Pumping it up:
ng and controlling groundwater depletion

Rebecca Nelson, Jessica Reeves, Vanessa Mitchell

Connecting the Dots: The Food, Energy , Water, and Climate Nexus

Stanford University

Friday, April 22, 2011

Overview

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1. Groundwater depletion – high level
   - The big picture problem
   - Policy and legal issues
   - Technical issues and uncertainties
   - Big picture connections

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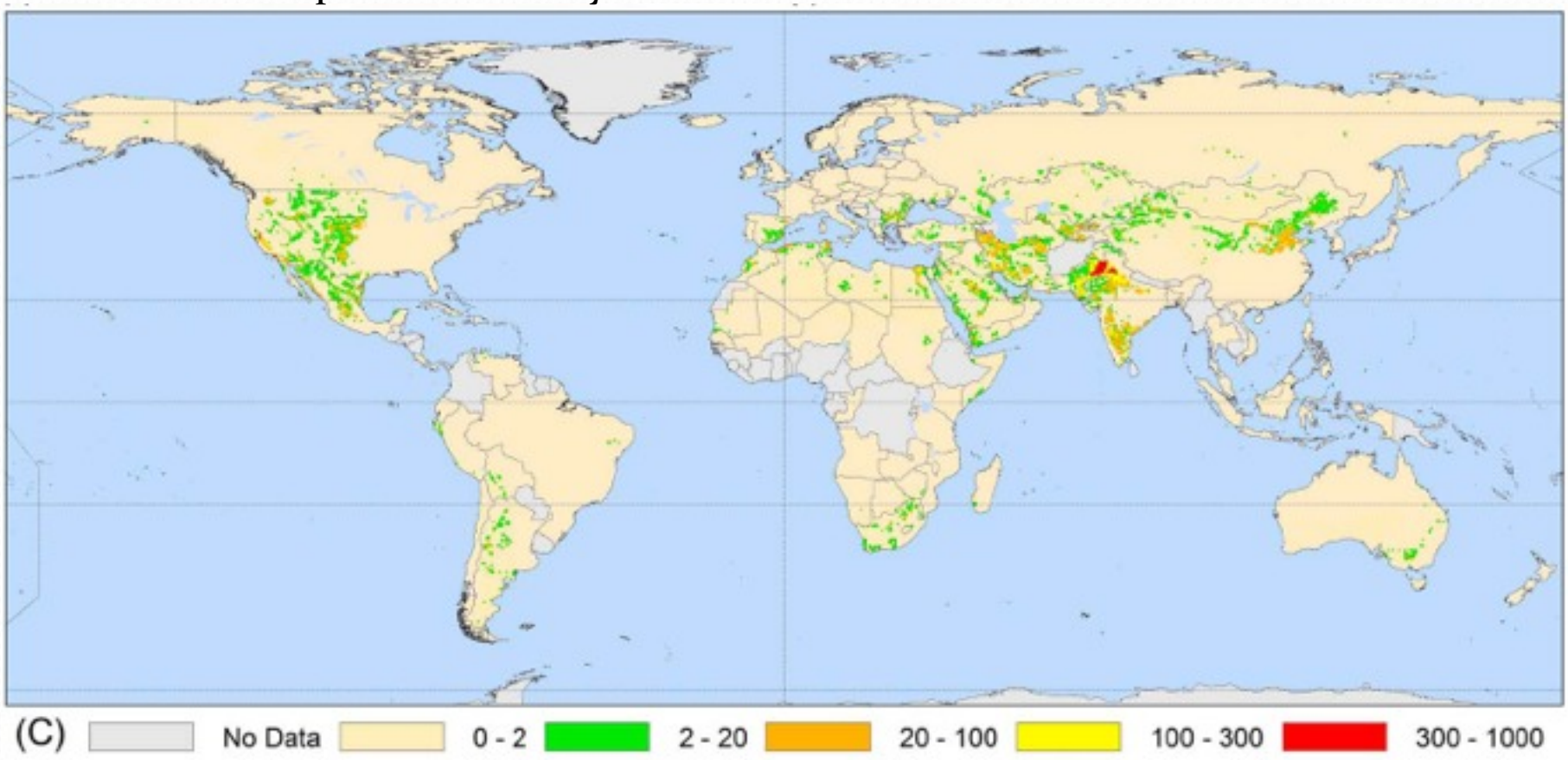
3. A taste of Stanford research

1. Groundwater depletion at a high level

Groundwater depletion:

The big picture problem

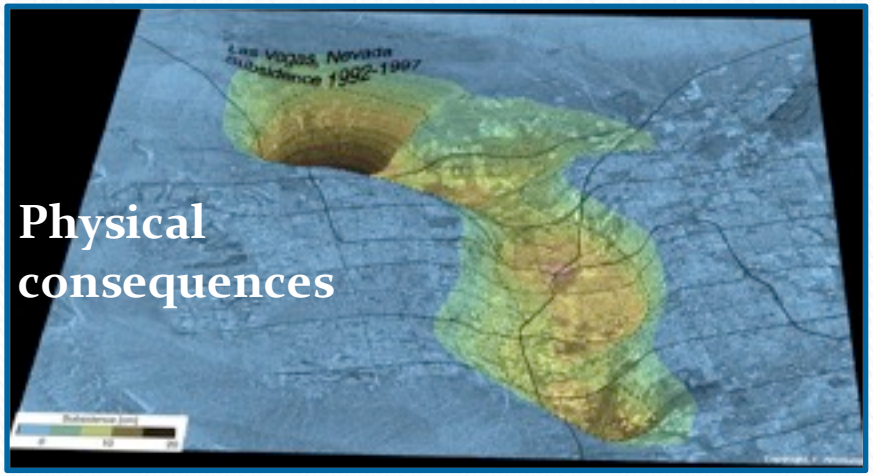
Groundwater depletion in mm/yr



Source: Wada et al, 2010.

Groundwater depletion:

The big picture problem



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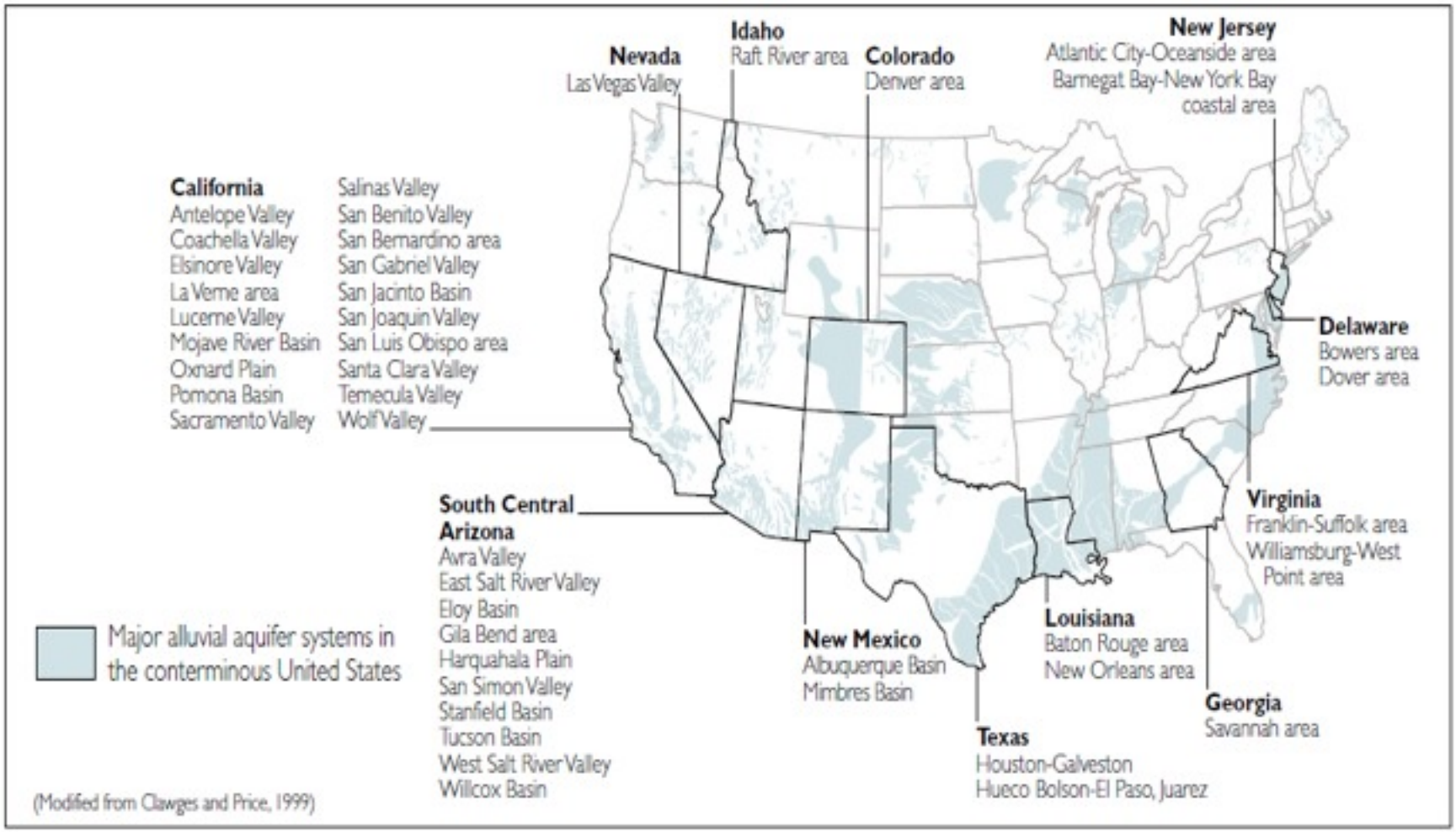

