Statewide Water Assessment Researcher Panel

Moderated by Bruce Thomson, University of New Mexico

Bruce Thomson will be retiring from the University of New Mexico where he is a Regent's Professor in the Department of Civil Engineering at the University of New Mexico and is Director of the UNM Water Resources Program. He has a BS degree in civil engineering from the University of California at Davis, and MS and PhD degrees in environmental science and engineering from Rice University, Houston, TX. Bruce teaches in the areas of water chemistry and treatment, ground water hydrology and remediation, and water resources management. Recent research has included projects on water resources of New Mexico, the impact of energy and mineral development on water resources, and water reuse and treatment. He has served on many federal, state and local committees involved with management and protection of water resources. Bruce was recently elected to the Board of Directors of the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA). He is a licensed Professional Engineer in the State of New Mexico and received the 2013 New Mexico Public Sector Engineer of the Year award.

A Dynamic Statewide Water Budget for New Mexico by River Basin

Jesse Roach, Tetra Tech, Inc.

Jesse Roach is a Senior Water Resources Engineer at Tetra Tech Inc., in the Santa Fe, New Mexico office. His focus is on operations modeling in river systems using a variety of software including PowerSim and RiverWare. Jesse has 8 years of professional experience in simulation modeling of river systems including among others, the Rio Grande, and the Tigris and Euphrates. Jesse's system level expertise includes surface-groundwater dynamics, agricultural operations and demand, municipal operations and demand, and potential climate change impacts on water resources. Recently, Jesse was the lead modeler on a Bureau of Reclamation funded assessment of potential climate change impacts to water resources, and possible resulting changes to water operations in the Upper Rio Grande basin: http://www.usbr.gov/WaterSMART/wcra/reports/urgia.html. Jesse holds Bachelor and Master's degrees in Civil and Environmental Engineering from Stanford, and a Ph.D. from the University of Arizona in Hydrology and Water Resources. He worked at Sandia National Labs from 2006 to 2014 as a senior member of the technical staff focused on building system level simulation models.

Description

The dynamic, statewide water budget (DSWB) will synthesize water supply and demand information from across the state into a single, easily accessible location, and in such a way that users can view information at a variety of spatial scales (Figure 1). The overall objective of the project is a holistic view of water resources in the state to help support local and regional education and planning to improve stewardship of New Mexico's limited and critically important water resources.

Methodology

The DSWB is being built by pulling existing information from a variety of sources, predominately the New Mexico Office of the State Engineer / Interstate Stream Commission's

Regional Water Plans (NM-OSE-ISC, 1999-2008), the New Mexico Office of the State Engineer's Water Use reports (Longworth, Valdez, Magnuson, & Richard, 2013) and USGS stream gage information.

Results to Date and Work Remaining

- Model development to date has been documented (Figure 2). Specifically, the current draft documentation (which will make up a large portion of the final report) includes descriptions of the human population model, municipal and self supplied domestic water use, and agricultural use including descriptions of precipitation data manipulation and evapotranspiration calculations. (This completes remaining work item "j" in the October 1 progress report.)
- The regional plans were mined for agricultural area and consumption, and no new information was found, but a new NMSU reference was discovered that helped in quantification of agricultural areas. (This completes remaining work item "k" in the October 1 progress report.)
- Conversations did occur with Nathan Myers at USGS and Talon Newton at NMBG about the status of their work and if and how we will be able to incorporate it into our modeling efforts. The NMBG recharge work will only produce locational information this year, and so will not be particularly useful. The USGS work will be useful, especially in quantifying losing and gaining reaches. (This completes remaining work item "l" in the October 1 progress report.)
- We have completed implementation of Blaney Criddle crop consumption and are reaching out to OSE staff to see why our calculations give numbers consistently higher than the numbers they publish.
- We have added riparian area and riparian consumption information to the model.
- We have plotted consumption as a fraction of diversions for public supplied and domestic self-supplied water by county to use in estimates of indoor and outdoor use.
- We have updated our conceptual mass balance model.
- We produced a poster and an oral presentation summarizing our work for the WRRI conference.
- Remaining work: We need to add use information for livestock, mining, and energy production to the consumption portion of the model.
- Remaining work: We need to add surface water information from the USGS work to the model. This will involve choosing gages as representative of surface water entering or leaving a particular mass balance accounting unit.
- Remaining work: We need to add groundwater recharge information and storage change information as available. Need to talk to Stacy Timmons at NMBG to see if she will have groundwater storage change estimates we can use.
- Remaining work: We need to find reservoir storage data for Pecos reservoirs, Canadian reservoirs, San Juan reservoir. Others? Ruidoso?

Investigators

Principal: Jesse Roach Ph.D., Tetra Tech Inc. Unfunded Collaborators: Vince Tidwell Ph.D., Sandia National Laboratories, Bruce Thompson Ph.D., University of New Mexico. Other researcher: Kenneth Peterson M.S., New Mexico State University.

References

Longworth, J. W., Valdez, J. M., Magnuson, M. L., & Richard, K. (2013). New Mexico Water Use by Categories 2010. Santa Fe: New Mexico Office of the State Engineer.

NM-OSE-ISC. (1999-2008). New Mexico Regional Water Plans. Santa Fe: New Mexico Office of the State Engineer / Interstate Stream Commission.

