NWS FORM E-5 (11-88) (PRES. by NWS Instruction 10-924)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NATIONAL WEATHER SERVICE	HYDROLOGIC SERVICE AREA (HSA) **Tulsa, Oklahoma (TSA)**
MONTHLY REPORT OF RIVER AND FLOOD CONDITIONS		REPORT FOR: MONTH **September** YEAR **2019**
TO: Hydrometeorological Information Center, W/OH2 NOAA / National Weather Service 1325 East West Highway, Room 7230 Silver Spring, MD 20910-3283		SIGNATURE **Steven F. Piltz** (Meteorologist-in-Charge) DATE **October 8, 2019**

When no flooding occurs, include miscellaneous river conditions, such as significant rises, record low stages, ice conditions, snow cover, droughts, and hydrologic products issued (NWS Instruction 10-924)

☐ **An "X" in the box indicates no flood stages were reached in this Hydrologic Service Area (HSA) during the month above.**

Most of eastern OK and northwest AR received below normal rainfall this month, though some places did experience flash flooding late in the month. September 2019 was a very warm month, with most locations 7-8 degrees above normal. Fayetteville, AR recorded its warmest September, while Fort Smith, AR and Tulsa, OK ranked as 2nd warmest this year. Water Year 2019 was above normal for the entire area, with Fort Smith, AR having its 2nd wettest Water Year on record. Normal rainfall for September ranges from 4.2 inches in Okmulgee County to 5.4 inches in Delaware County. In the Ozark region of northwest Arkansas, rainfall averages 4.5 inches for the month. This report, past E-5 reports, and monthly hydrology and climatology summaries can be found at http://www.weather.gov/tsa/hydro-monthly-summary.

Monthly Summary

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 1a), rainfall totals for September 2019 ranged from 1.50" to around 10" across eastern OK and northwest AR. These rainfall totals correspond to 25%-90% of the normal September rainfall for a large portion of eastern OK and northwest Arkansas (Fig. 1b). However, some areas did receive 125%-250% of the normal September rainfall.

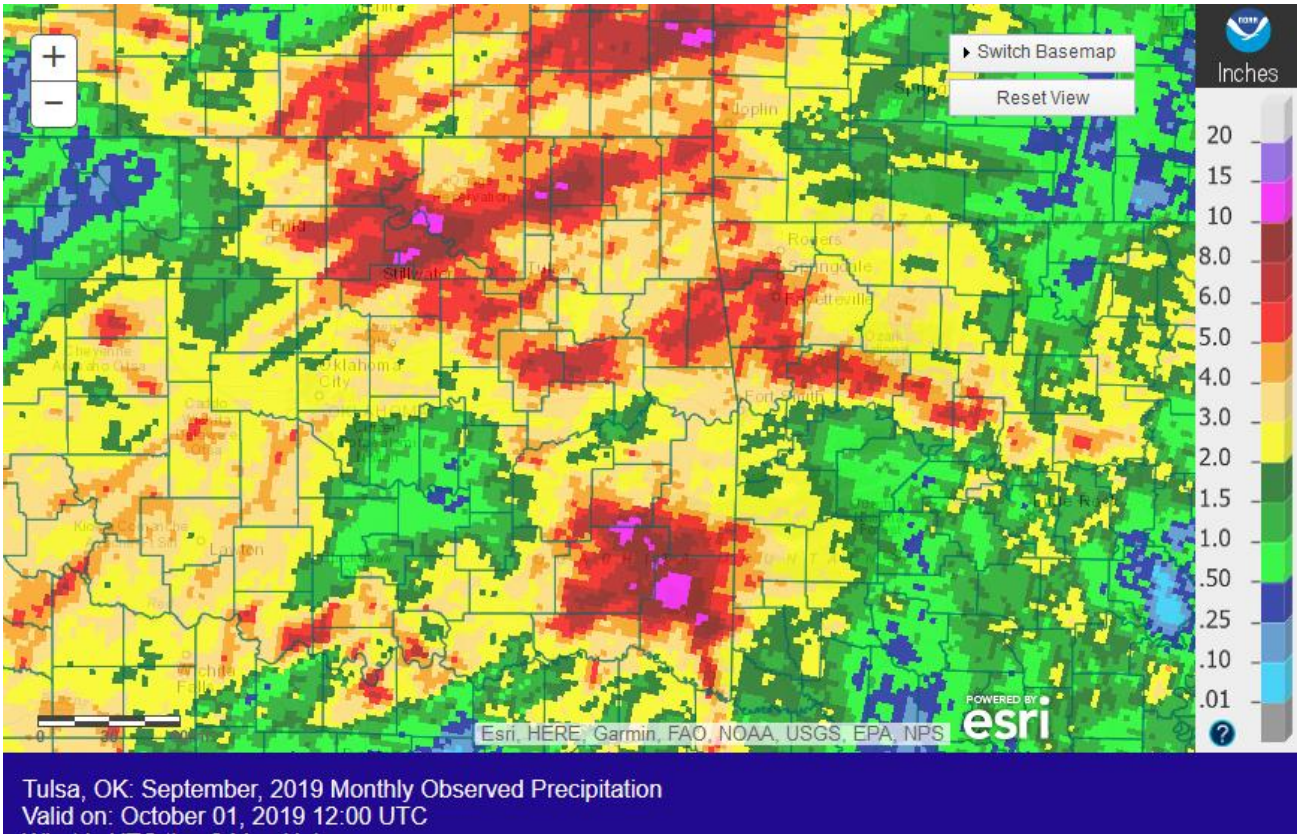


Fig. 1a. Estimated Observed Rainfall for September 2019

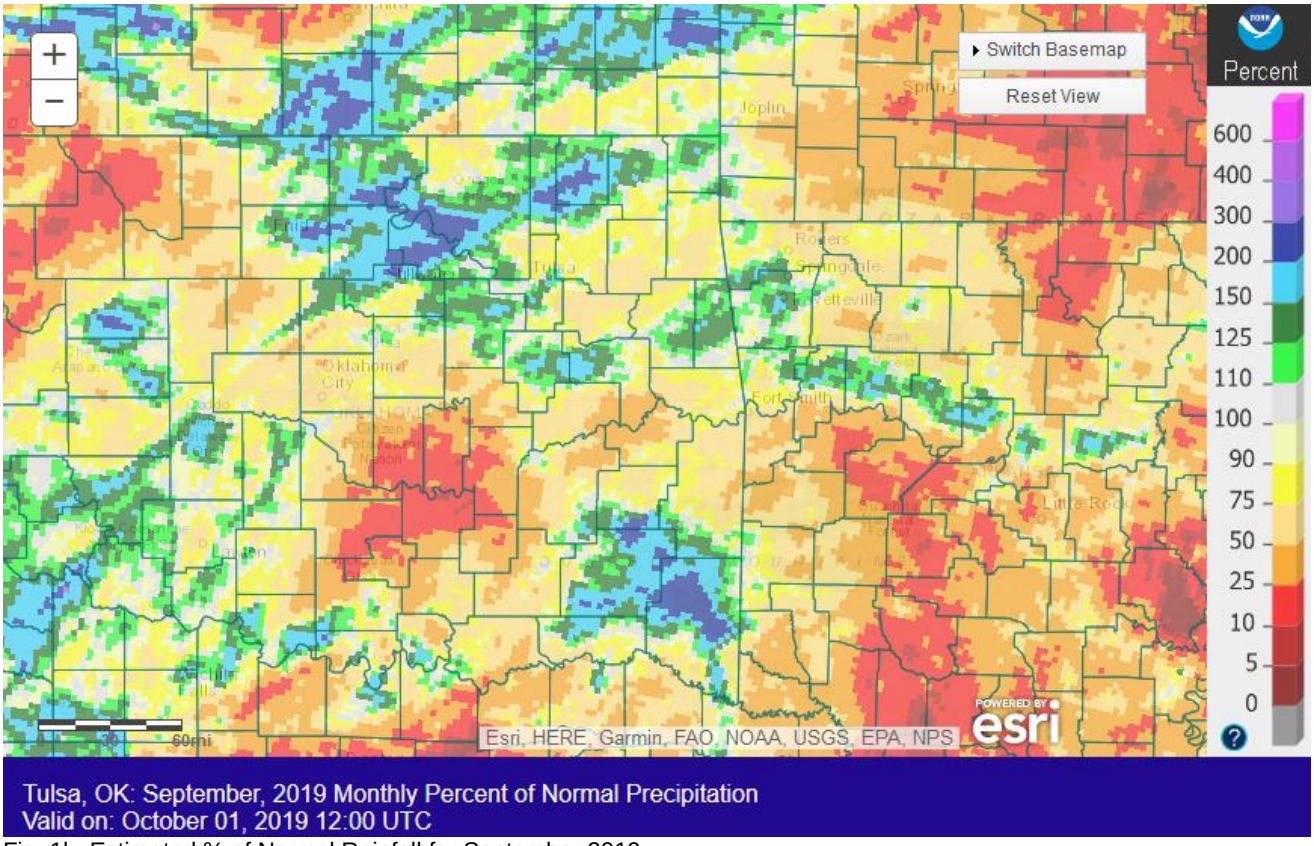


Fig. 1b. Estimated % of Normal Rainfall for September 2019

In Tulsa, OK, September 2019 ranked as the 2nd warmest September (81.2°F, record is 81.9°F in 1931; since records began in 1905) and the 49th wettest September (3.93"; since records began in 1888). Fort Smith, AR had the 2nd warmest September (81.7°F, record is 83.4°F in 1939; since records began in 1882) and the 61st driest September (2.74"; since records began in 1882). Fayetteville, AR had the Record warmest (76.3°F, previous record 76.2°F in 1998) and the 7th wettest (7.58") September since records began in 1949.

Some of the larger precipitation reports (in inches) for September 2019 included:

Ralston, OK (coop)	12.25	Clayton, OK (meso)	10.01	Talala, OK (meso)	9.56
Nowata, OK (meso)	8.94	Antlers, OK (coop)	8.31	West Fork 0.1SSW, AR (coco)	8.12
Pawnee, OK (meso)	7.82	Wynona, OK (meso)	7.80	Mountainburg 2NE, AR (coop)	7.66

Some of the lowest precipitation reports (in inches) for September 2019 included:

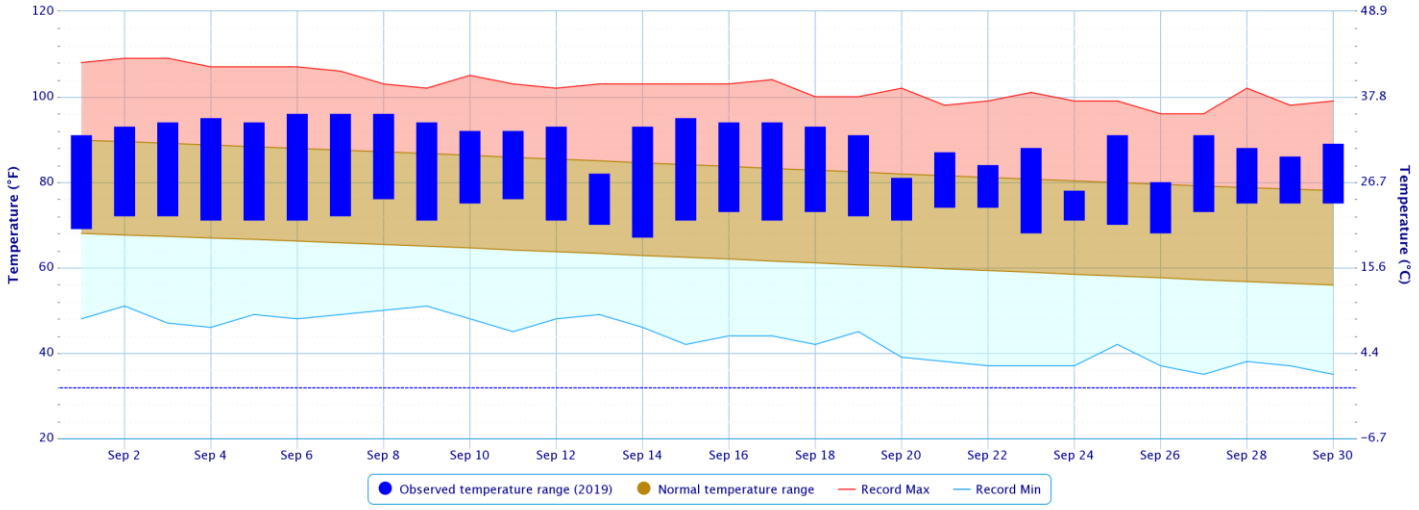
Stigler, OK (meso)	1.57	Okemah, OK (meso)	2.08	Muskogee, OK (ASOS)	2.25
Fort Smith, AR (ASOS)	2.26	McAlester, OK (ASOS)	2.37	Wister, OK (meso)	2.45
Kingston 2S, AR (coop)	2.70	Foraker, OK (meso)	2.91	Eufaula, OK (meso)	3.15

According to statistics from the Oklahoma Climatological Survey (OCS) Mesonet:

Rank since 1921	September 2019	Last 60 Days (Aug 2 – Sep 30)	Last 90 Days (Ju1 1 – Sep 30)	Last 120 Days (Jun 3 – Sep 30)	Last 180 Days (Apr 4 – Sep 30)	Year-to-Date (Jan 1 – Sep 30)	Water Year 2019 (Oct 1, 2018 – Sep 30, 2019)
Northeast OK	28th wettest	**5th wettest**	**5th wettest**	**5th wettest**	**1st wettest**	**2nd wettest**	**2nd wettest**
East Central OK	43rd driest	11th wettest	23rd wettest	13th wettest	**9th wettest**	**7th wettest**	**8th wettest**
Southeast OK	21st wettest	18th wettest	36th wettest	19th wettest	**10th wettest**	14th wettest	**8th wettest**
Statewide	43rd wettest	**10th wettest**	30th wettest	25th wettest	**4th wettest**	**6th wettest**	**3rd wettest**

Daily Temperature Data - Tulsa Area, OK (ThreadEx)

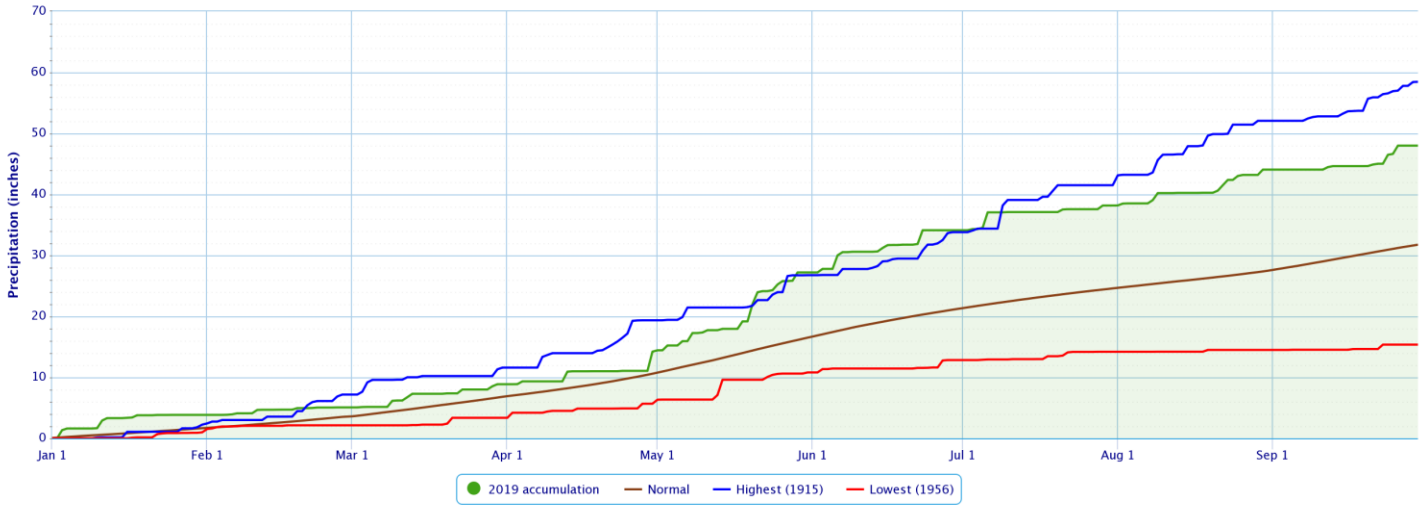
Period of Record - 1905-01-06 to 2019-09-30. Normals period: 1981-2010. Click and drag to zoom chart.



