Effects of Ditch and Field Irrigation Seepage on Rio Grande Flow

PD: Alexander “Sam” Fernald
CO-PDs: Steve Guldan, J. Phillip King,
Vincent Tidwell – Sandia National Laboratories

PhD Students: Carlos Ochoa
Yeliz Cevik

MS Student: Ciara Cusack

Other Participants and Cooperators

Amber Helmus
John Hawley
Manoj Shukla
Marquita Ortiz
Christopher Brown
April Ulery
Zohrab Samani
Max Bleiweiss

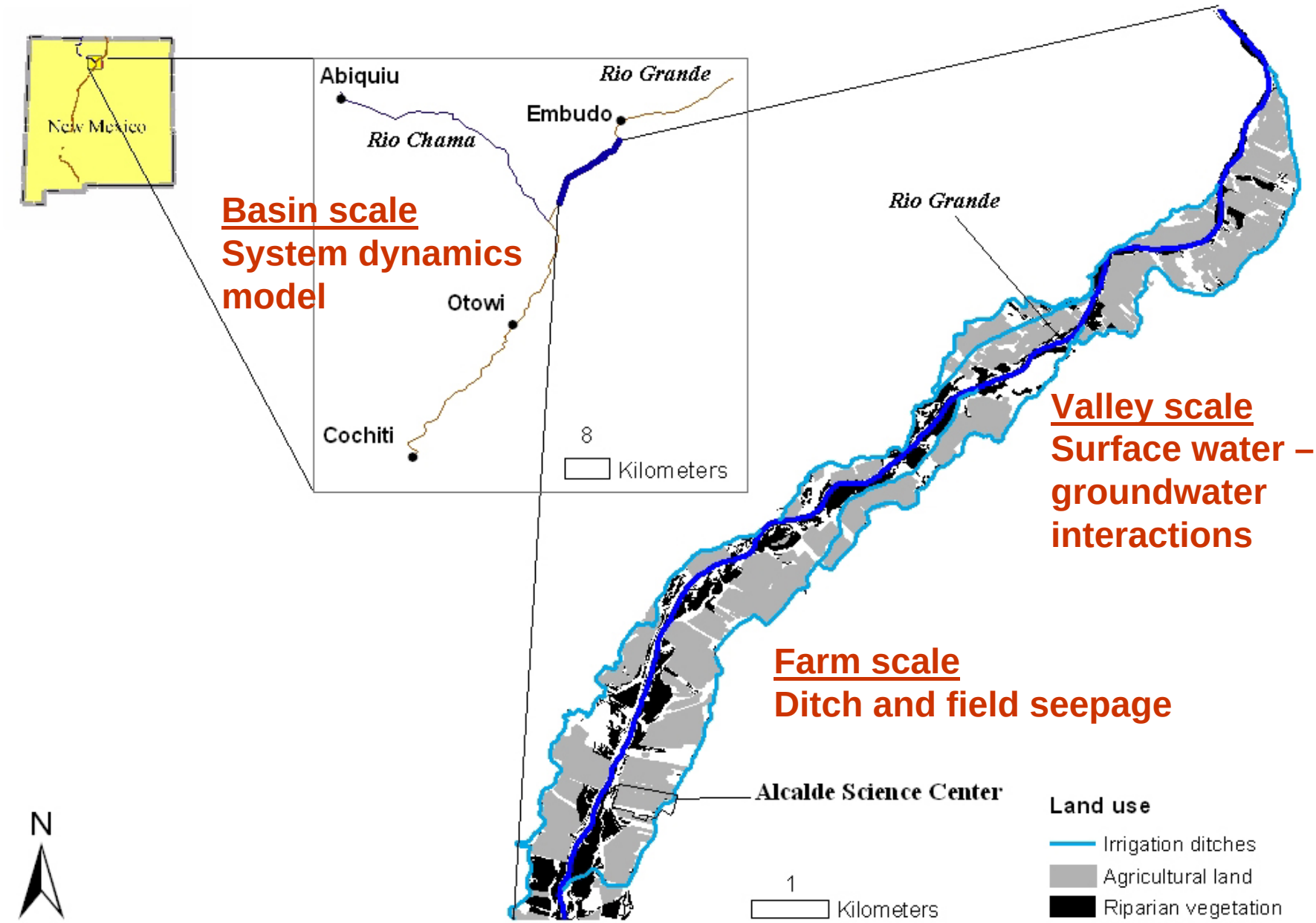
Dawn Vanleeuwen
Terrell Baker
Laurie Abbott
David Archuleta
Val Archuleta
Alcalde and other community Acequias (Ditches)
Many farmer and rural cooperators

Primary Objective:

Study site: **NMSU - Alcalde Sustainable Agriculture Science Center**

To answer the question: How does seepage from irrigation ditches and flood-irrigated fields affect shallow groundwater return flow and river flow in irrigated corridors in semi-arid regions?