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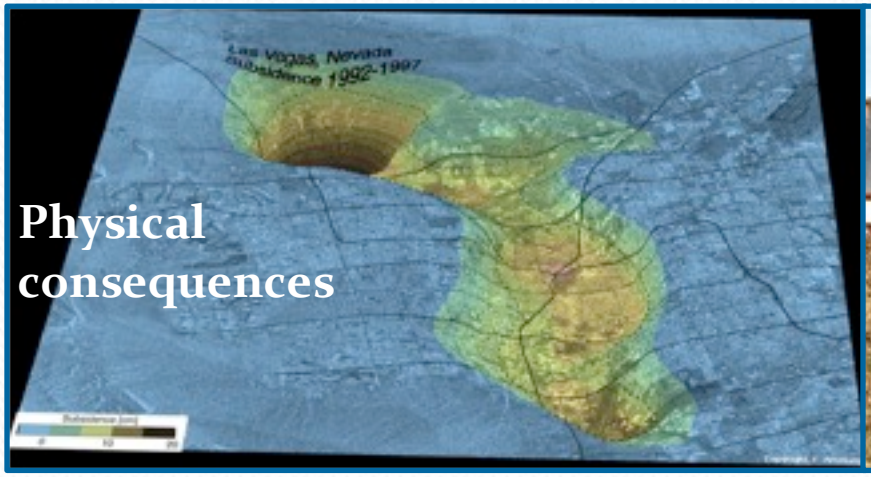

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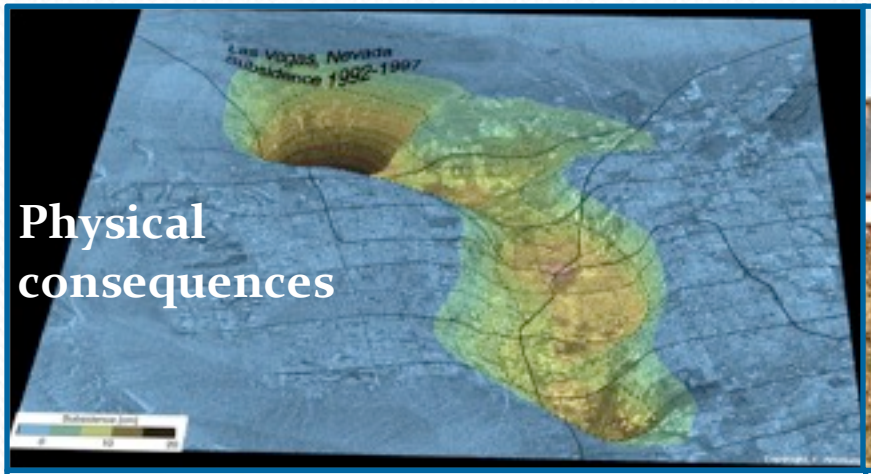

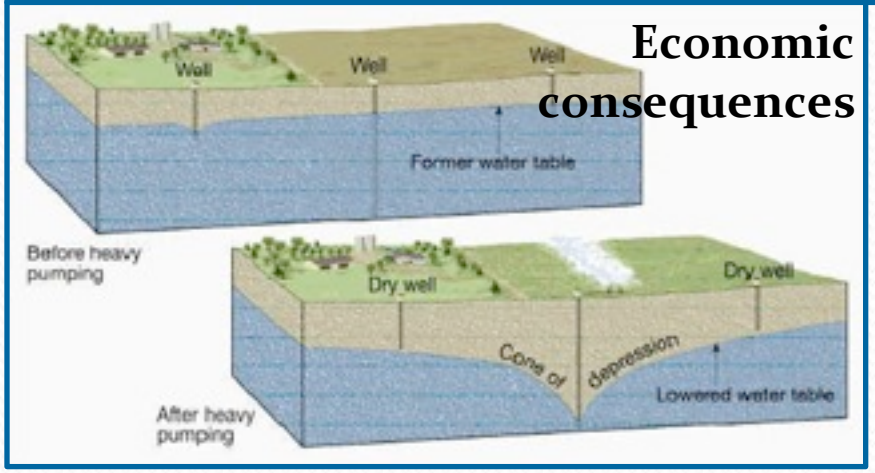

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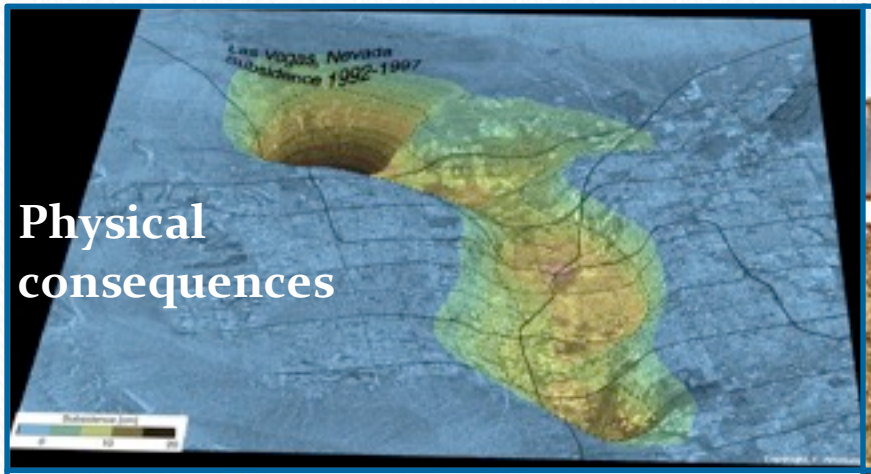

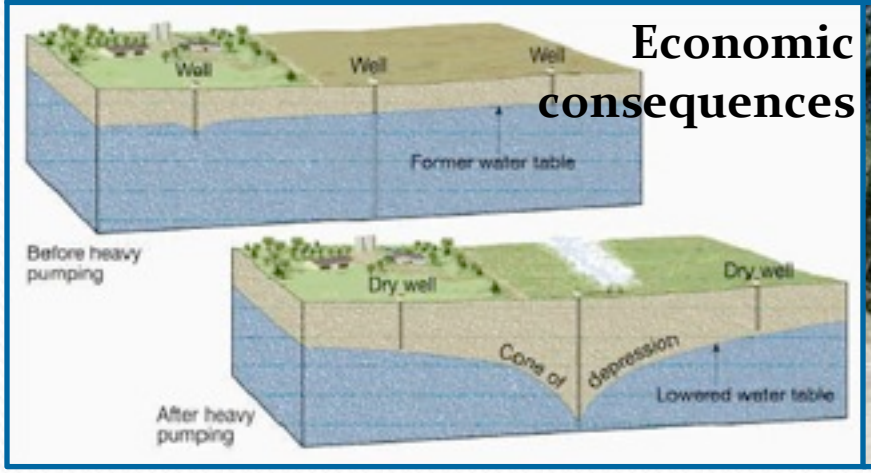

Groundwater depletion:

Policy and legal issues

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Limiting extraction

Exempting small uses

Aquifer recharge/groundwater banking

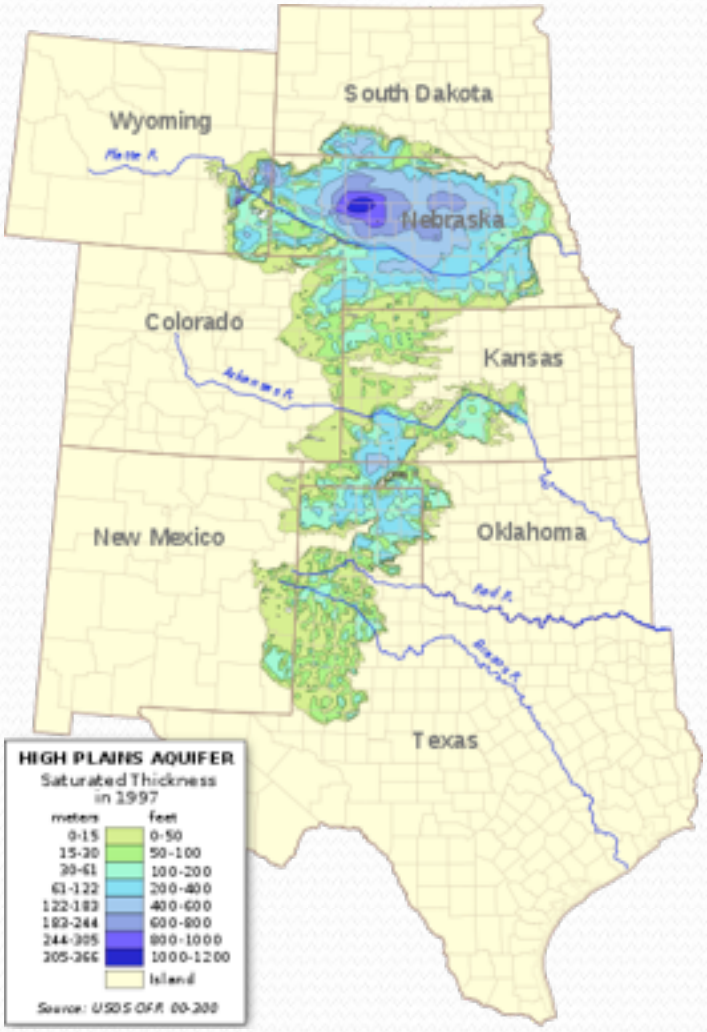
Groundwater depletion:

Policy and legal issues

Groundwater depletion:

Technical issues & uncertainties

How much water is there?



Groundwater depletion:
Technical issues & uncertainties

How much water is there?