Powered by ACIS

Accumulated Precipitation - Tulsa Area, OK (ThreadEx)

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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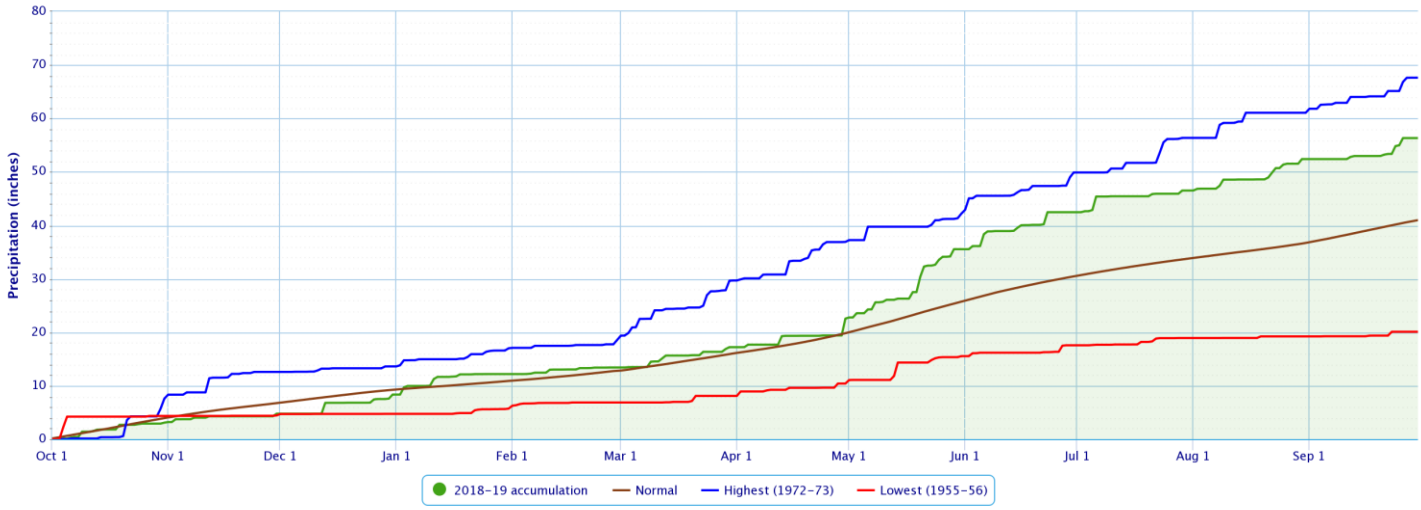
Accumulated Precipitation - Tulsa Area, OK (ThreadEx)

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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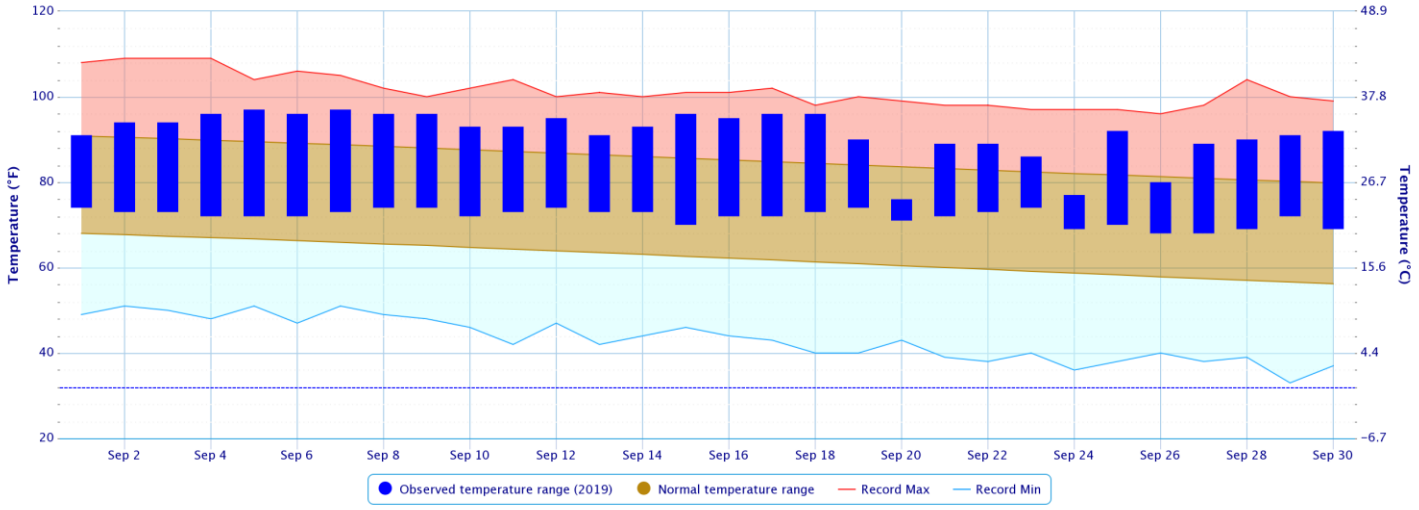
Daily Temperature Data - Fort Smith Area, AR (ThreadEx)

Period of Record - 1882-06-01 to 2019-09-30. Normals period: 1981-2010. Click and drag to zoom chart.



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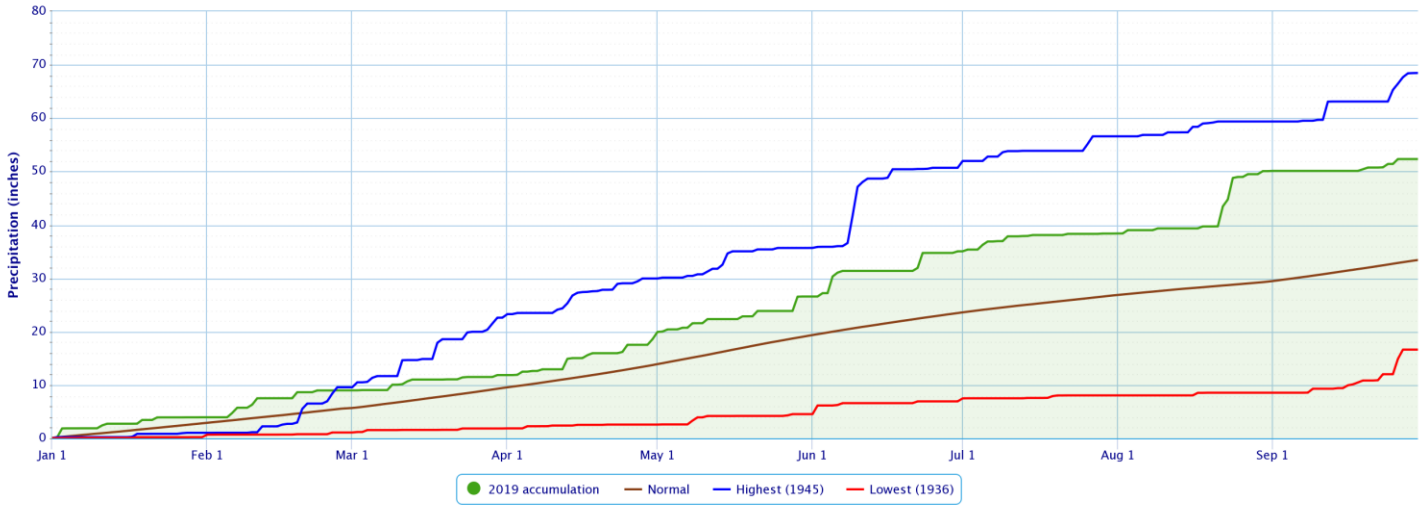
Accumulated Precipitation - Fort Smith Area, AR (ThreadEx)

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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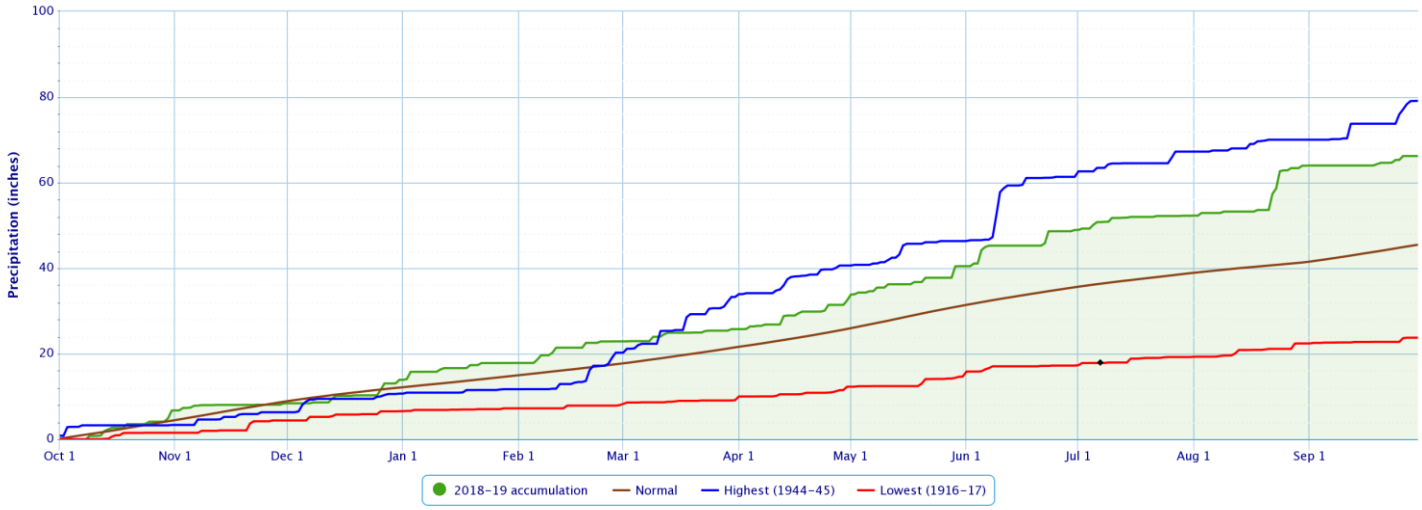
Accumulated Precipitation - Fort Smith Area, AR (ThreadEx)

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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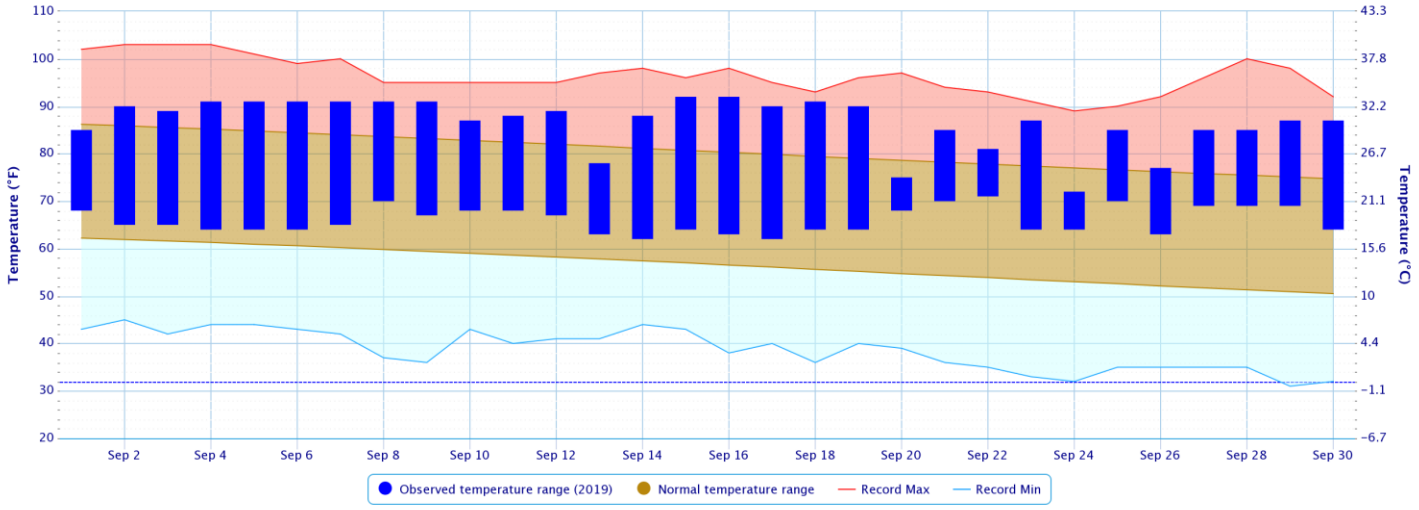
Daily Temperature Data - FAYETTEVILLE DRAKE FIELD, AR

Period of Record - 1949-07-14 to 2019-09-30. Normals period: 1981-2010. Click and drag to zoom chart.



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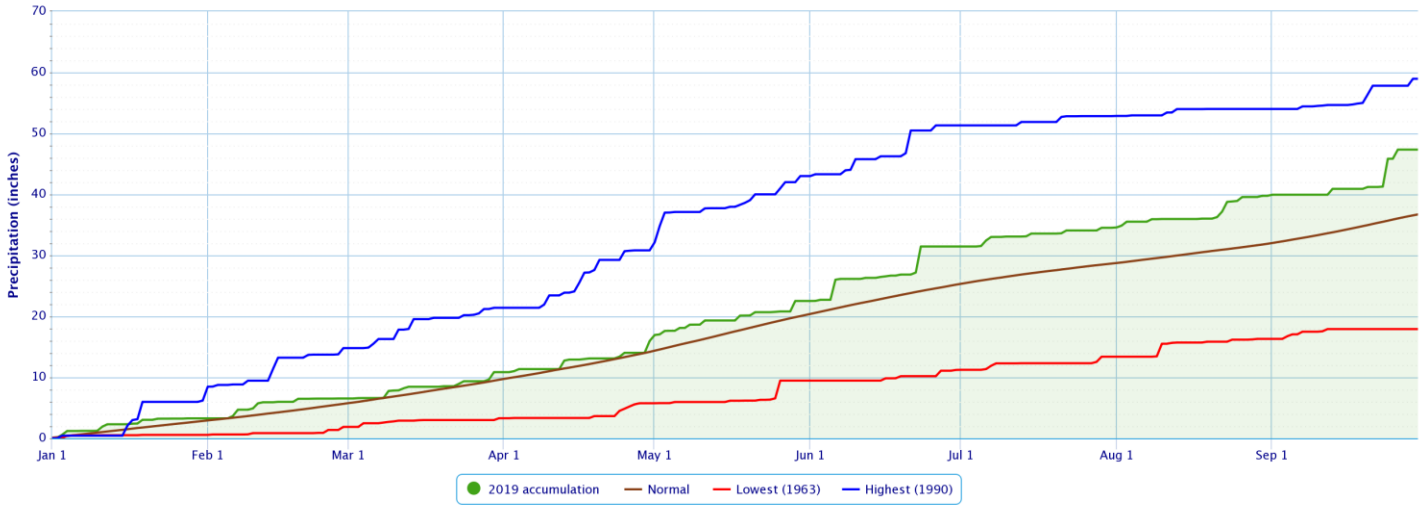
Accumulated Precipitation - FAYETTEVILLE DRAKE FIELD, AR