Ongoing USDA CSREES-funded study to determine seepage effects on Rio Grande flow



Five Research Questions Addressed to Accomplish Primary Objective:

1) What is the amount and timing of irrigation ditch seepage recharge to shallow groundwater?
2) Is seepage from flood-irrigated fields a significant source of recharge to shallow groundwater?
3) What are the rates and timing of shallow groundwater extraction by riparian vegetation evapotranspiration?
4) What are contributions of ditch and field seepage to groundwater return flow and river flow?
5) What are the projected effects of future management scenarios on timing and magnitude of seepage, groundwater return flow and river flow?

Impoundment seepage results:

- **Average seepage loss of 11.3 cm/day**

- **At least 5 % of total ditch flow lost to seepage at Alcalde Science Center**

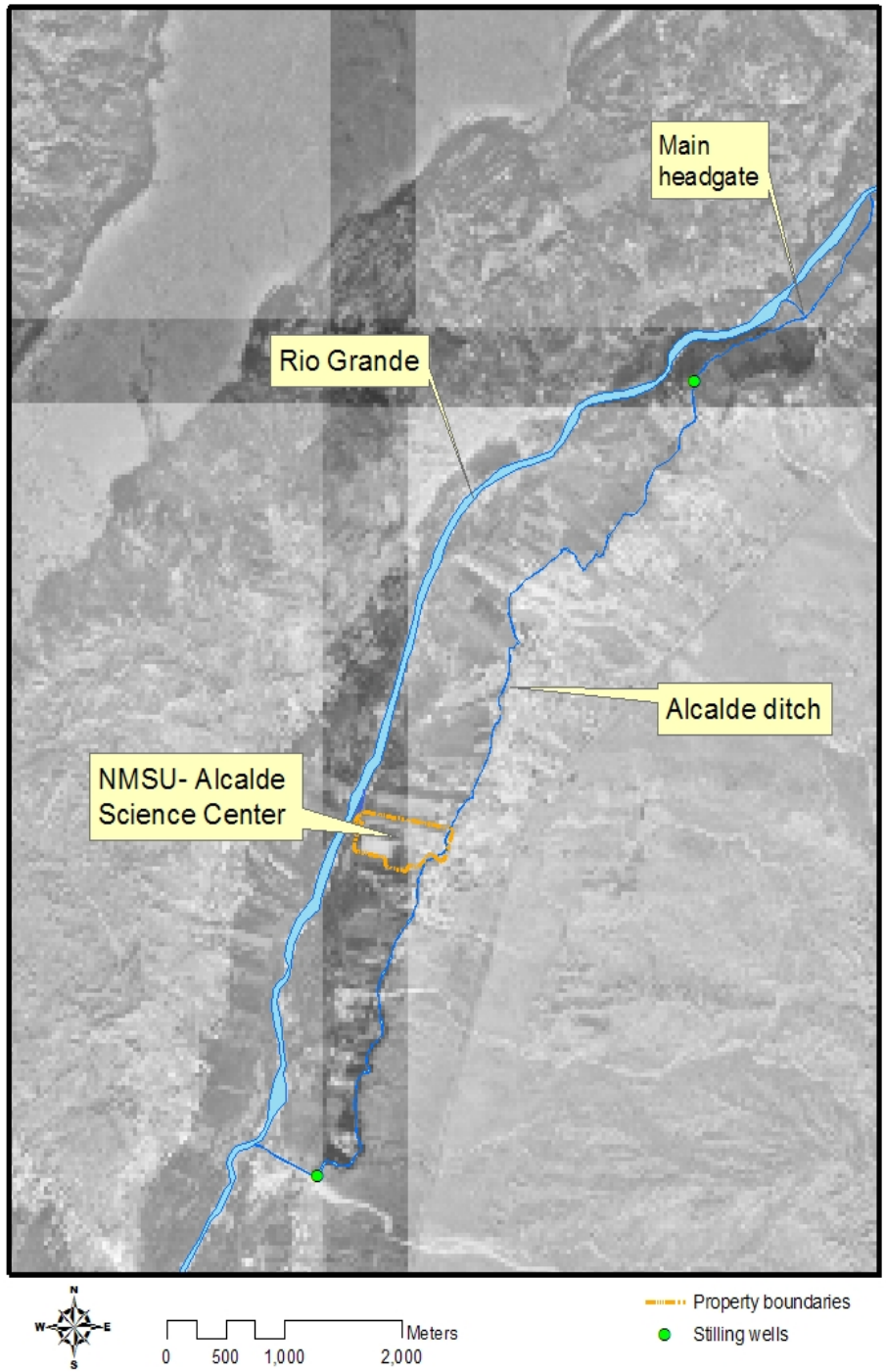
Inflow-outflow seepage results

- Stable flow conditions with no irrigation diversions

- 54.5 cfs inflow

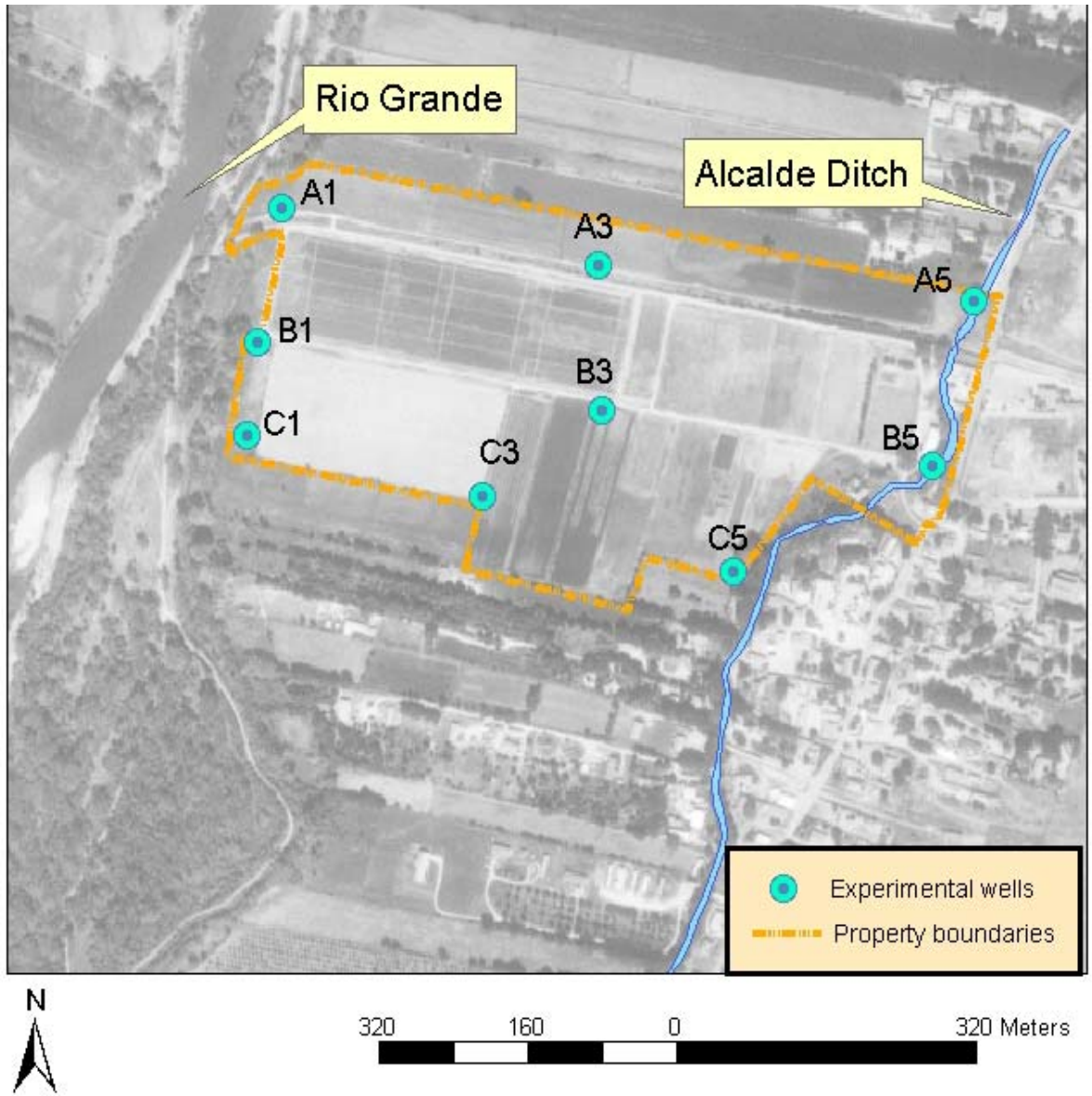
- 45.6 cfs outflow

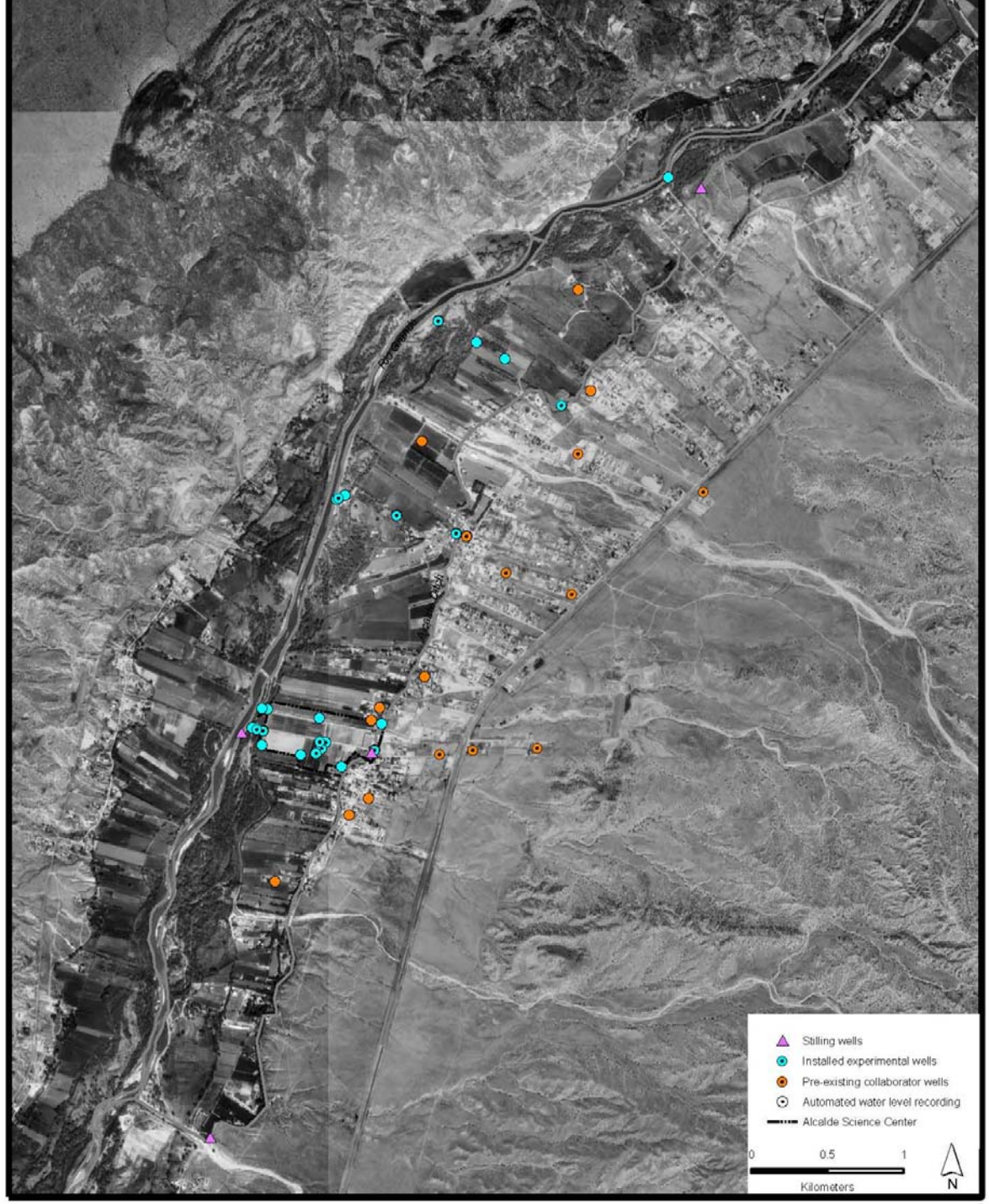
- 16 % seepage over length of Alcalde Ditch

