

REGIONAL WATER QUALITY NEWSLETTER

DATE: Report for July 2008
Sampling conducted June 7 & 9 2008

From the Phoenix, Tempe, Glendale, Peoria, CAP, SRP – ASU Regional Water Quality Partnership

<http://enpub.fulton.asu.edu/pwest/tasteandodor.htm>

DISTRIBUTION: ACTarvers@FTMCDOWELL.ORG; mary.reker@phoenix.gov; knghiem@cseai.com; Kandis.Knight@asu.edu; gary.moore@tempe.gov; sandra.dewittie@tempe.gov; kspooner@citlink.net; bardizzone@carollo.com; wtrask@mw2h2o.com; jnafsey@mw2h2o.com; JJWilliams@GLENDALEAZ.com; raghunatha.komaragiri@phoenix.gov; mxerxis@scottsdaleaz.gov; mnguyen@ndep.nv.gov; RussellGRhodes@MissouriState.edu; paul.kinshella@phoenix.gov; brian.fayle@phoenix.gov; paul.zelenka@phoenix.gov; patricia.puryear@phoenix.gov; Wontae.Lee@hdrinc.com; kjacobs@ag.arizona.edu; k.kruger@asu.edu; addotson@gmail.com; Hye.Moon@asu.edu; Pedram.Shafieian@asu.edu; Daisuke.Minakata@asu.edu; Billt@gilbert.az.us; paul.mally@phoenix.gov; Braden.Allenby@asu.edu; Rittmann@asu.edu; Jeffrey.Stuck@amwater.com; nina.miller@amwater.com; wayne.janis@asu.edu; jim.holway@asu.edu; gober@asu.edu; rscott@glendaleaz.com; safischer@fs.fed.us; aimce.conroy@phoenix.gov; alan.martindale@cityofmesa.org; alice.brawley-chesworth@phoenix.gov; allison.shepherd@phoenix.gov; AGhosh@PIRNE.COM; antoniot@ci.gilbert.az.us; anupa.jain@ci.chandler.az.us; arw716@earthlink.net; awirtz@fs.fed.us; bakerenv@earthlink.net; bardizzone@carollo.com; bhenning@cap-az.com; btalabi@scottsdaleaz.gov; bkmoohe@srpnet.com; BobCarlson@scwater.com; bonnie.smith@phoenix.gov; Bradley.fuller@tempe.gov; brian.fayle@phoenix.gov; brian.k.watson@phoenix.gov; carl.meyer@phoenix.gov; carlos.padilla@phoenix.gov; cseidel@dswa.net; Charolotte.Jones@cityofmesa.org; chennemann@carollo.com; chris.rounseville@phoenix.gov; Chris.Kincaid/COC@ci.chandler.az.us; christenson.kara@epa.gov; CityofMesaWTP@compuserve.com; cwilson@scottsdaleaz.gov; D'Ann.O'Bannon@phoenix.gov; diwanski@goodyearaz.gov; davev@peoriaaz.com; dempster@asu.edu; dlopez@fs.fed.us; dorothy@peoriaaz.com; drcrosby@cap-az.com; dwalker@Ag.arizona.edu; dxprigge@srpnet.com; edna.bienz@phoenix.gov; erin.pysell@phoenix.gov; mario.esparza_soto@hotmail.com; francisco.gonzalez@phoenix.gov; frank.blanco@phoenix.gov; giloomis@fs.fed.us; GMaseeh@PIRNE.COM; Gregg.Elliott@srpnet.com; goelliot@srpnet.com; grant.osburn@tempe.gov; Greg.Ramon@Phoenix.Gov; gtday@amwater.com; GThelin@carollo.com; guy.carpenter@hdrinc.com; hugiang@asu.edu; Jackie.Strong@ci.chandler.az.us; jdoller@carollo.com; jeffrey.van.hoy@phoenix.gov; jennifer.calles@phoenix.gov; jwilliams@glendaleaz.com; JohnRK@PeoriaAZ.com; josh.berdeaux@msn.com; kremmel@ci.glendale.az.us; Larry.Duffy@ci.chandler.az.us; laxman.devkota@phoenix.gov; Linda.Bezy-Botma@peoriaaz.gov; Lori.mccallum@ci.chandler.az.us; lroberts@buckeyeaz.gov; luis.manriquez@phoenix.gov; Marisa.Masles@asu.edu; mark.roye@phoenix.gov; matthew.rexing@cityofmesa.org; maureen.hymel@phoenix.gov; mdehaan@dswa.net; Mdew1@mail.ci.tucson.az.us; mhelton@scottsdaleaz.gov; Michael.Bershad@tempe.gov; Milton.Sommerfeld@asu.edu; matt.palenica@phoenix.gov; MURPHYSP@wattsind.com; nancy.milan@ci.chandler.az.us; nicholas.silides@cityofmesa.org; nicoleta.buliga@phoenix.gov; ANUNEZ@SCOTTSDALEAZ.GOV; paul.burchfield@phoenix.gov; paulwestcott@appliedbiochemists.com; pdent@cap-az.com; pfenner@fs.fed.us; Randy.Gottler@phoenix.gov; raymond.schultz@phoenix.gov; robert.hollander@phoenix.gov; robert.goff@ci.chandler.az.us; robert_ek@ci.mesa.az.us; ron.jennings@phoenix.gov; rsqoch@srpnet.com; rscott@glendaleaz.com; rcarpenter@glendaleaz.com; sgrendahl@SCOTTSDALEAZ.GOV; shan.miller@phoenix.gov; sherman.mccutcheon@tempe.gov; SRot@ci.glendale.az.us; scottas@cap-az.com; sacqualfreda@dswa.net; steven.schoen@phoenix.gov; susan.potter@phoenix.gov; tara.ford@tempe.gov; terrance.piekarz@phoenix.gov; tjillogly@carollo.com; THockett@GLENDALEAZ.com; thomas.martin@phoenix.gov; thomasdempster@hotmail.com; tjeffer1@ci.tucson.az.us; tkacerek@cap-az.com; tom.doyle@phoenix.gov; Tom.Hartman@tempe.gov; troy.hayes@phoenix.gov; Victoria.Sharp@ci.chandler.az.us; vlee@carollo.com; waerma@bv.com; wahid.alsmadi@phoenix.gov; warrens@sgm-inc.com; [wendy.chambers@ci.chandler.az.us](mailto>wendy.chambers@ci.chandler.az.us); wes.cannon@ci.chandler.az.us; wes.taylor@phoenix.gov; wtaylor@mw2h2o.com; William.Hughes@cityofmesa.org; swilson@scottsdaleaz.gov; Younqil.Kim@asu.edu; yu.chu.hsu@phoenix.gov; LindaW@PeoriaAZ.com; Yongsheng.Chen@asu.edu; keli@asu.edu; [jcirtt@asu.edu](mailto:jcritt@asu.edu); uiyer@glendaleaz.com; Michael.Helton@amwater.com; Kim.Caggiano@cityofmesa.org; Keith.Greenberg@amwater.com; harry.brown@AMwater.com; mnguyen@ndep.nv.gov; bzachman@dswa.net; hdubin@dswa.net; Tony.Mardam@ch2m.com; paul.zelenka@phoenix.gov; agrochowski@cap-az.com; bradley.fuller@tempe.gov; JBryck@PIRNE.COM; Susanne.Neuer@asu.edu; Mohan.Seetharam@asu.edu; Chao-An.Chiu@asu.edu; susan.michael@peoriaaz.gov; tammy.perkins@phoenix.gov; Michael.Kennedy@cityofmesa.org; ZChowdhury@PIRNE.COM; Shari.Lange@phoenix.gov; nmegonnell@calgoncarbon-us.com; Cynthia.Bain@peoriaaz.gov; Ryan.Rhoades@CH2M.com; jim.kudlinski@srpnet.com; Gambatese.Jason@epamail.epa.gov; charlotte.jones@phoenix.gov

