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Bosque Ecosystem Monitoring Program

BOSQUE SCHOOL

scholarship • community • integrity

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BOSQUE ECOSYSTEM MONITORING PROGRAM
(BEMP) SITE MONITORING REPORT FOR 2017

2017 ANNUAL SITE MONITORING TECHNICAL REPORT

Submitted March 30th, 2018

2017 Final Report submitted to:
US Army Corps of Engineers, USACE Solicitation Number: W912PP-15-R-0035
Valencia Soil and Water Conservation District
Middle Rio Grande Conservancy District
Valle de Oro National Wildlife Refuge

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Bosque Ecosystem Monitoring Program (BEMP)
Report on 2016-17 Education and Monitoring
March 2018

Objective: To collect and analyze abiotic and biotic data at BEMP sites in the Middle Rio Grande Bosque. Additionally, to involve K-12 and university students in learning about and monitoring this ecosystem.

All data and reports are available on the BEMP website, www.BEMP.org

Scope of Work: The Bosque Ecosystem Monitoring Program (BEMP) combines long-term ecological research with community outreach by involving K-12 teachers and their students in monitoring key indicators of structural and functional change in the Middle Rio Grande riparian forest, or "bosque." In 1996, BEMP began as a collaboration between the University of New Mexico, Department of Biology and Bosque School in Albuquerque, with fewer than 200 participants in its first year. Now, BEMP averages approximately 9000 participants annually. The experiences of these community members support science education reform efforts and help to increase understanding and appreciation of the Rio Grande riparian ecosystem. BEMP findings derived from student-gathered data are used by government agencies to inform multi-million dollar river and riparian management decisions.

During this reporting period, BEMP had 31 active monitoring sites along 250 miles of the Rio Grande, including 30 sites within the Middle Rio Grande (Figure 1). Through the strategic location of these sites, BEMP aims to study the ecological drivers of fire, flooding, climate change, and human alteration on the bosque ecosystem. Two thirds of the BEMP sites were installed at the request of natural resource managers to monitor the long-term ecological impacts of restoration projects such as mechanical clearing, wood chipping, and bank-lowering. Both biotic and abiotic variables are monitored. Our abiotic datasets are depth to groundwater; water level in ditches and drains; precipitation; above- and belowground temperature; and water quality in the Rio Grande, ditches and drains, and groundwater. Our biotic datasets are litterfall; vegetation cover; fuel load and woody debris; cottonwood sex and diameter; surface-active arthropod richness and abundance; and tamarisk leaf beetle distribution, abundance and impact. BEMP hosts two events during the year to present new data, visualizations, and analyses to management agencies: the Fall Field Tour and the Crawford/Green Trails Symposium. BEMP staff and students present BEMP data to managers, professionals and students several times throughout the year depending on conference availability. Some examples of conferences where BEMP data have been shared include: The Tamarisk Coalition, The Land and Water Summit, Wildland-Urban Interface, Sevilleta Science Symposium, The Society of American Foresters National Convention, and more.

Timing of Data Collection: Depth to groundwater, water level in nearby ditches and/or drains, precipitation, and litterfall are collected during the week of the third Tuesday of each month. Surface-active arthropods are collected three times each year, in the spring, summer and fall. Vegetation cover is collected once each year in August/September. Tamarisk leaf beetle monitoring is conducted during the week of monthly monitoring from May-August. All other datasets are collected as funding permits.

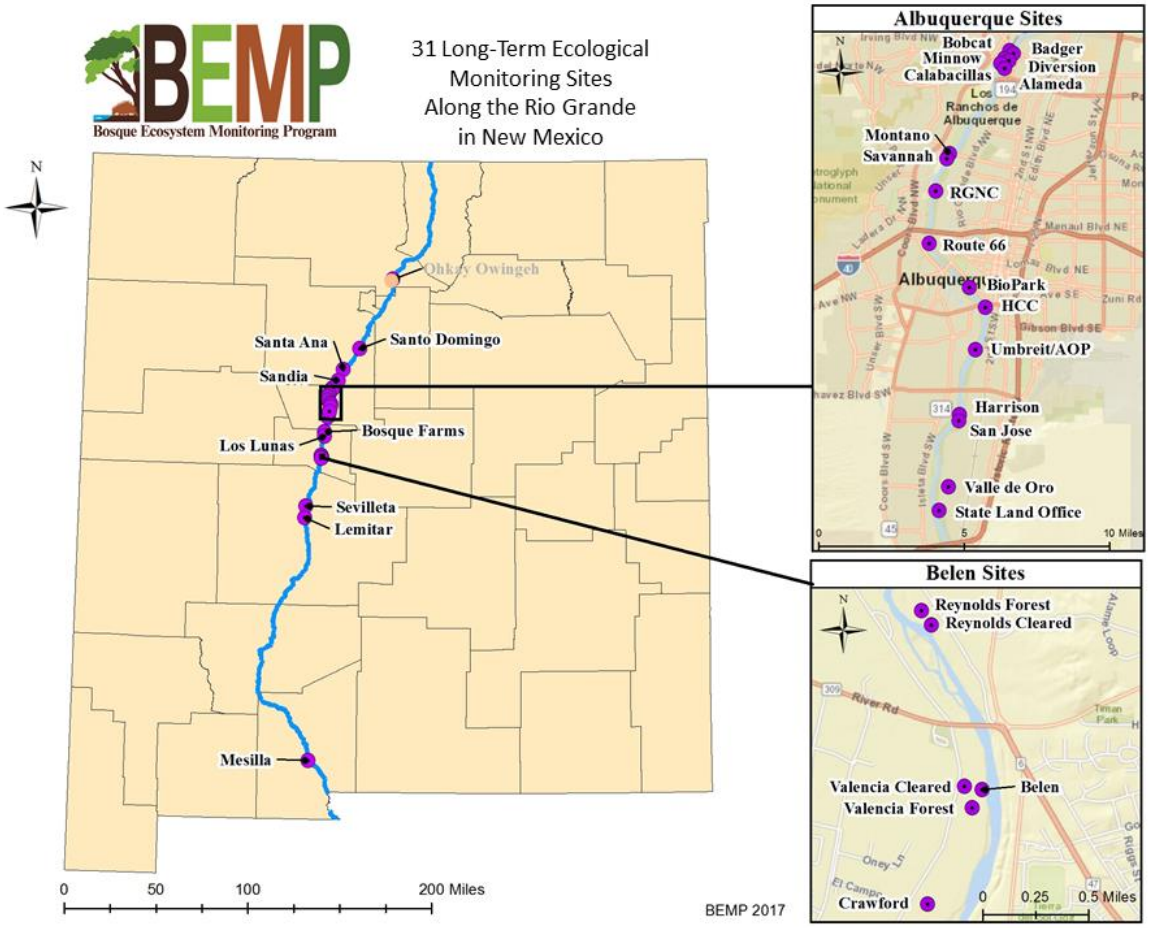

Figure 1. Map of 31 active BEMP sites along the Rio Grande; Ohkay Owingeh is no longer an active site and is shown in orange and grey.

Education and Outreach:

BEMP Education and Outreach, 2016-2017 School Year:

Forty schools from Sandoval, Bernalillo, Valencia, Socorro, and Doña Ana counties are involved with BEMP. Participants include traditional public, charter, parochial, private, alternative, and home school students. Throughout the school year, BEMP staff deliver Common Core-correlated curricula both in the classroom and out in the field. At the end of the school year, BEMP hosts two annual student congresses in partnership with a variety of local agencies and organizations. Students present and share their experiences at their sites with each other and engage in bosque-related activities and workshops. As BEMP is the official schoolyard program for the Sevilleta Long-Term Ecological Research (LTER) Network site, our students also present at the LTER Schoolyard Spanish Webinar. This symposium connects Spanish-speaking BEMP students with students at the Luquillo, Puerto Rico LTER site to share data and compare experiences. (Taken from BEMP 2016 Annual Site Monitoring Technical Report)

In the 2016-2017 school year, 8403 community members, largely students and teachers, participated in BEMP's education and outreach (Table 1). Over 5000 participants were out in the field conducting core BEMP monitoring or collecting data for special research projects. Of those, over 2000 students were involved in year-round monthly monitoring with follow-up classroom sessions. This number is mostly limited by staff time constraints and budgeting needs. There has been a shift this year to more students being involved in long-term monitoring as opposed to single-day classroom visits or field trips, resulting in a lower total number than the 2015-2016 school year (Figure 2). There were about 20 students involved in in-depth research projects with BEMP, which included field work, data analysis, and presentation/dissemination of the data to broader audiences at professional conferences and local events. (Taken from BEMP 2016 Annual Site Monitoring Technical Report (submitted July 5, 2017))

Table 1. BEMP participation numbers by category of outreach

BEMP 2016-2017 Outreach	**students**	**adults**	**total**	**%**
long term multiple field days	2148	123	2271	27.0%
short term field or classroom (1-2 days)	2862	148	3010	35.8%
summer programs	305	55	360	4.3%
wildlife programs	14	0	14	0.2%
adult/teacher training	0	76	76	0.9%
festivals, events, etc.	1291	595	1886	22.4%
conferences, meetings, etc.	42	744	786	9.4%
	6662	**1741**	**8403**	100%

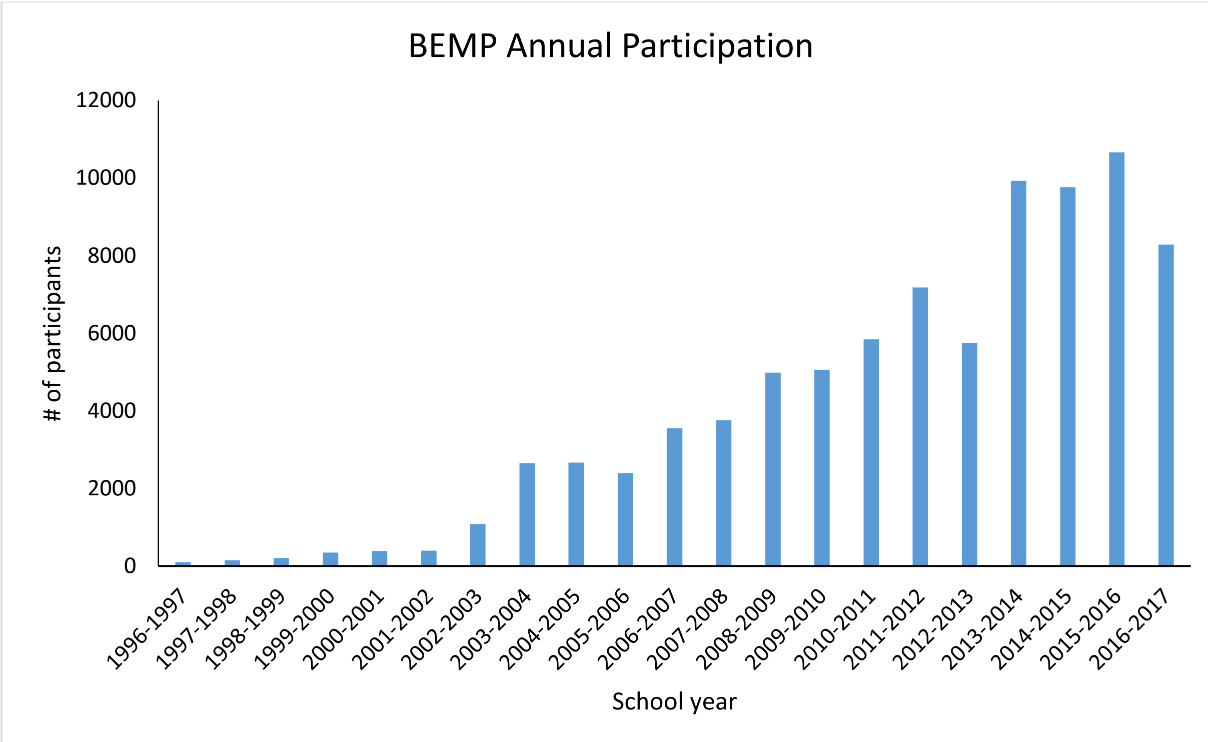

Figure 2: BEMP annual participation numbers from 1996 through the 2016-2017 school year

(Table and Figure are from BEMP 2016 Annual Site Monitoring Technical Report*)*

Rio Grande Phenology Trail Overview

The Rio Grande Phenology Trail uses the online program, "Natures Notebook" to engage both the general public and K-12 students in tracking ecological phenomena as manifested in phenology along the Rio Grande and its watershed. This is done through a *Nature's Notebook Rio Grande Phenology Trail Network* Coordinator position. This position connects urban audiences, especially students, to the outdoors and conservation through weekly monitoring efforts of seasonal changes (phenology). The coordinator offers trainings for local teachers, land managers, and community members on how to implement the protocols and how to use the software associated with the project. The coordinator hosts events and meetings to connect various groups monitoring the seasonal changes in the plants and animals along the Middle Rio Grande, from Santa Fe to Sevilleta National Wildlife Refuge.

Rio Grande Phenology Trail Program

The purpose of the RGPT is twofold: (1) to connect like-minded organizations through a shared community project and (2) use phenology at the Valle de Oro NWR to integrate management and science objectives with education and outreach objectives. It encourages people to engage in active, outdoor education, and ask and answer local science, management and climate questions. It is a citizen science project that uses the Nature's Notebook interface, a phenology citizen science program of the USA-National Phenology Network (USA-NPN). There are 11 volunteers who monitor regularly at the six

RGPT partner sites. These sites include Valle de Oro NWR, Sevilleta NWR, Whitfield Wildlife Conservation Area, Albuquerque BioPark Botanic Garden, BEMP, and the Santa Fe Botanical Garden.

Each of the six RGPT sites monitors 4-18 species weekly. The longitudinal span of the Trail enables National Phenology Network partners, RGPT partners, and specifically land managers at Valle de Oro to better understand how climatic shifts are manifesting changes in local species' phenology. Cottonwood (*Populus deltoids* ssp. *wislizenii*) and Siberian elm (*Ulmus pumila*) are the principle plant species studied at RGPT sites. Several other plants, avian, and mammalian species are monitored regularly at the sites.

Building from the existing partnerships established by the first RGPT Coordinator in 2014-16, the RGPT engaged with 1589 people throughout New Mexico during the 2016-2017 school year. Volunteers and students working with the RGPT contributed 48,894 observations to the National Phenology Network through the Nature's Notebook interface in 2017. In order to inform the public and specifically the conservation and science communities about ongoing accomplishments, successes, and progress of the RGPT, the Coordinator presented the RGPT poster at BEMP's Crawford Symposium (200 people, March 2017) and Valle de Oro's Environmental Justice Community Day (100 people, April 2017).

RGPT Adult Volunteer Support and Adult Outreach:

To support volunteers at the RGPT sites, the RGPT Network Coordinator met regularly with volunteers to hear updates, to shadow the volunteers during monitoring, and to identify needs for the groups of volunteers. Although each site has a unique history and volunteer recruitment strategy, the Coordinator assisted partner sites in engaging and training volunteers. One staff member at a partner site expressed how "this is an important part of the work that [we] do. Without Nature's Notebook, we could collect data, but it would not be going anywhere. This allows us, a small [organization], to contribute to a much larger field of knowledge." During the 2016-2017 school year, the Coordinator scheduled workshops and site tours geared toward volunteer needs and interests, such as: "Making accurate bird counts," (3 people) with Valle de Oro Biologist Ariel Elliott. Partner site volunteers hosted a tour of the Nature's Notebook monitoring at Valle de Oro NWR.

To reach a broader audience beyond the RGPT network partners and volunteers themselves, the Coordinator organized or attended several public events in the Albuquerque and Santa Fe areas. The Coordinator reached 150 people at community events at Valle de Oro (Valle de Oro Birthdays and EarthForce events). The Coordinator also hosted three public lectures about the RGPT, phenology monitoring, and citizen science engagement in biodiversity conservation. Finally, RGPT partnered with New Mexico Public Broadcasting Service to host a screening of the citizen science docu-series "The Crowd and The Cloud," which featured Valle de Oro and the RGPT. Additional partner organizations Earth Force, the Friends of Valle de Oro, BEMP, and Bosque School supported this event with financial and in-kind donations. This event was possible because of the strong partnerships of the RGPT network.

RGPT Student Support and Outreach:

BEMP's study Trips: BEMP's RGPT site is just one of the six RGPT sites, but it has a unique model for phenology data collection. During most weeks of the school year, on Thursdays and Fridays, unique student groups from throughout Albuquerque come to BEMP's RGPT site for a "Study Trip" or interpretive hike through the Rio Grande bosque. To ensure that each student has the opportunity to collect climate change/phenology data, they all participate in cottonwood tree observations and upload their data directly with phone apps to the National Phenology Network. In the 2016-2017 school year, 662 students did Study Trips that directly contributed data to the RGPT.

Horizons: During summer 2017, and during three Saturday events in fall, winter, and spring, the RGPT Network Coordinator did RGPT education programming with 20 5th graders from the Horizons Albuquerque program. Horizons is an academic enrichment program to address the achievement gap for low-income students. These 5th graders did weekly phenology monitoring through the Nature's Notebook app and crafted creative "wheel-phenophase" calendars to compare data between three of the RGPT sites. Students presented their phenology research in July 2017 at the end of their six-week summer experience to families, teachers, and the public.

Southwest Season Tracker Project with Jefferson Middle School: An 8th grader at Jefferson Middle School has been working with the RGPT Network Coordinator to collect data specifically about dryland plants for the Southwest Season Tracker project of Nature's Notebook. This student monitored 4 species at a local golf course and at the BEMP RGPT site throughout summer 2017 and during the 2017-2018 school year. He monitors these plants weekly and will generate a science fair project based on his research using the Nature's Notebook app and data analysis tools.

Schoolyard: In the 2016-17 school year, the RGPT program initiated a pilot project – the Schoolyard Phenology Program. For this enterprise, the RGPT Network Coordinator worked directly with teachers at three schools in Albuquerque (Manzano Day School (72 students), Montessori of the Rio Grande Charter School (6 students), and Reginald Chavez Elementary School (50 students)) and three schools in Las Cruces (J. Paul Taylor Academy (50 students), Zia Elementary School (270 students), and Mesquite Elementary School (85 students). The Network Coordinator provided initial training and educational materials for teachers and students, assisted with account set-up and registration, and was present during initial monitoring field trips. As the classroom teachers became more proficient with protocols and technology, they took over more of the project management, with occasional supplemental support from the RGPT Network Coordinator as needed.

(Left) 5th Graders from Georgie O'Keefe Elementary school decorate their faces with charcoal from a previous fire as they learn about the how the bosque responds to fire. (Right) A 7th grader from Jefferson Middle school collects litterfall during monthly monitoring from the Route 66 BEMP site.

Monitoring Data:

Depth to Groundwater

Depth to groundwater is monitored at all but two BEMP sites (Pueblo of Santa Ana and Pueblo of Santo Domingo). Groundwater data from the Pueblo of Sandia are given directly to the Pueblo and must be requested through the tribal administration office. At the remaining 28 BEMP sites, five groundwater wells are monitored each month during monthly monitoring week (based on the third Tuesday of the month), along with the nearby ditch or drain. The USGS river flow data are downloaded based on the day of monitoring and the nearest upstream gage for each site. Samples of the site data are given in Figures 2-5, but depth to groundwater at the five wells, depth to water in the nearby ditch or drain, and USGS river flow graphs are provided for all sites at the end of this document (Appendix G).

Depth to groundwater at the majority of BEMP sites is strongly tied to river flow (Figures 2-5). As river flow declines, groundwater levels drop at bosque sites. Some areas are more susceptible than others to declining water tables, as seen in the annual groundwater data and threshold maps (Figures 6-10). The high river flow in April and May 2017 led to flooding at 17 BEMP sites (Figure 4). By June monthly monitoring, just one month later, the decline in river flows lead to a 108 to 125 cm drop in groundwater levels at the flood sites (Figure 11). The decline in groundwater levels at sites that did not flood ranged from nearly a meter to less than 10 cm (Figure 11). Sites with lower groundwater levels were not as impacted by the dropping off of high river flows. At sites that did flood, the overbank flooding followed by rapid decline of groundwater levels was not conducive to new cottonwood and willow germination at BEMP sites.

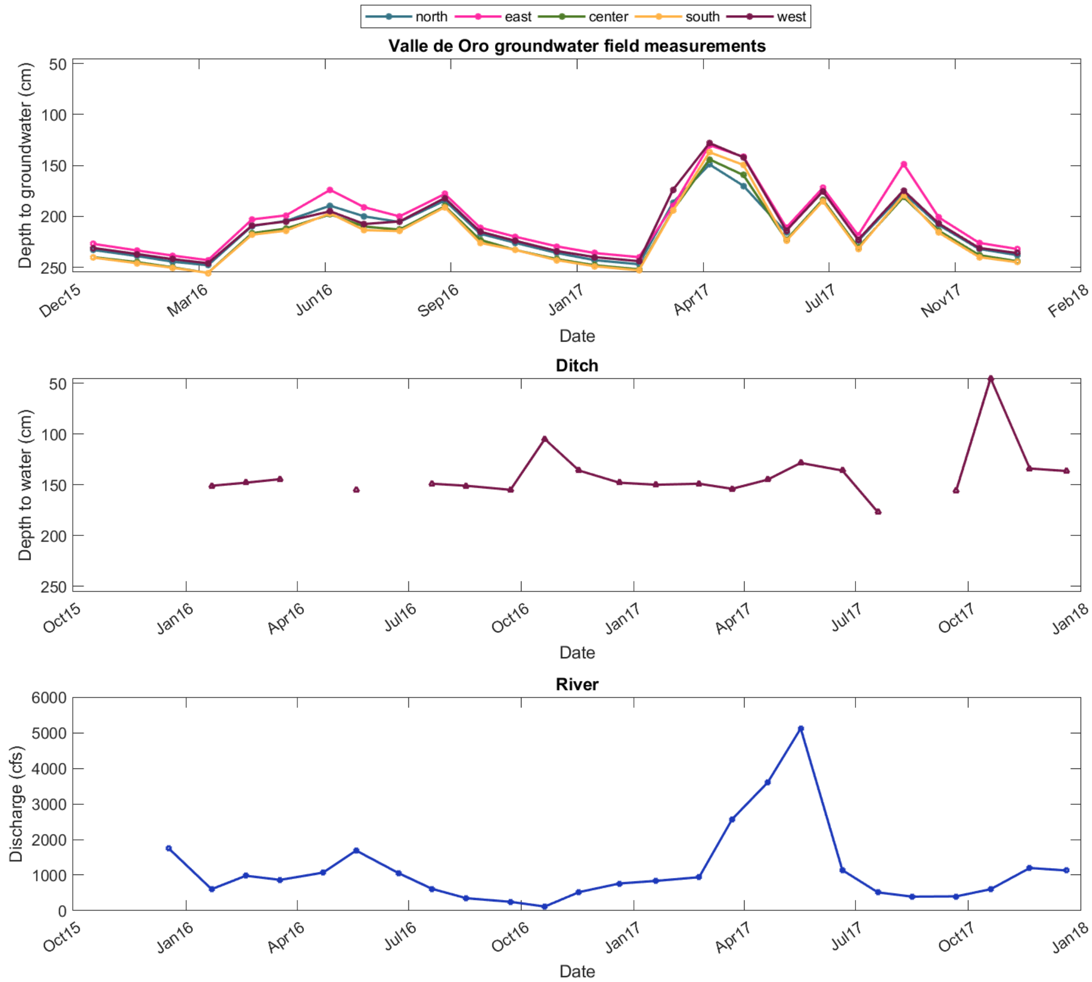

Figure 2. Depth to groundwater, depth to water level in the nearby ditch, and river flow (USGS) at the Valle de Oro BEMP site from December 2015 – January 2018.

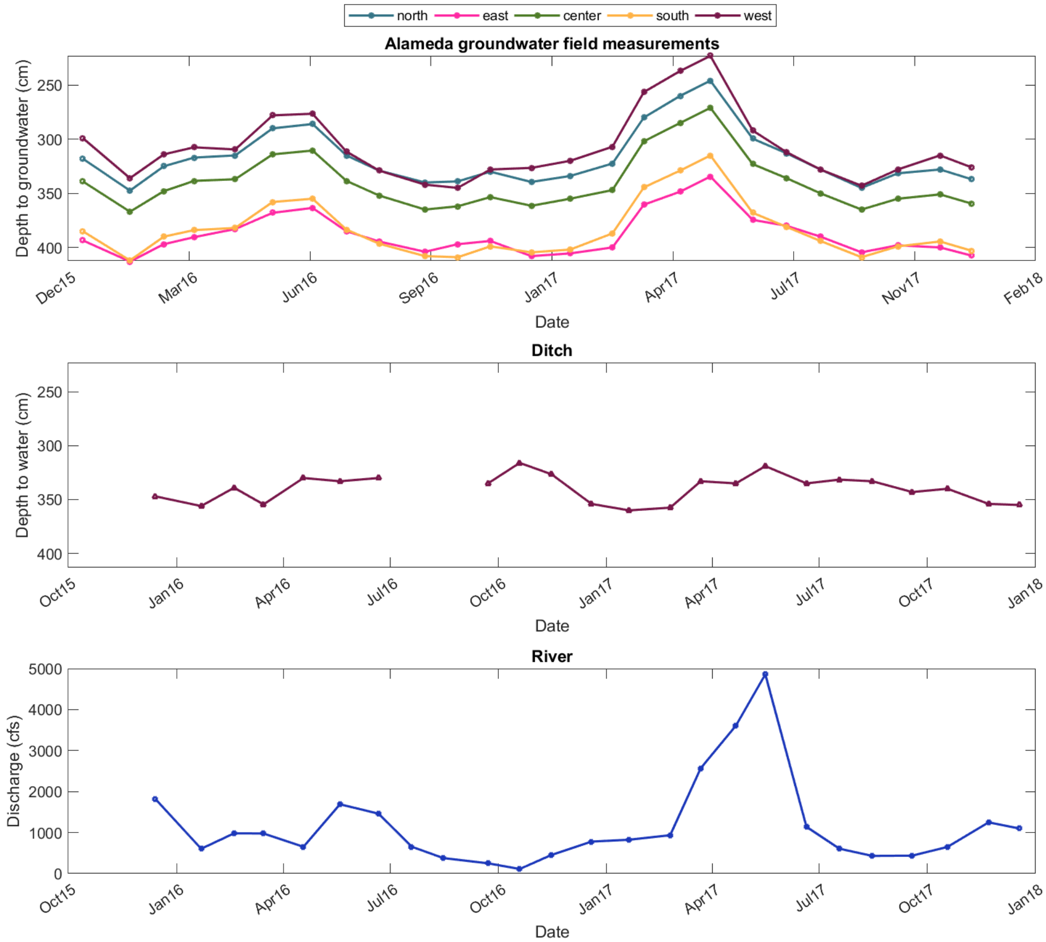

Figure 3. Depth to groundwater, depth to water level in the nearby ditch, and river flow (USGS) at the Alameda BEMP site from December 2015 – January 2018.

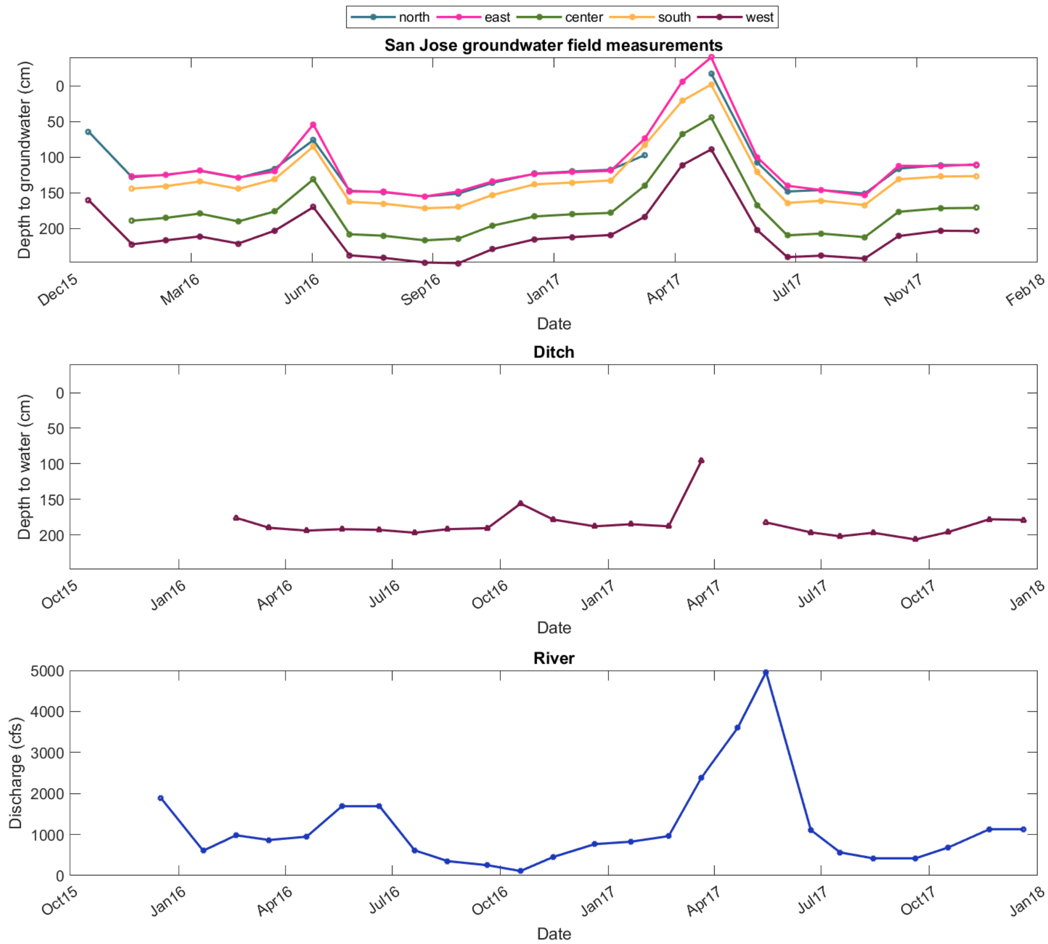

Figure 4. Depth to groundwater, depth to water level in the nearby ditch, and river flow (USGS) at the San Jose BEMP site from December 2015 – January 2018.

