Long-term Nutrient Monitoring Trends and Coastal Louisiana

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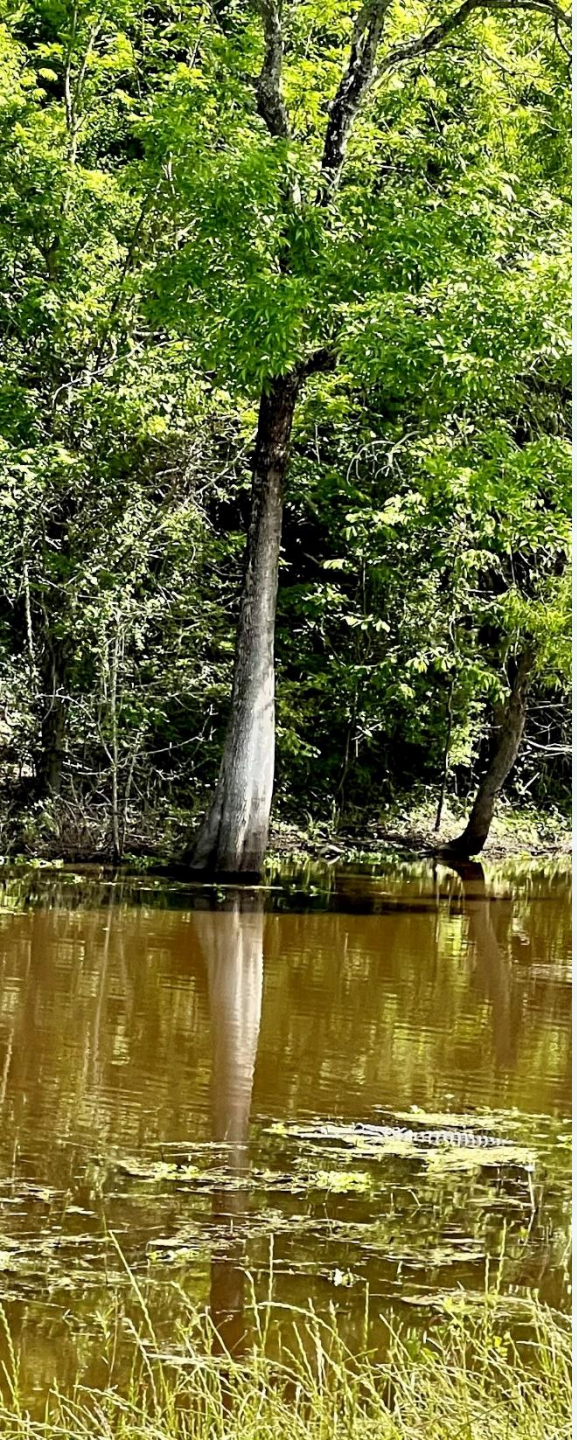
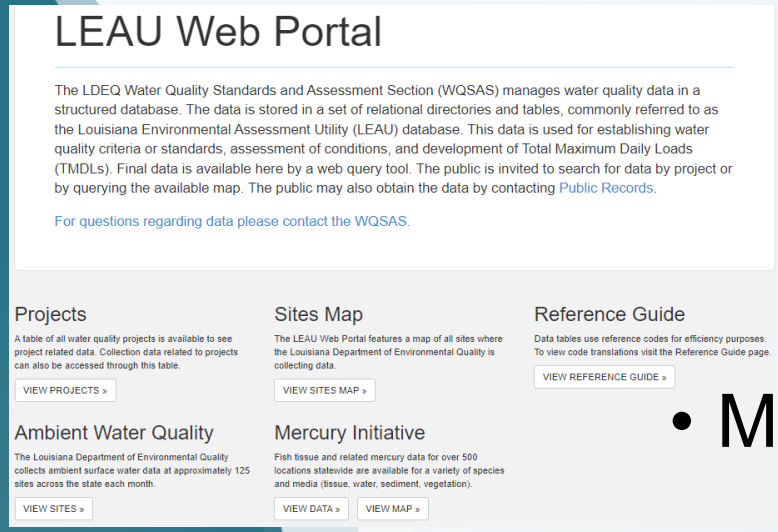


Louisiana Department of Environmental Quality

Mission: …provide service to the people of Louisiana through comprehensive environmental protection in order to promote and protect health, safety and welfare while considering sound policies regarding employment and economic development.

Sherburne WMA South Farm, Maringouin, LA.
Photo by Amanda Marshall



LDEQ Water Quality Monitoring

- Monitoring state waters to identify priority watersheds.
- Monitoring effluents in waters with elevated nutrients.
- Coordinating with nonpoint source communities to promote storm water best management practices and model ordinances.
- Publicly available LDEQ water quality data is available through the LEAU Web Portal.

https://waterdata.deq.louisiana.gov

LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY ENVIROSCHOOL

LDEQ Water Quality Standards & Assessment

- Dissolved Oxygen
  - *Dissolved Oxygen*—the amount of oxygen dissolved in water, commonly expressed as a concentration in terms of milligrams per liter (mg/L) (LAC 33:IX.1105).
  - Weight-of-evidence approach (physiological, water quality, biological, and habitat data; modeling; literature; other states)
  - Inland Rivers & Streams; Coastal Waters
- Minerals (Chlorides, Sulfates, TDS)
  - Statewide & site-specific; TDS ion component analysis; literature reviews; toxicity studies.
- Nutrients
  - Nutrient stressor-response study including water quality, chlorophyll-a (seston and periphyton), macroinvertebrates, fish, habitat data collection

LDEQ Nonpoint Source (NPS) Pollution Program

- LDEQ's *Nonpoint Source Annual Report* estimated that in 2019, program efforts resulted in an estimated annual reduction of 23,809 pounds of nitrogen and 4,646 pounds of phosphorus from nonpoint sources to Louisiana water bodies.

- The 2023 report (most recent) estimated a reduction of 19,282 points of nitrogen and estimated 3,623 pounds of phosphorus from nonpoint sources to Louisiana water bodies.

https://deq.louisiana.gov/page/nonpoint-source

Louisiana's Nutrient Reduction & Management Strategy

- The Hypoxia Task Force (HTF) was established in 1997 to address eutrophication and hypoxia in the Gulf of Mexico, and called for each state to develop a strategy in 2008.
- Louisiana implemented its Nutrient Reduction & Management Strategy (NRMS) in 2014, which identified Ten Strategic Components for a Louisiana Nutrient Management Strategy.
- Identifies and describes methods for pollution control and nutrient capture.
- Incentives facilitate voluntary participation in efforts to manage nutrients through realizing opportunities for both nutrient reduction and assimilation.

Left: LDEQ's active Ambient Water Quality Monitoring Sites (~482, green) sampled regularly as part of the four-year cyclical monitoring rotation & long-term ambient monitoring sites (21, pink) sampled monthly.

