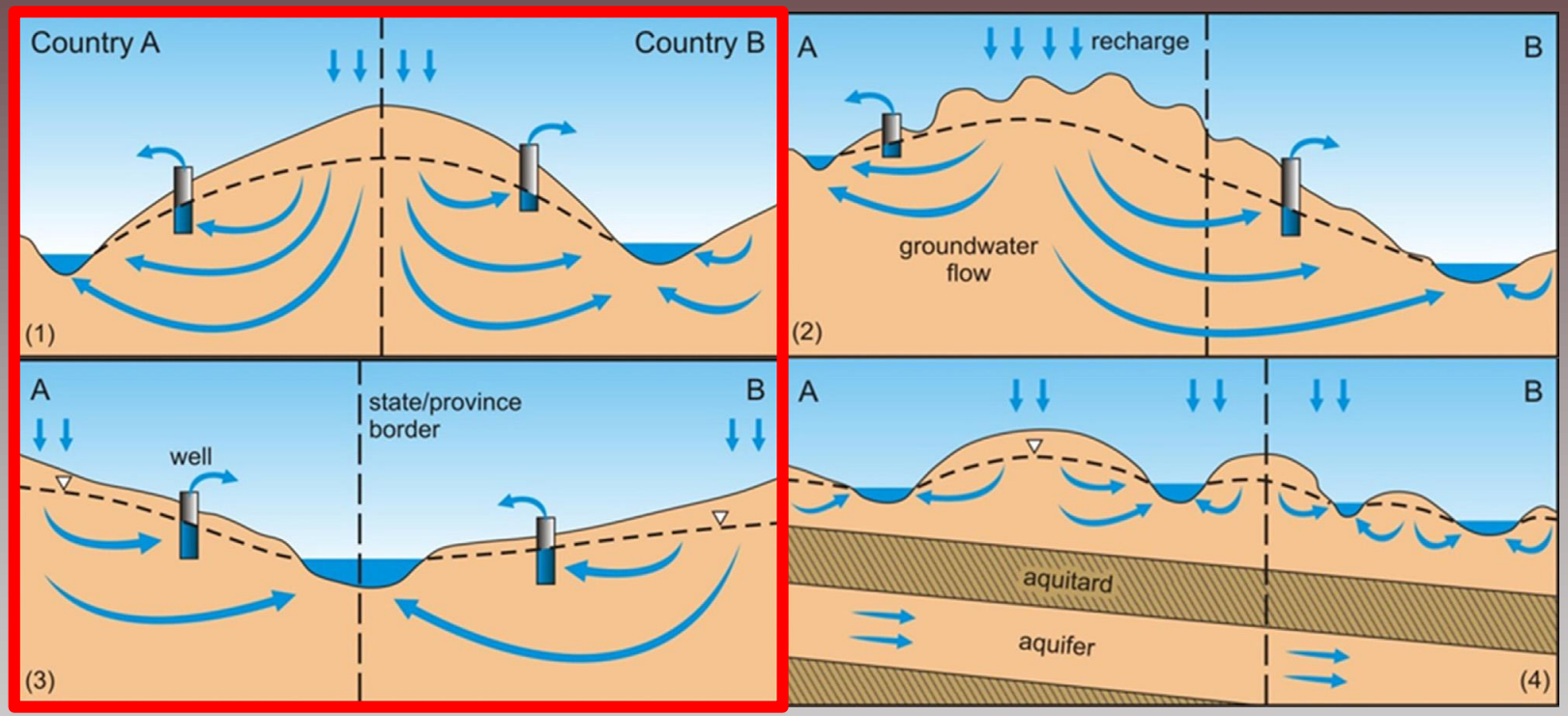
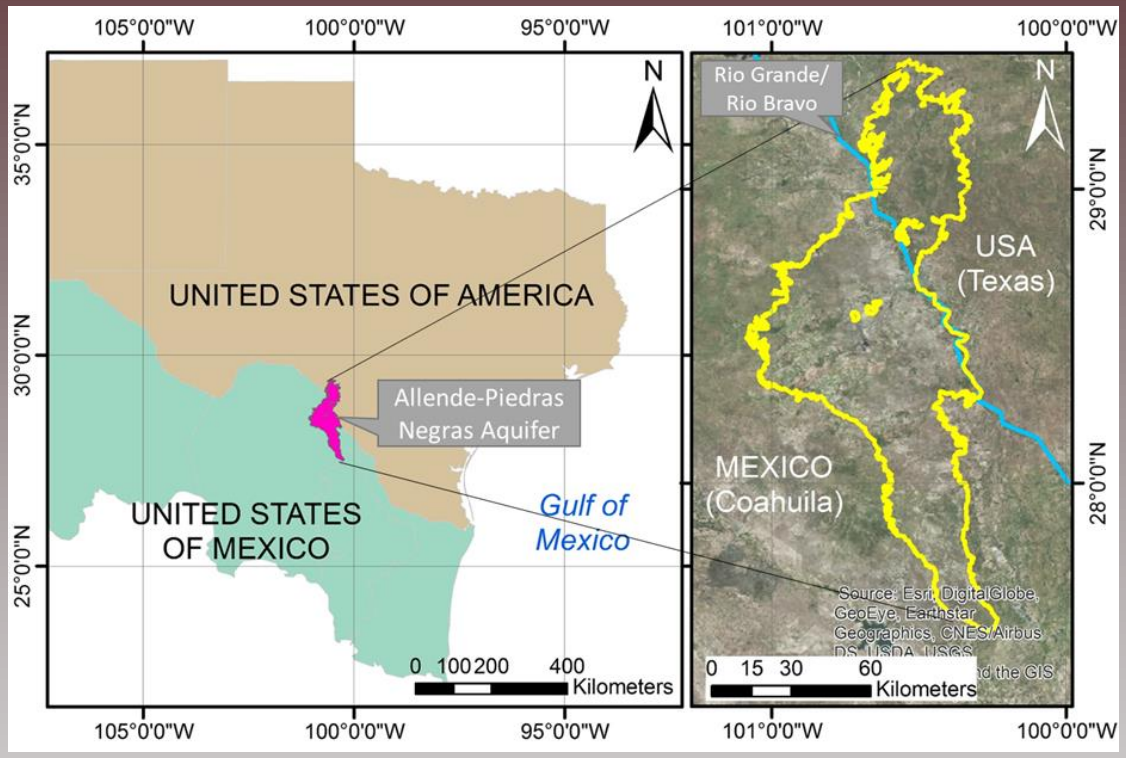
WHAT IS A TRANSBOUNDARY AQUIFER?



- IT IS A NATURAL SUBSURFACE PATH OF GROUNDWATER FLOW, INTERSECTED BY AN INTERNATIONAL BOUNDARY, SUCH THAT **WATER TRANSFERS FROM ONE SIDE OF THE BOUNDARY TO THE OTHER.**

CRITERIA FOR AQUIFER SELECTION



P=500 mm/yr
T=20° C
ET=433 mm/yr

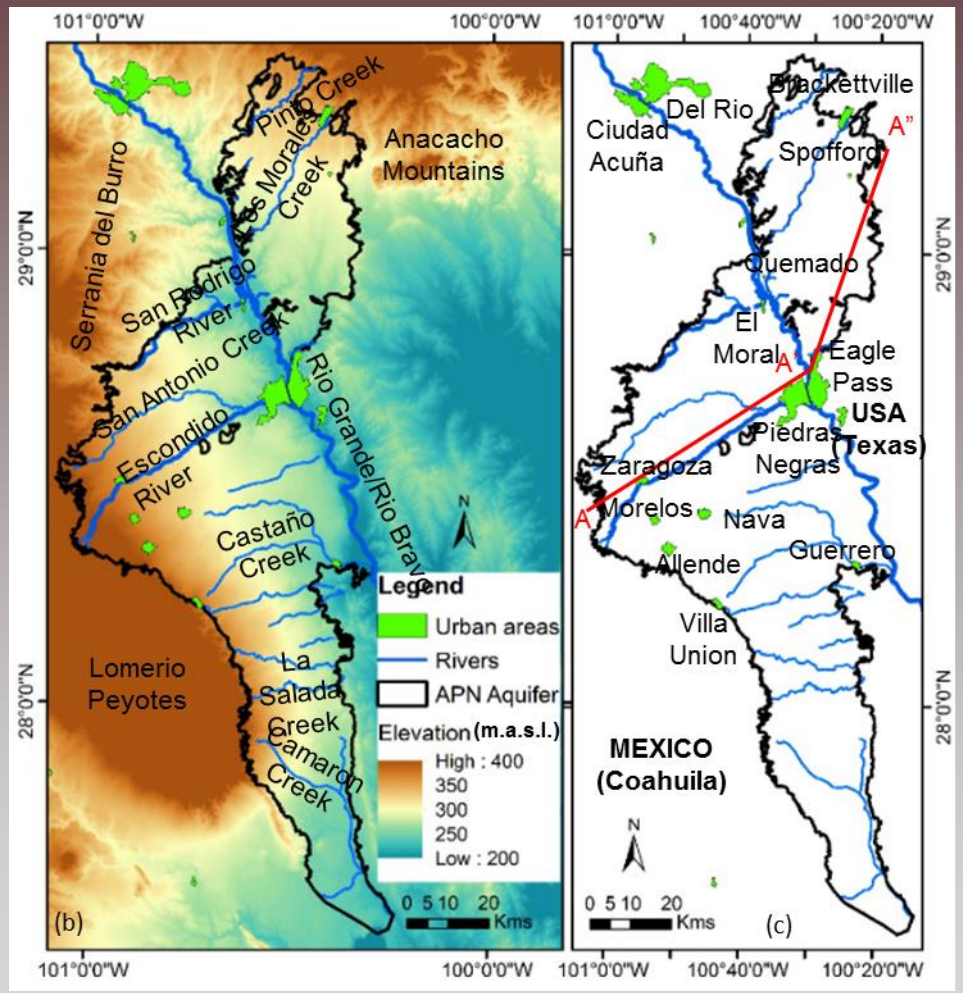
7023.8 km2
5426.8 km2 in Mexico
1597 km2 in USA

337309 pop.
92% Mex - 8% USA

- Location.
- The bi-national 1944 water treaty (allocation of 350000 acre/feet water per year flowing into Rio Grande from USA and Mexico).