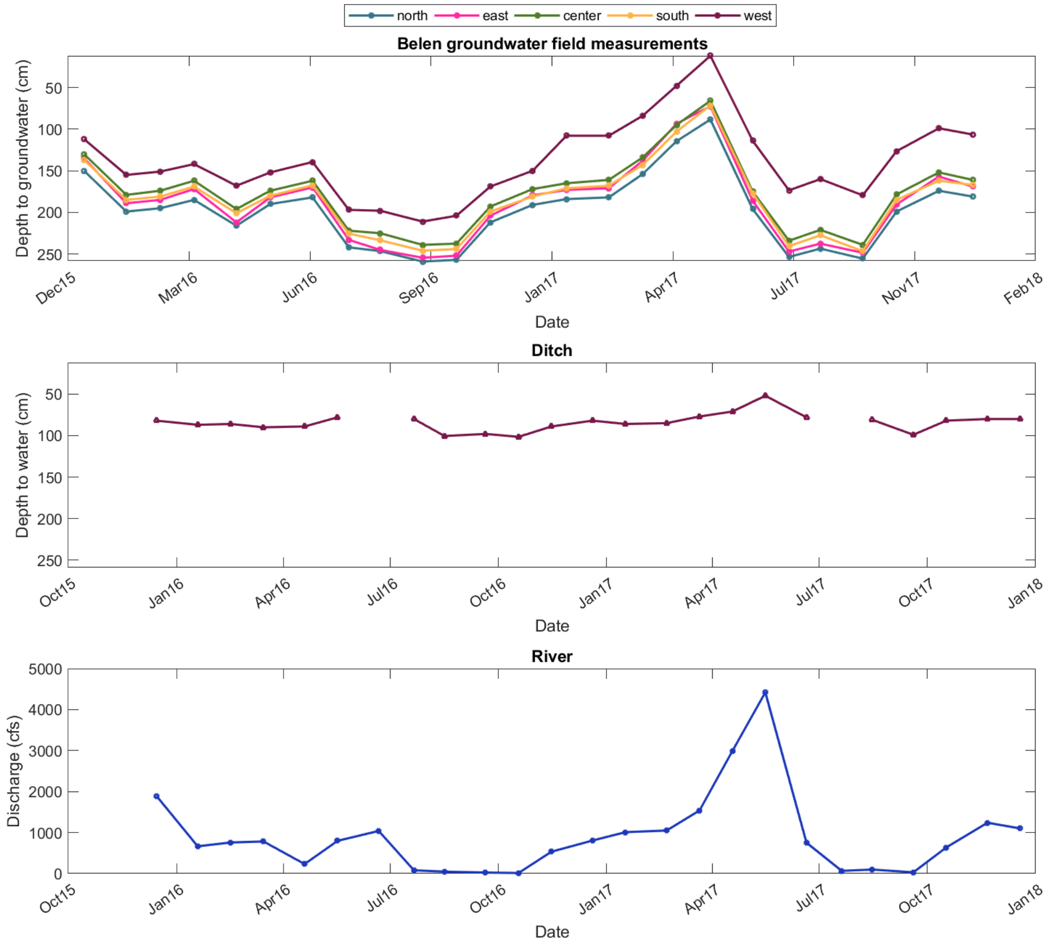

Figure 5. Depth to groundwater, depth to water level in the nearby ditch, and river flow (USGS) at the Belen BEMP site from December 2015 – January 2018.

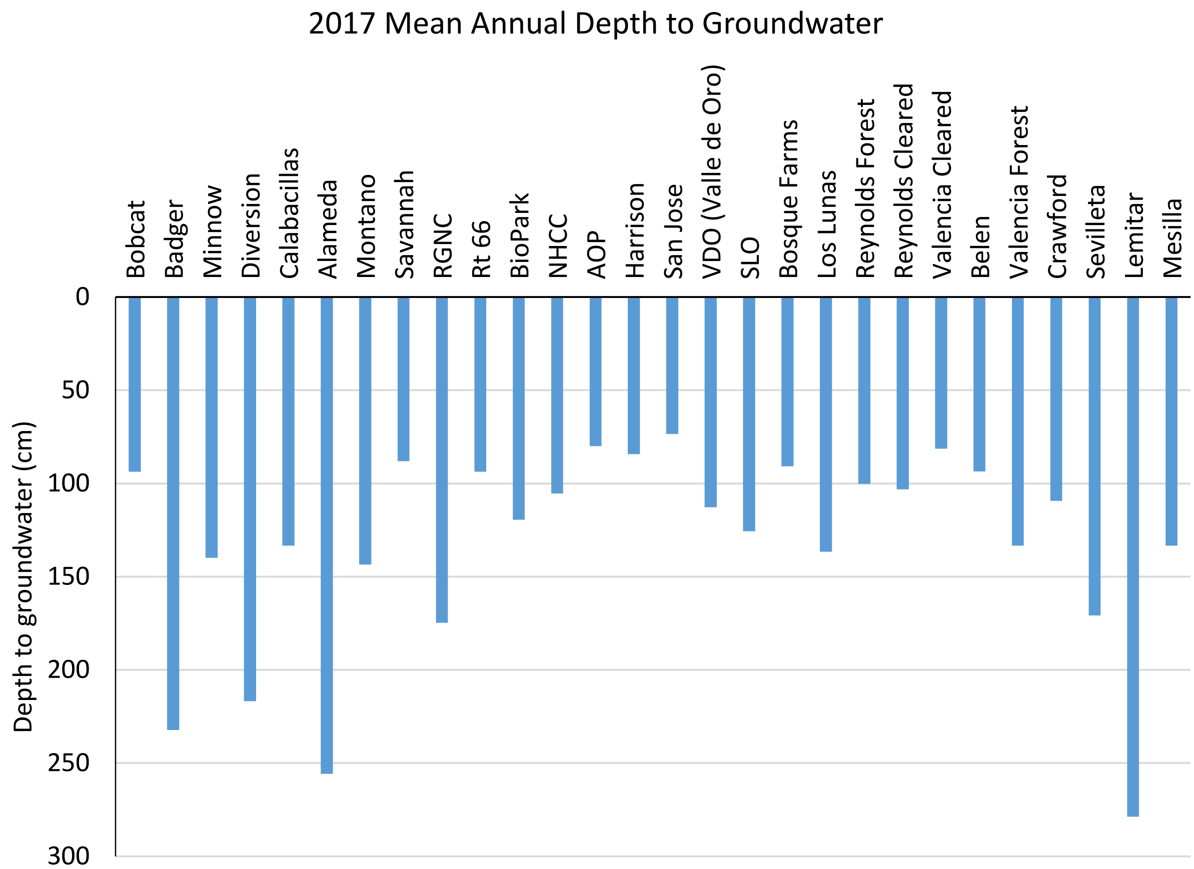

Figure 6. 2017 mean annual depth to groundwater at sites north to south.

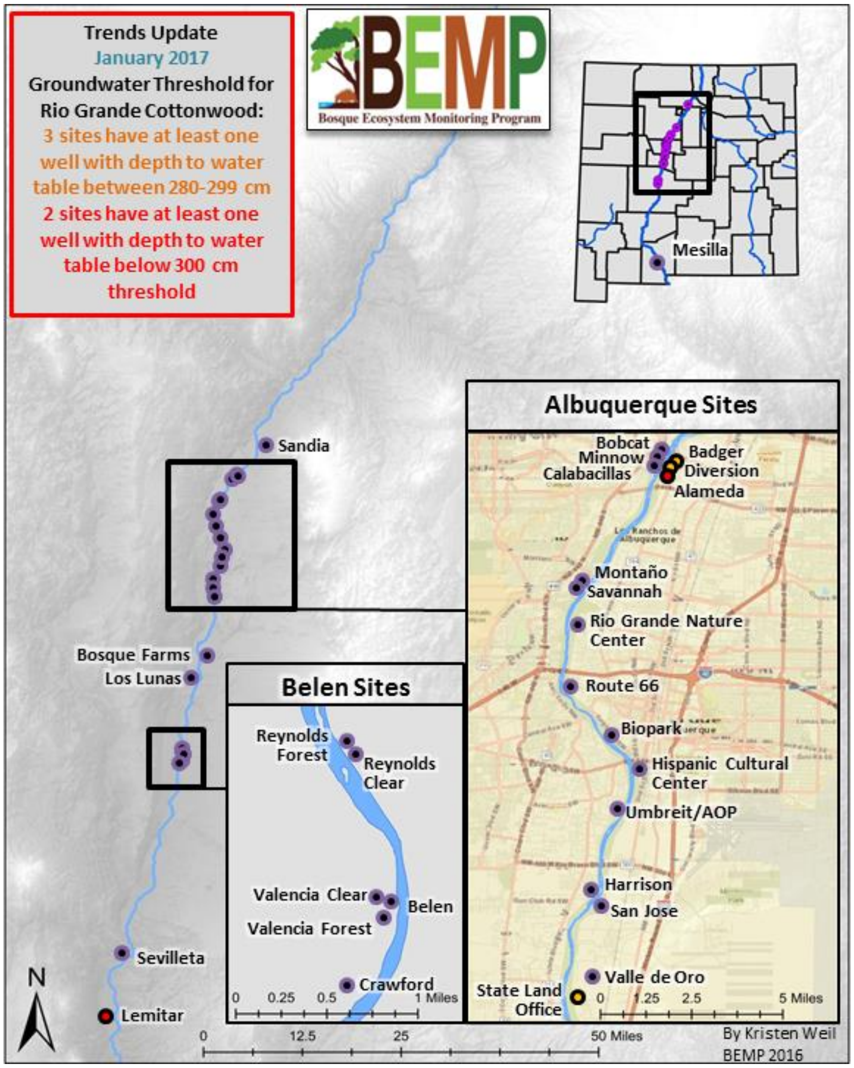

Figure 7. Groundwater threshold map for the Rio Grande cottonwood, which has roots that grow to about 300 cm below ground surface, shows three sites with at least one well with a groundwater depth between 280-299 cm (approaching maximum cottonwood root depth) and two sites with groundwater exceeding cottonwood root extension.

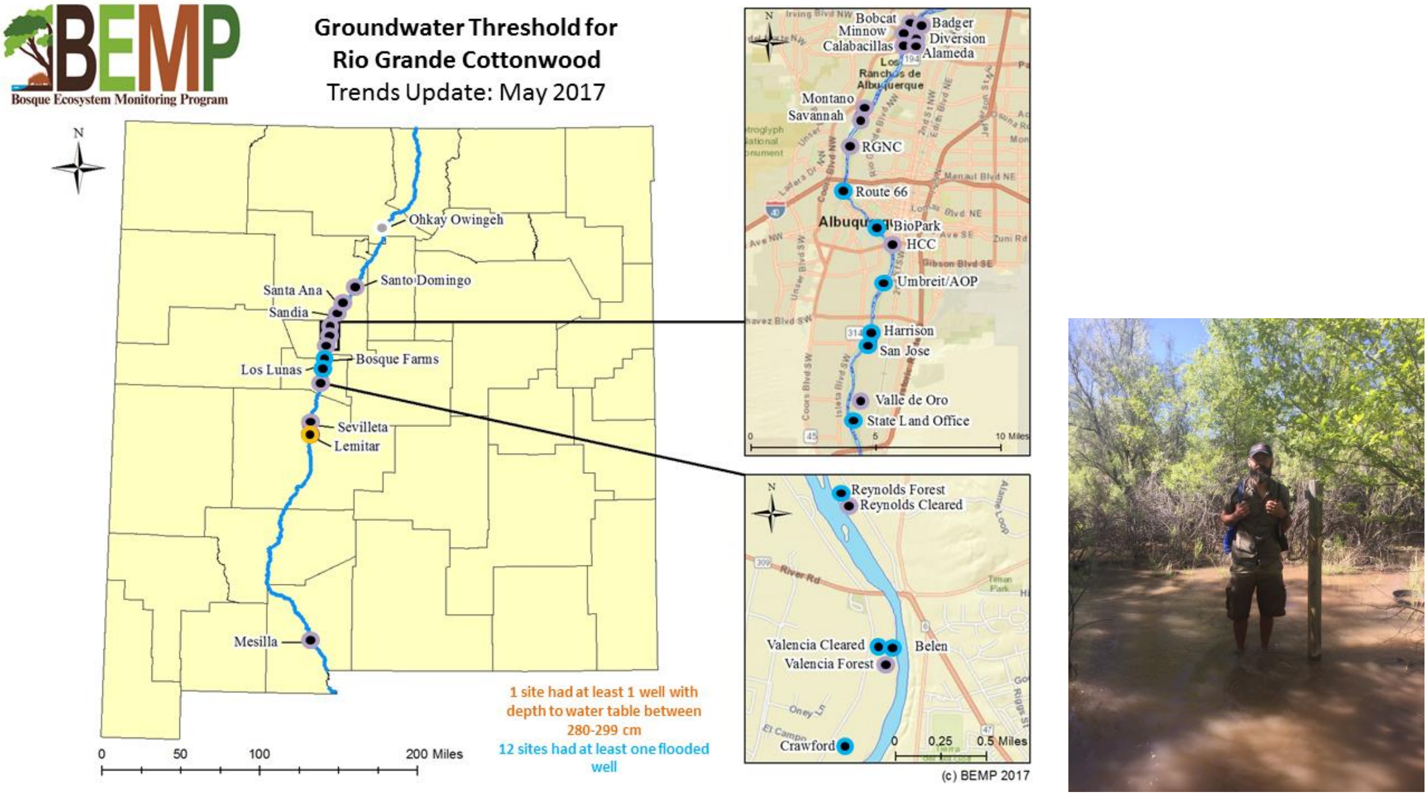

Figure 8. The threshold map from May 2017 shows flooding at 12 BEMP sites. Seventeen sites had some level of flooding, but only sites that had standing water at the groundwater wells were displayed. Photo: flooding at Belen.

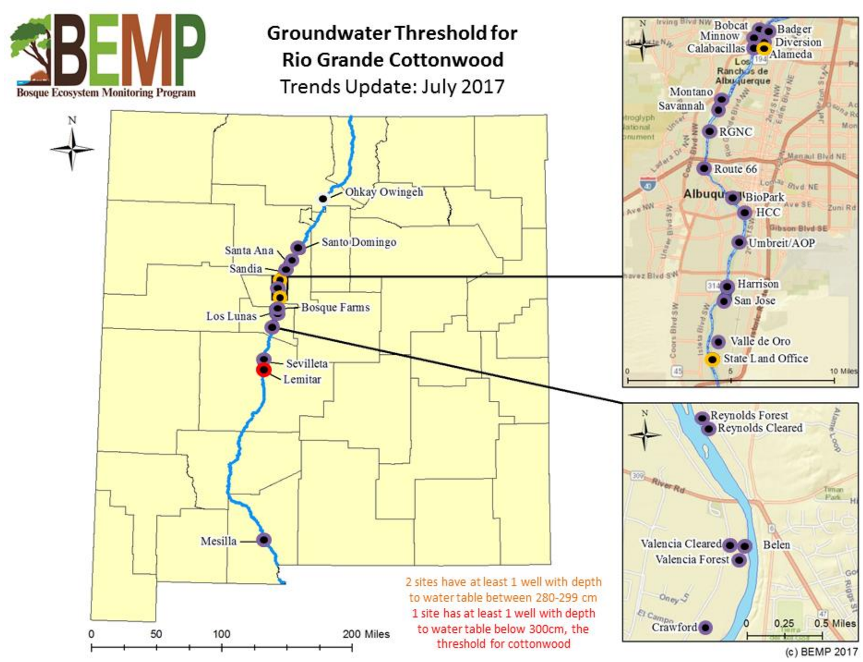

Figure 9. The threshold map from July 2017 shows the rapid decline of groundwater following the floods in May. Two Albuquerque sites had wells approaching cottonwood root growth threshold and Lemitar had wells with groundwater exceeding 3 meters.

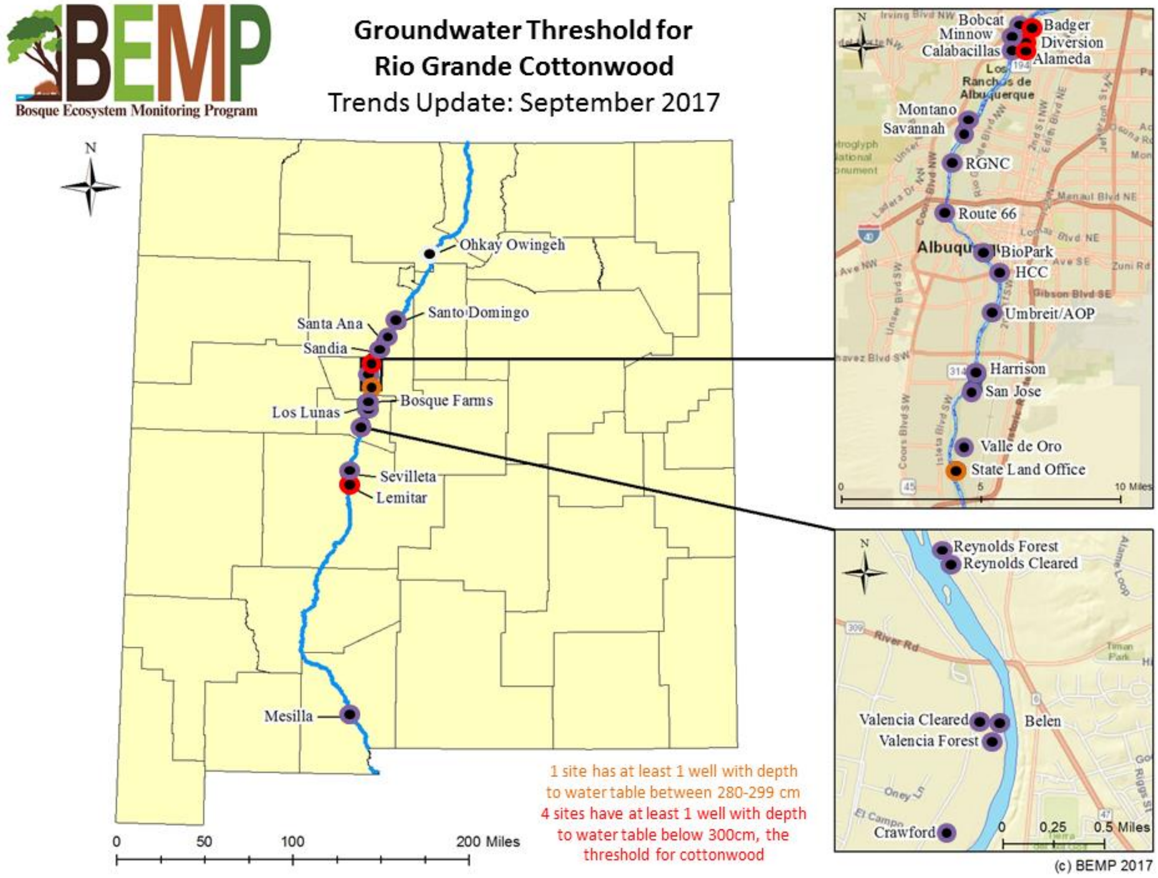

Figure 10. Groundwater threshold map from September 2017 shows the increase in depth to groundwater and further threat to cottonwood trees. Cottonwood threshold was exceeded at four sites and one site approached the threshold four months after the spring floods.

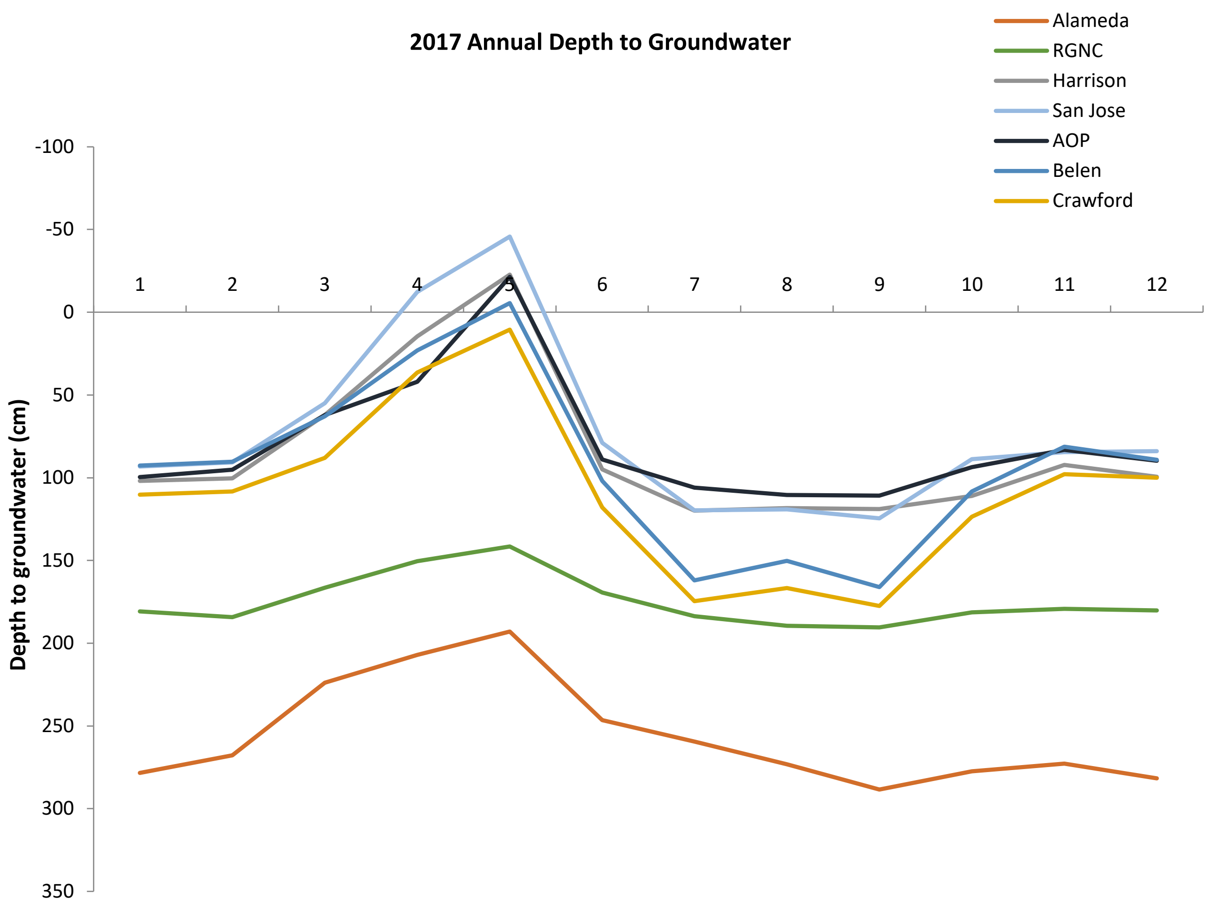

Figure 11. 2017 mean monthly depth to groundwater at select sites.

Precipitation

Precipitation is monitored at each site during monthly monitoring. There are two rain gauges, one underneath a canopy and one in the open. Oil is put in the rain gauges to prevent evaporation. There are two types of rain gauges currently in use, the Tru-Check rain gauge and a cylindrical rain gauge. The Tru-Check gauges have been used since BEMP began, but in 2016 they started randomly cracking, so we added the second type of rain gauge to the sites. There is an R^2 value of 0.95 between the readings of the two gauges, but to increase accuracy, a regression formula is applied to the readings of the cylindrical rain gauge to keep the readings consistent across time.

Precipitation, while critical for some vegetative groundcover, is not as predictive of phreatophyte health. Cottonwoods, willows, and other phreatophyte species rely on a shallow water table, which is not as responsive to precipitation events like monsoons, as it is to prolonged snowmelt runoff. Extreme precipitation events in the fall and summer months are not enough to significantly increase the annual mean river flow data (taken from USGS) during dry years (Figure 12). While not as dry as 2016, 2017 was another fairly dry year, with rainfall less evenly distributed throughout the year (Figure 13). 2017 river flow had high runoff in the spring, while precipitation events in 2017 were highest in January and October, with no rainfall in November or December (Figure 13). There is some variation between sites and regions, with higher precipitation occurring in the southern sites this year (Figure 14).

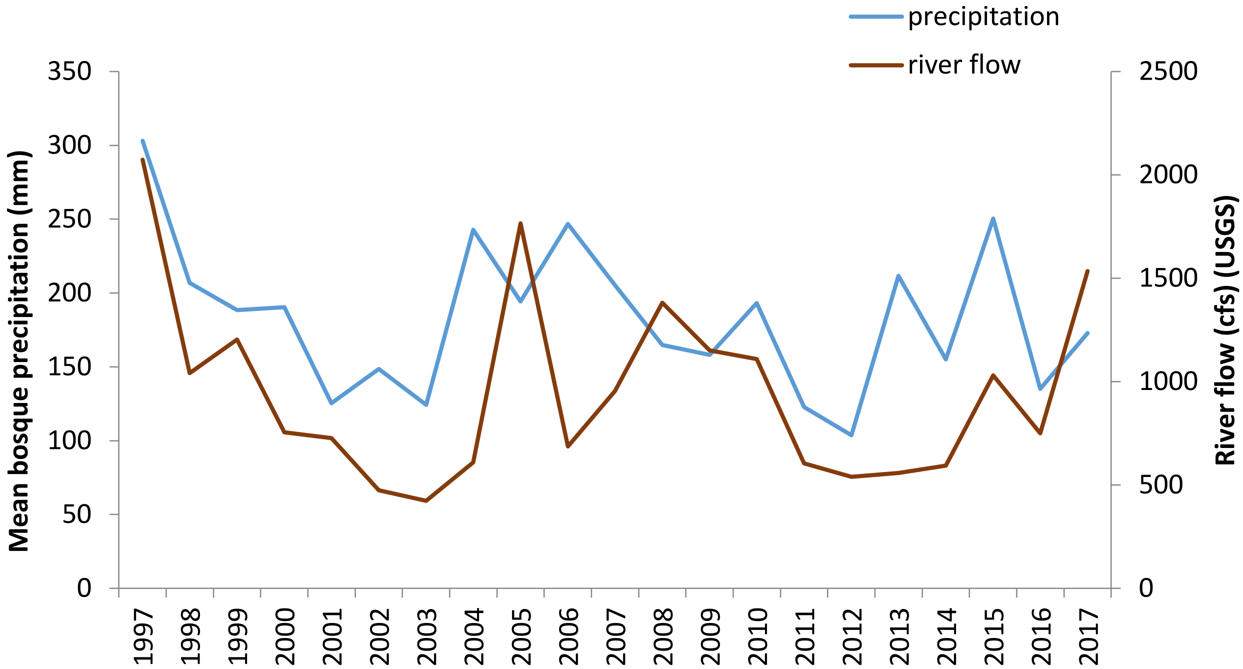

Figure 12. Mean annual bosque precipitation averaged across BEMP sites compared with USGS mean annual river flow data from the Central gage in Albuquerque on the days of monthly monitoring.