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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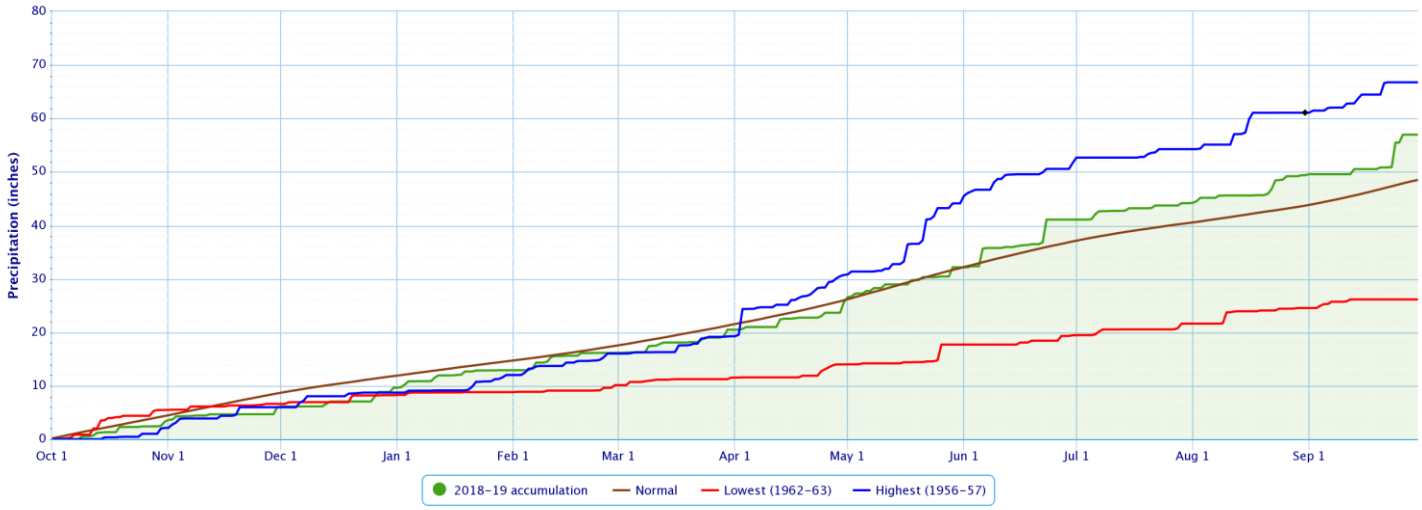
Accumulated Precipitation - FAYETTEVILLE DRAKE FIELD, AR

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



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Water Year 2019 Summary (October 1, 2018-September 30, 2019)

Using the radar-derived estimated observed precipitation from the RFCs (Fig. 2a), rainfall totals for Water Year 2019 ranged from 40” to 80” across eastern OK and northwest AR. These rainfall totals correspond to 125% to near 200% of the normal Water Year rainfall for much of northeast OK, and 100% to around 150% for the remainder of eastern OK and northwest Arkansas (Fig. 1b).

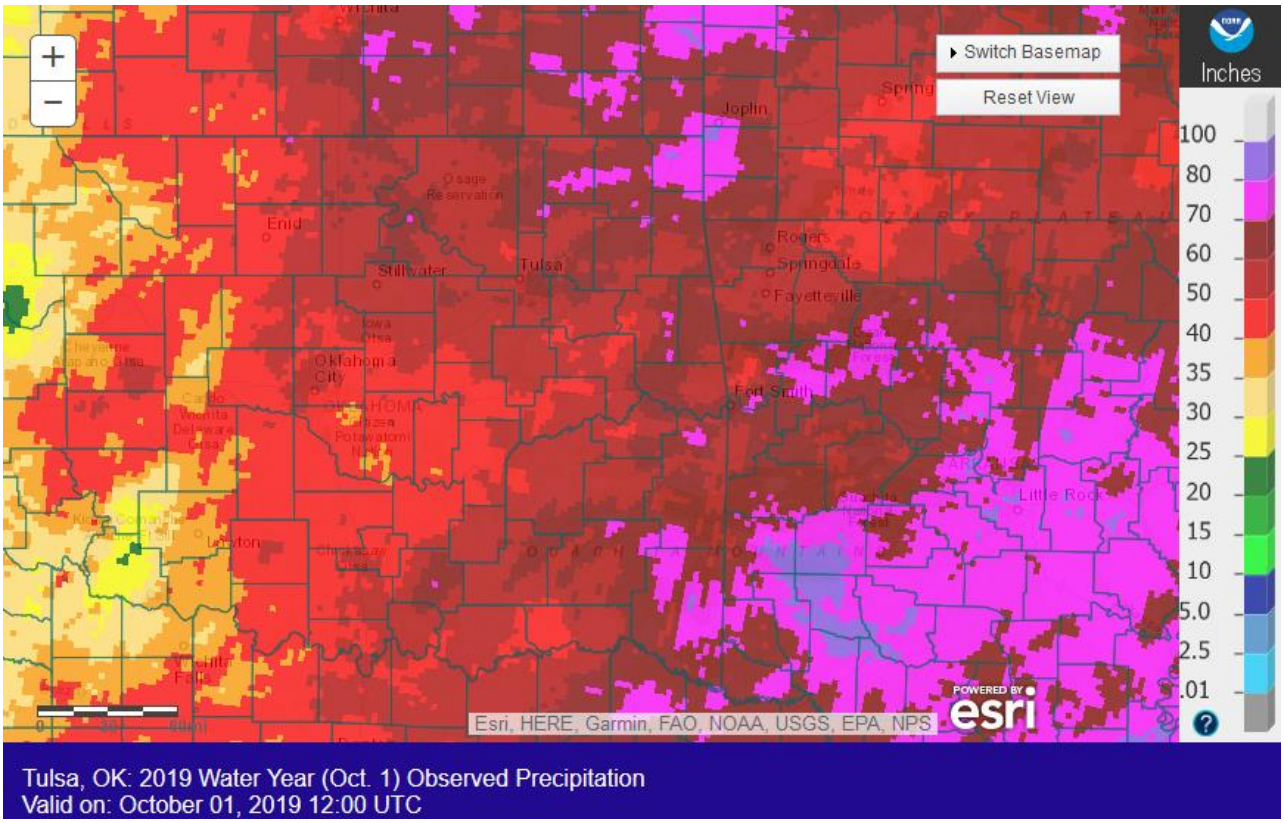


Fig. 2a. Estimated Observed Rainfall for Water Year 2019

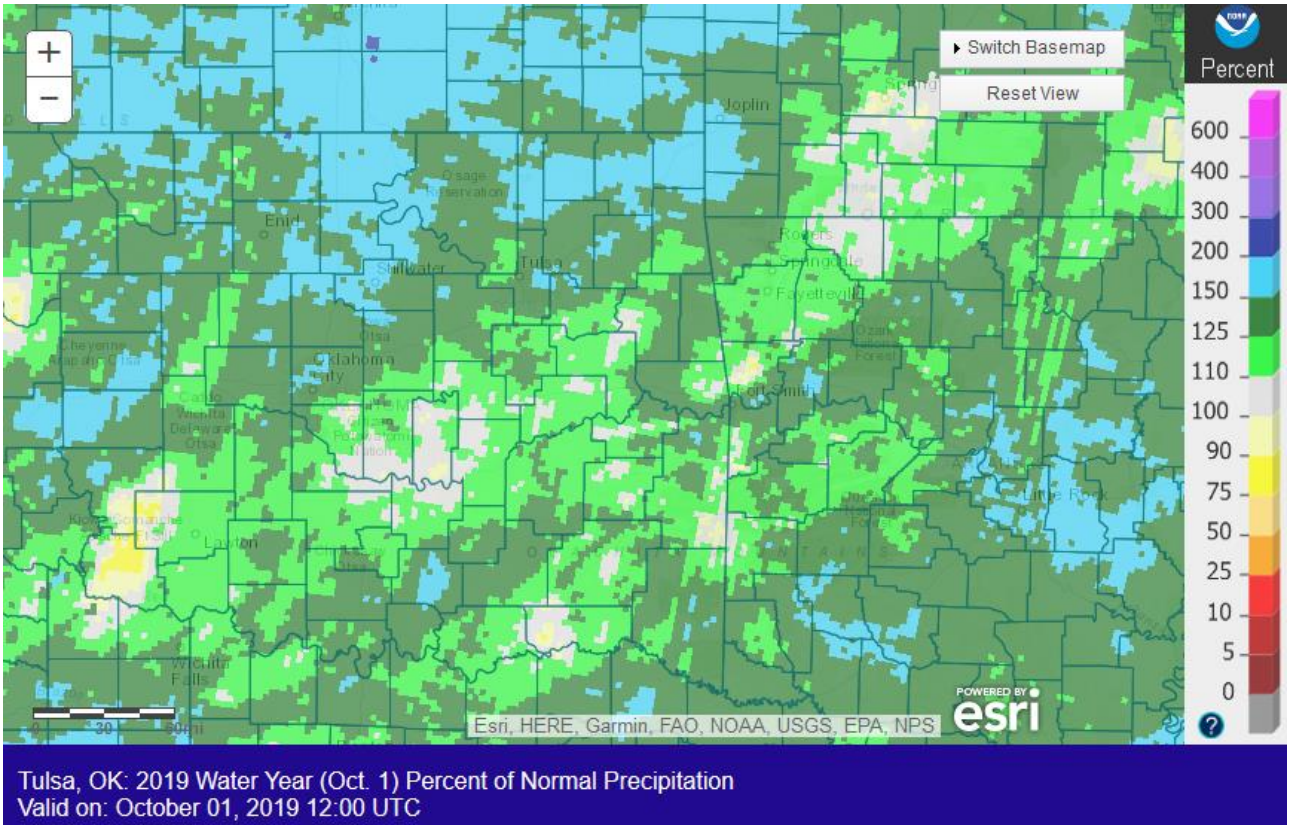
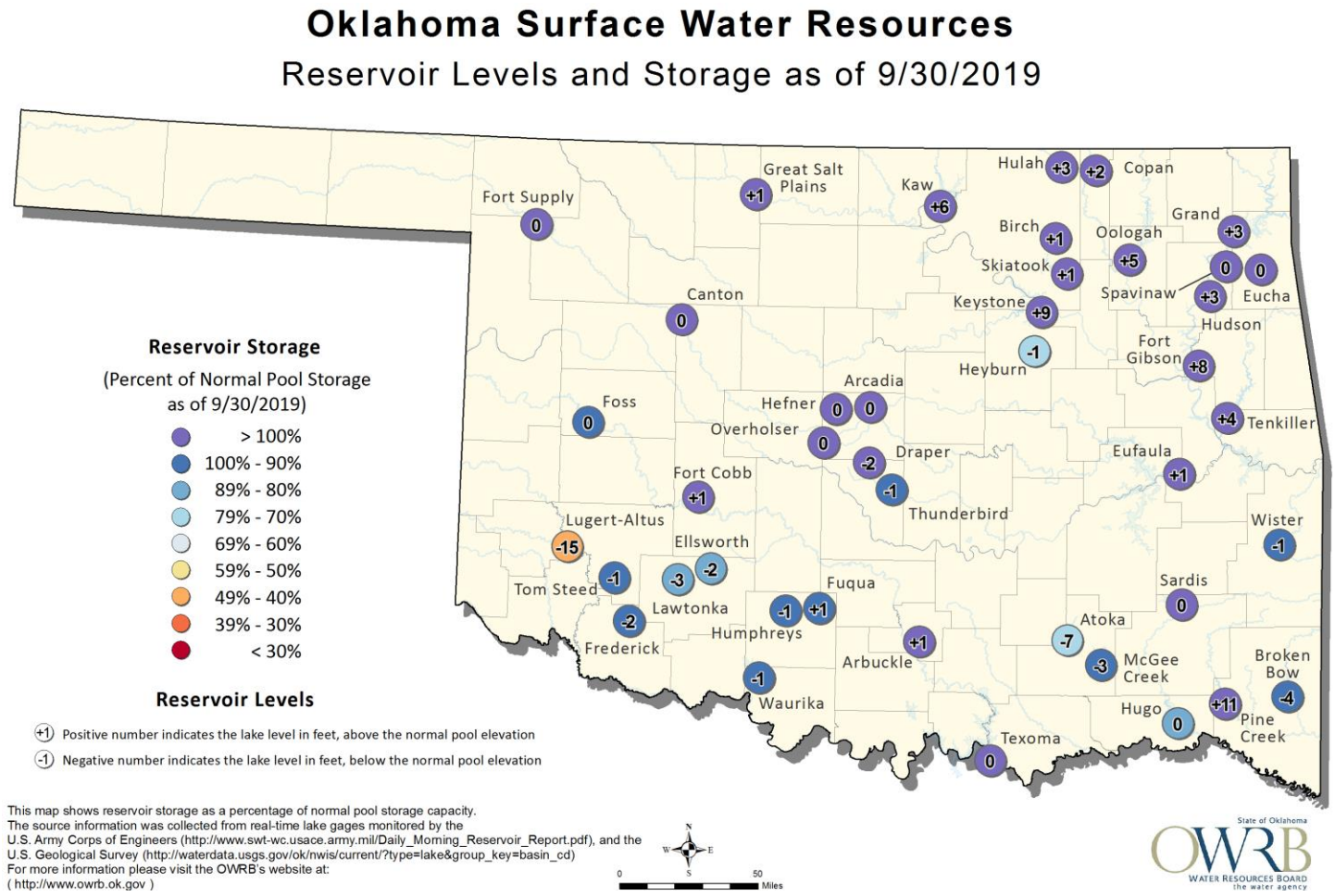


Fig. 2b. Estimated % of Normal Rainfall for Water Year 2019

In Tulsa, OK, Water Year 2019 ranked as the 53rd warmest Water Year (60.7°F, tied 1995, 1985, 1982, 1966, 1965, 1957, 1943; since records began in 1905-06) and the 7th wettest Water Year (56.33"; since records began in 1893-94). Fort Smith, AR had the 30th warmest Water Year (62.5°F, tied 1955, 1933, 1923, 1914, 1898; since records began in 1882-83) and the 2nd wettest Water Year (66.21", record is 79.11" in 1944-45; since records began in 1882-83). Fayetteville, AR had the 30th warmest (57.6°F, tied 1983, 1964) and the 10th wettest (56.97") Water Year since records began in 1949-50.

Reservoirs

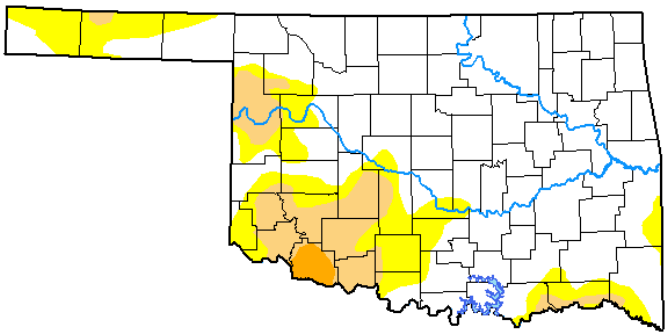


According to the USACE, most of the lakes in the HSA were utilizing more than 3% of their flood control pools as of 9/30/2019: Ft. Gibson Lake 19%, Grand Lake 19%, Keystone Lake 18%, Oologah Lake 17%, Hudson Lake 14%, Kaw Lake 12%, Tenkiller Lake 11%, Skiatook Lake 8%, Copan Lake 5%, Beaver Lake 5%, and Eufaula Lake 4%. Two lakes were below the top of their conservation pools: Heyburn Lake 61% and Wister Lake 91%.

Drought

According to the U.S. Drought Monitor (USDM) from October 1, 2019 (Figs. 3a, 3b), Moderate (D1) Drought conditions were occurring near the Red River in southern Choctaw County. Abnormally dry, but not in drought, conditions (D0) were present in portions of Le Flore, Pushmataha, and Choctaw Counties in eastern OK and Sebastian County in west central AR. The remainder of eastern OK and northwest AR was drought free.