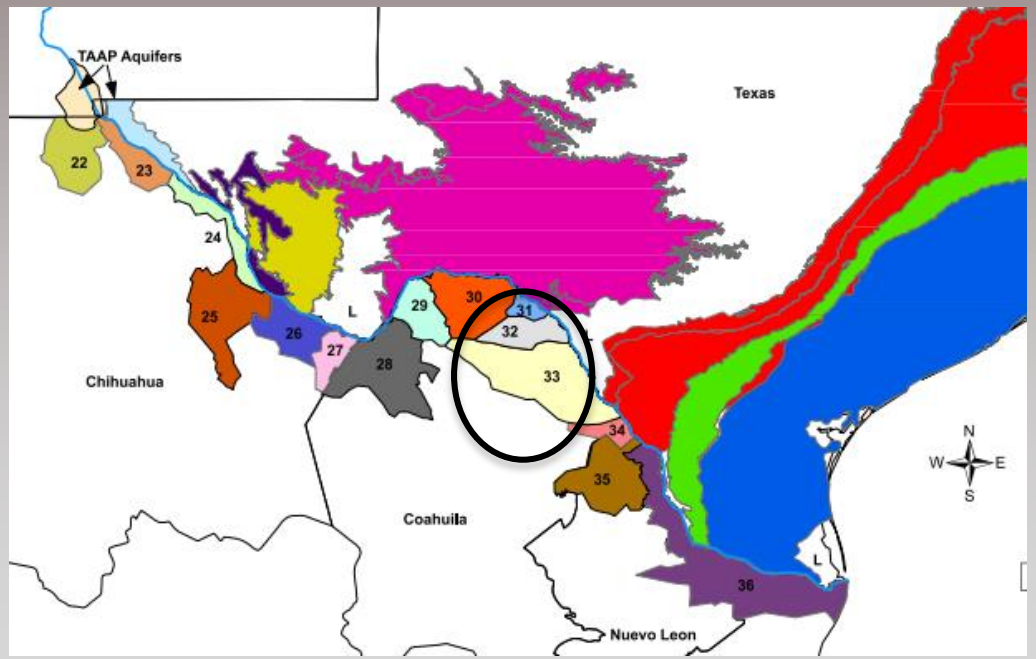
CRITERIA FOR AQUIFER SELECTION

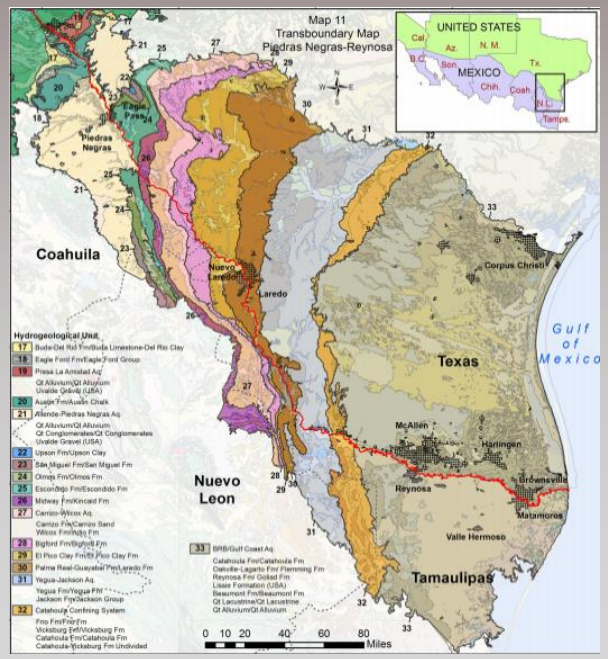
- Escondido River fulfills part of the 1944 water treaty.
- Material extraction over San Rodrigo river affects the riparian zones causing deforestation and water quality degradation.



CRITERIA FOR AQUIFER SELECTION

- 36 potential transboundary aquifers have been identified in the Mexican-U.S border (Sanchez et.al., 2016; 2018). 16 aquifers were identified as transboundary. Only 11 aquifers recognized officially as transboundary by Mexico and the united states.



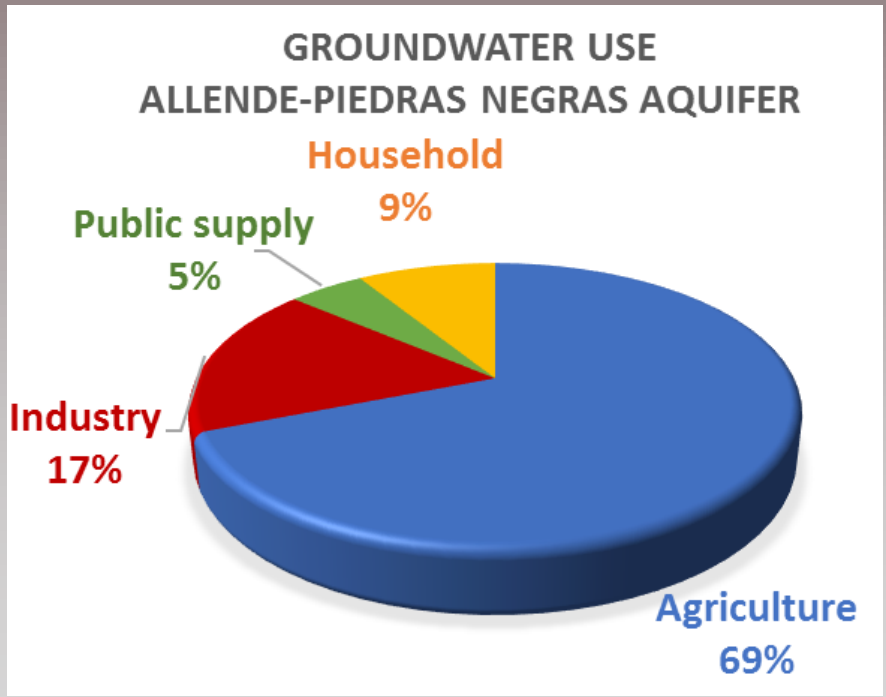


CRITERIA FOR AQUIFER SELECTION

- Socioeconomic factors (mining, agriculture, cattle, other industries).
- Population growth of 3.7% adding pressure to the nat. res. on the border.