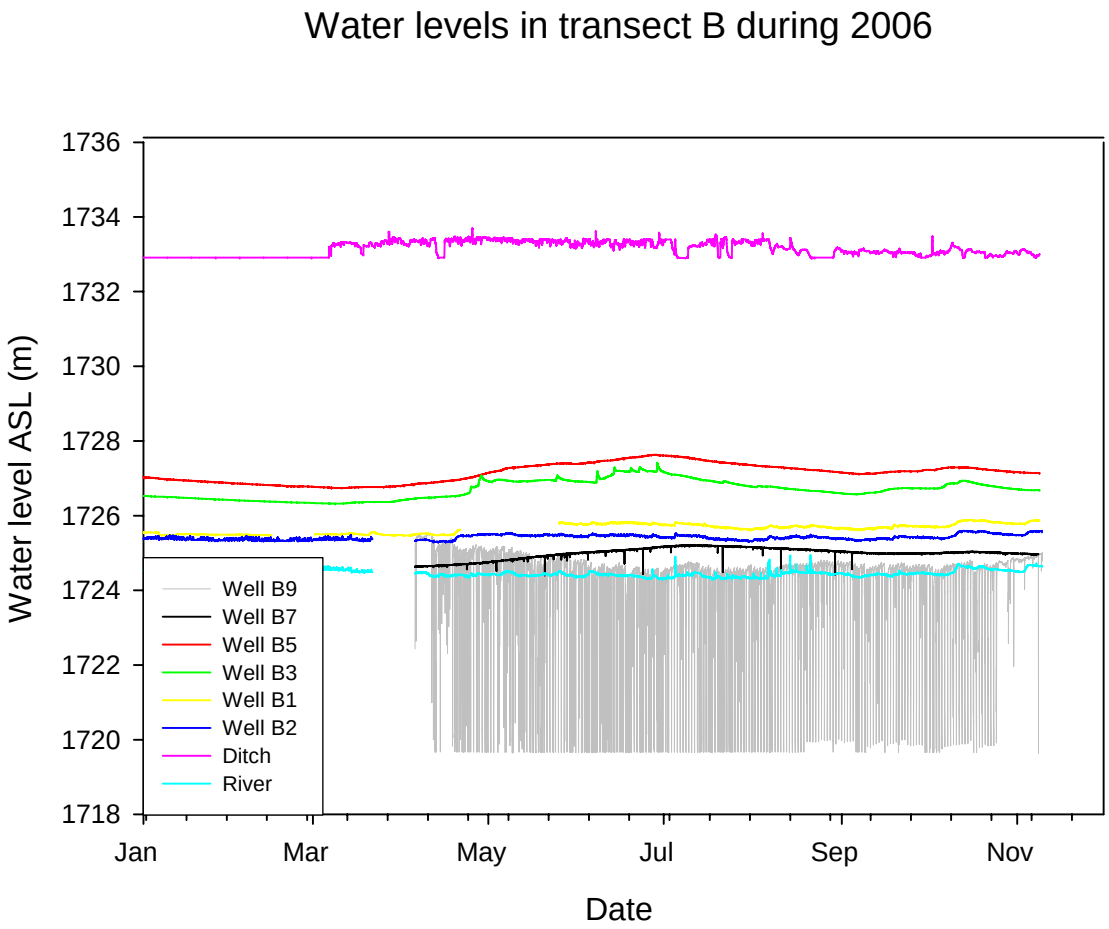


Shallow groundwater response to seepage

- Three transects of 2” wells: A, B, and C
- Water level readings since March 2002
- Water quality sampling since July 2003




Stilling wells
Installed experimental wells
Pre-existing collaborator wells
Automated water level recording
Alcalde Science Center
0
0.5
1
Kilometers
N


Water levels in transect B during 2006
Water level ASL (m)
1736
1734
1732
1730
1728
1726
1724
1722
1720
1718
Jan
Mar
May
Jul
Sep
Nov
Date
Well B9
Well B7
Well B5
Well B3
Well B1
Well B2
Ditch
River