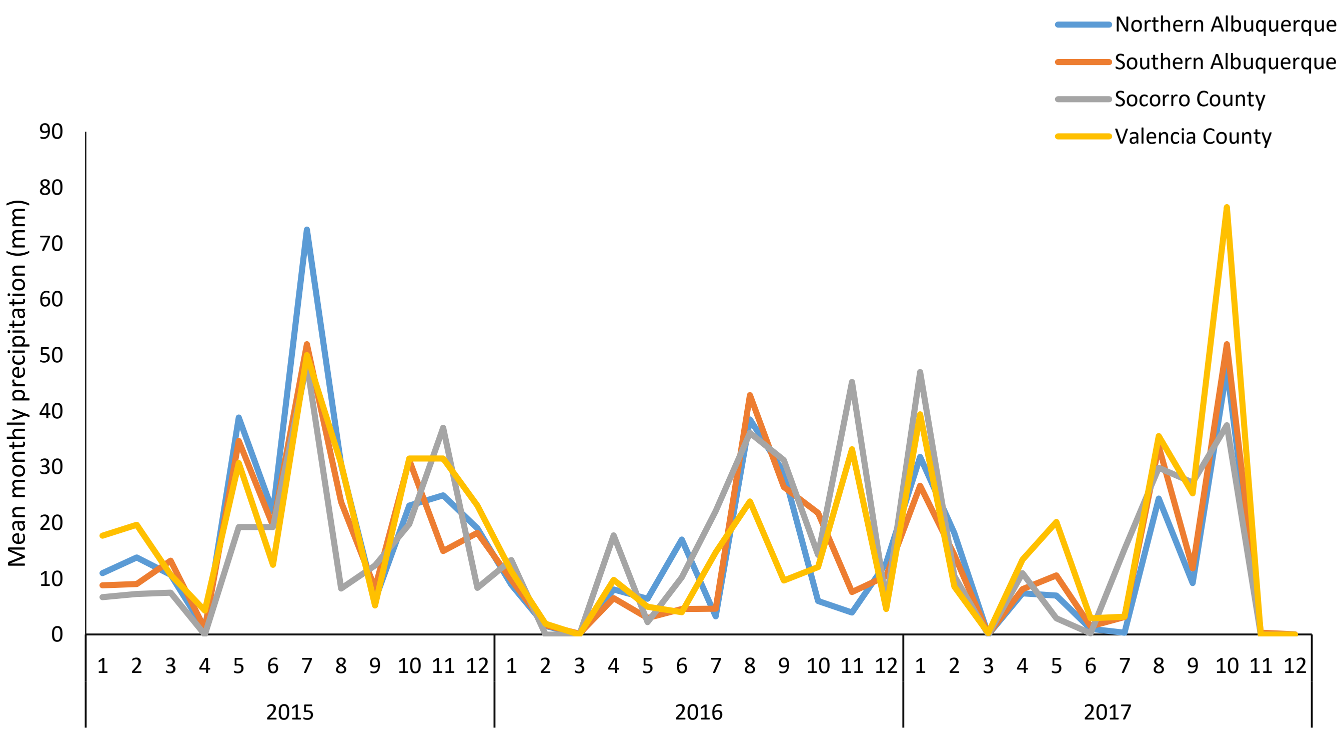

Figure 13. Mean monthly precipitation within four regions of BEMP sites: northern Albuquerque (north of I-40), southern Albuquerque (south of I-40), Valencia County, and Socorro County.

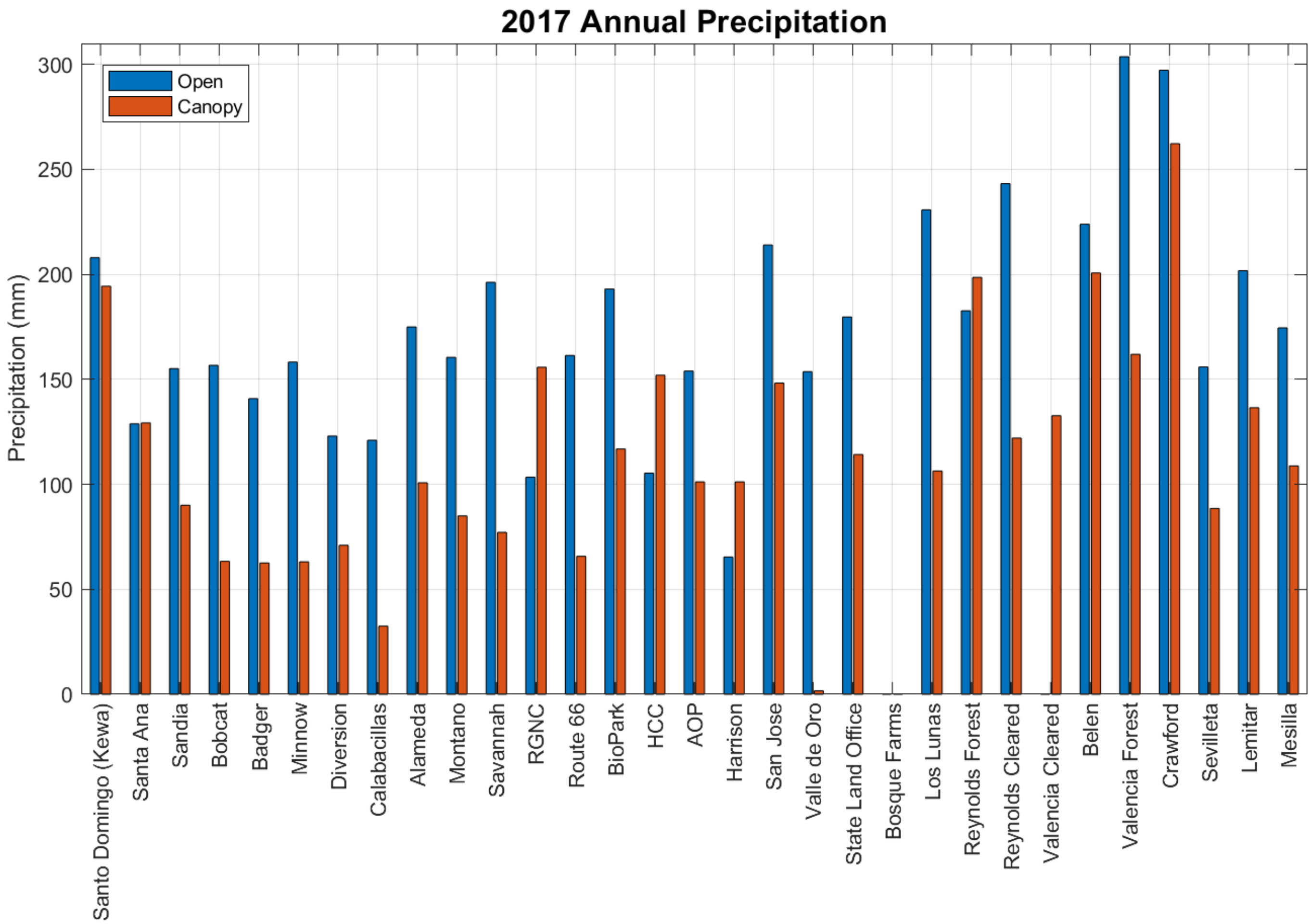

Figure 14. 2017 annual sum of precipitation in the open and canopy rain gauges across sites north to south. There are no rain gauges at the Bosque Farms BEMP site due to high vandalism.

Concluding Remarks:

There were over 2000 students involved in year-round monthly monitoring during the 2016-17 school year, and another 3000 students involved in hands-on field work. BEMP continues to support students with multiple contacts in the field and in the classroom.

Groundwater fluctuations were greater in 2017 at many sites due to the high river flows in April and May 2017, which resulted in overbank and/or seep flooding at 17 sites, followed by the low river flows and dropping of the water table in later months. No cottonwood or willow recruitment were seen at BEMP sites following the floods.

Cottonwood senescence can be tracked through cottonwood leaf fall at sites and within regions. Cottonwood decline is apparent in most areas, but is especially evident to the north of Albuquerque as well as in Albuquerque.

All data and reports are currently available at BEMP.org. Additional graphs and maps can be produced upon request.

Acknowledgements:

The information in this report is based upon BEMP's non-proprietary datasets, collected between January 2016 and December 2017, with reference to data collected from 1997-2017. All raw data are available upon request. We would like to thank the US Army Corps of Engineers, US Bureau of Reclamation, Bernalillo County Open Space, Valencia Soil and Water Conservation District, Middle Rio Grande Conservancy District, City of Albuquerque Open Space, Albuquerque Bernalillo County Water Utility Authority, Contributors to BEMP through Bosque School's Annual Fund, Environmental Protection Agency – Urban Waters, NM State Land Office, National Science Foundation (through Sevilleta Long-Term Ecological Research), NM State Parks, Albuquerque Community Foundation, McCune Foundation, Davidson Foundation, Goodman Foundation, Greater Rio Grande Watershed Association, Middle Rio Grande Stormwater Quality Team, and the Black Institute for their ongoing support of this vital monitoring and education work along the Middle Rio Grande.

Appendix A - Litterfall 2016

Litterfall is collected at each site during monthly monitoring. There are ten litterfall tubs at each site, placed alongside the randomly located vegetation plots. Each month, the contents of the tubs are collected and sent to the UNM lab to be dried for 48 hours. The contents are then sorted and weighed. Leaves from six dominant native trees/shrubs and four exotic trees/shrubs are identified. Reproductive parts are also identified based on two different native trees and three exotic trees. Other leaves and reproductive parts are labeled as “other” for each of the broad categories. The final category identified and weighed is wood.

2016 litterfall data show continued native dominance at the majority of sites (Figure 15). The two sites that have more exotic leaf fall than native leaf fall, Diversion and Lemitar, both have had a decline in natives as well as an increase in exotics (Figures 17-18). In order to gauge cottonwood senescence, sites were lumped into regions: Pueblos (north of Albuquerque), Northern Albuquerque (Albuquerque sites north of I-40), Southern Albuquerque (Albuquerque sites south of I-40), Valencia (sites in Valencia County), and Socorro (sites in Socorro County). In order to minimize the impact of adding sites, only 2010-2016 were analyzed. In most regions, there is a definite decline in cottonwood leaf fall (in the Pueblo region, $R^2 = 0.70$) (Figure 16). In the two southernmost regions, there was no change (Socorro) or a slight increase in cottonwood leaf fall (Valencia). In the latter case, this is influenced by the Belen and Crawford sites, overbank flooded sites where young cottonwoods are maturing.

Of increasing concern, with cottonwood senescence occurring rapidly at many sites, is the wood fall, which contributes to the potential fuel load. There were 12 sites with wood fall of over 12 g/m^2 in 2016 (Figure 19). In each case this was due to one or two branches falling into a litterfall tub at the site. While this is indicative of the wood falling at these sites, it is also indicative of the ease with which total sums (averaged over 10 tubs at each sites) can be skewed by large woody debris. This underlines the value of using the fuel load/woody debris data (see Appendix E) in addition to the wood fall data to access the fuel load of a site.

Another useful combination of datasets is the comparison of monthly litterfall data with tamarisk leaf beetle data (Appendix D). This allows us to see the impacts of high beetle abundance on the timing of litterfall (Figures 20 and 25).

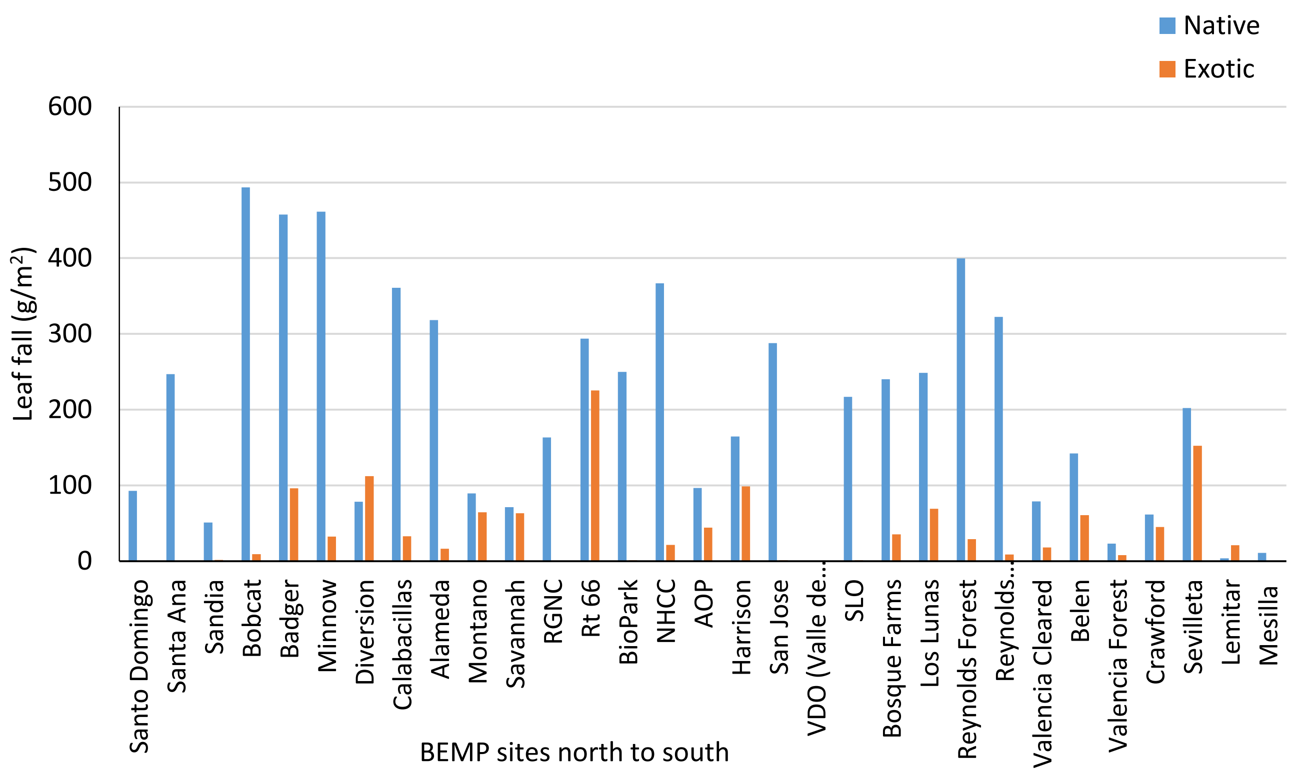

Figure 15. 2016 annual sum of native and exotic litterfall at sites north to south. Native species weights consist of cottonwood, willow species, New Mexico olive, seepwillow, thicket creeper, and indigo bush. Exotic species weights consist of saltcedar, Russian olive, Siberian elm, and mulberry.

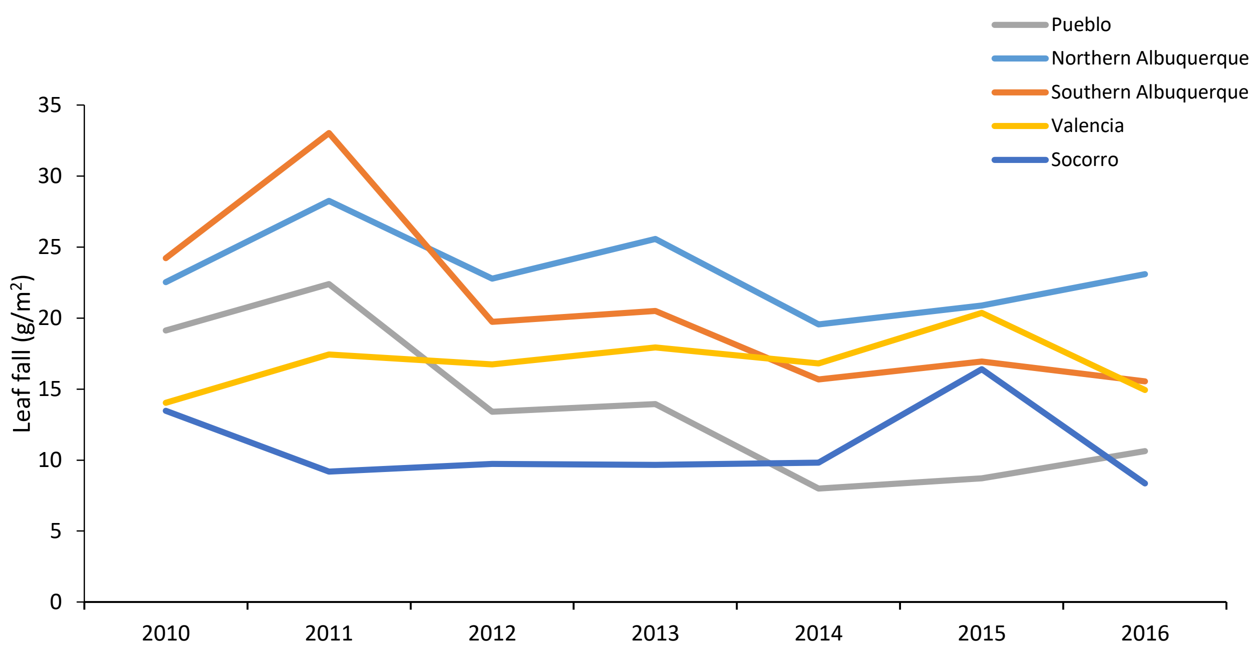

Figure 16. Cottonwood leaf fall averaged over BEMP sites within different regions. Most areas have a trend of declining cottonwoods. The Valencia and Socorro regions do not have a decline.

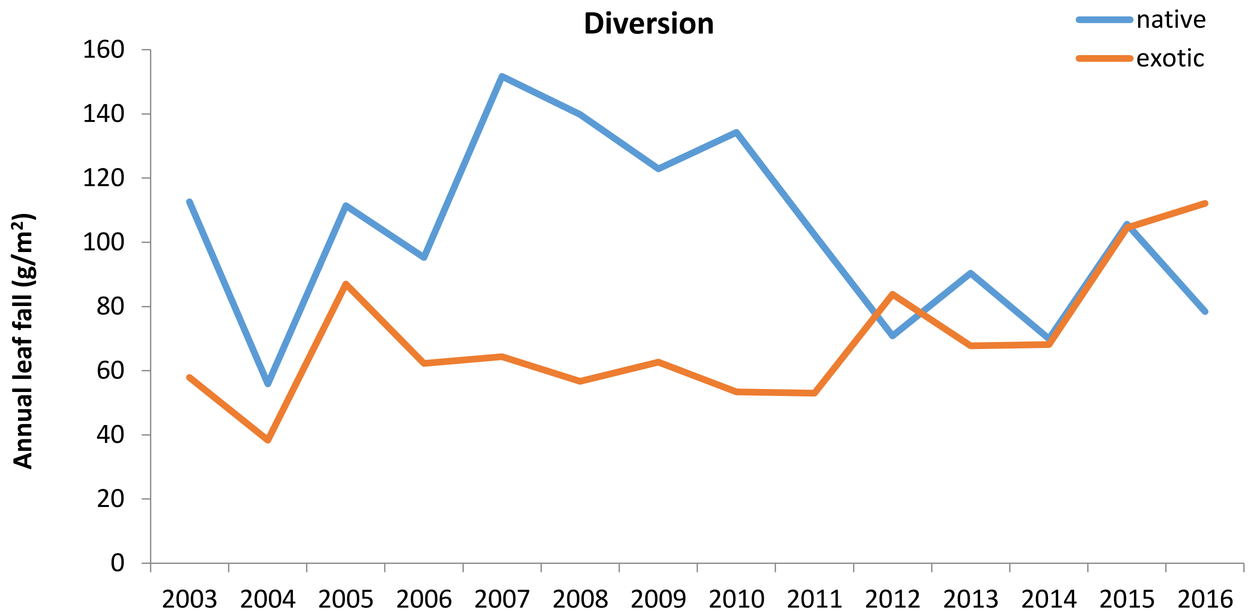

Figure 17. Sum of annual native and exotic leaf fall at Diversion. The drop in litterfall in 2004 followed removal of exotic trees at the site.

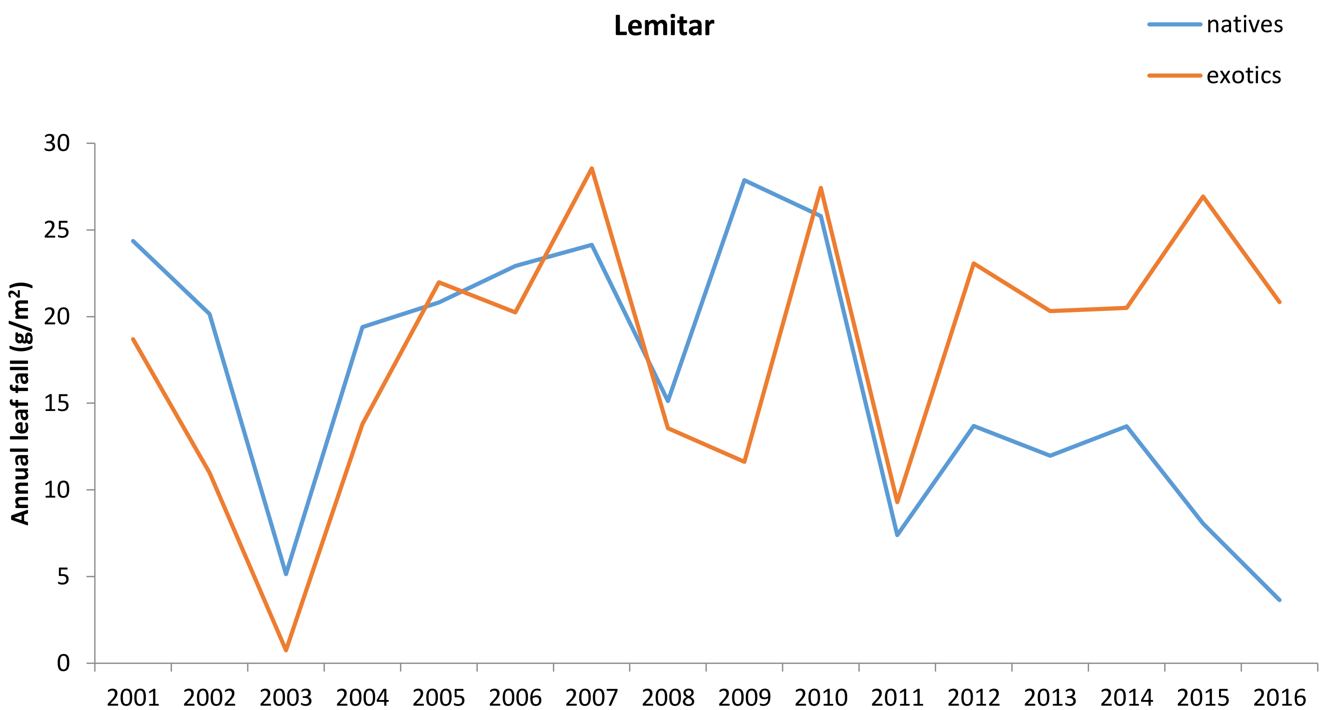

Figure 18. Sum of annual native and exotic leaf fall at Lemitar.

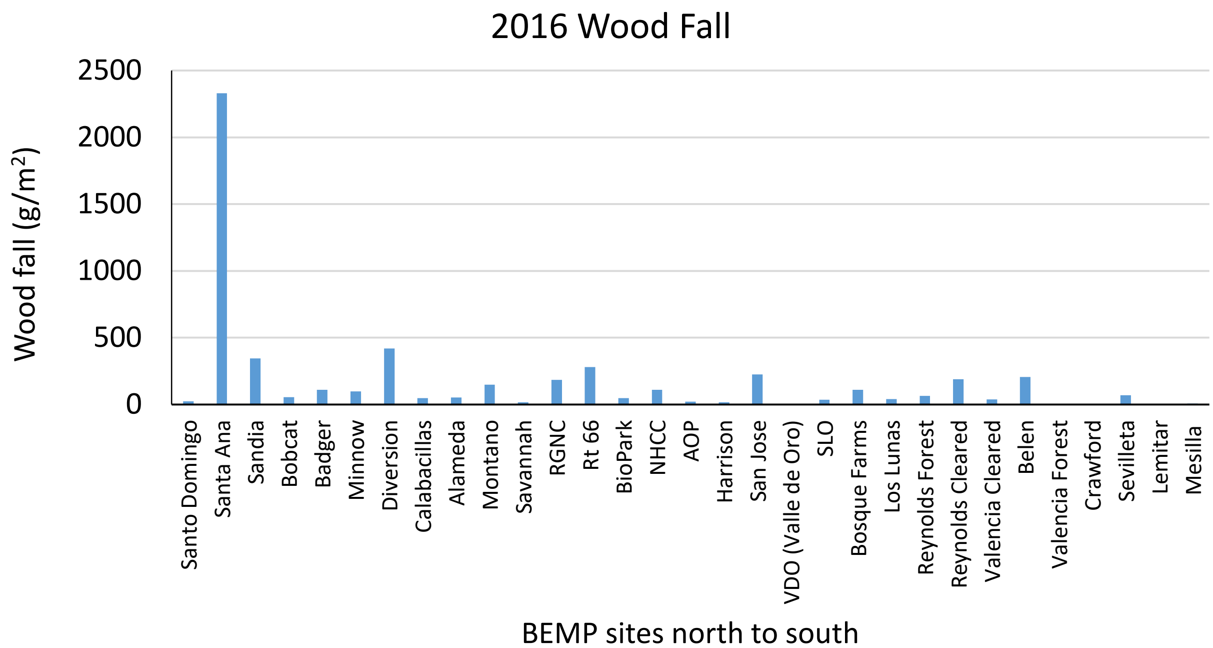

Figure 19. 2016 annual sum of wood fall at sites north to south.

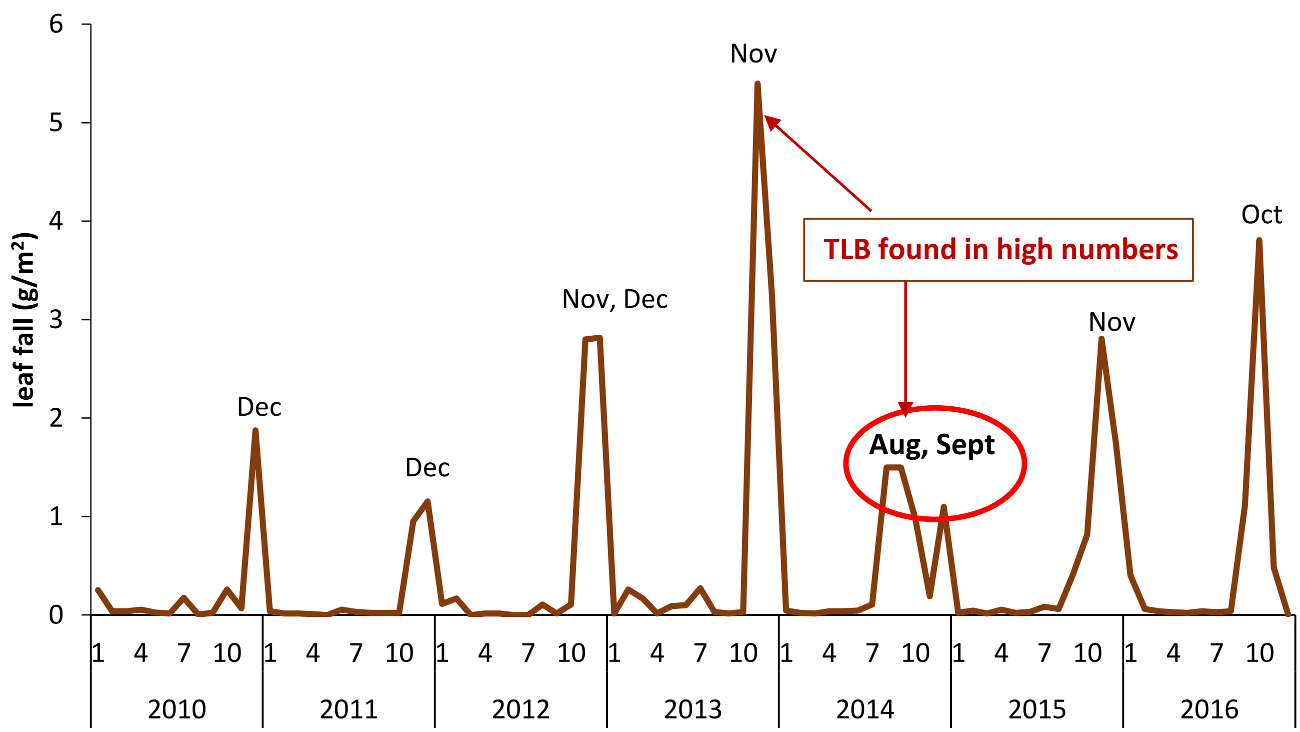

Figure 20. Monthly saltcedar leaf fall at the Diversion BEMP site in Albuquerque. Tamarisk leaf beetles show up at Diversion in high numbers in 2013 and 2014; in 2014, there is a temporary shift in timing of saltcedar leaf fall, from November/December to August/September.

Appendix B. Vegetation Cover 2016 –coming in September

Appendix C. Arthropods 2016 –coming in Sept.

Appendix D. Tamarisk Leaf Beetle 2017

Tamarisk leaf beetle monitoring happens every May, June, July, and August each year. Of the 27 BEMP sites monitored for tamarisk leaf beetle (TLB), only three sites had no TLB presence in 2017: AOP, Calabacillas, and Bosque Farms (Figure 21). Beetle abundance was higher at southern sites in 2017 than to the north (Figures 21 and 23). Images from each site will be available on the UNM Digital Repository in 2018 (e.g., Figure 22). This is the first year with TLB presence at the Mesilla BEMP site, in Las Cruces. Since monitoring began in 2013, there has been a trend of high TLB abundance moving from the north to south (Figure 24). 2013 had the highest TLB abundance in the sites north of Albuquerque and no TLB presence at the southern sites. The following year the highest TLB abundance was found in Albuquerque, and this year, the TLB populations are most abundant at the sites south of Albuquerque. The sites north of Albuquerque had a population lull in 2015, but the TLB numbers have since increased. It is very likely that we will continue to observe this sort of boom-bust cycle in TLB abundance.

Saltcedar mortality has still only been observed at Santa Ana, where all trees are dying and not just saltcedar. Even severe defoliation of saltcedar has been followed by refoliation within the year. Branch mortality has been recorded at 22 of the 27 sites, and severe branch mortality (50% or greater) has been recorded at five sites, but even the severe branch mortality is only from nine out of 25 trees at these sites.