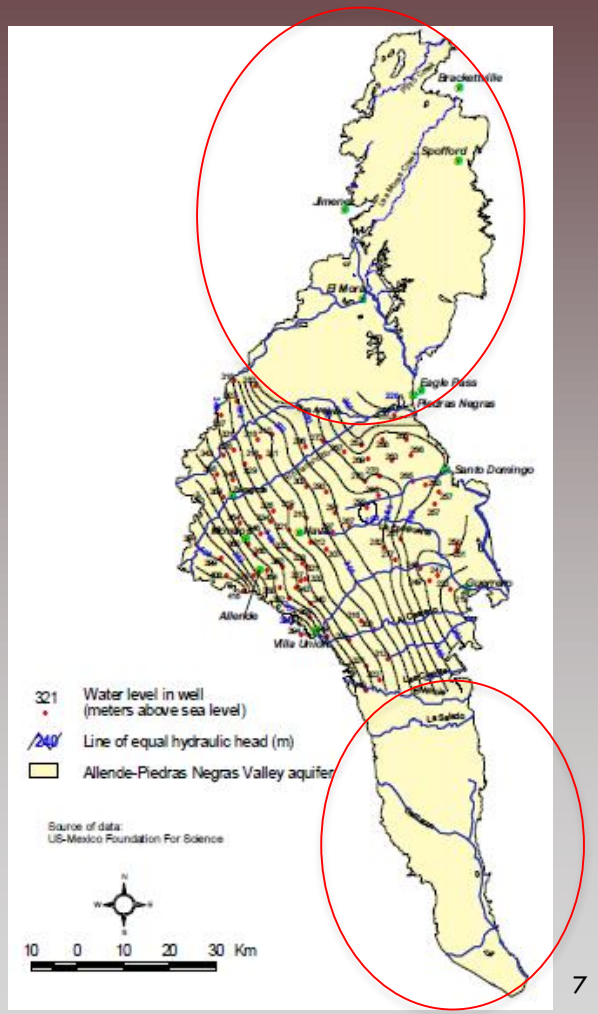
15 %

85 %



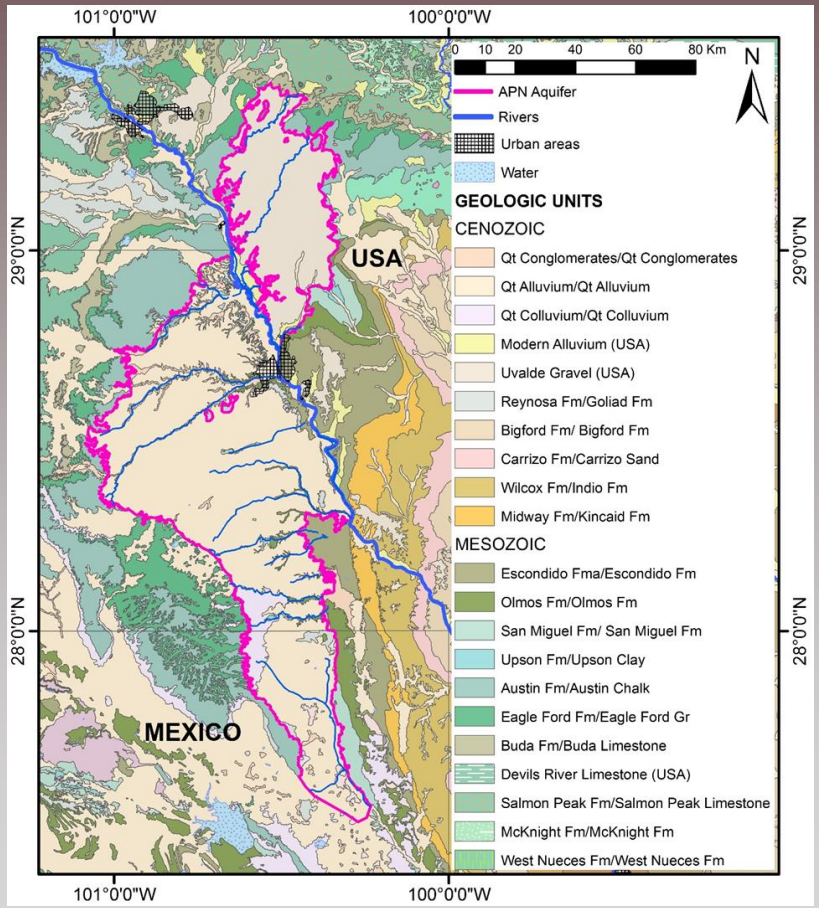
OBJECTIVES

- To include Texas and southern portions of the aquifer to better understand the transboundary nature of the system.
- Update the aquifer model developed by Boghici (2002) and Grupo Modelo (2011) with recent information from both sides of the USA/Mexico border.



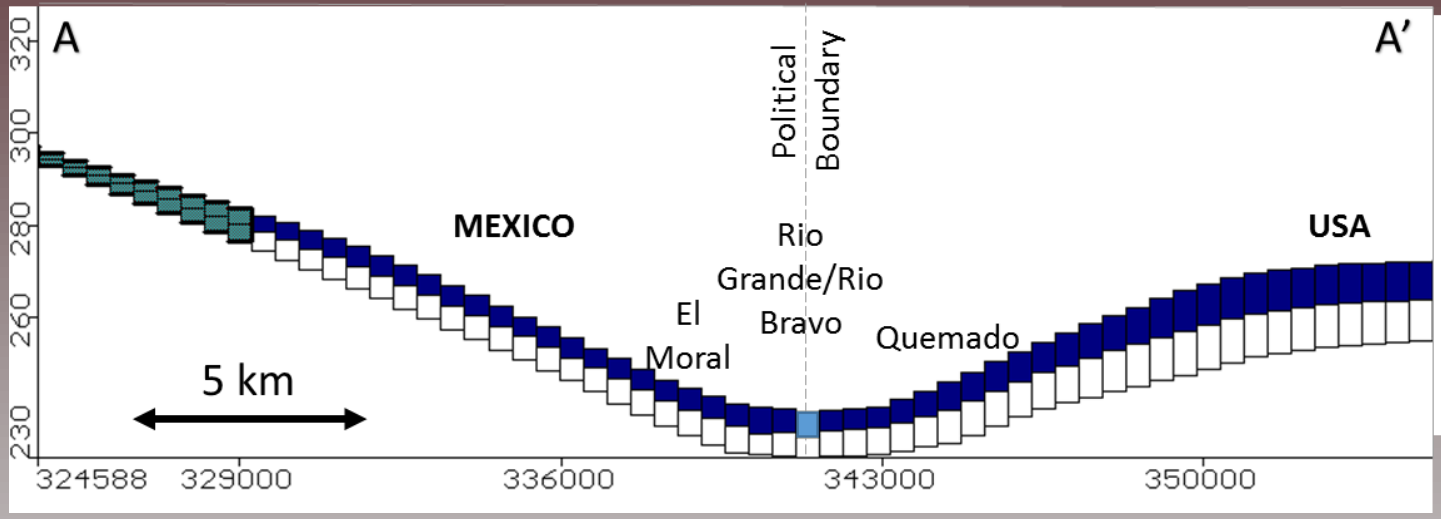
Boghici (2002)

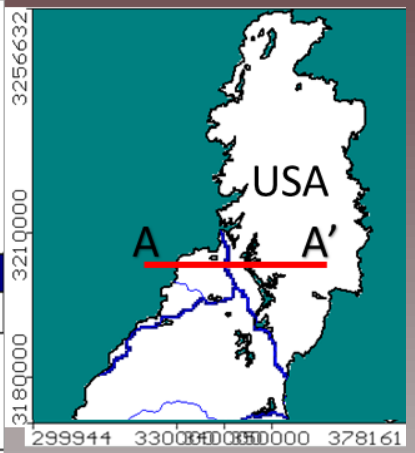
METHODOLOGY



- Aquifer geometry and boundary definition. 1-40m (geology)
- Data collection on:
  - Water levels measured from wells.
  - Daily river flow rates from river gages international boundary and water commission (IBWC)
  - Monthly precipitation and ET from remote sensing images (TRMM and GLDAS).