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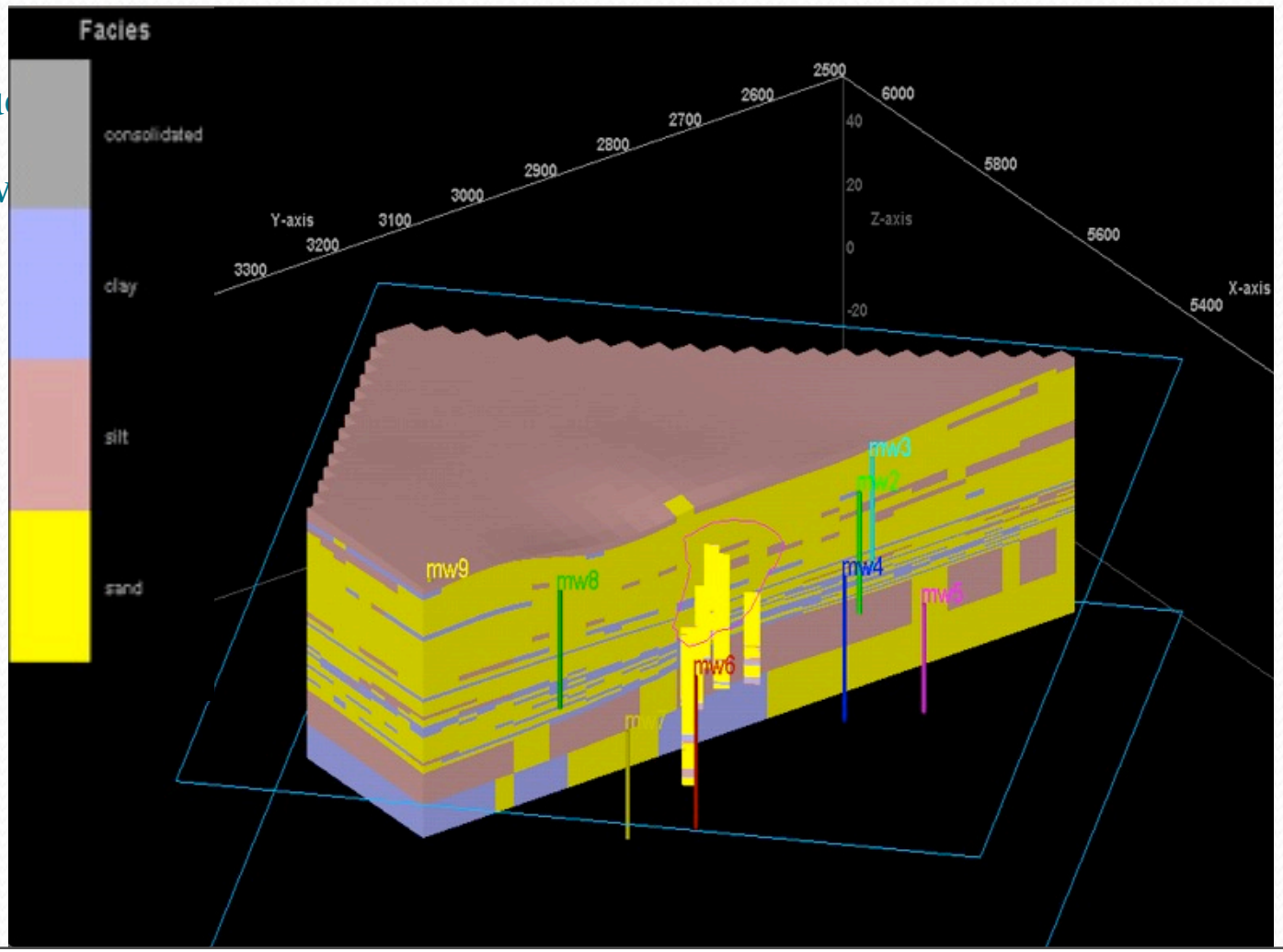

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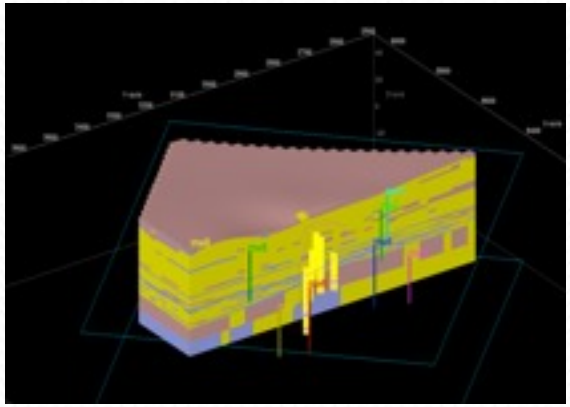

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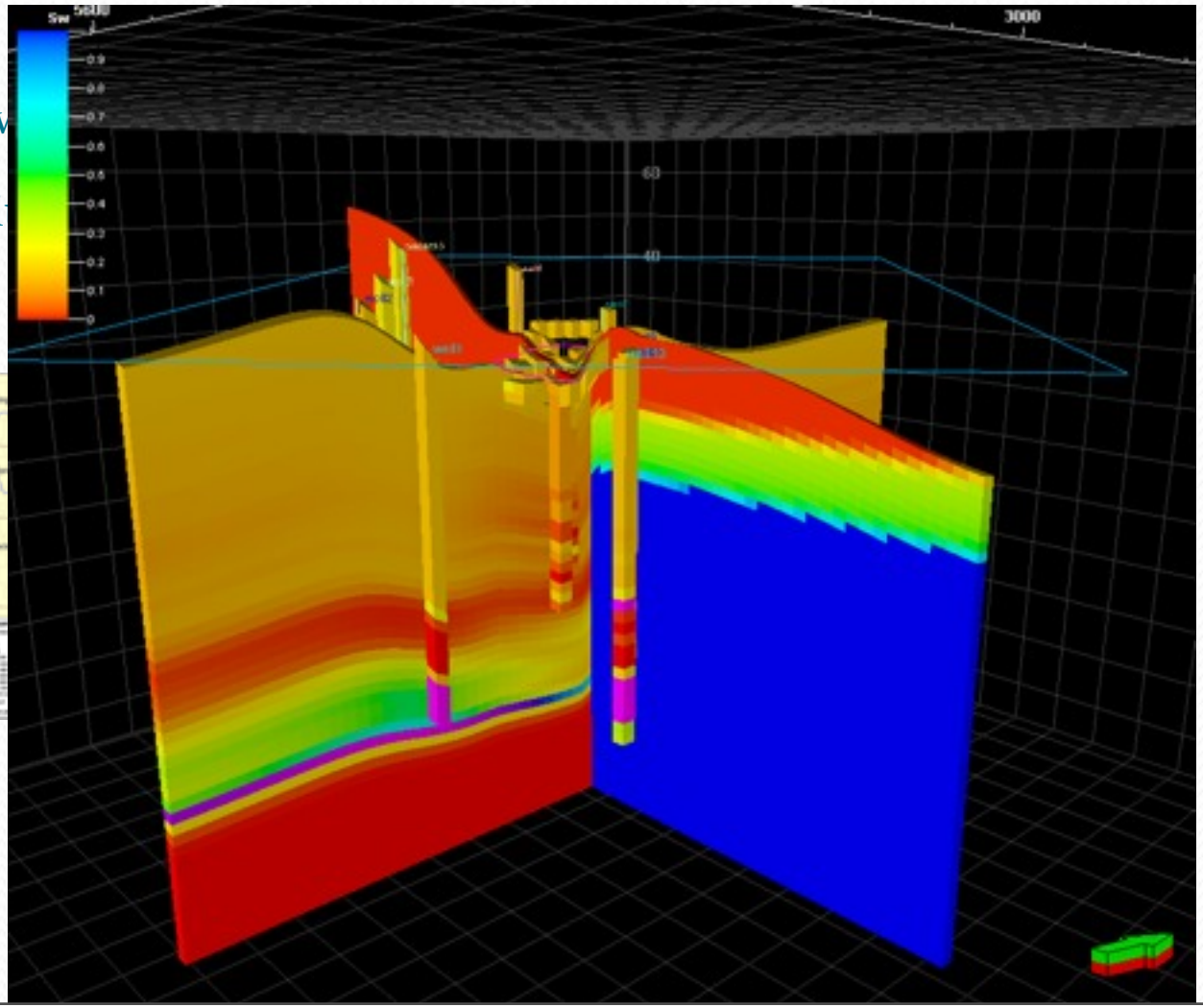

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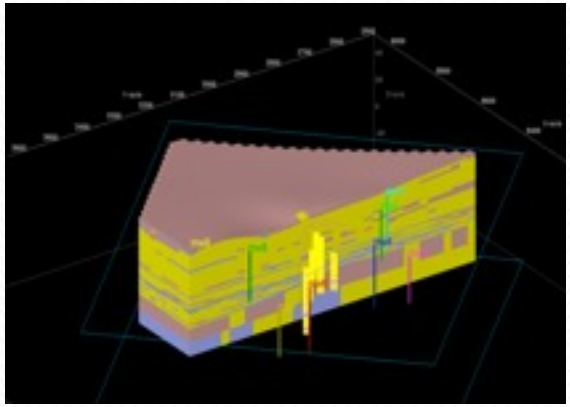