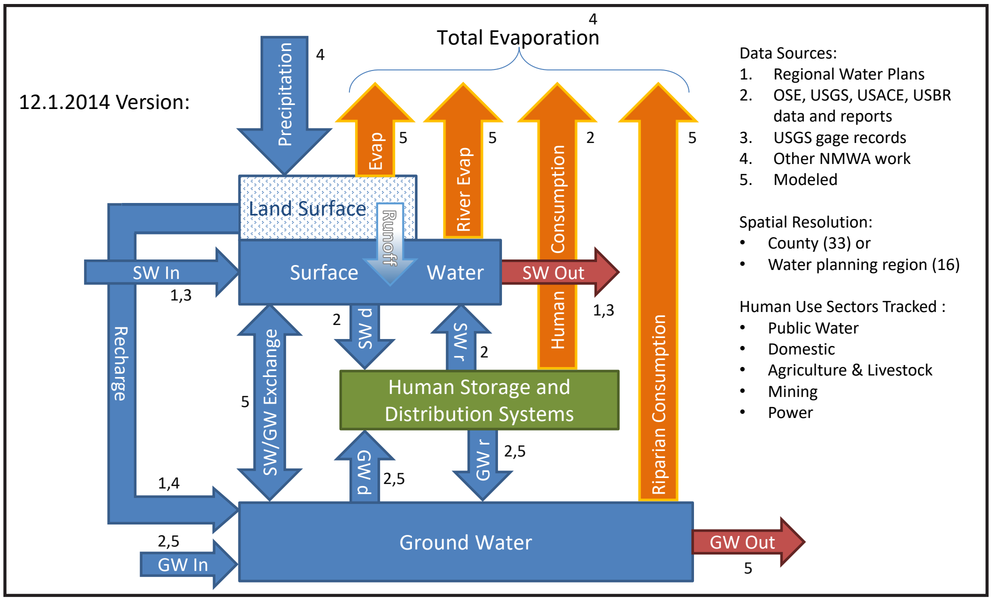

Figure 1. NM Dynamic Statewide Water Budget (DSWB): conceptual model.

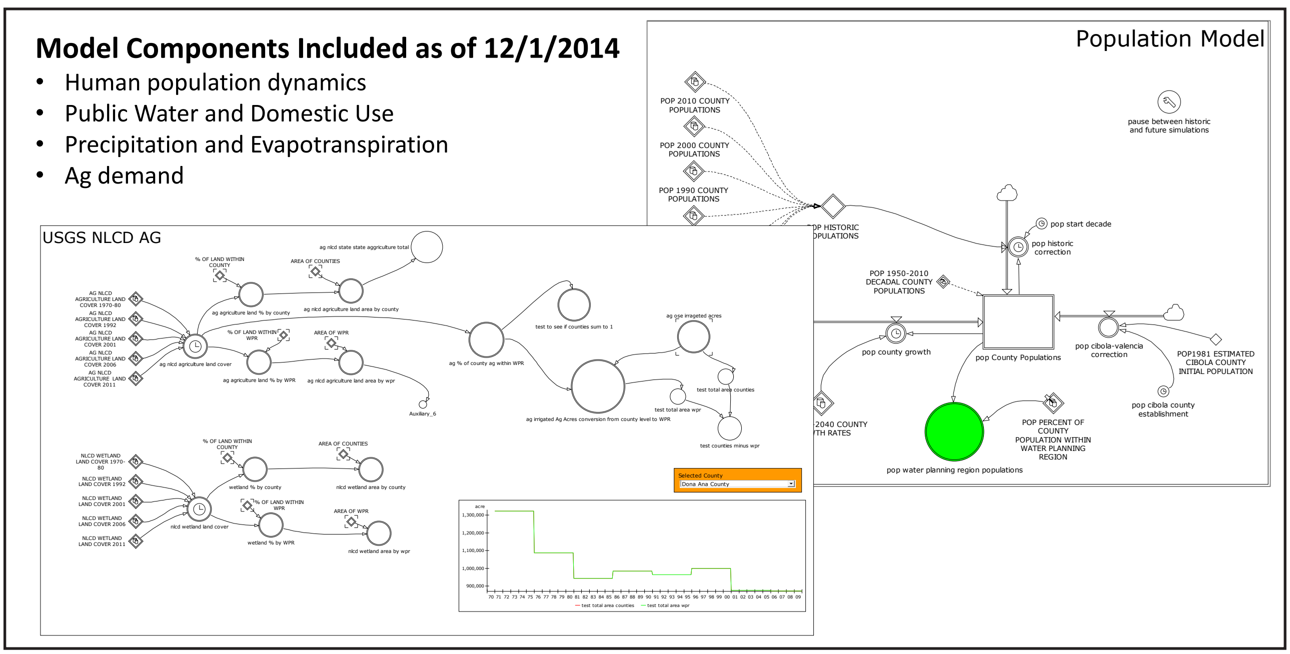

Figure 2. DSWB: model building progress.

Assessment of Spatiotemporal Groundwater Level Changes Throughout New Mexico

KC Carroll, New Mexico State University

Kenneth C. Carroll (KC) is an assistant professor in the Plant and Environmental Sciences Department at NMSU and supports the Interdisciplinary Degree Program in Water Science & Management. Formerly, he was a research scientist at Pacific Northwest National Laboratory. KC received a BS in geology from Ohio University, MS in aqueous/environmental geochemistry also from Ohio University, and PhD in hydrology and water resources from the University of Arizona. His research interests include advancing our understanding of water supply and water quality in arid regions, and development of innovative water resources, environmental-remediation, carbon-capture, and energy-production alternatives. KC is currently working with NM WRRI on the statewide water assessment on spatiotemporal groundwater level changes throughout New Mexico.

Description of Project

Fundamentally, fluctuations in groundwater levels reflect changes to the total water storage within an aquifer or aquifer system, which can highlight changes in either recharge or discharge to an aquifer. As groundwater is an important freshwater resource for both agriculture and municipal use in New Mexico, tracking and understanding changes in groundwater levels is beneficial for the overall assessment of freshwater resource allocation. More importantly, identifying localized changes in groundwater trends on a regional to statewide scale can help identify potential areas of current or future water stress, where groundwater is being mined instead of being pumped at a sustainable rate.

The hypothesis evaluated herein is that the spatial distribution and magnitude of change in groundwater elevation can be assessed and will support the evaluation of groundwater pumping change on the potential depletion of groundwater as a resource. The objectives of this study are to 1) transmit data from a groundwater database into a Geographic Information System (GIS) to map out the spatial distribution of groundwater level changes for visual and spatial analysis, 2) calculate groundwater elevation, change in groundwater elevation, and change in groundwater pumping and population, and 3) evaluate the potential impact of increased groundwater pumping on changes in groundwater elevation (Figure 1). The potential impact will be evaluated through comparisons of changes in groundwater elevation change and groundwater pumping through space and over time (Figure 2).

