MISSOURI DEPARTMENT OF NATURAL RESOURCES

Celebrating 50 Years of Environmental Stewardship

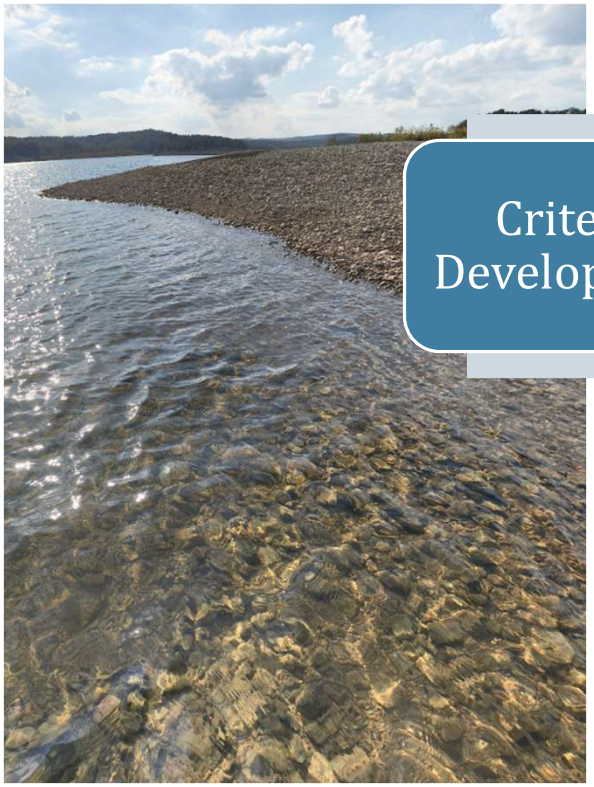
Lake Nutrients: Assessment and TMDLs

Robert Voss and Sebastien Clos-Versailles

Water Protection Program, Missouri Department of Natural Resources

50 YEARS MISSOURI DEPARTMENT OF NATURAL RESOURCES

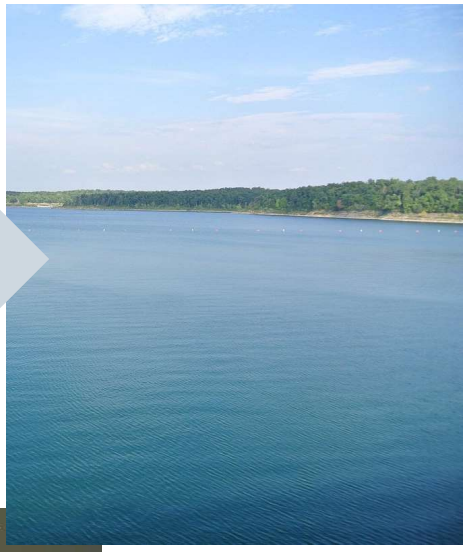
Missouri Lake Nutrient Criteria

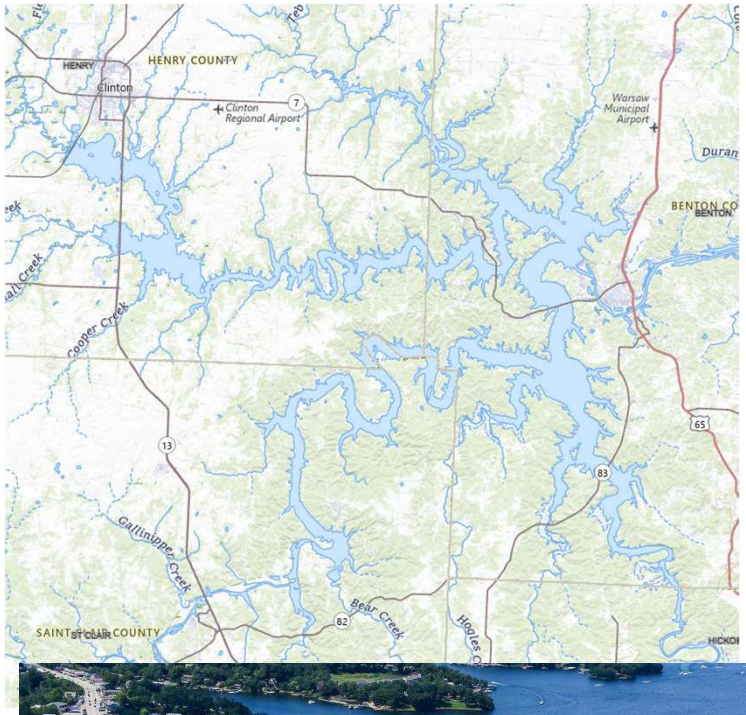


Criteria Development

303(d) Assessments

Modeling & TMDL





Missouri Lakes

- Vast majority of lakes in MO are man made riverine impoundments.
- Many are multipurpose use reservoirs; flood control, hydropower, drinking water, boating, swimming, fishing, etc.
- No “reference” conditions

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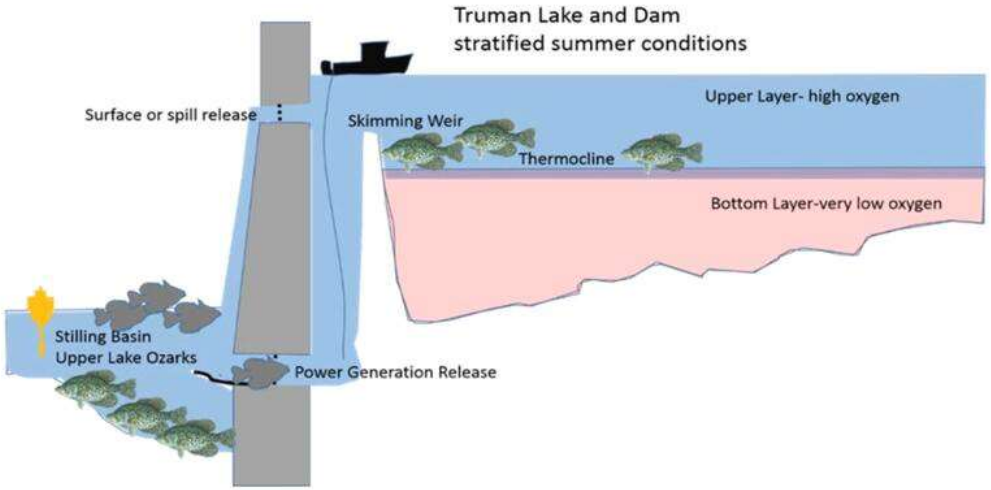
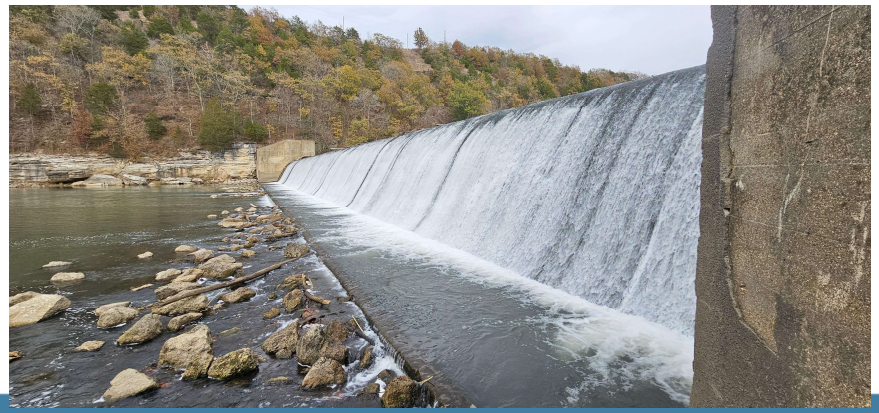
Missouri Lakes