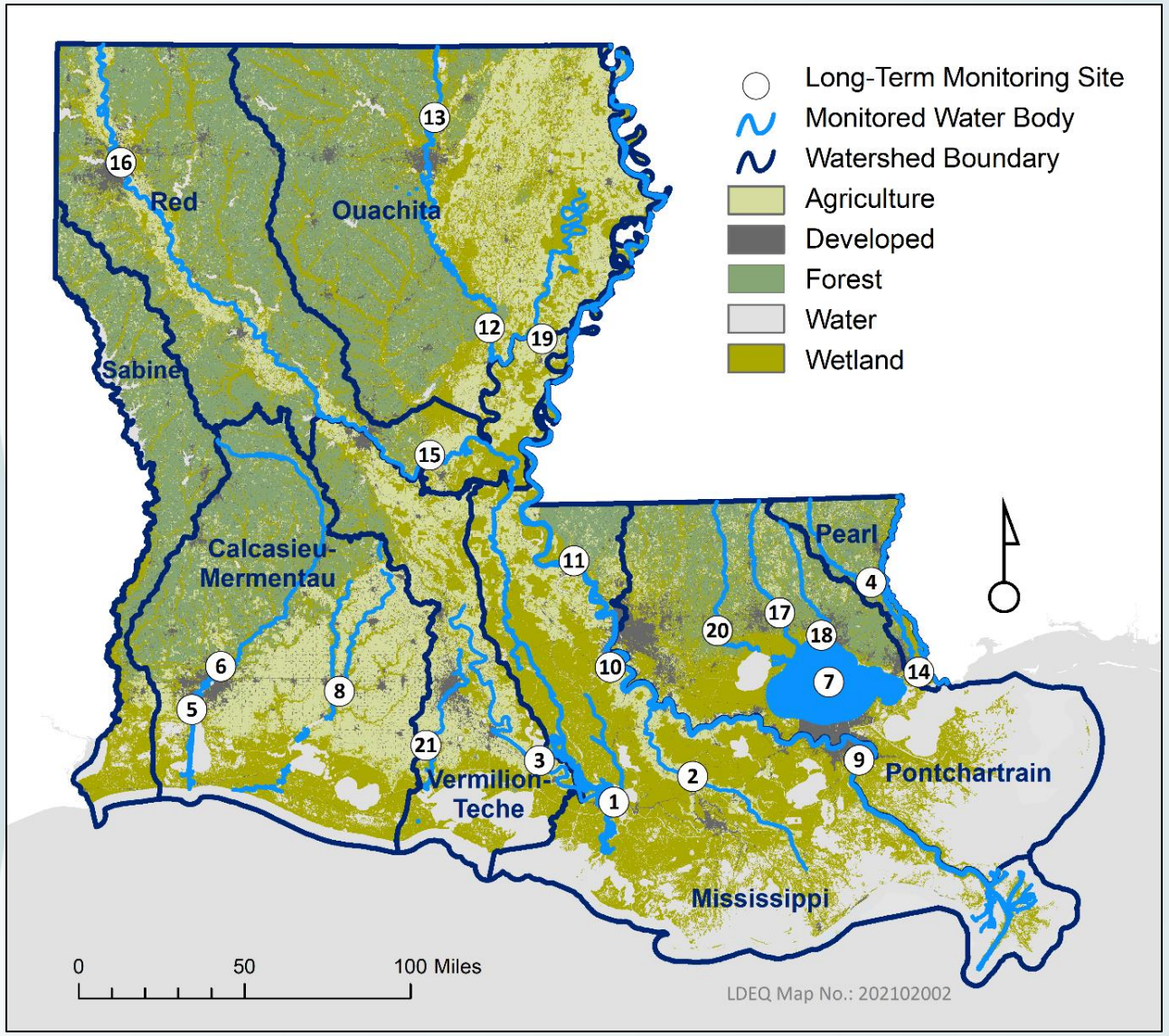
Above: The Mississippi River Basin drainage area and major sub-basins.

Long-term monitoring site information

Site Name	Map #	LDEQ Site #	LDEQ Subsegment	LDEQ Basin Name
Atchafalaya River – Morgan City	**1**	**0039**	**LA010501_00**	**Atchafalaya River Basin**
Bayou Lafourche – Thibodaux	**2**	**0293**	**LA020401_00**	**Barataria Basin**
Bayou Teche – Adeline	**3**	**0030**	**LA060401_00**	**Vermilion-Teche River Basin**
Bogue Chitto River – Bush	4	0064	LA090501_00	Pearl River Basin
Calcasieu River – Burton Landing	**5**	**0026**	**LA030304_00**	**Calcasieu River Basin**
Calcasieu River – Moss Bluff	**6**	**0093**	**LA030201_00**	**Calcasieu River Basin**
Lake Pontchartrain –Metairie	**7**	**0138**	**LA041001_00**	**Lake Pontchartrain Basin**
Mermentau River – Mermentau	**8**	**0003**	**LA050401_00**	**Mermentau River Basin**
Mississippi River – Belle Chasse	**9**	**0051, 0320**	**LA070301_00**	**Mississippi River Basin**
Mississippi River – Plaquemine	**10**	**0053, 0319**	**LA070301_00**	**Mississippi River Basin**
Mississippi River – St. Francisville	11	0055, 0318, 4031	LA070201_00	Mississippi River Basin
Ouachita River – Harrisonburg	12	0085	LA080201_00	Ouachita River Basin
Ouachita River – Sterlington	13	0013	LA080101_00	Ouachita River Basin
Pearl River – Slidell	**14**	**0105**	**LA090202_00**	**Pearl River Basin**
Red River – Marksville	15	0024	LA100201_00	Red River Basin
Red River – Shreveport	16	0120	LA100101_00	Red River Basin
Tangipahoa River –Robert	**17**	**0033**	**LA040701_00**	**Lake Pontchartrain Basin**
Tchefuncte River – Madisonville	**18**	**0106**	**LA040802_00**	**Lake Pontchartrain Basin**
Tensas River – Clayton	19	0159	LA081201_00	Ouachita River Basin
Tickfaw River – Springville	**20**	**0116**	**LA040501_00**	**Lake Pontchartrain Basin**
Vermilion River – Perry	**21**	**0001**	**LA060802_00**	**Vermilion-Teche River Basin**

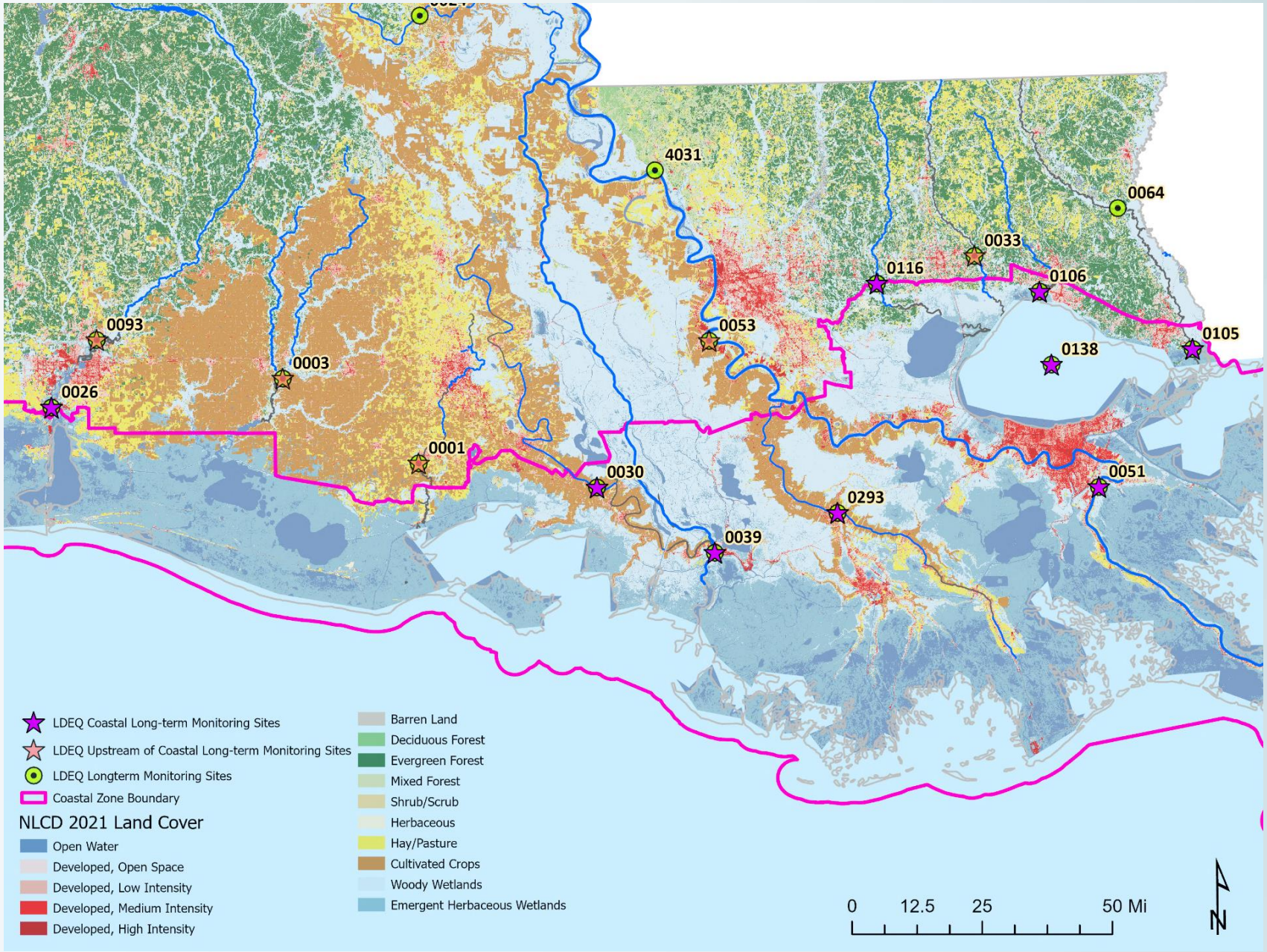
Sites in bold & highlighted orange are coastal/coastal upstream sites.