One of the impacts of high TLB numbers is seen in the litterfall data. At sites with abundant saltcedar, years of high TLB defoliation result in saltcedar leaves coming down in summer months (e.g., July) instead of staying on until November (Figure 25). This has direct implications for habitat quality provided by saltcedar thickets, as well as implications for the health of the trees themselves. The impacts of early seasonal defoliation are also seen in the vegetation data (Figure 26), as saltcedar cover can be lower during years when TLB abundance is high. Any recovery in the impacted trees will be seen in the 2017 vegetation data (report due in September 2018).

In 2017, the Greater Rio Grande Watershed Alliance (GRGWA) requested and funded the monitoring of two sites off of the Rio Grande: Sanchez and Brazil, located in Mountainair, NM (Figures 21 and 23). TLB were abundant at both these sites.

For more information on 2017 TLB monitoring (including additional information about the Mountainair sites), see BEMP’s 2017 Annual Tamarisk Leaf Beetle Monitoring Technical Report for the Greater Rio Grande Watershed Alliance.

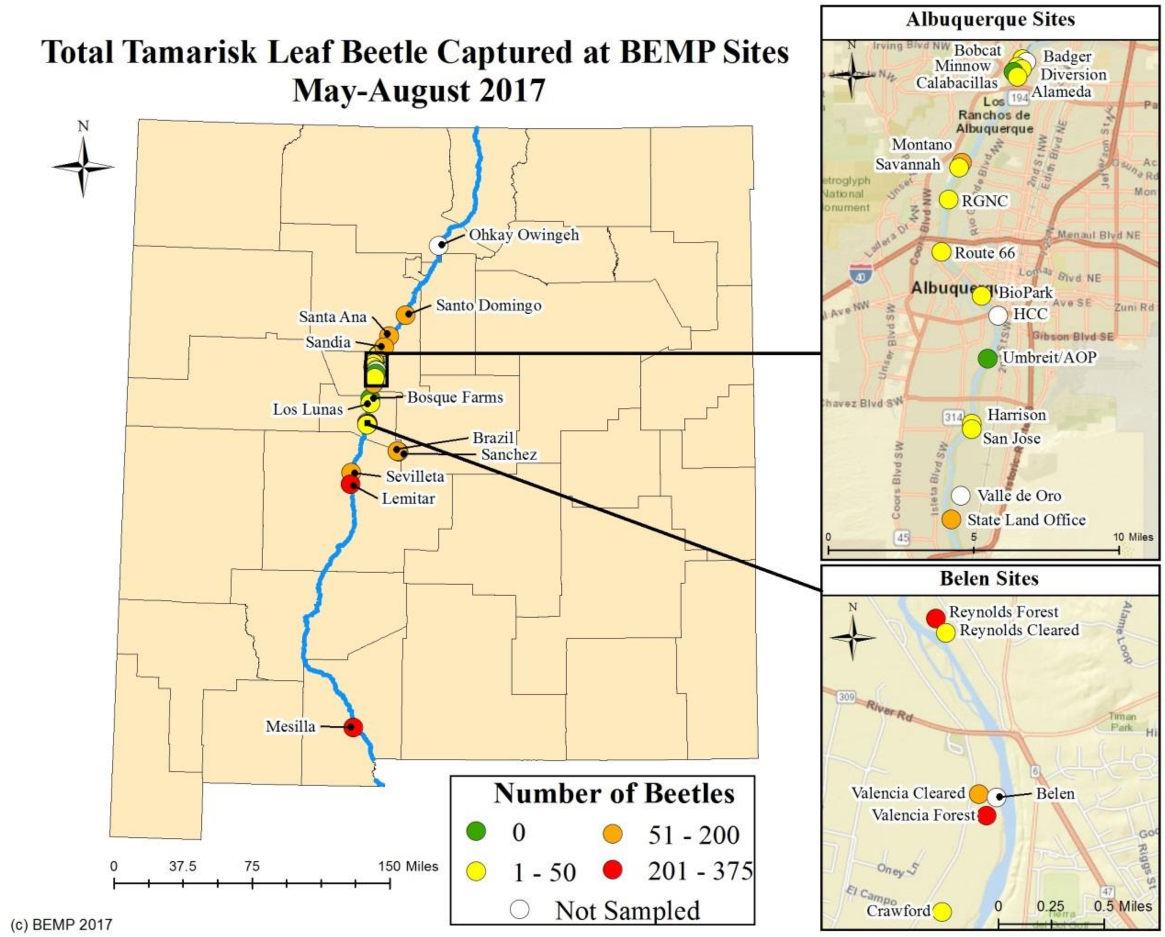

Figure 21. Total TLB captured at BEMP sites in 2017.

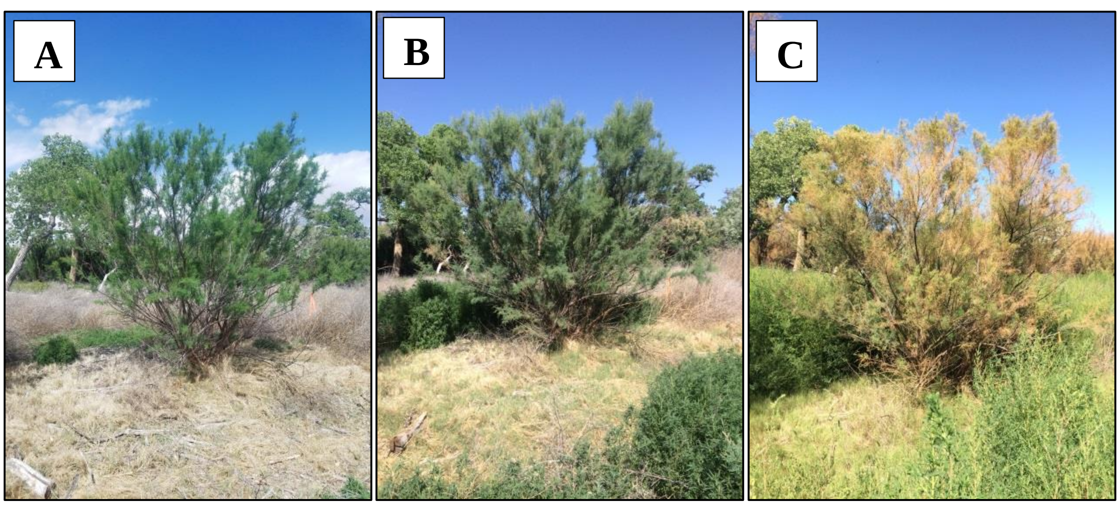

Figure 22. Saltcedar #5 at the BEMP Valencia Clear site during (A) May, (B) June, and (C) August of 2017.

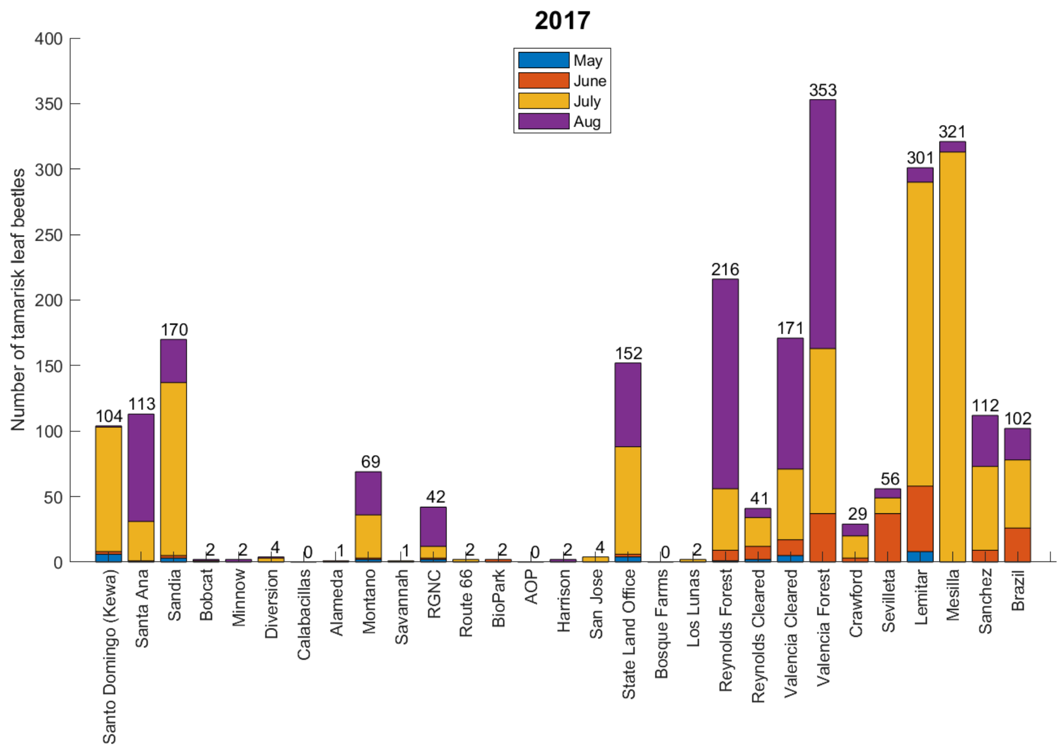

Figure 23. 2017 TLB abundance at sampled BEMP sites north to south (with two additional sites, Sanchez and Brazil, in Mountainair). TLB numbers represent larvae and adults.

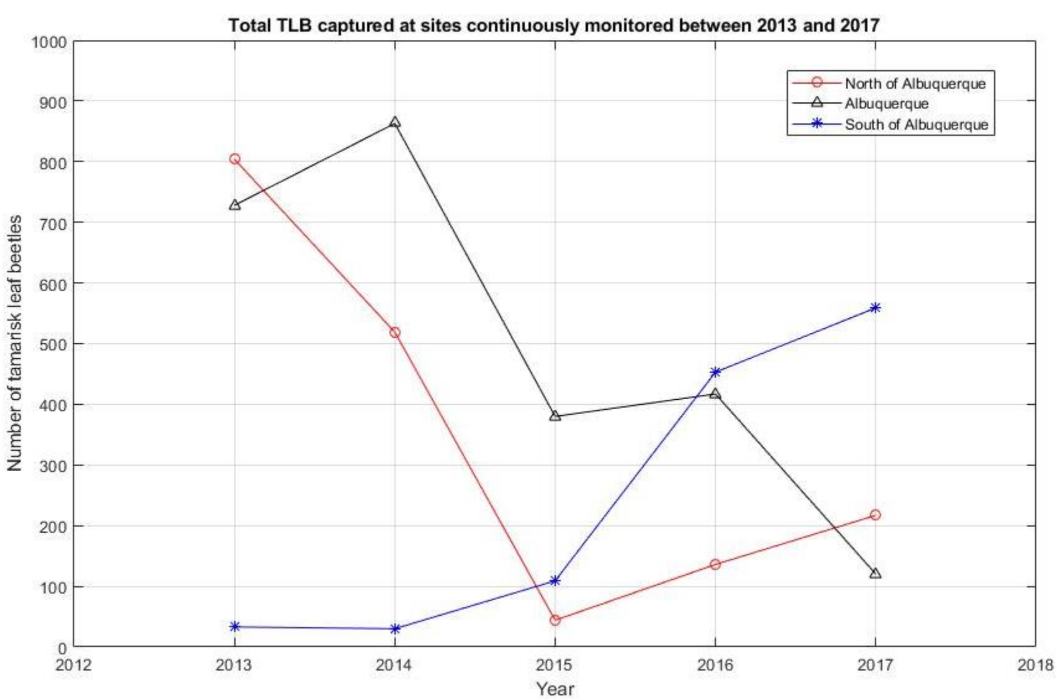

Figure 24. Total TLB captured at BEMP sites to the north of Albuquerque, sites within Albuquerque, and sites to the south of Albuquerque. Representative of sites continuously monitored between 2013 and 2017.

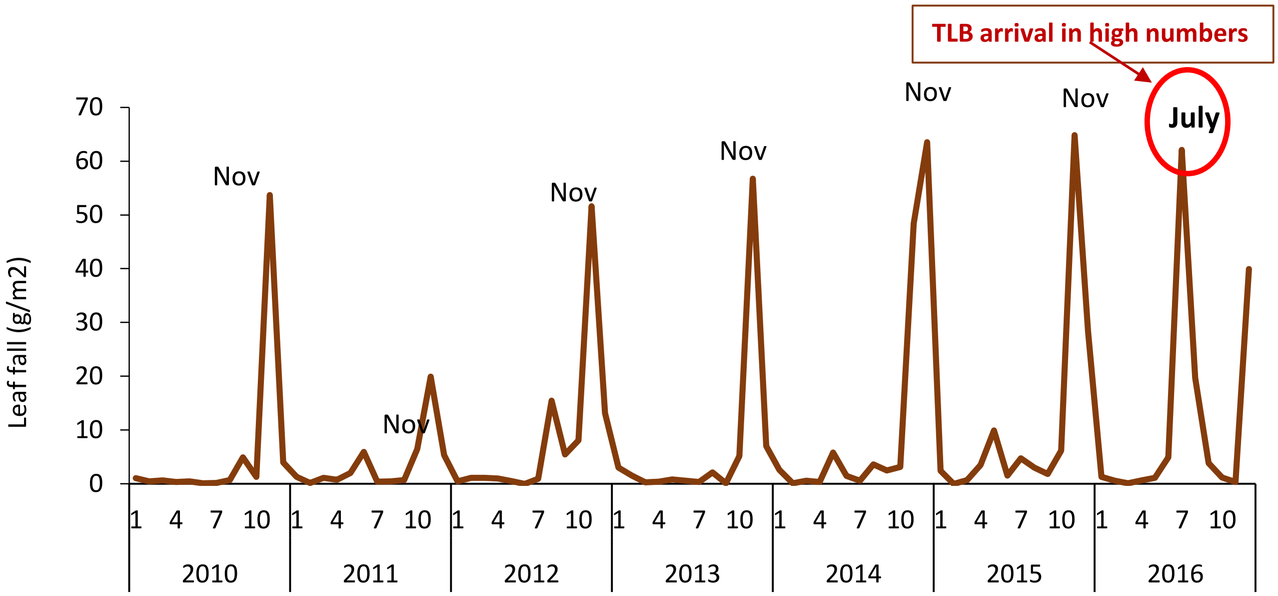

Figure 25. Sevilleta site monthly saltcedar leaf fall. Peak saltcedar leaf fall occurs in November every year except the year TLB arrive in high numbers, 2016, and then peak leaf fall occurs in July.

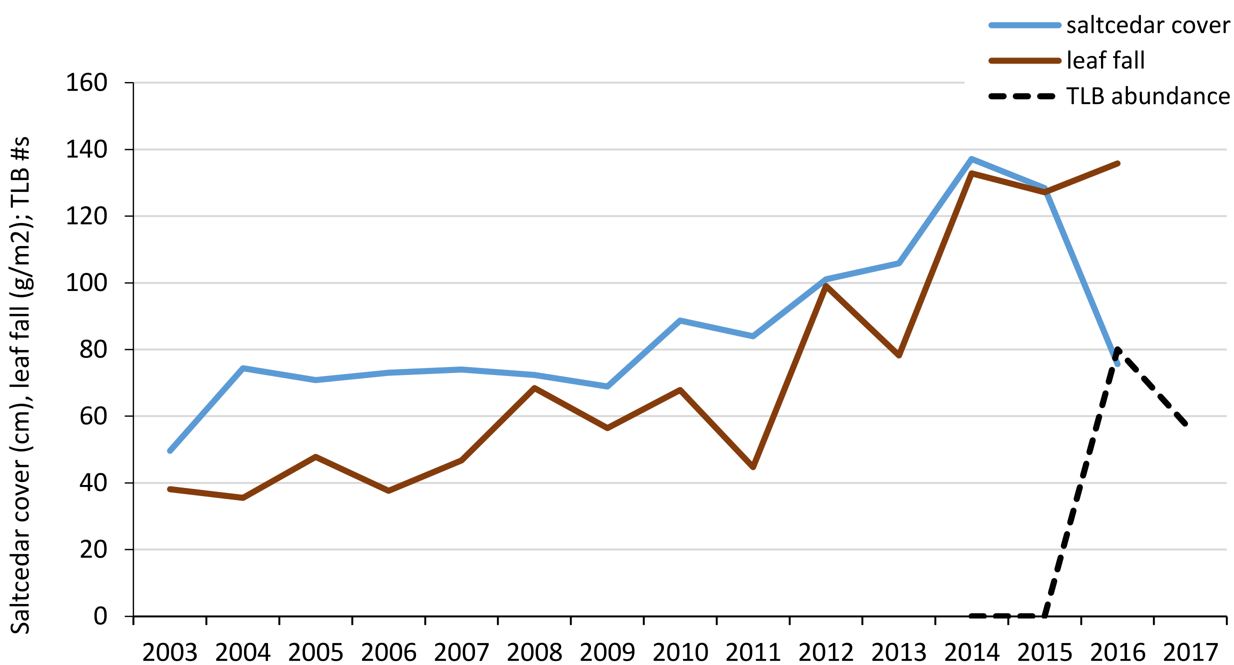

Figure 26. Sevilleta site's annual saltcedar cover (blue), annual saltcedar leaf fall (brown), and tamarisk leaf beetle abundance (black dashes). In 2016, with high TLB abundance (following no TLB presence), saltcedar cover declined.

Appendix E. Fuel Load and Woody Debris 2016

Woody debris/fuel load sampling is conducted each year at Albuquerque sites and at all sites every 3-4 years (depending on funding). Woody debris data were collected along ten 30-foot transects at 17 monitoring sites within the Albuquerque bosque. The depth of duff (litterfall) and of wood chips were measured at two locations and the maximum height of dead and down woody fuel was measured three times along each transect (Figure 27). Dead and down stems/twigs that crossed the transect were counted for three different size classes: 0 to ¼", ¼"to 1", and 1" to 3". In addition, the diameter of all woody debris larger than 3" was measured and identified to species because different types of wood have different burn intensities. Information from each of the ten plots within the site was then entered into a MatLab script that organized and calculated the data based on James K. Browns equations of calculating fuel load in tons/ acre as can be found in the *Handbook for Inventorying Downed Woody Material* (figure 28). BEMP's woody debris dataset was formally processed through the FMAPlus 3, DDWoodyPC software and was changed to the current processing method to better represent the specific burn characteristics of wood species found in the Middle Rio Grande bosque. Digital photos were taken at the beginning of each transect looking towards the west in order to compare site compositional changes over time.

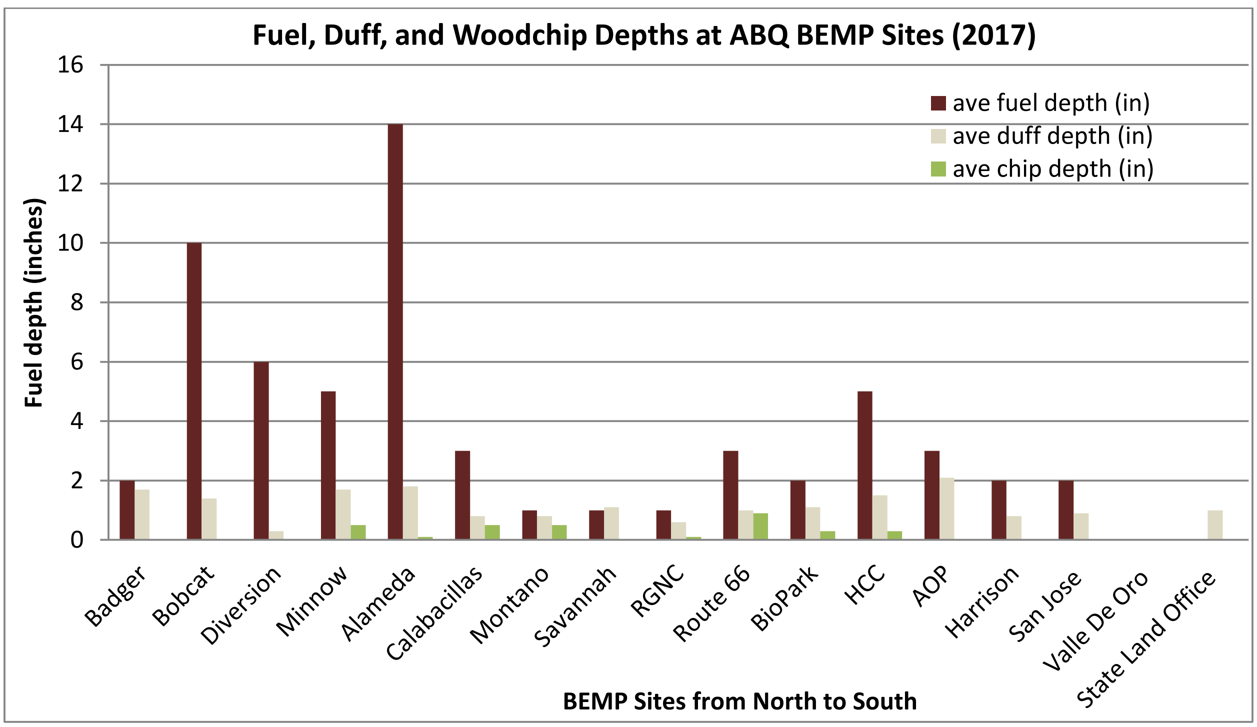

Figure 27. Average fuel depth (inches) broken down to average depth of woody debris (fuel), duff, and woodchips. The depth of fuel, brown, can indicated ladder fuel threats, while the depth of duff and woodchips, green and light brown respectively, can indicated potential fire source ignition threats.

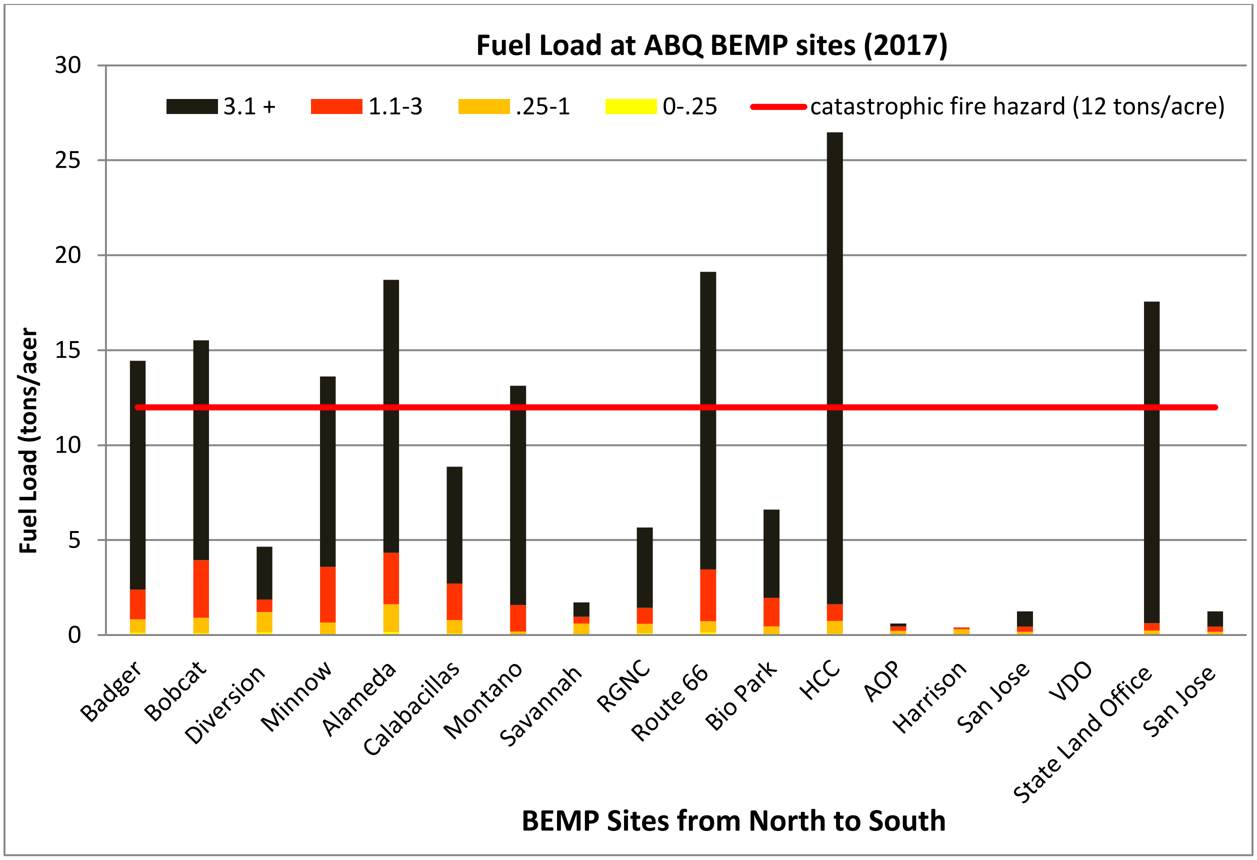

Figure 28. Fuel Load in tons/acre broken down into each independent sized class woody stems. The red line indicates a 12 tons/acre which categorizes a fuel amount that represents a catastrophic fire hazard concern. There are currently eight sites that are at or above this hazard amount within the city. Sites that have a greater amount of the overall fuel load made up from smaller fuel types, yellow, orange, and red, represent a greater fire hazard due to increased likelihood of fire propagation. The sites at this heightened risk are the Badger, Bobcat, Minnow, Alameda and Rt. 66 sites.

In March of 2017 there was a bosque fire that reportedly burned ~ 3 acres near the Alameda Bridge. Of the five sites located within the city that are both at a catastrophic fuel load amount and heightened fire risk due to amount of small fuel size, three were located in close proximity to the fire's location (Figure 29).

Figure 29. Aerial view of March 2017 fire and BEMP sites near the Alameda Bridge.

Appendix F. Water Quality

Water quality monitoring occurred on one day each month following the week of monthly monitoring data collections. Five river sites between southern Bernalillo and southern Albuquerque were sampled starting with the furthest downstream site, State Land Office (SLO), followed by Montano, Badger, North Diversion Channel, and Coronado (Figure 30). The intention of this study was to investigate how the river chemistry changes as it flows into, through, and out of Albuquerque.

Students from La Academia de Esperanza assisted BEMP staff in collecting field parameters including: water temperature (ºC), pH, turbidity (NTU), dissolved oxygen (% and mg/L), conductivity and specific conductance (µS/cm). BEMP staff collected water samples for *E.coli* testing, which were taken to the New Mexico State Scientific Laboratories for analysis. Other field observations included: air temperature (ºC), barometric pressure (hPa), water appearance, general weather conditions, number of upstream waterfowl, and any unusual odors or instream activities. Upstream photos were taken at each site during each sampling event.

Four *E.coli* samples were in exceedance of the EPA limit of 410 MPN (Figure 31). All of those samples were from the SLO site during the warmest months of the year which were July, August, September, and October. Water temperature was not highly variable between sites and did not show any consistent trends as the water flowed downstream. Temperatures were highly variable with a range from 3.8 - 25.9 ºC (Figure 31). Dissolved oxygen concentrations rose during colder months with the highest concentration (12.08 mg/L) observed at the Coronado site in October and lowest was seen (5.71 mg/L) at SLO in July (Figure 32). Dissolved oxygen tended to decreased with downstream distance. The pH remained between 7 and 9 at all five sites throughout the year with a slight decrease across all sites from August to September. Conductivity was consistently higher at SLO site compared to the other four sites. Levels were highest during months with lower river discharge and were lower during months of higher flow. Spring flows from March through May were between 2,500 to 5,500 cfs.

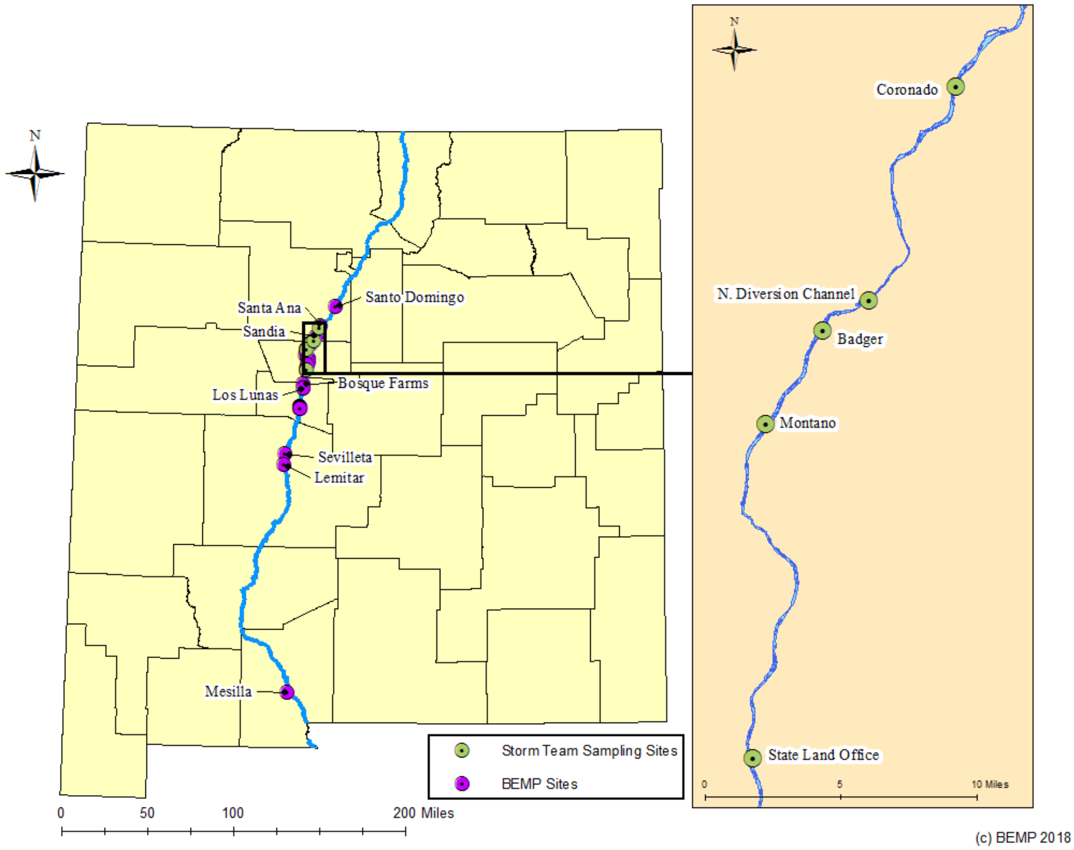

Figure 30. Location map of the five sites sampled in 2017 for the Stormwater Quality Team (green) and all active BEMP sites (purple).