- These differ from natural lakes in ways that affect nutrient dynamics and responses; such as residence time, sediment loads, water level fluctuations, and shoreline length
- MO Lakes have relatively high flushing rates

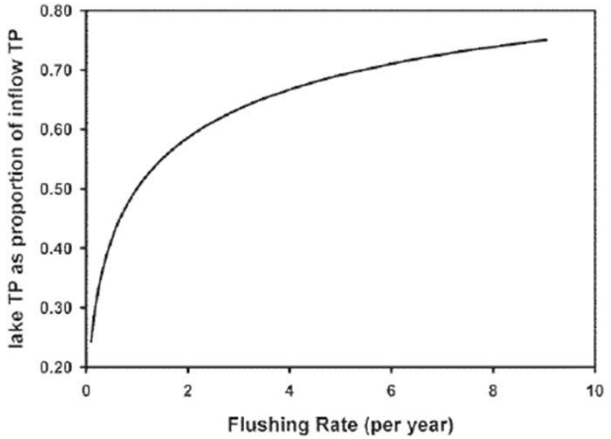
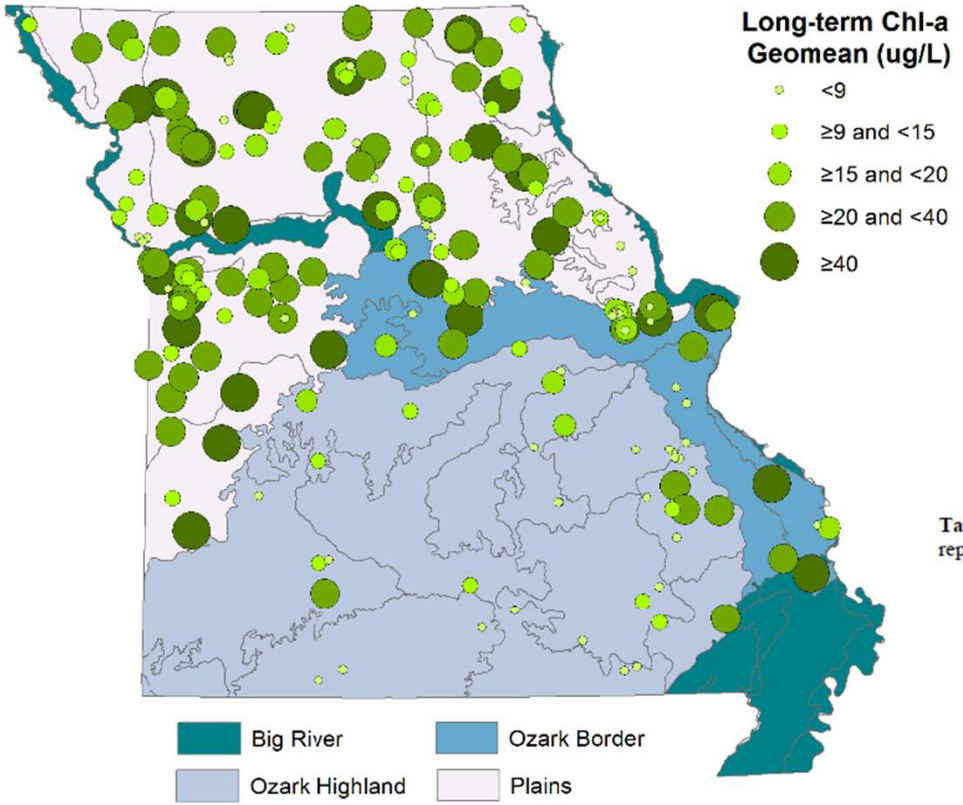


Figure 5-4. Estimated Relationship between In-Lake Total Phosphorus as a Proportion of Inflow TP to Flushing Rate from Welch and Jacoby 2004 as presented in Jones et al. 2008b.

Missouri Lakes



- Due to regional differences across the state, criteria were developed by Ecoregion.
- Lakes <10 acres and in the Big River floodplains were excluded.
- Aquatic Life designated use determined as the most sensitive use

Table 5-1. Trophic State Thresholds for Missouri Reservoirs from Jones et al. 2008a. Values in parentheses represent the range of chlorophyll values reported for each trophic category worldwide (Nurenburg 1996).

Trophic State	Upper Limit of Chlorophyll for Trophic State (µg/L)
Oligotrophic	3 (2 – 4.3)
Mesotrophic	9 (5 – 10)
Eutrophic	40 (18 – 40)
Hypereutrophic	>40

Missouri's Lake Nutrient Criteria (Attempt #1)

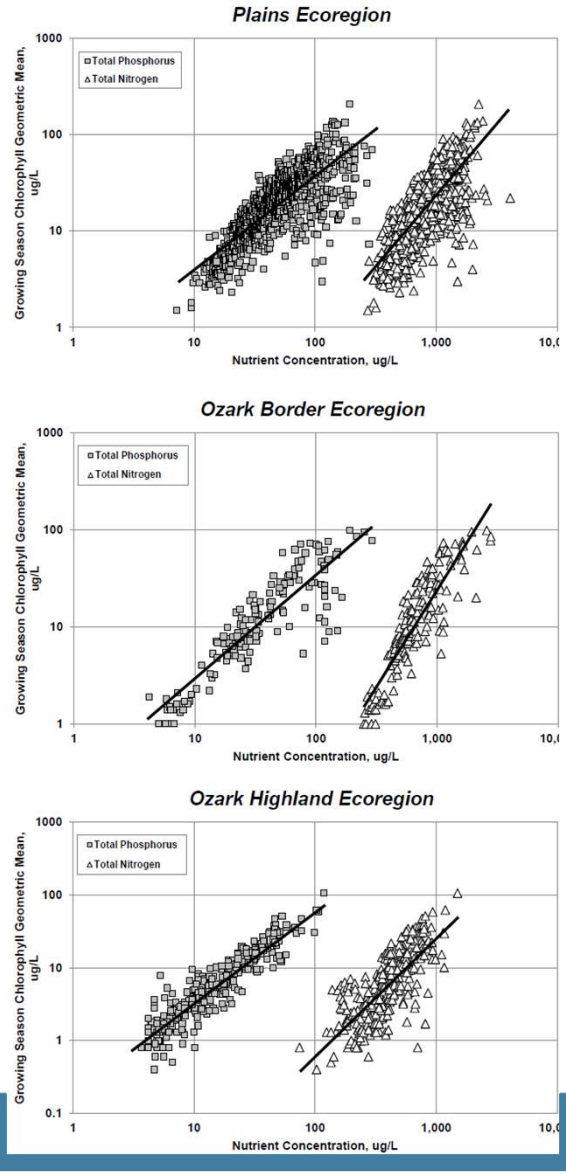
Site Specific Criteria (~2009)

- First attempt was disapproved by EPA, with exceptions for Site Specific Lakes
- Generally, apply to the highest quality lakes in MO
- Specific numeric criteria for TN, TP, and Chl-a
- Applies to <30 lakes throughout the state
- Geometric mean of minimum 3 years of data; at least 4 samples per year collected from the surface near the outflow of the lake May through September