U.S. Drought Monitor
Oklahoma



October 1, 2019
(Released Thursday, Oct. 3, 2019)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	71.94	28.06	11.08	1.01	0.00	0.00
Last Week *09-24-2019*	72.39	27.61	11.41	2.10	0.00	0.00
3 Months Ago *07-02-2019*	99.98	0.02	0.00	0.00	0.00	0.00
Start of Calendar Year *01-01-2019*	94.85	5.15	0.00	0.00	0.00	0.00
Start of Water Year *10-01-2019*	71.94	28.06	11.08	1.01	0.00	0.00
One Year Ago *10-02-2018*	76.55	23.45	8.94	2.91	0.00	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

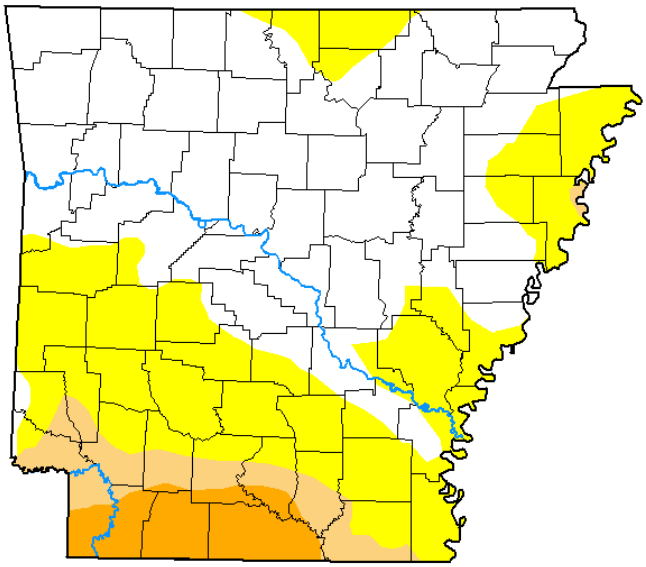
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brian Fuchs
National Drought Mitigation Center

droughtmonitor.unl.edu

Fig. 3a. Drought Monitor for Oklahoma

U.S. Drought Monitor
Arkansas



October 1, 2019
(Released Thursday, Oct. 3, 2019)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	54.35	45.65	11.77	5.79	0.00	0.00
Last Week *09-24-2019*	58.32	41.68	9.16	4.31	0.00	0.00
3 Months Ago *07-02-2019*	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year *01-01-2019*	98.79	1.21	0.00	0.00	0.00	0.00
Start of Water Year *10-01-2019*	54.35	45.65	11.77	5.79	0.00	0.00
One Year Ago *10-02-2018*	93.42	6.58	2.54	0.00	0.00	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brian Fuchs
National Drought Mitigation Center

droughtmonitor.unl.edu

Fig. 3b. Drought Monitor for Arkansas

Outlooks

The Climate Prediction Center (CPC) outlook for October 2019 (issued September 30, 2019) indicates an enhanced chance for above normal temperatures across all of eastern OK and northwest AR. This outlook also calls for a slightly enhanced chance for above median precipitation northwest of I-44, with equal chances for above, near, and below median precipitation elsewhere across eastern OK and northwest AR. This outlook takes into account dynamical model guidance and the weeks 3-4 outlook. The upper-level atmospheric pattern is expected to be zonally oriented over the CONUS by the second week of October. Therefore, a warmer pattern is favored to develop for the eastern two-thirds and southwest CONUS as a result of this more zonal oriented flow and increasing coverage of positive 500-hPa height departures along the southern tier and eastern CONUS. Additionally, long term trends and ongoing Madden-Julian Oscillation (MJO) activity favor above normal temperatures for most of the central and eastern CONUS.

For the 3-month period October-November-December 2019, CPC is forecasting an enhanced chance for above normal temperatures and equal chances for above, near, or below median rainfall across all of eastern OK and northwest AR (outlook issued September 19, 2019). This outlook is based on both statistical and dynamical forecast tools, and decadal timescale climate trends. According to CPC, the combined effect of the ocean-atmosphere system is consistent with ENSO neutral conditions during August and early September. The consensus forecast is for ENSO neutral conditions to be the most likely through the winter, with a very low chance for La Niña. With ENSO-neutral favored to persist through the upcoming winter, the odds of other sub-seasonal factors, such as the Arctic Oscillation (AO), will play a larger role in the temperature pattern.

Summary of Heavy Precipitation Events Daily quality-controlled rainfall maps can be found at: http://water.weather.gov/precip/index.php?location_type=wfo&location_name=tsa

Around midnight on the 1st, showers and thunderstorms developed across east central OK and northwest AR in response to a mesoscale convective vortex (MCV), slowly drifted eastward, and then dissipated shortly after sunrise. Rainfall totals ranged from 0.10” to around 2” (Fig. 4).

A line of weak showers and thunderstorms initially moved into eastern Kay and Osage Counties during the early afternoon of the 12th ahead of a cold front. Convection then increased in coverage and intensity by late afternoon along and just ahead of the cold front from west central OK into eastern KS. The line of storms then moved southeast across northeast OK through the evening hours, with only isolated storms affecting northwest AR. As the front stalled, the convection continued primarily across northeast OK through the overnight hours. Most of the activity dissipated by sunrise on the 13th. Rainfall totals were 0.25” to around 2” for much of the affected area, though higher totals of 2”-5” fell over portions of Creek, Pawnee, and Osage Counties (Fig. 5).

The remnants of Imelda moved north out of northeast TX and into southeast OK and west central AR during the morning of the 20th and persisted for much of the day. Precipitable water (PWAT) values were in excess of 2.2” within a zone of enhanced moisture transport, and this, combined with lift from a shortwave trough, resulted in back-building storms and heavy rain across southeast OK. The rain finally dissipated during the evening, after bringing 3”-8” to portions of Choctaw, Pushmataha, and Le Flore Counties in southeast OK (Fig. 6). The remainder of southeast OK and west central AR received 0.50”-2” of rain. 24-hour rainfall totals from Oklahoma Mesonet stations on the 20th: Antlers 4.92”; Cloudy 4.09”; Hugo 3.47”.

High tropical atmospheric moisture continued over the area as the southwest flow aloft transported moisture from Hurricane Lorena into the region. An area of showers and thunderstorms moved across northeast OK, along and northwest of I-44, during the morning hours of the 21st as an MCV traversed the area. A line of showers and isolated thunderstorms developed across western OK during the evening and began to move into eastern OK during the early morning hours of the 22nd. This activity primarily affected locations northwest of I-44 through noon. A narrow line of broken showers and thunderstorms ahead of a cold front affected northeast OK along and northwest of I-44 through the afternoon and evening hours of the 22nd, with isolated showers and thunderstorms occurring elsewhere in eastern OK and northwest AR through the overnight hours. 24-hour rainfall totals through 7 am 9/22 ranged from 0.25” to 2.5” (Fig. 7), and another 0.25” to 4” fell in the 24-hours ending at 7 am 9/23 (Fig. 8). Heavy rain also fell in southeast KS, resulting in flooding along the Neosho River near Commerce (see preliminary hydrographs at the end of this report; see E3 Report for details).

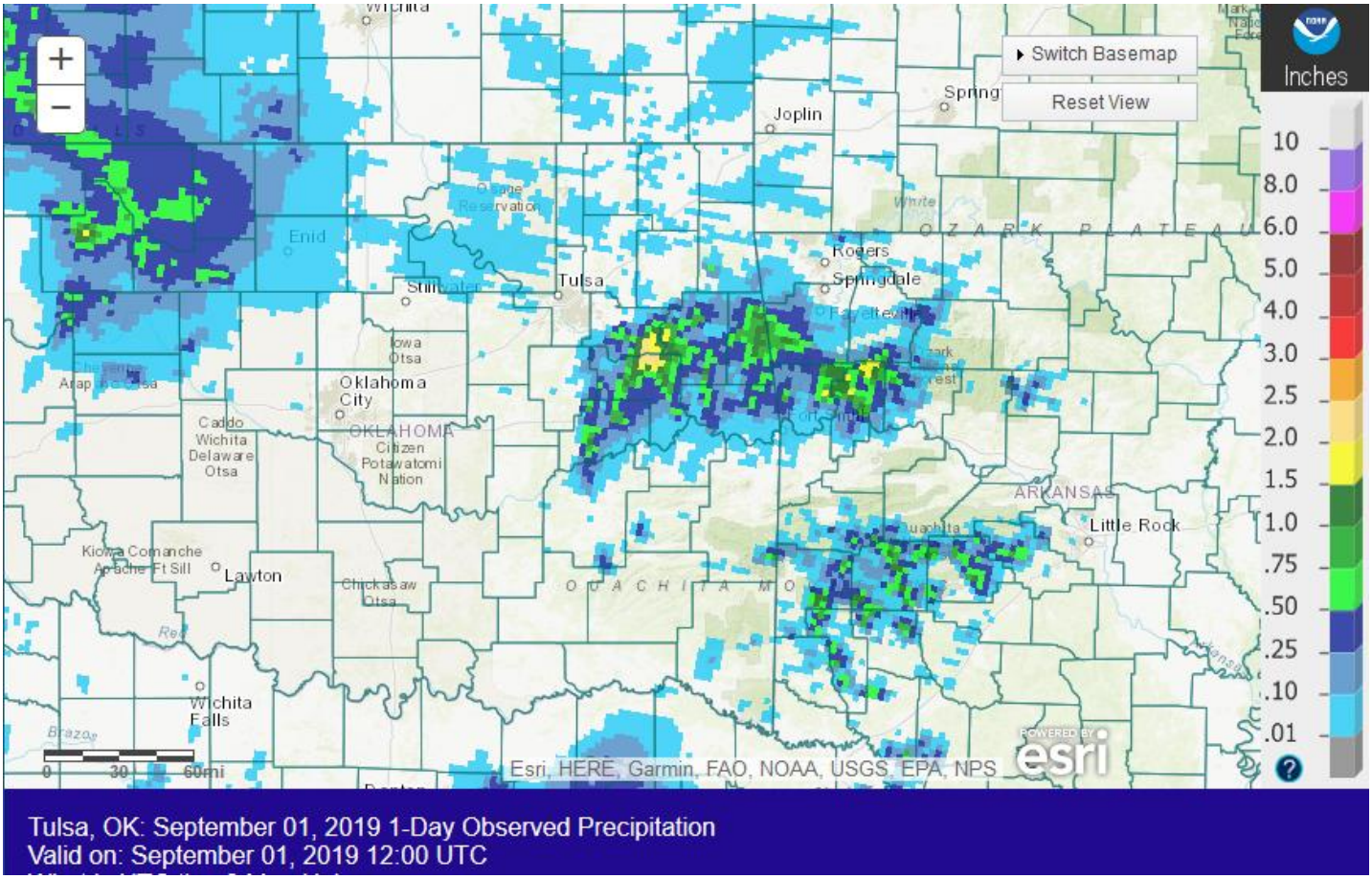


Fig. 4. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/01/2019.

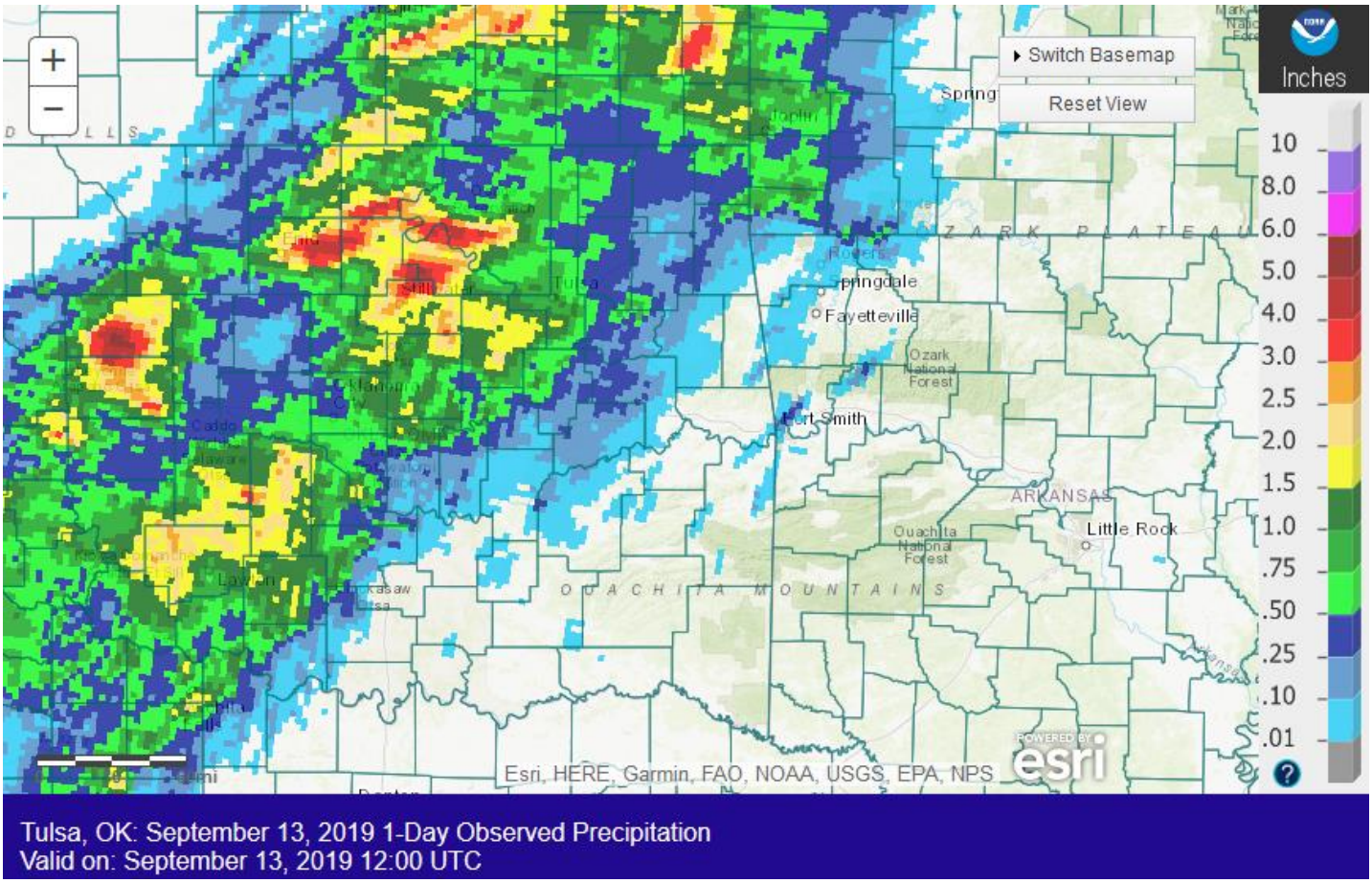


Fig. 5. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/13/2019.