‘Nitrogen and Phosphorus Trends of Long-Term Ambient Water Quality Monitoring Sites in Louisiana’



- Developed in support of NRMS Strategic Action 5.h. to determine trends in nutrient water quality at long-term monitoring stations.
- First trend analysis released 2015, this update released Nov. 2021.

Coastal sites



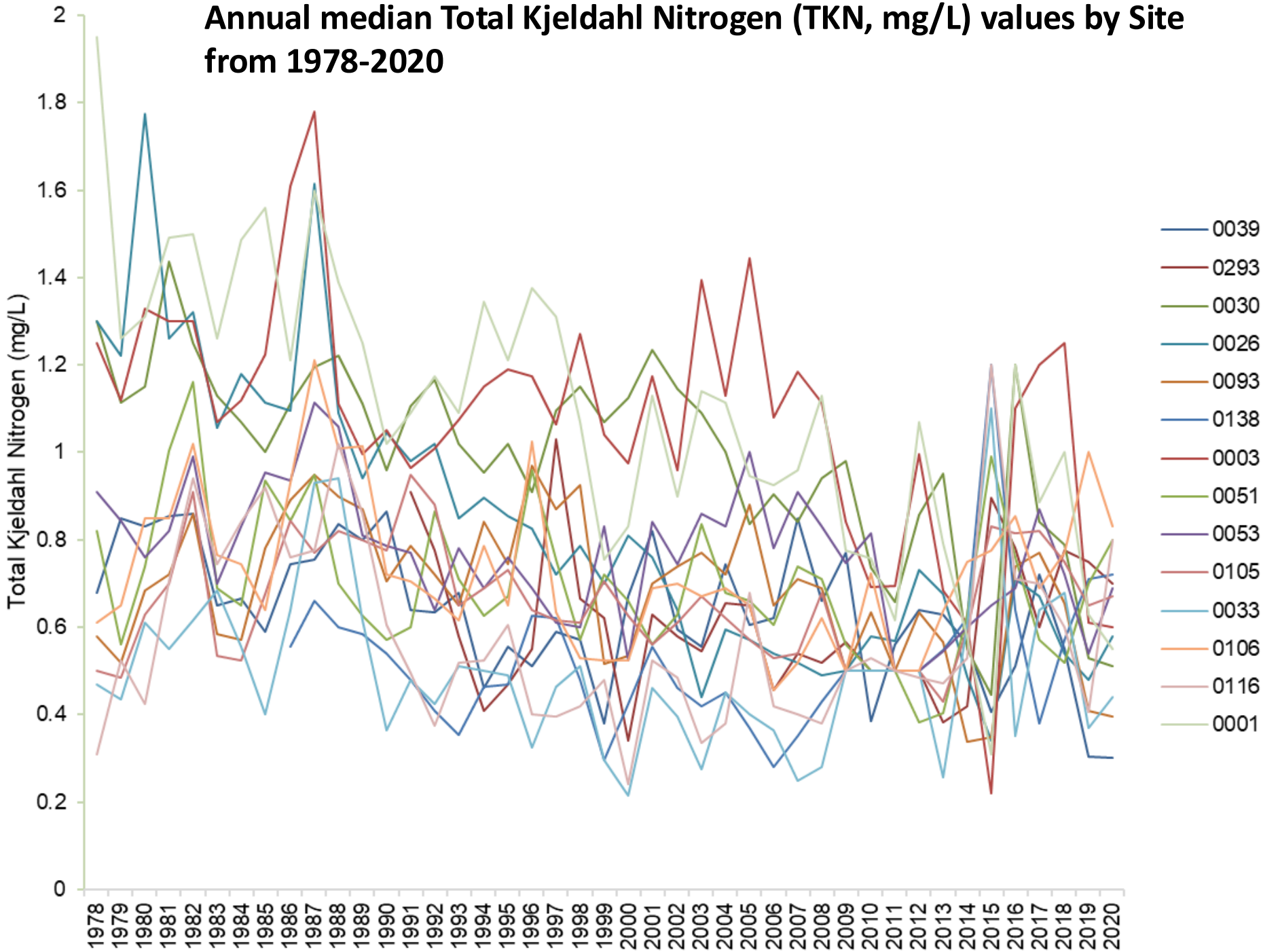
- 9 sites within the coastal zone boundary (magenta)
- 5 sites directly upstream of long-term coastal zone sites (orange)

Long-term ambient water quality monitoring sites for Louisiana and within the coastal (saltwater) zone. Land use from NLCD Cropland Data Layer 2021.

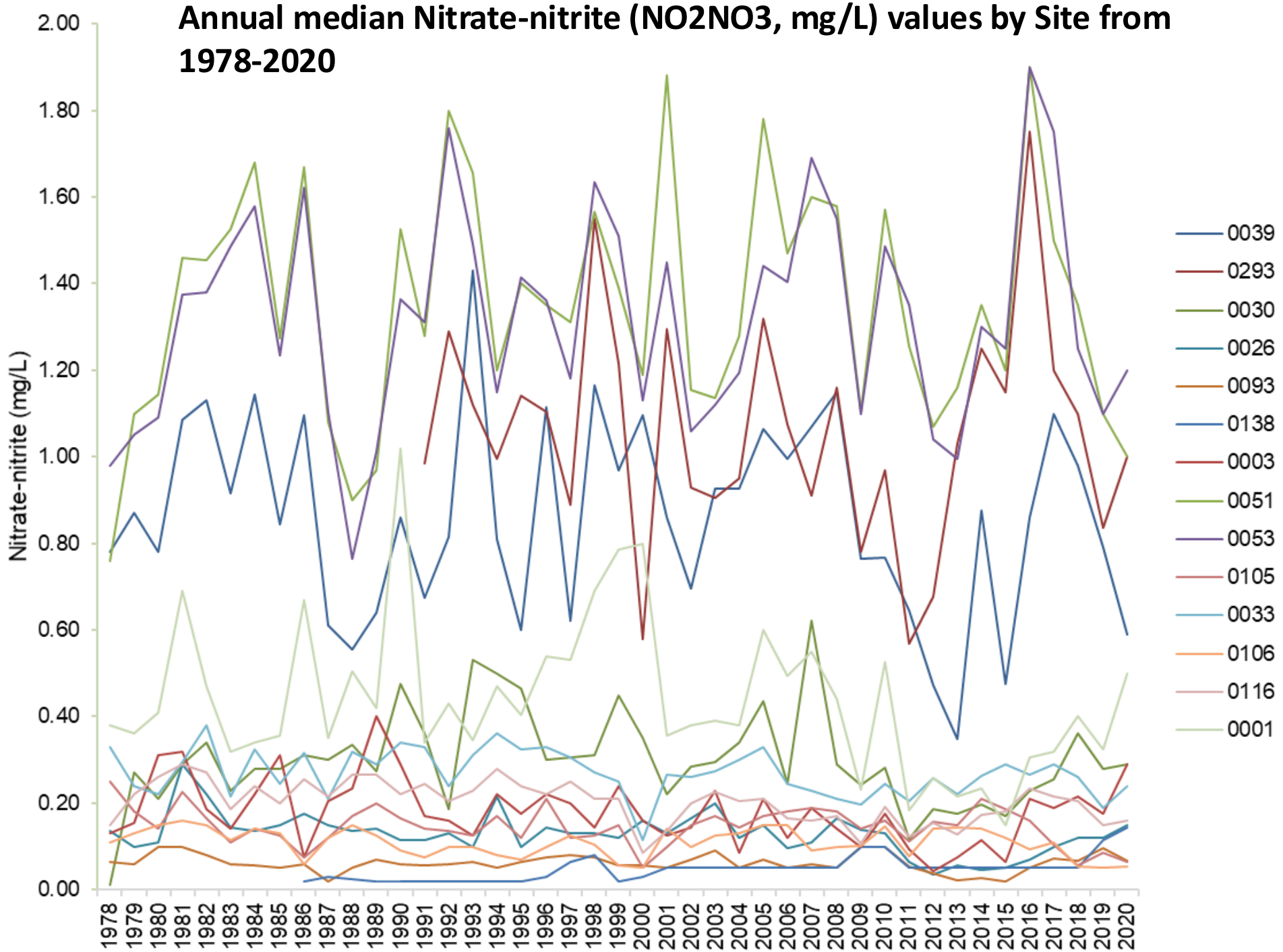
Methods

- Analyzed monthly nutrient concentration data from AWQMN long-term monitoring sites from Oct. 1, 1978 – Sept. 30, 2020 for trends by site and watershed.
- Nutrient parameters included Total Kjeldahl Nitrogen (TKN, mg/L), Nitrate-nitrite (NO2NO3, mg/L), and Total Phosphorus (TP, mg/L)
- Utilized nonparametric methods with R (RStudio)
  - Kaplan-Meier descriptive statistics, Kendall's tau correlation analyses, censored Seasonal Kendall trend analyses.
- Also preformed a land use correlation between median nutrient concentrations, which included correlation with Total Suspended Sediment (TSS) data.