If you wish to receive the *Newsletter* and are not on our list, send your email address to Dr. Paul Westerhoff (p.westerhoff@asu.edu) get a free “subscription”.

SUMMARY: EVALUATION AND RECOMMENDATIONS

1. WELCOME BACK PEORIA!! The City of Peoria has rejoined our Regional Water Quality group after taking 1 year off.
2. **MIB & Geosmin concentrations now above 10 ng/L at several locations** in the water supply system. We will continue our monthly sampling, but also augment it with selected sampling every 2 weeks at potential “hot spots”.
3. Dissolved organic carbon concentrations and temperatures in the raw and treated waters mean that cities will be challenged with maintaining low trihalomethane (THM) levels for the next few months.
4. An update on pharmaceutical monitoring is included
5. A project of using reverse osmosis to control THMs as a decentralized treatment option was contributed.

Table 1 Summary of WTP Operations

	Verde WTP	Union Hills	24 th Street WTP	N.Tempe J.G. Martinez	Deer Valley	Glendale Cholla WTP ³	Peoria Greenway WTP	Val Vista	South Tempe	Chandler WTP
	Verde River	CAP Canal	Arizona Canal					South Canal		
PAC Type and Dose			Calgon WPH 14 ppm		15 ppm Calgon	None	None	15 ppm Calgon	34 mg/L	
Copper Sulfate			0.24 ppm		None	None	None	0.25 ppm	None	
PreOxidation			none		None	2.5 ppm	3.5 ppm	None	None	
Alum Dose Alkalinity pH			66 131/101 6.7		59 137/95 6.8	35 132 6.8	25 141 7.2	60 138 6.9-7.1	30 124 7.4	
Finished water DOC DOC removal ²		2.6 mg/L 17%	2.67 mg/L 44 %	3.7 mg/L 21%	2.3 mg/L 51 %	3.1 mg/L 34% ³	3.6 mg/L 24%	2.8 mg/L 40%	3.6 mg/L 21%	
Average turbidity over last 7 days			8-15 NTU		15-20 NTU	9 NTU	9-12 NTU	11 NTU	5	
Recommendations										

¹ Ferric chloride instead of alum; plus 2.25 ppm polymer (308)

² Calculated based upon influent and filtered water DOC (note that DOC – not TOC – is used in this calculation)

³ Sample from finished water includes a blend of surface and ground water sources

SRP/CAP OPERATIONS - Values in cfs, for July 7, 2008

System	SRP Diversions	CAP
Arizona Canal	833	79
South Canal	658	0
Pumping	91	0
Total	1582	79

- **SRP is releasing water from both Verde and Salt River Systems.** Salt River release from Saguaro Lake: 1097cfs; Verde River release from Bartlett Lake: 400 cfs.
- **Lake Roosevelt is 95% full** and the Verde River system is 66% full. Flow over Granite Reef dam into the Salt River Channel = 0 cfs.

Table 2 - Water Treatment Plants – July 7, 2008

Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)	
24 th Street WTP Inlet	4.9	3.2	8.9	
24 th Street WTP Treated	10.9	<2.0	43.8	****
Deer Valley Inlet	6.7	3.6	8.4	
Deer Valley WTP Treated	<2.0	<2.0	<2.0	
Val Vista Inlet	13.7	<2.0	87.5	
Val Vista WTP Treated –East	4.1	<2.0	<2.0	
Val Vista WTP Treated -West	<2.0	<2.0	<2.0	
Union Hills Inlet	<2.0	7.1	53.6	
Union Hills Treated	4.8	7.0	<2.0	
Tempe North Inlet	4.3	<2.0	7.0	
Tempe North Plant Treated	4.6	<2.0	6.5	
Tempe South WTP	3.9	<2.0	<2.0	
Tempe South Plant Treated	4.1	<2.0	<2.0	
Tempe South Plant Treated (Lab)				
Greenway WTP Inlet	14.6	<2.0	47.9	
Greenway WTP Treated	10.0	<2.0	6.4	
Glendale WTP Inlet	6.3	3.4	6.2	
Glendale WTP Treated	<2.0	<2.0	<2.0	

MIB & Geosmin are taste and odor compounds, detectable by the human nose in drinking water at 10 to 15 ng/L for the sum of MIB + Geosmin concentrations.

*** It is unusual to see effluent levels so much higher than influent levels. The sample was re-run, but the original sample value seems valid.