Modeling Components

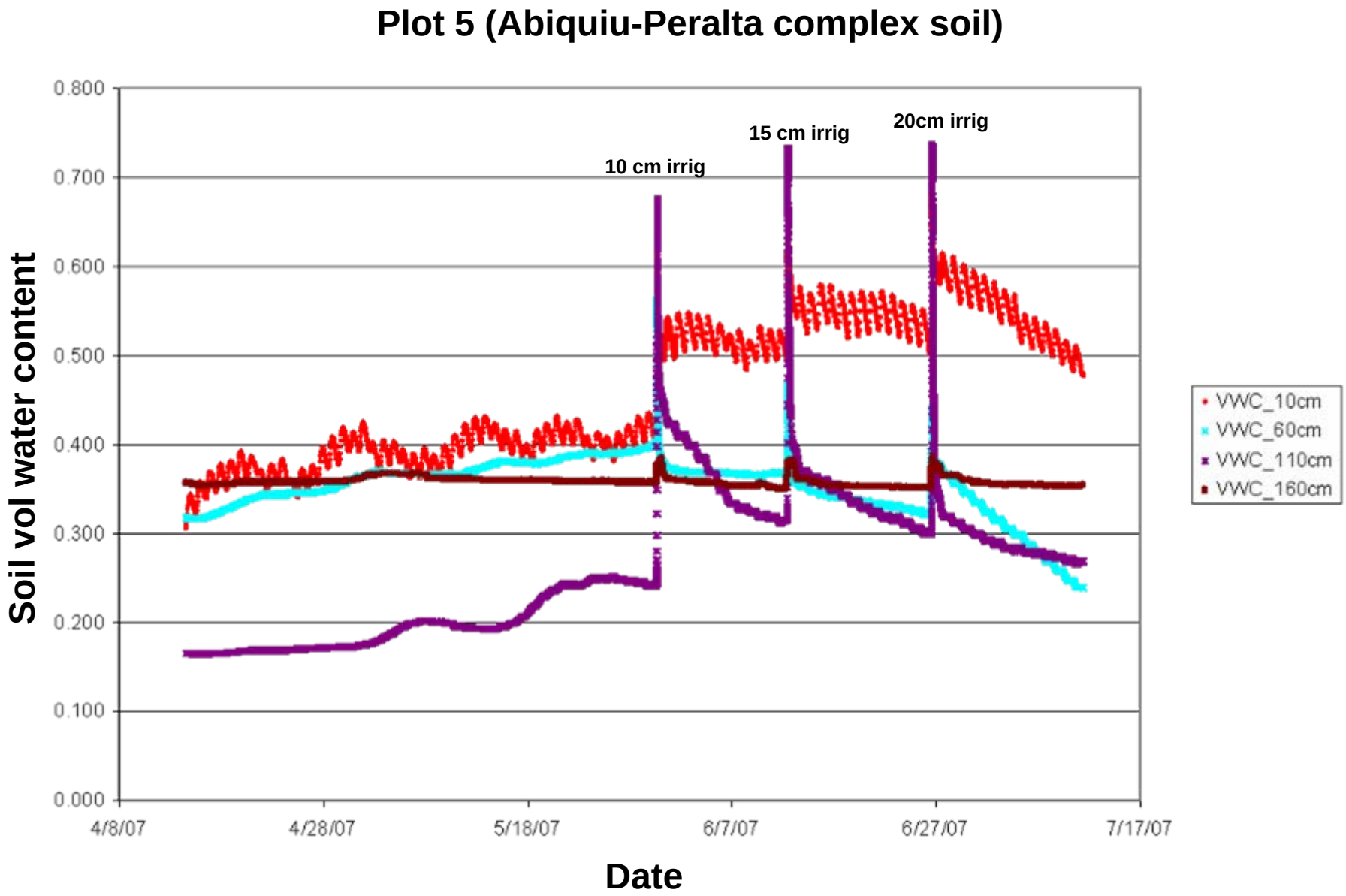
- 1-D (RZWQM and Hydrus-1D) field seepage
- 2-D (Hydrus-2D) crop and ditch seepage to shallow groundwater
- 3-D (MODFLOW) seepage, groundwater flow, and return flow along Alcalde Ditch and larger valley
- RIP-ET riparian evapotranspiration
- System Dynamics Model incorporation of seepage and return flow into interactive Rio Grande Basin

