



Illinois River Basin (IRB)

Flow and Water Quality



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Illinois River Basin (IRB) Model Development

Model produced and will be published at <https://ok.hawqs.tamu.edu/>
Consistent with Arkansas SWAT model and previous EPA HSPF model
Federally approved input datasets

Inputs:

- Modeled at the huc12 scale [$\sim 24,320$ acres (38 mi^2)] for subbasins and streams (NHDPlus v2)
- County level soil (SSURGO)
- Comprehensive Land Use information for crops, fields, and wetlands (NLCD 2019, NASS-CDL 2017-19, NWI)
- High resolution Weather Data (PRISM)
- 10-meter DEM Elevation (NED)
- Current Point Sources (ICIS-NPDES)
- Similar management for Urban areas
- Similar management for pasture lands for grazing cattle, hog and dairy farms, poultry litter, and fertilizer

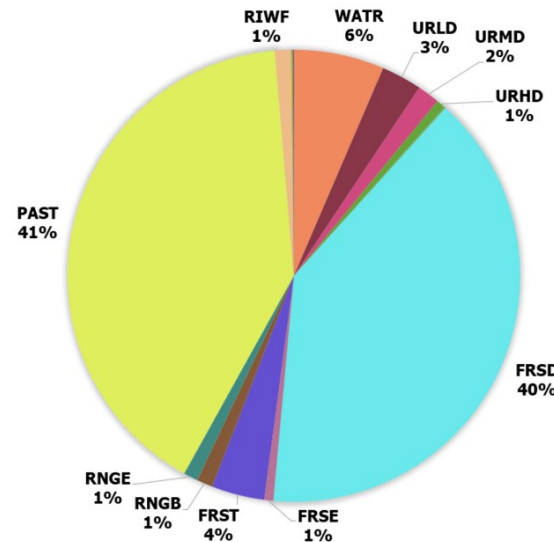
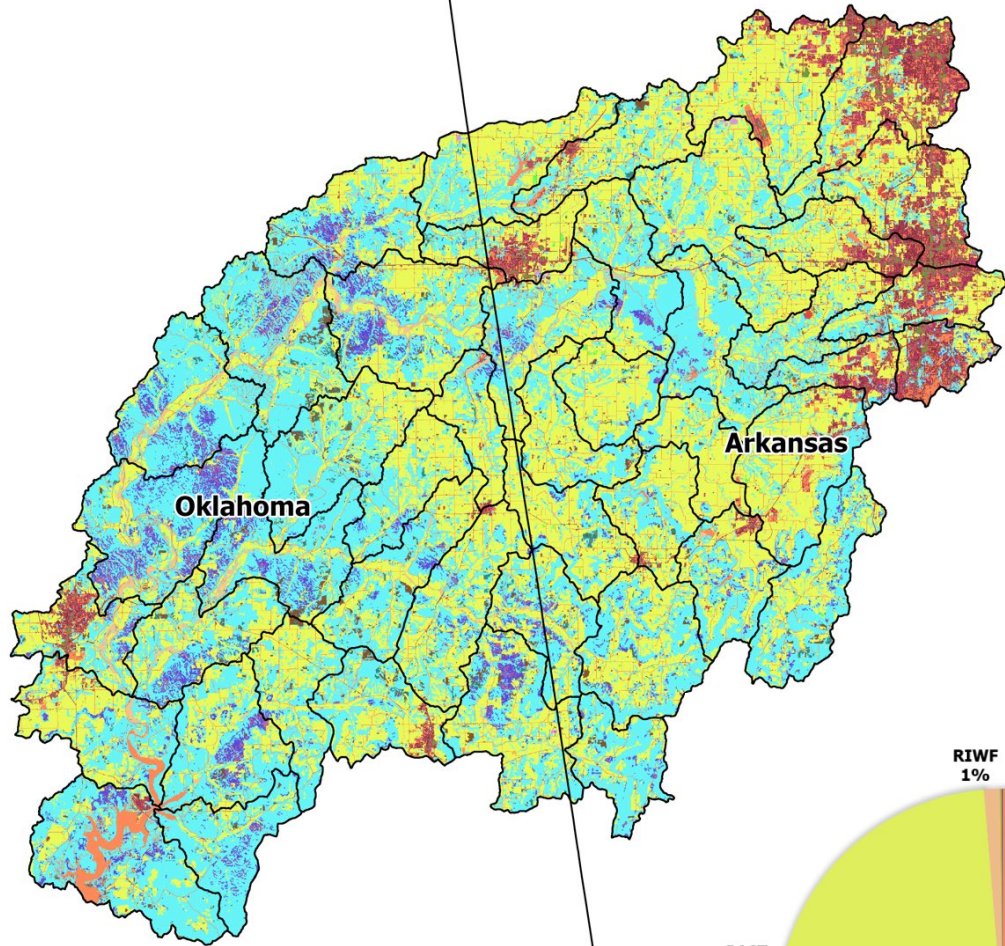
Verification Data:

- Natural State Streams LLC 2021 streambank erosion study
- USGS Gages for Flow
- USGS, DEQ, and AWRC Gages for Water Quality



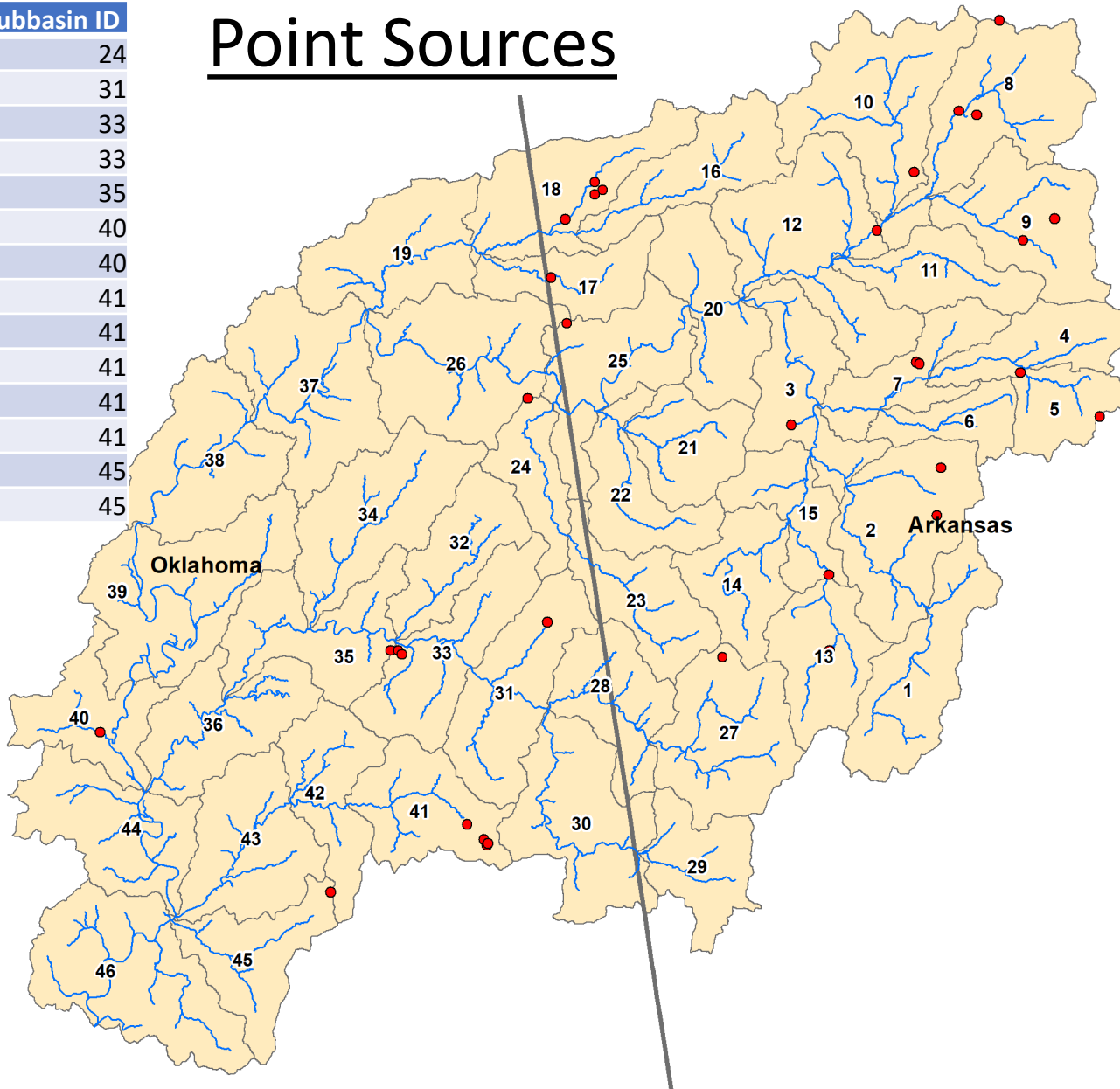
Model Set-up and Run

- IRB model created using subbasin 111101030906 (Lake Tenkiller) as outlet (HUC12 scale)
 - Model had 46 subbasins and 6,906 HRUs with a total area of 1,535.24 mi² (982,500 acres)
- All HRUs were used to ensure soil and slope compatibility from AR model
- Scenario was created and run:
 - PRISM Weather Data
 - Simulation from 1/1/1998 to 12/31/2020
 - 2-year warm-up period
 - Daily output print setting
 - SWAT model Rev 688
 - Management updated using similar values used in AR model



NPDES ID	Outfall ID	Subbasin (huc12)	Subbasin ID
OKP003073	001-A	111101030605	24
OK0028126	001-A	111101030705	31
OK0045586	003-A	111101030707	33
OK0045586	002-A	111101030707	33
OK0045586	004-A	111101030709	35
OK0026964	TX1-Q	111101030804	40
OK0026964	001-A	111101030804	40
OK0030341	001-A	111101030901	41
OK0030341	TX1-Q	111101030901	41
OKG830049	001-A	111101030901	41
OKP003044	001-A	111101030901	41
OKP003044	002-A	111101030901	41
OKG950050	001-A	111101030905	45
OKG950050	002-A	111101030905	45

Point Sources



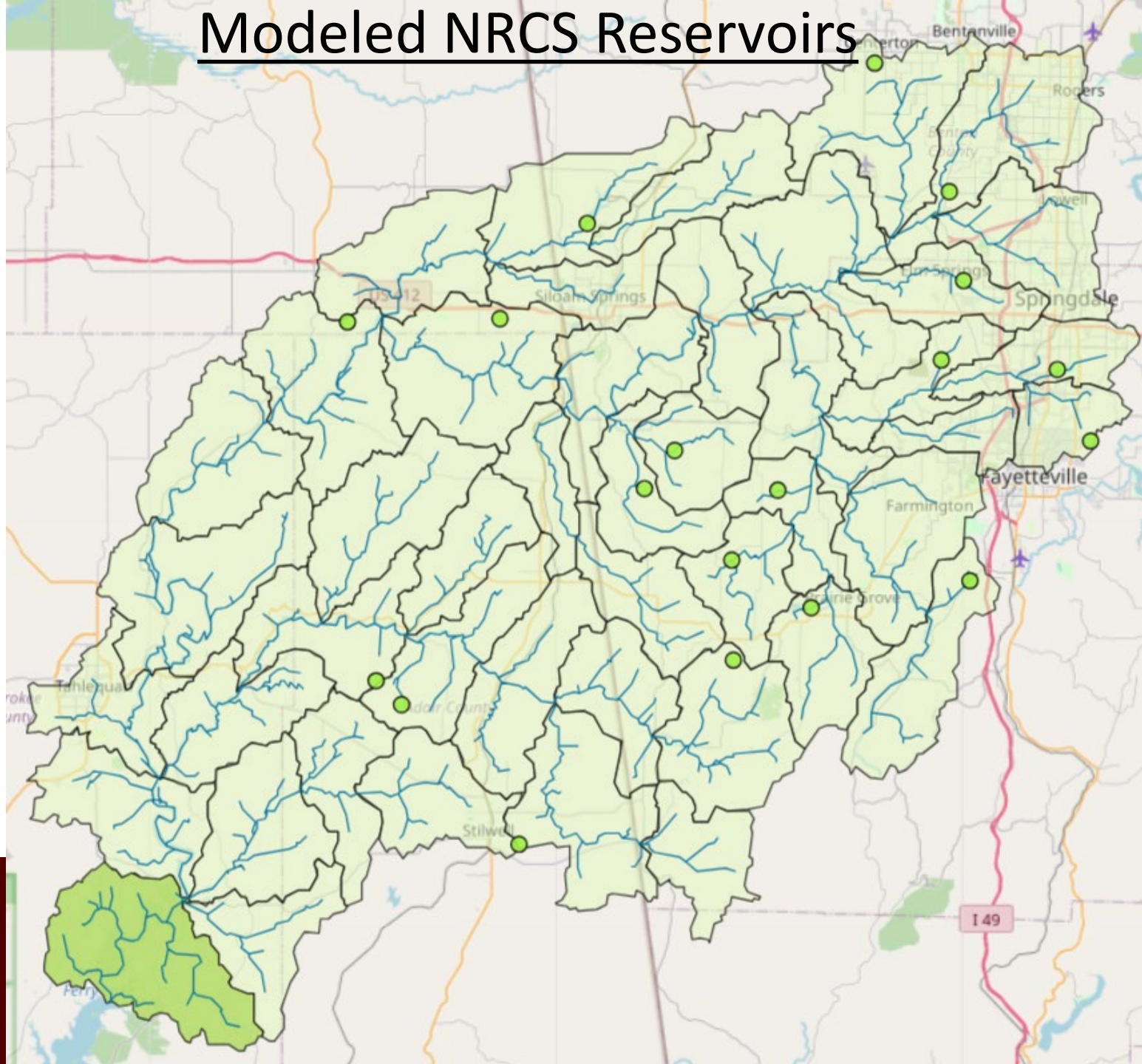
NPDES ID	Outfall ID	Subbasin (huc12)	Subbasin ID
AR0050288	001-A	111101030102	2
ARG550569	001-S	111101030102	2
AR0033910	001-A	111101030103	3
AR0033910	001-Q	111101030103	3
ARG250008	001B-A	111101030201	4
ARG250008	001A-A	111101030201	4
ARG550636	001-S	111101030202	5
ARG160045	003-A	111101030204	7
ARG160045	001-A	111101030204	7
AR0043397	001-B	111101030301	8
AR0043397	002-A	111101030301	8
AR0050652	001-A	111101030301	8
AR0022063	001-A	111101030302	9
ARG750087	001-A	111101030302	9
ARG750087	001-Q	111101030302	9
AR0052868	001-A	111101030303	10
AR0050024	001-A	111101030305	12
AR0022098	002-A	111101030401	13
ARG640066	101-A	111101030401	13
ARG640066	101-Q	111101030401	13
AR0020273	001-A	111101030502	17
AR0020184	001-A	111101030503	18
AR0037842	401-A	111101030503	18
AR0037842	001-A	111101030503	18
AR0037842	101-A	111101030503	18
ARG640175	101-A	111101030606	25
ARG640175	101-Q	111101030606	25
AR0035246	001-A	111101030701	27

Point Source modifications

- Subbasin 8 = 38 mgd
- Subbasin 16 = 9.5 mgd
- Subbasin 17 = 6.6 mgd



Modeled NRCS Reservoirs



Distribution of Managed Land

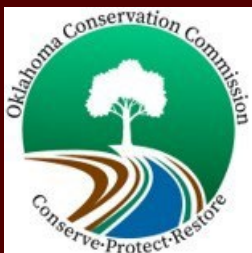
(acres)	IRB Watershed	Arkansas	Oklahoma
Total Pasture Area	427,418	289,113 (67.6%)	138,305 (32.4%)
Applied Hog Manure	6,598 (1.5%)	6,598 (2.3%)	0
Applied Dairy Manure	4,596 (1.1%)	4,596 (1.6%)	0
Grazing Cattle	385,929 (90.3%)	257,706 (89.1%)	128,223 (92.7%)
Applied Poultry Litter	30,295 (7.1%)	20,213 (7.0%)	10,082 (7.3%)
Urban Management	56,552	50,652 (89.6%)	5,901 (10.4%)



Poultry Litter Management

- March:
Application of supplemental Nitrogen
Plant Hay
- April, May, and June:
Apply Poultry Fertilizer (total of three months equivalent to average value from FTN ~1,071 lbs/ac))
- October:
Harvest Hay
- Poultry Litter was applied to ~ 7% of the pasture land across the watershed
- Value of supplemental Nitrogen applied same as FTN
- Values of Poultry Fertilizer used was the weighted average of amount applied by FTN across AR

	IRB Watershed (acres)	Arkansas (acres)	Oklahoma (acres)	Nitrogen (lbs/ac)	Poultry Fertilizer per application (lbs/ac)
Total Pasture Area	427,418	289,113 (67.6%)	138,305 (32.4%)		
Applied Poultry Litter	30,295 (7.1%)	20,213 (7.0%)	10,082 (7.3%)	79	357



Cattle Grazing Management

- Land cover status set to “growing”
- Land Cover ID set to fescue grass
- Initial leaf index set to 2
- Initial biomass set to 892 lbs/ac
- Number of heat units to bring lawn to maturity to 1500
- Minimum biomass for grazing 1,070 lbs/ac