Table 3 - Canal Sampling – July 7, 2008

System	Sample Description	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
CAP	Waddell Canal			
	Union Hills Inlet	<2.0	7.1	53.6
	CAP Canal at Cross-connect	4.2	4.3	3.8
AZ Canal	Salt River @ Blue Pt Bridge	6.6	3.1	12.0
	Verde River @ Beeline	4.8	2.5	5.9
	AZ Canal above CAP Cross-connect	6.3	3.9	<2.0
	AZ Canal below CAP Cross-connect	5.2	<2.0	9.3
	AZ Canal at Highway 87	6.7	3.7	9.6
	AZ Canal at Pima Rd.	6.2	2.4	6.8
	AZ Canal at 56th St.	5.8	2.4	5.8
	AZ Canal - Inlet to 24 th Street WTP	4.2	3.2	8.9
	AZ Canal - Central Avenue	7.8	4.0	10.9
	AZ Canal - Inlet to Deer Valley WTP	6.7	3.6	8.4
	AZ Canal - Inlet to Glendale WTP	6.3	3.4	6.2
South and Tempe Canals	South Canal below CAP Cross-connect	6.3	<2.0	11.3
	South Canal at Val Vista WTP	13.7	<2.0	87.5
	Head of the Tempe Canal	6.0	<2.0	8.5
	Tempe Canal - Inlet to Tempe's South Plant	3.9	<2.0	<2.0

There is no apparent production of T&O compounds in the Arizona Canal. There appears to be a significant increase in MIB and Cyclocitral in the upper parts of the South Canal, which is quite unusual and we have not seen this previously.

Table 4 - Reservoir Samples –July 9, 2008

Sample Description	Location	MIB (ng/L)	Geosmin (ng/L)	Cyclocitral (ng/L)
Lake Pleasant (June08)	Eplimnion	<2.0	<2.0	<2.0
Lake Pleasant (June08)	Hypolimnio	10.7	<2.0	<2.0
Lake Pleasant (July08)	Eplimnion	<2.0	<2.0	<2.0
Lake Pleasant (July08)	Hypolimnio	8.3	<2.0	2.5
Verde River @ Beeline		4.8	2.5	5.9
Bartlett Reservoir	Epilimnion	8.3	<2.0	<2.0
Bartlett Reservoir	Epi-near dock	10.7	<2.0	<2.0
Bartlett Reservoir	Hypolimnio	2.6	<2.0	<2.0
Salt River @ BluePt Bridge		6.6	3.1	12.0
Saguaro Lake	Epilimnion	<2.0	3.9	17.9
Saguaro Lake	Epi - Duplicate	<2.0	3.9	22.3
Saguaro Lake	Epi-near doc	<2.0	3.6	26.6
Saguaro Lake	Hypolimnio	<2.0	3.0	10.5
Verde River at Tangle Creek (25June08)		4.8	<2.0	7.3
Havasu (June08)		2.3	2.5	<2.0
Havasu (July08)		5.2	20.7	<2.0

It is quite unusual to see higher MIB levels in the hypolimnion than in the epilimnion of Lake Pleasant, but this trend existed now over 2 months. It does not appear to be affecting MIB levels in water released from Lake Pleasant into the CAP canal though.

In June 2008 CAP started releasing Lake Pleasant Water into the CAP canal. This may have affected the stratification in the lake. We are tracking down the stratification data to better understand this potential.

Table 5 - Water Treatment Plants – July 07, 2008

Sample Description	DOC (mg/L)	UV254 (1/cm)	SUVA (L/mg-m)	TDN	DOC removal (%)
24 th Street WTP Inlet	4.73	0.11	2.4	0.491	44
24 th Street WTP Treated	2.67	0.04	1.6	0.361	
Deer Valley Inlet	4.65	0.11	2.4	0.475	51
Deer Valley WTP Treated	2.30	0.03	1.4	0.342	
Val Vista Inlet	4.84	0.12	2.45	0.459	37
Val Vista WTP Treated –East	3.07	0.05	1.67	0.399	
Val Vista WTP Treated -West	2.66	0.04	1.55	0.375	45
Union Hills Inlet	3.11	0.05	1.67	0.631	17
Union Hills Treated	2.60	0.03	1.04	0.564	
Tempe North Inlet	4.72	0.11	2.41	0.430	21
Tempe North Plant Treated	3.72	0.07	1.86	0.391	
Tempe South WTP	4.83	0.12	2.44	0.433	26
Tempe South Plant Treated	3.56	0.06	1.78	0.372	
Peoria WTP Inlet	4.68	0.11	2.46	0.443	24
PeoriaWTP Treated	3.57	0.03	0.93	0.460	
Glendale WTP Inlet	4.62	0.11	2.5	0.440	34
Glendale WTP Treated	3.05	0.05	1.6	0.878	

DOC = Dissolved organic carbon

UV254 = ultraviolet absorbance at 254 nm (an indicator of aromatic carbon content)

SUVA = UV254/DOC

TDN = Total dissolved nitrogen (mgN/L)

A run of WTP.exe which simulates TOC removal and THM formation suggests TTHM levels of 53, 64 and 85 ug/L leaving the plant, after 1 day and after 5 days of contact time in the distribution system. The running average for TTHM at any given location should be < 80 ug/L.