Percolation plots

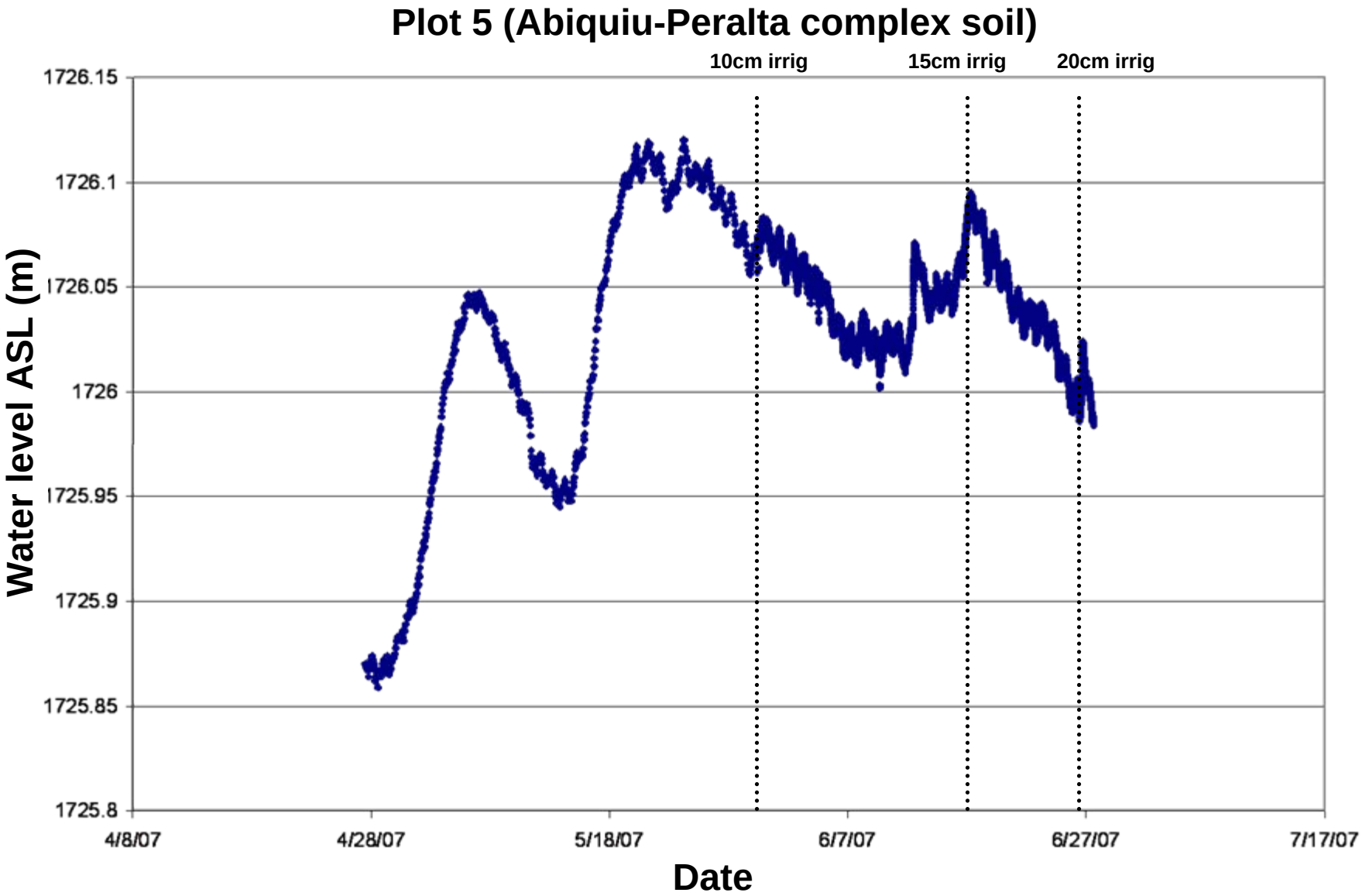
Objectives:

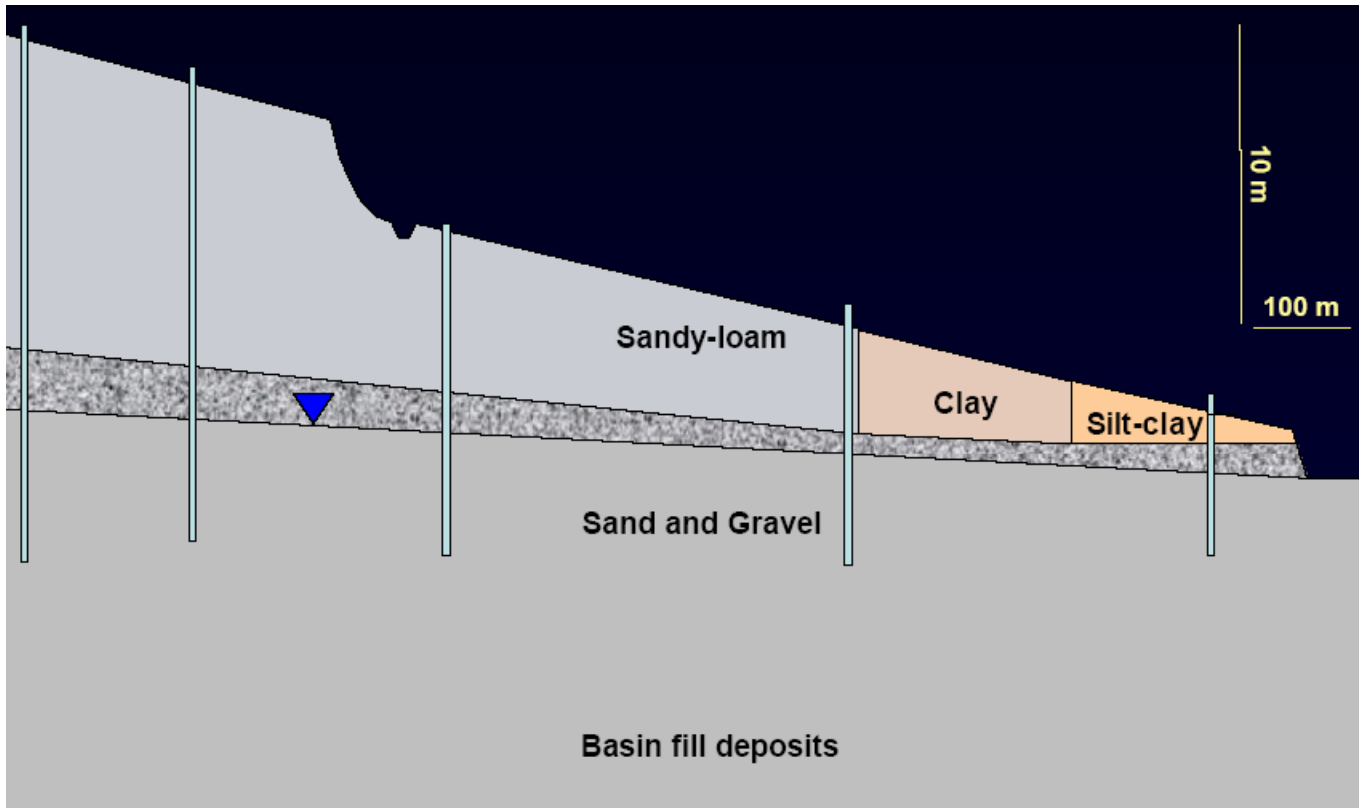
- Calculate water transport velocity and water flux into the aquifer after flood irrigation.
- Determine the water budget of three different soil profiles following flood irrigation.
- Characterize the shallow groundwater response to different amounts of flood irrigation.