- Mid April – Early November
Grazing Cattle for 200 days

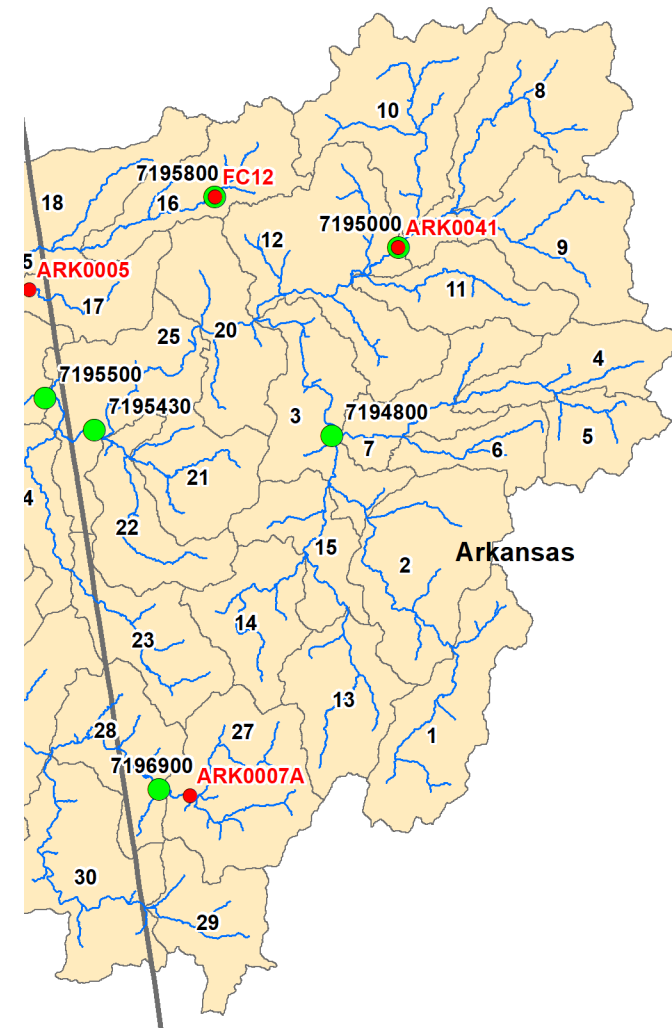
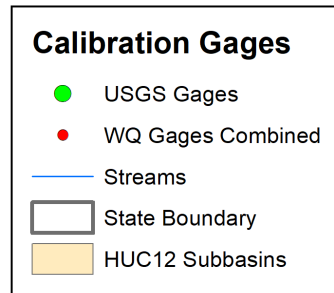
- Mid April – Late December
Grazing Cattle for 250 days

- Amount of pasture land selected was a 75/25 split between well managed (200 days) and over grazed (250 days)

	IRB Watershed (acres)	Arkansas (acres)	Oklahoma (acres)
Total Pasture Area	427,418	289,113 (67.6%)	138,305 (32.4%)
Grazing Cattle Total	385,929 (90.3%)	257,706 (89.1%)	128,223 (92.7%)
Grazing Cattle 200 Days	289,014 (74.9%)	196,325 (76.2%)	92,689 (72.3%)
Grazing Cattle 250 Days	96,915 (25.1%)	61,381 (23.8%)	35,534 (27.7%)



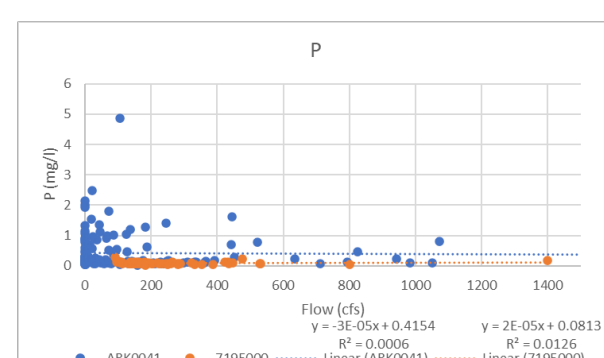
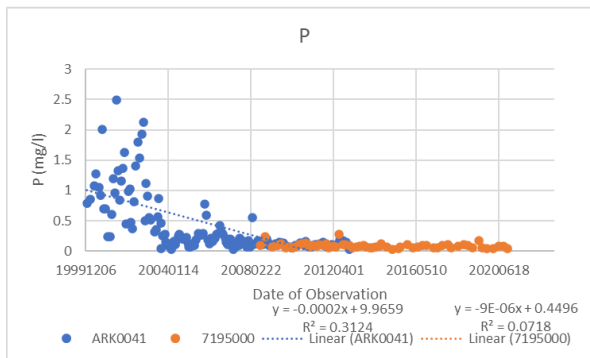
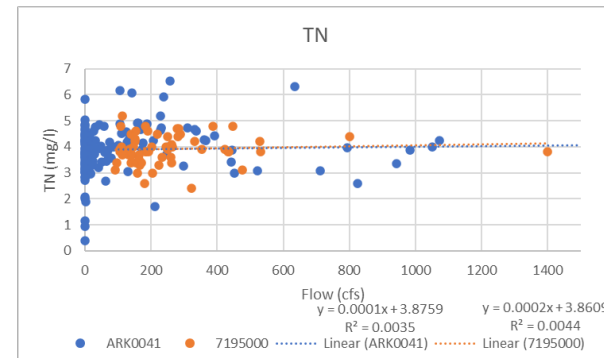
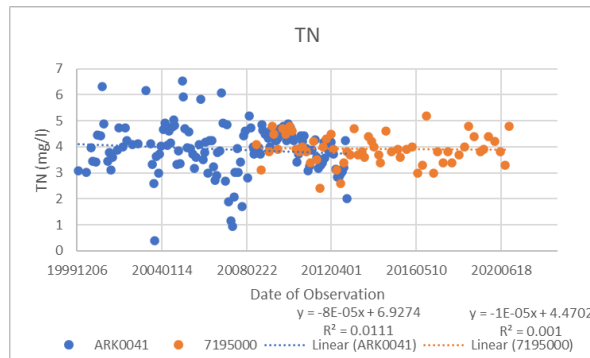
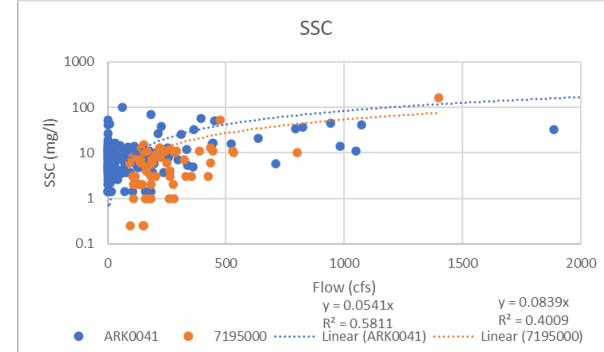
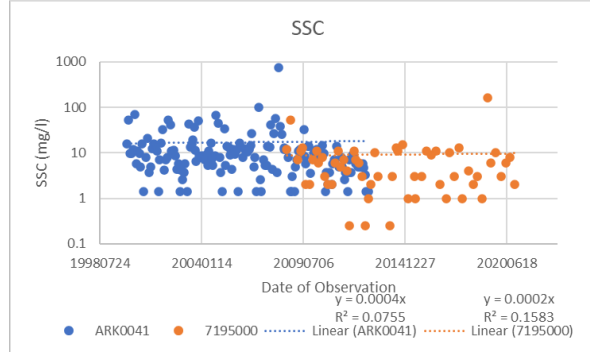
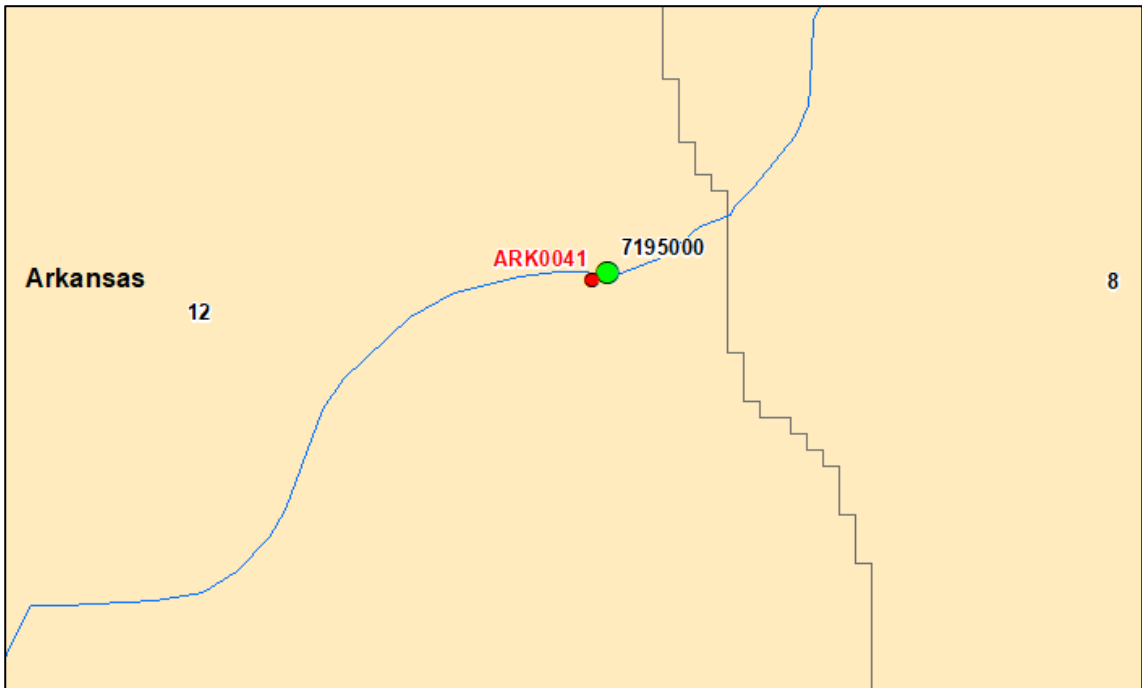
Arkansas Side of Illinois River Basin



HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	Flow Time Period	WQ Time Period	WQ Constituents
3	111101030103	07194800	1.57	10/2001-12/2020	10/2001-12/2020	NOx, OP, P, SSC,TN
8	111101030305	07195000-ARK0041	1.00	01/2000-12/2020	01/2000-12/2020	P, SSC, TN
16	111101030501	07195800 (FC12)	2.06	01/2000-12/2020	07/2009-06/2015	P, SSC, TN
25	111101030606	07195430	1.10	01/2000-12/2020	01/2000-12/2020	NOx, OP, P, SSC,TN
27	111101030701	07196900-ARK0007A	1.01	01/2000-12/2020	01/2000-12/2020	P, SSC, TN



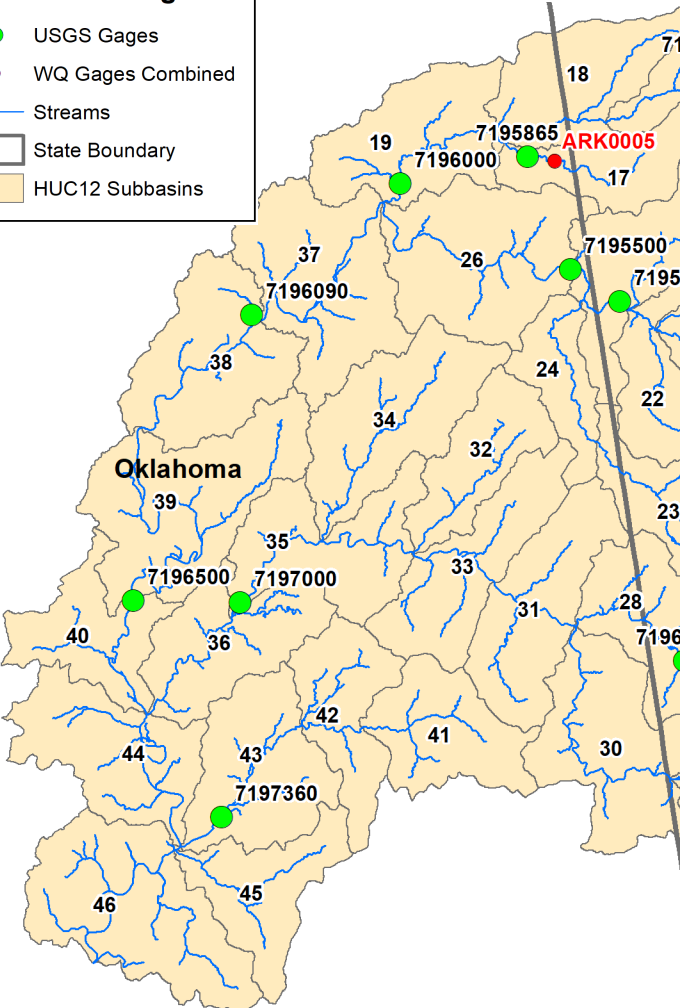
Combined Locations: ARK0041 and 07195000



Oklahoma Side of Illinois River Basin

Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- State Boundary
- HUC12 Subbasins

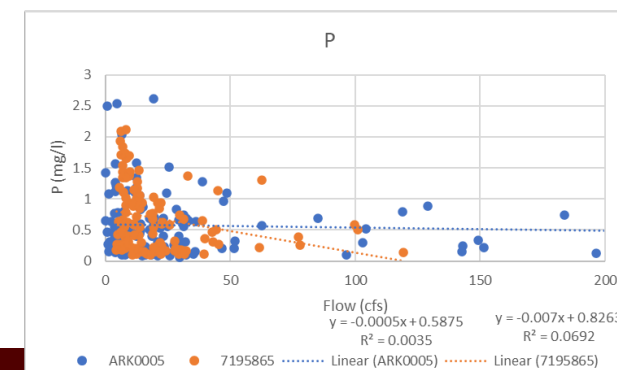
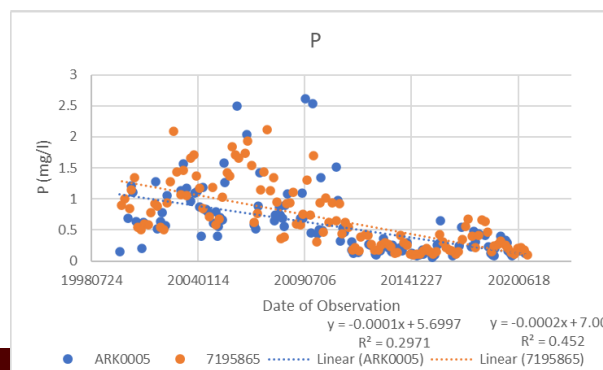
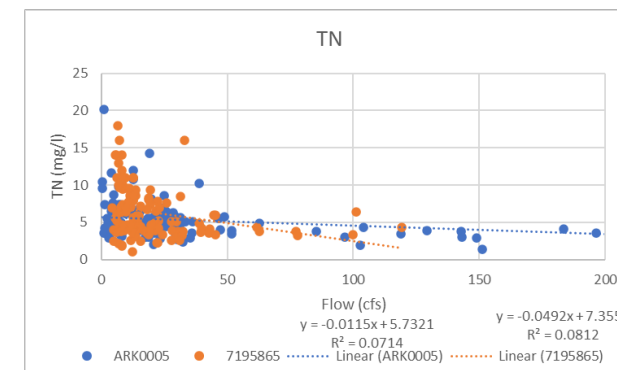
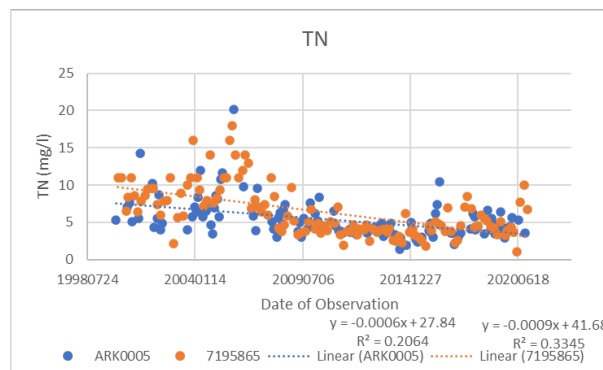
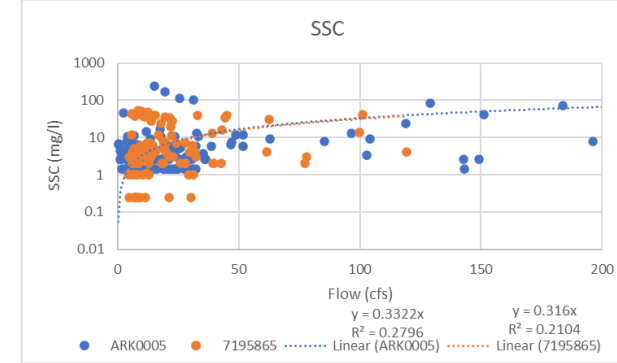
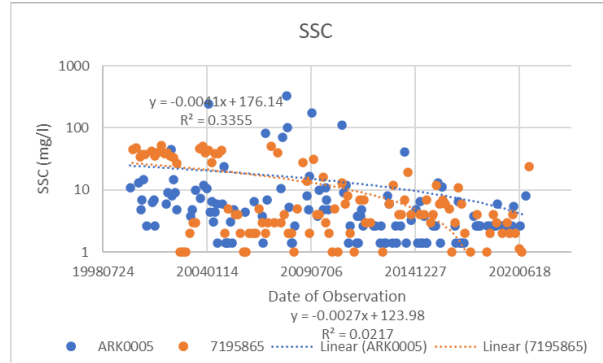
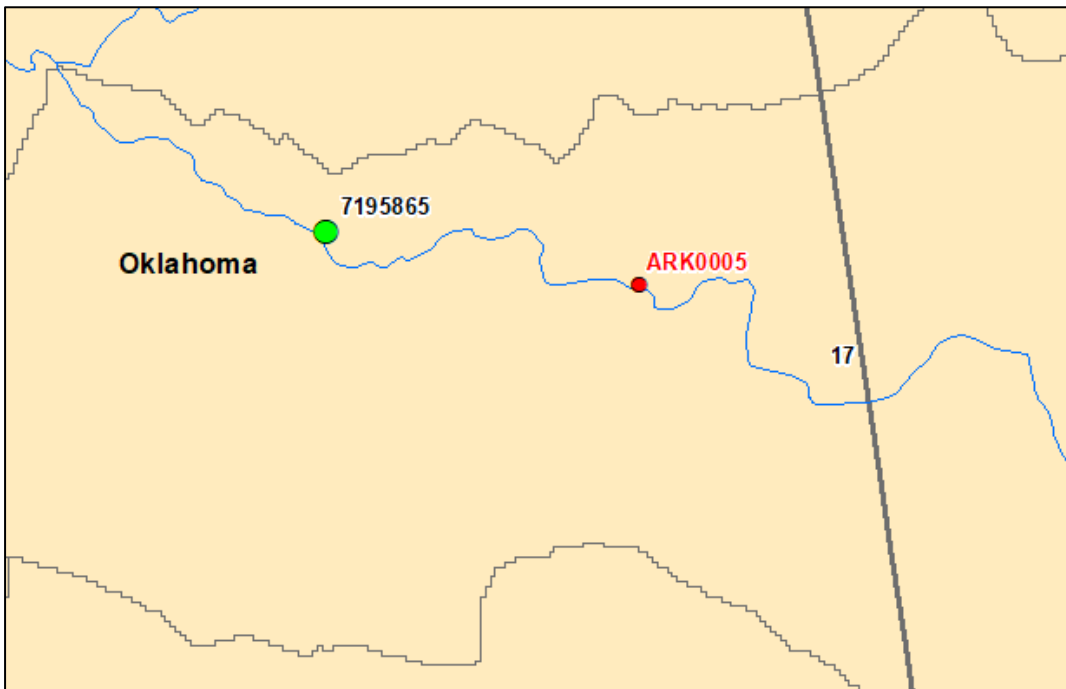


HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	Flow Time Period	WQ Time Period	WQ Constituents
17	111101030502	07195865-ARK0005	1.14	01/2000-12/2020	01/2000-12/2020	P, SSC, TN
19	111101030504	07196000	1.09	01/2000-12/2020	01/2000-12/2020	NO _x , OP, P, SSC, TN
25	111101030607	07195500	1.00	01/2000-12/2020	01/2000-12/2020	P, SSC, TN
35	111101030709	07197000	1.00	01/2000-12/2020	01/2000-12/2020	NO _x , OP, P, SSC, TN
37	111101030802	07196090	1.04	07/2010-12/2020	06/2010-12/2020	NO _x , OP, P, SSC, TN
39	111101030804	07196500	1.00	01/2000-12/2020	01/2000-12/2020	NO _x , OP, P, SSC, TN
43	111101030903	07197360*	1.05	01/2000-12/2020	01/2000-09/2010	NO _x , OP, P, SSC, TN

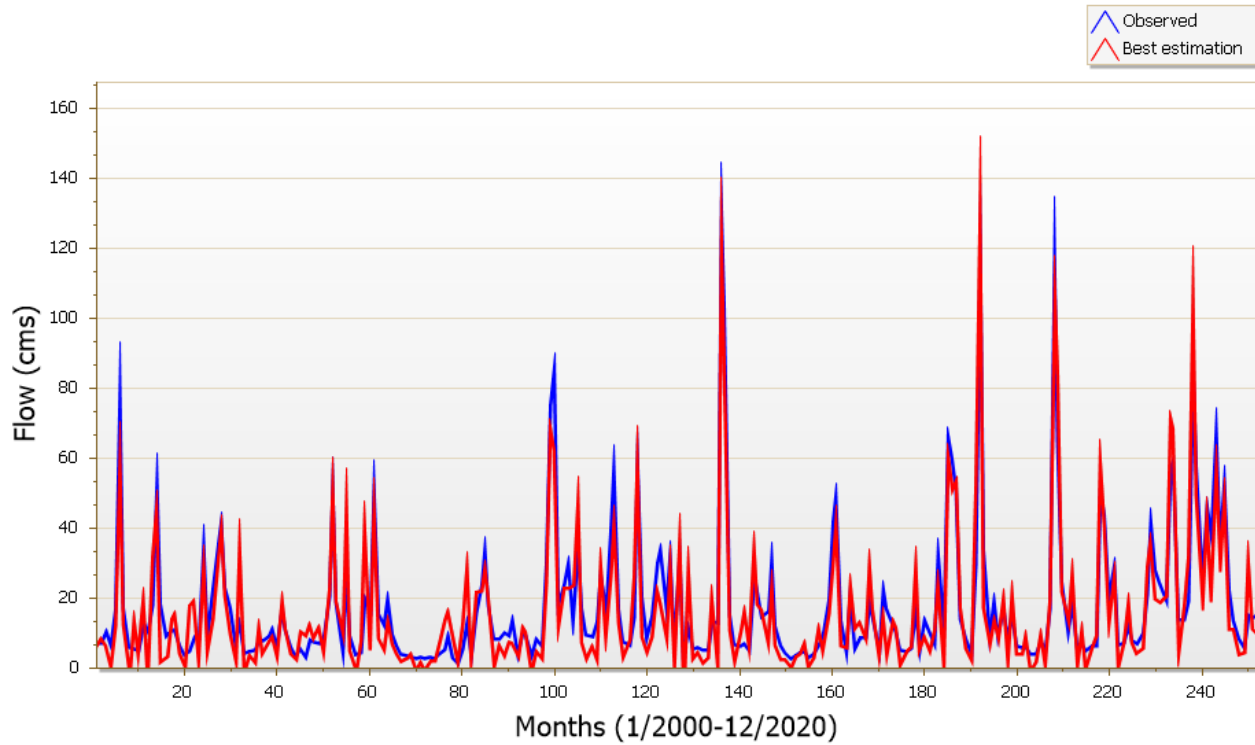
* SSC is from 2/2001 – 8/2010



Combined Locations: ARK0005 and 07195865



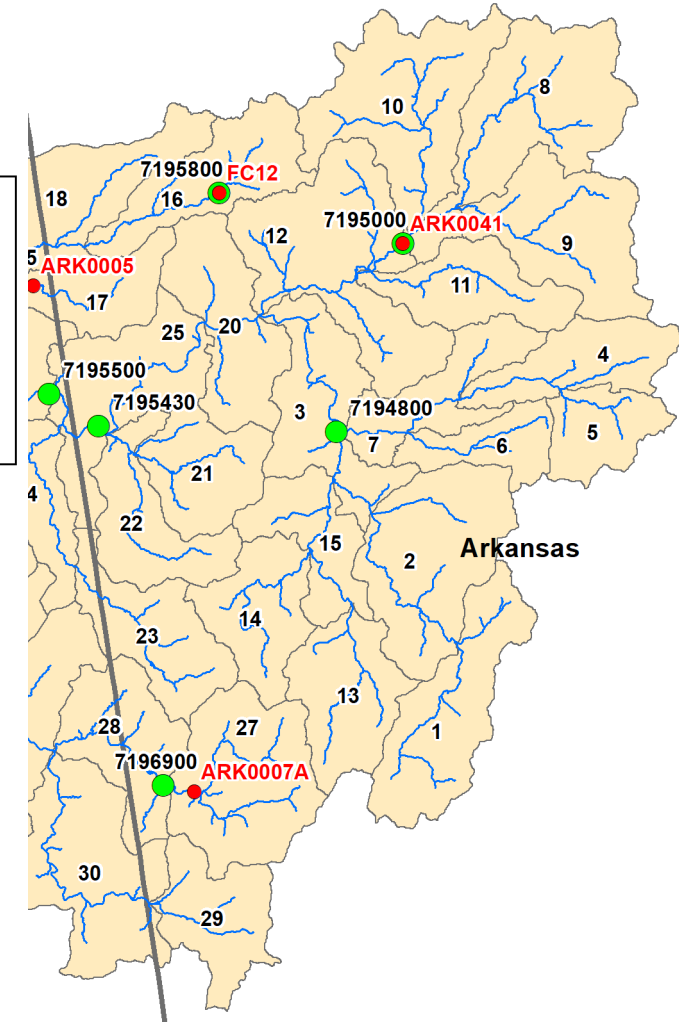
FLOW_OUT_25_7195430



Arkansas Flow Calibration

Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- ▭ State Boundary
- ▭ HUC12 Subbasins



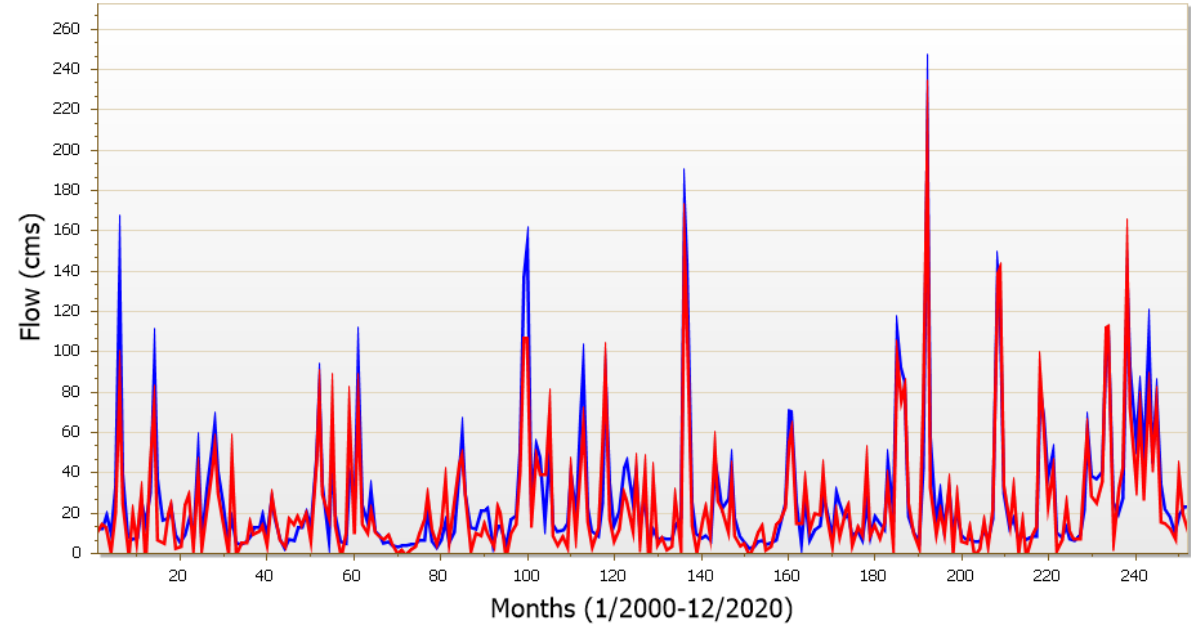
HUC12 Subbasin	HUC12 ID	USGS Gage	Flow Time Period	NSE	PBIAS	KGE
3	111101030103	07194800	10/2001-12/2020	0.85	-5.1	0.84
8	111101030305	07195000	01/2000-12/2020	0.85	-3.6	0.91
16	111101030501	07195800	01/2000-12/2020	0.63	3.2	0.8
25	111101030606	07195430	01/2000-12/2020	0.87	3.8	0.93
27	111101030701	07196900	01/2000-12/2020	0.77	-9.8	0.8



Oklahoma Flow Calibration

FLOW_OUT_39

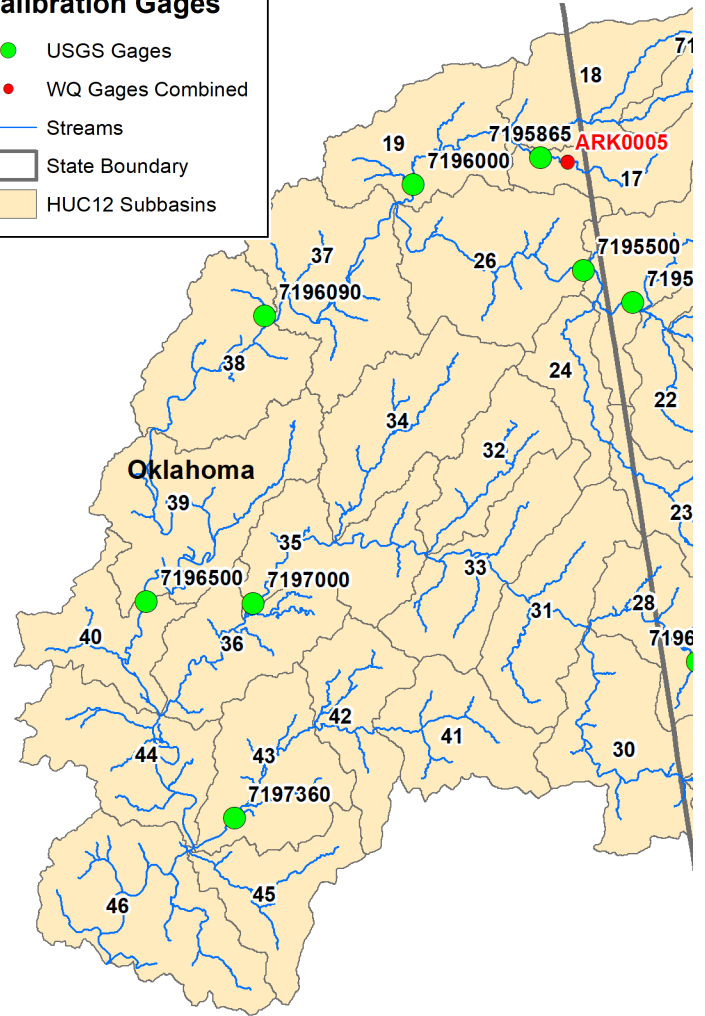
△ Observed
▲ Best estimation



HUC12 Subbasin	HUC12 ID	USGS Gage	Flow Time Period	NSE	PBIAS	KGE
17	111101030502	07195865	01/2000-12/2020	0.81	8.7	0.7
19	111101030504	07196000	01/2000-12/2020	0.81	-10.4	0.85
25	111101030607	07195500	01/2000-12/2020	0.88	7.4	0.9
35	111101030709	07197000	01/2000-12/2020	0.84	-10.6	0.84
37	111101030802	07196090	07/2010-12/2020	0.91	-2.9	0.94
39	111101030804	07196500	01/2000-12/2020	0.87	6.3	0.88
43	111101030903	07197360	01/2000-12/2020	0.76	-14	0.81

Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- State Boundary
- HUC12 Subbasins



Calibration Parameters use for Flow

Parameter Name	Description	Fitted Value	Minimum Value	Maximum Value
V__EPCO.hru	Plant uptake compensation factor	0.745	0.5	1
R__CN2.mgt	Initial SCS runoff curve number for moisture condition II	0.048	-0.1	0.1
V__ALPHA_BF.gw	Baseflow alpha factor	0.067	0.005	0.1
A__GW_DELAY.gw	Groundwater delay	1.25	-30	90
A__GWQMN.gw	Threshold depth of water in the shallow aquifer required for return flow to occur	937.50	-1000	1000
V__GW_REVAP.gw	Groundwater revap coefficient	0.046	0.02	0.1
A__RCHRG_DP.gw	Deep aquifer percolation fraction	-0.036	-0.05	0.05
A__REVAPMN.gw	Threshold depth of water in the shallow aquifer for revap to occur	-265.63	-750	750
V__ESCO.hru	Soil evaporation compensation factor	0.712	0.6	0.85
R__SOL_AWC(..).sol	Available water capacity of the soil layer	-0.014	-0.05	0.05
V__CANMX.hru	Maximum canopy storage	4.90	0	10
V__SLSOIL.hru	Slope length for lateral subsurface flow	17.19	0	150
V__LAT_TTIME.hru	Lateral flow travel time	0.73	0	14
V__ALPHA_BF_D.gw	Baseflow alfa factor for deep aquifer	1.00	0	1

R = multiplied by (1+fittedvalue), V = replaced, A = added to.