HYDRAULIC PROPERTIES

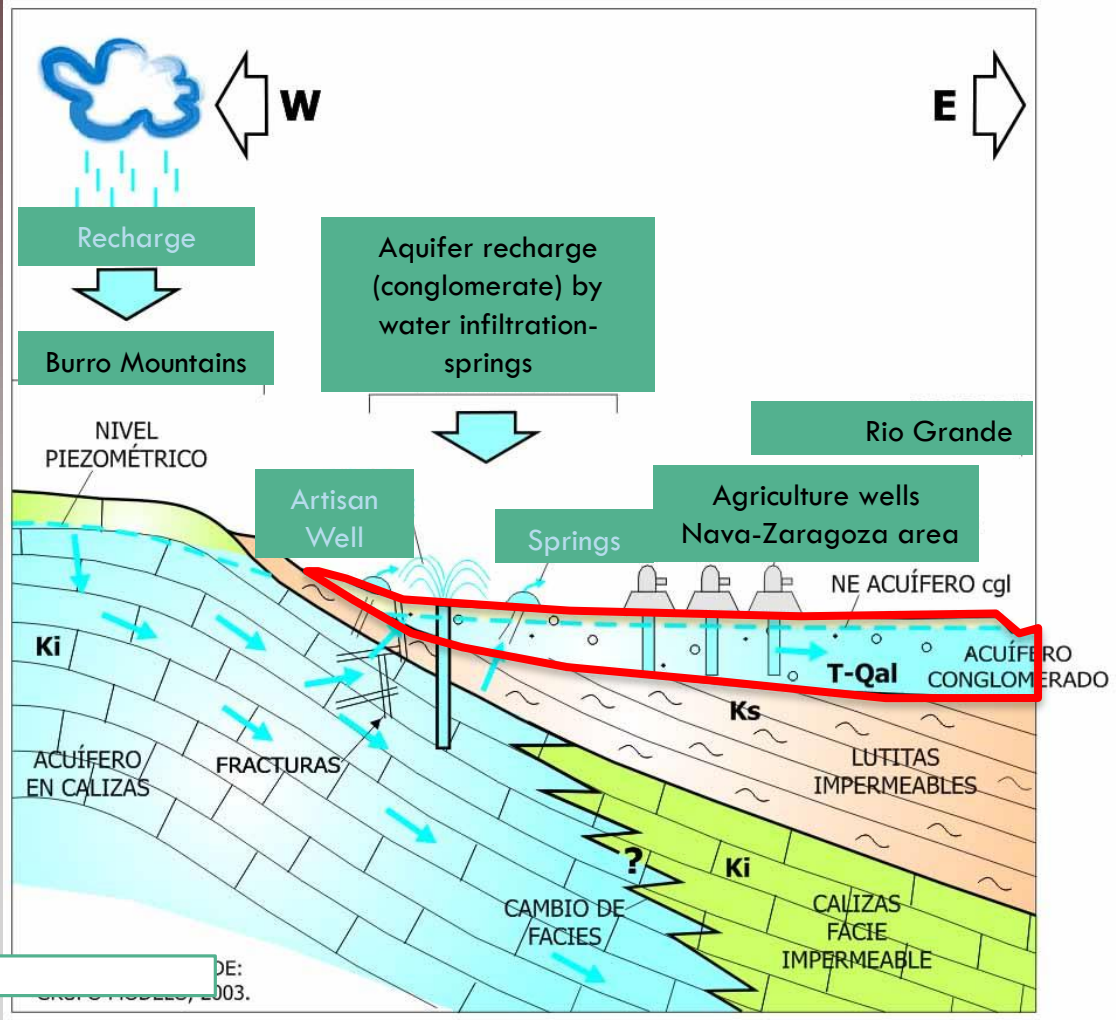




2 layers
n = 0.22
φ = 0.17
K = 7, 64, 160 m/day

Ss = 0.001
Pumping wells = 799
Water levels for 2008, 2011, 2014

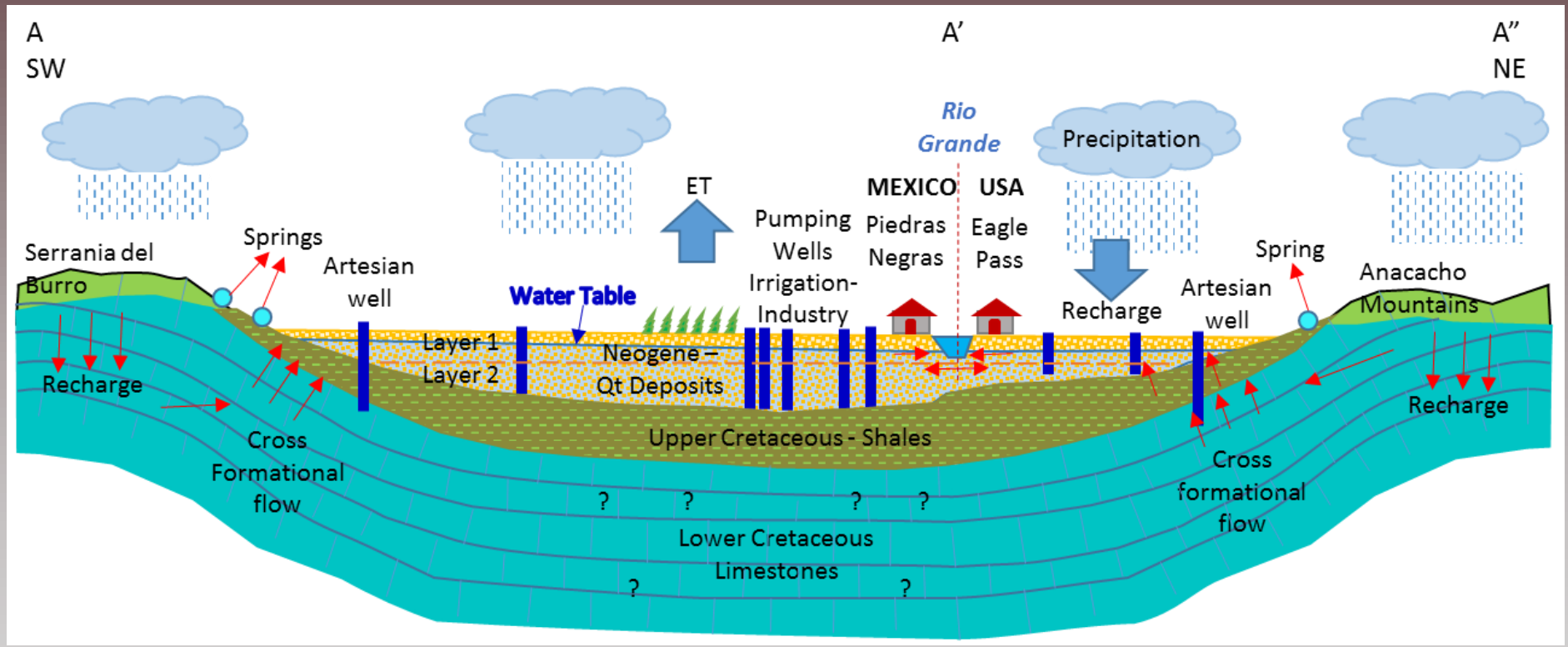
CONCEPTUAL MODEL AND BOUNDARY CONDITIONS



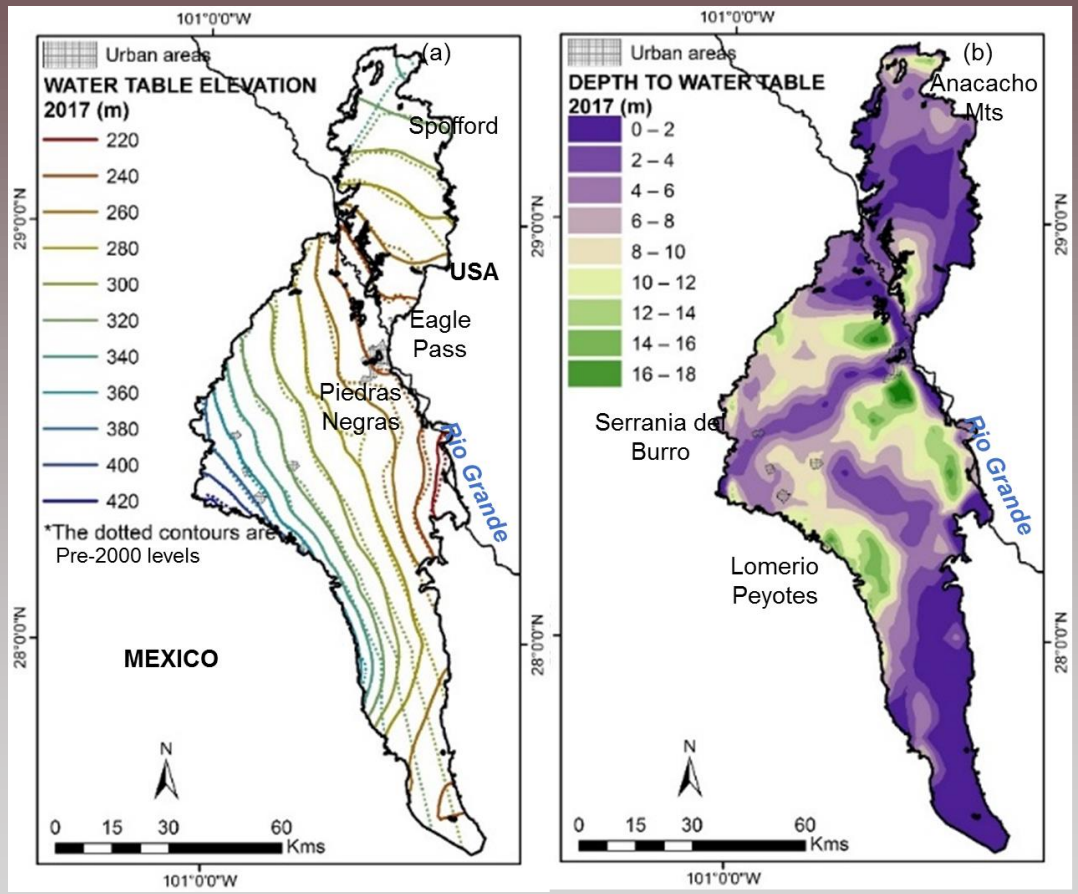
- Two layers for the model
- Unconfined aquifer
- No cross-formational flow
- Homogeneous lithology (gravel-sand)
- Modeled period 2000-2017