Lake Ecoregion	Lake	County	Site-Specific Criteria (µg/L)		
			TP	TN	Chl-a
Plains	Bowling Green Lake	Pike	21	502	6.5
	Bowling Green Lake (old)	Pike	31	506	5.0
	Forest Lake	Adair	21	412	4.3
	Fox Valley Lake	Clark	17	581	6.3
	Hazel Creek Lake	Adair	27	616	6.9
	Lincoln Lake – Cuivre River State Park	Lincoln	16	413	4.3
	Marie, Lake	Mercer	14	444	3.6
	Nehai Tonkaia Lake	Chariton	15	418	2.7
	Viking, Lake	Daviess	25	509	7.8
	Waukomis Lake	Platte	25	553	11.0
	Weatherby Lake	Platte	16	363	5.1
Ozark Border	Goose Creek Lake	St Francois	12	383	3.2
	Wauwanoka, Lake	Jefferson	12	384	6.1
Ozark Highland	Clearwater Lake	Wayne-Reynolds	13	220	2.6
	Council Bluff Lake	Iron	7	229	2.1
	Crane Lake	Iron	9	240	2.6
	Fourche Lake	Ripley	9	236	2.1
	Loggers Lake	Shannon	9	200	2.6
	Lower Taum Sauk Lake	Reynolds	9	203	2.6
	Noblett Lake	Douglas	9	211	2.0
	St. Joe State Park Lakes	St Francois	9	253	2.0
	Sunnen Lake	Washington	9	274	2.6
	Table Rock Lake	Stone	9	253	2.6
	Terre du Lac Lakes	St Francois	9	284	1.7
	Timberline Lakes	St Francois	8	276	1.5

Criteria Development (Round 2)

- Data from the MU Limnology Laboratory (Statewide Lake Assessment Program [SLAP] and Lakes of Missouri Volunteer Program [LMVP]) were compiled for analysis.
- SLAP employs students as field technicians to collect water samples and make field measurements while LMVP relies on citizen volunteers. Laboratory analyses for both programs are performed by the MU Limnology Laboratory. Most all the data were collected during the summer growing season (May through September). Data collected outside of the summer growing season were not included in the database.
- Both LMVP and SLAP collect water samples for chlorophyll-a, TN, TP, volatile and nonvolatile solids, and Secchi depth
- Reservoirs were attributed in the database for geographic coordinates, size, and ecoregion.
- The number of reservoirs sampled has varied over time, but LMVP samples approximately 66 reservoirs between four and eight times each year, whereas SLAP samples approximately 75 reservoirs four times each summer.
- Data were limited to sample sites located near the reservoir dam and excluded sites located in reservoir arms.
- The dataset included 32,000+ records from 200+ reservoirs spanning approximately 15 years (1999-2014).



Criteria Development (Round 2)

- Chl-a was selected as the response variable
- Chl-a responds reliably to TP; fish/AQ life linked to TP
- TP-Chl-a relationship used to determine Chl-a impairment threshold

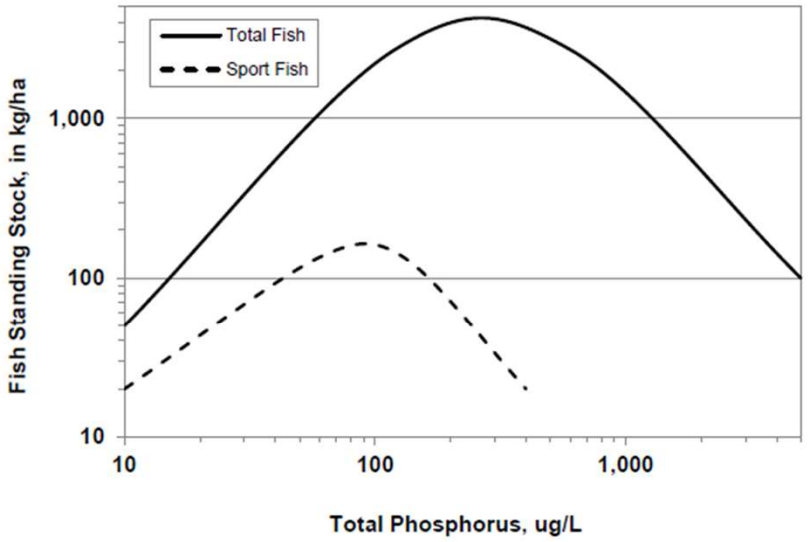
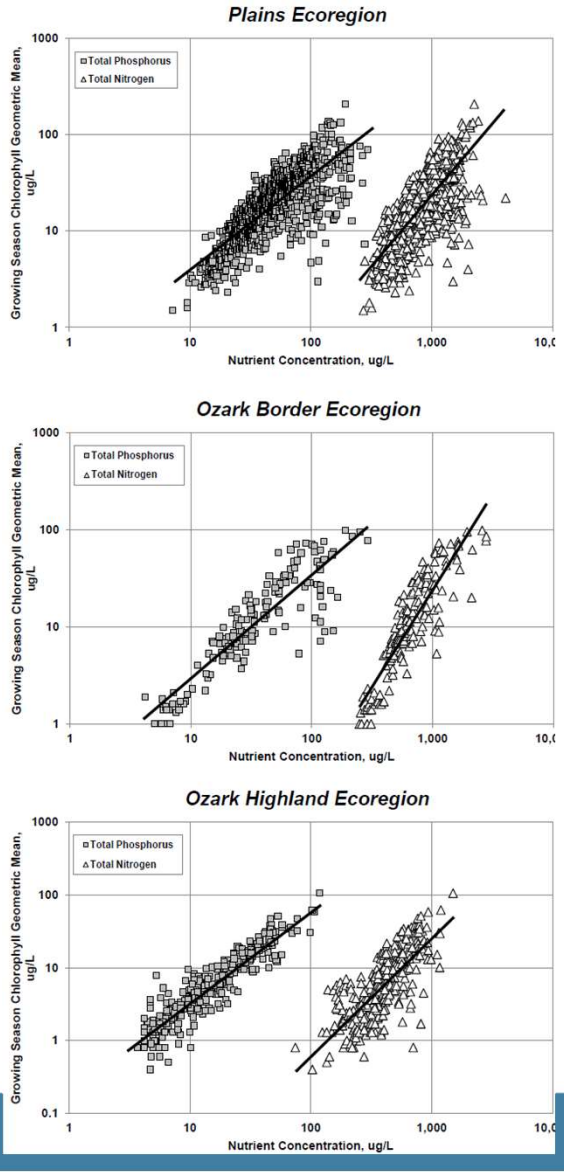


Figure 6-1. Generalized Relationship of Total and Sport Fish Standing Stock to Total Phosphorus Concentrations in Reservoirs Adapted from Ney 1996.

Criteria Development (Round 2)

- Nutrient screening thresholds to address the "gray zone"
- Chl-a NSTs were set equal to the 50th percentile of the distribution of growing season chlorophyll data for each ecoregion (Figure 5-2).
- TP and TN NSTs were back calculated using the respective chlorophyll NST and relationships presented in Figure 5-3.