USGS LOAD ESTimator (LOADEST)

- Created by USGS to estimate constituent loads in streams and rivers
- Inputs
 - time series of streamflow, dates and time of observations, and constituent concentration
- Develops a regression model for the estimation of constituent load (calibration)
 - Mean load estimates, standard errors, and 95 percent confidence intervals are developed on a monthly and(or) seasonal basis
- Calibration and estimation procedures within LOADEST are based on three statistical estimation methods
 - **Adjusted Maximum Likelihood Estimation (AMLE)** and Maximum Likelihood Estimation (MLE)
 - appropriate when the calibration model errors (residuals) are normally distributed
 - Absolute Deviation (LAD), is an alternative when the residuals are not normally distributed
- LOADEST output includes diagnostic tests and warnings to assist in interpreting the estimated loads
 - B_p = Concentration Bias in Percent
 - Positive (negative) values indicate over (under) estimation.
 - *****The model should not be used when the + or - bias exceeds 25%*****
 - PCR = Partial Concentration Ratio
 - Values > 1 indicate overestimation; values < 1 indicate underestimation
 - E = Nash Sutcliffe Efficiency Index
 - E = 1; a perfect fit to observed data.
 - E = 0; model estimates are as accurate as the mean of observed data
 - E < 0 ; the observed mean is a better estimate than the model estimates



LOADEST Statistics

* Values in **red** indicate LOADEST results may not be statistically acceptable to use

Bp = Bias Percent

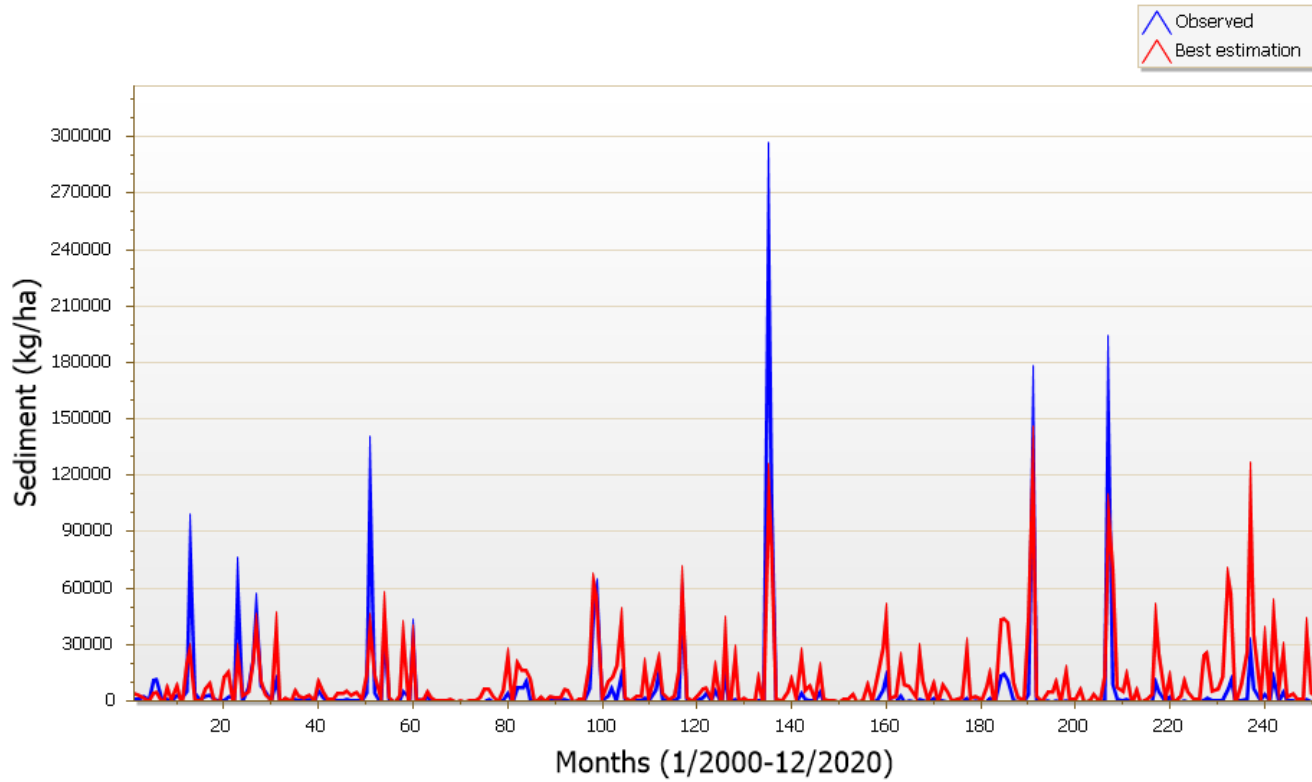
PCR = Partial Load Ratio

E = Nash Sutcliffe Efficiency

Station	State	Sub. HUC12 ID	Sediment			TN			P			OP			NOx		
			Bp [%]	PCR	E	Bp [%]	PCR	E	Bp [%]	PCR	E	Bp [%]	PCR	E	Bp [%]	PCR	E
07194800	AR	3 111101030103	-2.91	0.971	0.54	0.79	1.008	0.28	-7.21	0.928	0.47	2.52	1.025	0.07	4.30	1.043	0.36
07195000-ARK0041	AR	8 111101030305	29.48	1.295	-2.43	1.41	1.014	0.12	-6.58	0.934	0.44						
FC12 (07195800)	AR	16 111101030501	-34.16	0.658	0.57	0.09	1.001	0.23	-11.51	0.885	0.55						
07195430	AR	25 111101030606	28.77	1.288	-1.16	0.42	1.004	0.47	3.23	1.032	0.42	4.78	1.048	0.53	0.19	1.002	0.47
07196900-ARK0007A	AR	27 111101030701	-15.40	0.846	0.22	3.79	1.038	0.34	-0.58	0.994	0.30						
07195865-ARK0005	OK	17 111101030502	-8.94	0.911	0.46	0.01	1	0.44	1.75	1.017	0.45						
07196000	OK	19 111101030504	81.29	1.813	-7.96	0.77	1.008	0.53	-0.03	1	0.61	0.26	1.003	0.62	0.76	1.008	0.56
07195500	OK	25 111101030607	26.04	1.26	-0.96	0.42	1.004	0.46	2.95	1.03	0.43						
07197000	OK	35 111101030709	70.20	1.702	-6.16	1.61	1.016	0.60	3.66	1.037	0.28	0.79	1.008	0.72	4.49	1.045	0.56
07196090	OK	37 111101030802	21.82	1.218	0.42	0.52	1.005	0.68	2.32	1.023	0.59	1.81	1.018	0.65	0.68	1.007	0.55
07196500	OK	39 111101030804	45.31	1.453	-2.60	1.35	1.014	0.69	7.94	1.079	0.37	5.65	1.056	0.57	3.45	1.034	0.54
07197360	OK	43 111101030903	-22.36	0.776	0.57	0.59	1.006	0.69	-1.39	0.986	0.64	0.03	1	0.43	4.27	1.043	0.56



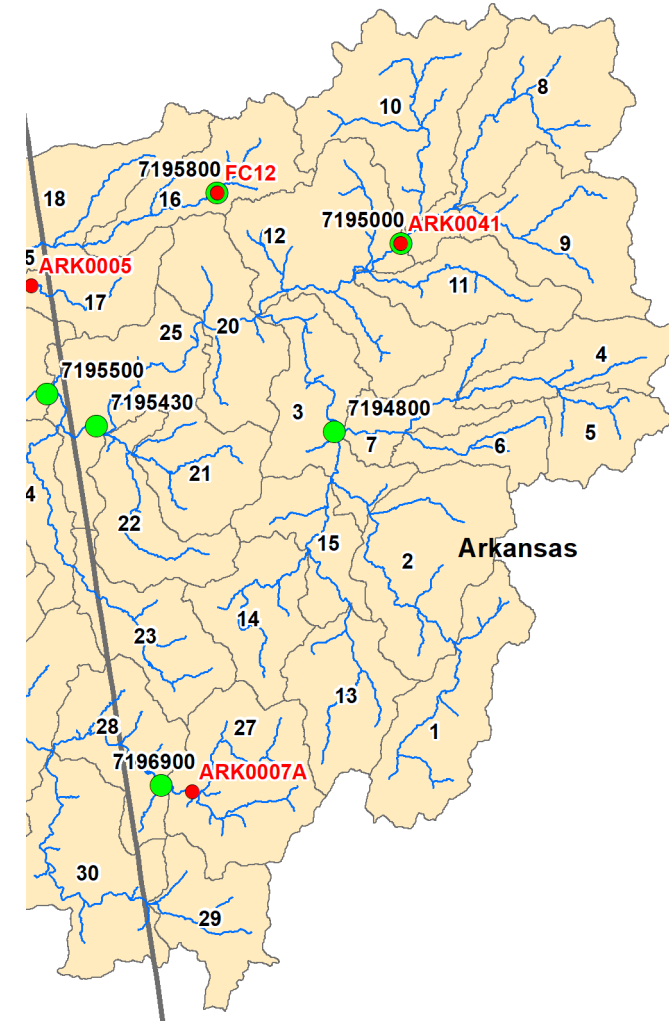
SED_OUT_25_07195430



Arkansas Sediment Calibration

Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- State Boundary
- HUC12 Subbasins



HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	NSE	PBIAS	KGE
3	111101030103	07194800	1.57	10/2001-12/2020	0.37	-70.7	0.07
8	111101030305	07195000-ARK0041	1.00	01/2000-12/2020	0.09	66.1	-0.17
16	111101030501	07195800 (FC12)	2.06	07/2009-06/2015	0.15	-28.3	0.03
25	111101030606	07195430	1.10	01/2000-12/2020	0.51	-66.3	0.24
27	111101030701	07196900-ARK0007A	1.01	01/2000-12/2020	-63.14	-1416.2	-14.3

Red subbasin numbers indicate observations from LOADEST might not be acceptable

Purple subbasin numbers indicate model needs further investigation

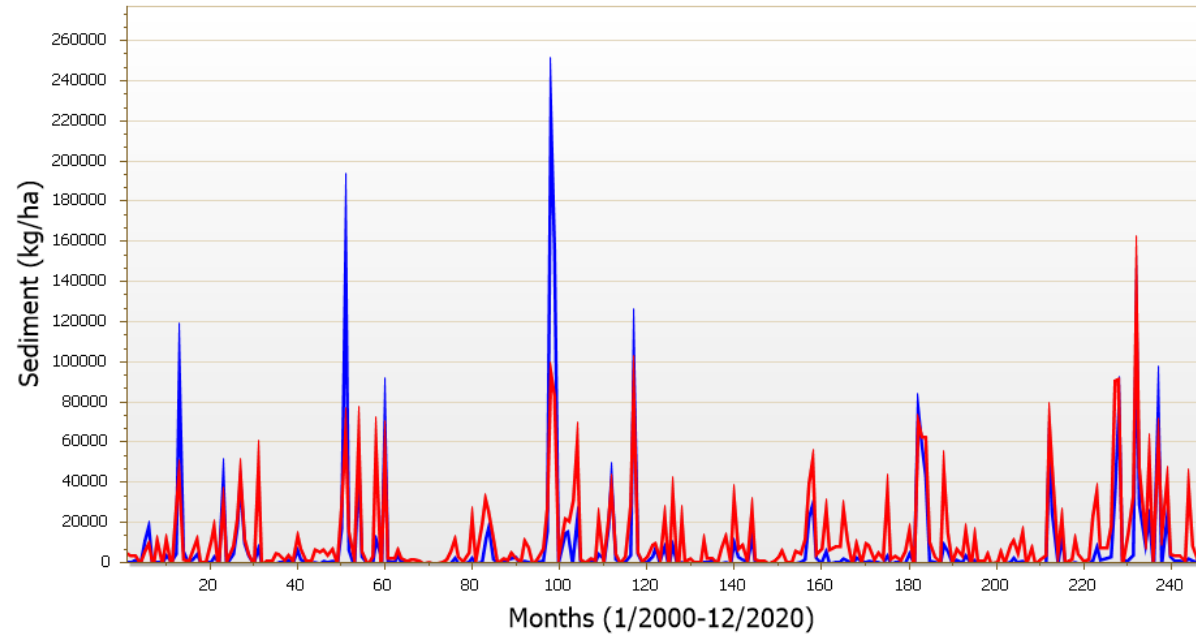


TEXAS A&M
AGRI LIFE
RESEARCH

Oklahoma Sediment Calibration

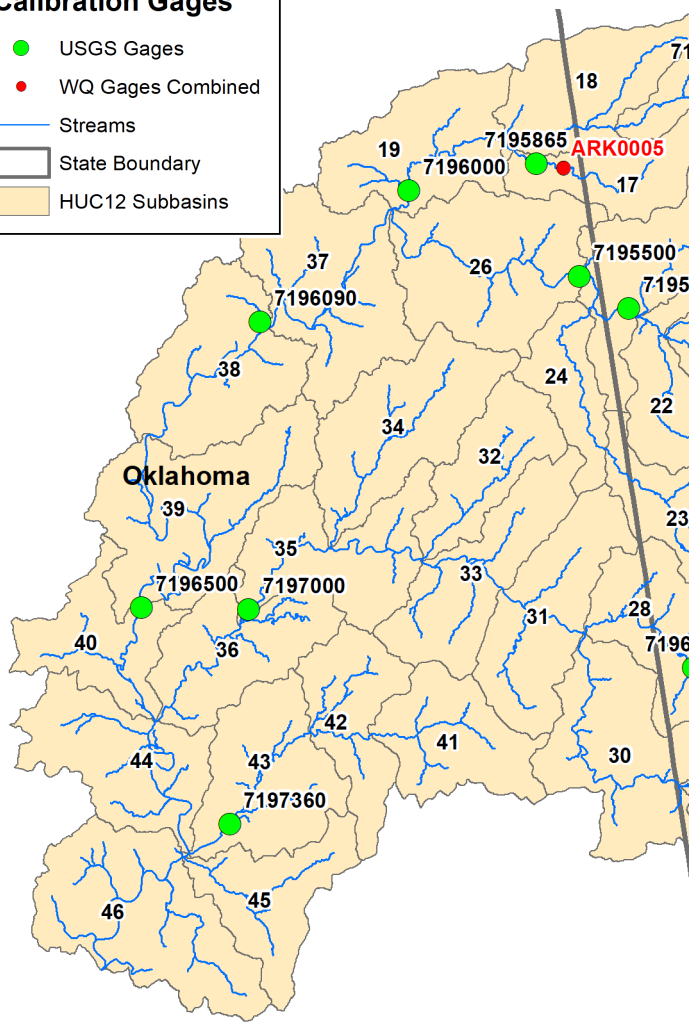
SED_OUT_39

△ Observed
△ Best estimation



Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- State Boundary
- HUC12 Subbasins



HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	NSE	PBIAS	KGE
17	111101030502	07195865-ARK0005	1.14	01/2000-12/2020	-0.64	-236.4	-1.44
19	111101030504	07196000	1.09	01/2000-12/2020	0.07	-176.4	-0.8
25	111101030607	07195500	1.00	01/2000-12/2020	0.53	-61.1	0.28
35	111101030709	07197000	1.00	01/2000-12/2020	0.35	-62.6	0.13
37	111101030802	07196090	1.04	06/2010-12/2020	0.55	-39.1	0.44
39	111101030804	07196500	1.00	01/2000-12/2020	0.61	-47.9	0.43
43	111101030903	07197360	1.05	02/2001-08/2010	-0.47	-156.5	-0.64

Red subbasin numbers indicate observations from LOADEST might not be acceptable
Purple subbasin numbers indicate model needs further investigation



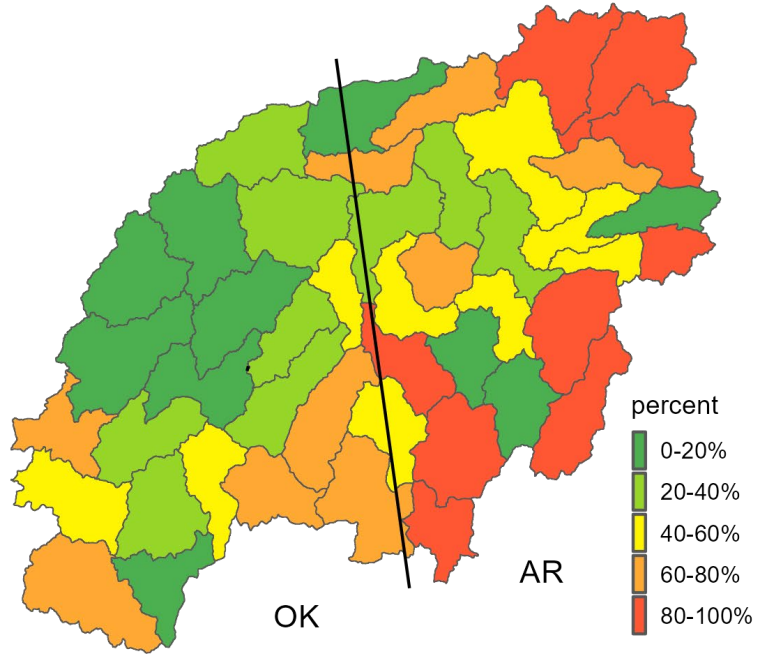
Calibration Parameters use for Sediment, Phosphorus, and Nitrogen