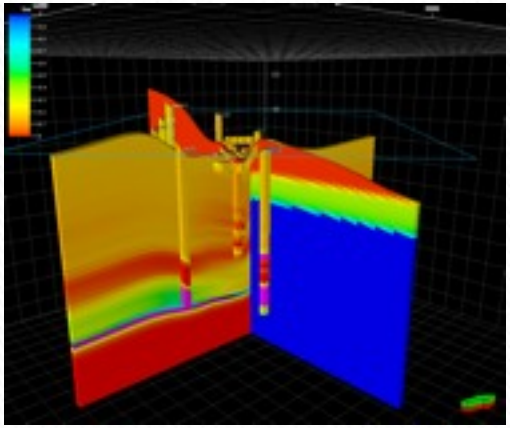

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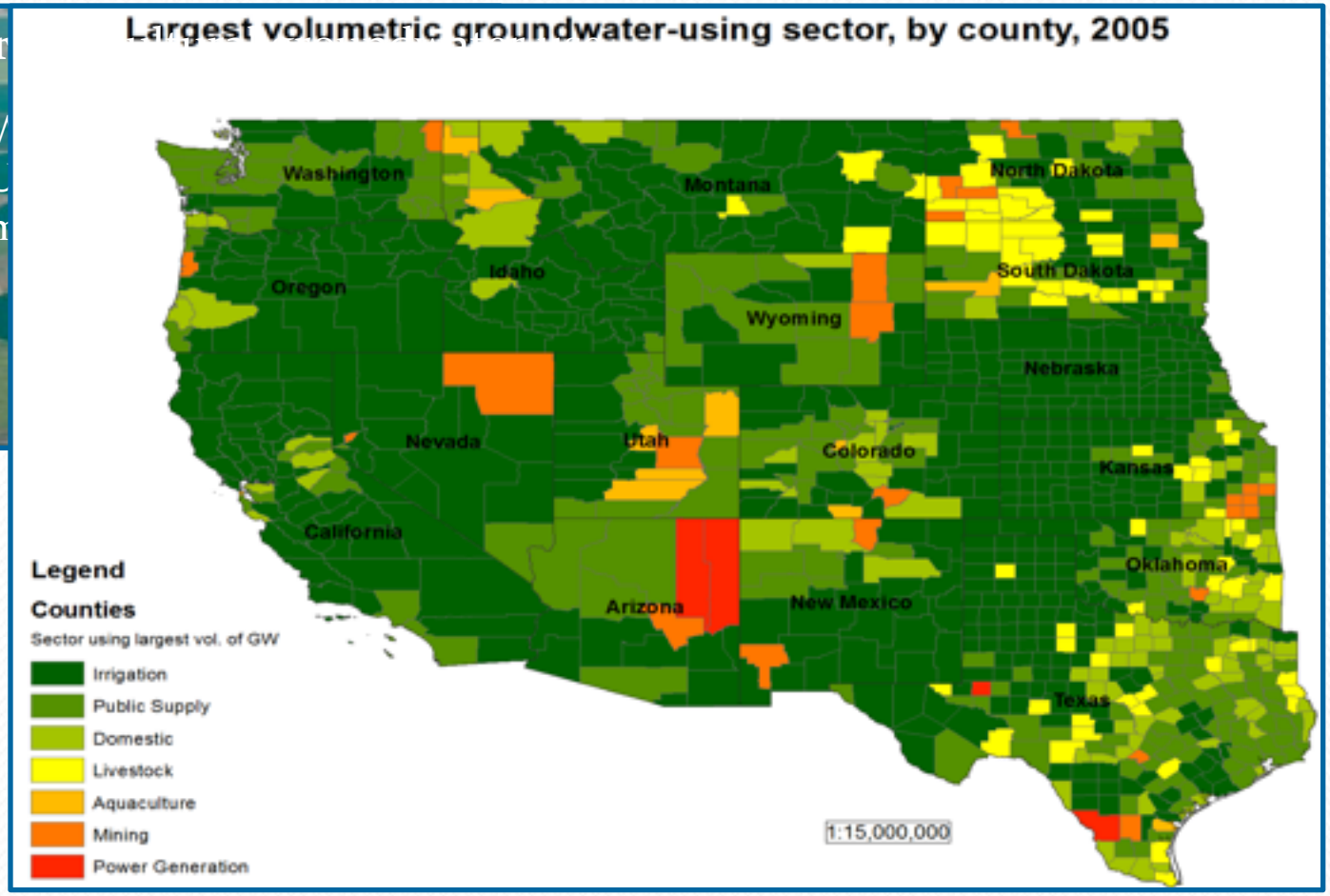

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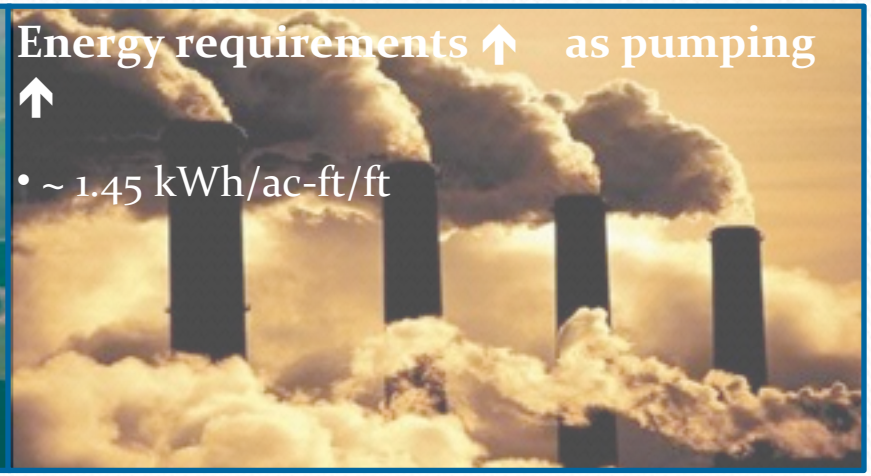

Groundwater depletion:

Big picture connections

Agricultural groundwater use

- Often largest GW user globally
- Largest user in U.S., CA
- Largest user in most Western U.S. counties

Energy requirements ↑ as pumping ↑

- ~ 1.45 kWh/ac-ft/ft

Climate change

- Surface water: ↓ reliability, $ ↑
- ↑ ET ↑ water demand
- $ power ↑

- *Central Valley, CA: climate induced decline in groundwater levels of 45-234 feet*
(Dale et al, 2008)

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Effects of climate change on overall water supply sustainability

- Water demand, deficit & withdrawals
- Groundwater use
- Drought susceptibility

(NRDC, 2010)

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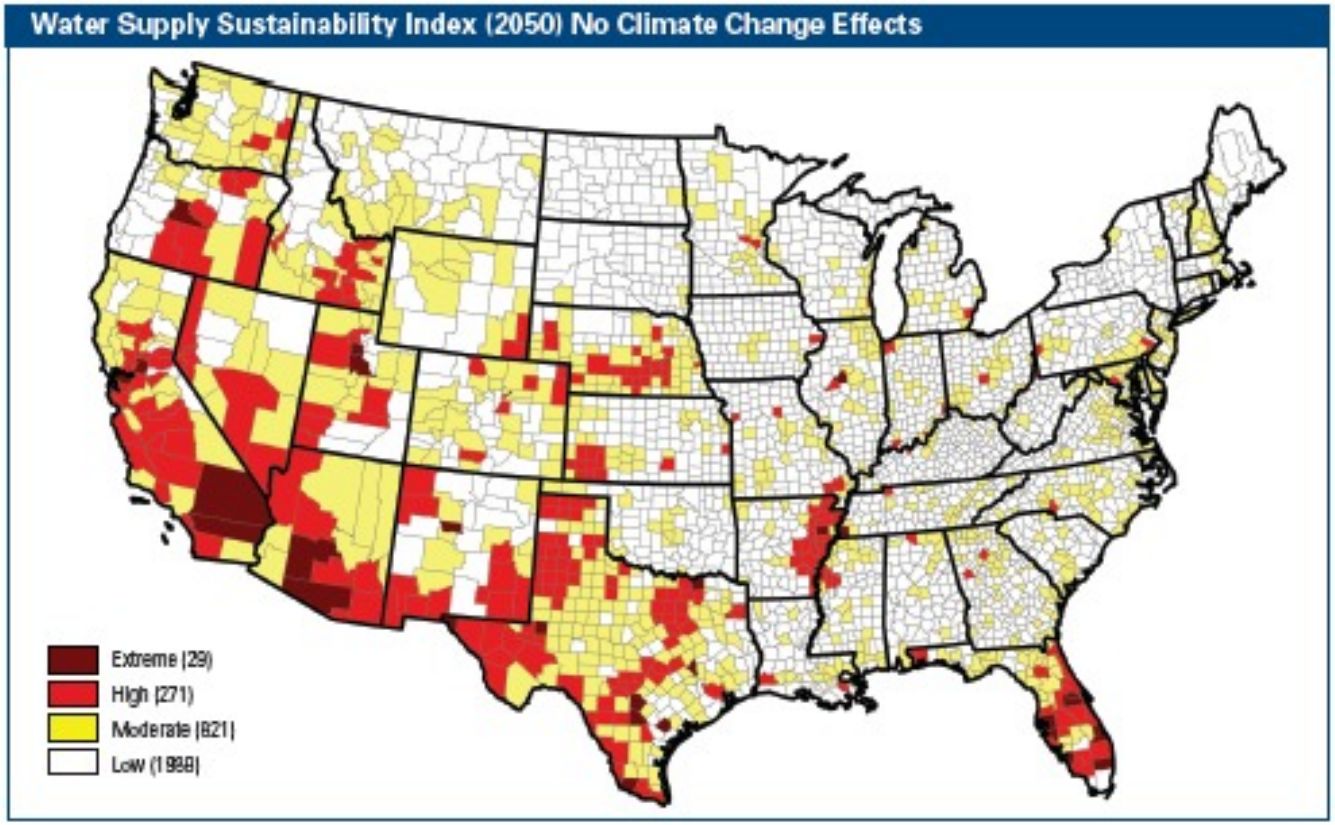