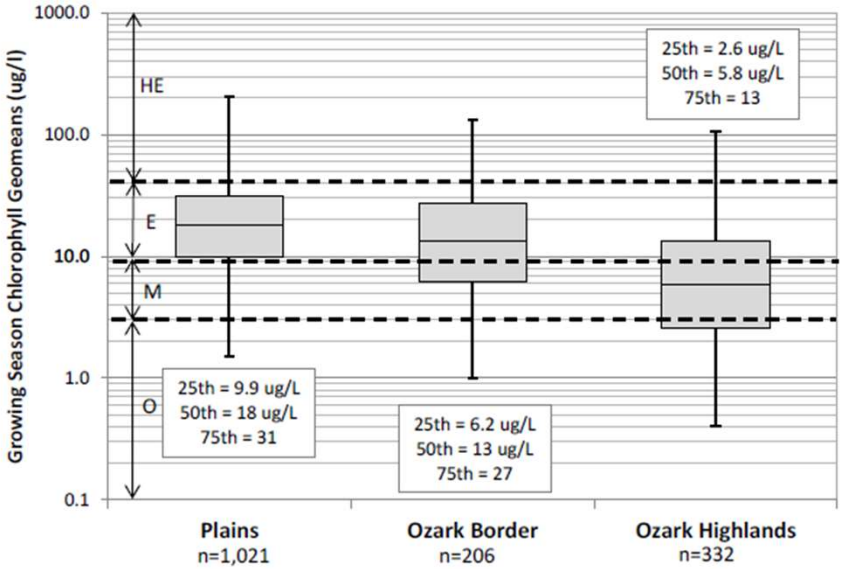


Figure 5-2. Distribution of Growing Season Chlorophyll Geometric Means by Ecoregion for Missouri Reservoirs.

Missouri's Lake Nutrient Criteria (Round 2)

Ecoregional Criteria (~2018)

- Targets aquatic life designated use, focuses on the biological response to nutrients,
- Considers ecoregional differences and existing trophic levels, and
- Supplements response impairment thresholds with conservative nutrient screening thresholds and biological response assessment endpoints to better support determinations of impairment.
- Annual geometric mean consisting of at least 4 samples per year collected from the surface near the outflow of the lake May 1 through September 30.
- 1-in-3 year allowable exceedance frequency of the Response Impairment Threshold (Chl-a)
- Response Assessment Endpoint must occur in same year as Nutrient Screening Threshold exceedance

Table L: Lake Ecoregion Chl-a Response Impairment Threshold Values (µg/L)

Lake Ecoregion	Chl-a Response Impairment Thresholds
Plains	30
Ozark Border	22
Ozark Highland	15

Table M: Lake Ecoregion Nutrient Screening Threshold Values (µg/L)

Lake Ecoregion	Nutrient Screening Thresholds		
	TP	TN	Chl-a
Plains	49	843	18
Ozark Border	40	733	13
Ozark Highland	16	401	6

Missouri's Lake Nutrient Criteria (Round 2)

Response Assessment Endpoints

- *Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms;*
- Epilimnetic excursions from dissolved oxygen or pH criteria;
- *Observed shifts in aquatic diversity attributed to eutrophication;*
- Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL);
- Excessive levels of mineral turbidity that consistently limit algal productivity

Annual Prospects Report

Binder Lake (150 acres) is situated on Dickerson Creek in the Ozark border region of Missouri on 710 acres of Jefferson City parkland. The park (managed by Jefferson City Parks and Recreation; 573-634-6482) contains numerous amenities including an RV campground, pavilions with picnic tables and barbecue grills, hiking trails, and public restrooms. The restrooms are open approximately April to November. The lake (managed by the Missouri Department of Conservation) has a concrete boat ramp, a disabled-accessible fishing dock and jetty, and two courtesy docks to assist boaters. **Largemouth bass** fishing should be much better in 2025. Electrofishing samples in 2024 sampled more bass over 15" than in previous years. Fish survey showed 30% of all bass sampled were over 15" and 8% were over 20". **Bluegill** fishing will be about the same in 2025 as in 2024. For bluegill that were sampled in 2024 43% were between 6-8". In the fall of 2024, the Missouri Department of Conservation stocked 4,000 additional **channel catfish**. The fish were 8-12" when stocked, so in 1-2 years these fish will make nice fillets. Spring of 2024 electrofishing sampling showed **redear sunfish** are numerous in the 7-9". Crappie collected in the spring survey, showed both white and black crappie are found in Binder Lake. **White crappie** were the most numerous species collected with 20% over 10" and 13% over 12", one white crappie was over 15". **Black crappie** will have a good population of fish between 8 and 10". In 2025, there should be a good number of black and white crappie over 9" available to anglers.

Region: Central

Information: 573-815-7900

BEST BETS

Largemouth Bass

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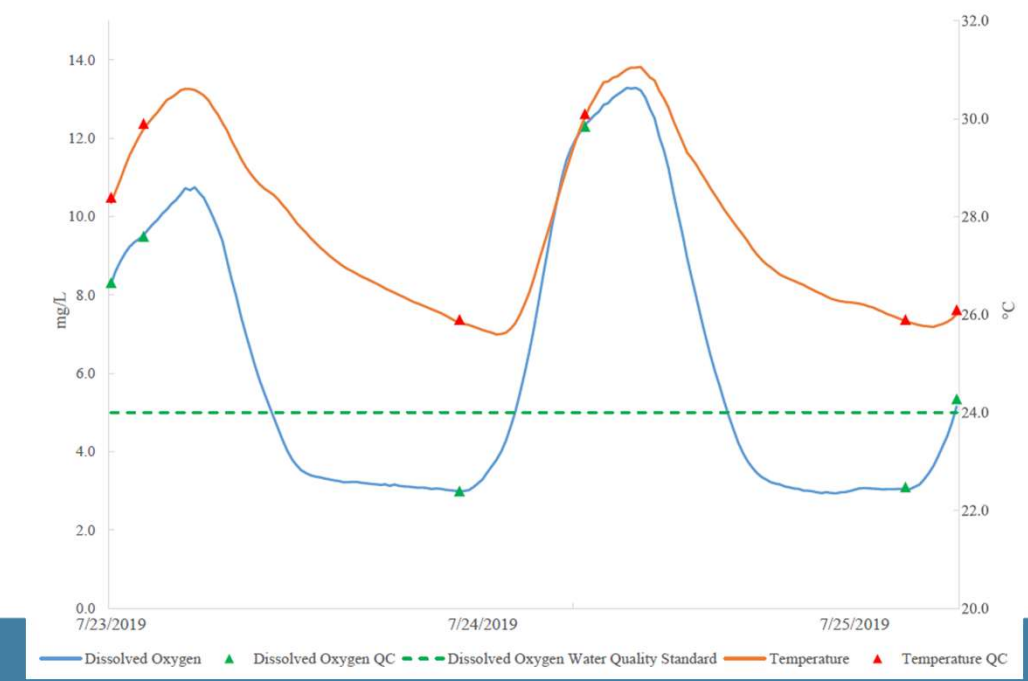
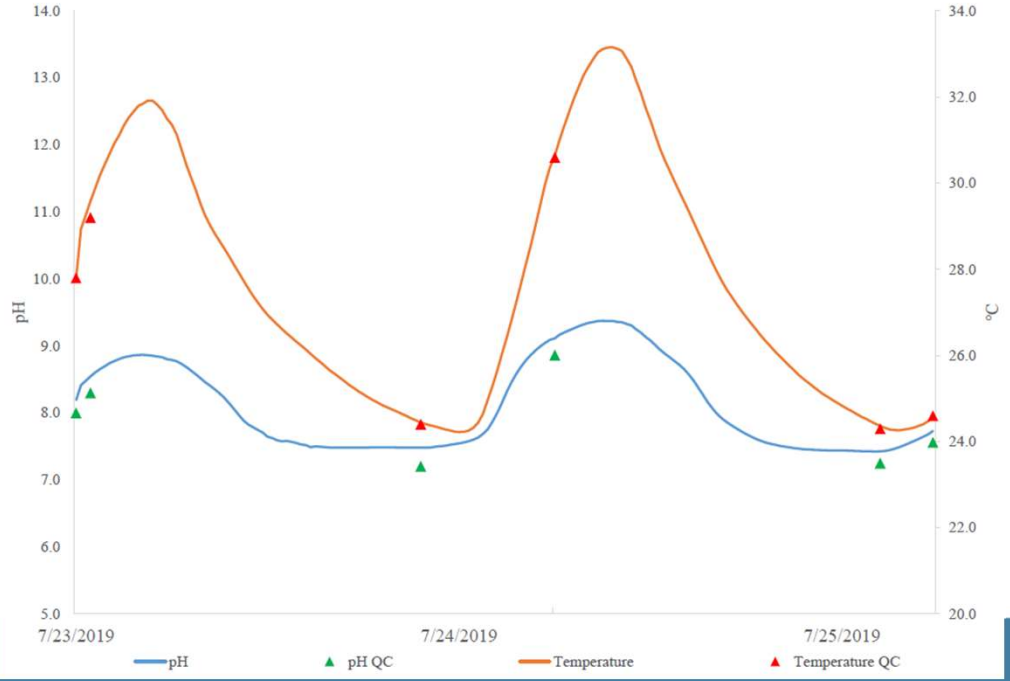
Missouri's Lake Nutrient Criteria (Round 2)

