Nutrient Threatened Evaluation

Introduction

Nutrients, including nitrogen (N) and phosphorus (P), are essential for plant growth and are often important limiting nutrients in aquatic environments. However, in situations of nutrient enrichment, the nutrients N and P are no longer limiting; in fact, they are readily available in the waterbody, which causes an increase in primary production and eutrophication. Eutrophication is defined by increased nutrient loading to a waterbody and the subsequent ecological response. Abundant input of nutrients into rivers leads to degraded waterbody conditions. Symptoms of eutrophication in rivers are listed below.

- Increased algal biomass (macroalgae and phytoplankton)
- Reductions in dissolved oxygen (hypoxia)
- Alterations in algal species composition
- Alterations in food resources and habitat structure
- Harmful algal blooms

The relationship between nuisance algae growth and nutrient enrichment in stream systems has been well-documented in the literature (Dodds and Welch, 2000; Biggs, 2000; Busse et al., 2006). Eutrophication and nutrient enrichment problems rank as one of the top causes of water quality impairment; phosphorus and nitrogen are the most widespread chemical stressor to the nation's waters (EPA, 2017). Increased algal biomass growth is visually observable and a measurable stream response to nutrient enrichment. The problems and impacts associated with algal biomass overgrowth can range from a recreational nuisance to serious aquatic life and public health concerns. For example, high amounts of algal biomass and other aquatic plants interfere with swimming or wading, angling, and/or aesthetic enjoyment of the waterbody and impair the recreational beneficial uses. The aquatic life impacts of eutrophication can include fish kills, lowered fishery production, loss or degradation of important habitats (e.g. cobble/gravel niche space), and smothering of benthic organisms (EPA CADDIS).

The Oklahoma water quality standards (WQS) (Title 785, Chapter 45) define the goals for a waterbody and work to safeguard human health and aquatic life by establishing provisions to limit pollution to the state's lakes, rivers, and wetlands. The WQS include a narrative nutrient criterion (785:45-5-9(d)), which states,

> *"Nutrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton, or aquatic macrophyte communities which impairs any existing or designated beneficial use."*

The Implementation of Oklahoma's WQS (Title 785, Chapter 46) provides a method to implement this narrative criterion and make a determination regarding a stream's identification as nutrient threatened (785:46-15-10(c)). This method employs benthic algal biomass data measured at seasonal baseflow; if the mean value of algal biomass is greater than 100 mg/m^2 or if two or more values are greater than 200 mg/m^2 the waterbody is identified as nutrient threatened.

The Illinois River watershed (HUC 11110103) is located in northeastern Oklahoma and northwestern Arkansas and spans the political boundary between the two states. The waters within the Illinois River watershed are among Oklahoma's most beautiful and popular waters. In fact, the three primary rivers (Illinois River, Flint Creek, Barren Fork Creek) within the watershed are all Oklahoma scenic rivers and are recognized to have great aesthetic, ecological, and recreational value. The protection of these waters by means of water quality standards and other water quality management programs is of the utmost importance to the state of Oklahoma. The Oklahoma WQS designated beneficial uses for these waters are public water supply, aquatic life, aesthetics, body contact recreation, and agriculture. Because the Illinois River watershed spans the political boundary between Oklahoma and Arkansas the two state's environmental agencies have engaged in a series of agreements focused on improving water quality in the watershed. The *Second Statement of Joint Principles and Actions* was signed in February 2013 and under this agreement the states completed the Joint Phosphorus Criteria Study (Joint Study). The Joint Study was conducted from 2014 through 2016 and culminated in a Final Report. A key parameter collected as part of this study was algal biomass (Joint Study, 2016). The algal biomass data from this study has been utilized in a nutrient threatened evaluation in accordance with 785:46-15-10(c) as part of this Integrated Report.

Analysis

The 2016 Joint Study collected benthic algal biomass measured as chlorophyll *a* at twenty-one sites on thirteen rivers and streams across three HUC-8 watersheds in eastern Oklahoma (Figures 1 and 2). Samples were collected every other month from June 2014 to

April 2016, for a total of twelve events at each site except two (site sample size listed in Table 1). The twelve sampling events lasted one week on average; however, Event 2 lasted 21 days as ILLI8 was sampled 15 days after the conclusion of sampling at all other sites.