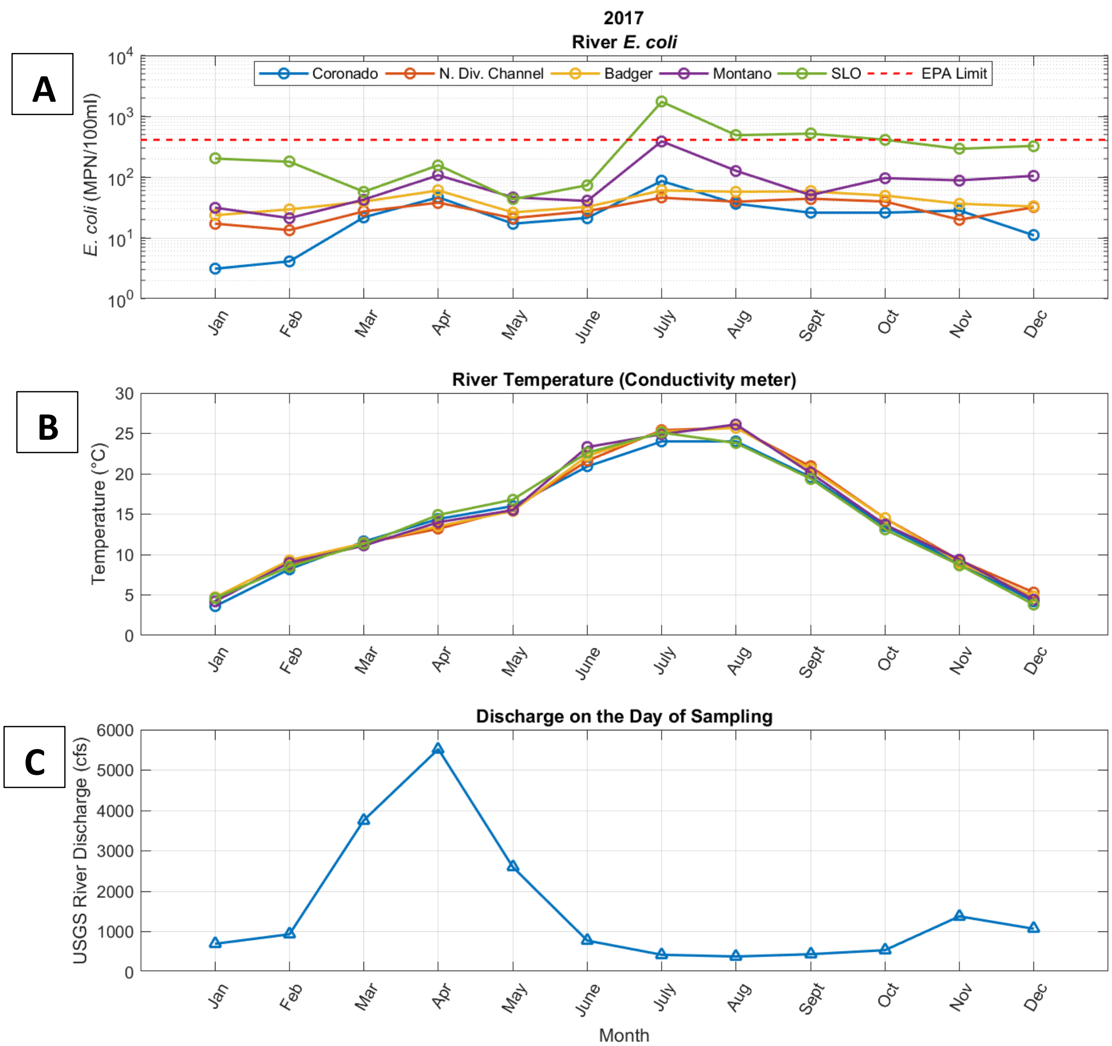

Figure 31. A.) *E. coli* levels sampled each month at Coronado, N. Div. Channel, Badger, Montano, and SLO. The dashed red line marks the EPA single sample limit of 410 MPN/100ml. Note the y-axis is on a logarithmic scale. B.) Temperature (ºC) of the water at the time of conductivity sampling. C.) Discharge of the Rio Grande measured at the USGS gage station located at the Albuquerque Central Bridge (gage ID 08330000). Discharge measurements were considered provisional data by the USGS.

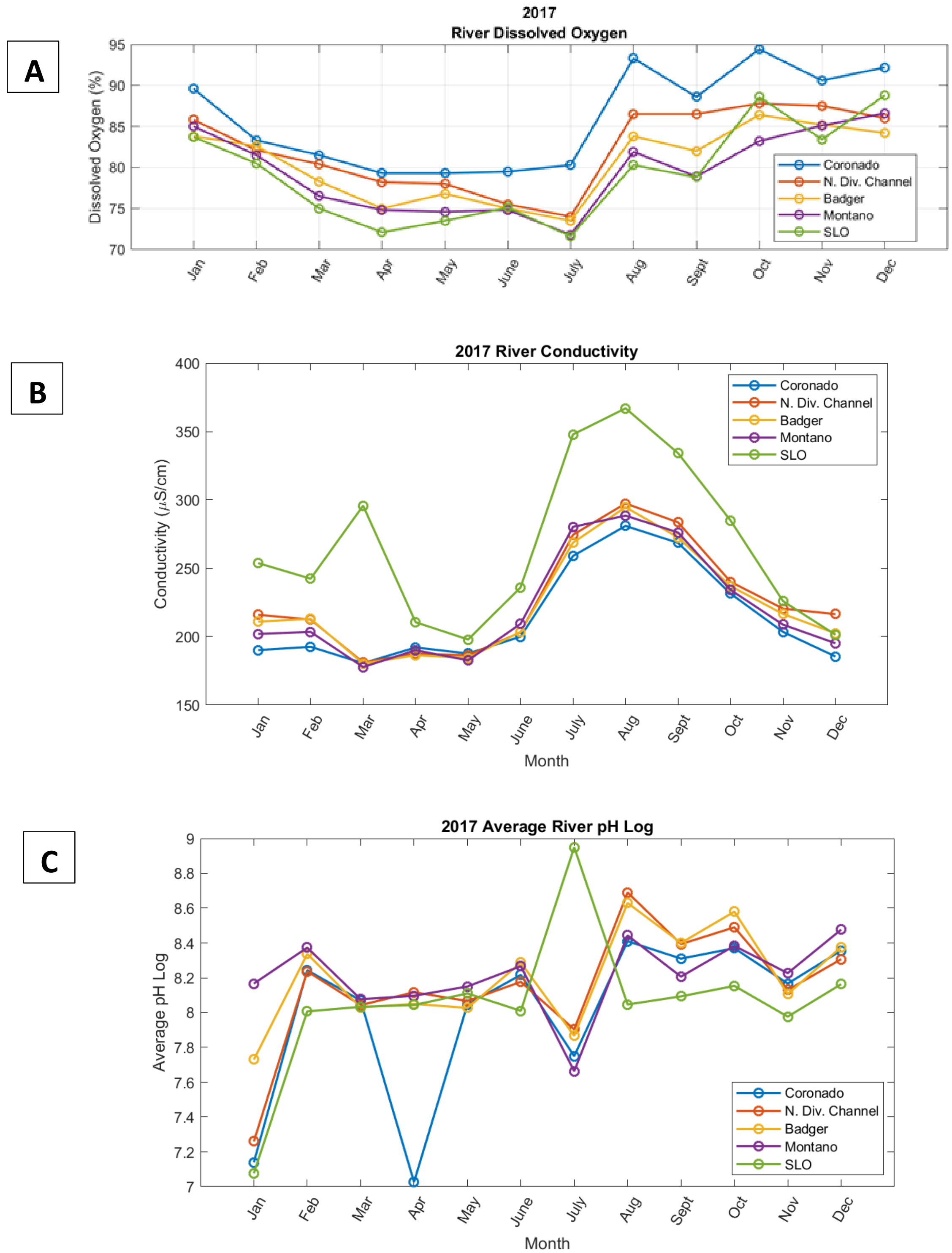

Figure 32. A.) Dissolved oxygen (%) B.) Conductivity (µS/cm) and C.) average pH log levels sampled each month at Coronado, N. Div. Channel, Badger, Montano, and SLO.

Figures are from BEMP 2017 Annual Stormwater Quality Team Technical Rep

Appendix G. Depth to groundwater, depth to water level in the nearby ditch or drain, and USGS river flow (from the closest stream gage to each site) for each BEMP site. Sites are listed in alphabetical order.

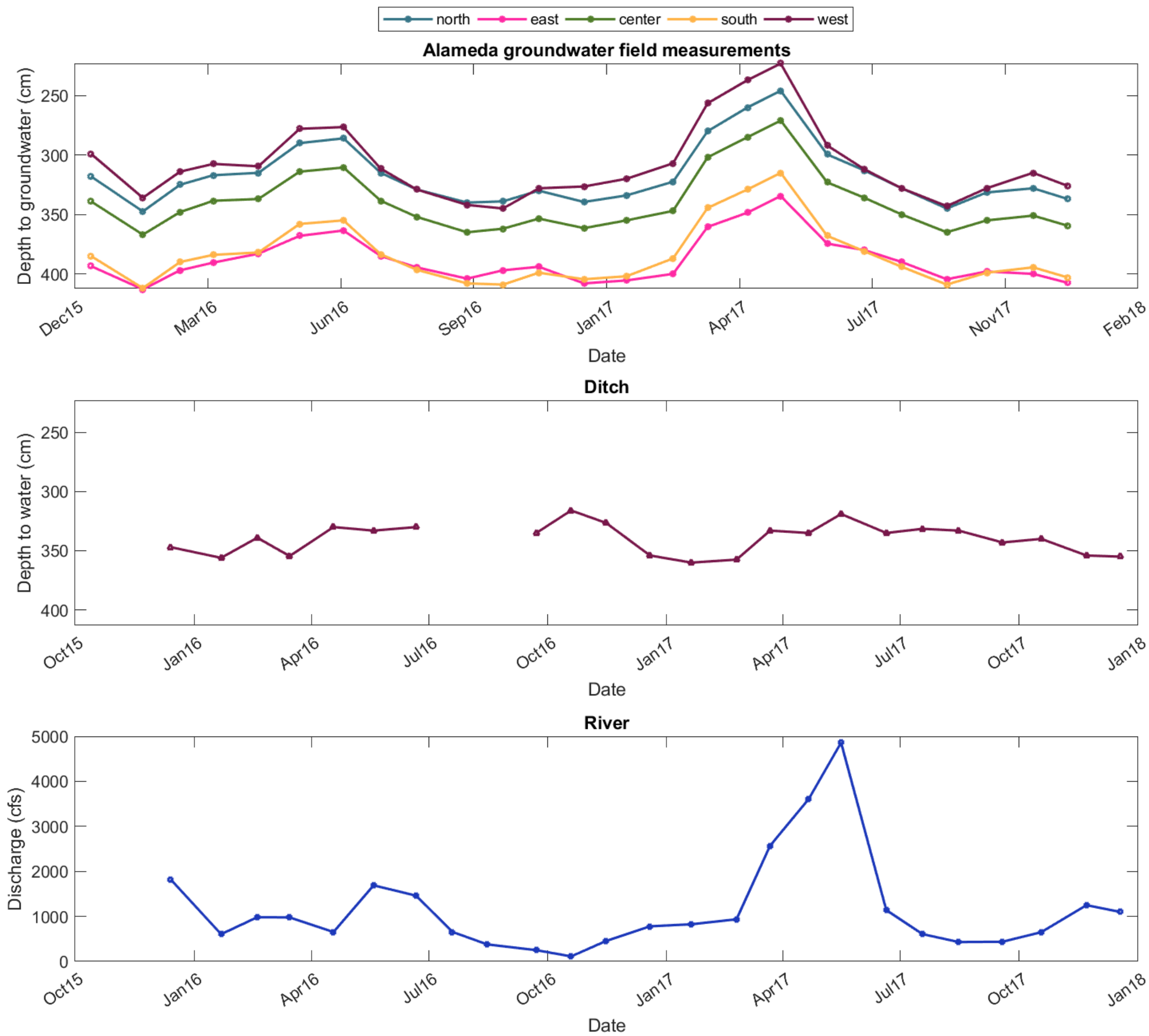

Figure 33. Depth to groundwater at the Alameda BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

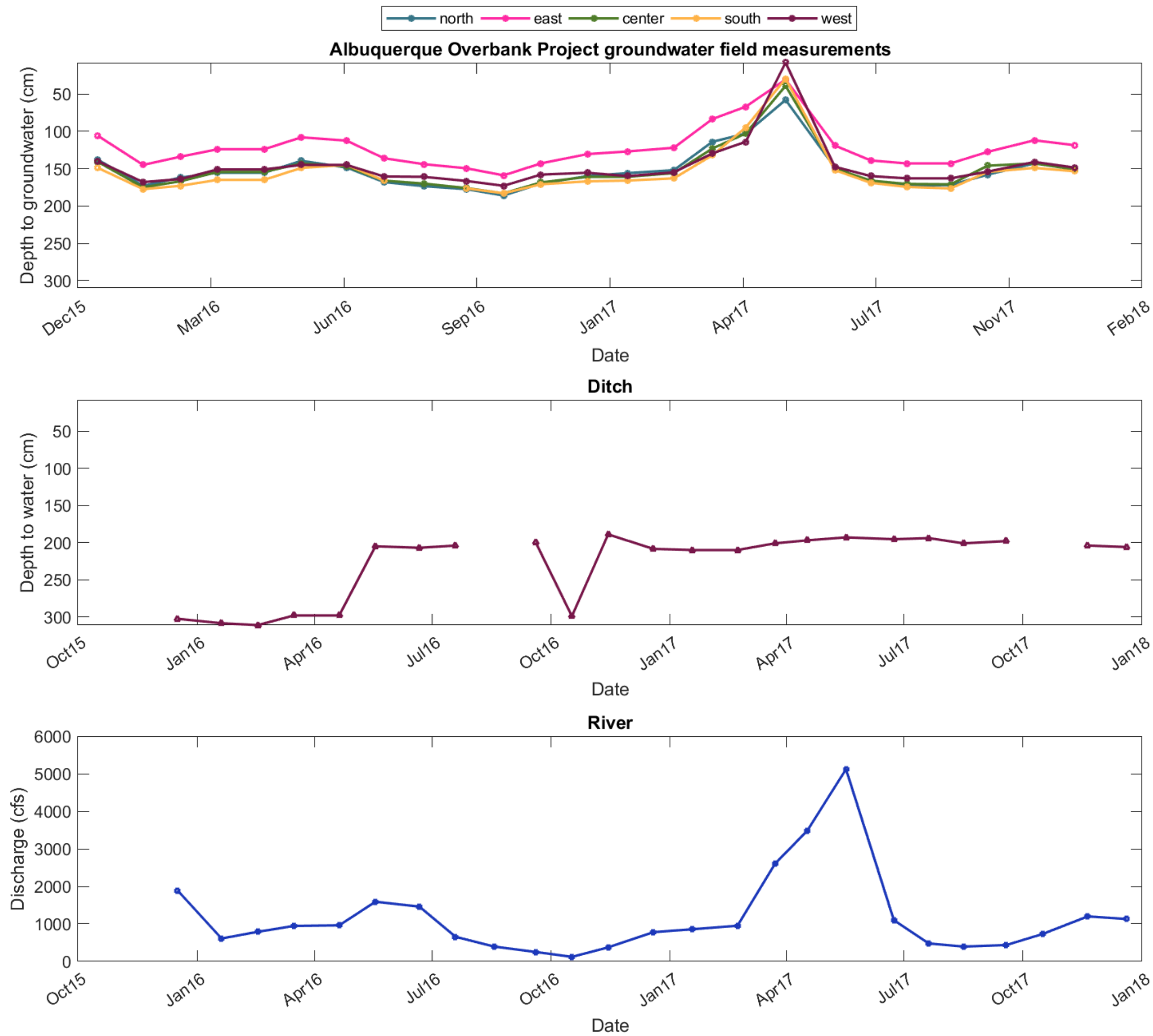

Figure 34. Depth to groundwater at the Albuquerque Oberbank Project (AOP) BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

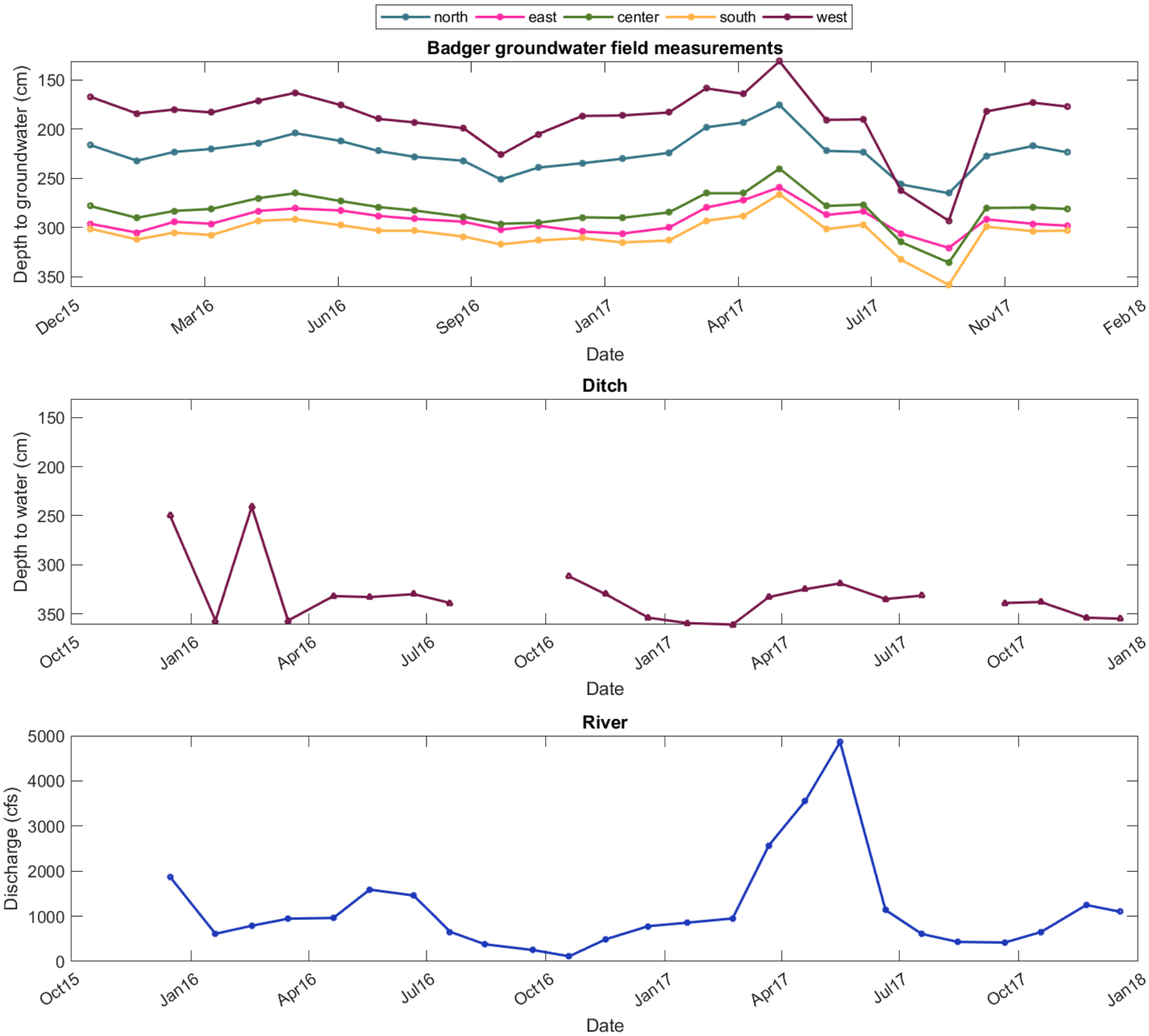

Figure 35. Depth to groundwater at the Badger BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

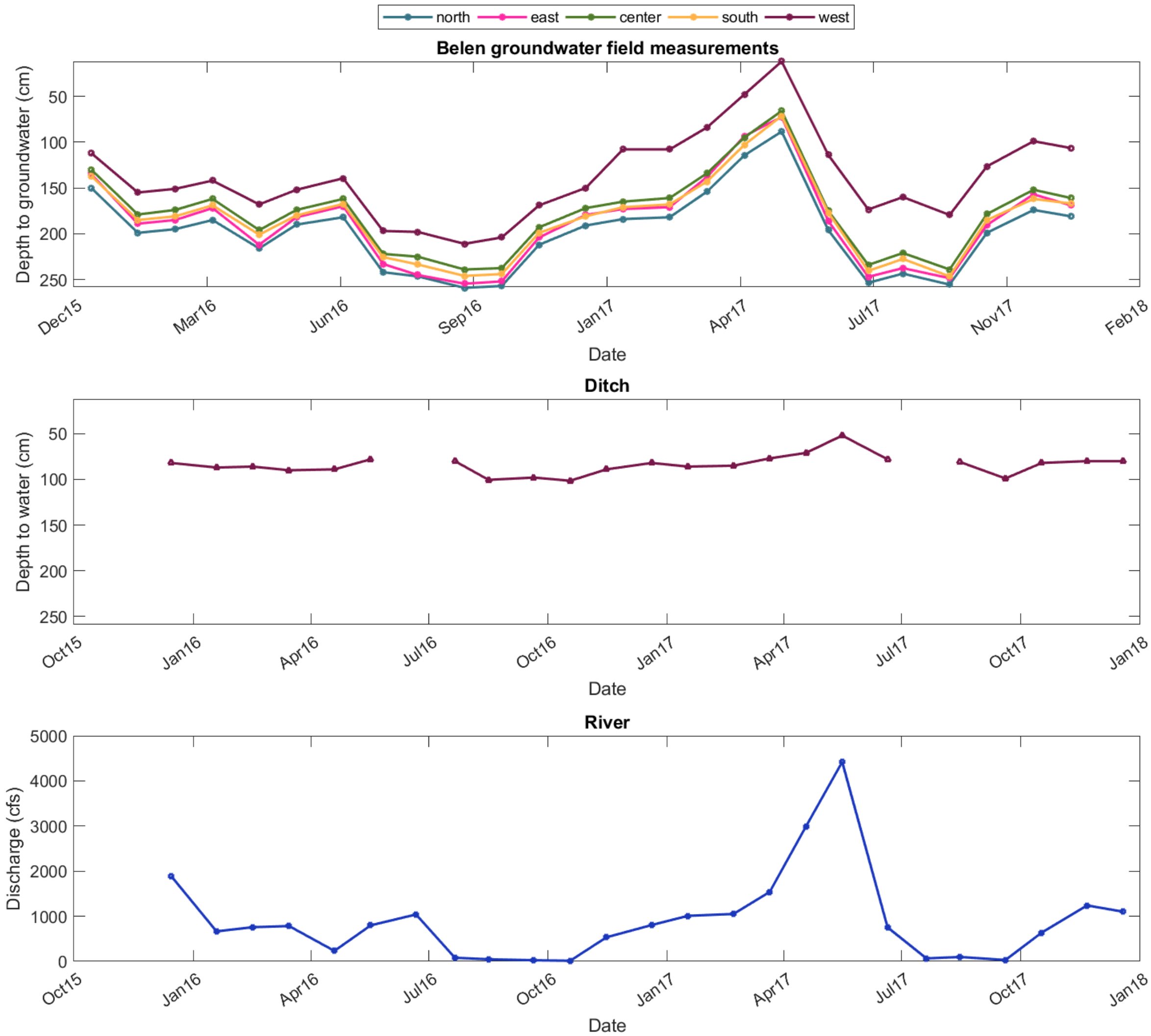

Figure 36. Depth to groundwater at the Belen BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

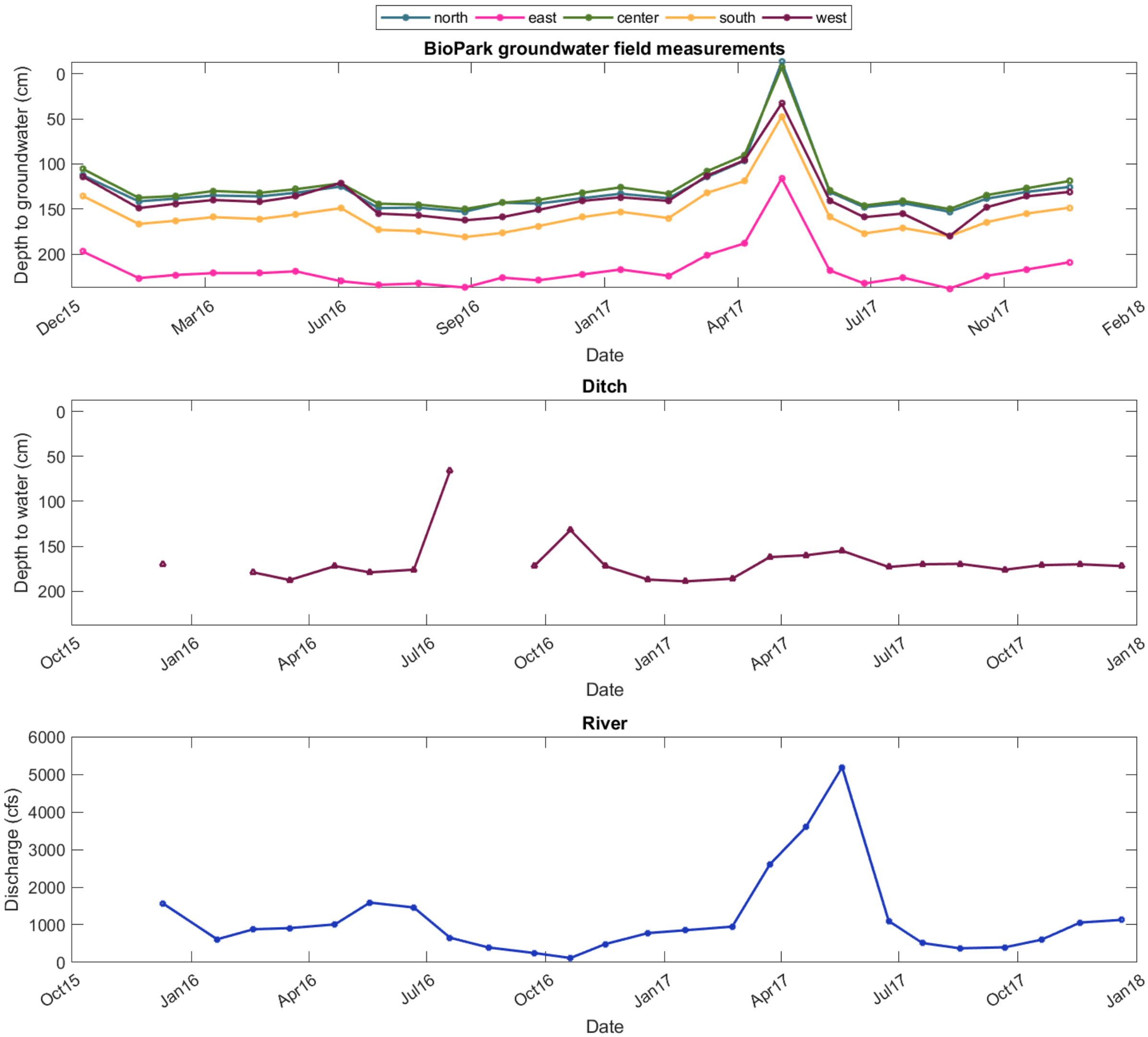

Figure 37. Depth to groundwater at the BioPark BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