Table 6 - Canal Sampling – July 7, 2008

System	Sample Description	DOC (mg/L)	UV254 (1/cm)	SUVA (L/mg-m)	TDN
CAP	Waddell Canal				
	Union Hills Inlet	3.11	0.052	1.67	0.631
	CAP Canal at Cross-connect	3.12	0.051	1.65	0.621
AZ Canal	Salt River @ Blue Pt Bridge	5.04	0.119	2.36	0.584
	Verde River @ Beeline	4.03	0.120	2.96	0.298
	AZ Canal above CAP Cross-connect	4.79	0.119	2.48	0.435
	AZ Canal below CAP Cross-connect	4.64	0.108	2.33	0.468
	AZ Canal at Highway 87	4.61	0.112	2.43	0.447
	AZ Canal at Pima Rd.	4.77	0.114	2.38	0.405
	AZ Canal at 56th St.	4.87	0.115	2.35	0.457
	AZ Canal - Inlet to 24 th Street WTP	4.73	0.114	2.41	0.491
	AZ Canal - Central Avenue	4.68	0.113	2.41	0.464
	AZ Canal - Inlet to Deer Valley WTP	4.65	0.114	2.45	0.475
	AZ Canal - Inlet to Glendale WTP	4.62	0.114	2.46	0.440
South and Tempe Canals	South Canal below CAP Cross-connect	4.80	0.119	2.48	0.447
	South Canal at Val Vista WTP	4.84	0.119	2.45	0.459
	Head of the Tempe Canal	4.77	0.119	2.50	0.472
	Tempe Canal - Inlet to Tempe's South Plant	4.83	0.118	2.44	0.433
	Chandler WTP – Inlet	4.68	0.115	2.46	0.443

Table 7 - Reservoir Samples – July 07, 2008

Sample Description	Location	DOC (mg/L)	UV254 (1/cm)	SUVA (L/mg-m)	TDN
Lake Pleasant	Eplimnion	3.31	0.057	1.72	0.73
Lake Pleasant	Hypolimnio	3.83	0.053	1.37	0.28
Verde River @ Beeline		4.03	0.120	2.96	0.30
Bartlett Reservoir	Epilimnion	4.62	0.112	2.43	0.31
Bartlett Reservoir	Epi-near dock				
Bartlett Reservoir	Hypolimnio	4.54	0.128	2.83	0.36
Salt River @ BluePt Bridge		5.04	0.119	2.36	0.58
Saguaro Lake	Epilimnion	5.64	0.116	2.06	0.40
Saguaro Lake	Epi - Duplicate	5.83	0.118	2.03	0.44
Saguaro Lake	Epi-near doc				
Saguaro Lake	Hypolimnio	5.66	0.121	2.13	0.80
Verde River at Tangle					
Havasu		2.80	0.043	1.54	0.63

Pharmaceutical Data

Our group is working with ADHS to collect and analyze Endocrine disruptor and pharmaceutical occurrence in the water supply system. Our focus is on the Verde River, but we include a local wastewater treatment plant for reference. We have collected samples monthly in 2008. Over 20 different EDC/PPCPs are monitored. In our last months of data we have synthesized we can draw the following conclusions (data cited are for May 2008):

- Prior to significant recreational activities in Oak Creek which feeds into the Verde River, or below a wastewater treatment plant near Camp Verde, that most EDC/PPCP compounds occur at below 5 ng/L. The only exception is oxybenzone (sunscreen) and DEET (insect repellent) which occur at the 3 to 15 ng/L range; these do however periodically occur in our field blanks at 1 to 5 ng/L.
- We monitor one local WTP. Oxybenzone is present in the raw water and after sedimentation at 9.0 and 8.6 ng/L, respectively. After chlorination the concentration reduces to 0.9 ng/L. This clearly shows the “multiple barrier” approaches of water treatment plants that include physical and chemical processes are useful in destroying some EDC/PPCPs.
- In monitoring effluent from a local wastewater treatment plant whose effluent is reused, indicates significantly different EDC/PPCP levels than within the Verde River. Nearly all the EDC/PPCPs are present, at concentrations of 1 to > 300 ng/L. We do sample through the facility to assess the ability of compounds to be removed. Some are very well removed. Those that occur at higher concentration and exhibit minimal removal include: carbamazepine, meprobamate, and primidone which occur in the effluent at 269, 325, and 59 ng/L. Because these are present they are excellent *indicators* of wastewater influence in waters.
- Concentrations of carbamazepine, meprobamate, and primidone in the Verde River system (including SRP canals) for May 2008 is less than 1 ng/L. This indicates that the surface waters that provide use with drinking water supplies contain negligible influence from major sources of EDC/PPCPs.
- Our project has been extended for another year and we hope to continue to monitor seasonal changes, especially as the reservoirs and low Salt River become active recreation areas.