This work will help illuminate changes in water levels on a statewide scale, while also highlighting data gaps where future work is needed. In many regions of New Mexico, water levels are declining, but the data have not been compiled and analyzed to quantify regional changes in groundwater levels. Specifically, this project aims to update statewide groundwater level maps and to quantify the change in groundwater levels from 1994 to 2014, showing intermediate times with corresponding groundwater levels, within the state of New Mexico. As a result of this project, regional to statewide scale maps of groundwater levels and changes in groundwater levels will be produced alongside a spatial database containing groundwater level data for New Mexico. Additionally, this project will attempt to identify trends in population increase, change in land use, or other possible causes for groundwater depletion by creating maps comparing changes in groundwater levels with changes in the external variables mentioned above.

Methodology

In order to evaluate changes in groundwater levels within individual wells in New Mexico, trend analysis will be applied to groundwater level measurements collected from various agencies including, but not limited to, the United States

Geological Survey (USGS) and the New Mexico Office of State Engineer (NMOSE). The change in groundwater elevation will be calculated for individual wells as point location measures of the groundwater system. The groundwater level change is the difference between the water level at an earlier time and at a later time. The change in groundwater level will be plotted as a map across NM State, which will consist of a point map of the changes in groundwater over time at specific wells. The data will be plotted to support spatial analysis and visualization of trends (e.g., variable color or point size proportional to the amount of change) The trend of groundwater levels calculated for individual wells will then be used as a model for estimating relative groundwater levels at specified time intervals for each individual well. Once the trend analysis has been applied to the different well data points, GIS will be used to map the estimated changes in groundwater level across the state. After statewide groundwater level maps are created, census, land use, and other relevant spatial data will be collected and imported into ArcGIS to compare trends in groundwater depletion and changes in potential drivers for groundwater depletion.

Results to Date

Data are still being collected from the USGS, and are being compiled into a MS Access database. The bulk of the data is from the USGS, NMOSE, and NM Bureau of Geology & Mineral Resources (NMBGMR), which now includes about 5400 well locations and over 130,000 water level measurements. We are using the same data as the "Ground water level and storage changes" project to insure common data are being used between the two water-level projects. We have also been developing an R program for trend analysis of groundwater level over time using locally weighted scatterplot smoothing (LOESS) trend analysis. The code can be applied to individual wells currently, and we are automating the data entry and processing to work with all well data from the database. The trend calculations method will be used with the complete database, and exported results will then be imported into ArcGIS to complete the mapping of groundwater level change over time. We have also been compiling and developing a data subset into GIS coverages to support the project.

Investigators

Kenneth C. Carroll NMSU; Stacy Timmons, New Mexico Bureau of Geology and Mineral Resources; Matt Ely, USGS; Mike Johnson, Hydrology Bureau, New Mexico Office of the State Engineer; and Nathan Myers, USGS.

References

Burns, E.R., Snyder, D.T., Haynes, J.V., and Waibel, M.S., 2012, Groundwater status and trends for the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho: U.S. Geological Survey Scientific Investigations Report 2012–5261, 52 p., http://pubs.er.usgs.gov/publication/sir20125261.

Objectives

- Transmit data from a groundwater database into a Geographic Information System (GIS) to map out the spatial distribution of groundwater level changes for visual and spatial analysis
- Calculate groundwater elevation, change in groundwater elevation, and change in groundwater pumping and population
- Evaluate the potential impact of increased groundwater pumping on changes in groundwater elevation

Projected Outcomes

- Statewide maps showing changes in groundwater elevation from 1994 to 2014 (5-year time intervals)
- A map of the change in groundwater levels over time provides a spatiotemporal assessment of the impact of groundwater withdrawals over time throughout NM.

Figure 1. NM Statewide Water Assessment: Assessment of Spatiotemporal. Groundwater Level Changes Throughout New Mexico.

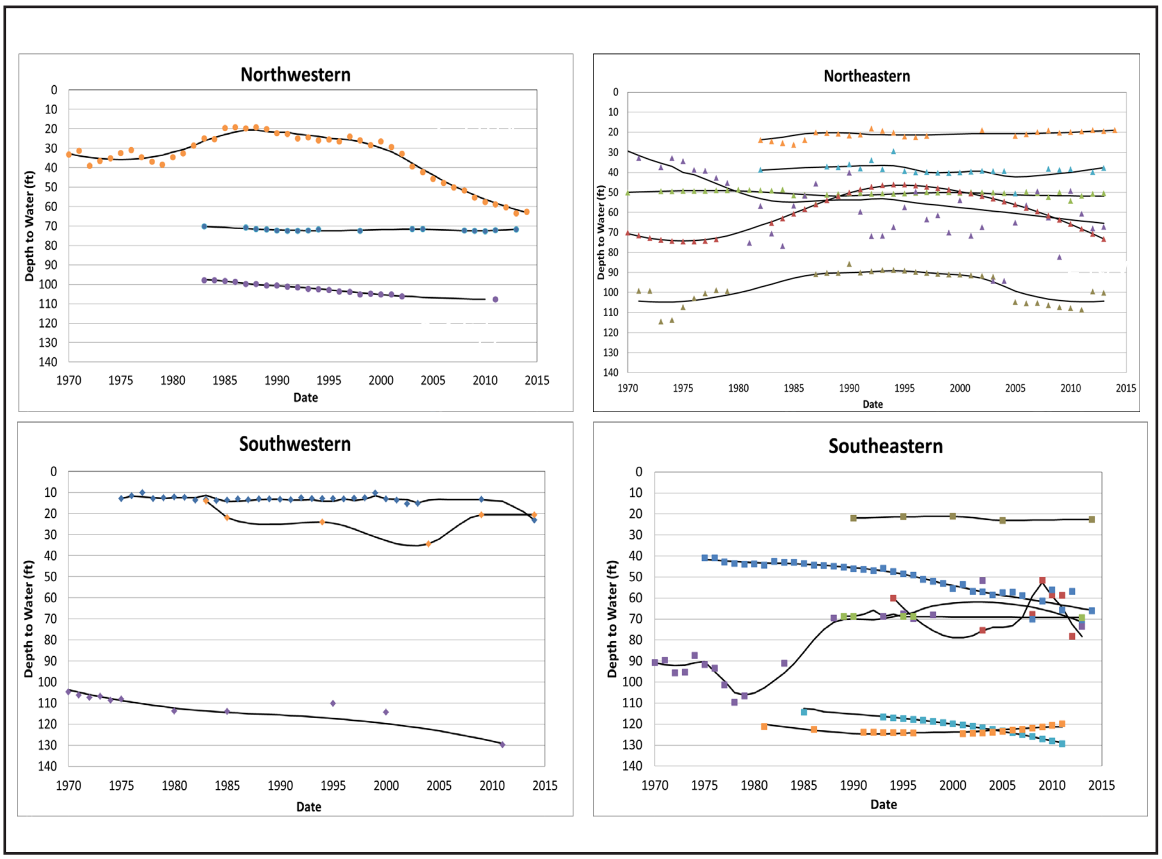

Figure 2. Selected shallow (0-150 ft) groundwater data & trends.