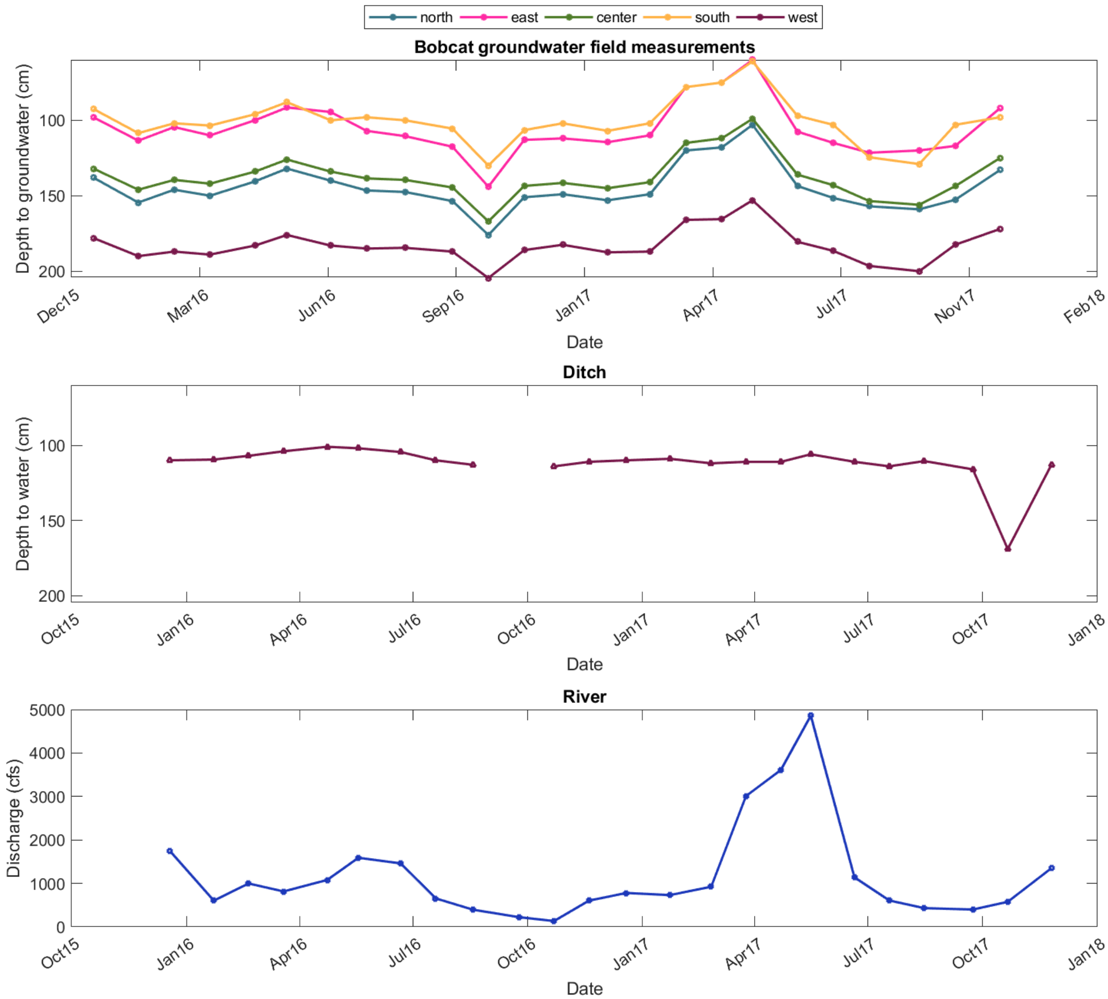

Figure 38. Depth to groundwater at the Bobcat BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

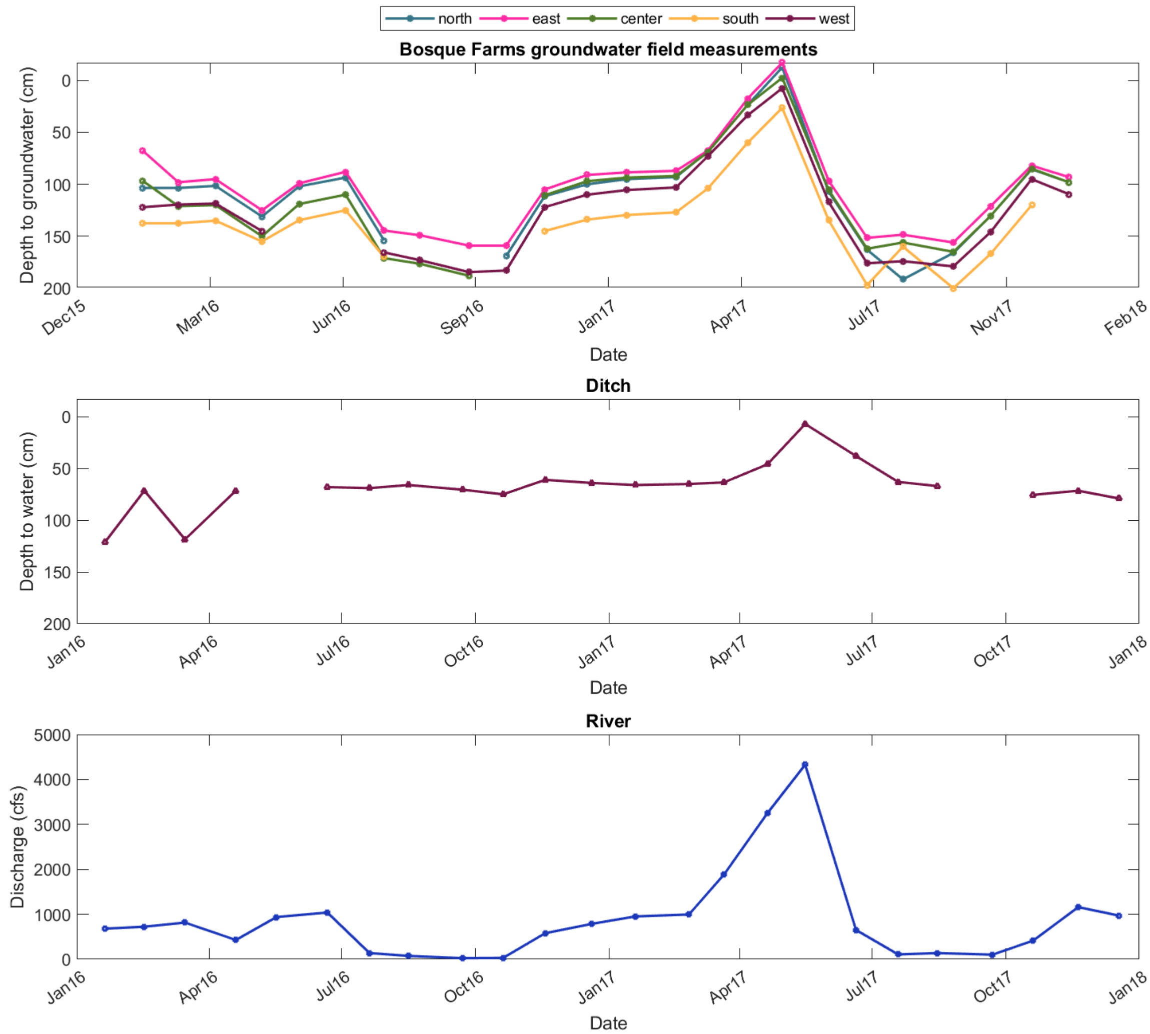

Figure 39. Depth to groundwater at the Bosque Farms BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

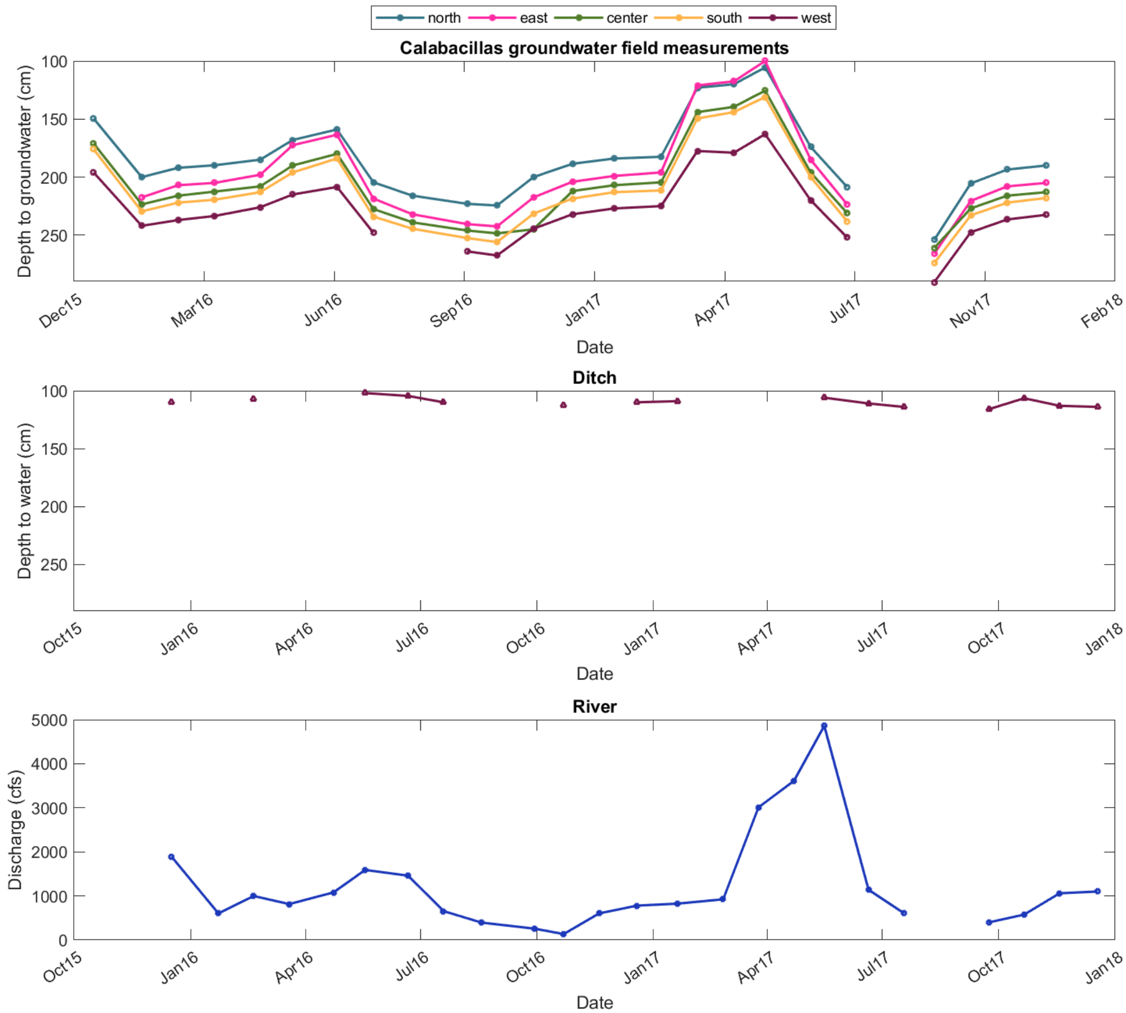

Figure 40. Depth to groundwater at the Calabacillas BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

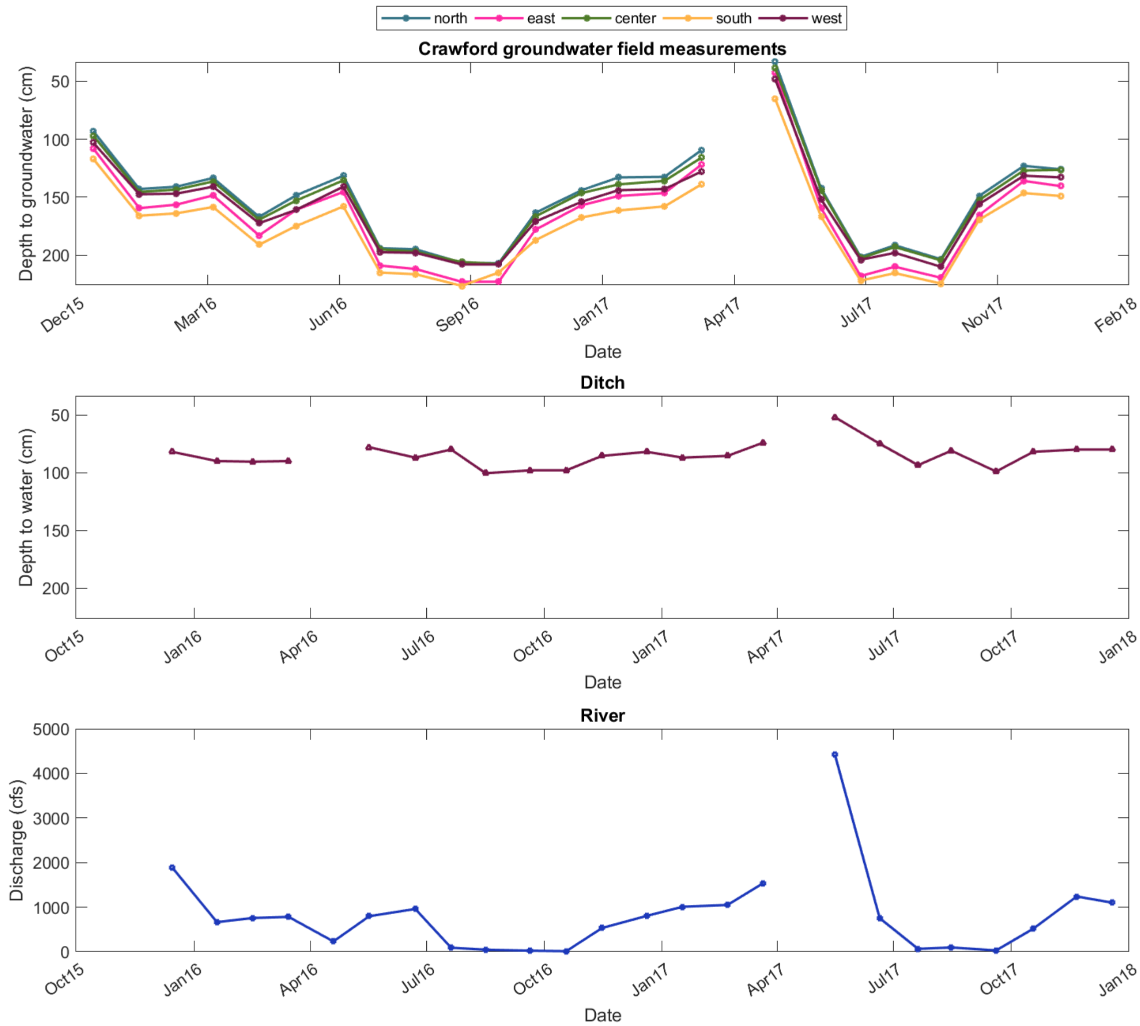

Figure 41. Depth to groundwater at the Crawford BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

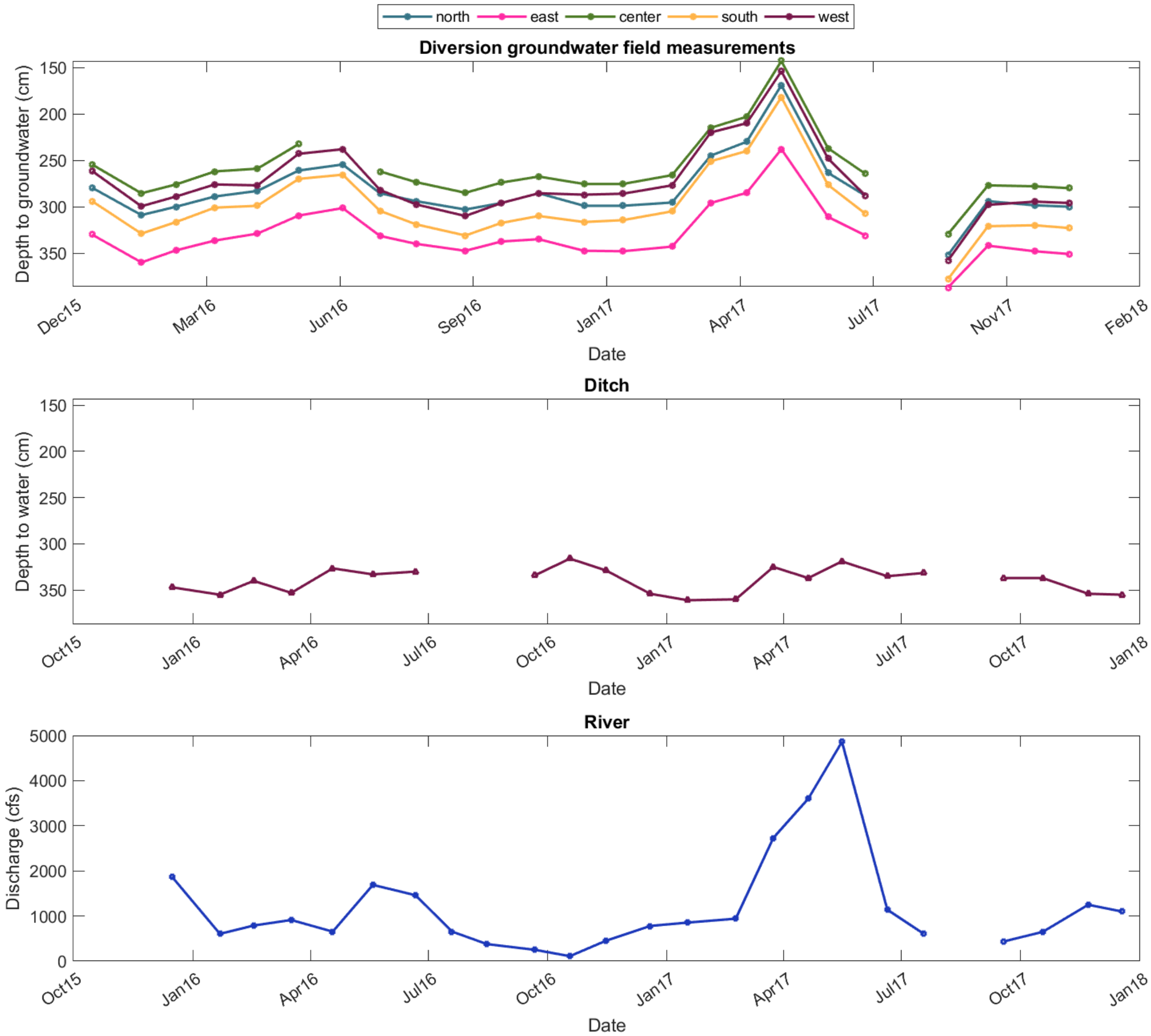

Figure 42. Depth to groundwater at the Diversion BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

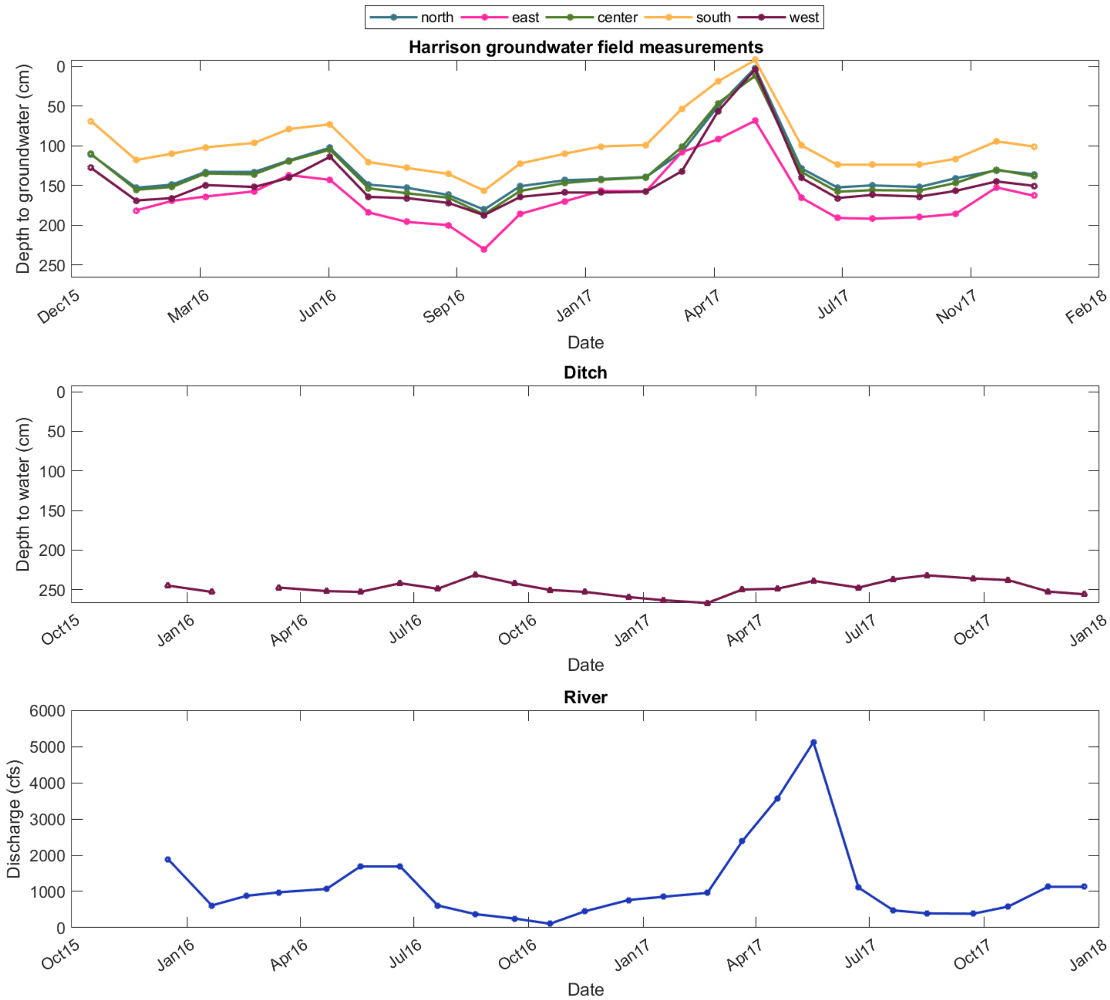

Figure 43. Depth to groundwater at the Harrison BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

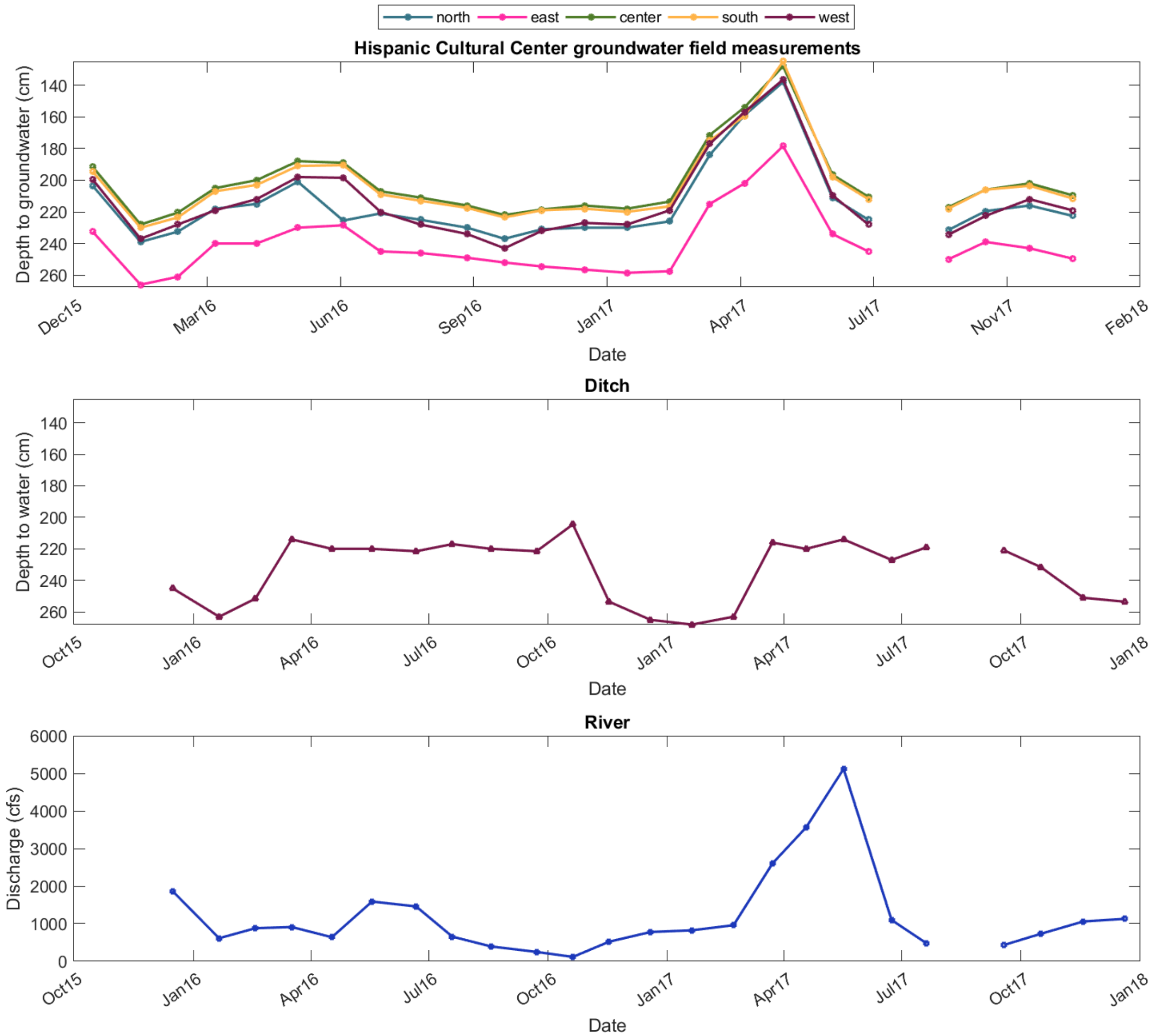

Figure 44. Depth to groundwater at the Hispanic Cultural Center BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

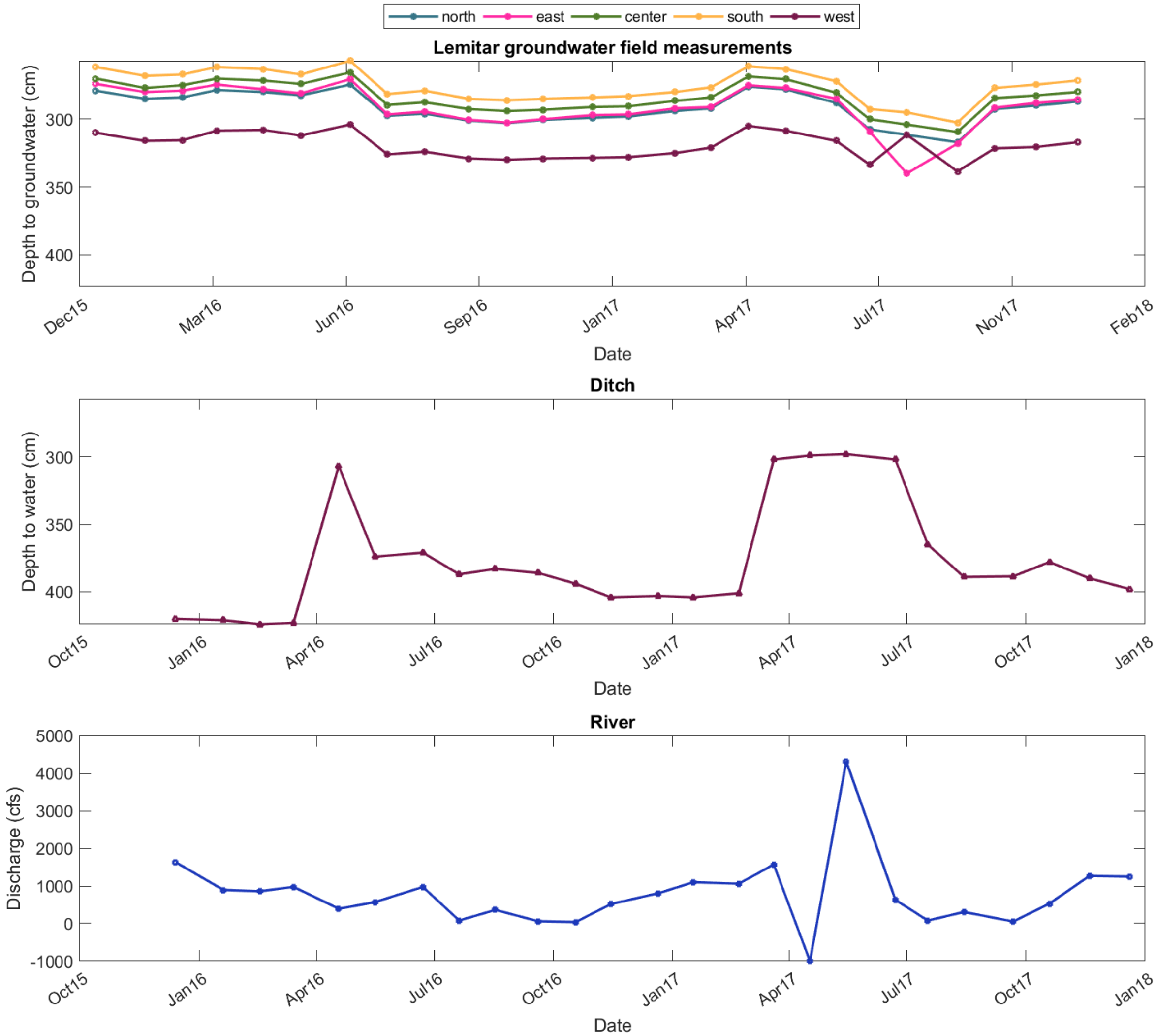

Figure 45. Depth to groundwater at the Lemitar BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