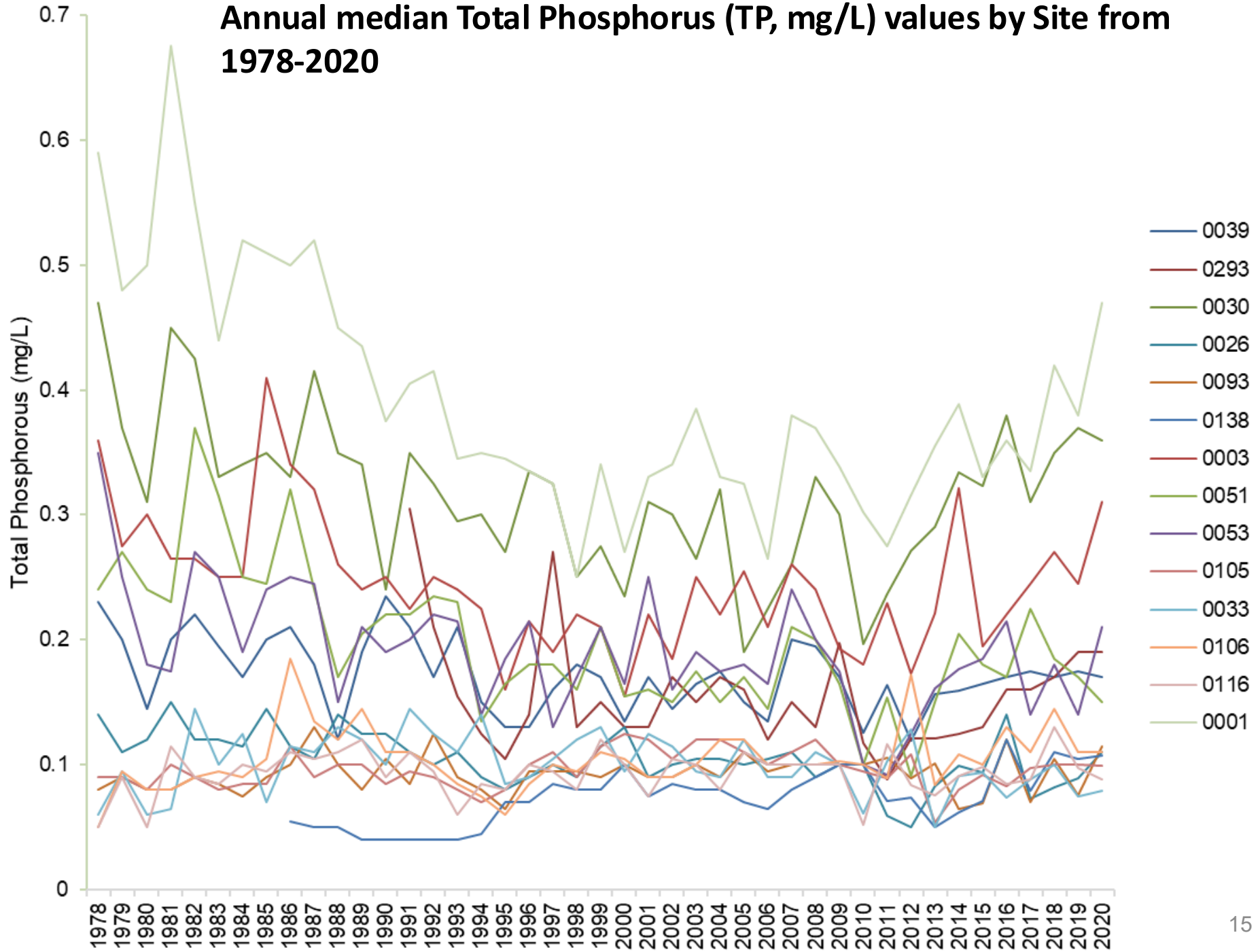
Annual median Total Kjeldahl Nitrogen (TKN, mg/L) values by Site from 1978-2020



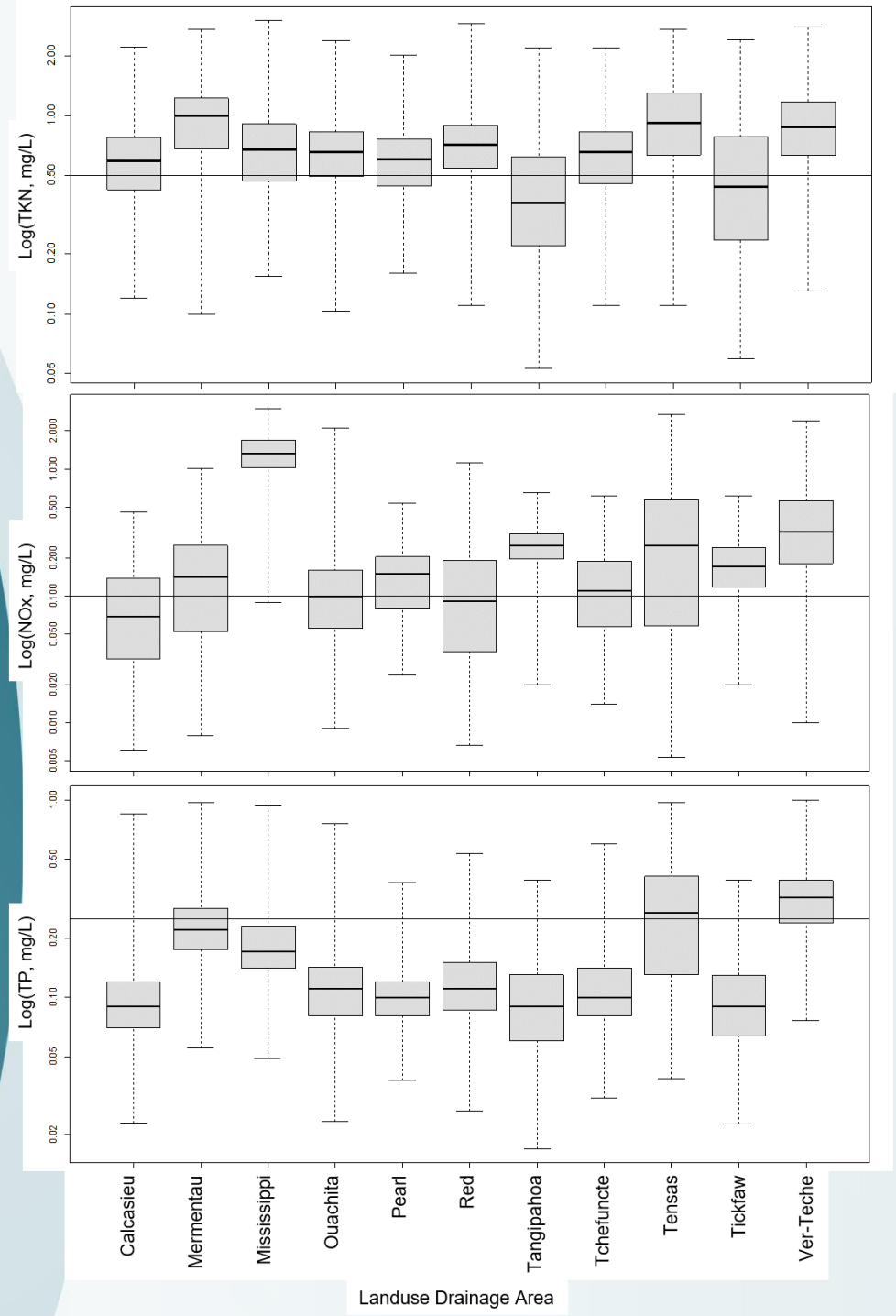
Annual median Nitrate-nitrite (NO2NO3, mg/L) values by Site from 1978-2020