Surface-Water Inflow, Outflow, Gains, and Losses in New Mexico

Mark Gunn, USGS, New Mexico Water Science Center

Mark Gunn is the Assistant Director at the USGS New Mexico Water Science Center. He is first author on a 2014 publication, "The USGS at Embudo, New Mexico: 125 Years of Systematic Streamgaging in the United States."

Description of Project

Surface water is the primary source of water for irrigators along major stream corridors in New Mexico and is increasingly being utilized by large municipalities, such as Albuquerque and Santa Fe, for potable water supply. Minimum surface-water flows into and out of the state are regulated by interstate compacts, but the total quantity of surface water can vary widely from year to year. In addition, the timing and volume of peak surface-water flows is changing because of changes in precipitation patterns and increases in mean annual temperatures.

The objectives of the proposed work are:

- quantify the volume of streamflow entering and leaving New Mexico at selected stream gages at or near state borders and at Interstate Compact gages and
- quantify streamflow gains and losses between selected gages in New Mexico.

The data will be provided as a set of Geographic Information System (ArcGIS) files, suitable for integration into a Statewide Water Assessment database. Within a Statewide Water Assessment database streamflow data and derived statistics could be used by water managers to plan for the best patterns of storage and use of surface water within the state while still meeting Compact obligations.

Methodology

Daily mean streamflow data will be obtained from the network of USGS streamflow gages in New Mexico and adjacent states. Gages selected for data analysis will include gages along major streams and selected tributaries in the state (Figure 1). Where major streams cross state borders, a gage near the border, either in New Mexico or in the adjoining state, will be included in the set of gages selected for analysis. Daily mean streamflow data and derivative products will be stored in ArcGIS files that are compatible with others being prepared for the Statewide Water Assessment database. Differences in monthly mean streamflow at selected gages will be analyzed for gains and losses in streamflow. For visualization of patterns of streamflow gains and losses, stream reaches between selected gages will be categorized on a seasonal basis as strongly gaining, gaining, no gain/loss, losing, and strongly losing.

Results to Date

- An initial selection of candidate streams has been done.
- Gages along the candidate streams have been identified.
- Initial streamflow data for analyses has been obtained.
- Screening of candidate streams is done.
- Screening of gages is done.

- Downloaded streamflow data for selected gages.
- Loaded streamflow data into GIS files.
- Currently exploring temporal and spatial aspects of streamflow data.
- Best time interval for analyses appears to be annual, but a monthly analysis period may be appropriate where gages are close together and there are few gains or losses between the gages.
- Computing differences in streamflow for gages and stream reaches is done for the Gila, San Francisco, San Juan, Cimarron, and Canadian Rivers.
- Gaining and losing stream reaches are being identified as we go.
- Working on ArcGIS animation where by gaging station symbol size varies according to magnitude of annual flows and river reach color and line width vary according to gain or loss and volume of gain or loss, respectively.

Work Remaining

- Explore temporal and spatial aspects of streamflow data. This element probably will be completed during report writing.
- Finish GIS work on remaining rivers.
- Finish ArcGIS animation setup.
- Document digital data sets (metadata).
- Write report.

Investigators

Nathan Myers, Matt Ely, and Joe Affinati, U.S. Geological survey, Albuquerque, NM

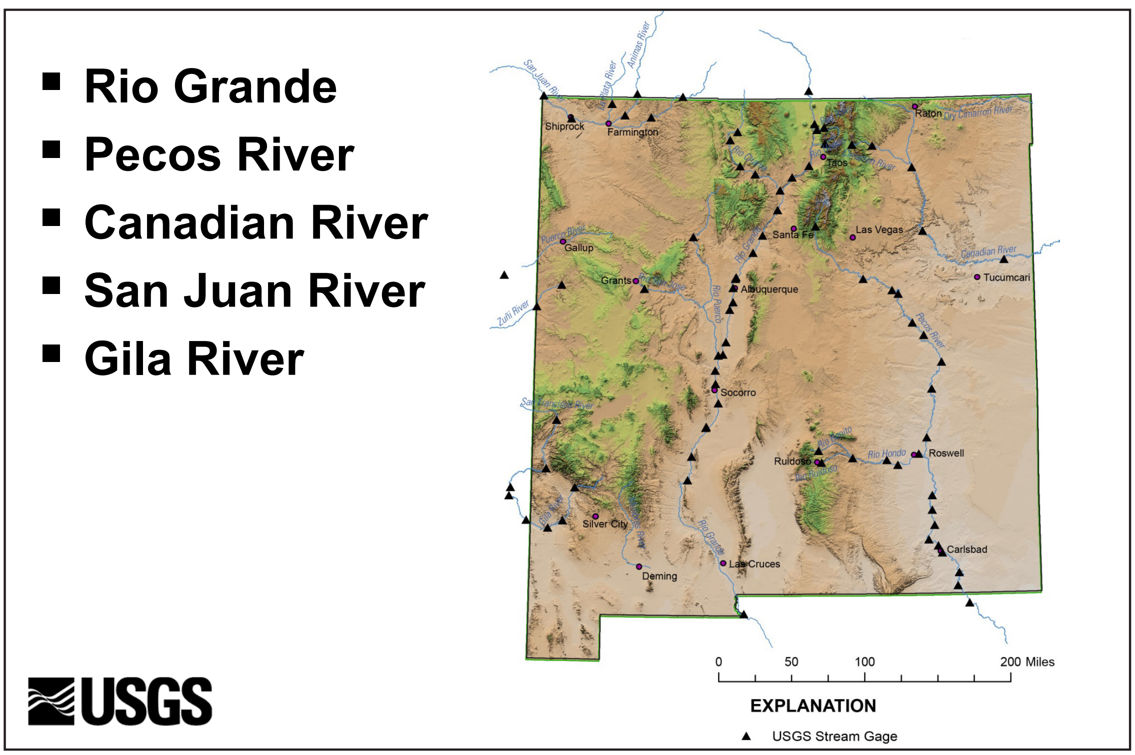

Figure 1. Major streams and USGS stream gages.