Response Assessment Endpoints

- Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms;
- *Epilimnetic excursions from dissolved oxygen or pH criteria;*
- Observed shifts in aquatic diversity attributed to eutrophication;
- Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL);
- Excessive levels of mineral turbidity that consistently limit algal productivity





Missouri's Lake Nutrient Criteria (Round 2)

Response Assessment Endpoints

- Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms;
- Epilimnetic excursions from dissolved oxygen or pH criteria;
- Observed shifts in aquatic diversity attributed to eutrophication; and
- *Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL);*
  - *Additionally algal toxin values exceeding the following thresholds:*
    - *Microcystin 8.0 µg/L*
    - *Cylindospermopsin 15.0 µg/L*
    - *Anatoxin-a 15.0 µg/L*
    - *Saxitoxin 8.0 µg/L*
- Excessive levels of mineral turbidity that consistently limit algal productivity

Missouri's Lake Nutrient Criteria (Round 2)

Response Assessment Endpoints

- Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms;
- Epilimnetic excursions from dissolved oxygen or pH criteria;
- Observed shifts in aquatic diversity attributed to eutrophication; and
- Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL);
- *Excessive levels of mineral turbidity that consistently limit algal productivity*
  - *ISS >10 mg/L*
  - *Chl-a:TP ratio <0.15*
  - *Secchi depth*
    - *Plains <0.6 meters*
    - *Ozark Border < 0.7 meters*
    - *Ozark Highlands < 0.9 meters*

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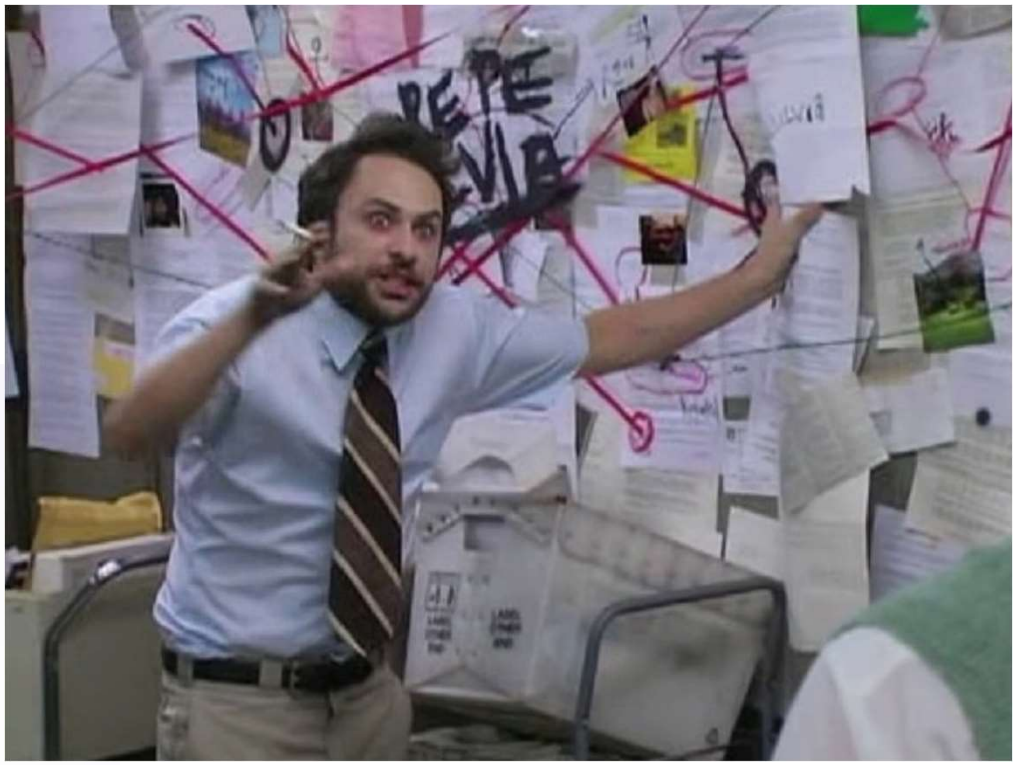
303(d) Assessments



Missouri Department of Natural Resources

Fox Valley Lake -- AUID: 7008 WBID: 7008.00

Missouri Dept. of Natural Resources, Univ. of Missouri, Columbia

HUC 8: 07110001

Org	Site Code	Site Name	Yr	Mo	Dy	Sample ID	ChlA (ug/l)	TN (ug/l)	TP (ug/l)
UMC	7008/0.1	Fox Valley Lake	2017	6	6	307404	119.901	1972	59
UMC	7008/0.1	Fox Valley Lake	2017	6	27	307406	51.439	910	37
UMC	7008/0.1	Fox Valley Lake	2017	7	26	307408	12.032	750	29
UMC	7008/0.1	Fox Valley Lake	2017	8	15	307410	5.762	734	21
UMC	7008/0.1	Fox Valley Lake	2018	5	30	294481	1.3	700	13
UMC	7008/0.1	Fox Valley Lake	2018	6	19	294482	2.9	690	16
UMC	7008/0.1	Fox Valley Lake	2018	7	17	294483	2.8	670	20
UMC	7008/0.1	Fox Valley Lake	2018	8	7	294484	4.7	620	19
UMC	7008/0.1	Fox Valley Lake	2019	6	11	296907	10.4	783	32
UMC	7008/0.1	Fox Valley Lake	2019	7	9	296909	10.9	762	37
UMC	7008/0.1	Fox Valley Lake	2019	7	31	296911	4.6	680	24
UMC	7008/0.1	Fox Valley Lake	2019	9	19	296913	7.1	627	17
UMC	7008/0.1	Fox Valley Lake	2020	6	23	376800	45.6	1113.3	31
UMC	7008/0.1	Fox Valley Lake	2020	7	29	376916	11.75	764	23.7
UMC	7008/0.1	Fox Valley Lake	2020	8	25	377077	10.2	683.3	18.7
UMC	7008/0.1	Fox Valley Lake	2020	9	15	377243	8	573.3	15
UMC	7008/0.1	Fox Valley Lake	2021	6	3	375579	42.1	1300	54.7
UMC	7008/0.1	Fox Valley Lake	2021	6	22	375581	2.85	790	15.7
UMC	7008/0.1	Fox Valley Lake	2021	7	13	375741	11.4	713.3	24
UMC	7008/0.1	Fox Valley Lake	2021	7	31	375744	3.6	530	16.3
UMC	7008/0.1	Fox Valley Lake	2022	5	25	377295	3.85	586.7	12.7
UMC	7008/0.1	Fox Valley Lake	2022	6	15	377349	1.95	586.7	12
UMC	7008/0.1	Fox Valley Lake	2022	7	13	377531	1.5	518	11.3
UMC	7008/0.1	Fox Valley Lake	2022	8	3	377671	2.55	566.7	12
UMC	7008/0.1	Fox Valley Lake	2023	5	24	382542	1.73	576.7	13.7
UMC	7008/0.1	Fox Valley Lake	2023	6	15	382638	2.35	540	15
UMC	7008/0.1	Fox Valley Lake	2023	7	12	382815	2.045	510	13
UMC	7008/0.1	Fox Valley Lake	2023	8	2	382954	2.11	580	13.2