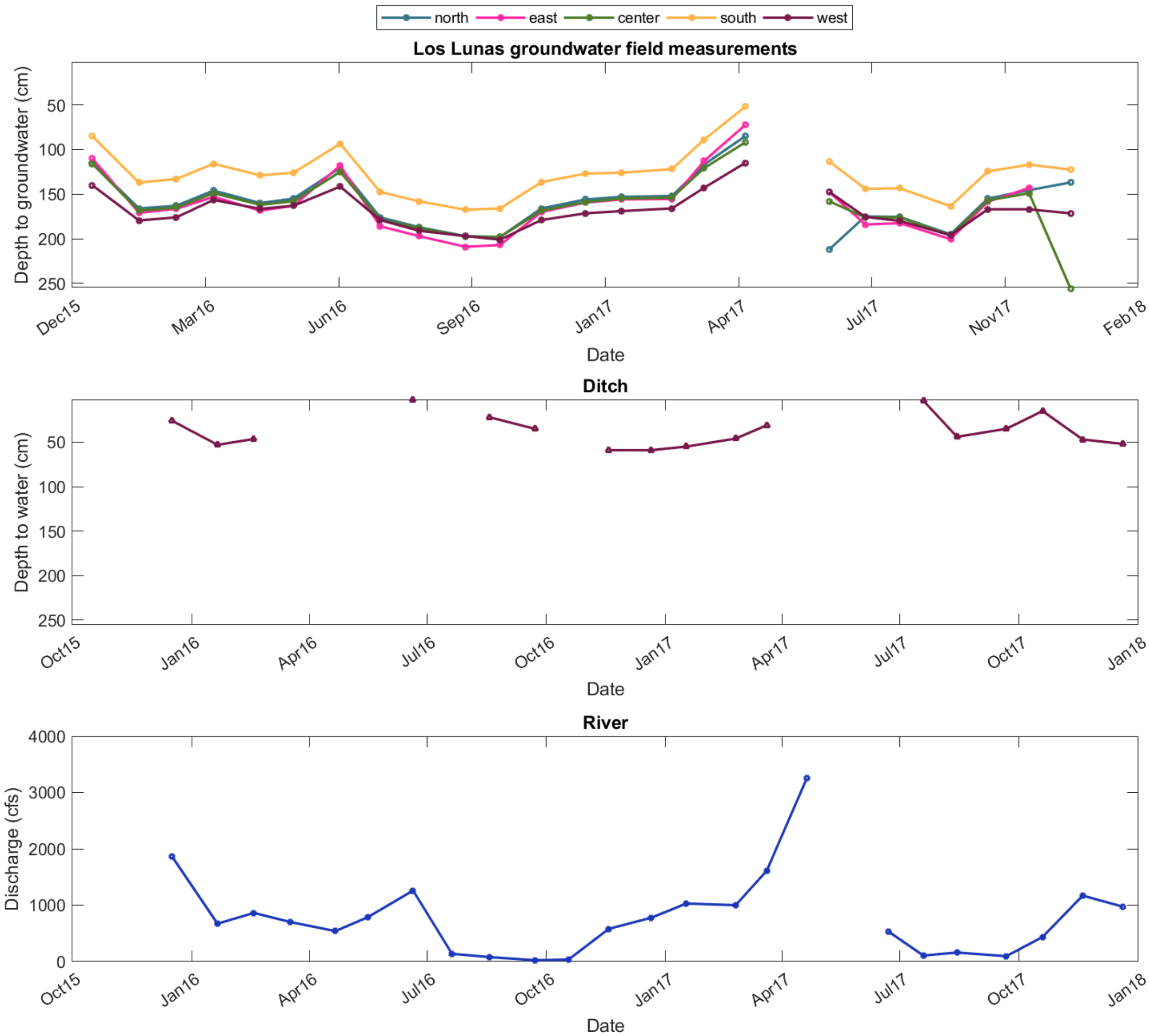

Figure 46. Depth to groundwater at the Los Lunas BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

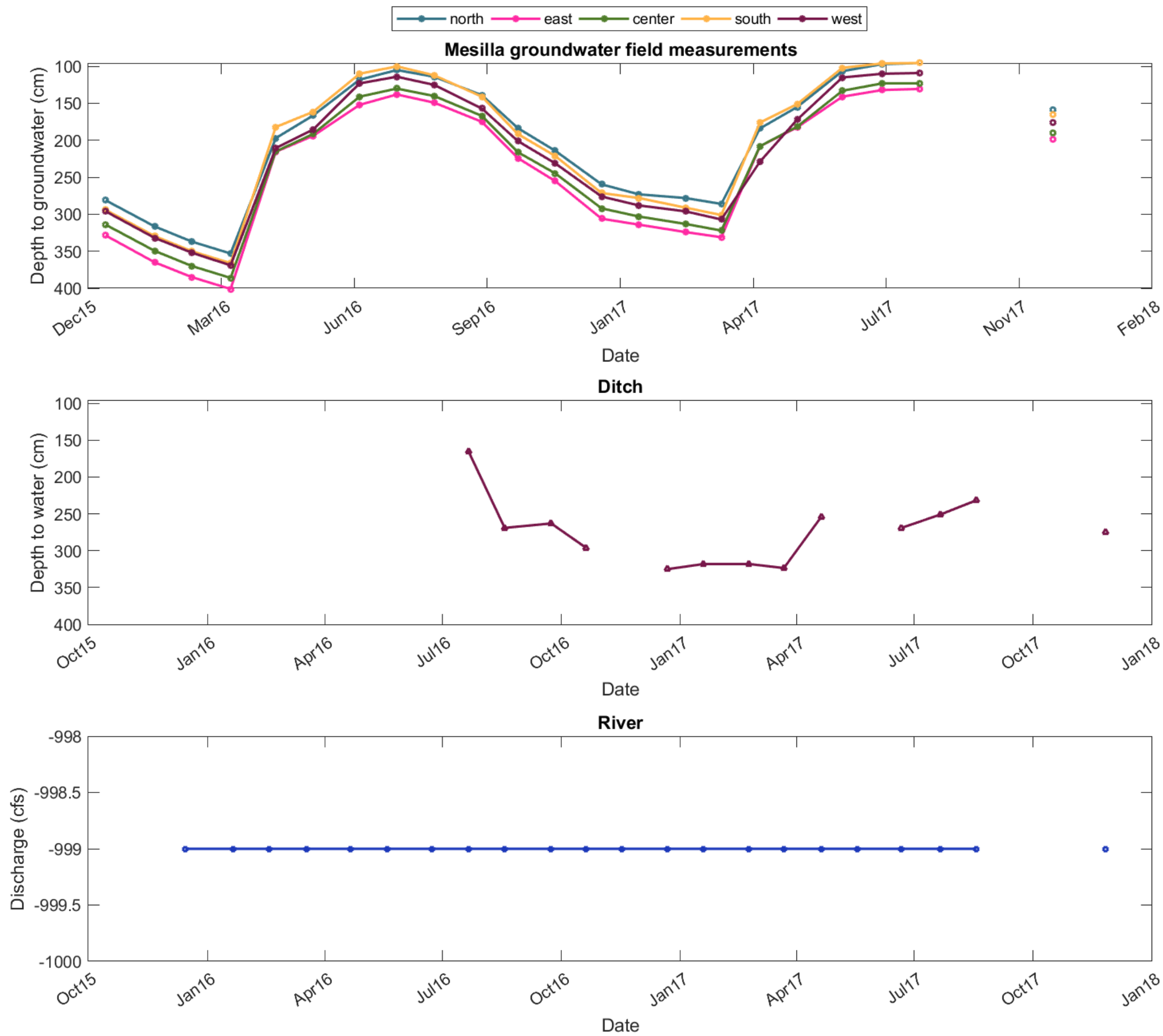

Figure 47. Depth to groundwater at the Mesilla BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

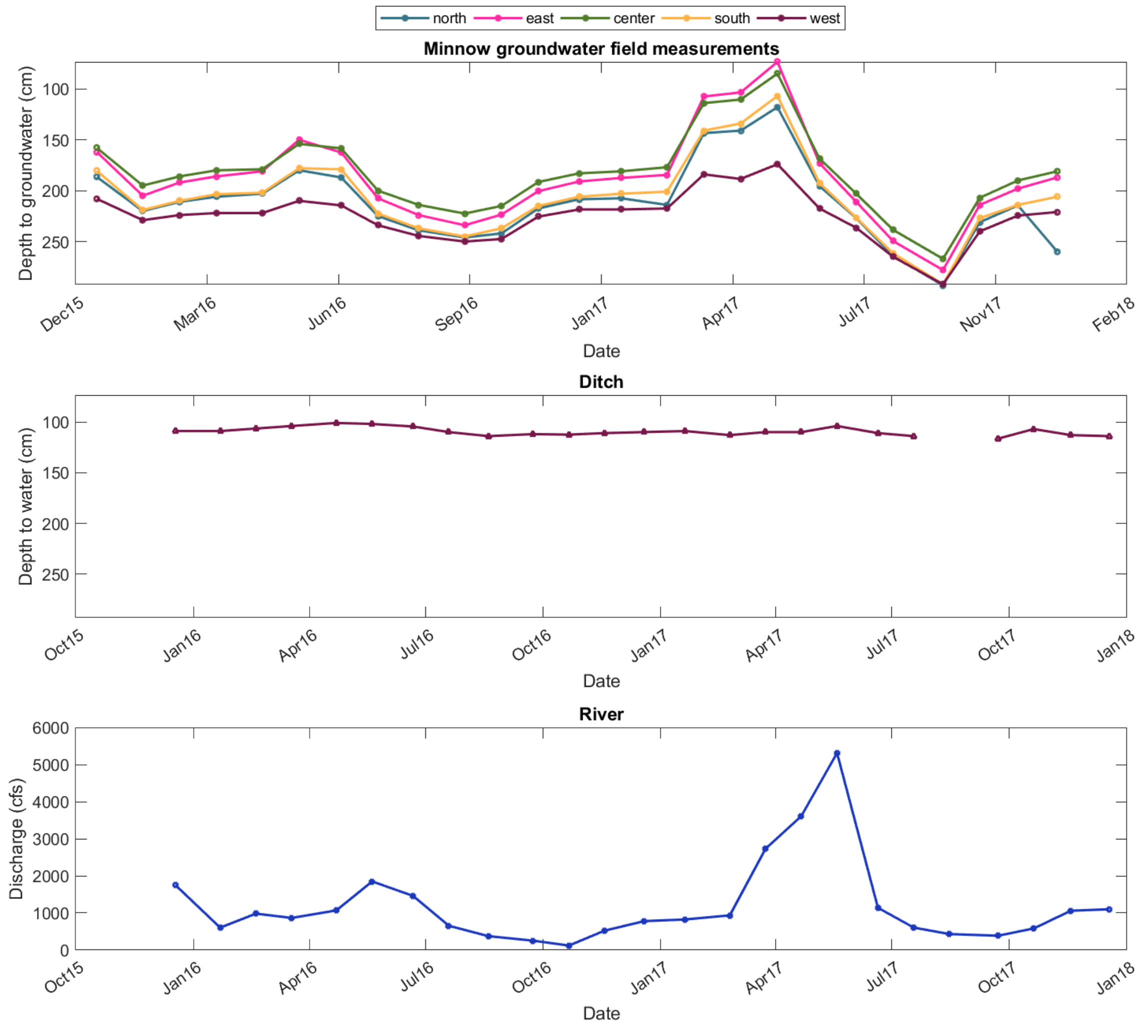

Figure 48. Depth to groundwater at the Minnow BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

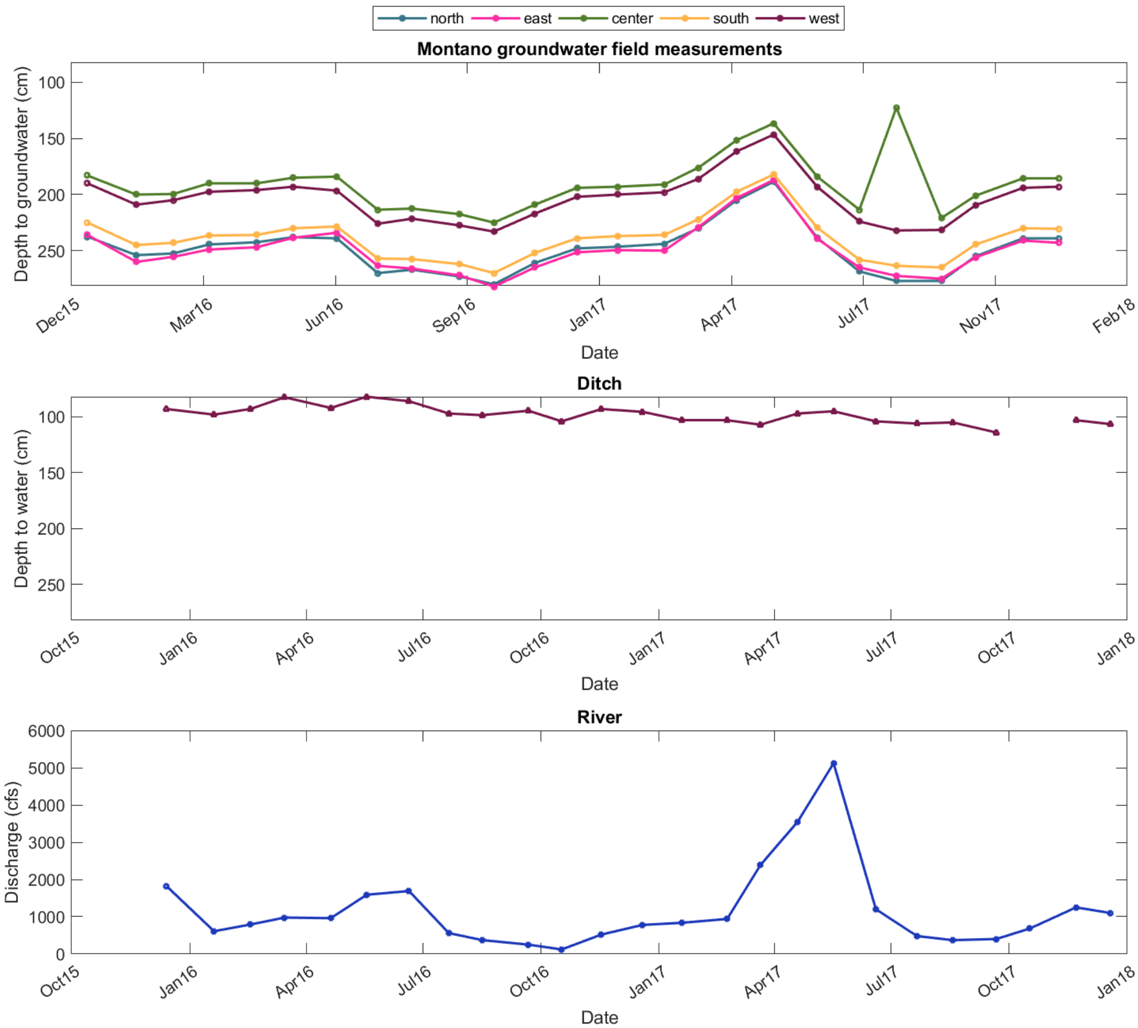

Figure 49. Depth to groundwater at the Montano BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

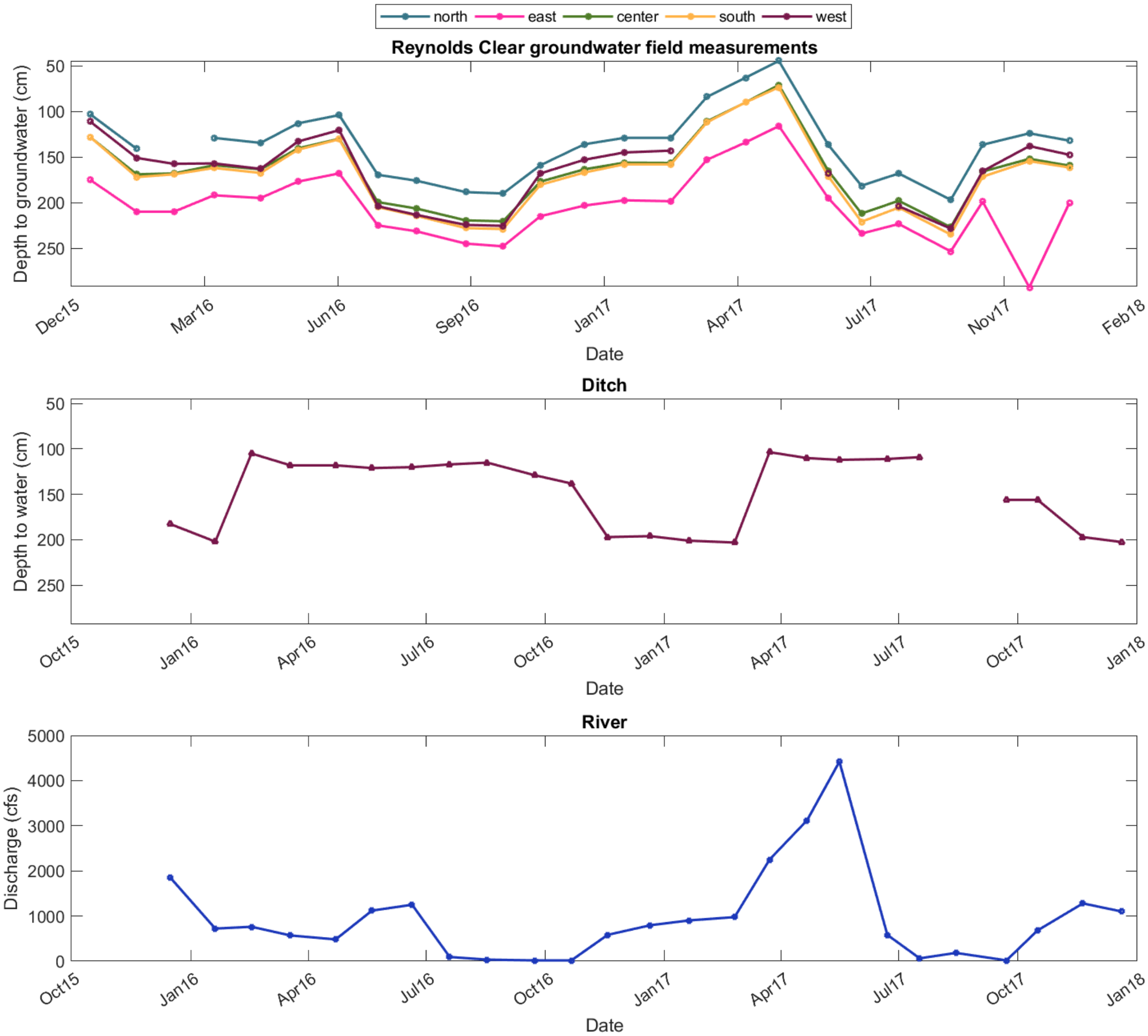

Figure 50. Depth to groundwater at the Reynolds Clear BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

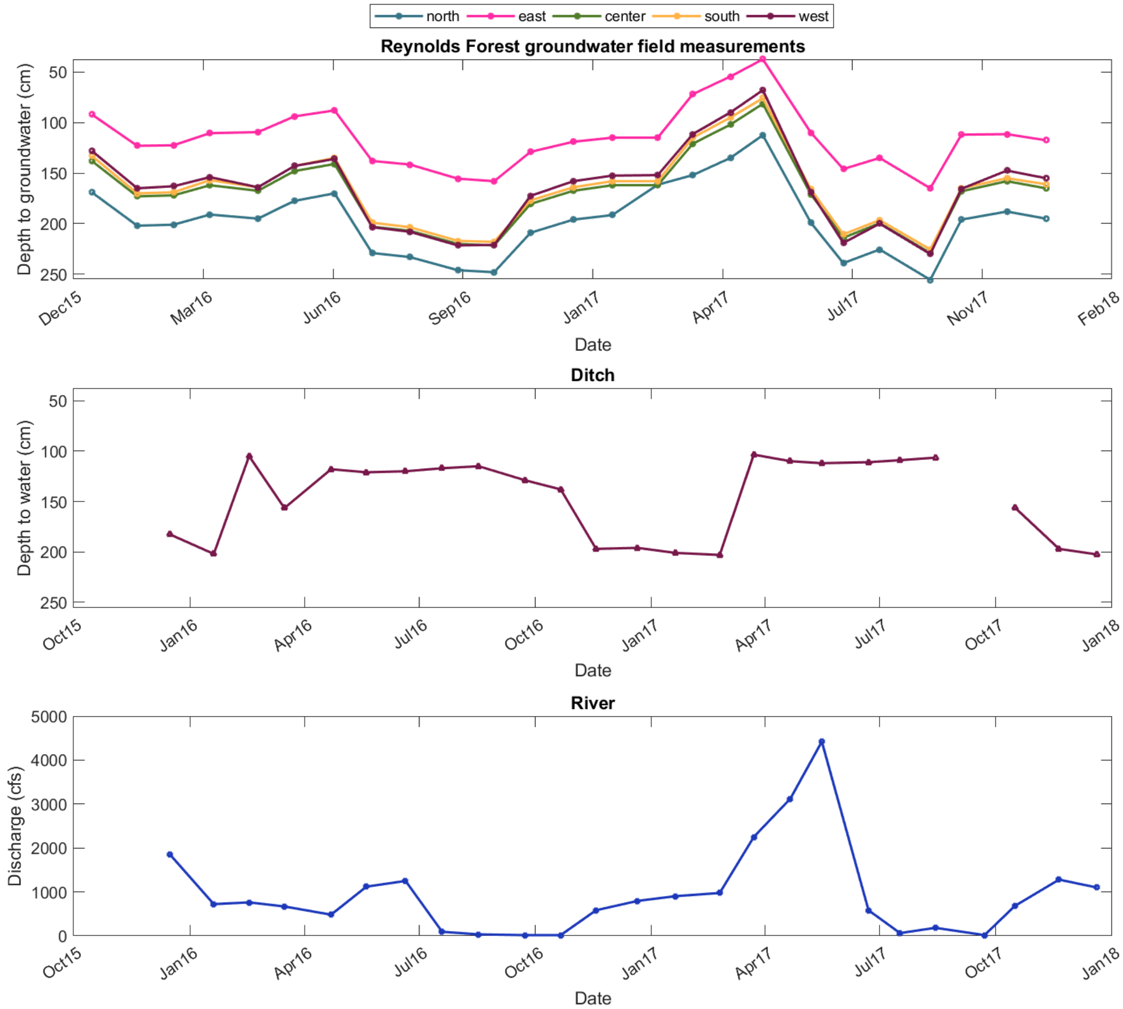

Figure 51. Depth to groundwater at Reynolds Forest BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

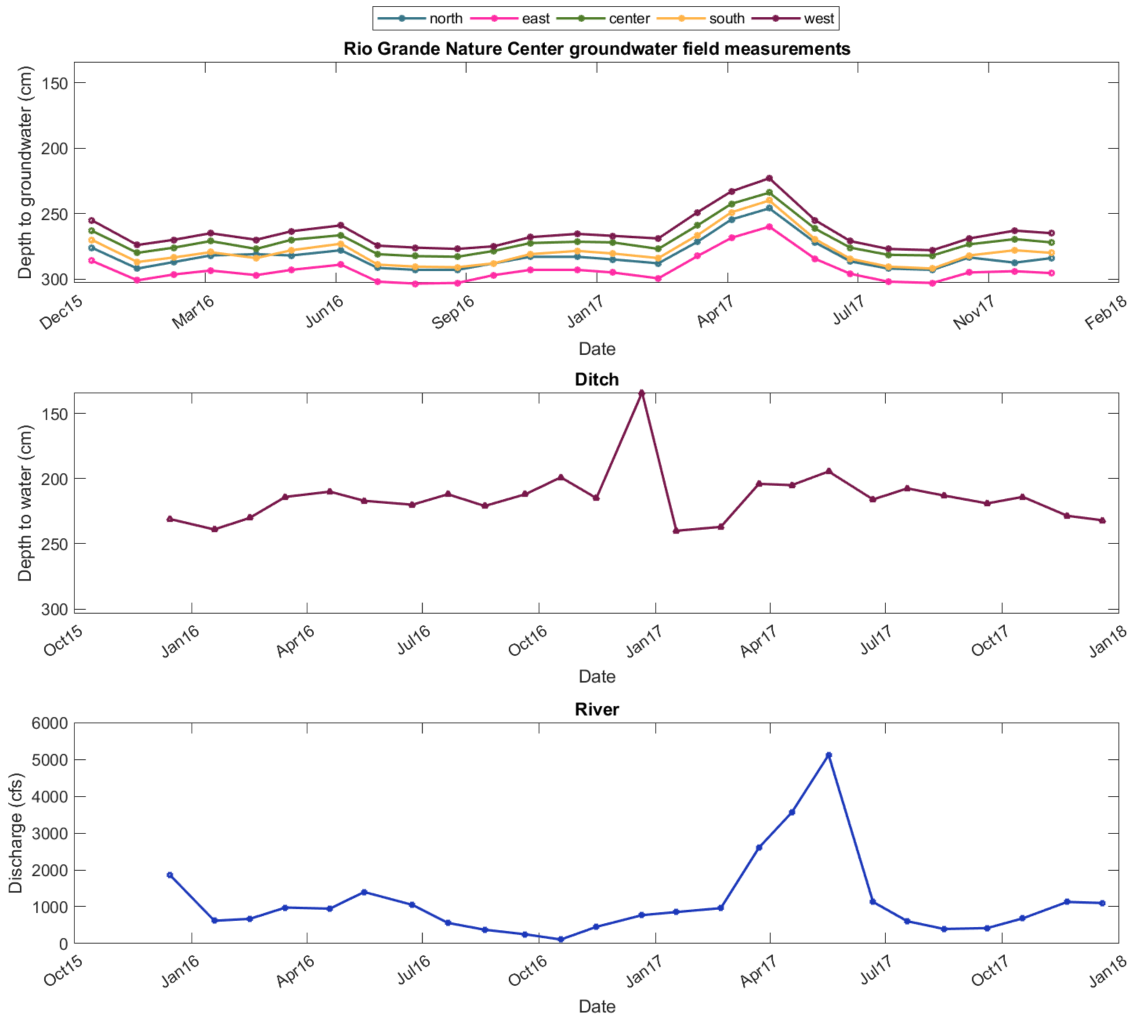

Figure 52. Depth to groundwater at the Rio Grande Nature Center BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

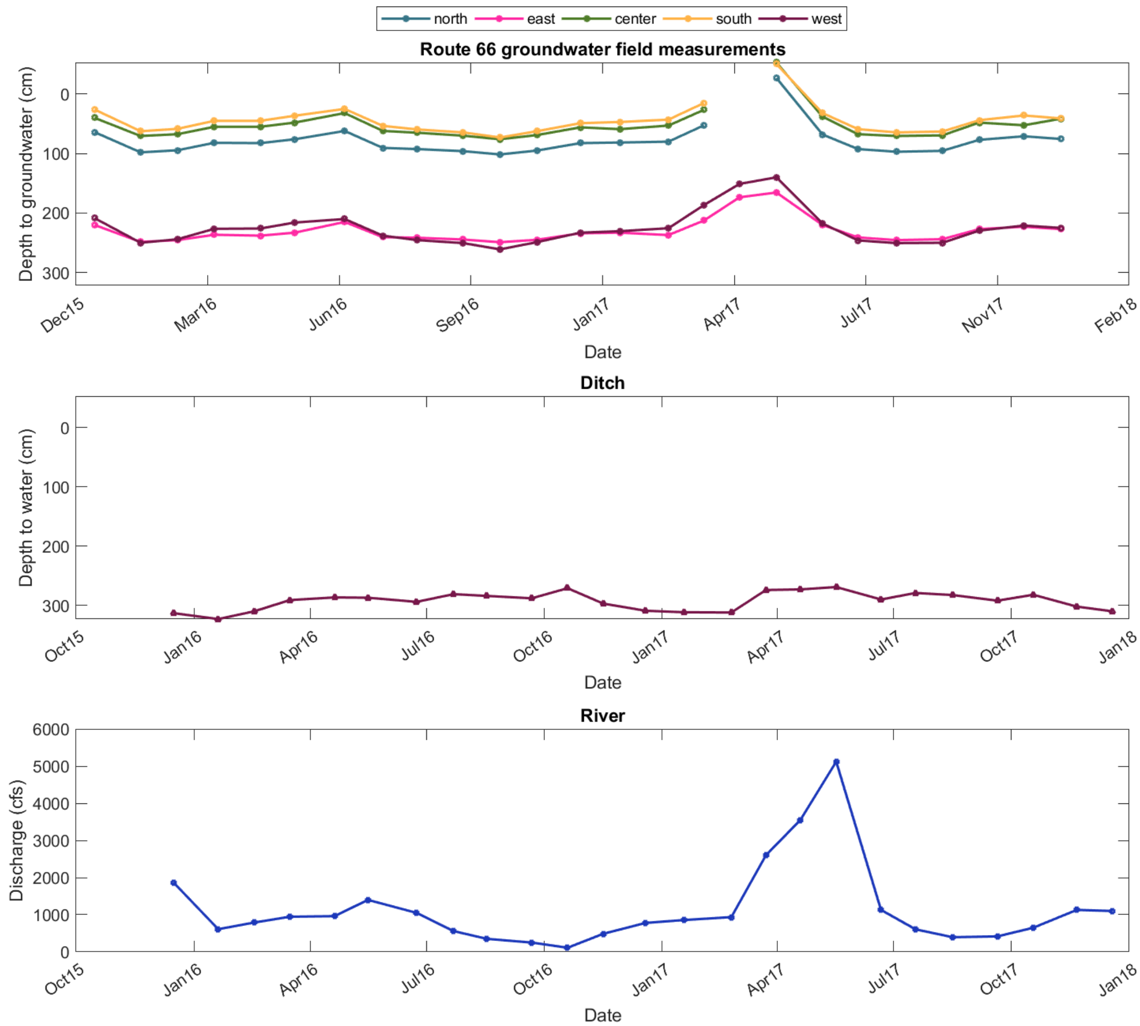

Figure 53. Depth to groundwater at the Route 66 BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