Comparison of Operational Precipitation and Evapotranspiration Products for the Statewide Water Assessment

Thomas Schmugge, NM Water Resources Research Institute

Tom Schmugge is a volunteer senior scientist at NM WRRI and is working on the institute's new initiative on developing a statewide water assessment. His expertise includes microwave and infrared remote sensing of the land surface. Formerly he was the Gerald Thomas Professor of Natural Resources at New Mexico State University. Tom served 33 years with NASA and the USDA Agriculture Research Service using satellite observations for Earth surface studies. He is a Fellow of the American Geophysical Union, from which he received the Union's Horton Metal in 2006. He received a PhD in physics from the University of California at Berkeley.

Description of Project

The economic vitality of New Mexico depends on its water availability, but no one knows exactly where, when, and how much water is available in the state. Precipitation and evapotranspiration are the major components of a water balance equation. We have identified five precipitation and three evapotranspiration products, currently available over New Mexico. The research objectives for this project are:

- We will compare and contrast the each of these products spatially and statistically (Phase 1).
- We will validate the products against reliable measurements: precipitation products against precipitation gauges and experimental ranges and evapotranspiration against METRIC model ET maps (Phase 2).
- We will validate two chosen products for assessment of reference ET to be used to fill in null values in existing ET products (Phase 3).
- We will produce statewide precipitation and evapotranspiration products for New Mexico with a quality assessment and a plan for how to improve these products at the proper spatial and temporal scales (Phase 4).

Methodology

Phase 1
Obtain and compile all data and base literature for each product model. Display all data across each year available for the entire state. Produce tabular itemizations for basic statistical analysis for the entire state, for each year, for each model. Produce comparison graphs, histograms, and spatial displays for each model.

Phase 2
Obtain and compile all data and base literature for each validation model or dataset. Produce correlation scatter plots that compare each validation product with each precipitation and evapotranspiration product. Establish one or two precipitation and evapotranspiration products to focus on as key products and require less model manipulation for further verification.

Phase 3
Validate two existing methods for assessment of the reference ET for the New Mexico environment. One is a remote sensing method, the other consists of calculating the reference ET from NLDAS (North American Land Data Assimilation Systems) data following the standard method of the American Society of Civil Engineers. The reference ET is needed for calculation of the reference ETr fraction (ETrF) that is needed to fill the missing data in the existing ET products. The ETrF is a steady variable that allows reliable interpolation of ET values where missing data occur.

Phase 4
Compile all precipitation and evapotranspiration data into a geodatabase and set of map documents at a spatial and temporal scale that will allow them to be combined with other water balance component data. Provide all pertinent metadata.

Results to Date

We have completed phase 2 (verification and validation) for the precipitation component and have concluded that PRISM is the most accurate model for our state (Figure 1). We still have to compile all of the results and organize them for display. We are in the process of ordering daily and monthly PRISM datasets for the years spanning 1984 to 2014.

We are in the process of verifying six NM Ameriflux Eddy Covariance ET flux towers for use in verification and validation of the ET models for the state (Figure 2). We are in contact with the PI (Marcy Litvak) of the project that collected the data to make sure that we are getting accurate results from compilation. These towers also have precipitation values for their immediate area that we will use as another validation element for the precipitation models.

We have had requests for our model datasets so that they can be used to calculate statewide recharge. The request has started with PRISM and SSEB data because they have performed well and don't have null values. Unfortunately, we don't have monthly or daily data for these datasets yet. We have attempted to retrieve at least monthly SSEB datasets from the USGS website, but they are in NetCDF format and we have had issues extracting the data from the file.

Investigators

Jan M.H. Hendrickx, New Mexico Tech and Thomas Schmugge, New Mexico State University. Other Researchers: Dan Cadol, New Mexico Tech and Ken Peterson, NM Water Resources Research Institute.