Source: NRDC, 2010

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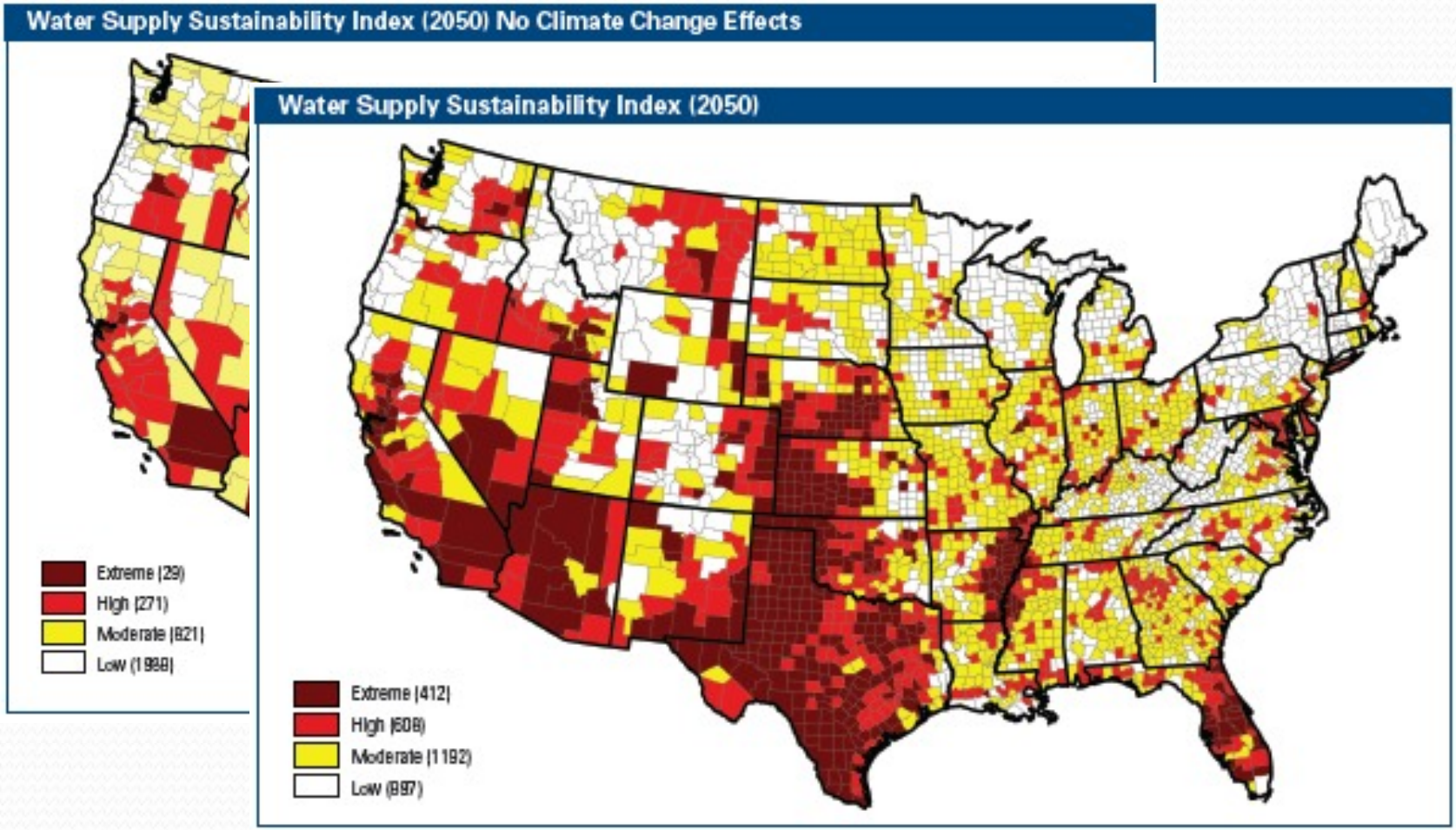

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2. Groundwater depletion in the San Luis Valley, Colorado

Groundwater depletion in the San Luis Valley:

Introduction

The Rio Grande Compact (1939)
Closed Basin Project (1980)
The Baca Project (1986)
Rio Grande Decision Support System(1998)
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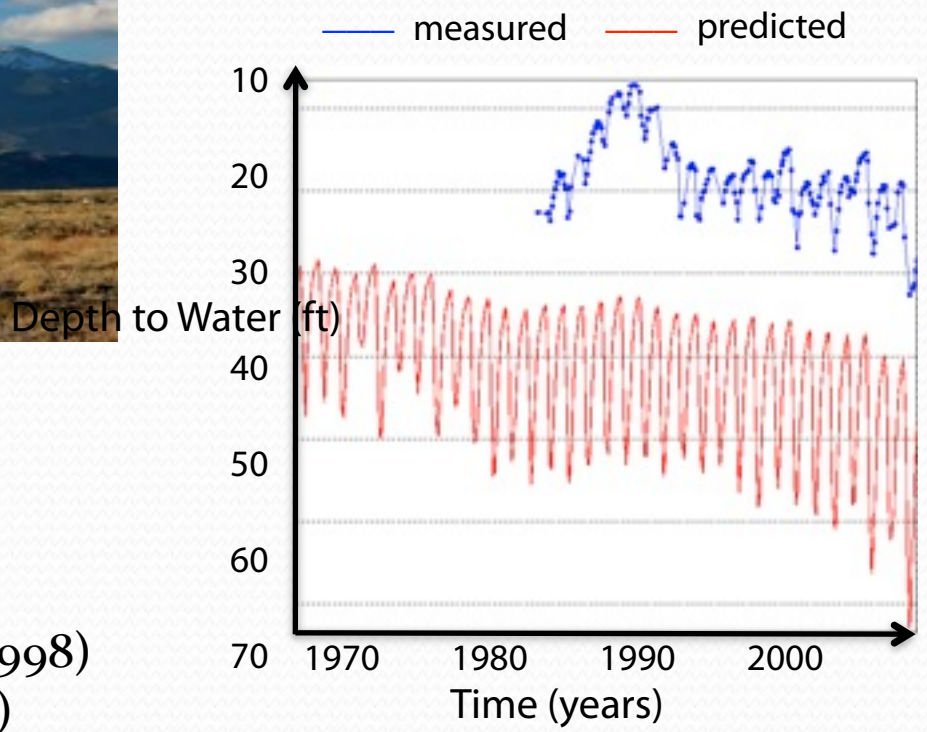

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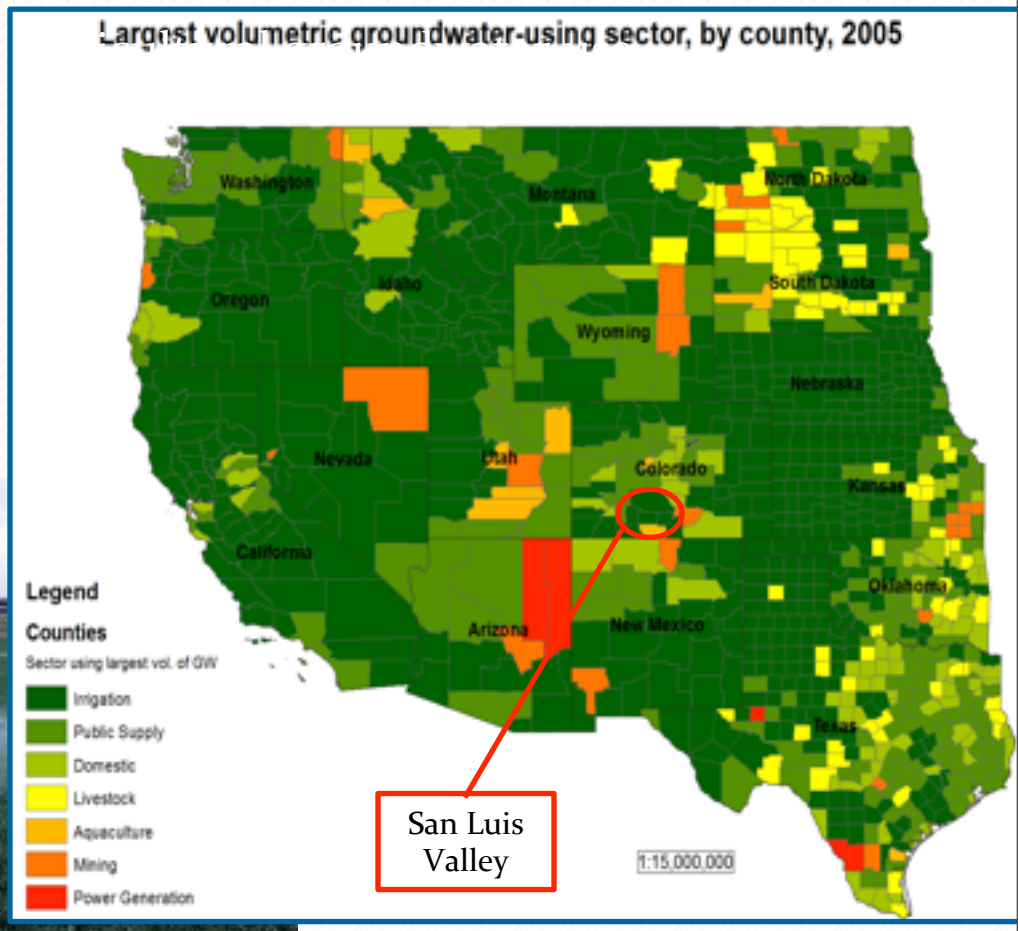
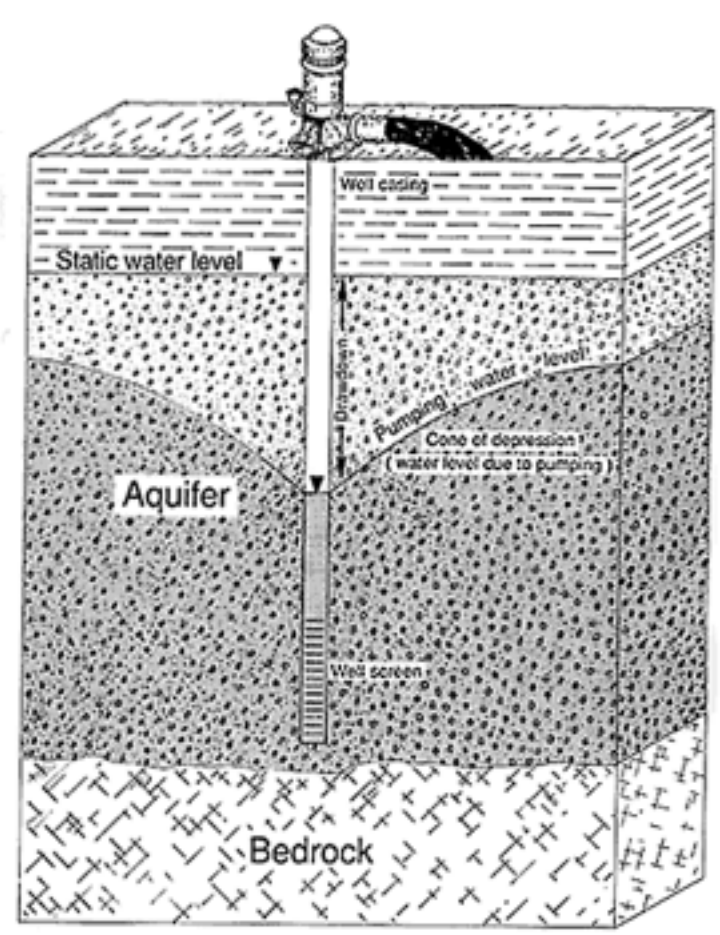