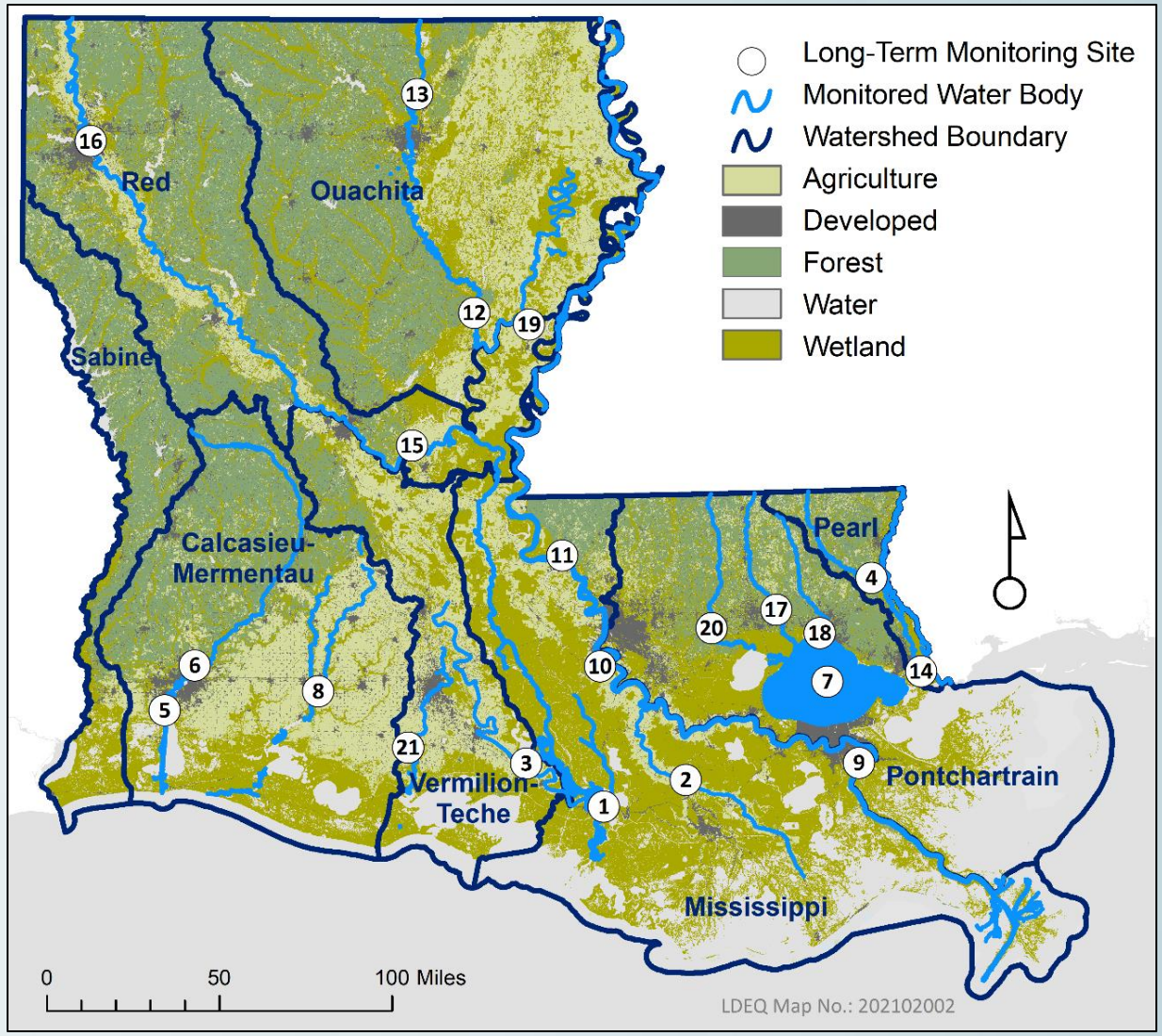


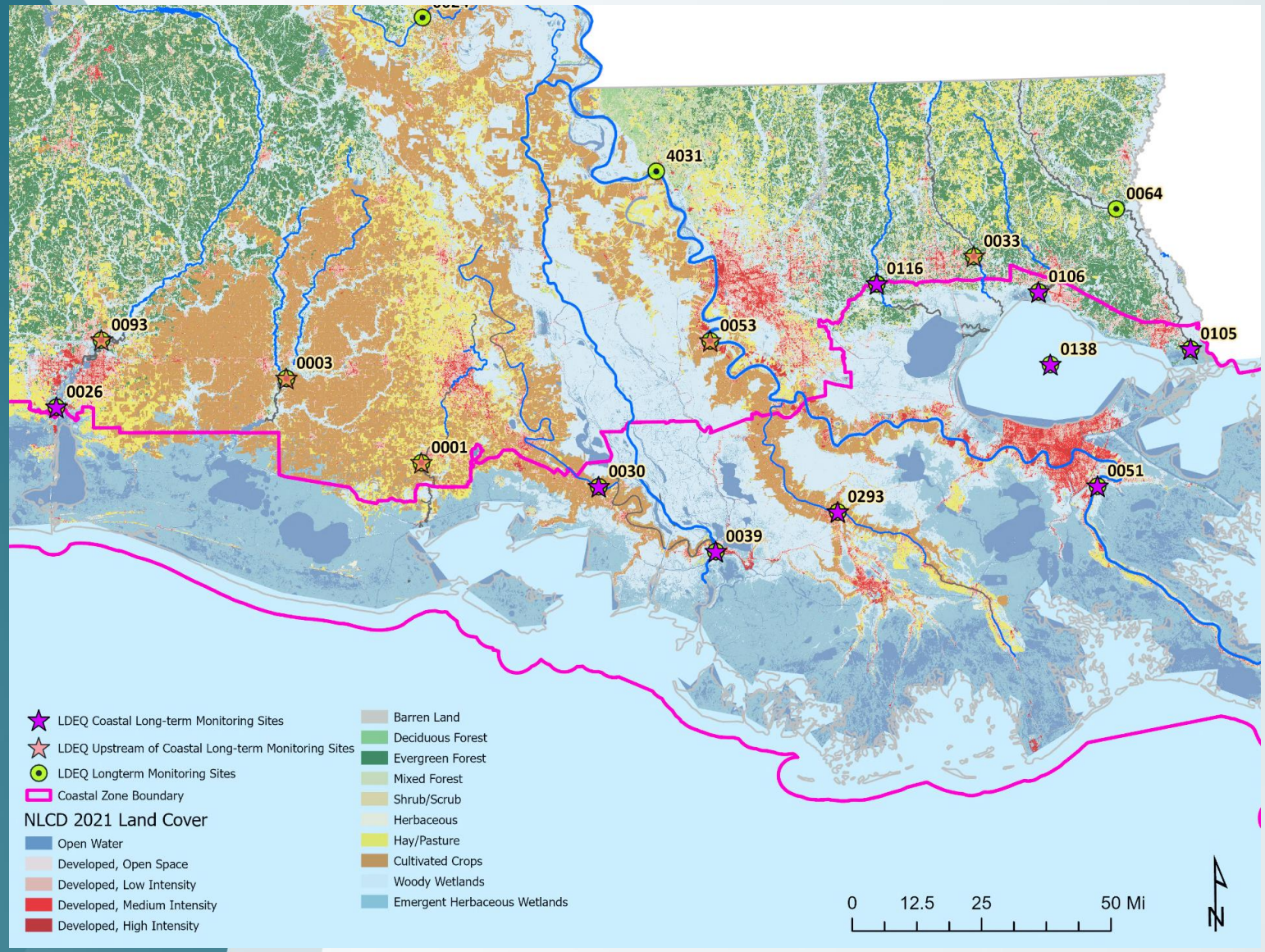
Annual median Total Phosphorus (TP, mg/L) values by Site from 1978-2020



Median nutrient levels by watershed







Site Name	LDEQ Site #
Atchafalaya River – Morgan City	**0039**
Bayou Lafourche – Thibodaux	**0293**
Bayou Teche – Adeline	**0030**
Bogue Chitto River – Bush	0064
Calcasieu River – Burton Landing	**0026**
Calcasieu River – Moss Bluff	**0093**
Lake Pontchartrain –Metairie	**0138**
Mermentau River – Mermentau	**0003**
Mississippi River – Belle Chasse	**0051, 0320**
Mississippi River – Plaquemine	**0053, 0319**
Mississippi River – St. Francisville	0055, 0318, 4031
Ouachita River – Harrisonburg	0085
Ouachita River – Sterlington	0013
Pearl River – Slidell	**0105**
Red River – Marksville	0024
Red River – Shreveport	0120
Tangipahoa River –Robert	**0033**
Tchefuncte River – Madisonville	**0106**
Tensas River – Clayton	0159
Tickfaw River – Springville	**0116**
Vermilion River – Perry	**0001**

Long-term ambient water quality monitoring sites for Louisiana. Land use from NLCD Cropland Data Layer 2021.