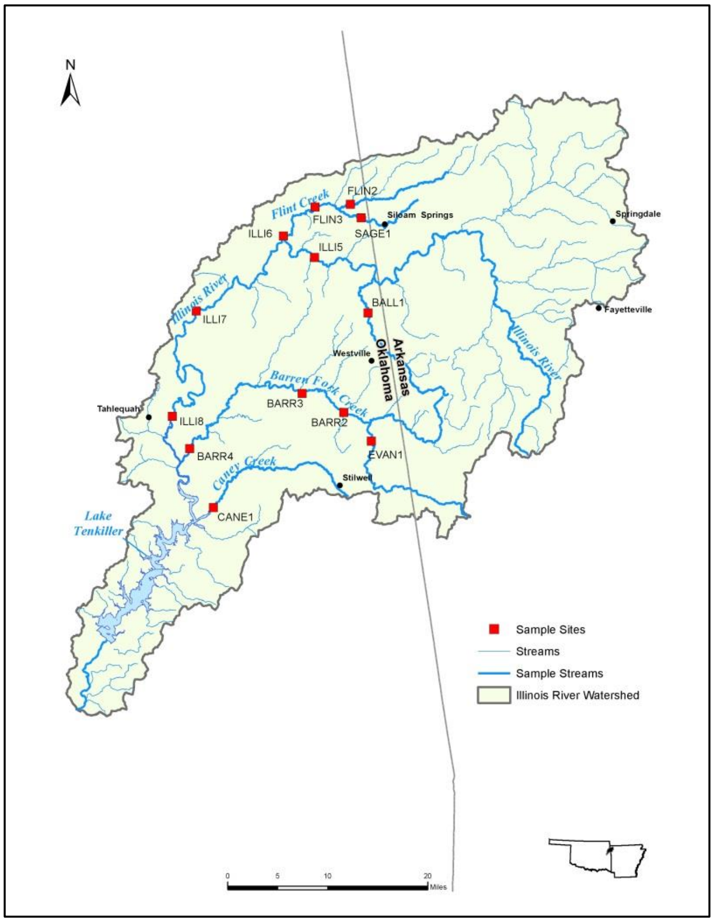

Figure 1. Illinois River watershed map with sample sites

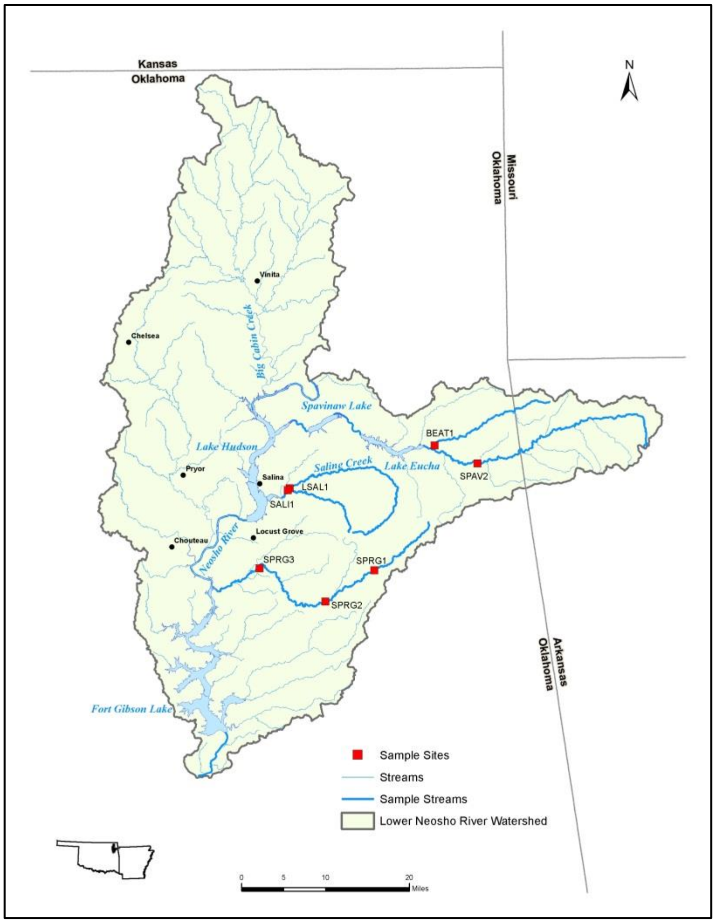

Figure 2. Lower Neosho watershed with sample sites

Thirteen sites in the Illinois River Watershed (11110103) on seven different rivers and streams - Ballard Creek, Barren Fork Illinois River, Caney Creek, Evansville Creek, Flint Creek, Sager Creek, and Illinois River - were analyzed (Table 1). Eleven of the thirteen sites in the Illinois River watershed were sampled twelve times; CANE1 was sampled ten times and EVAN1 was sampled eleven times. All sites exceeded the mean threshold of 100 mg/m^2 with mean values across the sites ranging from 174.7 mg/m^2 at EVAN1 to 638.9 mg/m^2 at ILLI5. All sites had two or more samples exceeding 200 mg/m^2, with exceedance totals ranging from four samples exceeding at BARR2, FLIN3, and EVAN1 to ten samples exceeding at ILLI5. Minimum benthic chlorophyll *a* values ranged from 23.3 mg/m^2 at BARR2 to 121.1 mg/m^2 at FLIN2, while maximum benthic chlorophyll *a* values ranged from 365.1 mg/m^2 at BARR4 to 2,254.9 mg/m^2 at ILLI5.

Table 1. Summary of algal biomass data for each site.

Waterbody Name	Site ID	Waterbody ID	HUC-8	Latitude	Longitude	n	Mean (mg/m^2)	Min. (mg/m^2)	Max. (mg/m^2)	Samples > 200 (mg/m^3)
Little Lee Creek	LLEE1	OK220200050040_00	11110104	35.57263	-94.5567	12	62.2	27.9	164.6	0
Ballard Creek	BALL1	OK121700030370_00	11110103	36.06137	-94.5732	12	282.3	79.5	644.9	8
Barren Fork* Illinois River	BARR2	OK121700050170_10	11110103	35.91906	-94.6193	12	195.8	23.3	468.6	4