Groundwater depletion in the San Luis Valley:

The groundwater-energy connection



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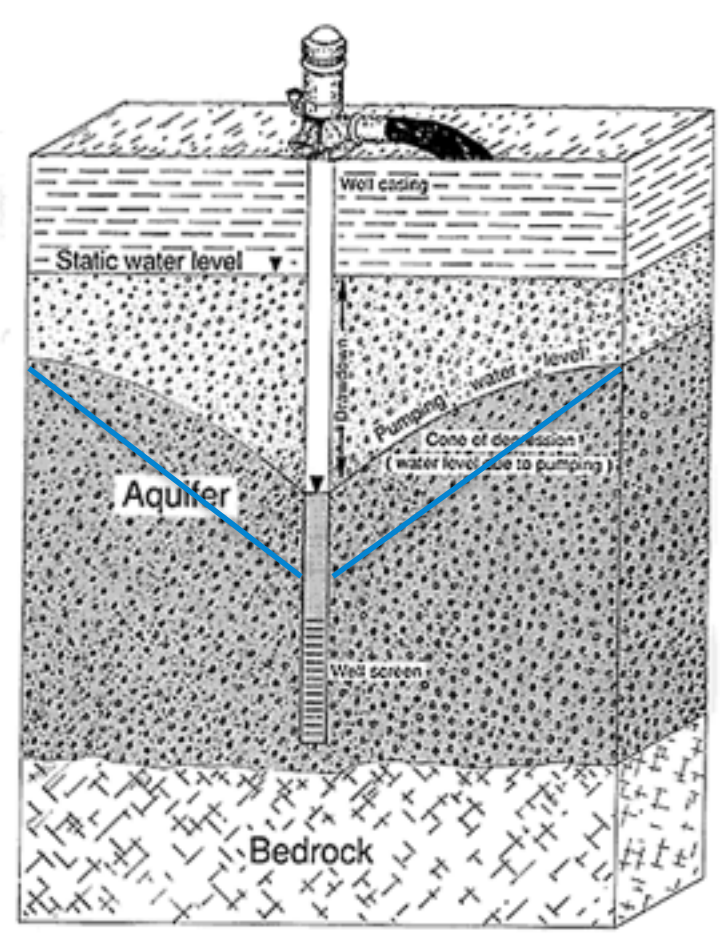

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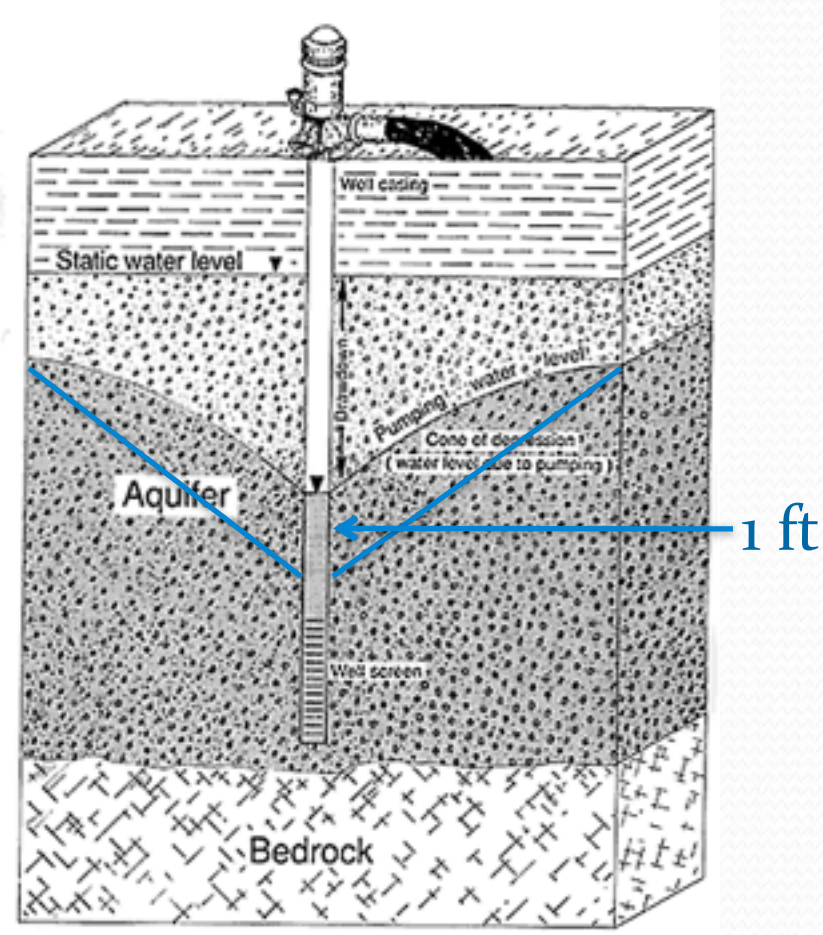

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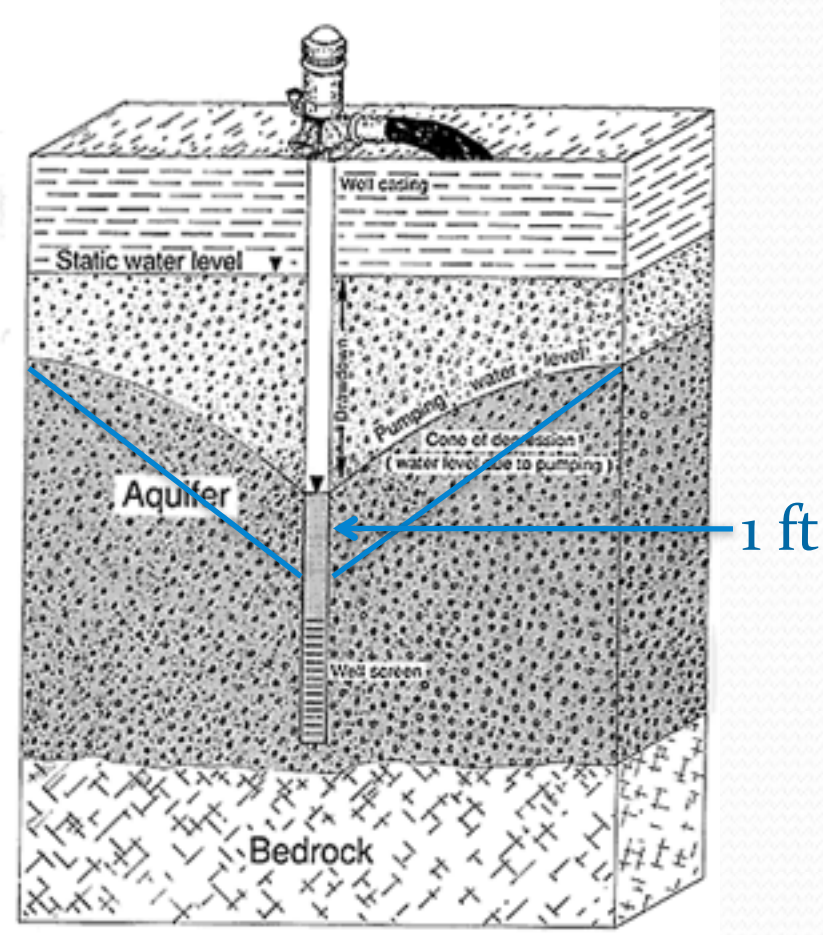

$ 0.25/acre-foot for every foot of lift

Source: DWR California, Center for Irrigation Technology CSU

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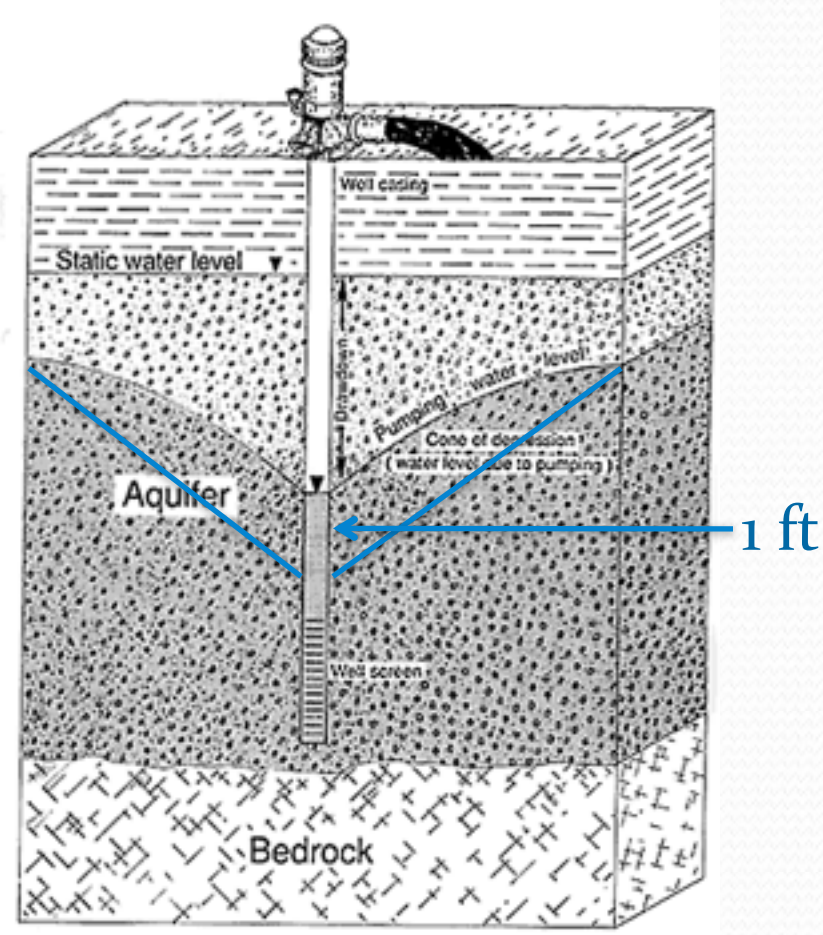