Range of nutrient parameter values and Censored Seasonal Kendall long-term trends by site from 1978-2020 (mg/L, p ≤ 0.05)

Site	Site No.	Total Kjeldahl Nitrogen (TKN)				Nitrate + Nitrite (NOx)				Total Phosphorous (TP)			
		Min	Median	Max	Trend	Min	Median	Max	Trend	Min	Median	Max	Trend
All Sites		0.01 [a]	0.72	25.0		0.01 [a]	0.22	379.0		0.01 [a]	0.14	121.0	
Atchafalaya	0039	0.02 [a]	0.66	8.36	↓	0.01 [a]	0.84	2.38	↓	0.02 [a]	0.17	0.64	↓
Lafourche	0293	0.10	0.59	3.46	NS	0.05	1.0	2.54	NS	0.01 [a]	0.15	37.6	NS
Teche	0030	0.10	1.02	9.1	↓	0.01 [a]	0.28	2.38	NS	0.03 [a]	0.31	2.54	↓
Calcasieu—BL	0026	0.02 [a]	0.79	7.1	↓	0.01 [a]	0.13	20.2	↓	0.01 [a]	0.10	1.49	↓
Calcasieu—MB	0093	0.02 [a]	0.69	2.72	↓	0.01 [a]	0.06	20.2	↓	0.01 [a]	0.09	0.85	NS
Lake Pontchartrain	0138	0.05 [a]	0.50	5.8	NS	0.01 [a]	0.05	1.3	NS	0.01 [a]	0.07	0.73	↑
Mermentau	0003	0.10	1.10	4.77	↓	0.01 [a]	0.17	1.13	↓	0.01 [a]	0.24	1.10	↓
Mississippi—BC	0051	0.01 [a]	0.69	10.2	↓	0.02 [a]	1.35	9.38	NS	0.01 [a]	0.20	2.60	↓
Mississippi—Pla	0053	0.03 [a]	0.77	6.0	↓	0.05	1.3	3.27	NS	0.02 [a]	0.19	47.6	↓
Pearl	0105	0.05 [a]	0.67	8.39	NS	0.01 [a]	0.15	1.8	NS	0.01 [a]	0.10	0.80	↓
Tangipahoa	0033	0.02 [a]	0.50	25.0	↓	0.02 [a]	0.27	0.82	↓	0.01 [a]	0.10	0.72	↓
Tchefuncte	0106	0.02 [a]	0.73	2.6	↓	0.01 [a]	0.11	0.62	NS	0.01 [a]	0.10	0.80	NS
Tickfaw	0116	0.01 [a]	0.55	4.0	↓	0.01 [a]	0.2	0.82	↓	0.01 [a]	0.10	0.78	NS
Vermilion	0001	0.10	1.06	5.7	↓	0.01 [a]	0.4	1.92	↓	0.05	0.38	1.51	↓