Barren Fork* Illinois River	BARR3	OK121700050010_00	11110103	35.94727	-94.6935	12	218.7	78.5	416	5
Barren Fork* Illinois River	BARR4	OK121700050010_00	11110103	35.87013	-94.897	12	192.1	36.1	365.1	6
Caney Creek	CANE1	OK121700040010_00	11110103	35.78497	-94.8559	10	265.8	43.3	528.2	6
Evansville Creek	EVAN1	OK121700050200_00	11110103	35.87742	-94.5706	11	174.7	48.5	389.2	4
Flint Creek	FLIN2	OK121700060010_10	11110103	36.21771	-94.6019	12	258.8	121.1	751	8
Flint Creek	FLIN3	OK121700060010_00	11110103	36.21454	-94.6655	12	207.7	50.4	558.2	4
Illinois River	ILLI5	OK121700030280_00	11110103	36.14201	-94.6681	12	638.9	30.7	2254.9	10
Illinois River	ILLI6	OK121700030280_00	11110103	36.17349	-94.7237	12	411.2	35.4	1359.3	9
Illinois River	ILLI7	OK121700030080_00	11110103	36.06755	-94.8823	12	367.5	41.2	1417.4	8
Illinois River	ILLI8	OK121700030010_00	11110103	35.91667	-94.928	12	352.2	59.4	2036.1	5
Sager Creek	SAGE1	OK121700060080_00	11110103	36.198	-94.5829	12	423.9	52.9	1737.5	7
Beaty Creek	BEAT1	OK121600050160_00	11070209	36.35495	-94.7767	12	265.7	54.4	725.2	6
Little Saline Creek	LSAL1	OK121600020070_00	11070209	36.28455	-95.0887	12	120	30.8	253.9	1
Saline Creek	SALI1	OK121600020030_10	11070209	36.28154	-95.0932	12	160.8	6.1	554.2	3
Spavinaw Creek	SPAV2	OK121600050150_00	11070209	36.32323	-94.6854	12	218.4	31.5	499	7
Spring Creek	SPRG1	OK121600010290_00	11070209	36.1429	-94.9091	12	157.4	47.1	317.1	4
Spring Creek	SPRG2	OK121600010290_00	11070209	36.09092	-95.0147	12	137.3	20.7	311.9	2
Spring Creek	SPRG3	OK121600010290_00	11070209	36.14833	-95.1548	12	139.4	4	397.3	3