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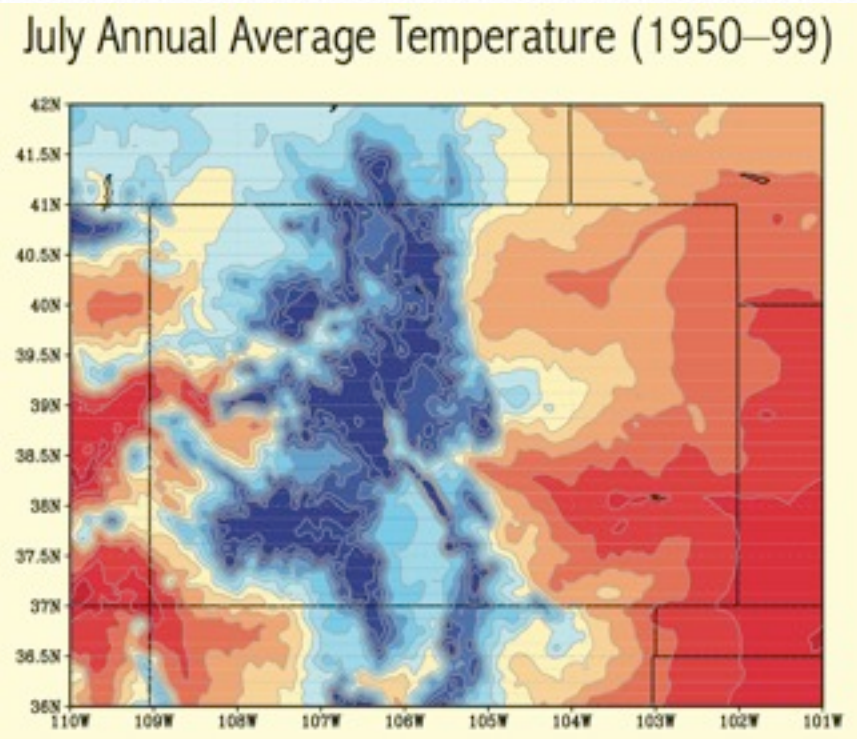
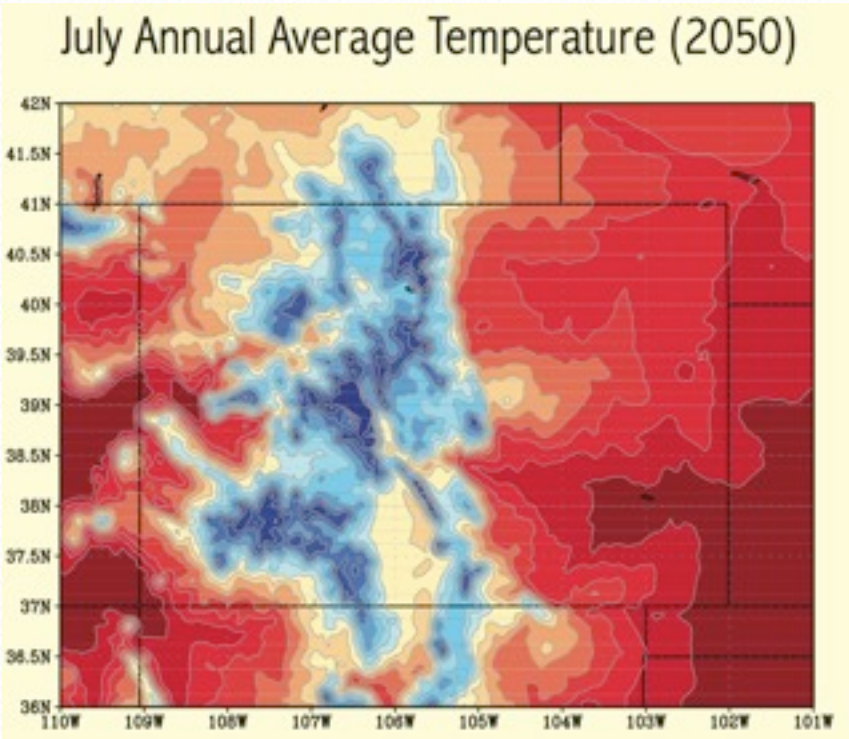
The SLV pumps 1.1 million acre-feet/year
= $300 000/year

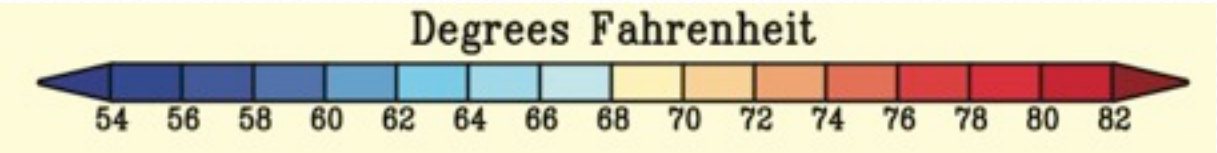
Source: DWR California, Center for Irrigation Technology CSU

Groundwater depletion in the San Luis Valley:

The groundwater-climate connection







Source: Colorado Water Conservation Board

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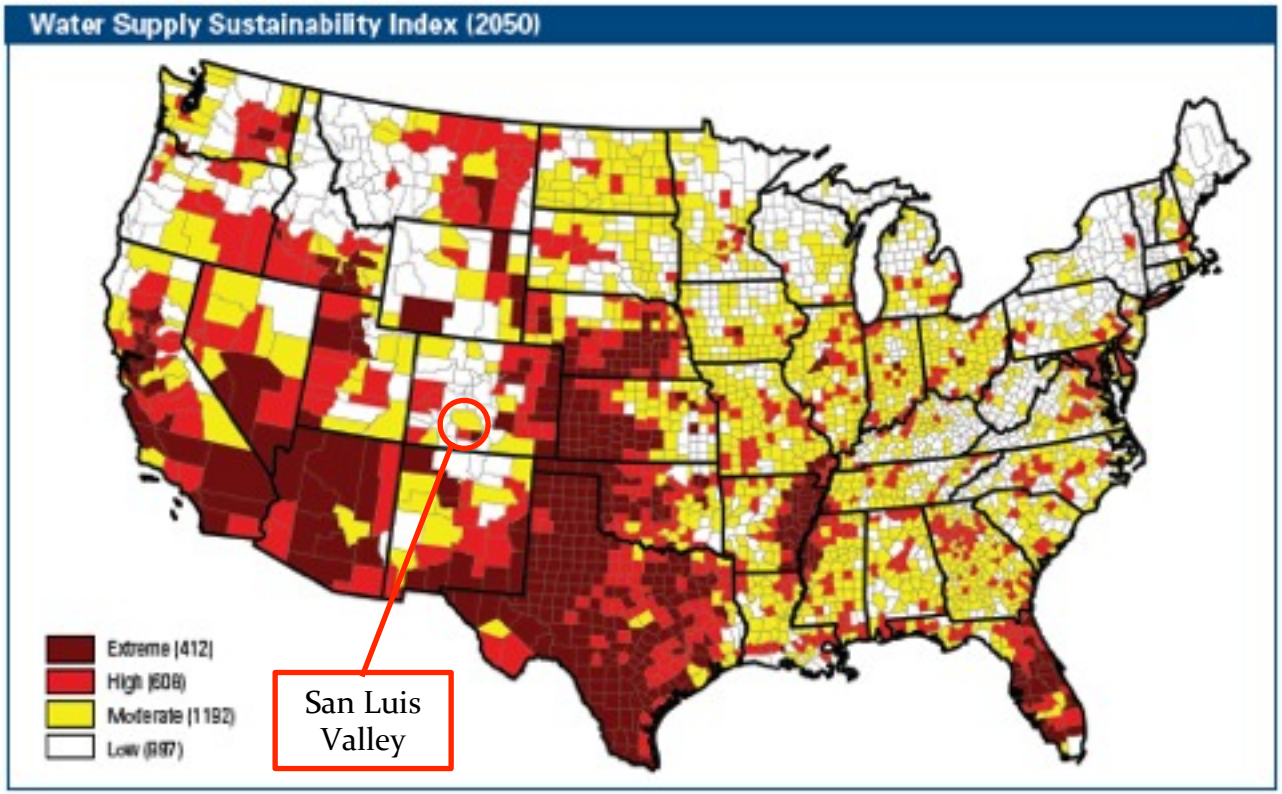
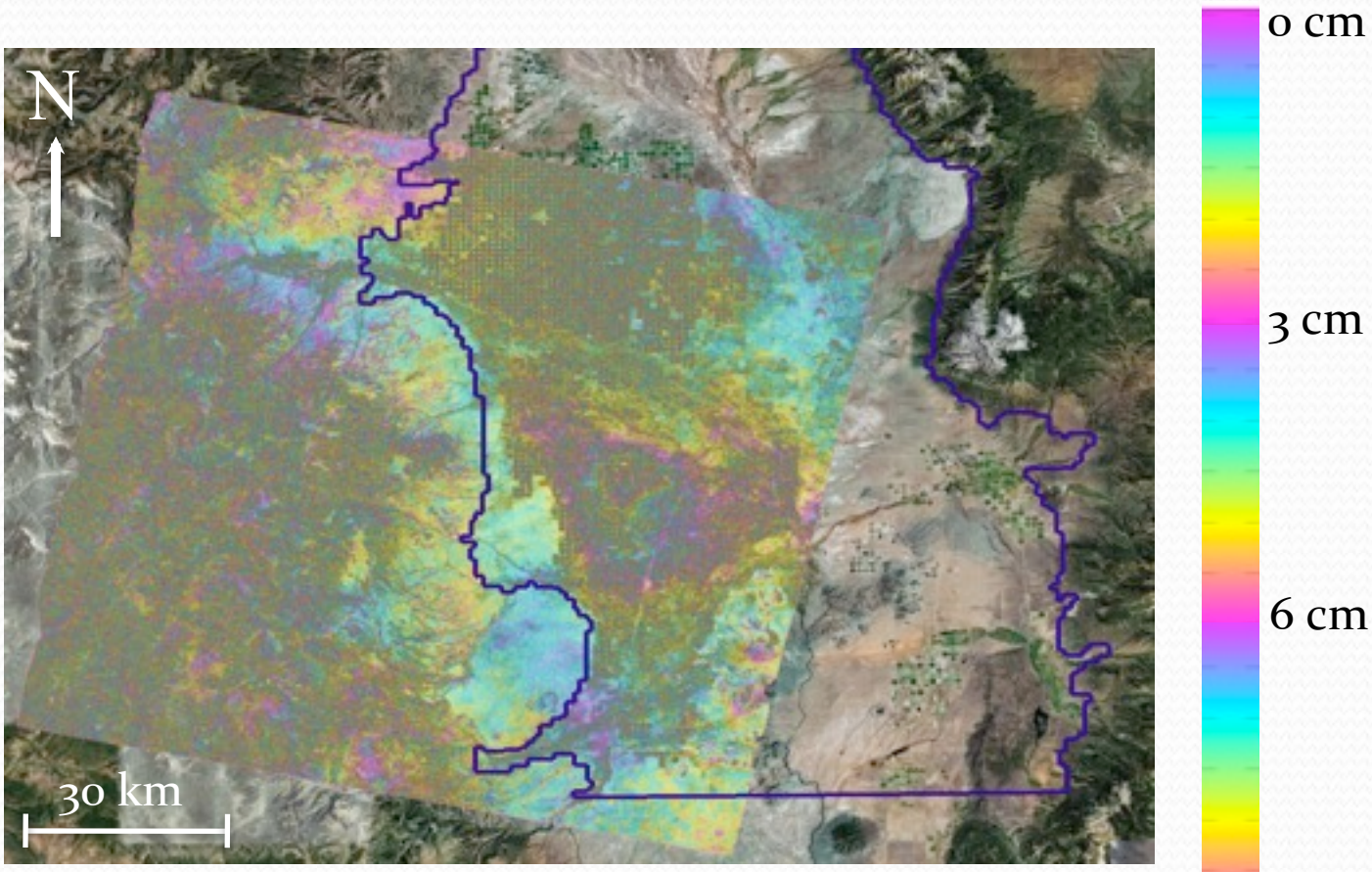