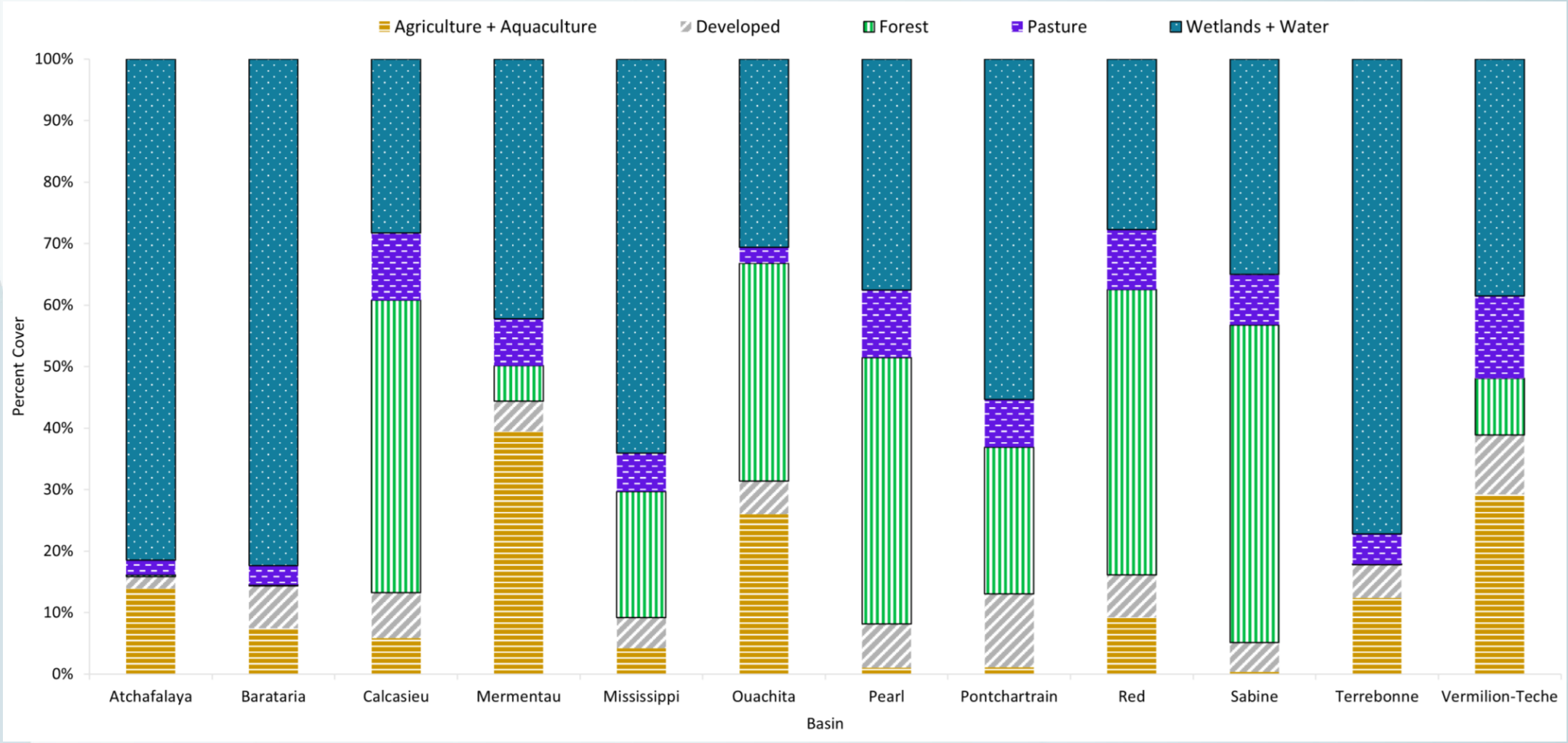
Long-term seasonal trends

Site Name	Site #	Season	Total Kjeldahl Nitrogen					Nitrite + Nitrate					Total Phosphorus				
			n	tau	pval	slope	trend	n	tau	pval	slope	trend	n	tau	pval	slope	trend
Calcasieu–MB	0093	Spring	122	-0.21	*0.00*	-0.01	↓	125	-0.20	*0.00*	0.00	↓	124	0.01	0.85	0.00	NS
		Summer	116	-0.20	*0.00*	-0.01	↓	123	-0.08	0.21	0.00	NS	120	0.05	0.44	0.00	NS
		Fall	112	-0.15	*0.02*	0.00	↓	117	-0.08	0.19	0.00	NS	114	-0.07	0.24	0.00	NS
		Winter	117	-0.18	*0.00*	-0.01	↓	121	-0.15	*0.01*	0.00	↓	119	-0.05	0.41	0.00	NS
Calcasieu–BL	0026	Spring	122	-0.40	*0.00*	-0.02	↓	126	-0.24	*0.00*	0.00	↓	124	-0.13	*0.03*	0.00	↓
		Summer	114	-0.47	*0.00*	-0.02	↓	122	-0.19	*0.00*	0.00	↓	117	-0.18	*0.00*	0.00	↓
		Fall	114	-0.41	*0.00*	-0.02	↓	117	-0.10	0.13	0.00	NS	116	-0.27	*0.00*	0.00	↓
		Winter	115	-0.51	*0.00*	-0.02	↓	119	-0.17	*0.01*	0.00	↓	117	-0.29	*0.00*	0.00	↓
Vermilion	0001	Spring	121	-0.44	*0.00*	-0.03	↓	127	-0.12	*0.05*	0.00	↓	125	-0.27	*0.00*	0.00	↓
		Summer	118	-0.27	*0.00*	-0.01	↓	126	-0.05	0.44	0.00	NS	123	-0.15	*0.01*	0.00	↓
		Fall	115	-0.30	*0.00*	-0.01	↓	123	-0.10	0.09	0.00	NS	118	-0.14	*0.03*	0.00	↓
		Winter	115	-0.36	*0.00*	-0.02	↓	120	-0.05	0.40	0.00	NS	116	-0.31	*0.00*	-0.01	↓
Mermentau	0003	Spring	114	-0.33	*0.00*	-0.02	↓	128	-0.10	0.11	0.00	NS	125	-0.09	0.16	0.00	NS
		Summer	117	-0.14	*0.02*	-0.01	↓	126	-0.12	0.05	0.00	NS	122	-0.07	0.25	0.00	NS
		Fall	115	-0.13	*0.04*	0.00	↓	122	-0.25	*0.00*	0.00	↓	118	-0.06	0.37	0.00	NS
		Winter	116	-0.32	*0.00*	-0.02	↓	120	-0.21	*0.00*	0.00	↓	120	-0.24	*0.00*	0.00	↓
Teche	0030	Spring	123	-0.24	*0.00*	-0.01	↓	128	0.00	0.99	0.00	NS	126	-0.11	0.07	0.00	NS
		Summer	124	-0.31	*0.00*	-0.01	↓	128	-0.03	0.59	0.00	NS	125	-0.14	*0.02*	0.00	↓
		Fall	116	-0.27	*0.00*	-0.01	↓	123	0.00	1.00	0.00	NS	120	-0.07	0.29	0.00	NS
		Winter	118	-0.33	*0.00*	-0.02	↓	120	0.03	0.58	0.00	NS	118	-0.23	*0.00*	0.00	↓
Atchafalaya	0039	Spring	112	-0.20	*0.00*	-0.01	↓	118	-0.21	*0.00*	-0.01	↓	115	-0.24	*0.00*	0.00	↓
		Summer	108	-0.27	*0.00*	-0.01	↓	110	0.04	0.56	0.00	NS	108	-0.08	0.21	0.00	NS
		Fall	103	-0.20	*0.00*	-0.01	↓	112	-0.10	0.11	0.00	NS	108	0.07	0.27	0.00	NS
		Winter	101	-0.15	*0.03*	-0.01	↓	105	0.01	0.90	0.00	NS	102	-0.11	0.10	0.00	NS
Mississippi–Pla	0053/0319	Spring	118	-0.22	*0.00*	-0.01	↓	128	-0.14	*0.02*	-0.01	↓	121	-0.22	*0.00*	0.00	↓
		Summer	105	-0.16	*0.01*	-0.01	↓	125	0.07	0.27	0.00	NS	115	-0.19	*0.00*	0.00	↓
		Fall	104	-0.01	0.92	0.00	NS	121	-0.02	0.71	0.00	NS	108	0.00	0.98	0.00	NS
		Winter	112	-0.25	*0.00*	-0.01	↓	124	0.02	0.72	0.00	NS	114	-0.22	*0.00*	0.00	↓

Long-term seasonal trends

Site Name	Site #	Season	Total Kjeldahl Nitrogen					Nitrite + Nitrate					Total Phosphorus				
			n	tau	pval	slope	trend	n	tau	pval	slope	trend	n	tau	pval	slope	trend
Lafourche	0293	Spring	66	0.00	0.97	0.00	NS	76	-0.12	0.14	-0.01	NS	70	0.02	0.82	0.00	NS
		Summer	75	-0.08	0.34	0.00	NS	85	0.03	0.72	0.00	NS	83	-0.04	0.63	0.00	NS
		Fall	56	-0.06	0.50	0.00	NS	68	0.19	*0.02*	0.01	↑	63	0.02	0.82	0.00	NS
		Winter	70	-0.03	0.76	0.00	NS	81	0.03	0.74	0.00	NS	78	0.05	0.56	0.00	NS
Tickfaw	0116	Spring	115	-0.24	*0.00*	-0.01	↓	121	-0.28	*0.00*	0.00	↓	116	-0.07	0.28	0.00	NS
		Summer	98	-0.16	*0.02*	-0.01	↓	109	-0.12	0.06	0.00	NS	106	-0.03	0.61	0.00	NS
		Fall	101	-0.02	0.75	0.00	NS	114	0.12	0.07	0.00	NS	109	0.08	0.20	0.00	NS
		Winter	102	-0.20	*0.00*	-0.01	↓	109	-0.29	*0.00*	0.00	↓	105	-0.10	0.13	0.00	NS
Tangipahoa	0033	Spring	121	-0.17	*0.01*	-0.01	↓	129	-0.16	*0.01*	0.00	↓	127	-0.20	*0.00*	0.00	↓
		Summer	113	-0.24	*0.00*	-0.01	↓	125	-0.02	0.78	0.00	NS	121	-0.12	0.05	0.00	NS
		Fall	109	-0.10	0.13	0.00	NS	121	0.07	0.26	0.00	NS	117	-0.01	0.92	0.00	NS
		Winter	115	-0.21	*0.00*	-0.01	↓	125	-0.31	*0.00*	0.00	↓	121	-0.18	*0.00*	0.00	↓
Tchefuncte	0106	Spring	110	-0.14	*0.03*	-0.01	↓	117	-0.13	*0.03*	0.00	↓	118	-0.08	0.18	0.00	NS
		Summer	98	-0.17	*0.01*	-0.01	↓	112	-0.06	0.34	0.00	NS	105	0.04	0.53	0.00	NS
		Fall	95	-0.08	0.24	0.00	NS	114	-0.03	0.67	0.00	NS	107	0.14	*0.03*	0.00	↑
		Winter	103	-0.27	*0.00*	-0.01	↓	110	0.15	*0.02*	0.00	↑	104	0.13	0.06	0.00	NS
Pontchartrain	0138	Spring	95	-0.11	0.12	0.00	NS	103	-0.02	0.76	0.00	NS	104	0.15	*0.02*	0.00	↑
		Summer	94	-0.07	0.34	0.00	NS	107	0.03	0.60	0.00	NS	101	0.14	*0.03*	0.00	↑
		Fall	80	0.07	0.36	0.00	NS	97	-0.03	0.68	0.00	NS	93	0.22	*0.00*	0.00	↑
		Winter	95	-0.14	*0.05*	-0.01	↓	103	0.07	0.30	0.00	NS	97	0.31	*0.00*	0.00	↑
Mississippi–BC	0051/0320	Spring	119	-0.20	*0.00*	-0.01	↓	127	-0.19	*0.00*	-0.01	↓	125	-0.30	*0.00*	0.00	↓
		Summer	111	-0.17	*0.01*	-0.01	↓	124	0.07	0.27	0.00	NS	118	-0.26	*0.00*	0.00	↓
		Fall	102	-0.10	0.15	0.00	NS	118	0.00	0.95	0.00	NS	109	-0.16	*0.01*	0.00	↓
		Winter	108	-0.21	*0.00*	-0.01	↓	120	0.01	0.94	0.00	NS	117	-0.21	*0.00*	0.00	↓
Pearl	0105	Spring	115	-0.11	0.07	0.00	NS	124	-0.10	0.10	0.00	NS	117	-0.01	0.91	0.00	NS
		Summer	113	-0.15	*0.02*	0.00	↓	123	-0.06	0.31	0.00	NS	122	0.06	0.35	0.00	NS
		Fall	107	-0.09	0.17	0.00	NS	121	0.03	0.67	0.00	NS	113	0.04	0.57	0.00	NS
		Winter	110	-0.15	*0.02*	-0.01	↓	120	0.02	0.71	0.00	NS	116	0.04	0.53	0.00	NS

Land use by LDEQ watershed



Land use categories aggregated from NLCD 2021 Cropland Data Layer to LDEQ watersheds