Parameter Name	Description	Fitted Value	Minimum Value	Maximum Value
v__CH_COV1.rte	Channel erodibility factor	0.31	0.3	0.7
v__CH_COV2.rte	Channel cover factor	0.02	0.005	0.2
v__SPCON.bsn	Maximum amount of sediment that can be reentrained	0.006	0.0001	0.01
v__SPEXP.bsn	Sediment reentrained in channel sediment routing	1.4	1.0	2.0
v__ADJ_PKR.bsn	Peak rate adjustment factor for sediment routing in the subbasin	0.9	0.5	2.0
v__PRF_BSN.bsn	Peak rate adjustment factor for sediment routing in the main channel	0.1	0	2.0
v__P_UPDIS.bsn	Phosphorus uptake distribution parameter	77.29	20	100
v__PPERCO.bsn	Phosphorus percolation coefficient	13.28	10	17.5
v__PHOSKD.bsn	Phosphorus soil partitioning coefficient	179.69	150	200
v__PSP.bsn	Phosphorus sorption coefficient	0.60	0.01	0.7
v__ERORGP.hru (Pasture)	Organic P enrichment ratio	0.32	0	5
v__CDN.bsn	Denitrification exponential rate coefficient	1.11	1.0	1.2
V__CMN.bsn	Rate factor for humus mineralization of active organic N	0.0025	0.001	0.003
v__NPERCO.bsn	Nitrogen percolation coefficient	0.99	0	1.0
V__RSDCO.bsn	Residue decomposition coefficient	0.07	0.02	0.1
V__SDNCO.bsn	Denitrification threshold water content	0.93	0.6	1.0
V__N_UPDIS.bsn	Nitrogen uptake distribution parameter	94.79	0	100

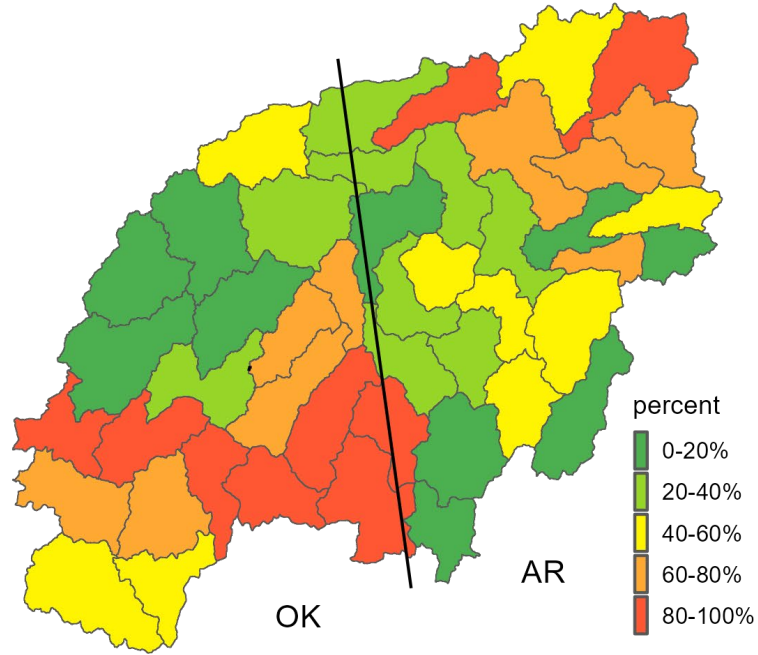
R = multiplied by (1+fittedvalue), V = replaced, A = added to.

IRB Hydrology and Sediment - Annual Mean Quantiles (2000-2020)

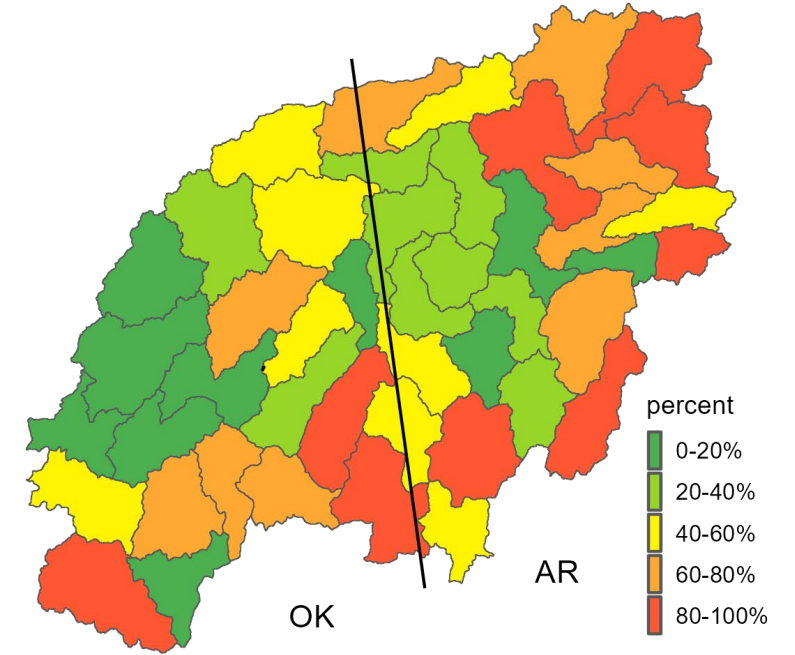
Surface Runoff



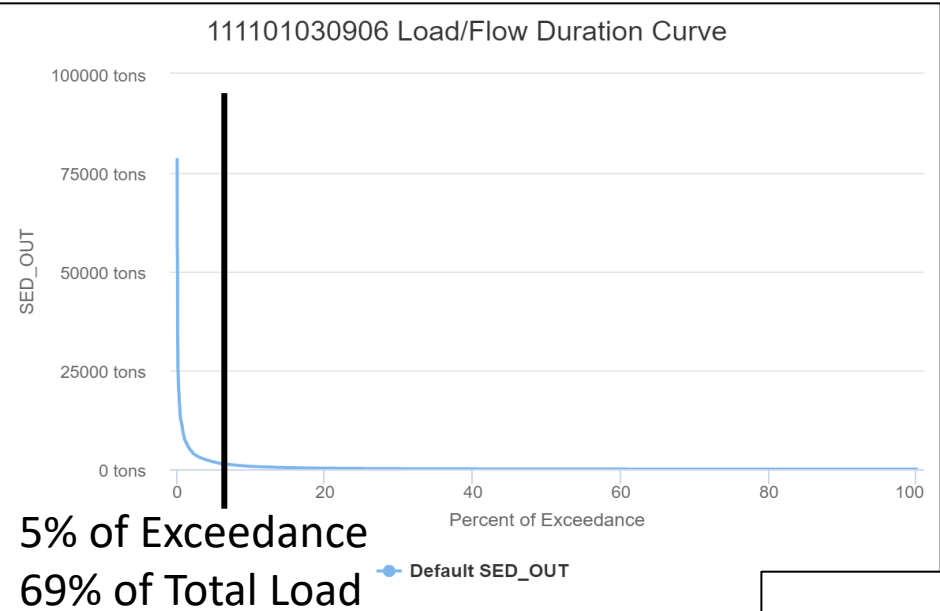
Groundwater Flow



Total Sediment to River

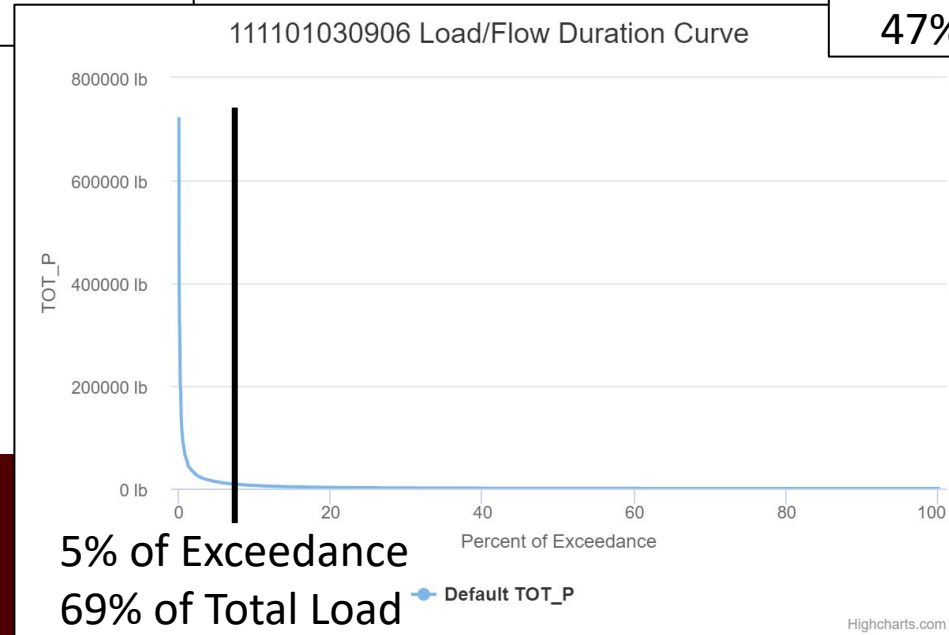
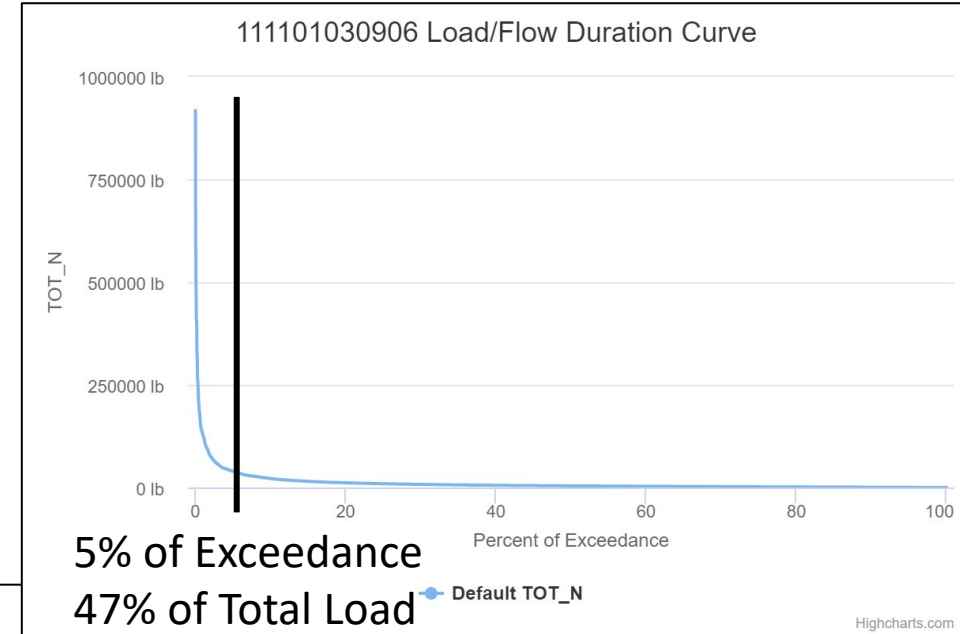


Water Quality Calibration Results - Overview



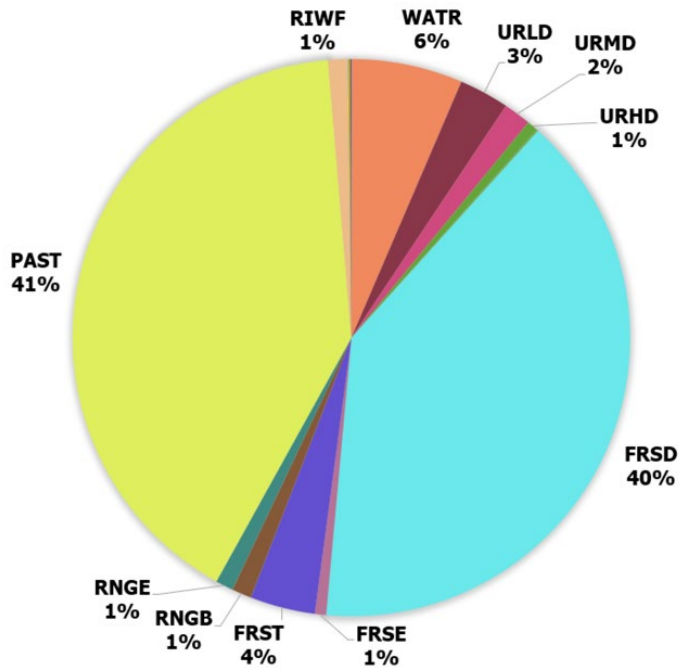
Example Loading at the outlet of the IRB

Across the watershed most of the sediment and nutrient loading is happening during extreme flow/rainfall events (top 5%)



Loading by Land Use

IRB Land Use Distribution



	Total N (lbs)	Total P (lbs)	Sediment (tons)
All Land	7,779,606	733,666	419,162
Range Land (2%)	125,481 (2%)	7,037 (1%)	6,971 (2%)
Forest Land (45%)	1,446,443 (19%)	62,038 (8%)	33,419 (8%)
Pasture Land (41%)	5,722,283 (74%)	624,137 (85%)	286,770 (68%)
Urban Land (6%)	399,811 (5%)	35,943 (5%)	37,161 (9%)
Other Land (6%)	85,589 (1%)	5,412 (1%)	54,841 (13%)



Continuation of Work

- Load contributions and allocations
- Scenario development
- Analysis between high flow and base flow
- Point source contributions





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Urban Management

- Land cover status set to “growing”
- Land Cover ID set to “lawn”
- Initial leaf index set to 2
- Initial biomass set to 892 lbs/ac
- Number of heat units to bring lawn to maturity to 2000
- Automatic Fertilization
 - Nitrogen application when stress factor falls below 0.8
 - Phosphorus application when stress factor falls below 0.5
- Automatic Irrigation
 - 1” of irrigation applied when soil moisture falls below 60%
- Mowing
 - Lawn mowed 6 times per growing cycle of grass

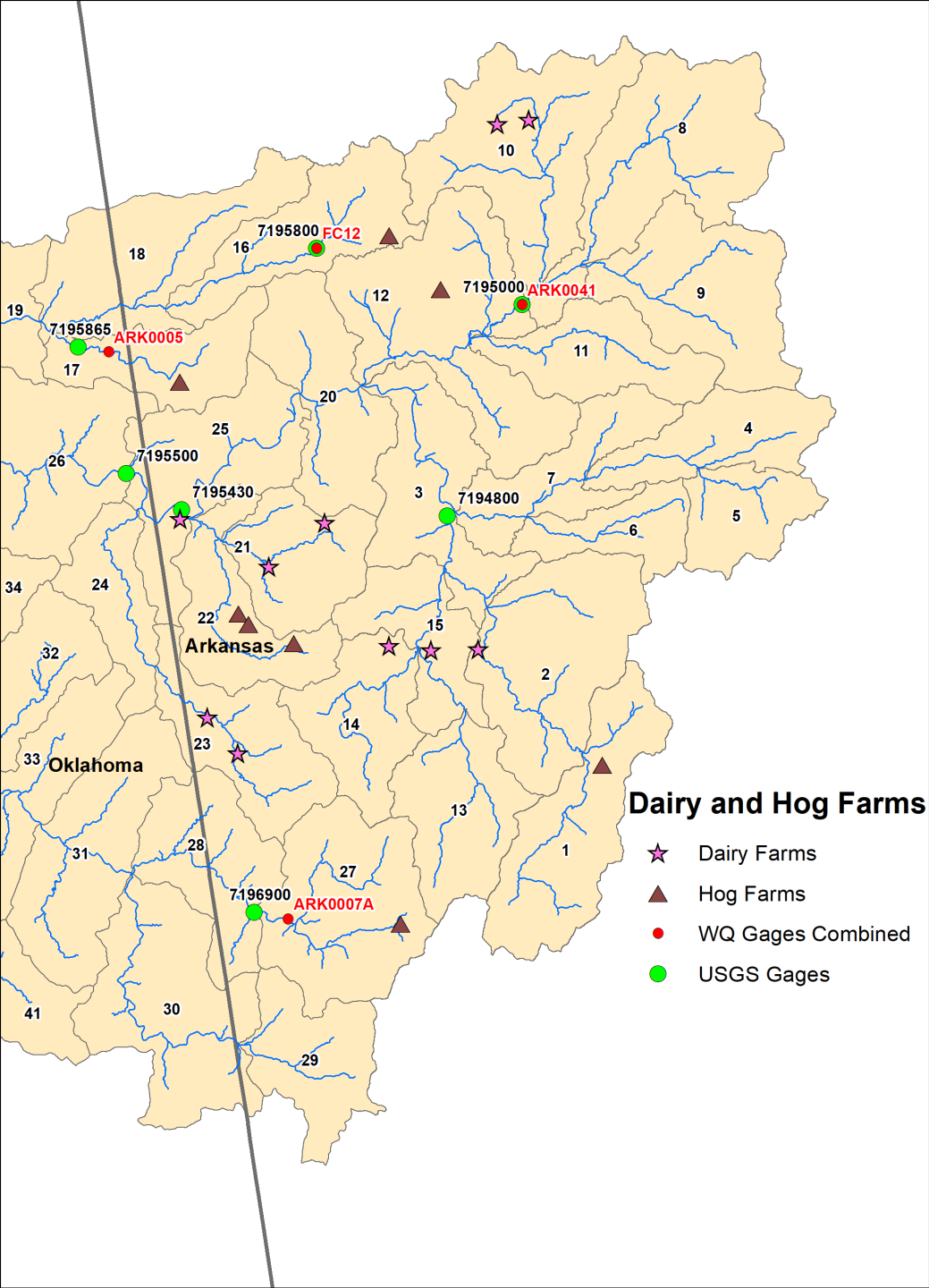
- Applied to all urban land within the watershed
- Values selected using common practices for urban land