*Alternative spelling in Oklahoma state documents: Baron Fork Creek

Seven sites in the Lower Neosho Watershed (11070209) on five different streams—Beaty Creek, Little Saline Creek, Saline Creek, Spavinaw Creek, and Spring Creek—were analyzed. All sites exceeded the mean threshold of 100 mg/m², with mean values ranging from 120 mg/m² at LSAL1 to 265.7 mg/m² at BEAT1 (Table 1). Six of the seven sites had two or more samples exceeding 200 mg/m², ranging from two samples exceeding at SPRG2 to seven samples exceeding at SPAV2. LSAL1 was the only site in the Lower Neosho Watershed that did not have two or more samples exceeding 200 mg/m². Minimum benthic chlorophyll *a* values ranged from 4 mg/m² at SPR3 to 554.2 mg/m² at SALI1.

The site (LLEE1) on Little Lee Creek was the only site analyzed in the Robert S. Kerr Watershed (11110104). This site had a mean benthic chlorophyll *a* value of 62.2 mg/m² and therefore did not exceed the mean threshold of 100 mg/m² (Table 1). None of the samples from LLEE1 exceeded 200 mg/m². The minimum sampled benthic chlorophyll *a* value at LLEE1 was 27.9 mg/m² and the maximum value was 164.6 mg/m².

Conclusion

Based on these analyses the waterbodies listed in Table 2 are nutrient threatened. Consistent with 785:46-15-10(f) and (g) a nutrient impairment study will be conducted for sites in these watersheds.

Table 2. Nutrient threatened waters in Illinois River and Lower Neosho watersheds

Waterbody Name	Site ID	Waterbody ID	HUC-8	Latitude	Longitude
Ballard Creek	BALL1	OK121700030370_00	11110103	36.06137	-94.5732
Barren Fork* Illinois River	BARR2	OK121700050170_10	11110103	35.91906	-94.6193
Barren Fork* Illinois River	BARR3	OK121700050010_00	11110103	35.94727	-94.6935
Barren Fork* Illinois River	BARR4	OK121700050010_00	11110103	35.87013	-94.897
Caney Creek	CANE1	OK121700040010_00	11110103	35.78497	-94.8559
Evansville Creek	EVAN1	OK121700050200_00	11110103	35.87742	-94.5706
Flint Creek	FLIN2	OK121700060010_10	11110103	36.21771	-94.6019
Flint Creek	FLIN3	OK121700060010_00	11110103	36.21454	-94.6655

Waterbody Name	Site ID	Waterbody ID	HUC-8	Latitude	Longitude
Illinois River	ILLI5	OK121700030280_00	11110103	36.14201	-94.6681
Illinois River	ILLI6	OK121700030280_00	11110103	36.17349	-94.7237
Illinois River	ILLI7	OK121700030080_00	11110103	36.06755	-94.8823
Illinois River	ILLI8	OK121700030010_00	11110103	35.91667	-94.928
Sager Creek	SAGE1	OK121700060080_00	11110103	36.198	-94.5829
Beaty Creek	BEAT1	OK121600050160_00	11070209	36.35495	-94.7767
Little Saline Creek	LSAL1	OK121600020070_00	11070209	36.28455	-95.0887
Saline Creek	SALI1	OK121600020030_10	11070209	36.28154	-95.0932
Spavinaw Creek	SPAV2	OK121600050150_00	11070209	36.32323	-94.6854
Spring Creek	SPRG1	OK121600010290_00	11070209	36.1429	-94.9091
Spring Creek	SPRG2	OK121600010290_00	11070209	36.09092	-95.0147
Spring Creek	SPRG3	OK121600010290_00	11070209	36.14833	-95.1548
* Alternative spelling in Oklahoma state documents: Baron Fork Creek					

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