RESULTS

HYDROGEOLOGICAL CONCEPTUAL MODEL



WATER LEVEL EVOLUTION



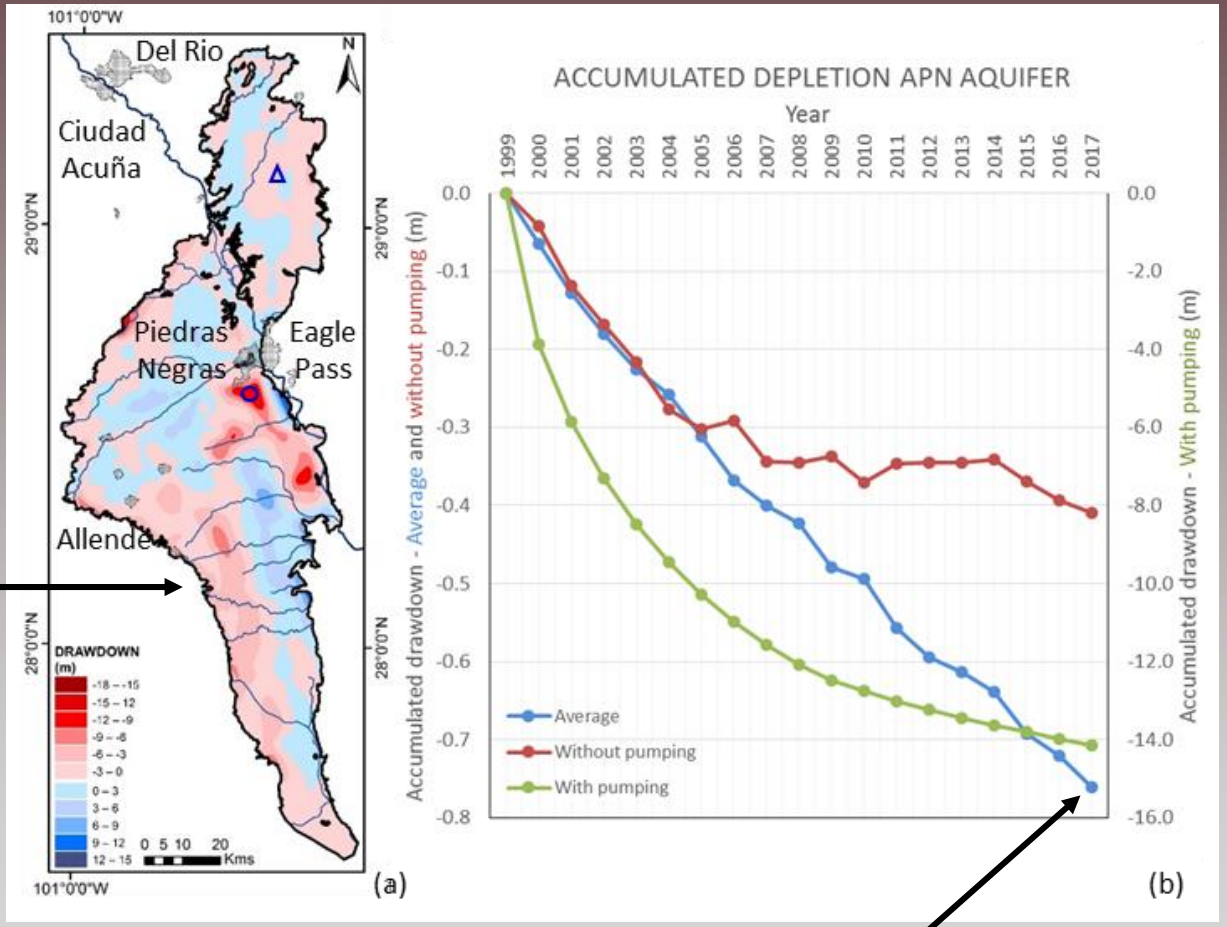
The water table follows the local topography.

Indicator of unconfined aquifers

Reversal of water flows with respect of topography.

TOTAL MODELED DRAWDOWN JANUARY 2000 - DECEMBER 2017

Border of the aquifer, low thickness

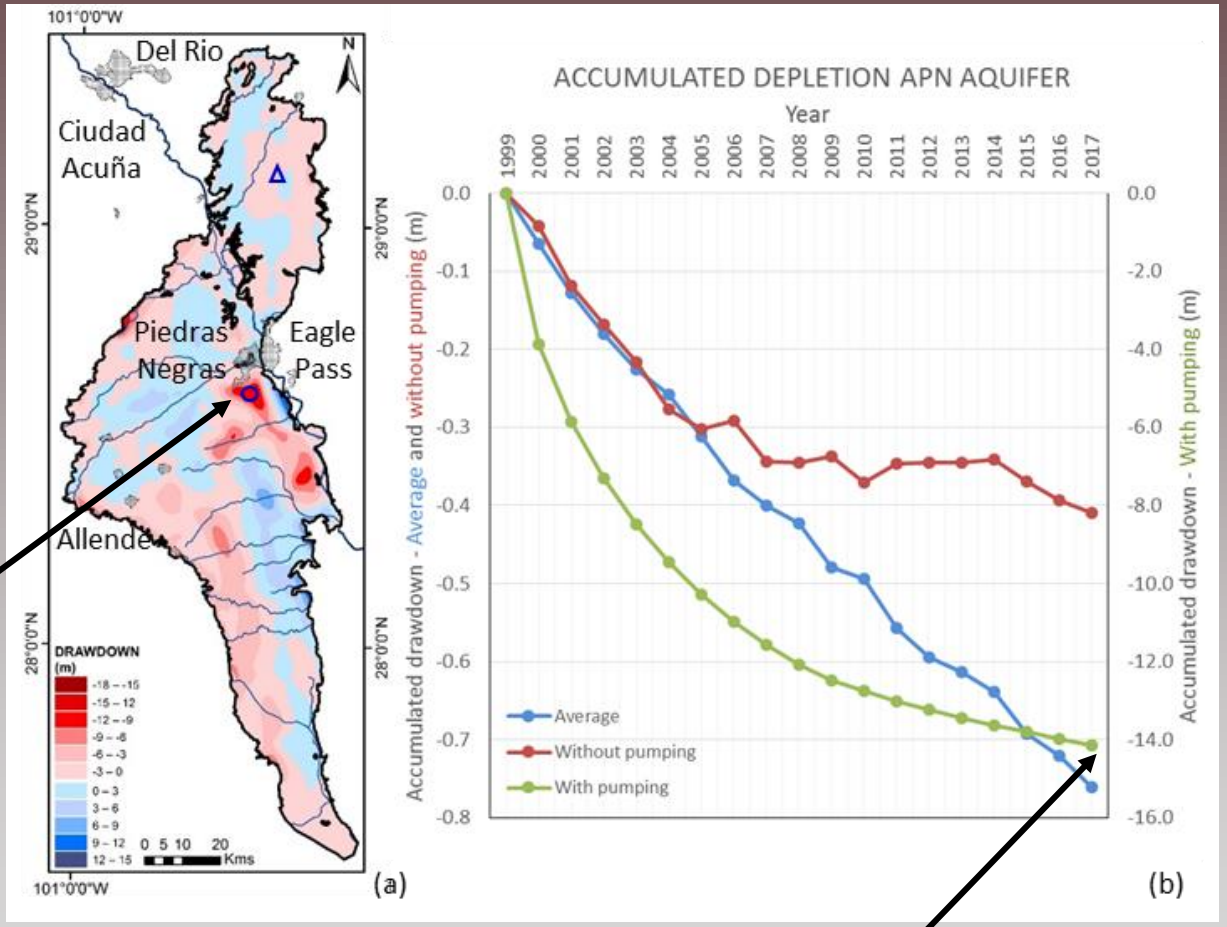


Average drawdown entire aquifer
0.76 m for 18 years

TOTAL MODELED DRAWDOWN JANUARY 2000 - DECEMBER 2017.

Extreme pumping

established industries between PN and Guerrero

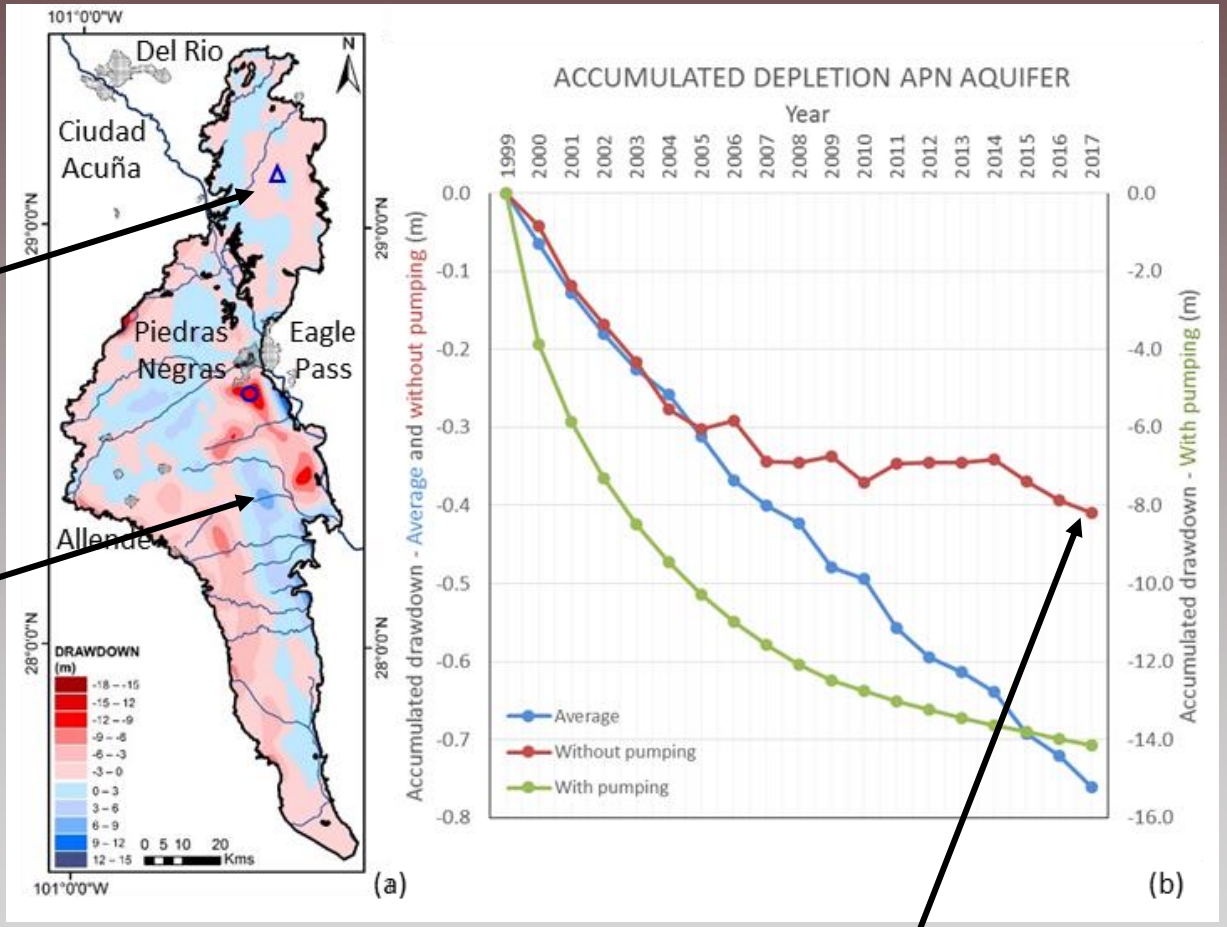


Drawdown of more than 14 m

TOTAL MODELED DRAWDOWN JANUARY 2000 - DECEMBER 2017.