	ChlA (ug/l)	TN (ug/l)	TP (ug/l)
Geometric Mean:	**6.1**	**707**	**20**
Nutrient Criteria (Table M):	**6.3**	**581**	**17.0**
Standard Deviation:	*24.74*	*297.64*	*12.31*
Square Root of Sample Size	*5.292*	*5.292*	*5.292*
LCL(60) =	4.9	**693**	**19.4**
UCL (60) =	**7.3**	**721**	**20.6**

303(d) Site Specific Lake Assessment

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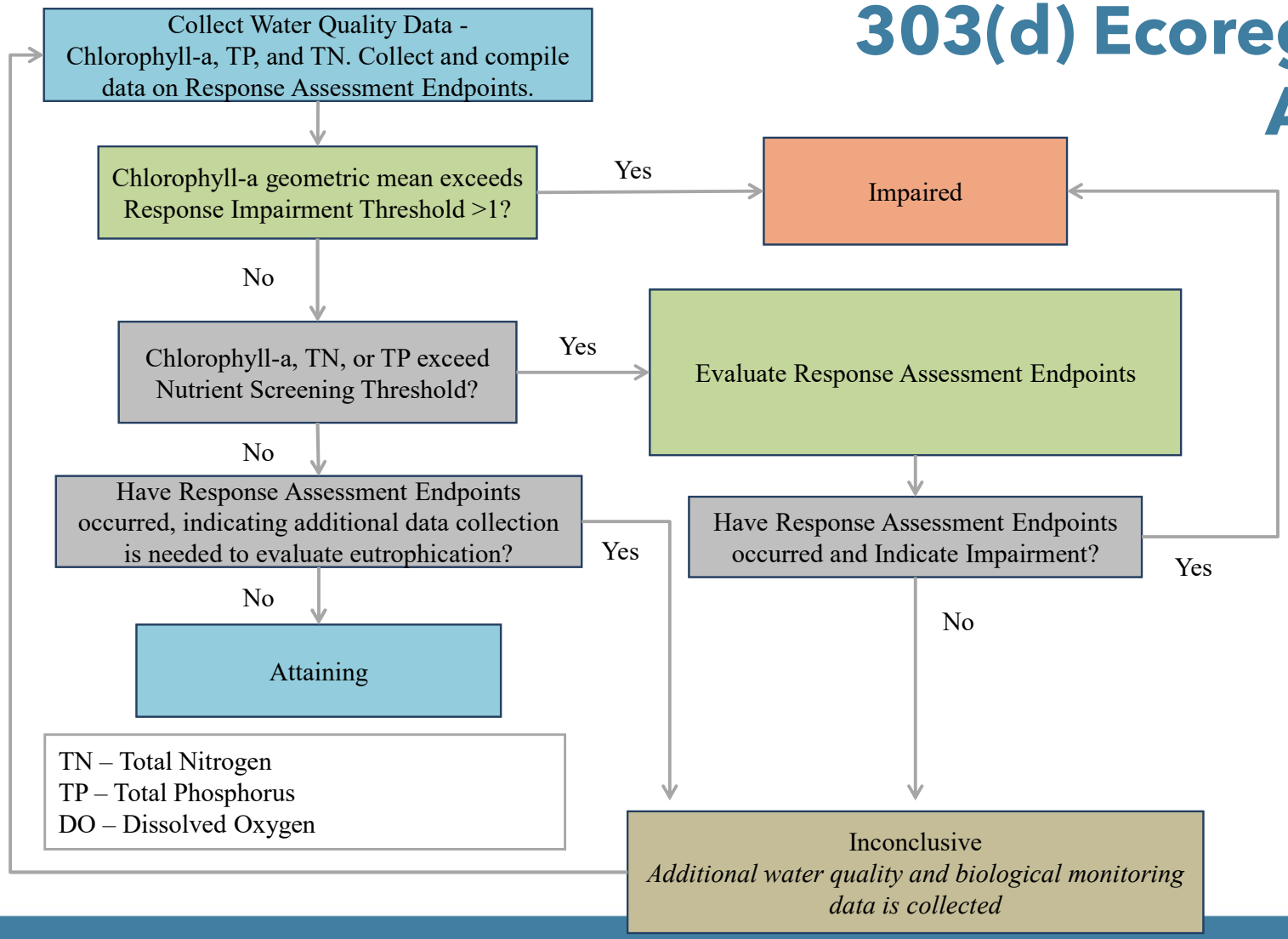
303(d) Ecoregional Lake Assessment



303(d) Ecoregional Lake Assessment

Missouri Department of Natural Resources

Pomme de Terre Lake -- AUID: 7238 WBID: 7238.00

Corps of Engineers, Kansas City District, Univ. of Missouri, Columbia

HUC 8: 10290107 - Lake Ecoregion: Ozark Highlands

Lake Size: 7,675 acres

Ecoregional Criteria Apply

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Sample ID	ChlA/TP Ratio	ChlA (ug/l)	DO (mg/l)	ISS (mg/l)	pH (pH units)	Secchi (m)	TN (ug/l)	TP (ug/l)
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	4	21	263522	0.14	14	10.22			0.8	740	100
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	5	24	263523	0.73	11	10.7			1.8	400	15
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	6	9	263524	0.34	15.1	11.1			1.8	860	45
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2016	6	15	271313	0.45	11.22	9.1	1.13	9.4	2.1	450	25
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	7	27	263525	0.46	21.9	9.03				480	48
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2016	7	27	271314	1.22	21.9	5.8	1.4	9.36	1.1	560	18
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2016	8	10	271315	0.87	16.47	5.3	1.1	9.09	1.4	540	19
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	8	24	263526	1.67	33.3	6.9			0.8	650	20
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2016	8	29	271316	1.34	30.74		0.9	9.2	1	720	23
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2016	9	27	263527	0.29	9.1	3.2			2.2	600	31
2016 May 1 - September 30 Geometric Mean or Arithmetic Mean:								ChlA/TP Ratio	ChlA Geomean	DO Avg.	ISS Avg.	pH Avg.	Secchi Avg.	TN Geomean	TP Geomean
								0.54	16.9	7.41	1.13	9.26	1.44	585	29
Ozark Highlands Ecoregion Criteria (Table L):									15						
Ozark Highlands Ecoregion Screening Threshold (Table M):									6					401	16
Eutrophication Factors:								0.15			10		0.9		