Source: NRDC, 2010

3. A taste of Stanford research on groundwater depletion

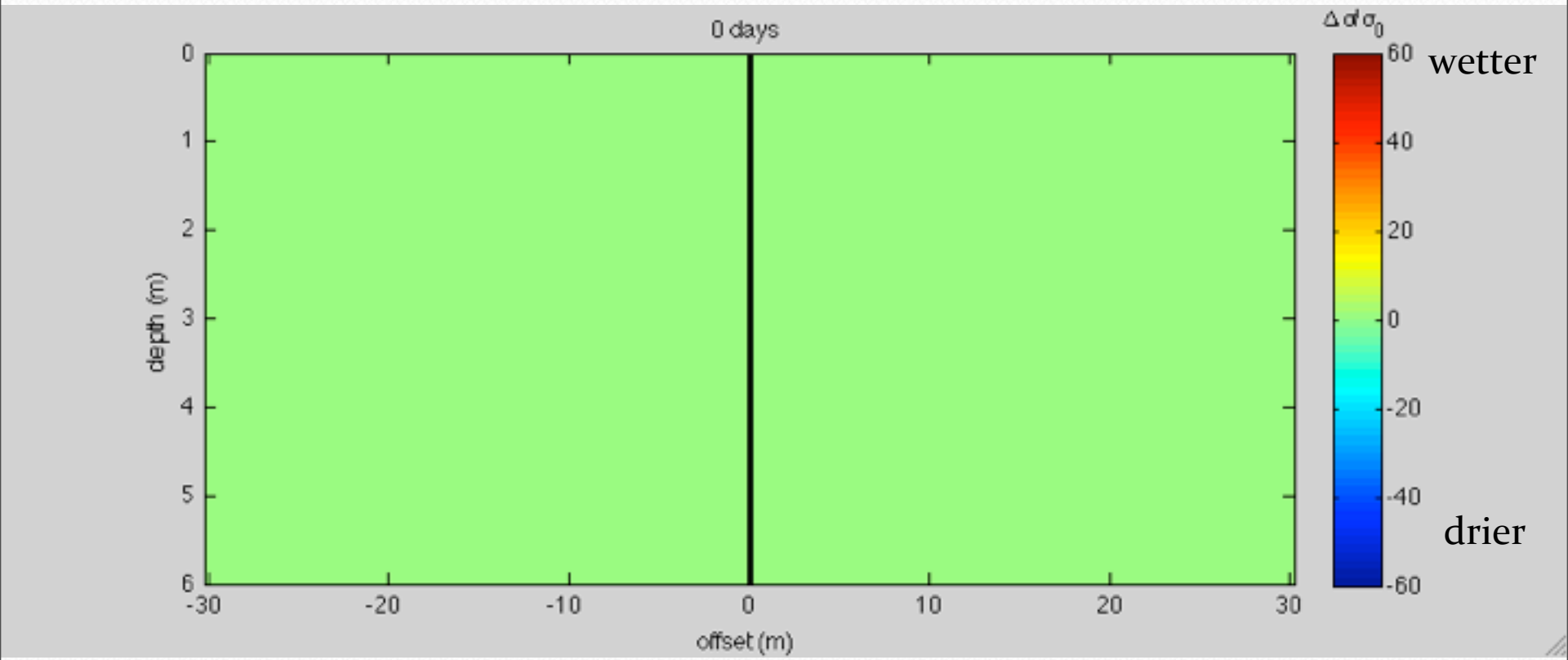
Addressing groundwater depletion through research:

Satellite-based InSAR (Jess Reeves)



change in phase November 1999 to July 2000

Addressing groundwater depletion through research: Recharge & saltwater intrusion (Vanessa Mitchell)

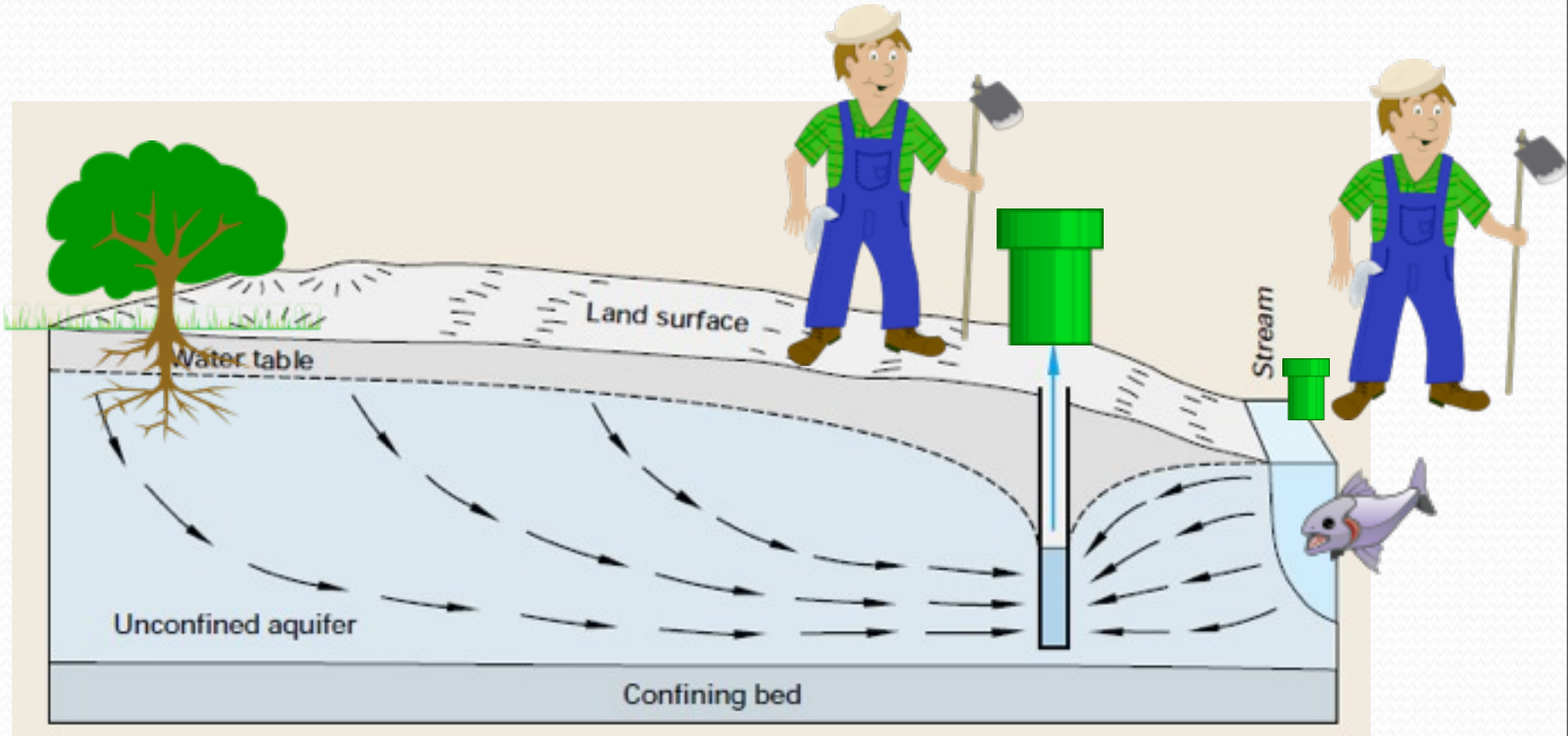


Addressing groundwater depletion through research: Recharge & saltwater intrusion (Vanessa Mitchell)

wetter

drier

Addressing groundwater depletion through research: Laws that recognize connections (Rebecca Nelson)



Source: Modified from T.C. Winter et al, *Ground Water and Surface Water: A Single Resource: USGS Survey Circular 1139* (1998), Fig. C-1

Question time

References

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- Dale et al. (2008). “The Interaction of Water and Energy in California: Climate Change and Price Impacts”, available at http://www.circleofblue.org.
- Natural Resource Defense Council (2010). “Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable”, available at http://www.nrdc.org.
- Colorado Water Conservation Board (2008). “Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation”, available at wwa.colorado.edu/CO_Climate_Report/index.html