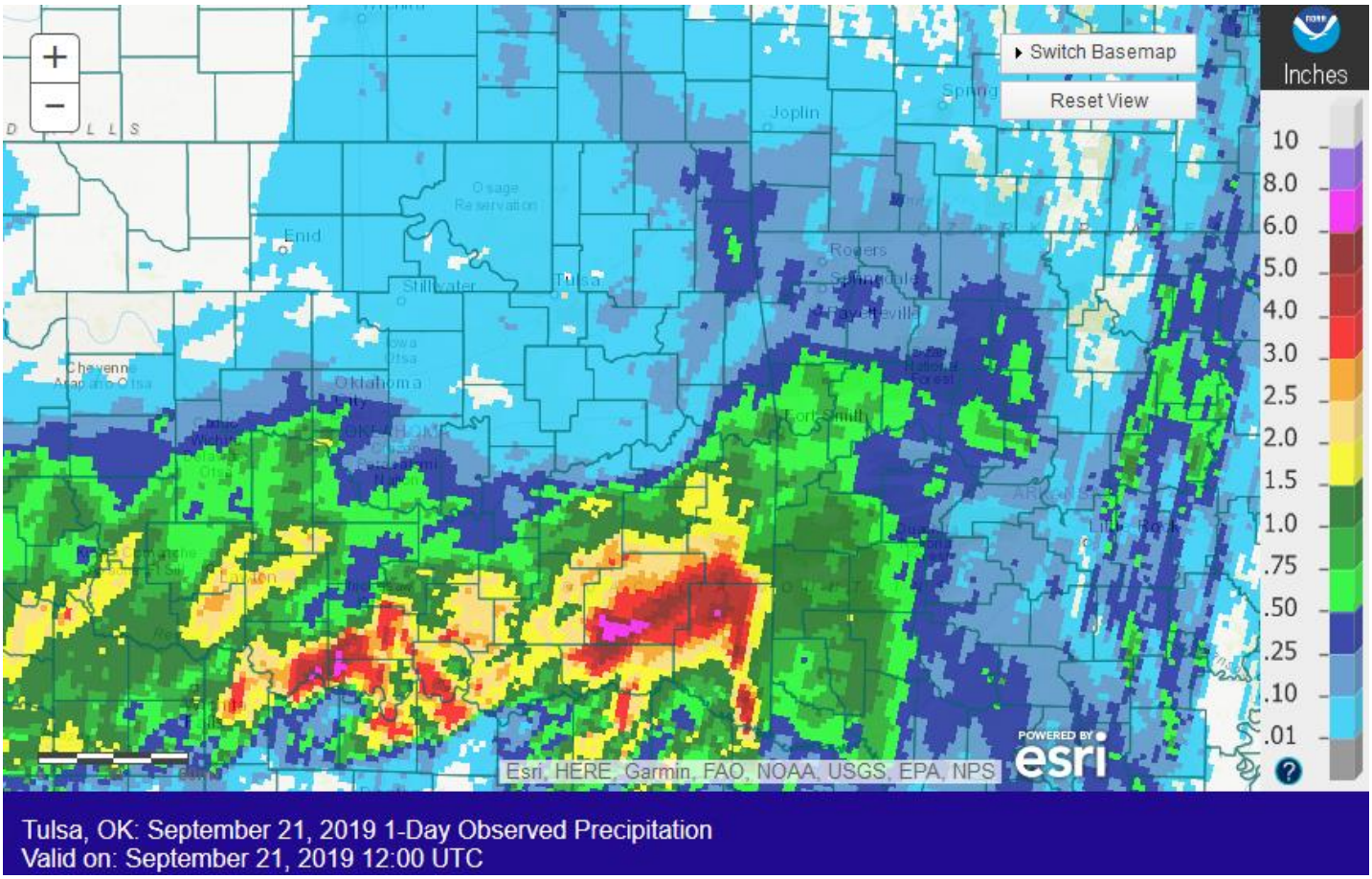


Fig. 6. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/21/2019.

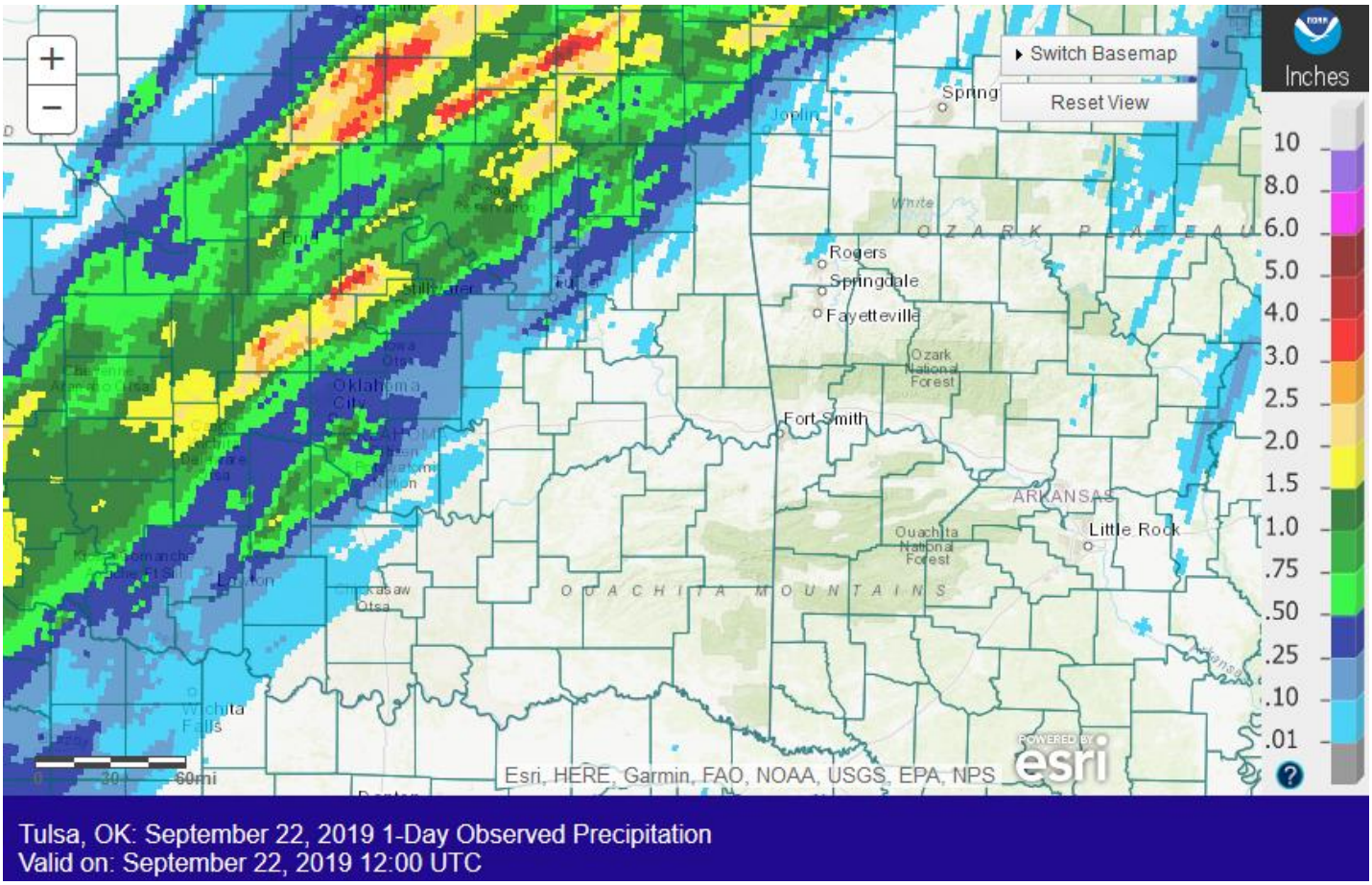


Fig. 7. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/22/2019.

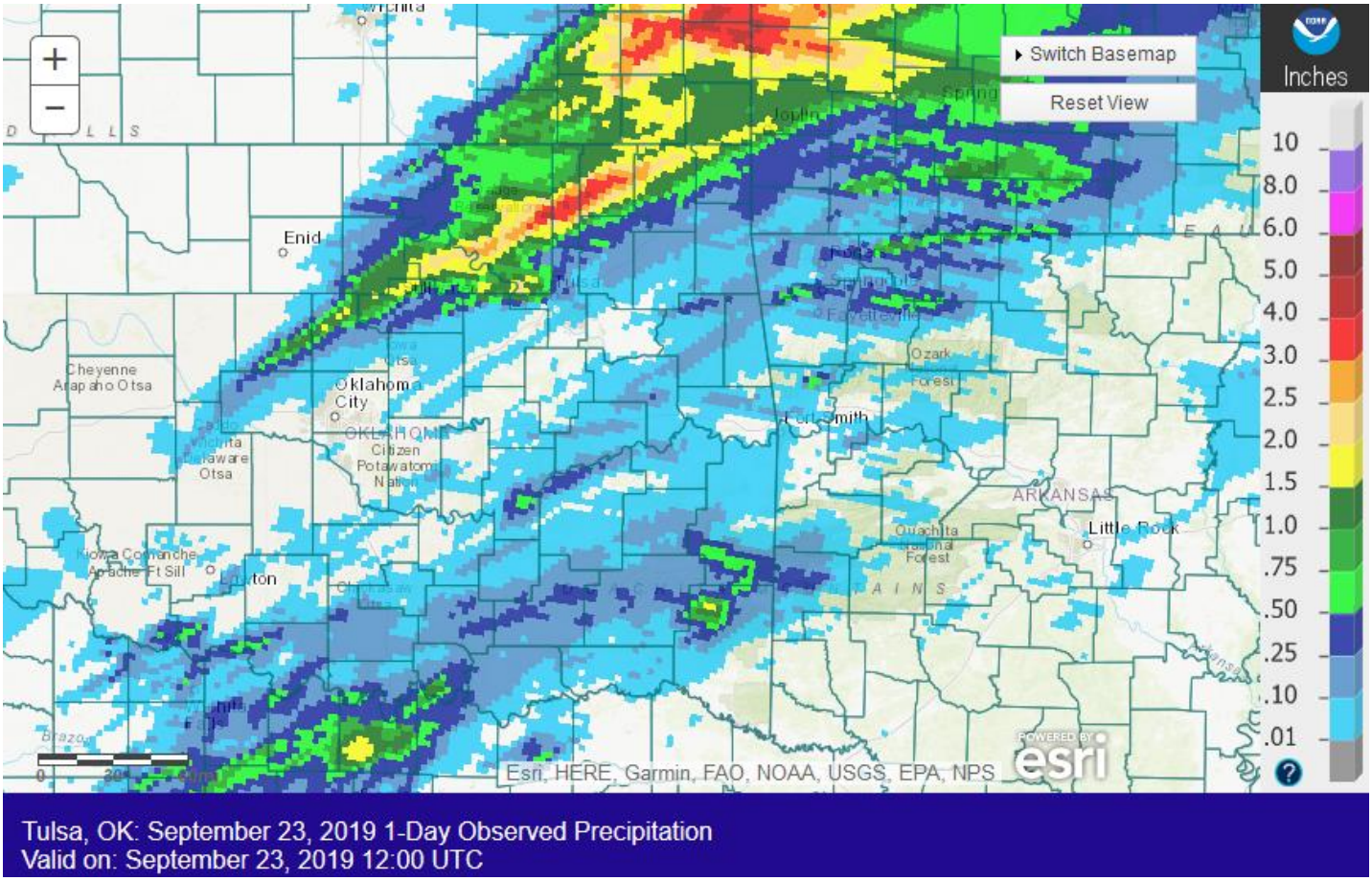


Fig. 8. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/23/2019.

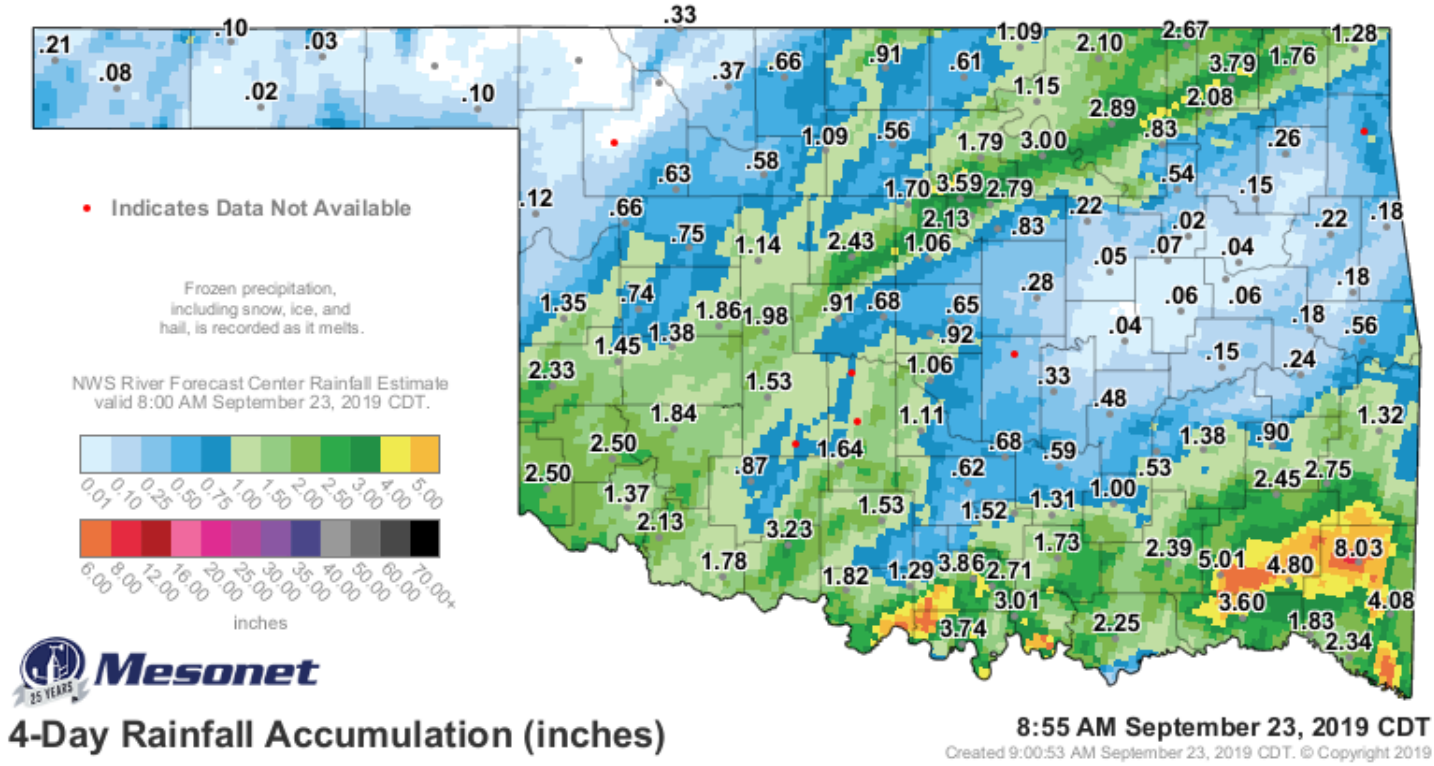


Fig. 9. OK Mesonet (values) and NWS RFC rainfall estimate (image) 4-day rainfall ending at 8:55 am CDT 09/23/2019.

The 4-day rainfall totals, ending on the morning of the 23rd, were 1”-4” north of I-44 in northeast OK and 1”-7” across southeast OK (Fig. 9). Less than 0.10” of rain fell in eastern OK between these two areas of heavy rain.

Scattered showers and thunderstorms occurred across southeast OK, along and south of a weak frontal boundary, during the late morning through early evening hours on the 23rd. These storms brought 0.25” to around 3” of rain to southeast OK (higher totals occurred in McCurtain Co., which is not part of the NWS Tulsa area of responsibility; Fig. 10). As the low-level jet increased during the night, new convection developed near the boundary along and north of I-40 in east central OK and west central AR. A warm advection regime at the tail end of a retreating frontal zone led to widespread showers and thunderstorms across northeast OK and northwest AR through the morning and early afternoon of the 24th. Precipitable water (PWAT) values were very high, on the order of 2” to 2.25”, which is nearly 220% of normal for this time of year. The high PWAT combined with training storms resulted in heavy rain and flash flooding. Reports of water rescues and numerous flooded roads were received from Benton, Washington AR, Muskogee, Tulsa, Craig, and Rogers Counties. This rain also resulted in higher levels along the Illinois River, though flood stage was not exceeded (see preliminary hydrographs at the end of this report). Rainfall totals were widespread 1” to 5” across eastern OK and northwest AR, along and north of I-40, with very heavy rainfall rates (Figs. 10-14). Showers and thunderstorms then developed during the afternoon hours of the 24th across southeast OK, primarily south of I-40, and shifted east across southeast OK and west central AR through the evening hours before pushing east of the region. These storms also produced heavy rain, with many locations in southeast OK receiving 1”-2” of rain. Southern Latimer and northern Pushmataha had higher totals of 3” to around 6” of rain (Fig. 11).