Preliminary results: Soil moisture



Preliminary results: Water level response




10 m
100 m
Sandy-loam
Clay
Silt-clay
Sand and Gravel
Basin fill deposits

Riparian ET Methods

Use RIP-ET model for overall ET estimate

- RIP-ET model: uses plant ecophysiology, water table depths, and climate data to estimate ET
- Use plot data to form plant functional sub-groups and map using GIS
- ET point estimates (Remote sensing/flux towers? Sap flow? Correlations with local alfalfa ET?)

Regional Geohydrologic Modeling:

- Literature review of existing models
- Developing geological model for the modeling area
- Developing model input layers by using ArcGis
- Field work
- Survey development
- Updating land use coverages for 2005
- Return flow calculations

Preliminary Conclusions

- Acequia systems act as aquifer storage and recovery
- Net reduction in losses to atmosphere from storage for 1-3 months underground
- Return flow provides wet water downstream when most needed after peak runoff season
- Modeling is integrating surface water and groundwater interactions to predict hydrologic effects of changing land use, water use, and climate

Impacts and Outputs

Abstracts & Meetings

- Fernald, A., A. Helmus, C. Ochoa, M. Ortiz, C. Brown, 2006. Surface water seepage effects on shallow groundwater and Rio Grande flow in northern New Mexico. Eos Trans. AGU 87(52), Fall Meet. Suppl., Abstract # H32B-06.
- Ochoa, C.G., A.G. Fernald, S.J. Guldan. 2006. Vadose zone transport and shallow groundwater response following flood irrigation. Eos Trans. AGU 87(52), Fall Meet. Suppl., Abstract # H11A-1236.
- Ochoa, C., A. Fernald, S. Guldan, V. Tidwell, J.P. King, Y. Cevik, A. Helmus. 2007. Surface water and shallow groundwater interactions in an irrigated valley in northern New Mexico. American Water Resources Association, Annual Meeting, Abstract # pending.

Abstracts & Meetings, cont.

- Ochoa, C.G., A.G. Fernald, S.J. Guldan. 2007. Water transport through the unsaturated zone and shallow groundwater response following flood irrigation in three different soils of northern New Mexico. Eos Trans. AGU 88(52), Fall Meet. Suppl., Abstract # H51C-0639.
- Fernald, A., S. Guldan, V. Tidwell, J.P. King, C. Ochoa, Y. Cevik, A. Helmus, C. Brown, Q. Ortiz, and J. Hawley. 2007. Ditch and field seepage effects on floodplain water budgets and river flow. New Mexico Water Resources Research Institute, Annual Meeting, Poster Abstract #19.
- Ochoa, C., A. Fernald, and S. Guldan. 2007. Water transport through the vadose zone and shallow groundwater response following flood irrigation. New Mexico Water Resources Research Institute, Annual Meeting, Presentation Abstract #16.

Manuscripts Planned for 2008

- Deep percolation and its effects on shallow groundwater level rise after flood irrigation in an alfalfa-grass field and in an apple orchard.
- Interactions between floodwater infiltration and groundwater recharge in three different soils of a shallow alluvial aquifer in northern New Mexico. Vadose Zone Journal.
- The constructed geophysical model of the Alcalde Valley.
- Overall hydrologic budget and the methodology used to estimate each component.

The work that this project funds has gained considerable interest and support:

For example:

Resolution passed in 2007 at 8th Annual Congreso de las Acequias, Santa Fe, NM, indicating interest in and support for enhancement of research, including new state-funded water resource specialist position to be located in north-central New Mexico.