**Sample is the average of two or more duplicate samples.*

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Sample ID	ChlA/TP Ratio	ChlA (ug/l)	DO (mg/l)	ISS (mg/l)	pH (pH units)	Secchi (m)	TN (ug/l)	TP (ug/l)
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	4	18	278614	0.09	1.3				0.9	620	14
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	5	16	278615	0.34	23.1				0.9	900	67
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	6	22	278616	0.34	14.1				1.4	740	41
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	7	13	278617	0.21	9.2				1.25	860	43
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2017	8	2	307634	0.54	10.19		0.78	8.77	1.57	436	19
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2017	8	17	307636	0.62	11.81		0.67	8.78	1.42	440	19
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	8	28	278618	0.3	9.8				1.7	360	33
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2017	9	10	307638	0.58	11.68		0.46	8.72	1.23	461	20
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2017	9	14	278619	0.67	12.8				1.5	420	19
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2017	9	27	307640	0.77	23.21		2.8	8.53	1.14	571	30
2017 May 1 - September 30 Geometric Mean or Arithmetic Mean:								ChlA/TP Ratio	ChlA Geomean	DO Avg.	ISS Avg.	pH Avg.	Secchi Avg.	TN Geomean	TP Geomean
								0.48	10.5		1.2	8.7	1.3	554	27
Ozark Highlands Ecoregion Criteria (Table L):									15						
Ozark Highlands Ecoregion Screening Threshold (Table M):									6					401	16
Eutrophication Factors:								0.15			10		0.9		

**Sample is the average of two or more duplicate samples.*

303(d) Ecoregional Lake Assessment

Ecoregional Criteria Apply

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Sample ID	ChlA/TP Ratio	ChlA (ug/l)	DO (mg/l)	ISS (mg/l)	pH (pH units)	Secchi (m)	TN (ug/l)	TP (ug/l)
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2020	6	15	376861	0.48	20.7	13.5		8.94	0.82	793	43
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2020	6	17	358565	0.19	22.34				0.4	870	115
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2020	7	8	377002	0.34	12.65	9.4		8.86	1.38	483	37
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2020	7	14	358567	0.14	7.25				1.35	520	53
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2020	8	7	377162	0.6	18.1	8.1		8.32	1.47	547	30
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2020	8	12	358568	0.74	8.91				1.1	440	12
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2020	8	19	377164	0.69	17.1	6.7		8.1	1.46	620	25
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2020	9	21	358569	0.19	9.37				1.05	710	49
2020 May 1 - September 30 Geometric Mean or Arithmetic Mean:								ChlA/TP Ratio	ChlA Geomean	DO Avg.		pH Avg.	Secchi Avg.	TN Geomean	TP Geomean
								0.32	**13.49**	9.11		8.55	1.13	**607**	**38**
Ozark Highlands Ecoregion Criteria (Table L):									15						
Ozark Highlands Ecoregion Screening Threshold (Table M):									6					401	16
Eutrophication Factors:								0.15					0.9		

**Sample is the average of two or more duplicate samples.*

COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	4	21	358570	0.04	4.43				1.8	1006	112
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	5	19	358571	0.63	57.13				0.8	1248	90
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	6	16	358572	0.42	37.73				1.45	810	89
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2021	6	16	375662	0.14	3.95	14		**9.13**	1.48	533	29
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2021	7	8	375842	0.22	4.95	8.5		8.93	1.52	557	23
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	7	21	358573	0.18	14.48				1.2	580	79
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2021	7	28	375845	0.3	6.9	9.8		8.32	1.07	593	23
UMC	7238/0.5	Pomme de Terre L. near dam	Grab	2021	8	5	375947	0.32	9.2	7.4			1.22	567	29
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	8	18	358574	0.24	15.92				1.4	590	65
COEKC	7238/0.3	Pomme de Terre L. at dam	Grab	2021	9	22	358576	0.18	15.97				1.1	620	89
2021 May 1 - September 30 Geometric Mean or Arithmetic Mean:								ChlA/TP Ratio	ChlA Geomean	DO Avg.	ISS Avg.	pH Geomean	Secchi Avg.	TN Geomean	TP Geomean
								0.13	**11.59**	9.64	1.05	8.79	1.3	**593**	**46**
Ozark Highlands Ecoregion Criteria (Table L):									15						
Ozark Highlands Ecoregion Screening Threshold (Table M):									6					401	16
Eutrophication Factors:								0.15			10		0.9		

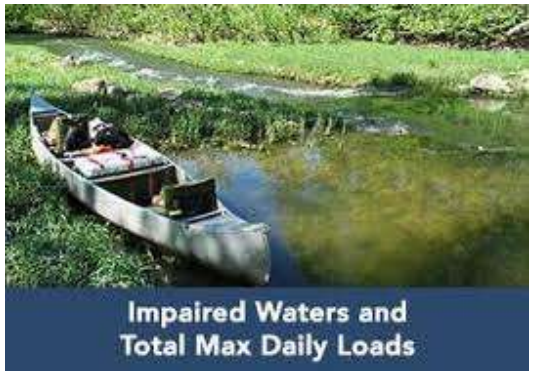
**Sample is the average of two or more duplicate samples.*

STATION	SAMPLE DATE	SAMPLE TIME	GENUS	DIVISION	TALLY	DENSITY cells/L	Density cell/ml	TOTAL BV um^3/L
Lake Pomme de Terre	5/19/2021		Navicula sp.	Bacillariophyta	1	3.61E+06	3606	4.01E+09
Lake Pomme de Terre	5/19/2021		Nitzschia sp.	Bacillariophyta	2	7.21E+06	7212	1.81E+09
Lake Pomme de Terre	5/19/2021		Sphaerellopsis sp.	Chlorophyta	2	7.21E+06	7212	4.25E+09
Lake Pomme de Terre	5/19/2021		Dolichospermum sp.	Cyanobacteria	1023	3.69E+09	3,688,777	2.60E+11
Lake Pomme de Terre	5/19/2021		Microcystis sp.	Cyanobacteria	277	9.99E+08	998,818	2.65E+10
			TOTAL		1305	4.71E+09	4705624	2.97E+11

Site	Date Received	Date Analyzed	Microcystin (µg/L)	Comments
Pomme de Terrre Lake	5/20/2021	5/24/2021	438.100	Original Sample diluted 1:100

Missouri TMDL Development

- First lakes listed on the 303(d) list under the new lake nutrient criteria was on the 2020 303(d) list.
- Lake nutrient TMDLs are listed as a priority on Missouri's Prioritization Framework
  - Data availability, designated uses, public health concerns (HABs), management priorities, and stakeholder engagement also play a role in the prioritization



Lake Nutrient TMDLs currently under development

- Pomme de Terre Lake – Impaired for chlorophyll-a
  - Currently just finished public comment period on May 12, 2025
- Lake St. Louis – Impaired for chlorophyll-a
  - Modeling complete, being prepared for public comment period
- Blind Pony Lake – Impaired for chlorophyll-a
  - Currently under development
- Harrison County Lake – Impaired for chlorophyll-a
  - Currently under development

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Pomme de Terre Lake Listing

- Initially listed on Missouri's 2022 303(d) list for Chlorophyll-a
- Subject to the Ozark Highland Lake Ecoregion Criteria