Reverse osmosis is being used in the valley for decentralized treatment of THMs

Here is a note in response to last months email about possible use of AOPs for decentralized THM treatment (such notes are welcome and help build the knowledge within our water community):

I wanted to comment on the decentralized treatment of DBP's. I have been working with ADEQ and small utilities here in AZ (and across the country) for compliance of arsenic using point of use reverse osmosis units. This has been widely accepted here in Arizona and Watts has numerous small utilities currently successfully in compliance with arsenic, fluoride and nitrate regulations through these point of use RO systems.

Just recently in conjunction with the City of Peoria these same RO units are being used for compliance with DBP's at a small community. The issue at hand is the community built a large treatment plant, however since the development is not complete there is a significant stagnation time in the pipeline, which is increasing the DBP's. It is anticipated that in the years to come as the development is completed and water demand is increased this problem will correct itself.

I wanted to mention this to you since you made the comment on decentralized, and I wanted to let you know that where it is not an AOP - the use of a specialized decentralized reverse osmosis unit can function as a means for successful DBP removal.

Feel free to contact me if you have any questions. I would be interested to discuss with you future projects in this area.

Sincerely,

Shannon Murphy

Vice President Municipal Programs
Watts Premier
Ph 623-505-1514
Fx 623-505-1519
e-mail: murphysp@watts.com
Web: www.wattspremier.com/SDWA

While we have gotten some nice monsoon rains recently – here is a drought forecast (this is for June, but the links bring you to interesting web-links)

The June Southwest Climate Outlook is online. This month's outlook provides [recent drought conditions](#) and the [latest seasonal forecasts](#). The feature article is entitled "The wet winter and the basins' bathtubs."

You can both view the latest Southwest Climate Outlook in html format or view the printer-friendly PDF file at: <http://www.climas.arizona.edu/forecasts/swoutlook.html>

Highlights from the June 2008 Outlook

Drought – March and April were extremely dry across Arizona, causing short-term drought status to be downgraded one category for most of the state's watersheds.

Temperature – In the past month, temperatures in western Arizona and northwestern New Mexico have been slightly colder than average, while temperatures in southeastern Arizona and southwestern and north central New Mexico have been slightly above average.

Precipitation – In the past thirty days, precipitation has been localized and isolated in both states, typical of convective thunderstorms. Many regions in Arizona have received greater than 200 percent of the average precipitation; some isolated storms have caused precipitation to be greater than 800 percent of the average values.

ENSO – A transition from La Niña to ENSO-neutral conditions is underway. Sea surface temperatures (SSTs) in the central and east-central equatorial Pacific Ocean have warmed since mid-February. The atmospheric manifestation of La Niña is also weakening. Most forecast models indicate ENSO-neutral SSTs during the coming June–August season.

Climate Forecasts – Temperature forecasts for the Southwest predict increased chances of above-average temperatures for most of the region through December. The precipitation outlook for Arizona and New Mexico calls for equal chances of above-, near-, and below-average precipitation through December.

The Bottom Line – Temperatures continued to be above average for much of the Southwest, and this trend is expected to continue. Precipitation was variable. The amount of monsoon rain, though difficult to predict, may provide drought relief in some areas.

Kristen E. Nelson

Associate Editor
Institute for the Study of Planet Earth
715 N. Park Ave., 2nd Floor
Tucson, AZ 85721
(520) 622-9001

To be automatically removed from the CLIMAS-NEWS listserv, send an email to listserv@listserv.arizona.edu with *signoff climas-news* in the body of the email message. Do not include any other text in the body of the message or subject line.