No pumping

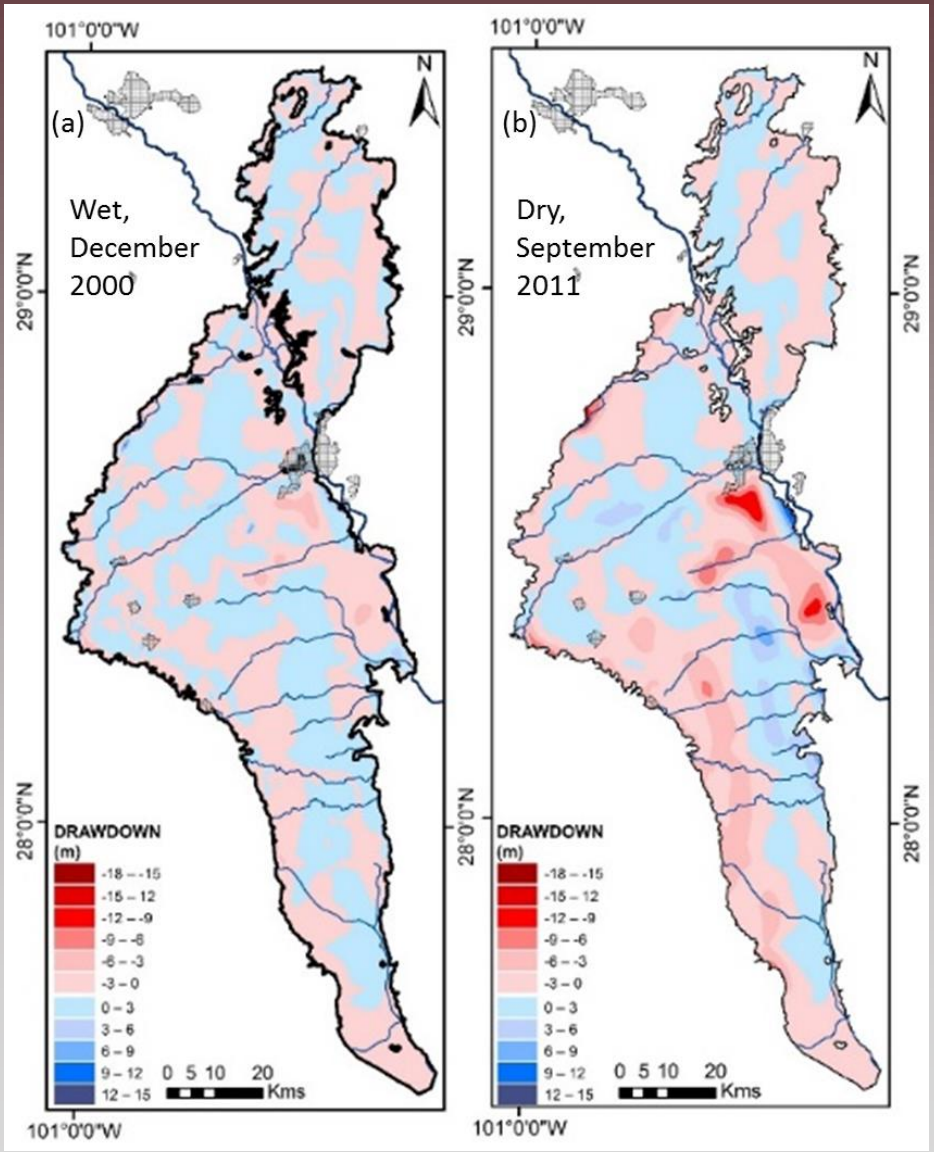
local water table recovery due to the cease of pumping activities