	IRB Watershed (acres)	Arkansas (acres)	Oklahoma (acres)	Nitrogen Application Range (lbs/ac)	Phosphorus Application Range (lbs/ac)	Irrigation per application (in.)
Urban Management	56,552	50,652	5,901	160 - 178	27 - 45	1



Hog and Dairy Farm Management

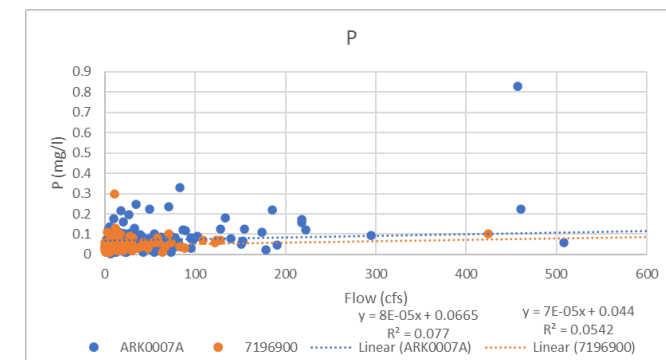
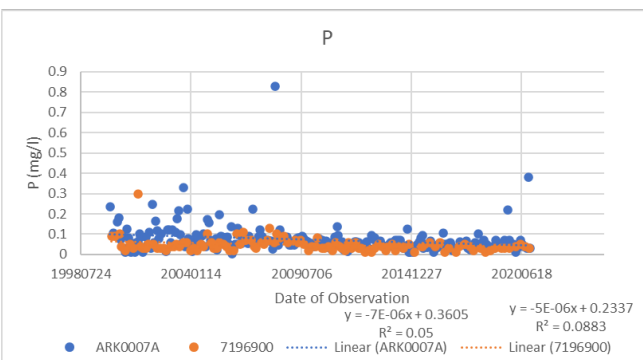
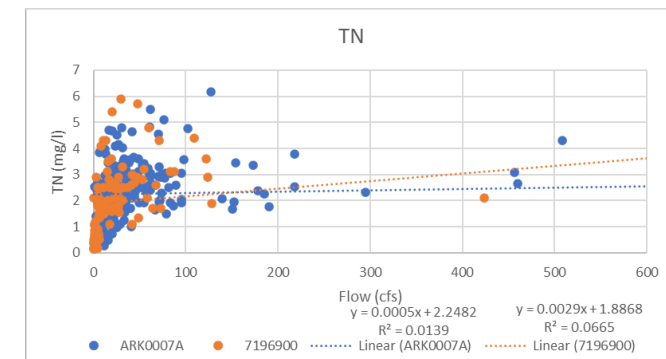
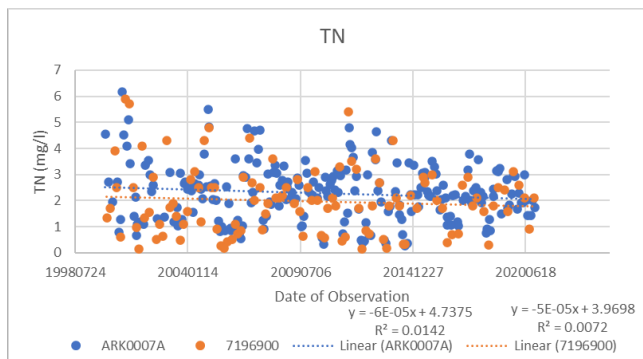
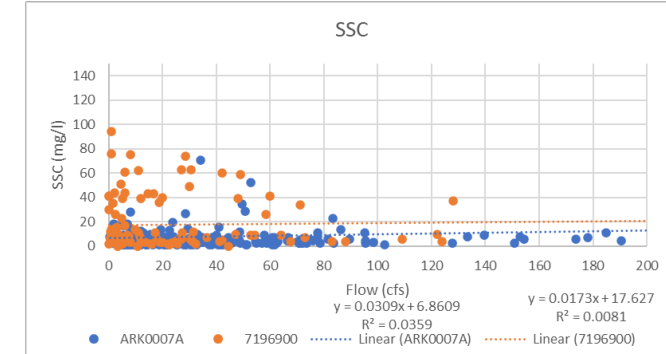
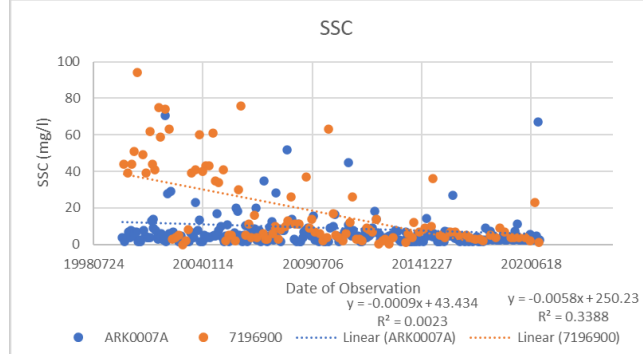
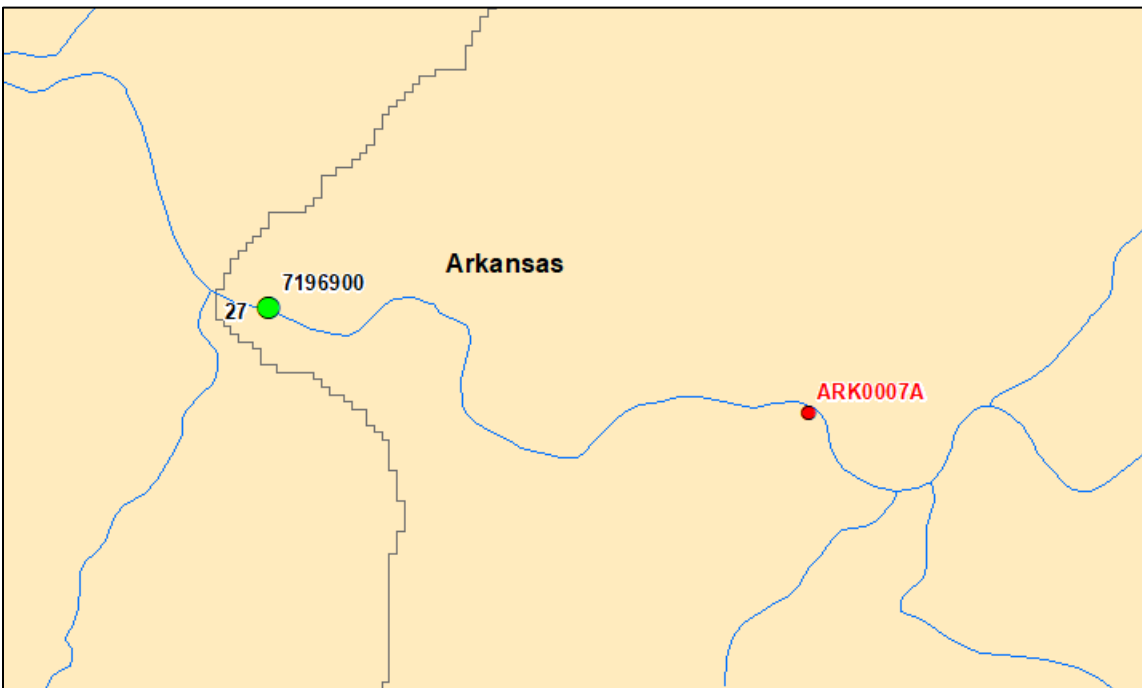
- March:
Plant Hay
- March, June, September, and December:
Apply Nitrogen and Phosphorus
Harvest Hay
- Locations of farms provided by FTN
- Values of N and P used are average of values used by FTN with highest and lowest farms removed from average



	Arkansas Area (acres)	Nitrogen Applied per application (lbs/ac)	Phosphorus Applied per application (lbs/ac)
Total Pasture Area	289,113		
Applied Hog Manure	6,598 (2.3%)	146.3	102.5
Applied Dairy Manure	4,596 (1.6%)	353.6	155.0

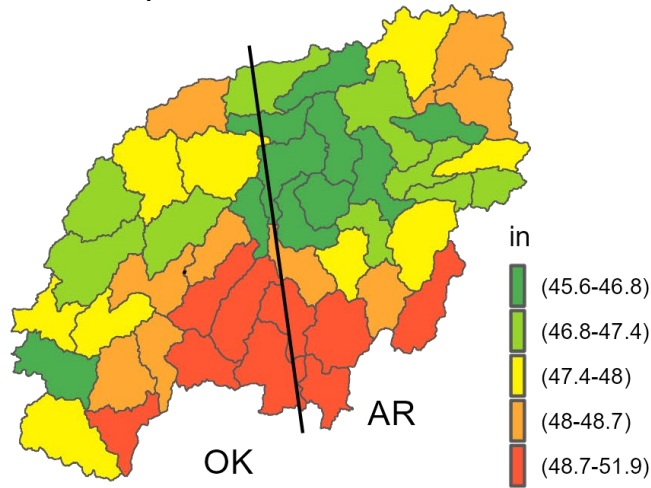


Combined Locations: ARK0007A and 07196900

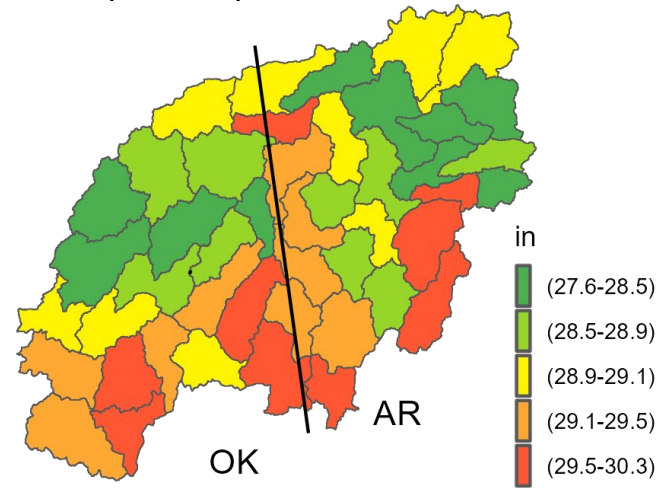


IRB Hydrology and Sediment - Annual Mean (2000-2020)