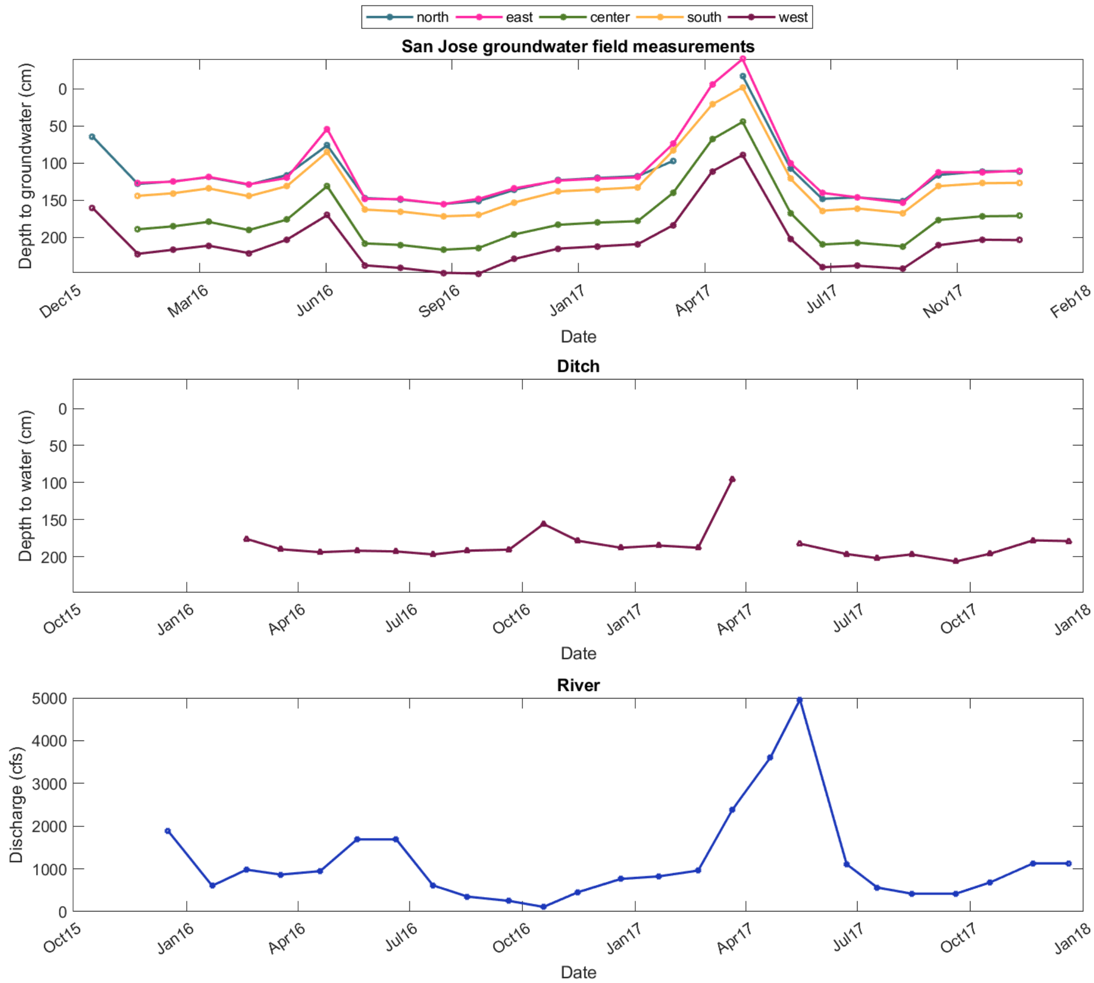

Figure 54. Depth to groundwater at the San Jose BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

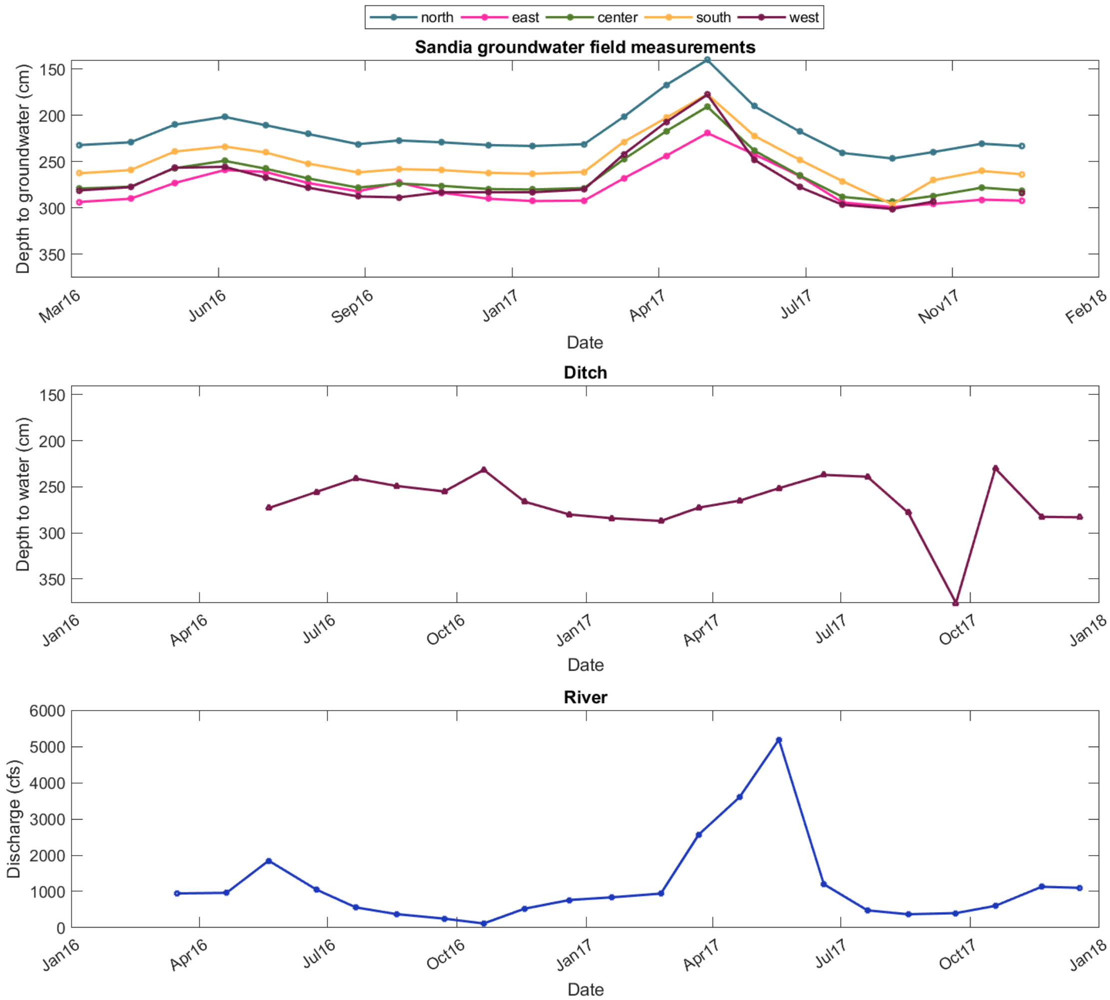

Figure 55. Depth to groundwater at the Sandia BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

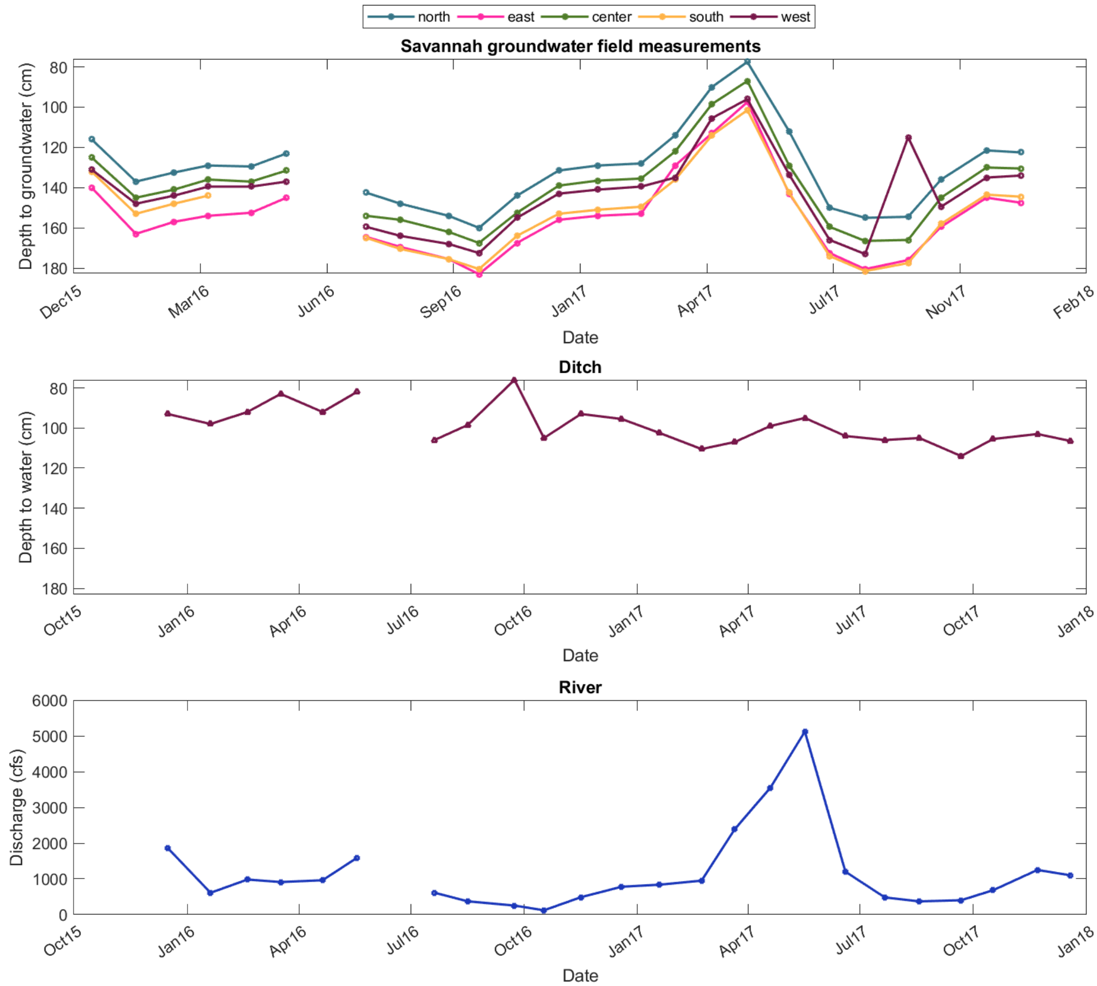

Figure 56. Depth to groundwater at the Savannah BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

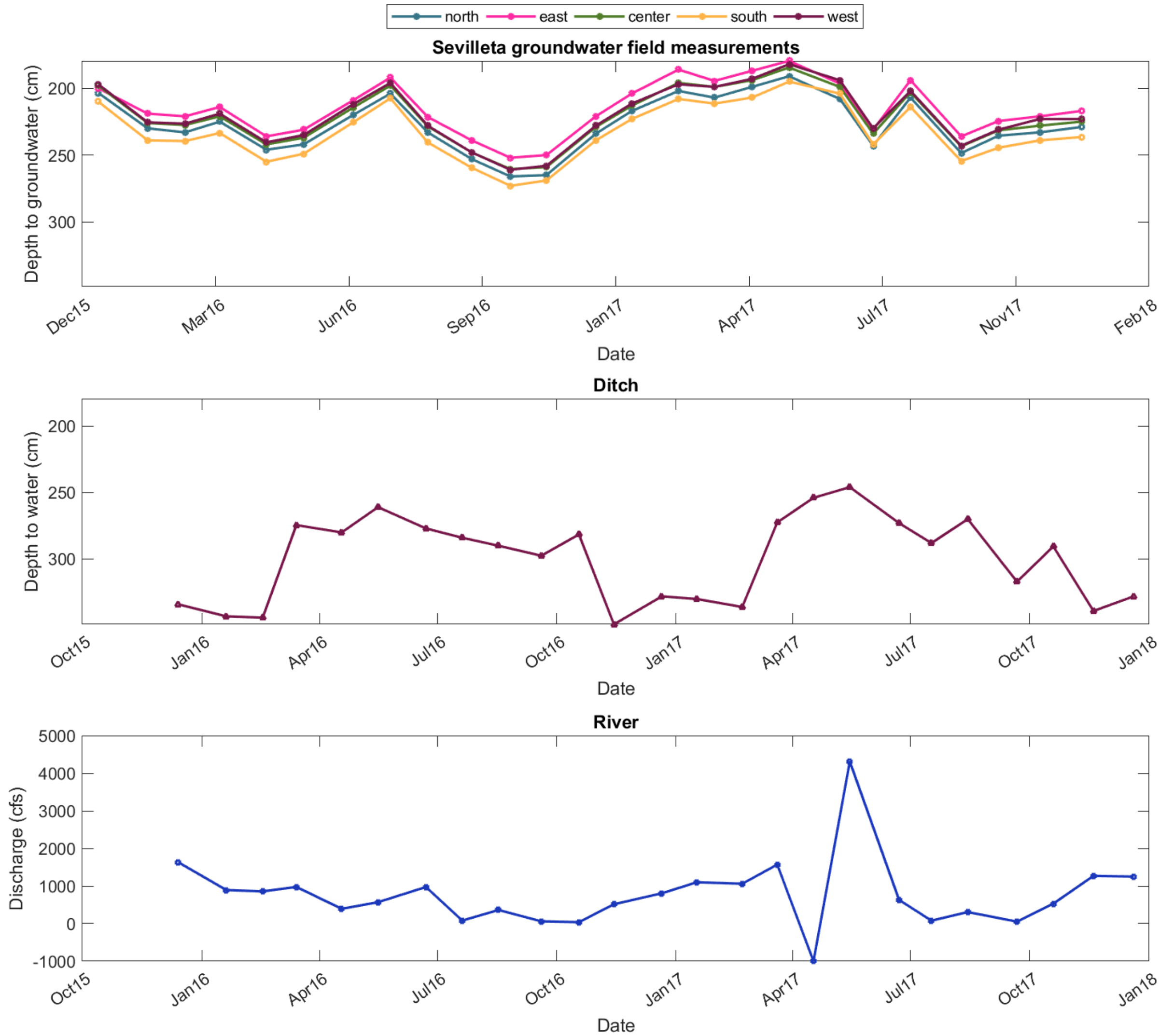

Figure 57. Depth to groundwater at the Sevilleta BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

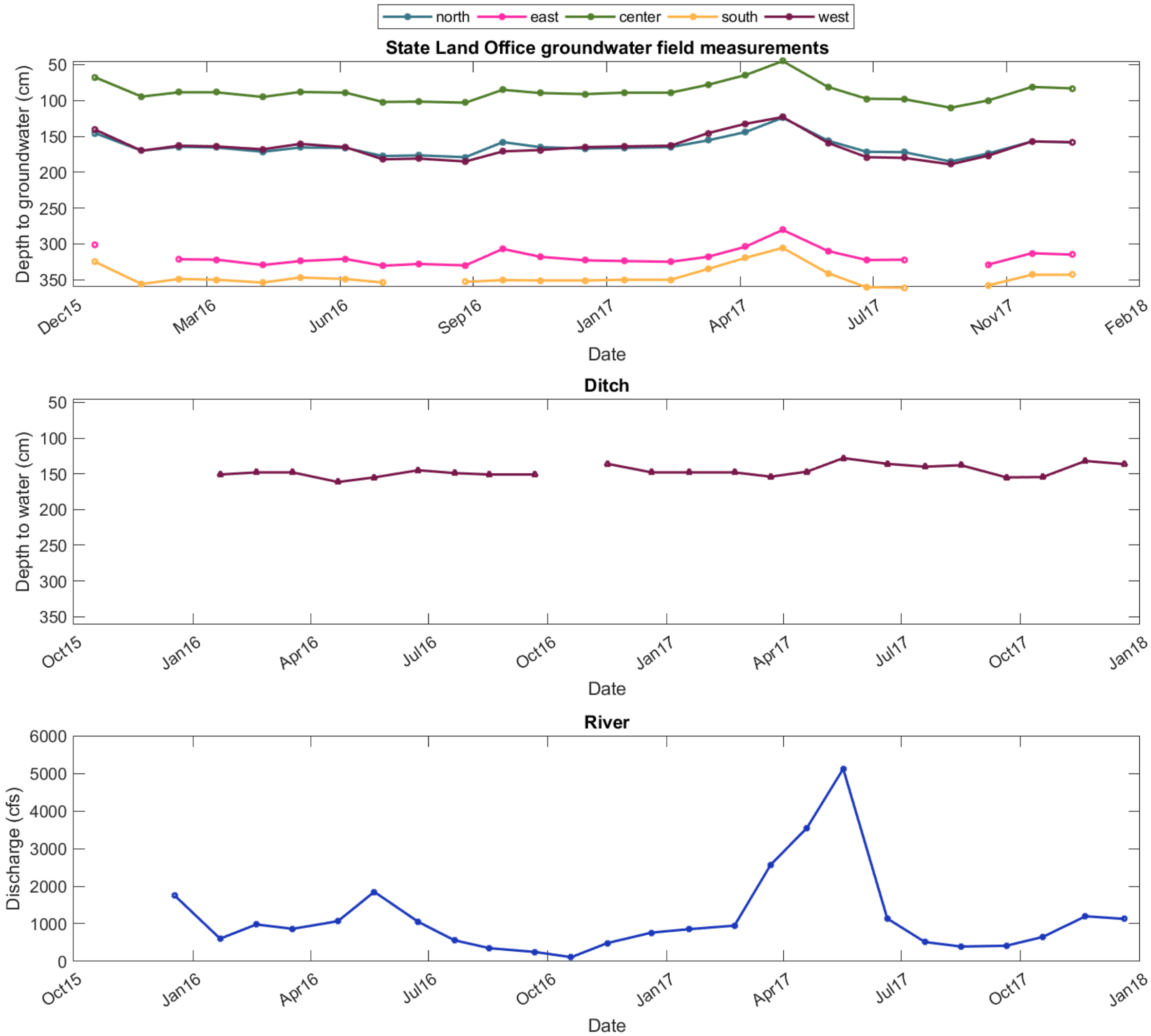

Figure 58. Depth to groundwater at the State Land Office BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

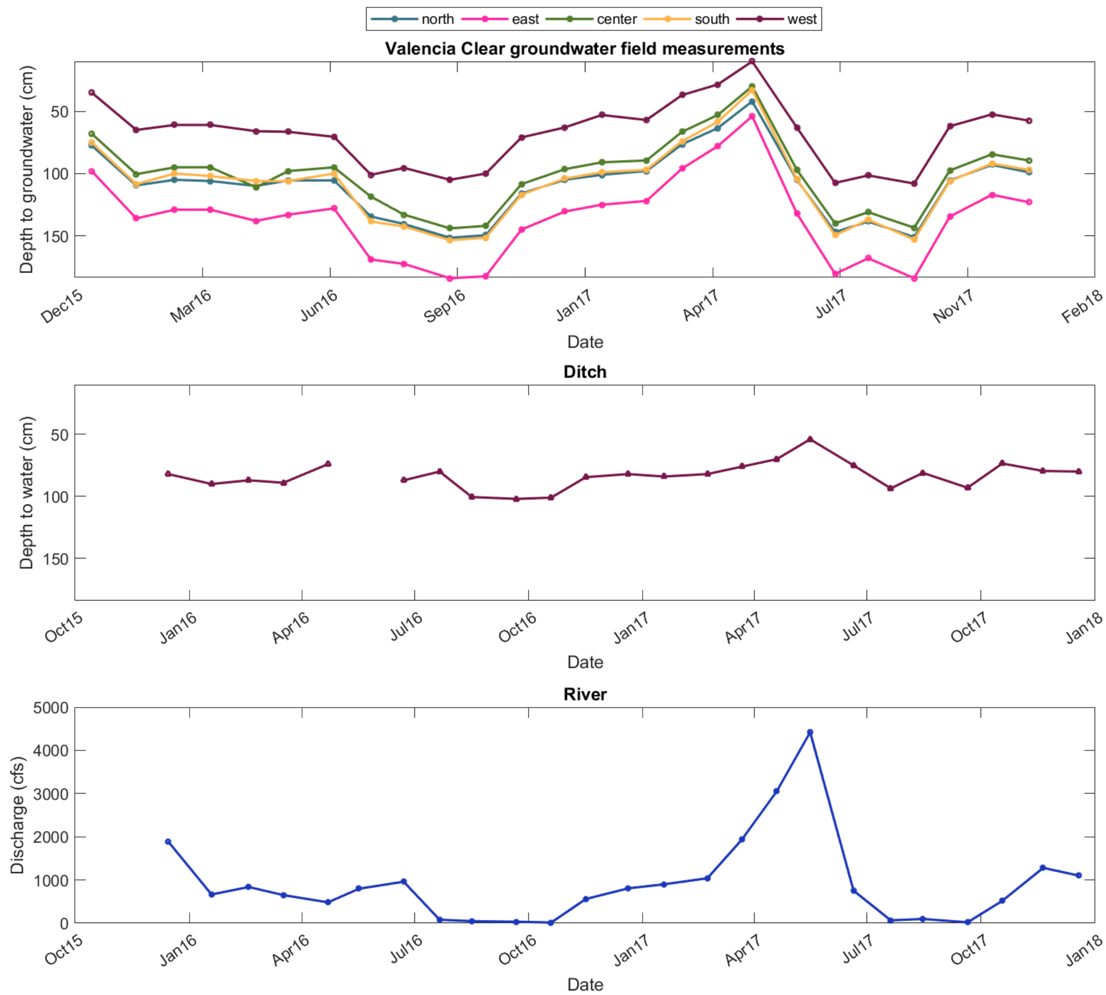

Figure 59. Depth to groundwater at Valencia Clear BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

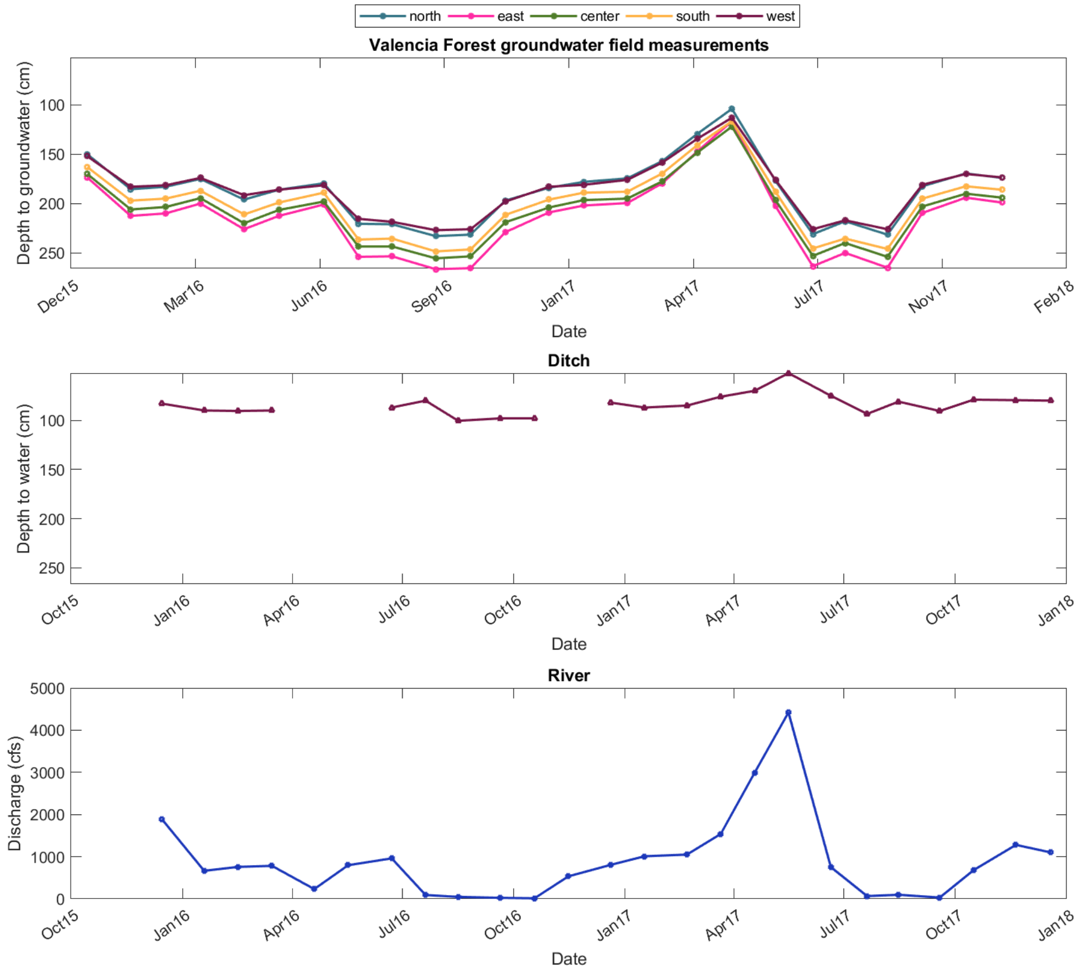

Figure 60. Depth to groundwater at the Valencia Forest BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.

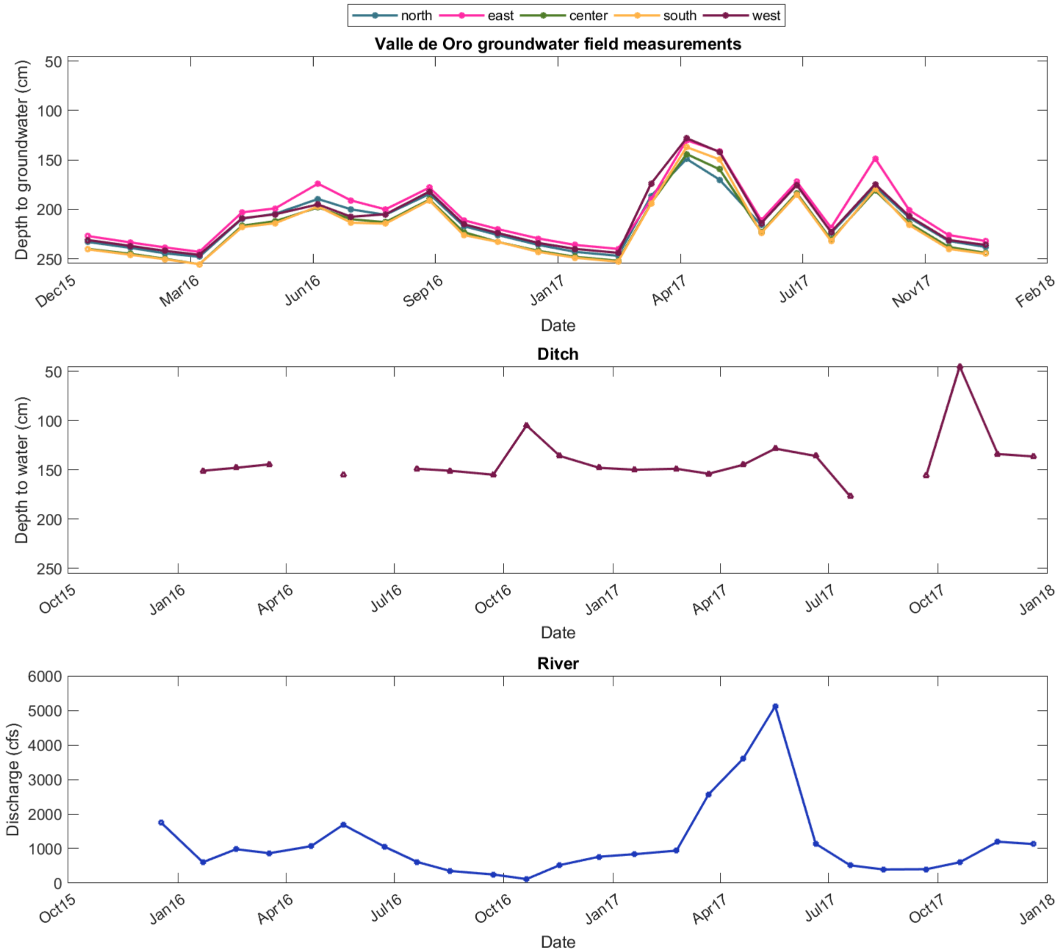

Figure 61. Depth to groundwater at the Valle de Oro (VDO) BEMP site, depth to water level in the nearby ditch or drain, and USGS river flow from the nearest gage.