A few isolated showers and thunderstorms, the remnants of a KS mesoscale convective system (MCS), affected northeast OK and northwest AR during the morning of the 25th. A cold front then sagged south into northeast OK and northwest AR during the evening and stalled over the area. The upper-level flow was parallel to the front and PWAT values were in the 1.75”-2” range, setting the stage for training of storms capable of producing heavy rainfall. A line of thunderstorms began to develop during the late evening hours near the OK/KS state line near the front, with isolated thunderstorms ahead of the front in northeast OK and northwest AR. The line moved south during the overnight and early morning hours. While most of the rain had moved southeast of the region shortly after sunrise on the 26th, scattered showers and thunderstorms lingered across eastern OK through early afternoon. By 7 am 9/26, most of eastern OK and northwest AR north of I-40 had received 1”-2.5” of rain, with localized amounts of 2.5”-5” (Figs 15, 17). Some of the higher 24-hour rainfall totals (by 7 am CDT 9/26/2019) included: Ralston, OK 4.25”; Miami 2NE, OK 3.43”; Big Cabin 5NE, OK 3.15”; Vinita 10NNW, OK 3.05”. Street flooding was reported in Broken Arrow, OK; Bella Vista, AR; Pawnee, OK; and Scipio, OK. An additional 1”-3” fell through the remainder of the morning and afternoon hours (Figs. 16, 17). This rain once again caused the Illinois River to rise to unsafe levels for recreation, but it remained below flood stage (see preliminary hydrographs at the end of this report).

The 4-day rainfall totals, ending at 8:45 am CDT 9/26/2019, were widespread 1”-4”, though several locations received 4”-9” (Fig. 18). The entire 7-day active weather period, ending at 3:50 pm CDT 9/26/2019, resulted in widespread 3”-5” of rain, and several areas of 5”-11” of rain (Fig. 19).

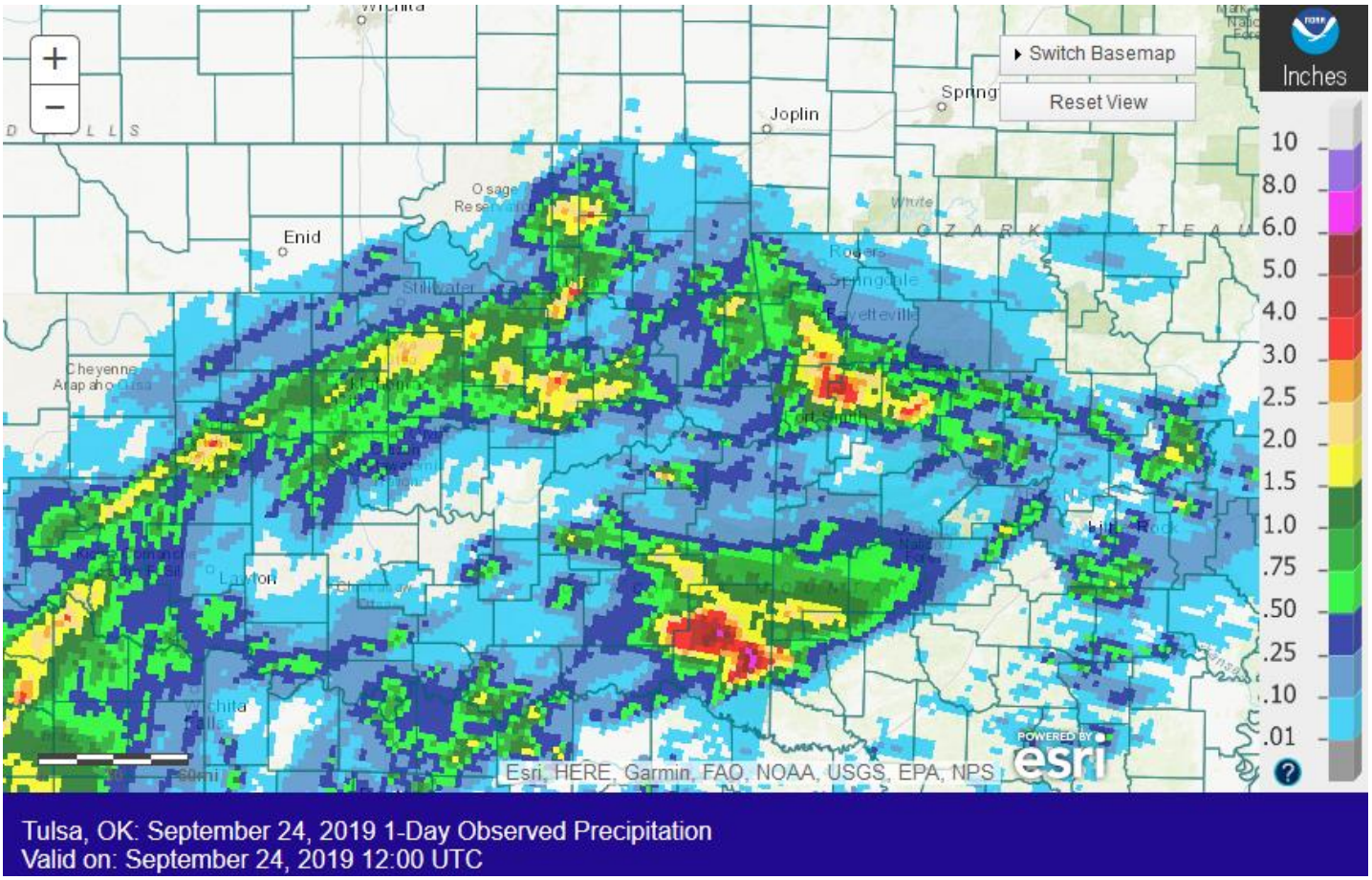


Fig. 10. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/24/2019.

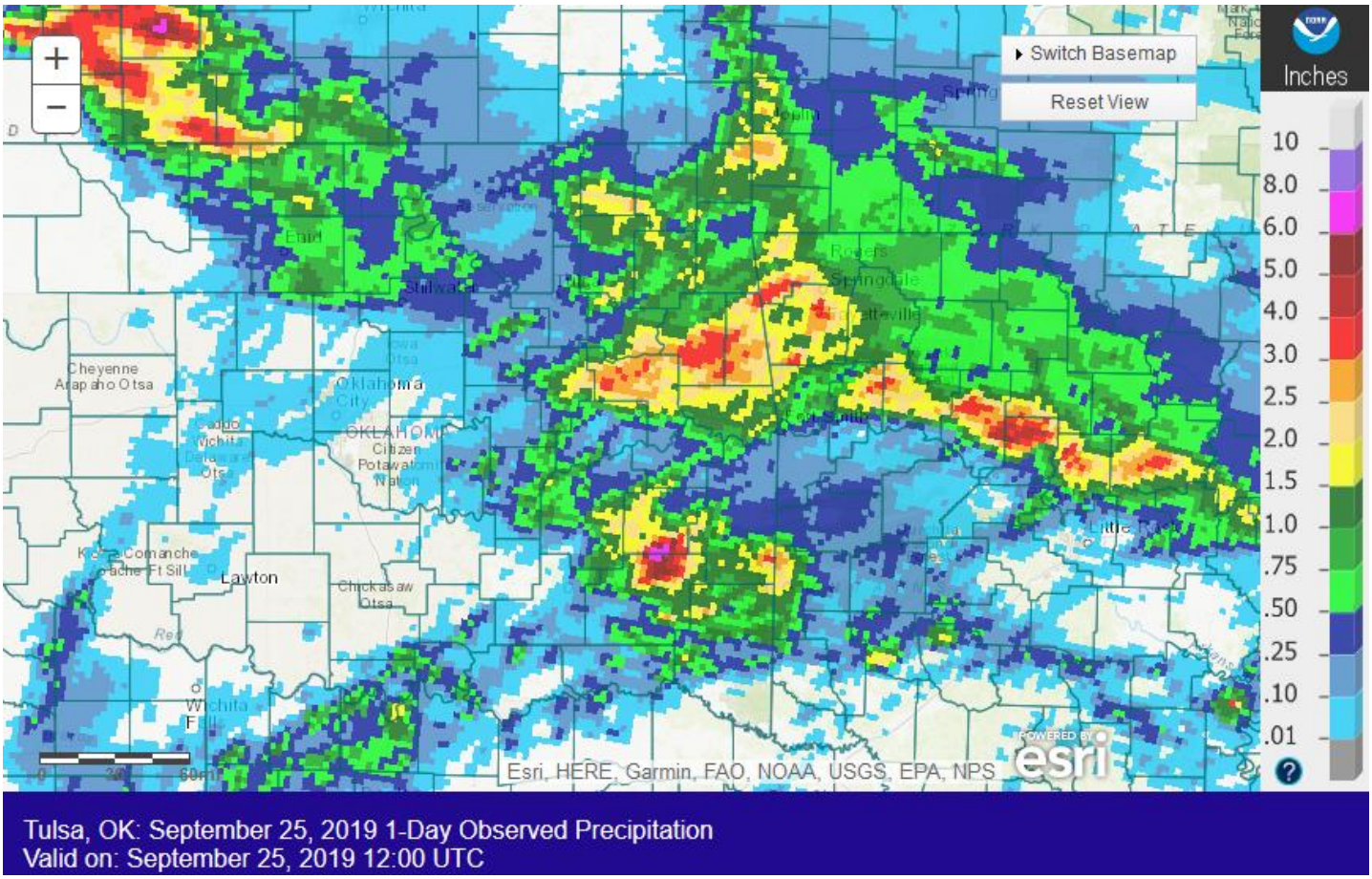


Fig. 11. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/25/2019.

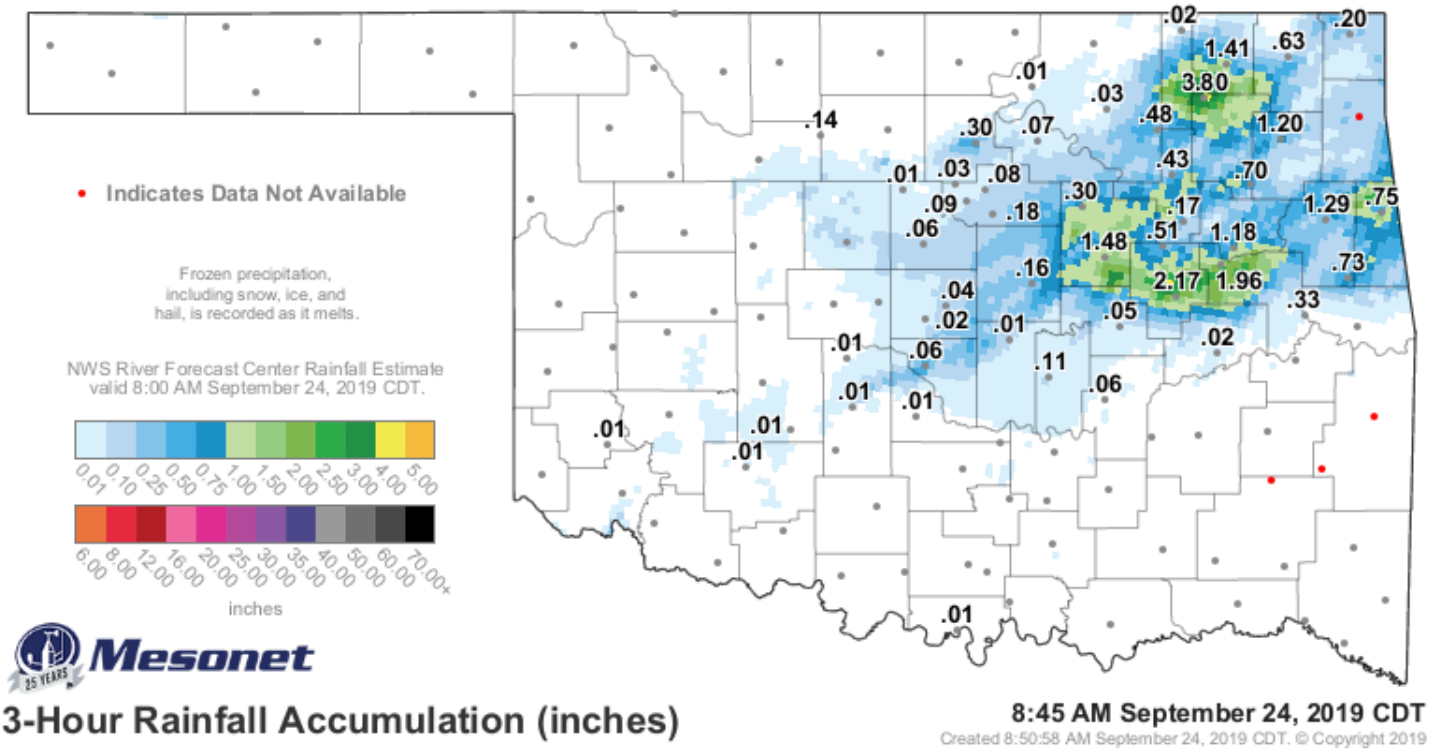


Fig. 12. OK Mesonet (values) and NWS RFC rainfall estimate (image) 3-hour rainfall ending at 8:45 am CDT 09/24/2019.

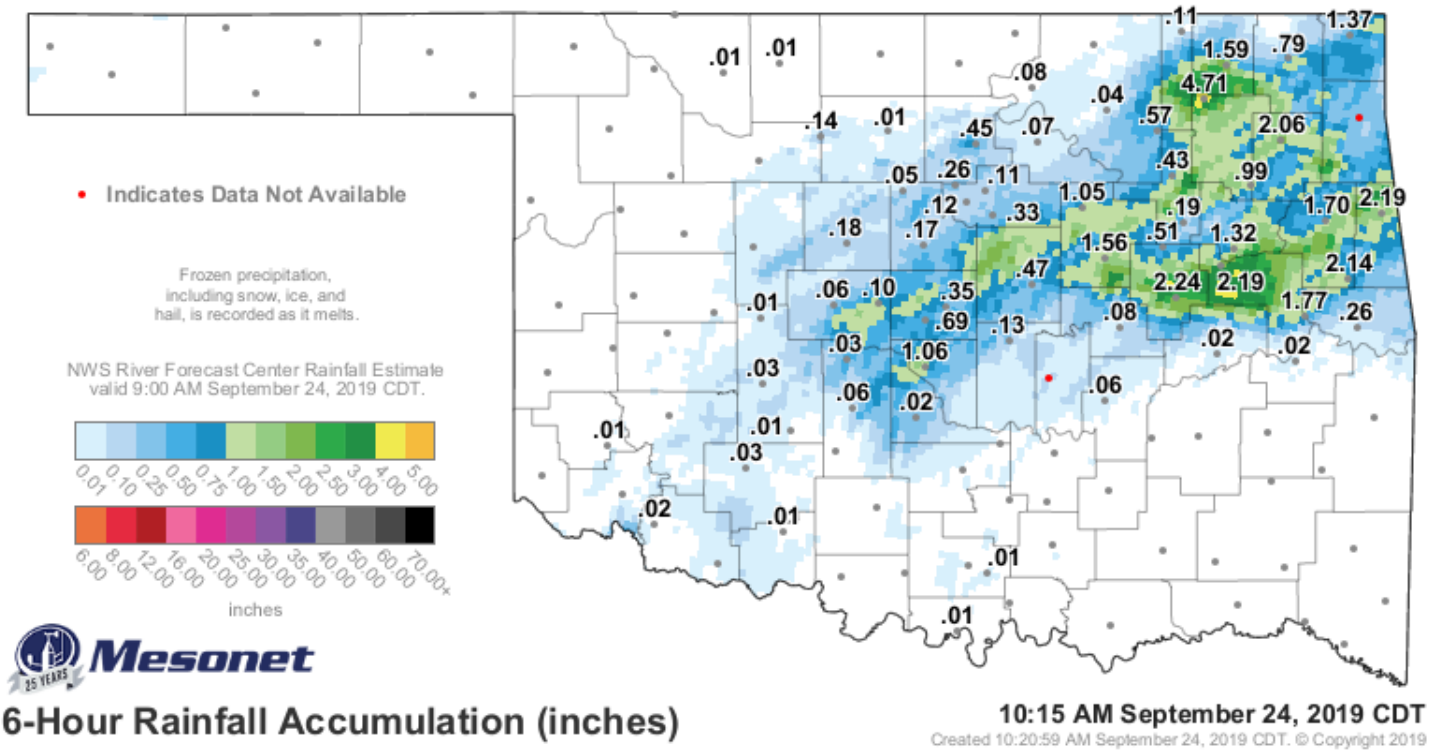


Fig. 13. OK Mesonet (values) and NWS RFC rainfall estimate (image) 6-hour rainfall ending at 10:15 am CDT 09/24/2019.