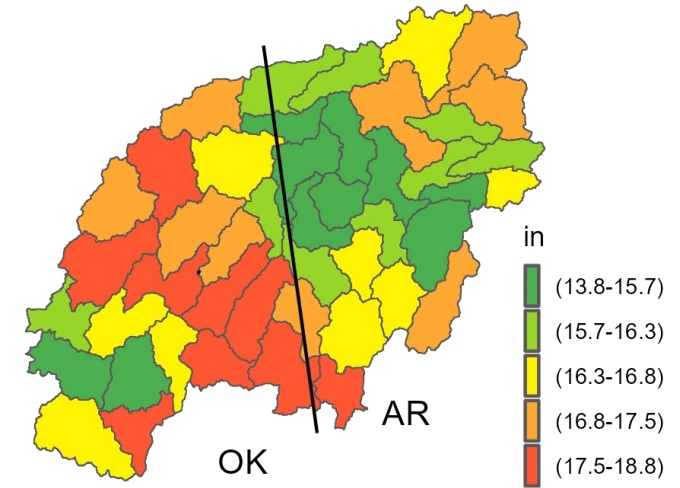
Precipitation



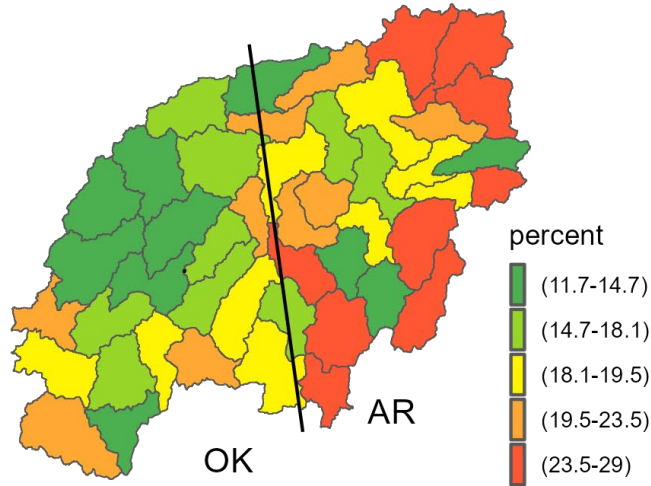
Evapotranspiration



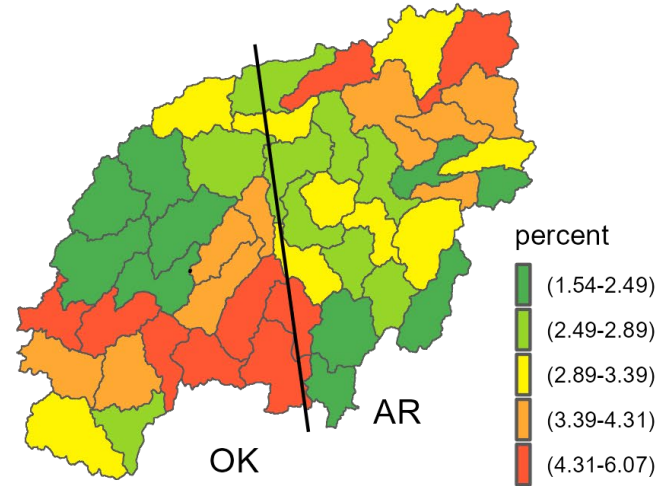
Total Runoff to River



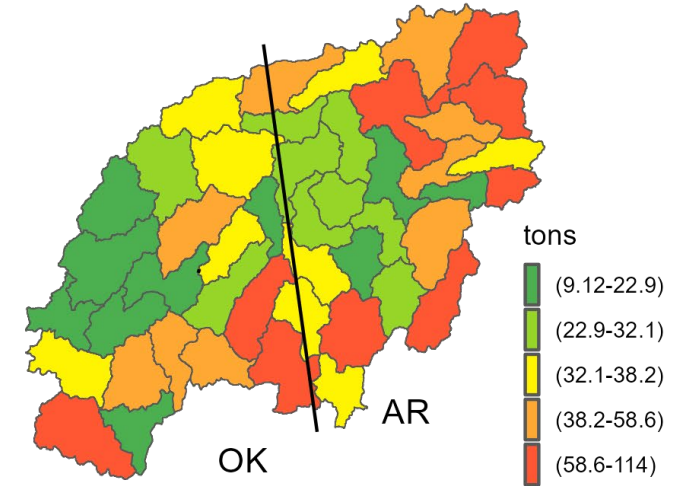
% of Surface Runoff to Precip



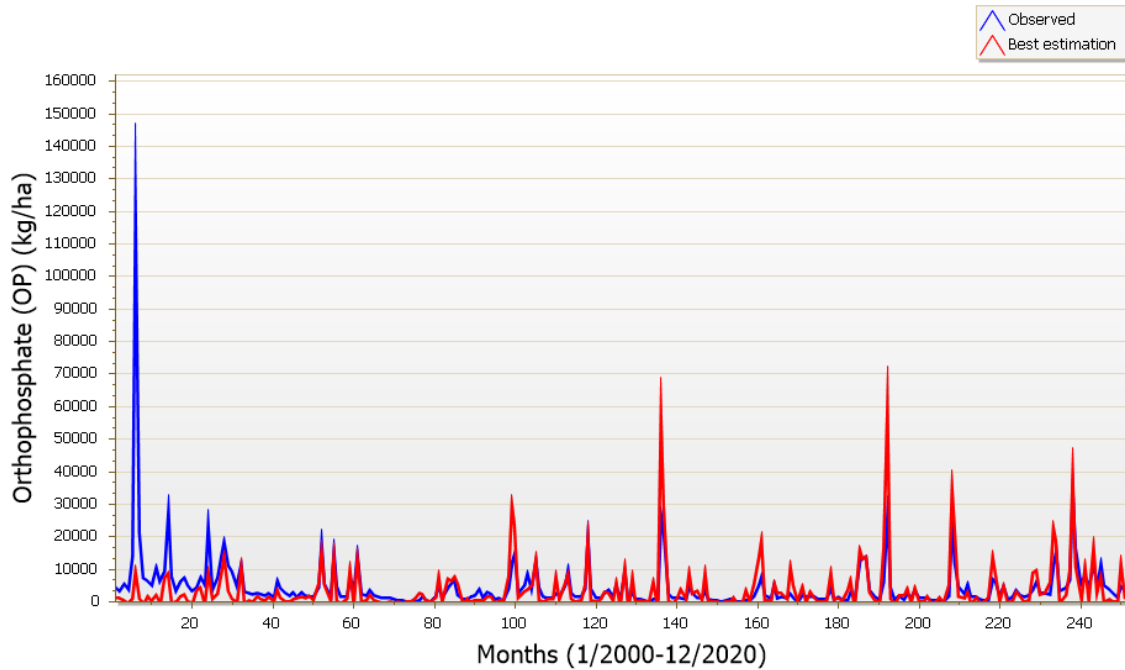
% of Groundwater Flow to Precip



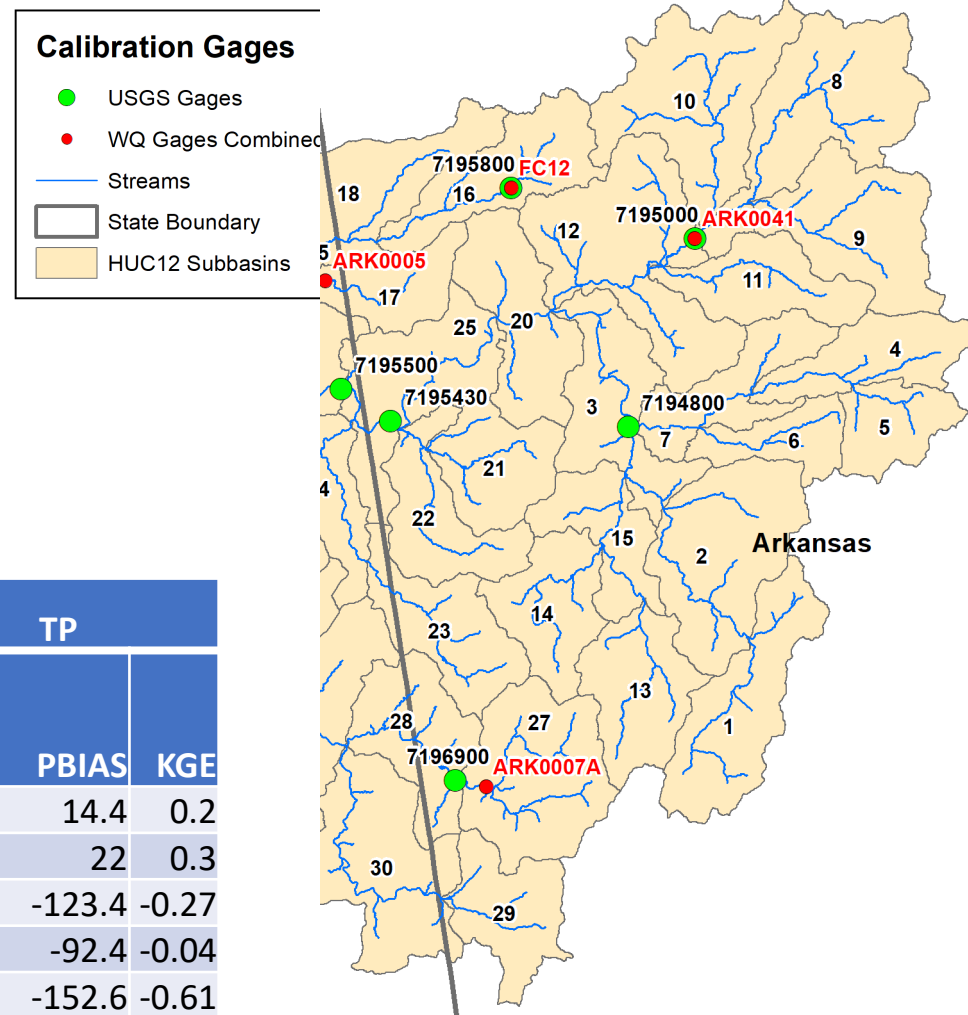
Total Sediment to River



OP_OUT_25_7195430



Arkansas Phosphorus Calibration



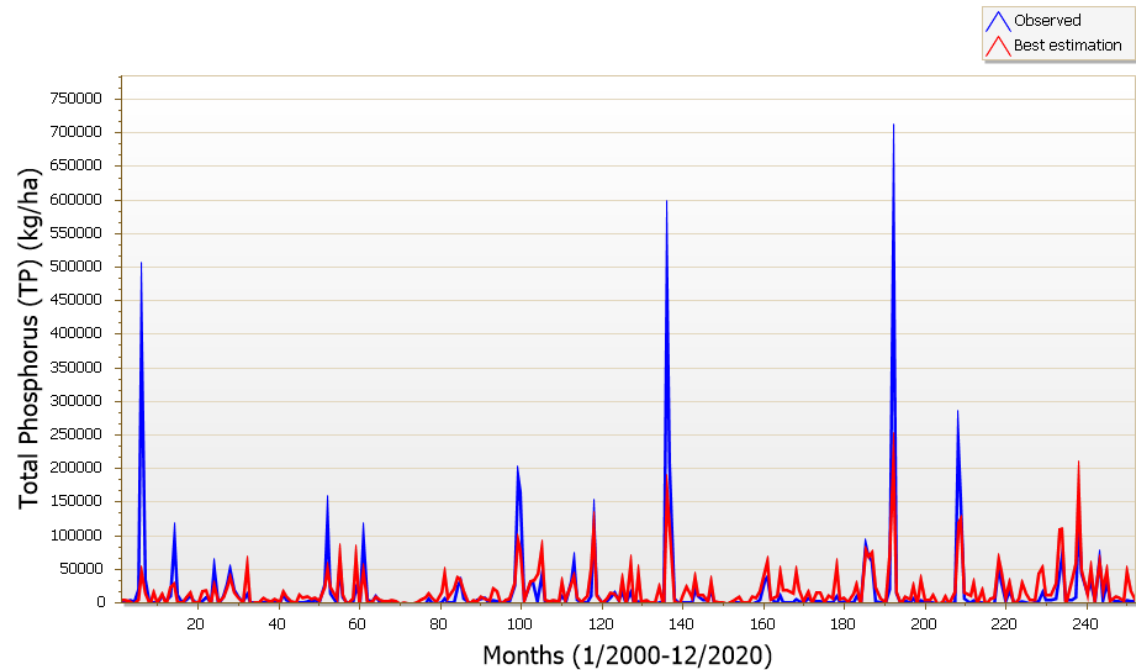
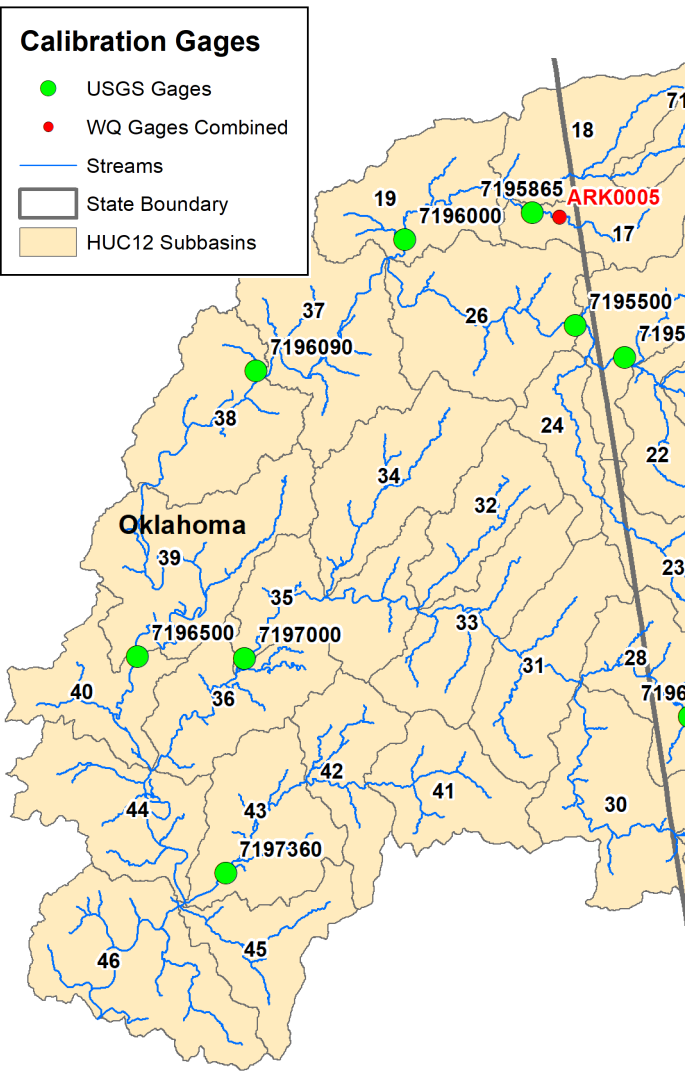
HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	OP			TP		
					NSE	PBIAS	KGE	NSE	PBIAS	KGE
3	111101030103	07194800	1.57	10/2001-12/2020	0.84	-11.7	0.78	0.31	14.4	0.2
8	111101030305	07195000-ARK0041	1.00	01/2000-12/2020				0.33	22	0.3
16	111101030501	07195800 (FC12)	2.06	07/2009-06/2015				0.44	-123.4	-0.27
25	111101030606	07195430	1.10	01/2000-12/2020	0.11	11.9	0.44	-0.05	-92.4	-0.04
27	111101030701	07196900-ARK0007A	1.01	01/2000-12/2020				-0.43	-152.6	-0.61

Purple subbasin numbers indicate model needs further investigation



Oklahoma Phosphorus Calibration

P_OUT_39



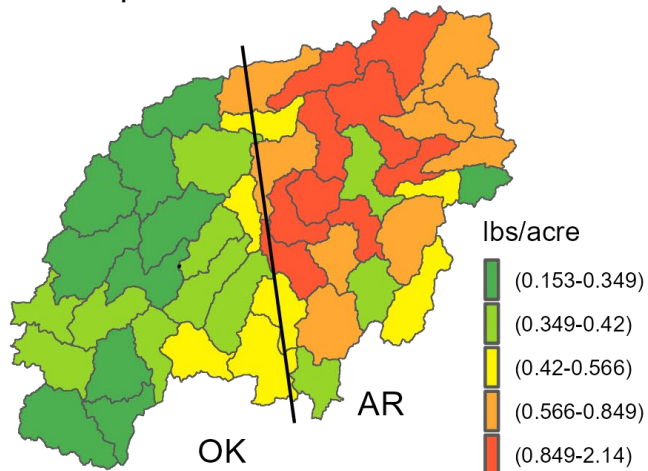
HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	OP			TP		
					NSE	PBIAS	KGE	NSE	PBIAS	KGE
17	111101030502	07195865-ARK0005	1.14	01/2000-12/2020				0.07	61.2	-0.11
19	111101030504	07196000	1.09	01/2000-12/2020	0.43	49.8	0.23	0.44	-8.3	0.42
25	111101030607	07195500	1.00	01/2000-12/2020				0.04	-81.7	0.06
35	111101030709	07197000	1.00	01/2000-12/2020	0.72	-40.5	0.56	0.28	19.9	0.17
37	111101030802	07196090	1.04	06/2010-12/2020	0.72	34.4	0.45	0.54	-17.1	0.42
39	111101030804	07196500	1.00	01/2000-12/2020	0.42	53.7	0.19	0.48	-0.5	0.4
43	111101030903	07197360	1.05	01/2000-09/2010	-2.26	-122.5	-0.74	0.39	-23.4	0.42

Purple subbasin numbers indicate model needs further investigation

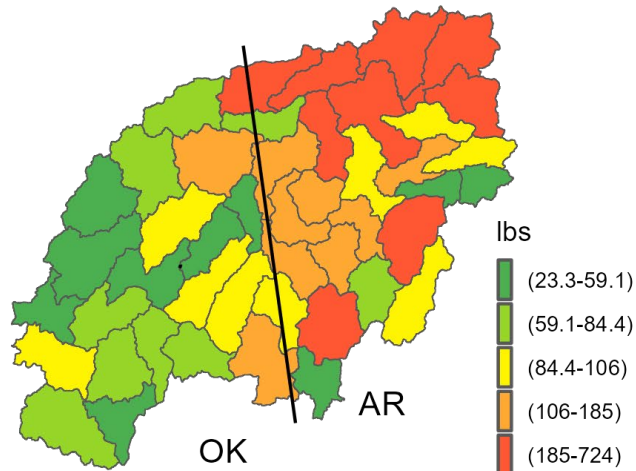


IRB Phosphorus - Annual Mean (2000-2020)

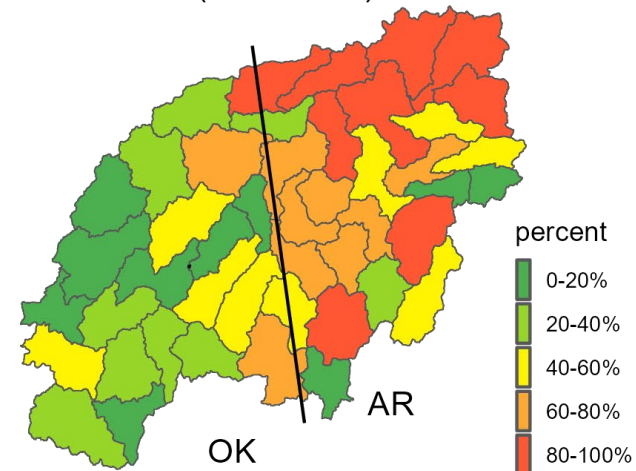
OP per Acre



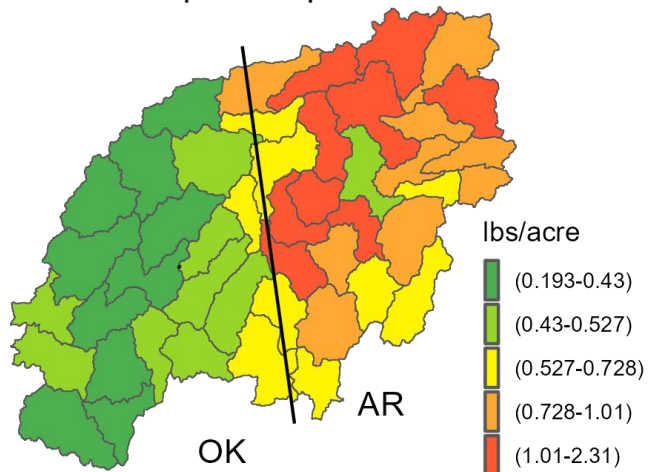
OP Load



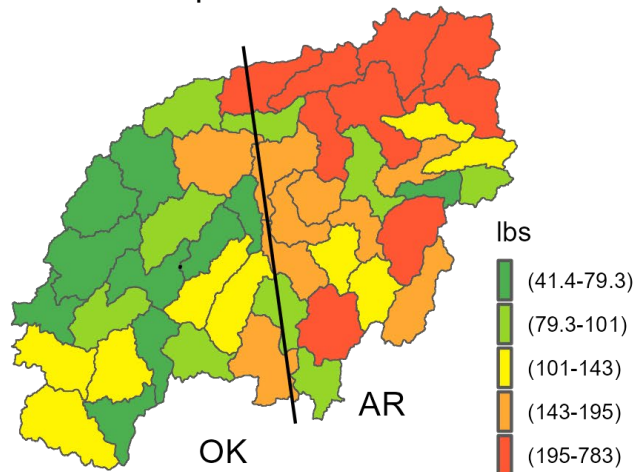
OP Load (Quantiles)