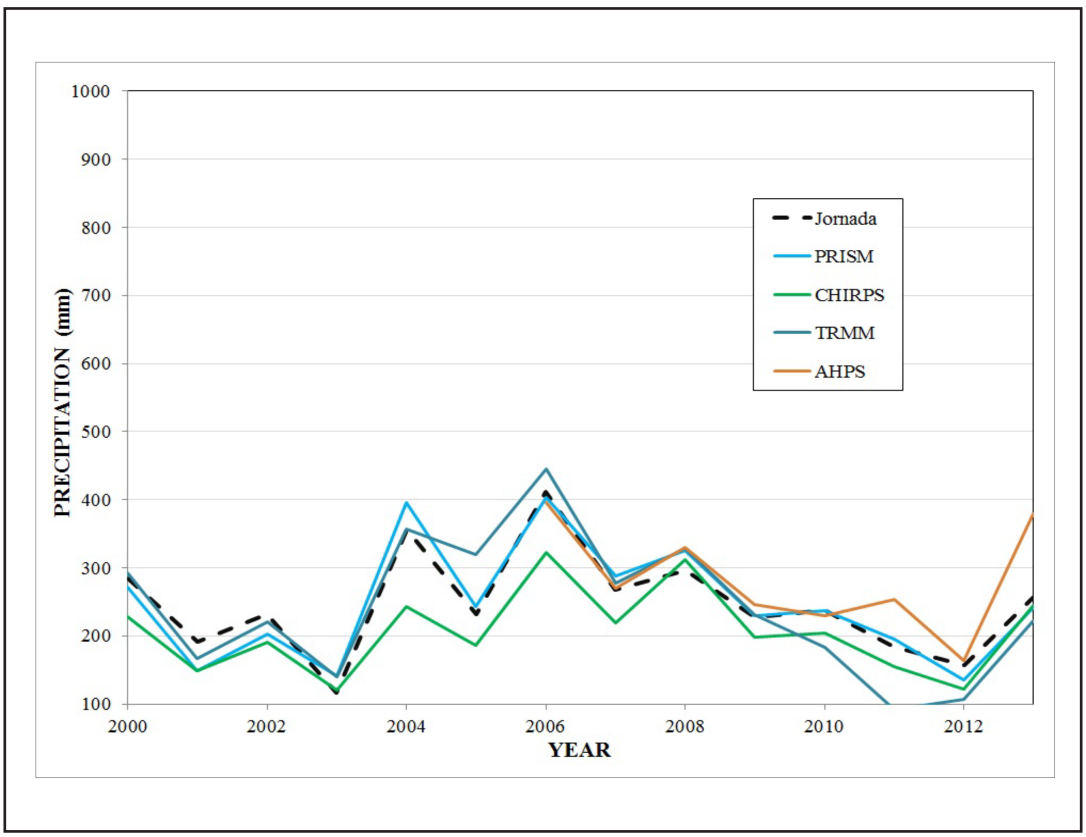

Figure 1. Model Values vs. Jornada Rain Gauge Measurements.

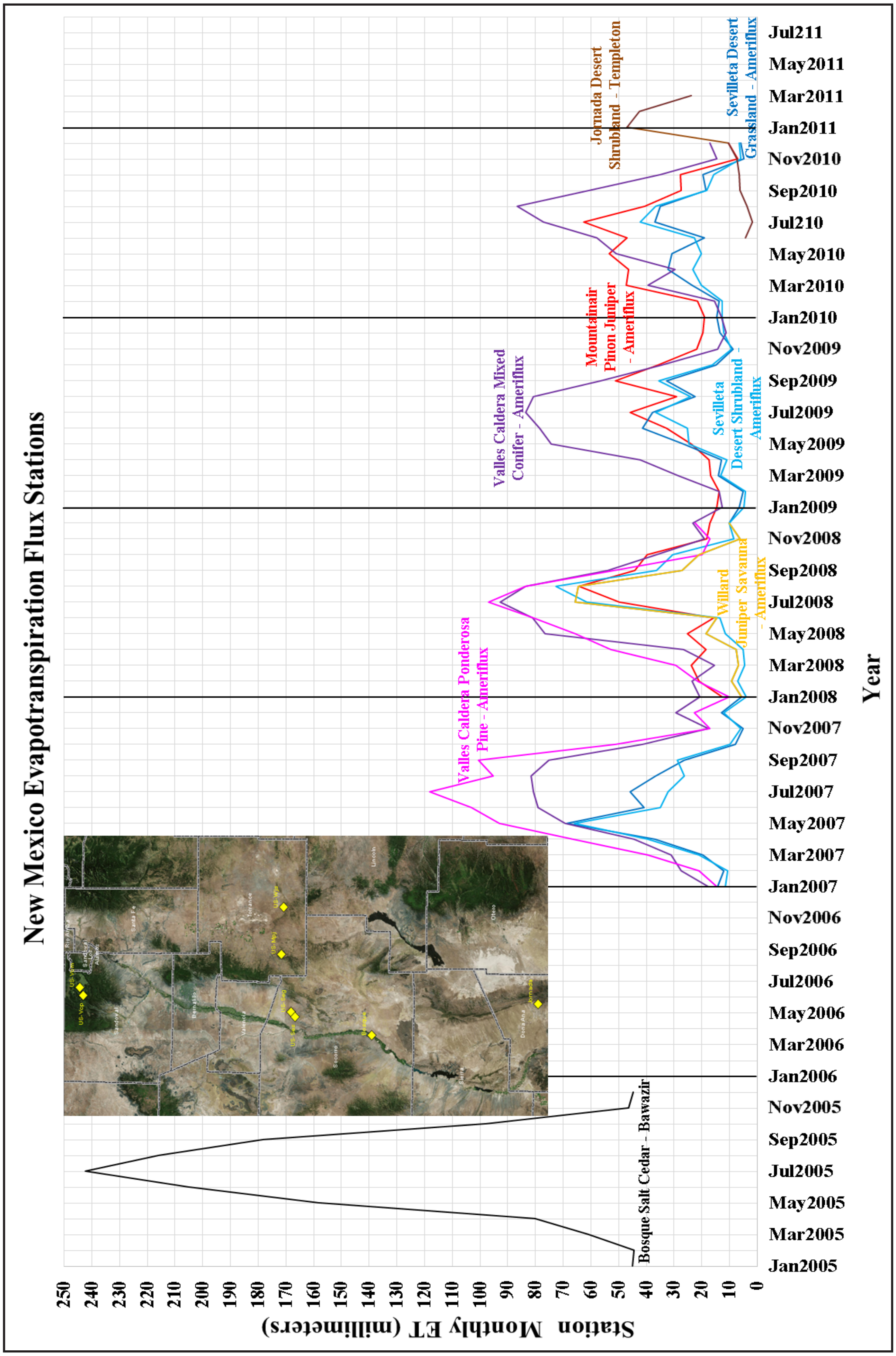

Figure 2. New Mexico Evapotranspiration Flux Stations.

Data from Litvak, Bawazir, and Templeton (built by Steve Walker, NM WRRI)

Recharge Data Compilation and Recharge Area Identification for the State of New Mexico

Fred Phillips, NM Tech

Fred Phillips is a professor of hydrology and director of the Hydrology Program at New Mexico Tech. He joined the university in 1981 after completing a PhD in hydrology from the University of Arizona. Fred also has an MS in hydrology from UA as well as a BA in history from the University of Santa Cruz. His scientific interest lies within the area where hydrology, geochemistry, and geology overlap. Fred has focused on the effects of climate change on the hydrologic cycle and the influence of the hydrologic properties of geologic materials on the transport of solutes in groundwater and soil water. His favorite tools for these investigations are stable and radioactive isotope techniques. Fred was elected into the American Geophysical Union in 2008 and in 2007, he was elected as a Fellow of the American Association for the Advancement of Science.

Description of Project

Quantification of groundwater recharge by precipitation is the most important gap in current understanding of the New Mexico water budget. Other important components of the water budget (e.g., precipitation, surface water flows) have been systematically studied for over 100 years, yet no such systematic effort has been attempted for recharge. The objectives of this project are to compile previous estimates of recharge and to construct a map based on Geographic Information System (GIS) layers that identifies areas where recharge is likely to occur (Figure 1). The recharge area map will integrate existing GIS layers, including monthly and annual precipitation, potential ET, geology, major streams and drainages, and vegetation. This recharge area map will be a valuable resource in and of itself and is a necessary step towards calculating accurate recharge rates throughout the entire state.