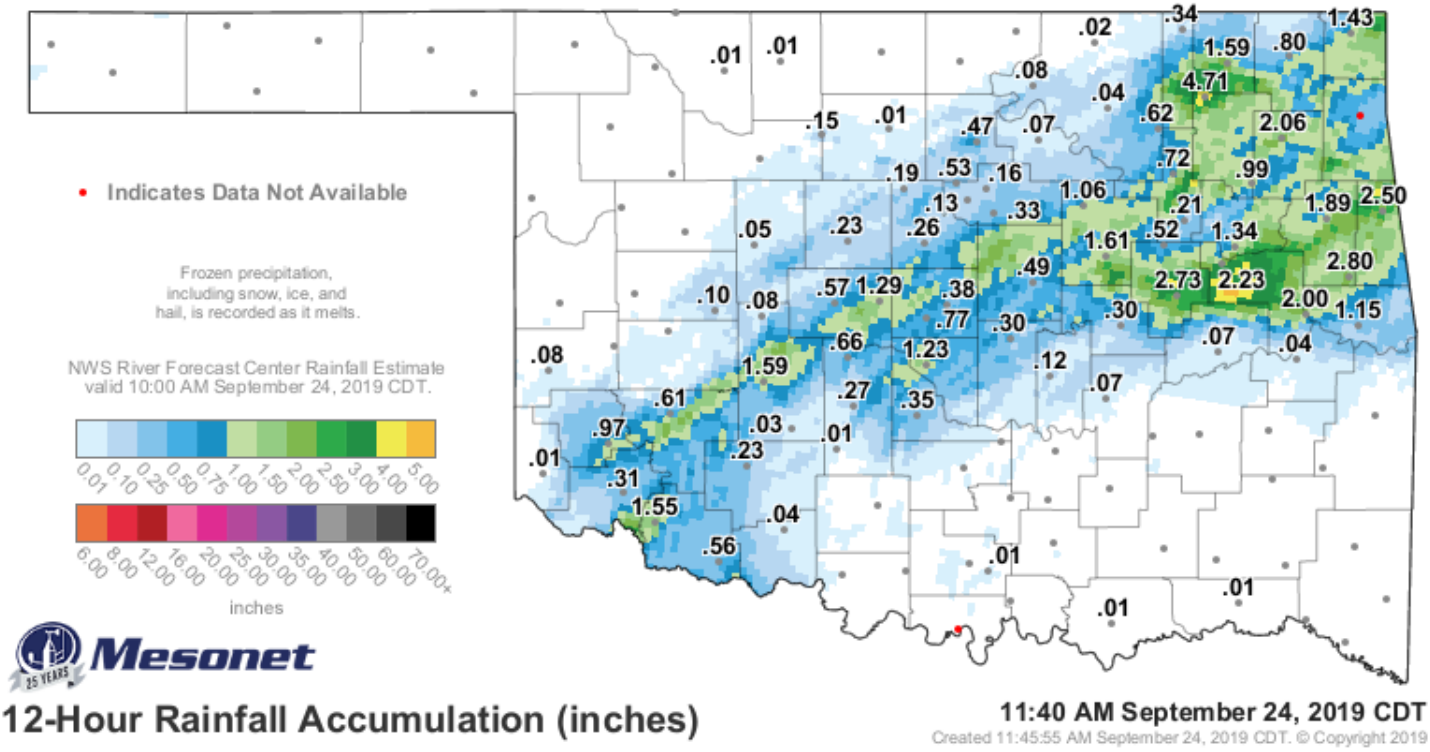


Fig. 14. OK Mesonet (values) and NWS RFC rainfall estimate (image) 12-hour rainfall ending at 11:40 am CDT 09/24/2019.

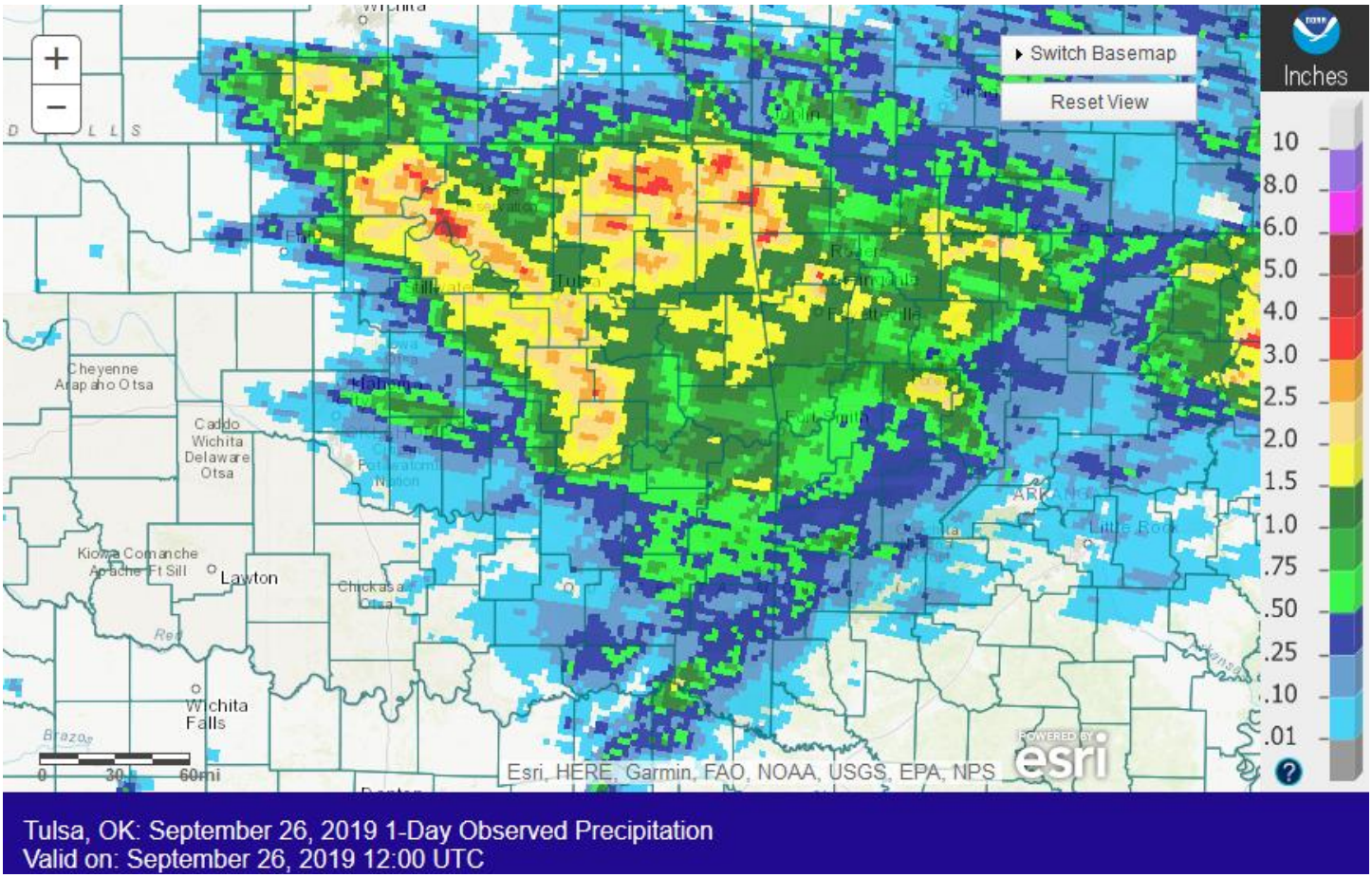


Fig. 15. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/26/2019.

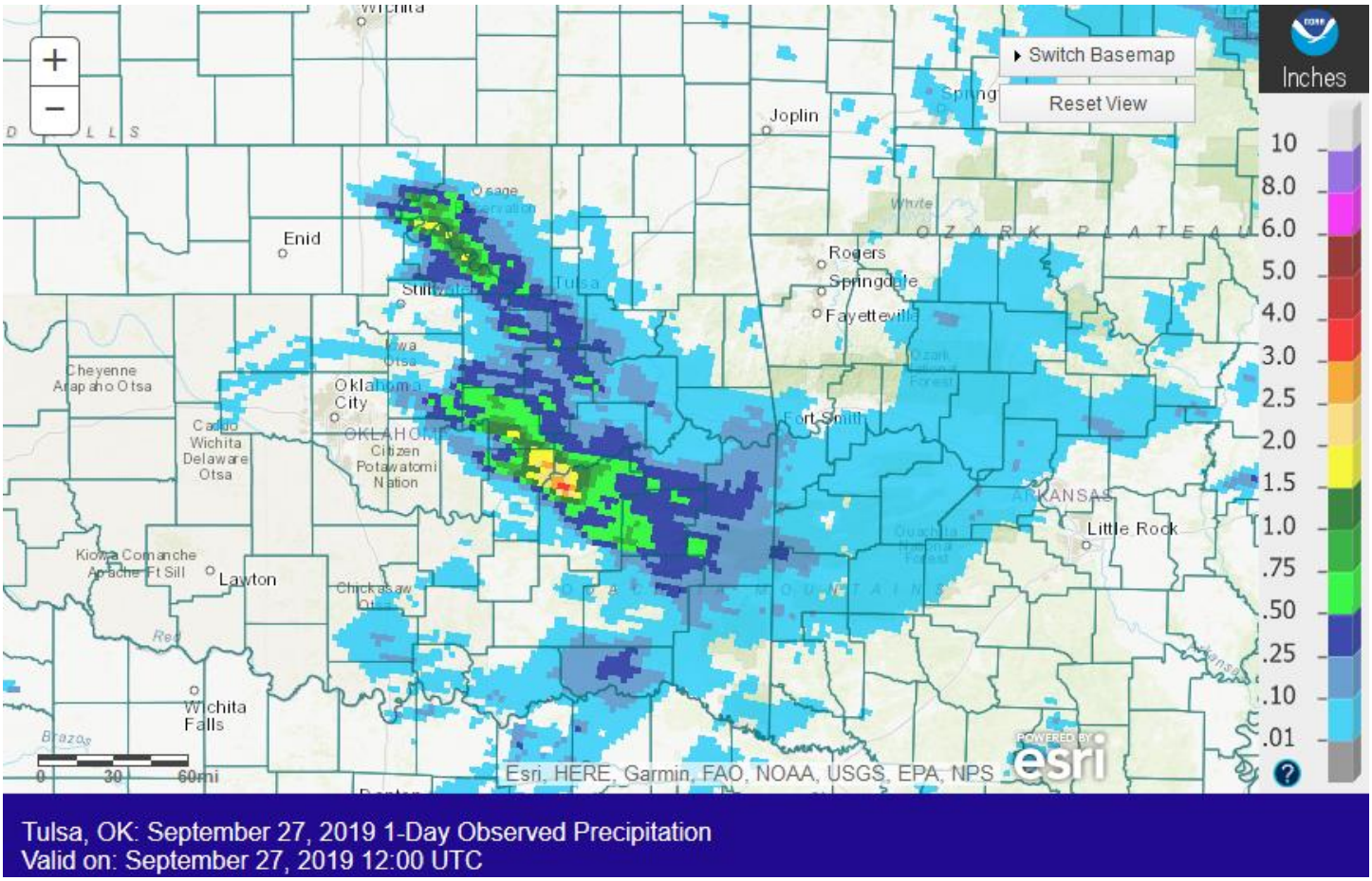


Fig. 16. 24-hour Estimated Observed Rainfall ending at 7am CDT 9/27/2019.

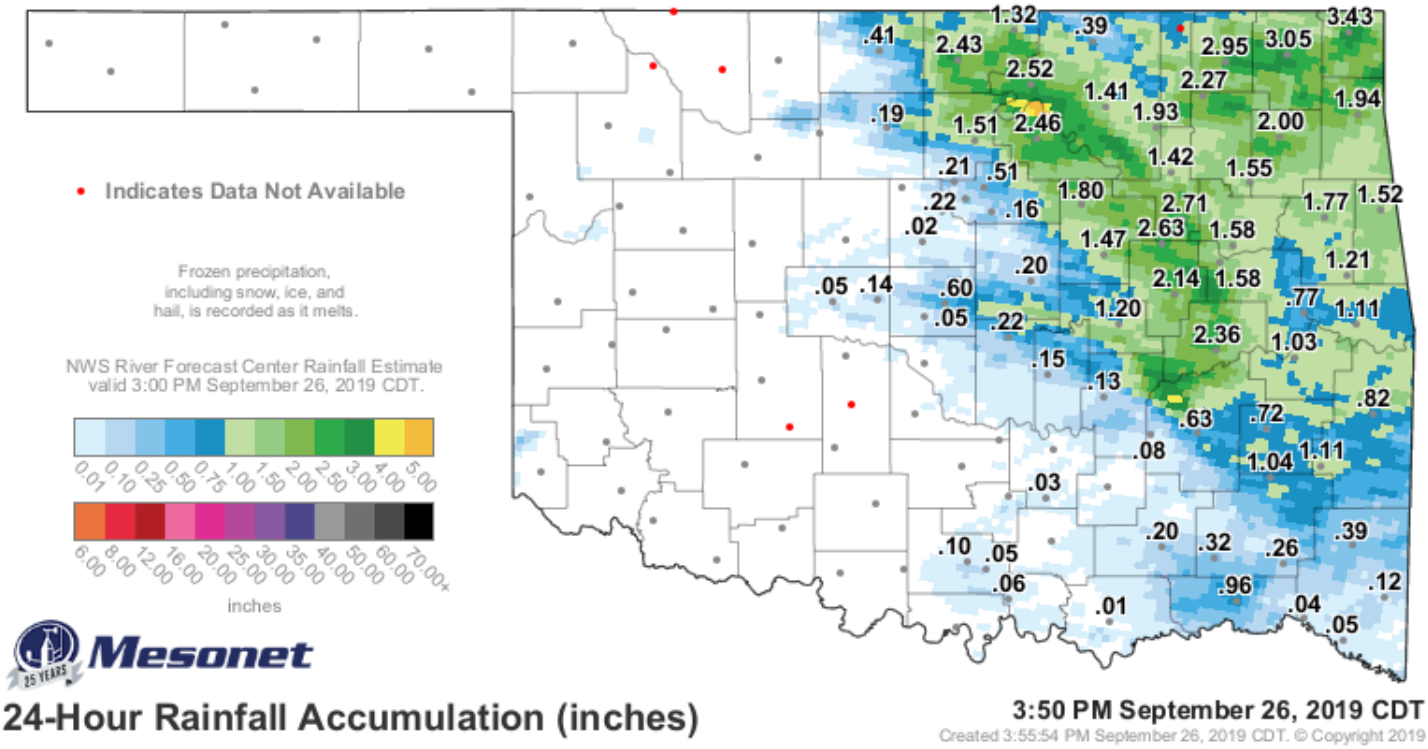


Fig. 17. OK Mesonet (values) and NWS RFC rainfall estimate (image) 24-hour rainfall ending at 3:50 pm CDT 09/26/2019.