Land use correlations

	Water Quality Parameter				Land Use							
	TKN	NO_x	TP	TSS	Wetlands	Forest	Developed	Grasslands	Agriculture	Rice/Aqua	N-fixer	non N-fixer
Drainage Area	mg/L				% cover							
Calcasieu	0.59	0.07	0.09	15.00	18%	50%	8%	18%	6%	4%	0%	2%
Mermentau	0.99	0.14	0.22	16.00	20%	13%	8%	12%	47%	29%	4%	13%
Mississippi	0.67	1.32	0.17	67.00	3%	23%	5%	36%	32%	0%	11%	20%
Ouachita	0.65	0.10	0.11	18.00	21%	49%	6%	11%	13%	1%	4%	7%
Pearl	0.60	0.15	0.10	27.00	18%	53%	7%	19%	2%	—	1%	1%
Red	0.71	0.09	0.11	27.50	4%	24%	4%	49%	18%	0%	1%	17%
Tangipahoa	0.37	0.25	0.09	13.00	16%	44%	7%	32%	1%	—	0%	1%
Tchefuncte	0.65	0.11	0.10	6.00	17%	48%	12%	22%	0%	—	0%	0%
Tensas	0.91	0.25	0.27	39.00	30%	0%	3%	0%	67%	4%	0%	63%
Tickfaw	0.45	0.17	0.09	15.00	23%	51%	4%	21%	0%	—	0%	0%
Ver-Teche	0.88	0.32	0.32	38.00	27%	12%	11%	18%	32%	6%	11%	15%

		TKN	NOx	TP
	tau	*0.463*	0.330	*0.539*
TSS	*p-val*	*0.050*	0.160	*0.026*
	tau	0.183	0.164	0.229
Wetlands	*p-val*	0.435	0.542	0.342
	tau	*-0.624*	-0.345	*-0.686*
Forest	*p-val*	*0.008*	0.165	*0.004*
	tau	-0.110	-0.164	-0.076
Developed	*p-val*	0.639	0.542	0.751
	tau	*0.661*	0.200	*0.686*
Agriculture	*p-val*	*0.005*	0.445	*0.004*
	tau	-0.220	0.091	-0.229
Grasslands	*p-val*	0.349	0.761	0.342

		TKN	NOx	TP
	tau	*0.514*	0.200	*0.610*
Non N-fixer	*p-val*	*0.029*	0.445	*0.011*
	tau	0.404	0.164	*0.534*
N-fixer	*p-val*	0.086	0.542	*0.027*
	tau	*0.477*	0.018	*0.496*
Rice/Aqua	*p-val*	*0.042*	1.000	*0.039*

Summary of Trends Analysis

- Overall nutrient concentration decreases for the majority of long-term monitoring sites within the state
  - Slight increases in the Bogue Chitto (NOx, TP) and Pontchartrain sites in Southeast LA (TP).
- Correlation analysis shows forested areas are associated with lower TKN and lower TP concentrations.
  - Sites in drainage areas with highest proportion forest cover (Pearl, Tickfaw, Calcasieu, Ouachita, Tchefuncte, and Tangipahoa) have the lowest median TKN and median TP values
  - Sites in drainage areas with highest agricultural land use (Tensas, Mermentau, Mississippi, Vermilion-Teche, and Red) have the highest median TKN and TP values.

Thank you

Questions?

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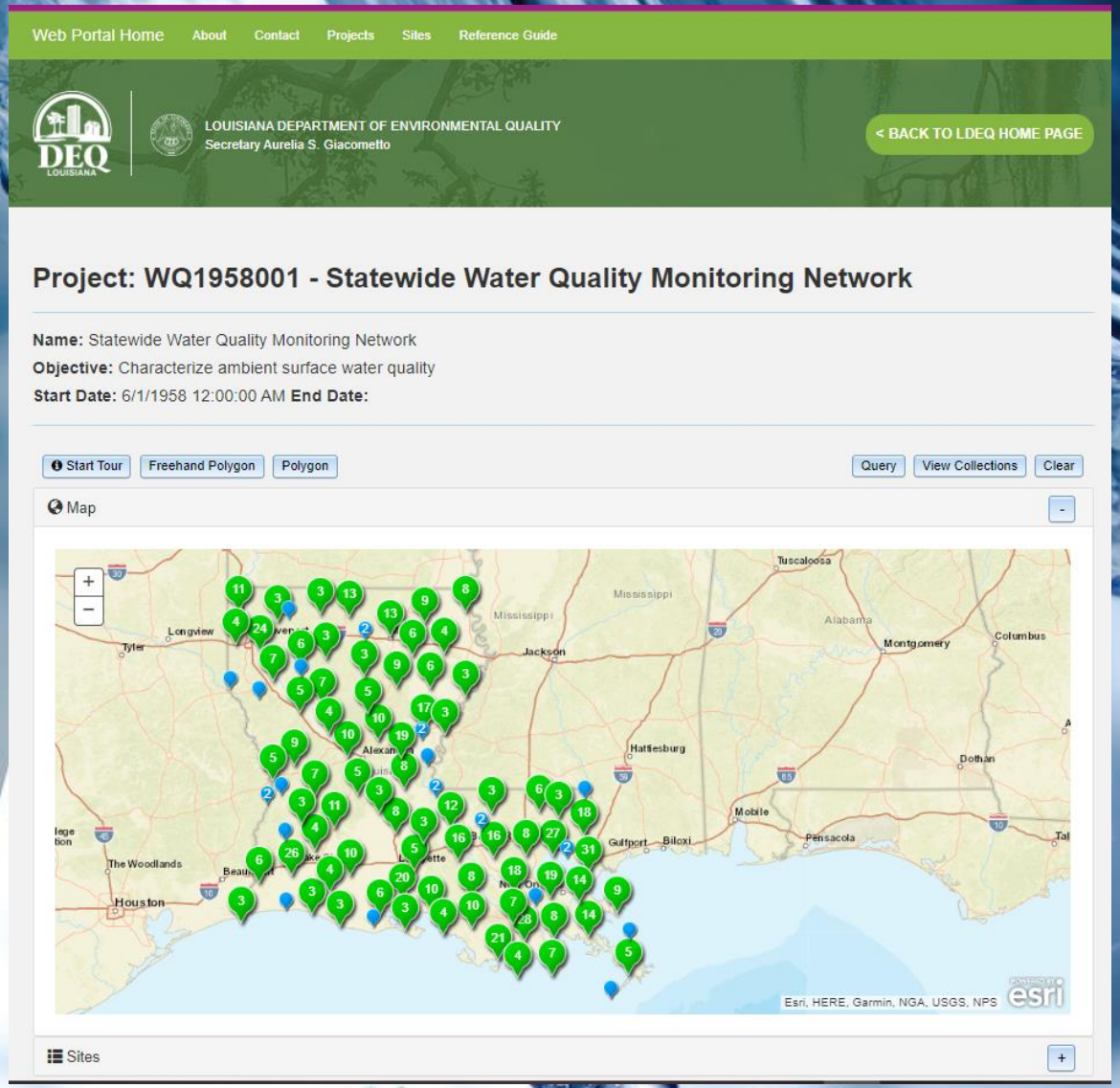

Links

- https://deq.louisiana.gov/page/nutrient-management-strategy
- https://waterdata.deq.louisiana.gov/Projects/WQ1958001
- https://deq.louisiana.gov/assets/docs/Water/Pub2994-G-NPS-Nutrients.pdf
- https://deq.louisiana.gov/assets/docs/Water/2022_NRMS_AR_5.26.23.pdf
- https://deq.louisiana.gov/assets/docs/Water/2013-01-18_FACTSHEET_LANUTRIENTSTRATEGY_3.pdf
- https://deq.louisiana.gov/page/nutrient-management-decision-support-tools
- https://www.deq.louisiana.gov/assets/docs/Water/Nitrogen-Phosphorus-Long-term-Trends.pdf
- https://www.epa.gov/system/files/documents/2023-04/State%20Workplans%20April%202023%20combined_508%20rev.pdf
- https://deq.louisiana.gov/assets/docs/Water/Nutrient_Management_Strategy/Water_Permit_Implementation_Strategy_Nutrient_Management_Strategy_053017_modified.pdf
- https://www.epa.gov/sites/default/files/2019-10/documents/2019_htf_point_source_progress_report_final_508.pdf
- https://www.epa.gov/sites/default/files/2018-05/documents/nps_measures_progress_report_1-_may_2018.pdf
- https://www.deq.louisiana.gov/assets/docs/About_LDEQ/enviroschool/BMP-in-SWPPlanning-and-Dev.pdf
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