Methodology

Phase I

Obtain and compile all existing recharge estimates and data (Figure 2). Display data in a format that includes the study citation, location (individual basins, counties, and water planning regions), recharge estimate, methodology, and other important information. Construct an interactive GIS-based map that shows locations of recharge estimate research and water resource planning studies.

Phase II

We will construct a New Mexico recharge area map within a GIS framework by combining several individual layers containing spatial data that can help to determine where groundwater recharge likely takes place. These spatial data sets include a digital elevation model (DEM), precipitation rates, potential ET rates, regional geology, vegetation cover, and stream locations. These layers will be evaluated and integrated to quantitatively rate different areas in terms of propensity for groundwater recharge. The difference between precipitation data and potential ET values will be used to evaluate the potential magnitude of recharge. Vegetation and geologic data will be categorized in a way that highlights areas where there is greater potential for recharge. Major rivers and streams in the state also likely contribute to groundwater recharge. The final report will describe quantitative methods and algorithms used to integrate these different data sets.

Results to Date

We have completed Phase I. Results of Phase I are tabulated data from many academic and government studies of groundwater recharge from around the state. The region of the most thoroughly collected and analyzed data has shown to be the populous central region of New Mexico. A working GIS-based map has been developed, showing compiled data associated with points based at the center of each of New Mexico's 16

Water Resource Planning regions and points for each specific study site at the basin scale. Early analysis of GIS data including precipitation models from PRISM and potential evapotranspiration data from MODIS (MOD16) is being completed. An initial map of likely recharge based on these parameters at a large temporal scale has been created. Data pertaining to geology, vegetation, soils, and surface hydrology has been acquired and is being prepared for processing.

Investigators

Talon Newton, New Mexico Bureau of Geology and Mineral Resources and Fred Phillips, Department of Earth and Environmental Science, New Mexico Tech. Other Researchers: Geoffrey Rawlings, New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech.

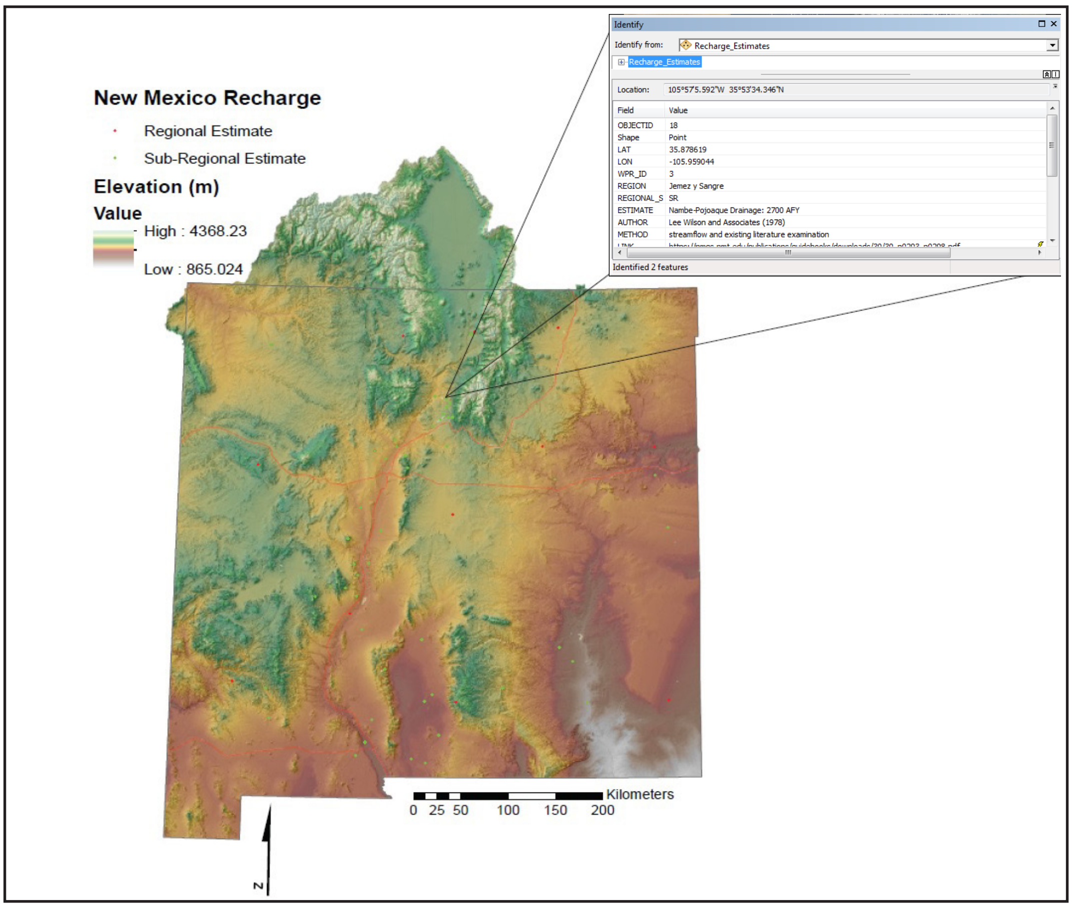

Figure 1. New Mexico recharge map.