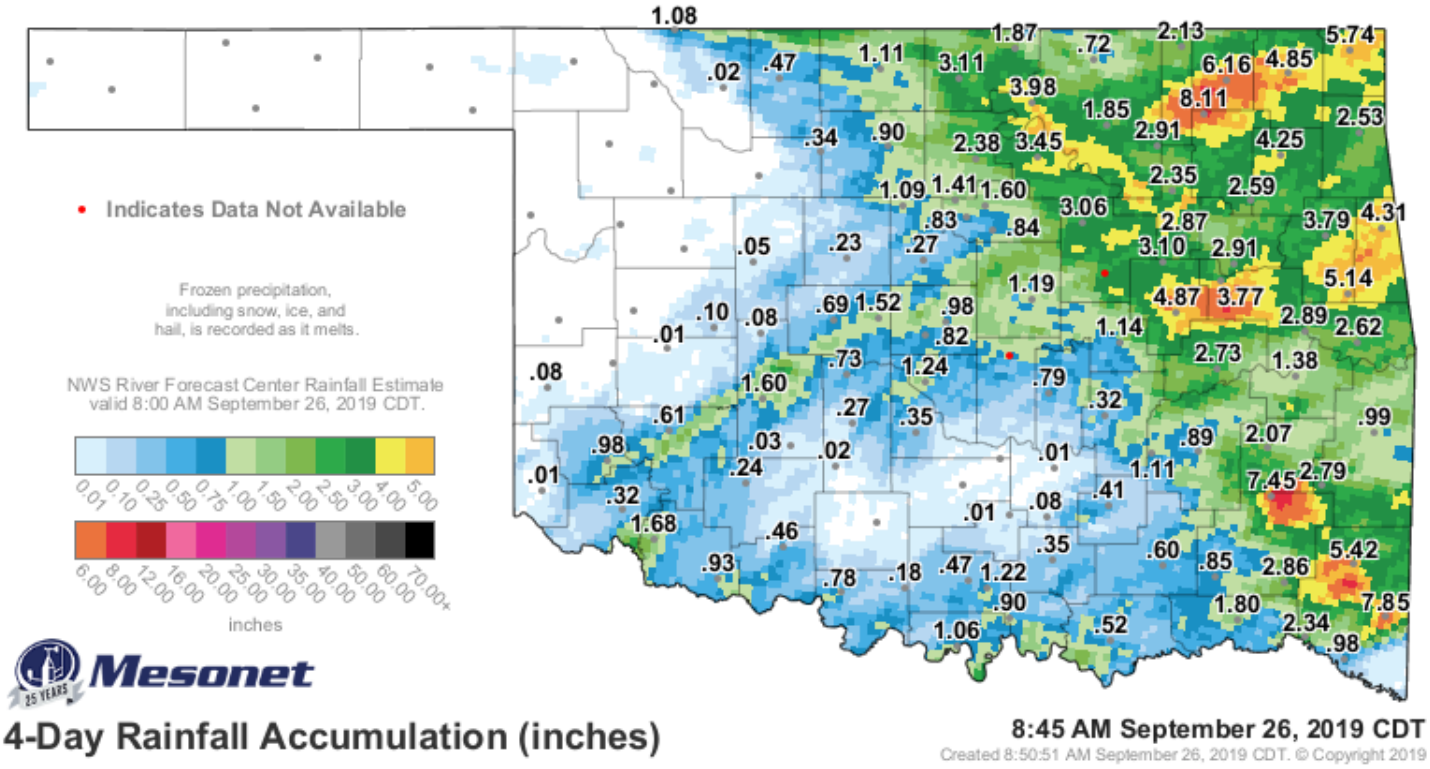


Fig. 18. OK Mesonet (values) and NWS RFC rainfall estimate (image) 4-day rainfall ending at 8:45 am CDT 09/26/2019.

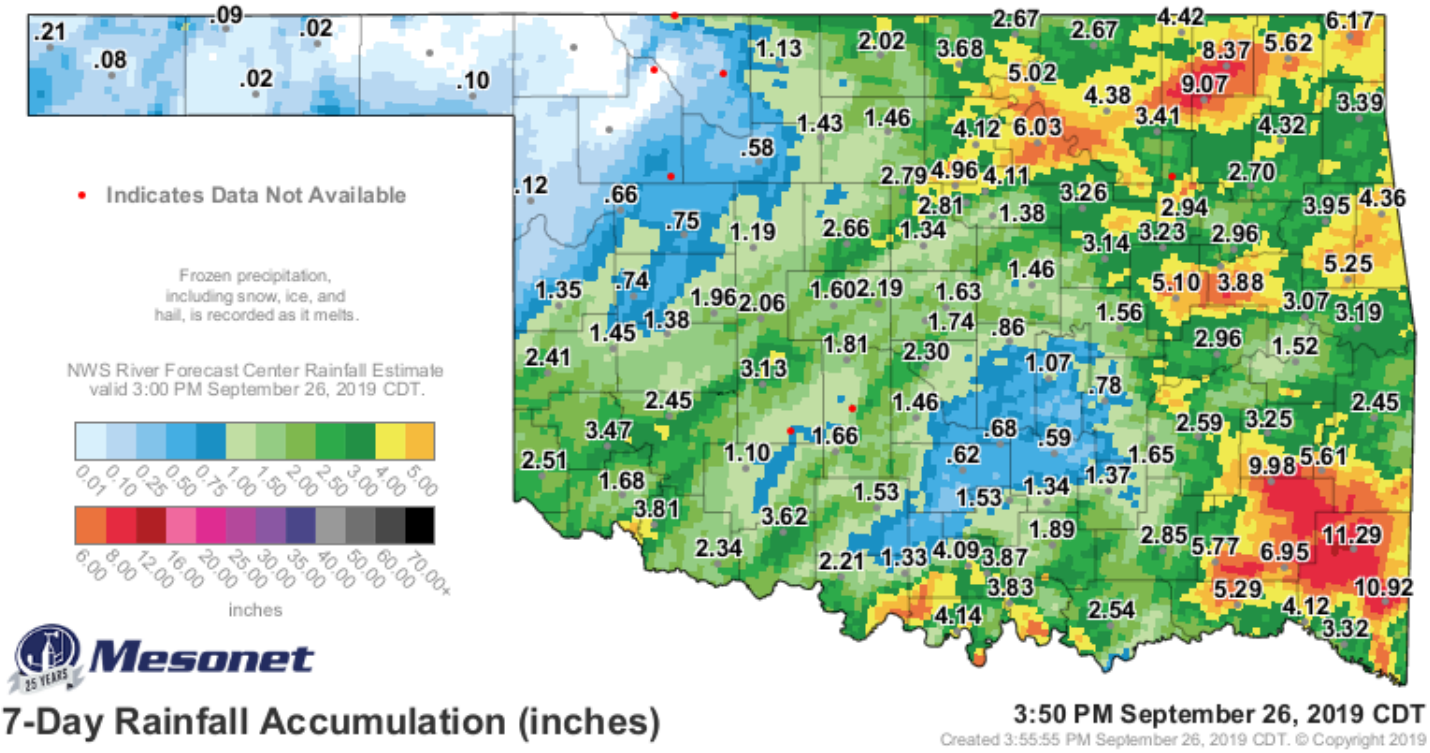


Fig. 19. OK Mesonet (values) and NWS RFC rainfall estimate (image) 7-day rainfall ending at 3:50 pm CDT 09/26/2019.

Written by:

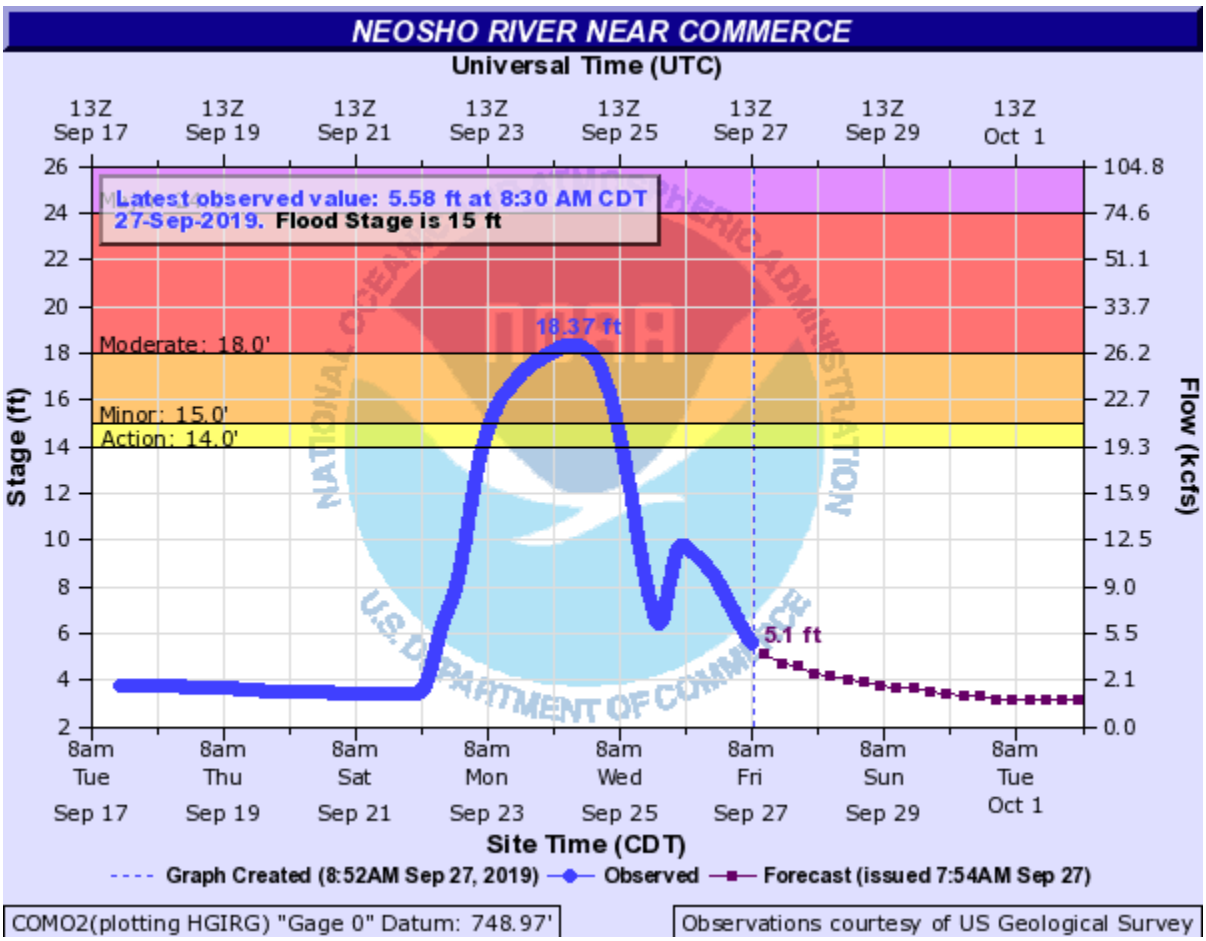
Nicole McGavock
Service Hydrologist
WFO Tulsa

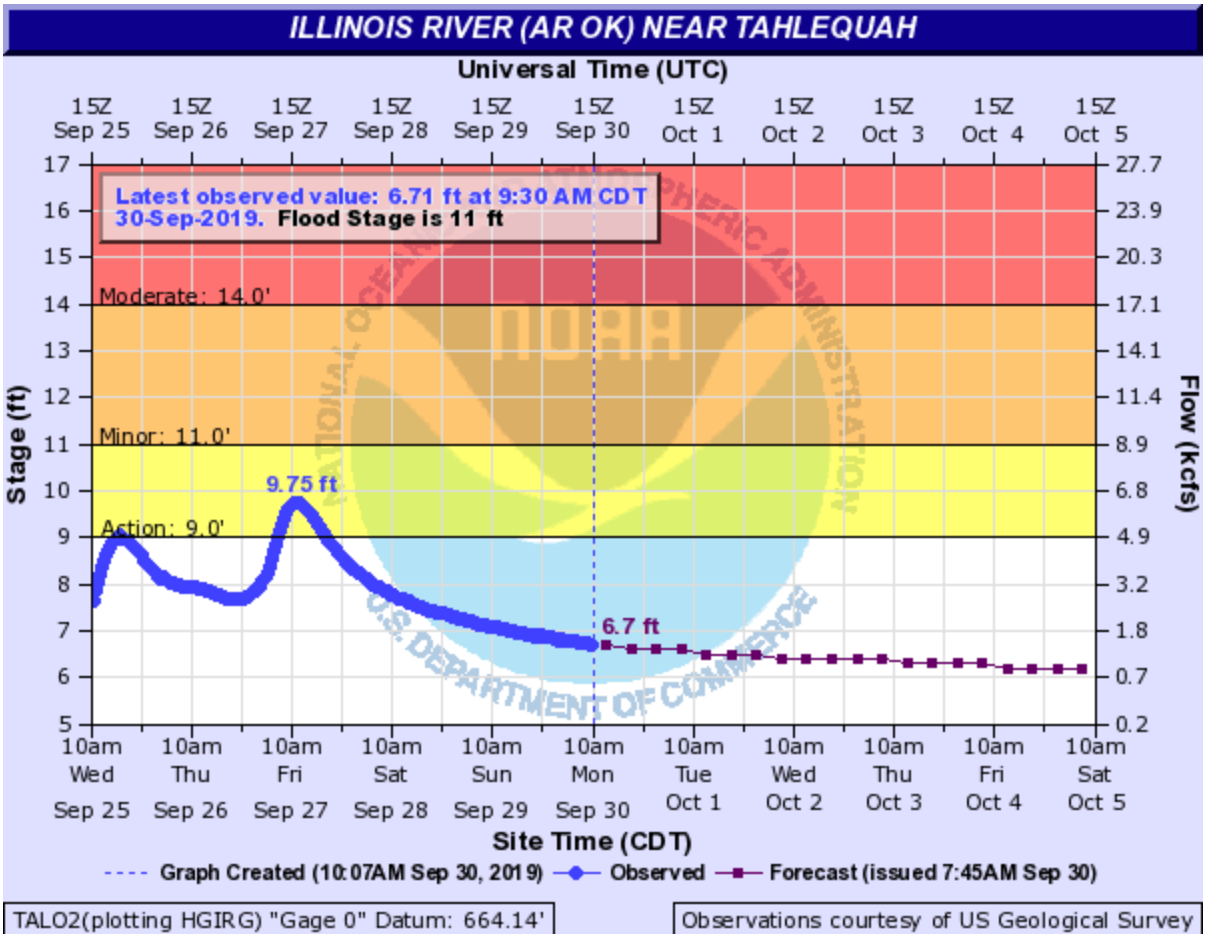
Products issued in September 2019:

*CWYO2 became a daily river forecast point September 7, 2016
*MLBA4 and OZGA4 transferred to NWS Tulsa HSA February 5, 2014
*Mixed case River Flood products began July 31, 2013

13 Flash Flood Warnings (FFW)
12 Flash Flood Statements (FFS)
3 Flash/Areal Flood Watches (FFA) (11 Watch FFA CON/EXT/EXA/EXB/CAN)
28 Urban and Small Stream Advisories (FLS)
3 Areal Flood Warnings (FLW)
0 Areal Flood Statements (FLS)
3 River Flood Warnings (FLW) (includes category increases)
15 River Flood Statements (FLS)
3 River Flood Advisories (FLS) (11 Advisory FLS CON/EXT/CAN)
0 River Flood Watches (FFA) (0 Watch FFA CON/EXT/CAN)
0 River Statements (RVS)
0 Hydrologic Outlooks (ESF)
0 Drought Information Statements (DGT)

Preliminary Hydrographs:




ILLINOIS RIVER (AR OK) NEAR TAHLEQUAH
Universal Time (UTC)
15Z Sep 25
15Z Sep 26
15Z Sep 27
15Z Sep 28
15Z Sep 29
15Z Sep 30
15Z Oct 1
15Z Oct 2
15Z Oct 3
15Z Oct 4
15Z Oct 5
Latest observed value: 6.71 ft at 9:30 AM CDT 30-Sep-2019. Flood Stage is 11 ft
Moderate: 14.0'
Minor: 11.0'
Action: 9.0'
9.75 ft
6.7 ft
Stage (ft)
Flow (kcfs)
17
16
15
14
13
12
11
10
9
8
7
6
5
27.7
23.9
20.3
17.1
14.1
11.4
8.9
6.8
4.9
3.2
1.8
0.7
0.2
10am Wed Sep 25
10am Thu Sep 26
10am Fri Sep 27
10am Sat Sep 28
10am Sun Sep 29
10am Mon Sep 30
10am Tue Oct 1
10am Wed Oct 2
10am Thu Oct 3
10am Fri Oct 4
10am Sat Oct 5
Site Time (CDT)
Graph Created (10:07AM Sep 30, 2019)
Observed
Forecast (issued 7:45AM Sep 30)
TALO2(plotting HGIRG) "Gage 0" Datum: 664.14'
Observations courtesy of US Geological Survey