Chlorophyll-a Response Impairment Threshold (µg/L)	Nutrient Screening Thresholds (µg/L)		
	TP	TN	Chlorophyll-a
15	16	401	6

- Impaired for exceedance of Nutrient Screening Threshold and Response Assessment Endpoint C
  - Cyanobacteria counts in excess of 100,000 cells per milliliter (cells/mL)

	Geometric Mean (µg/L)			Average	
May-September	TP	TN	Chlorophyll-a	Secchi Depth (m)	Microcystin (mg/L)
2017	29	547	13.2	1.35	0.07
2018	22	613	12.1	1.46	0.16
2019	45	567	13.5	1.38	0.18
2020	38	607	13.5	1.13	0.19
2021	49	652	12.9	1.25	87.8

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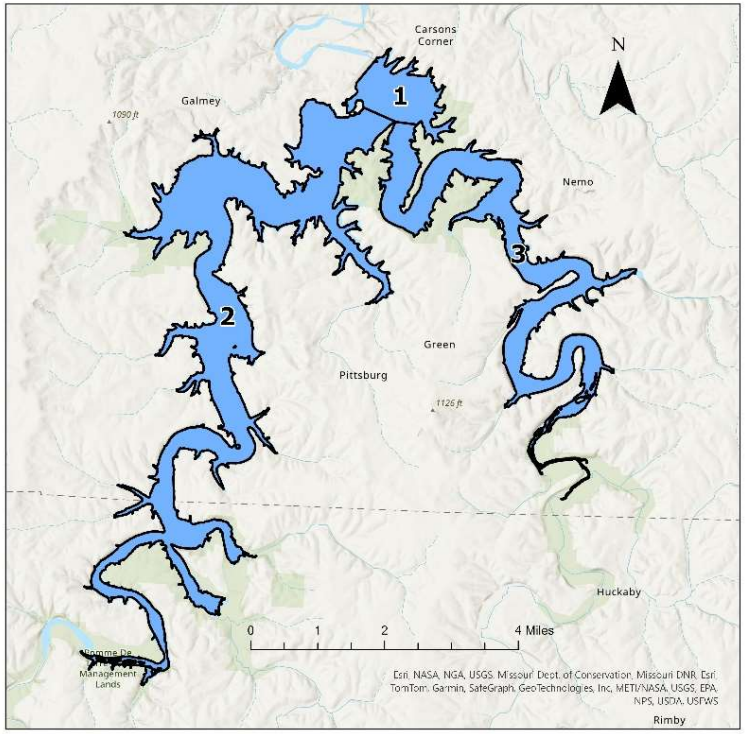
Pomme de Terre Lake Modeling Approach - SWAT

- Combination of SWAT (watershed) and BATHTUB (lake) models
  - SWAT was run through the Hydrologic and Water Quality System (HAWQS) online platform
- Used TN, TP, and flow data from 2010 – 2020, which included a very low flow year in 2012
- SWAT flow calibration performed by comparing average monthly flow output to observed average monthly flow data at two gages on the Pomme de Terre River and Lindley Creek
- SWAT model calibrated to TN and TP data collected at the gage on Pomme de Terre River.
- Outputs from SWAT were then input to BATHTUB model

Pomme de Terre Lake Modeling Approach - BATHTUB

- Lake was segmented into three segments
  - Based on areas with differences in temperature, depth, turbidity, stratification and/or other watershed characteristics (urban vs. rural).
  - Near Dam, West Arm, East Arm
- Residence time in the lake model is determined by inflow and outflow rates
- All inputs are annual averages



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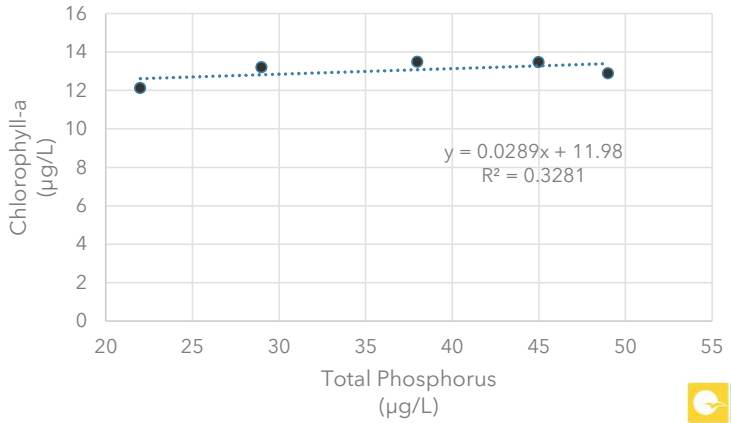
Pomme de Terre TMDL

- Targeted the nutrient screening thresholds as that was a factor in it being listed
  - Each segment must show attainment with water quality standards

	TMDL Water Quality Targets (µg/L)		
	TP	TN	Chlorophyll-a
Ozark Highlands Criteria	16	401	6
East Arm Targets	10	333	5.8
West Arm Targets	15	400	4.7
Near Dam Targets	15	400	4.2

- Use of regression analysis to show the link between phosphorus and chlorophyll-a. Chlorophyll-a is used as a proxy here for harmful algae.



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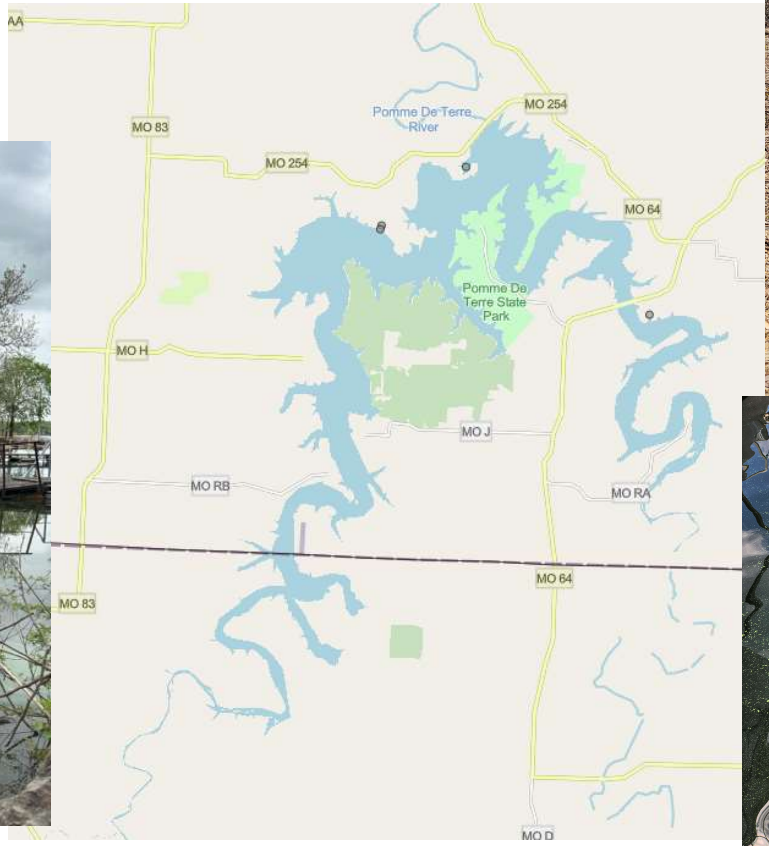
Pomme de Terre Today

- May 2, 2025



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Questions?

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