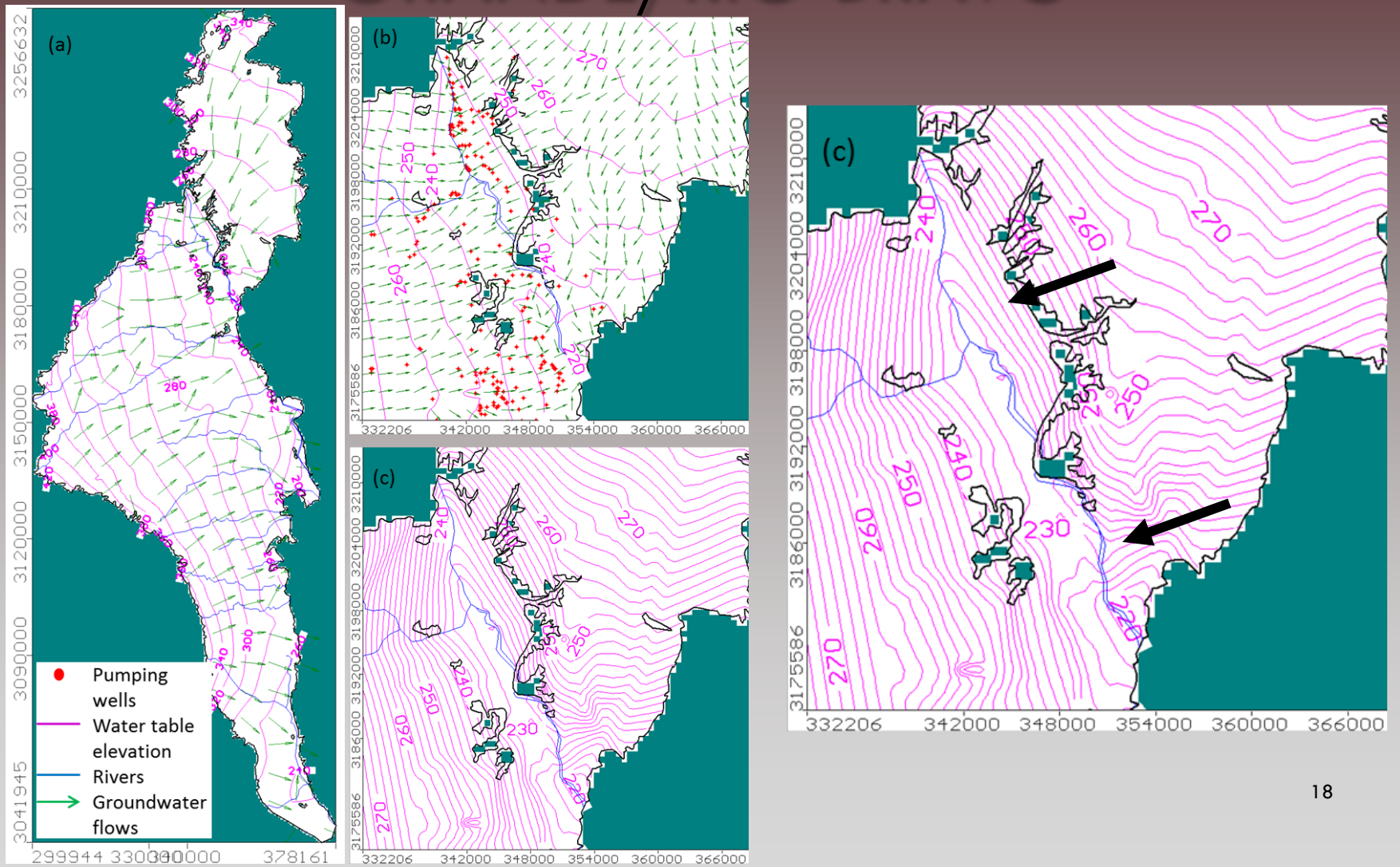
Drawdown of 0.4 m

WET-DRY SEASONS

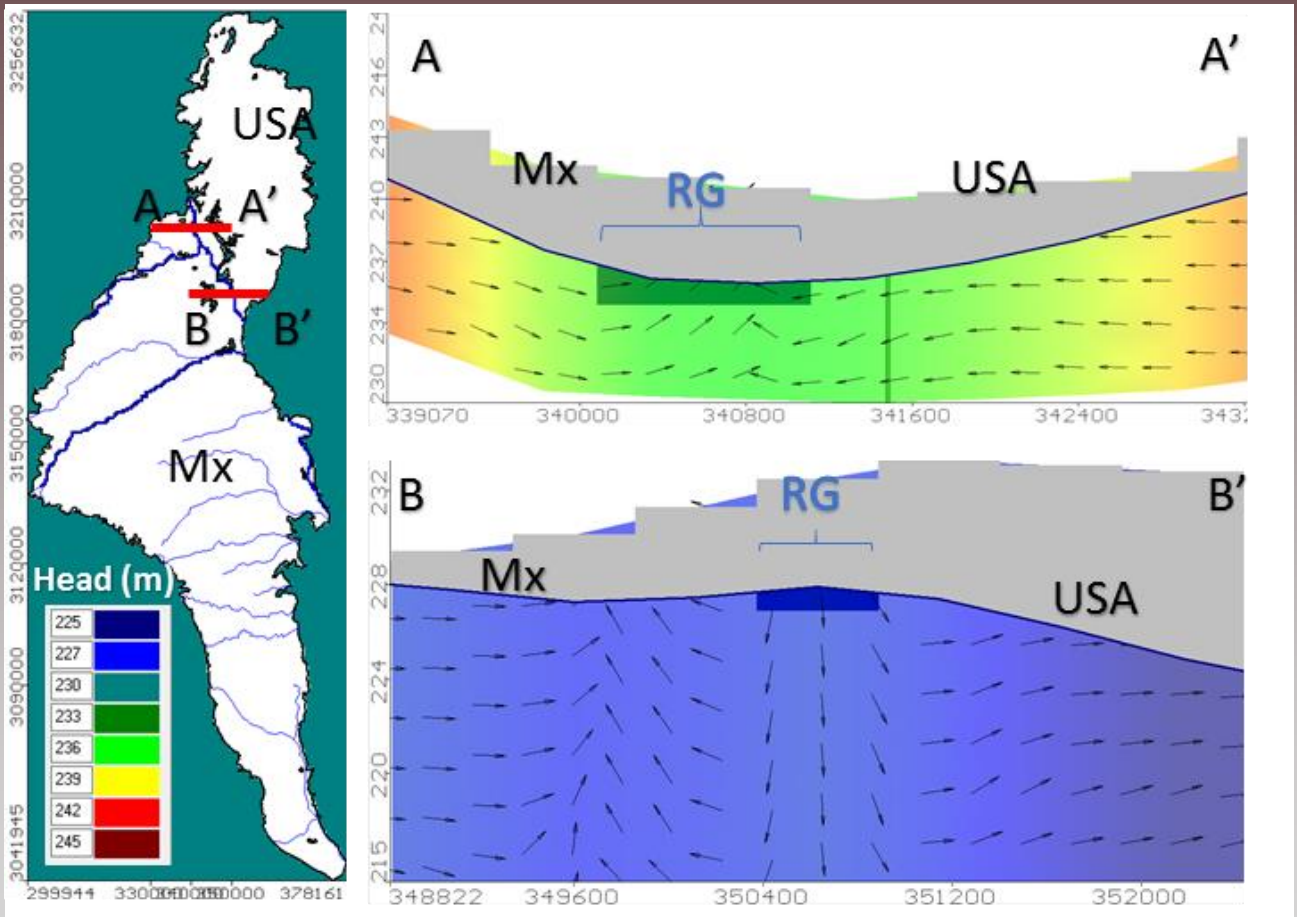
Deviation of water table from initial conditions during wet and dry seasons



WATER FLOW ACROSS RIO GRANDE/RIO BRAVO

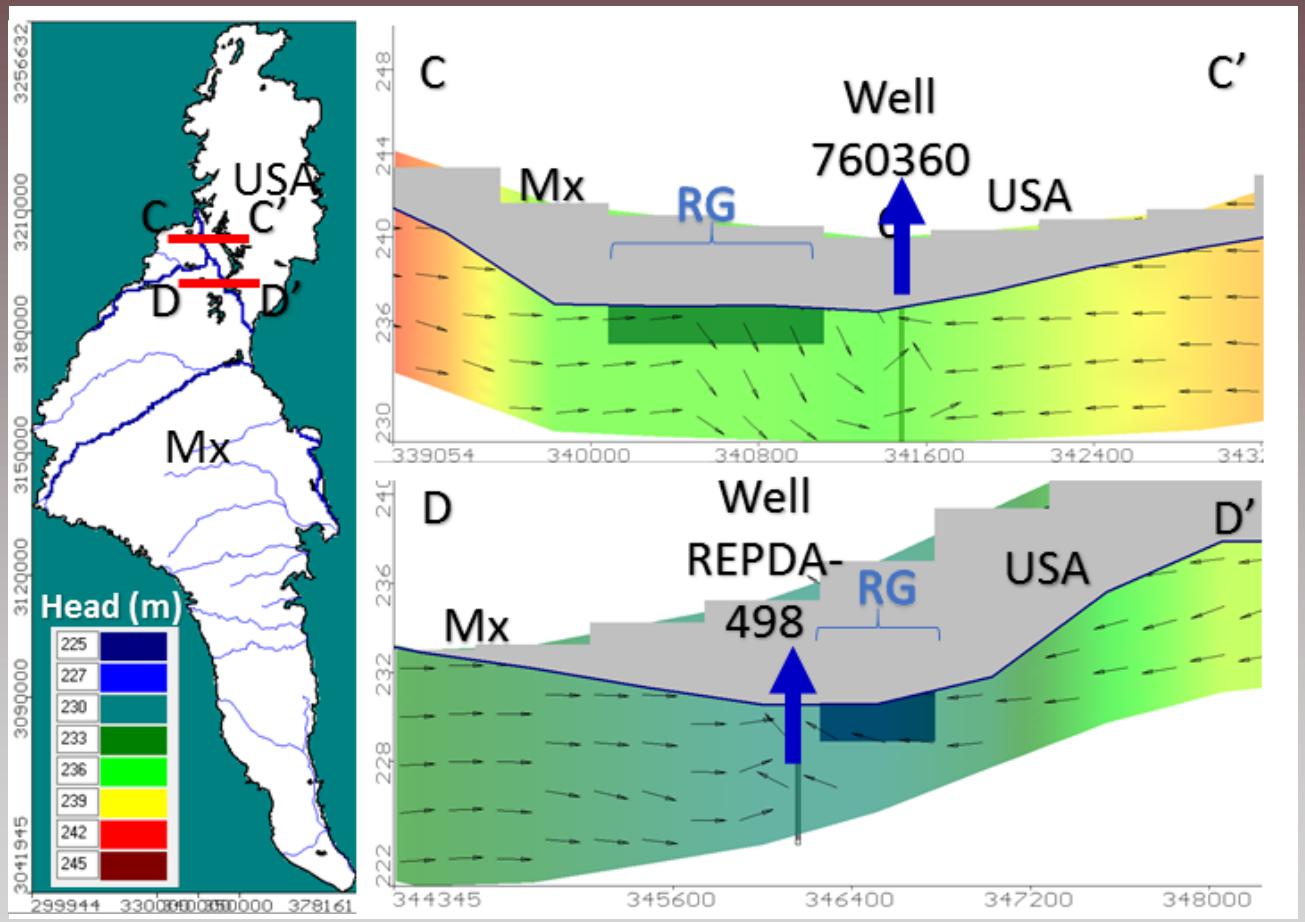


WATER FLOW ACROSS RIO GRANDE/RIO BRAVO



Pre-2000 conditions

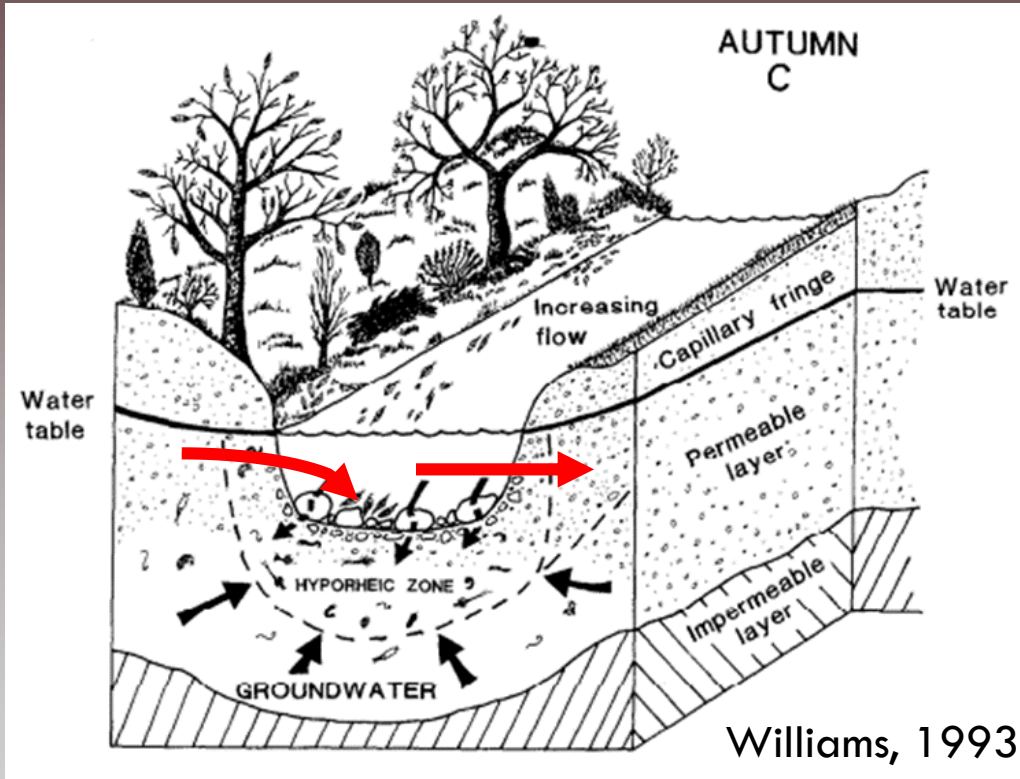
WATER FLOW ACROSS RIO GRANDE/RIO BRAVO



Post-2000 conditions under intensive pumping.