	D	E	F	G	H	I	
1	WPR_ID	REGION	REGIONAL/SUB	ESTIMATE	AUTHOR	METHOD	LINK
17	3	Jemez y Sangre	SR	La Cienega: 0.7"/yr	Spiegel and Baldwin (1963)	water mass balance	http://pubs.usgs.gov/wsp/152
19	3	Jemez y Sangre	SR	Nambe–Pojoaque Drainage: 2700 AFY	Lee Wilson and Associates (1978)	streamflow and existing literature examination	https://nmgs.nmt.edu/publica
20	3	Jemez y Sangre	SR	Tesuque R. Drainage: 1500 AFY	Lee Wilson and Associates (1978)	streamflow and existing literature examination	https://nmgs.nmt.edu/publica
21	3	Jemez y Sangre	SR	Sta Fe R. Drainage: 3500	Lee Wilson and Associates (1978)	streamflow and existing literature examination	https://nmgs.nmt.edu/publica
22	3	Jemez y Sangre	SR	Sta. Fe R. Drainage: 2070	Hearne (1985)	simulations based on streamflow estimates of Reiland (1975)	http://pubs.usgs.gov/wsp/220
23	3	Jemez y Sangre	SR	Pojoaque R. Drainage: 2250 AFY	Hearne (1985)	simulations based on streamflow estimates of Reiland (1975)	http://pubs.usgs.gov/wsp/220
24	3	Jemez y Sangre	SR	R. Chupadero Drainage: 390 AFY	Hearne (1985)	simulations based on streamflow estimates of Reiland (1975)	http://pubs.usgs.gov/wsp/220
25	3	Jemez y Sangre	SR	Tesuque R. Drainage: 1800 AFY	Hearne (1985)	simulations based on streamflow estimates of Reiland (1975)	http://pubs.usgs.gov/wsp/220
26	3	Jemez y Sangre	SR	R. En Medio: 890 AFY	Hearne (1985)	simulations based on streamflow estimates of Reiland (1975)	http://pubs.usgs.gov/wsp/220
29	3	Jemez y Sangre	SR	Pojoaque R. Drainage: 2250 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
30	3	Jemez y Sangre	SR	Mountain front recharge in Sta. F. R. Basin: 5390 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
31	3	Jemez y Sangre	SR	Mountain front recharge in Pojoaque Basin: 6080 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
33	3	Jemez y Sangre	SR	Mountain stream channel recharge to Sta. F. R. Basin: 5430 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
34	3	Jemez y Sangre	SR	Mountain stream channel recharge to Pojoaque Basin: 5900AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
35	3	Jemez y Sangre	SR	Mountain stream channel recharge A. de los Chamisos: 1010 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
36	3	Jemez y Sangre	SR	Mountain stream channel recharge A. Hondo: 510 AFY	McAda and Wasiolek (1988)	estimates based on streamflow estimates of Reiland (1975)	http://pubs.er.usgs.gov/publi
38	3	Jemez y Sangre	SR	Grand Total: 32020 AFY	McAda and Wasiolek (1988)	based on precip infiltration coeff of (0.05-0.5) varying accordi	http://pubs.er.usgs.gov/publi
39	3	Jemez y Sangre	SR	Total Direct Recharge: 7700 AFY	McAda and Wasiolek (1988)	based on precip infiltration coeff of (0.05-0.5) varying accordi	http://pubs.er.usgs.gov/publi
40	3	Jemez y Sangre	SR	9200 AFY	Wasiolek (in press)	water balance method from Toendle and Leaf (1980)	in http://pubs.usgs.gov/wri/19
41	3	Jemez y Sangre	SR	MFR R. en Medio: 1710 AFY	Wasiolek (in press)	water balance method from Toendle and Leaf (1980)	in http://pubs.usgs.gov/wri/19
42	3	Jemez y Sangre	SR	MFR Tesuque Cr. Dranaige: 1530 AFY	Wasiolek (in press)	water balance method from Toendle and Leaf (1980)	in http://pubs.usgs.gov/wri/19
43	3	Jemez y Sangre	SR	MFR Sta. Fe R. Drainage: 4170 AFY	Wasiolek (in press)	water balance method from Toendle and Leaf (1980)	in http://pubs.usgs.gov/wri/19
44	3	Jemez y Sangre	SR	MFR Little Tesuque Cr. Drainage: 1790 AFY	Wasiolek (in press)	water balance method from Toendle and Leaf (1980)	in http://pubs.usgs.gov/wri/19
45	3	Jemez y Sangre	SR	MFR to Tesuque A. of Espanola B.: 14700 AFY	Wasiolek (1995)	from NMOSE water budgets (0.13)(annual precip)	in http://pubs.usgs.gov/wri/19
46	3	Jemez y Sangre	SR	stream channel recharge Sta Fe R.: 1.7cfs over 2.5 mi reach above La Bajada	Thomas et. Al. (2000)	measure loss of flow, 745 obs, and assumed (0.02-0.08)(flow)	in http://pubs.er.usgs.gov/pu
47	3	Jemez y Sangre	SR	Stream channel recharge to A. Hondo: 13 AF (2000), 200 AF (2001), 0 AF (2002)	Moore (2007)	inverse modeling of infiltration using flow gauges spaced 2km	http://pubs.usgs.gov/pp/pp17
48	3	Jemez y Sangre	SR	Galisteo Cr.: 3600 AFY	Kernodle, McAda, Thorne (1995)	Mass balance involving precipitation, evaporation, and surfac	http://pubs.usgs.gov/wri/1994
49	3	Jemez y Sangre	SR	Sta Fe River Drainage: 4000 AFY	Kernodle, McAda, Thorne (1995)	Mass balance involving precipitation, evaporation, and surfac	http://pubs.usgs.gov/wri/1994
50	4	SW New Mexico	R	224000 AFY	DBS&A (2005)	Precipitation infiltration coefficient estimate	http://www.ose.state.nm.us/P
51	4	SW New Mexico	SR	3932 AFY Stream Channel Reacharge between Feywood and Spaulding	Cuddy and Keyes (2011)	Measurement of flow -loss	http://www.ose.state.nm.us/P
52	4	SW New Mexico	SR	76000 AFY Upper Mimbres Basin from Mountain Front Runoff, Stream Infiltration and I	Hanson et al (1994)	Analysis of mount-front runoff (Hearne and Dewey (1988), infil	http://pubs.er.usgs.gov/publi
53	5	Tularosa - Sacram	R	45300 AFY	Waltemeyer (2001)	Basin Climatic Characteristics Model	http://pubs.er.usgs.gov/publi
54	5	Tularosa - Sacram	R	67900 AFY	Mamer et al (2014)	Darcy Flow calculations (mean elev. Of each basin)(av. Annu	https://geoinfo.nmt.edu/publi
55	5	Tularosa - Sacram	R	75000 AFY	Livingston and Shoemaker (2006)	Surplus Precipitation Estimate	http://ci.alamogordo.nm.us/A

Figure 2. New Mexico recharge estimates table. Includes location, water resource planning region, recharge estimate, author, methodology, and link to online content.