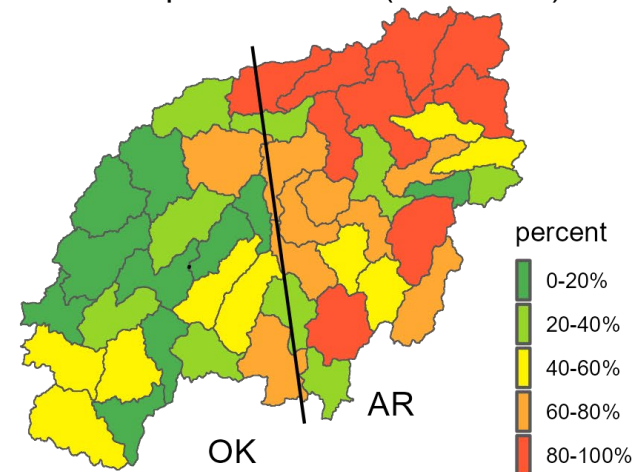
Total Phosphorus per Acre



Total Phosphorus Load



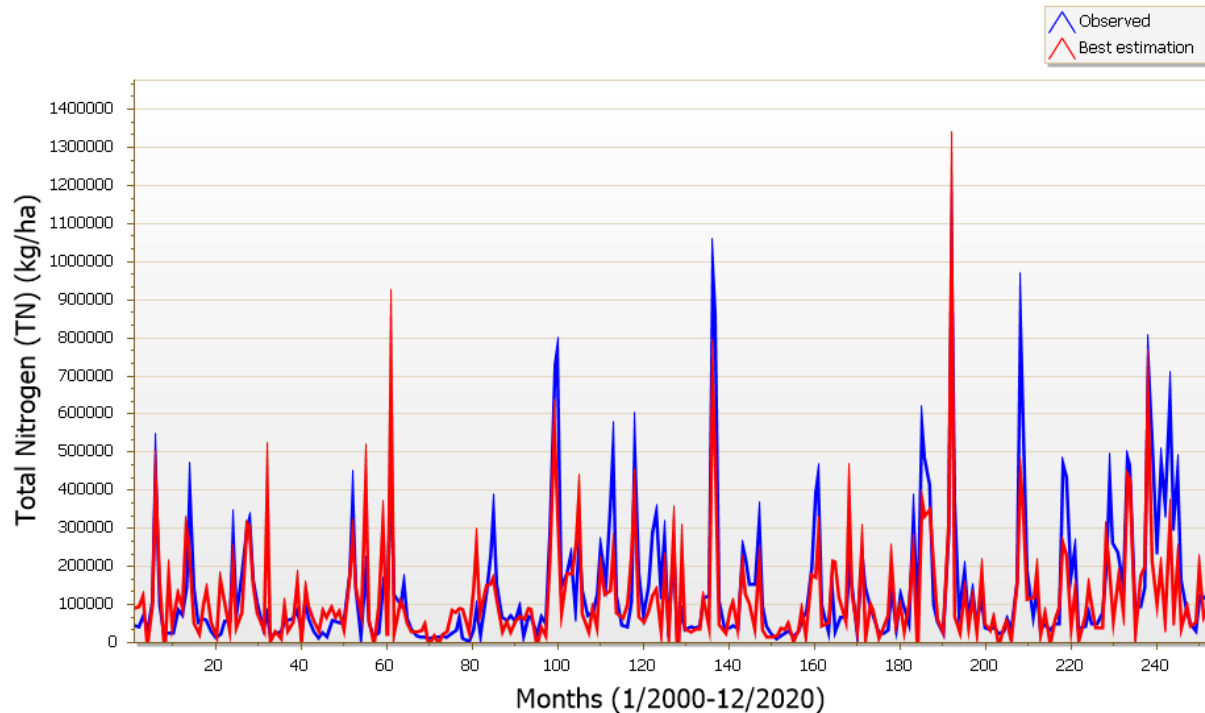
Total Phosphorus Load (Quantiles)



Orthophosphate (OP) = Soluble Phosphorus
 Total Phosphorus = Soluble + Organic P



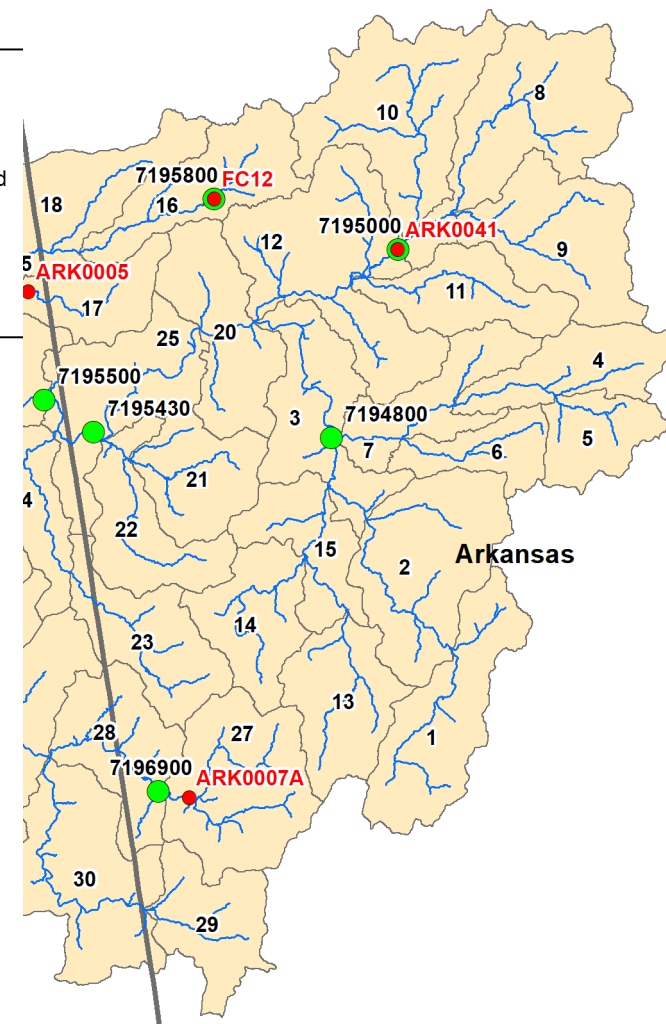
TN_OUT_25_07195430



Arkansas Nitrogen Calibration

Calibration Gages

- USGS Gages
- WQ Gages Combined
- Streams
- ▭ State Boundary
- ▭ HUC12 Subbasins



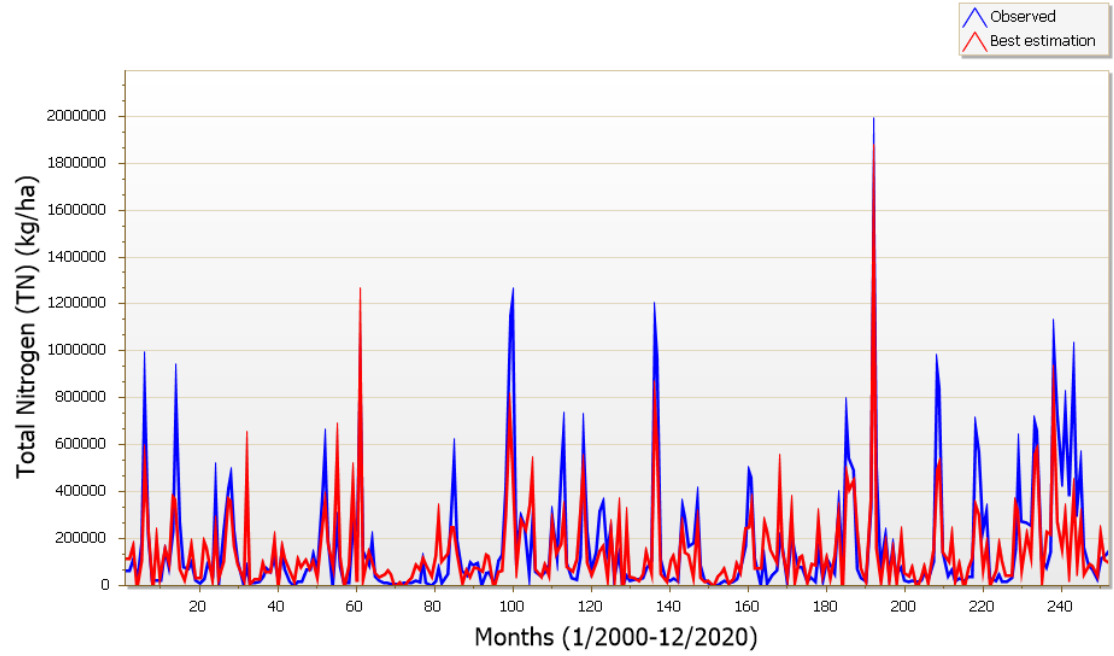
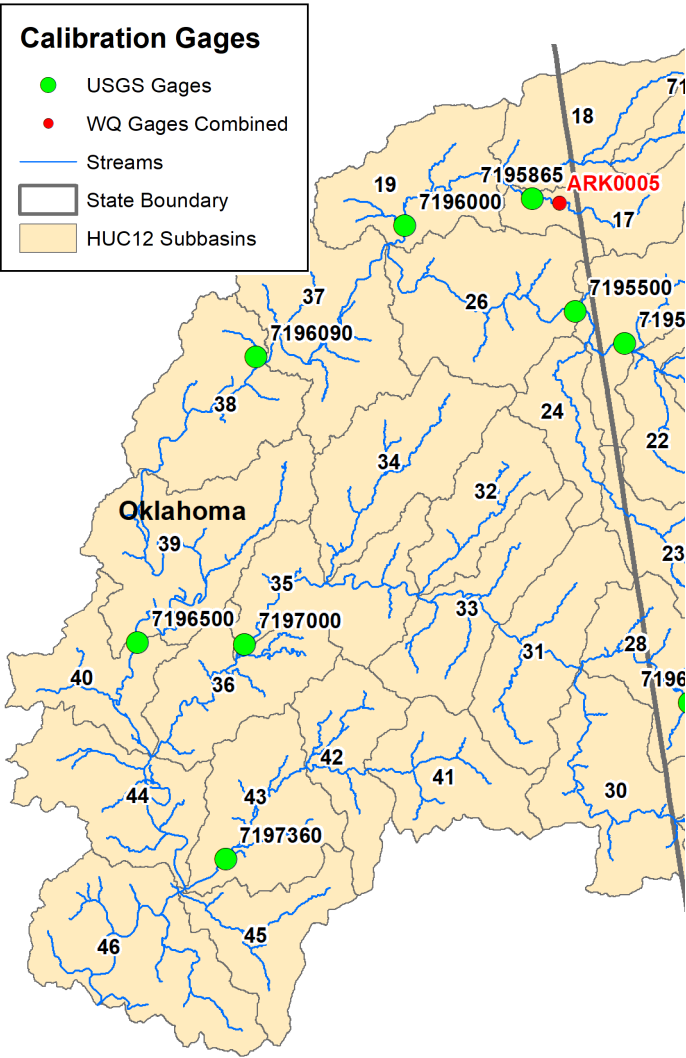
HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	NOx			TN		
					NSE	PBIAS	KGE	NSE	PBIAS	KGE
3	111101030103	07194800	1.57	10/2001-12/2020	0.06	-9.9	0.51	-1.24	-97.1	-0.27
8	111101030305	07195000-ARK0041	1.00	01/2000-12/2020				0.33	42.1	0.39
16	111101030501	07195800 (FC12)	2.06	07/2009-06/2015				-1.27	-1.7	0.16
25	111101030606	07195430	1.10	01/2000-12/2020	0.32	25.6	0.56	0.65	12.4	0.72
27	111101030701	07196900-ARK0007A	1.01	01/2000-12/2020				0.54	12.8	0.48

Purple subbasin numbers indicate model needs further investigation



Oklahoma Nitrogen Calibration

TN_OUT_39

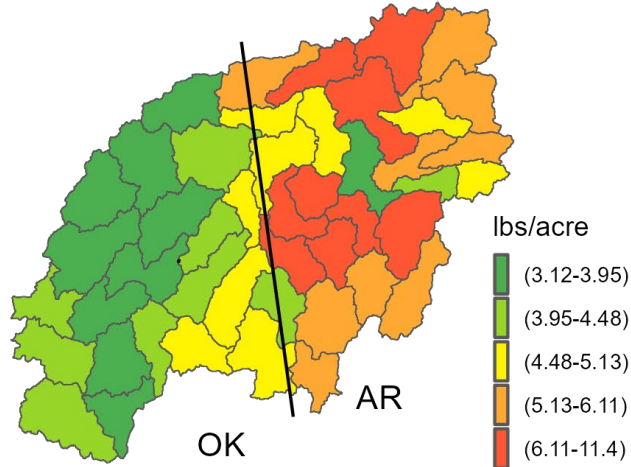


HUC12 Subbasin	HUC12 ID	USGS Gage/Combined	area diff.	WQ Time Period	NOx			TN		
					NSE	PBIAS	KGE	NSE	PBIAS	KGE
17	111101030502	07195865-ARK0005	1.14	01/2000-12/2020				0.27	38.7	0.37
19	111101030504	07196000	1.09	01/2000-12/2020	0.46	29.5	0.55	0.64	16.6	0.63
25	111101030607	07195500	1.00	01/2000-12/2020				0.66	15.3	0.69
35	111101030709	07197000	1.00	01/2000-12/2020	0.45	23.3	0.53	0.64	8.4	0.62
37	111101030802	07196090	1.04	06/2010-12/2020	0.55	16.2	0.67	0.75	9.4	0.74
39	111101030804	07196500	1.00	01/2000-12/2020	0.51	16.3	0.6	0.68	10.8	0.68
43	111101030903	07197360	1.05	01/2000-09/2010	0.19	-9.7	0.6	0.48	-26.9	0.6

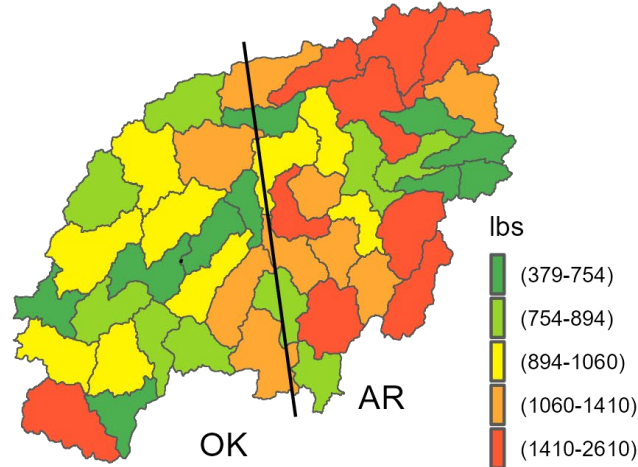


IRB Nitrogen - Annual Mean (2000-2020)

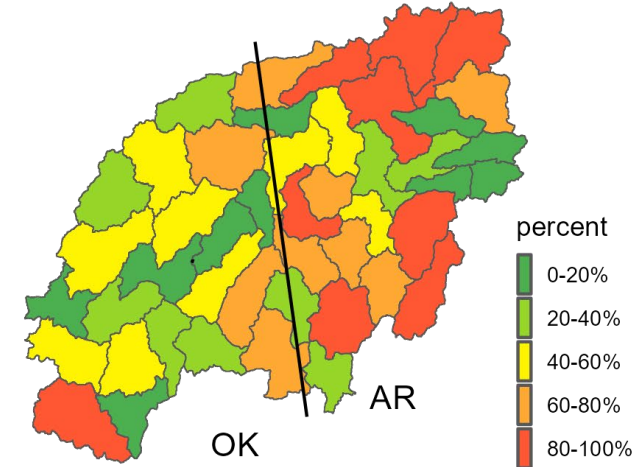
NOx per Acre



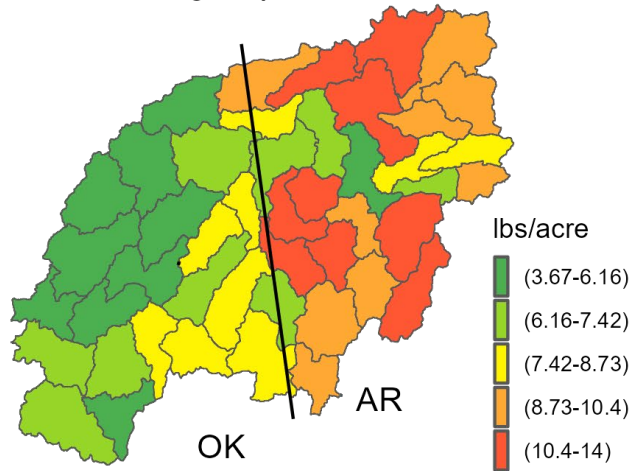
NOx Load



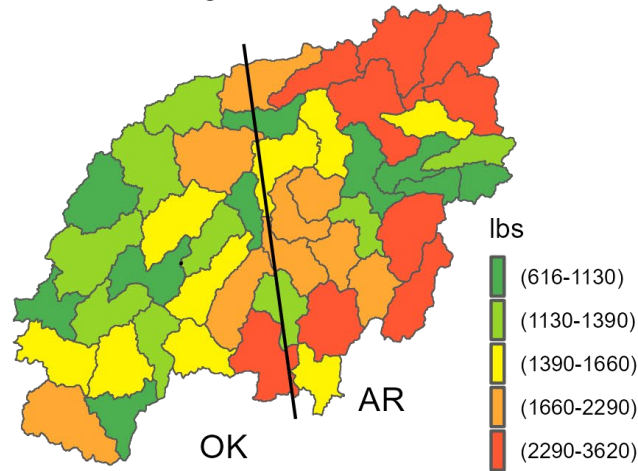
NOx Load (Quantiles)



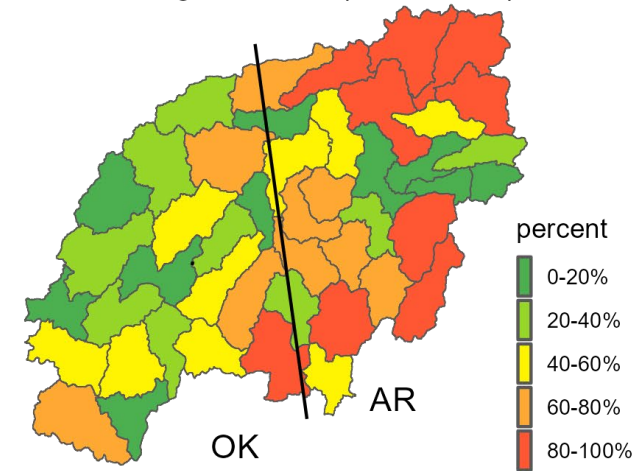
Total Nitrogen per Acre



Total Nitrogen Load



Total Nitrogen Load (Quantiles)



NOx = Surface + Lateral + Groundwater NO3
 Total Nitrogen = NOx + Organic N