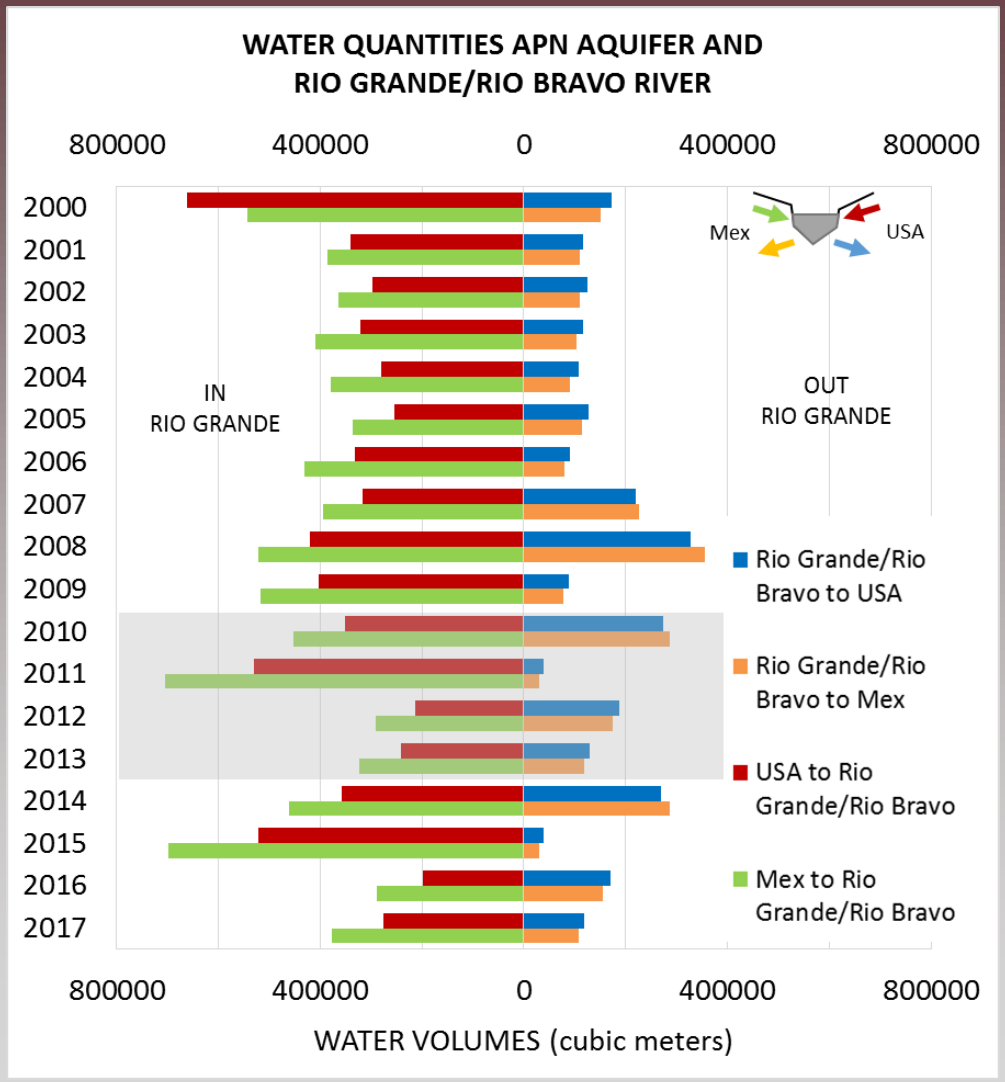
The extraction of groundwater affects the baseflow

WATER FLOW ACROSS RIO GRANDE/RIO BRAVO



Flow-through (Hoehn, 1998)

WATER BUDGET

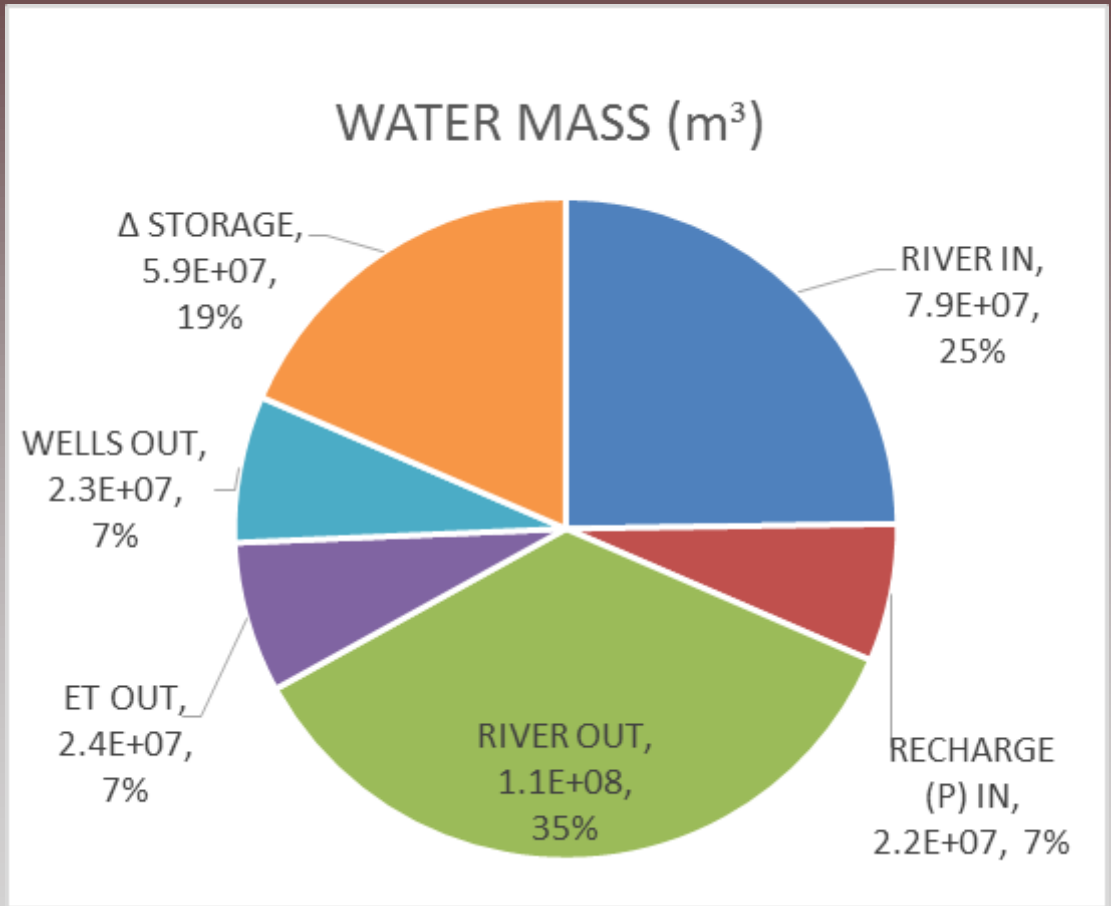


IN RG
56% from Mexico
44% from USA

OUT RG
49% into Mexico
51% into USA

The USA side captures a greater volume of recharge from the Rio Grande/Rio Bravo than Mexico

WATER MASS



Recharge < than Q(wells) + ET

Part of the water extracted comes from storage

CONCLUSIONS

- An average drawdown of 0.76 m was quantified for the simulation of 18 years. The aquifer has not recovered to pre-2000 water levels.
- Under pre-2000 conditions, the water flow paths from the aquifer converged into the Rio Grande, but after the growth in the number of pumping wells installed adjacent to the river, the flow convergence zone shifted to the side of the border with greater combined pumping rates. **This modification of the baseflow of the river and the change of hydraulic heads allows us to classify the APN aquifer as a transboundary groundwater flow system (Rivera, 2015).**

CONCLUSIONS

- According to the water budget, the amounts of water extracted from the aquifer surpassed the inflows, therefore the storage is still being depleted. This finding indicates that the APN aquifer is over-exploited
- Mexico pumps 95% of the total groundwater volume extracted per month from the APN, while Texas only accounts for 5%. This reflects the dependency on the APN aquifer in Mexico.
- The USA portion of the aquifer is discharging into the Rio Grande less water compared to the proportion discharging from Mexico. However, the proportion that recharges the U.S. portion of the APN aquifer from the Rio Grande is greater than the Mexican portion.

REFERENCES

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- CONAGUA 2014. Determinacion de la Disponibilidad de Agua en el Acuifero Allende-Piedras Negras, Estado de Coahuila. Mexico, DF: Subdireccion General Tecnica, CONAGUA.
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- SANCHEZ, R., RODRIGUEZ, L. & TORTAJADA, C. 2018. Transboundary aquifers between Chihuahua, Coahuila, Nuevo Leon and Tamaulipas, Mexico, and Texas, USA: Identification and categorization. Journal of Hydrology: Regional Studies.

THANK YOU!!!

QUESTIONS