The Input and Fate of Particulate Materials in Falls Lake, NC

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Why Particulate Materials ?

Percentage of Riverine Transport in a Particulate Form

Phosphorus	~ 85%	***(Meybeck, 1982; Seitzinger et al., 2005)***
Nitrogen	~40-85%	***(Mayer et al., 1998)***
Organic Carbon	~ 65%	***(Seitzinger et al., 2005)***

99–99.9%	Ga, Tm, Lu, Gd, Ti, Er, Nd, Ho, La, Sm, Tb, Yb, Fe, Eu, Ce, Al.
90–99	P, Ni, Si, Rb, U, Co, Mn, Cr, Th, Pb, V, Cs.
50–90	Li, N, Sb, As, Mg, B, Mo, F, Cu, Zn, Ba, K.

Martin and Meybeck, 1979

Therefore: release of only a small fraction from Particulate can have a major impact on the Dissolved load

Overview Question

"When and where do particulate materials enter Falls Lake and what is the fate of particulates within the reservoir"

Objectives:

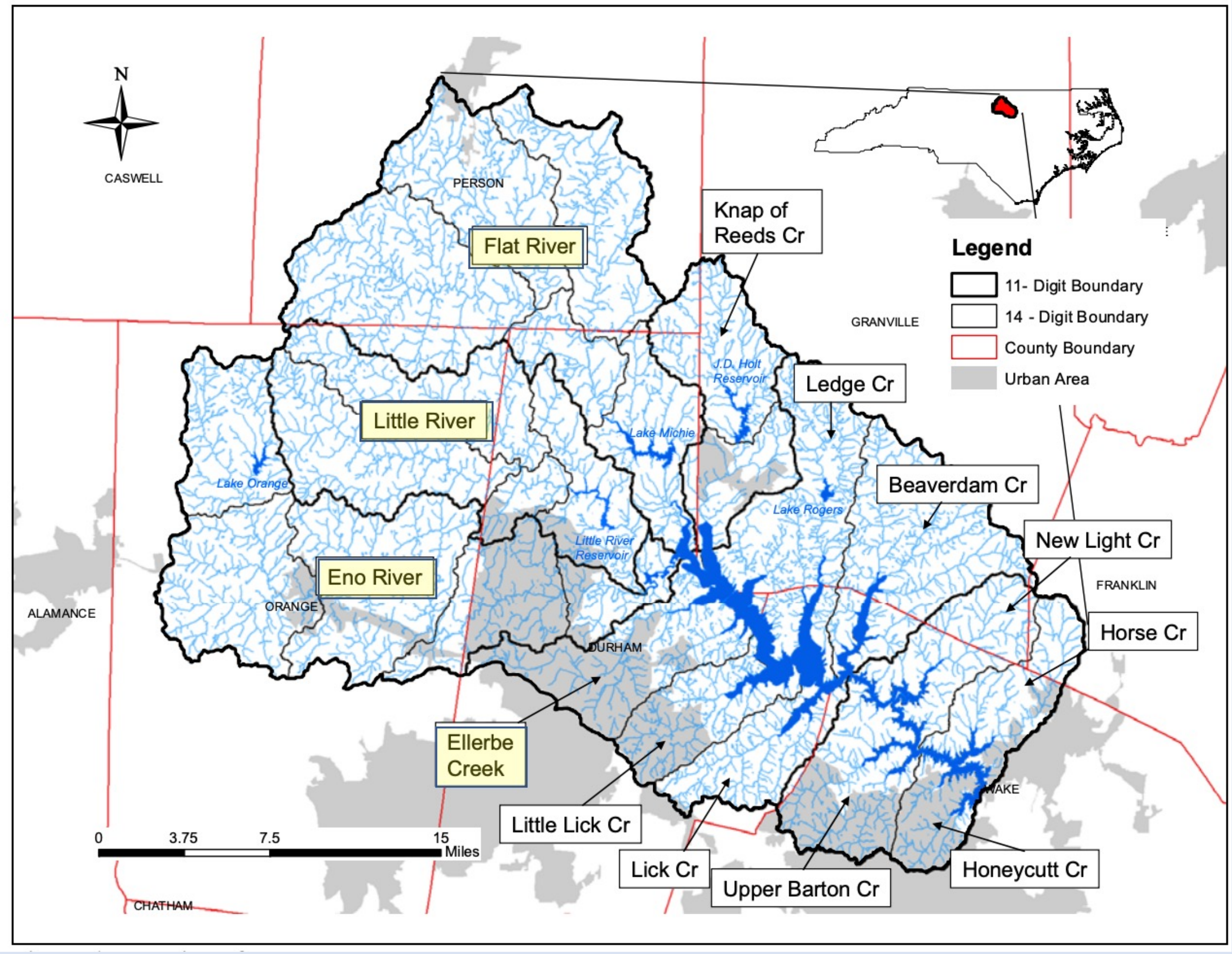
Inputs of particulate materials to Falls Lake

(1)To quantify the temporal and spatial inputs of suspended sediments and associated organic carbon to Falls Lake

Fate of particulate materials in Falls Lake sediments

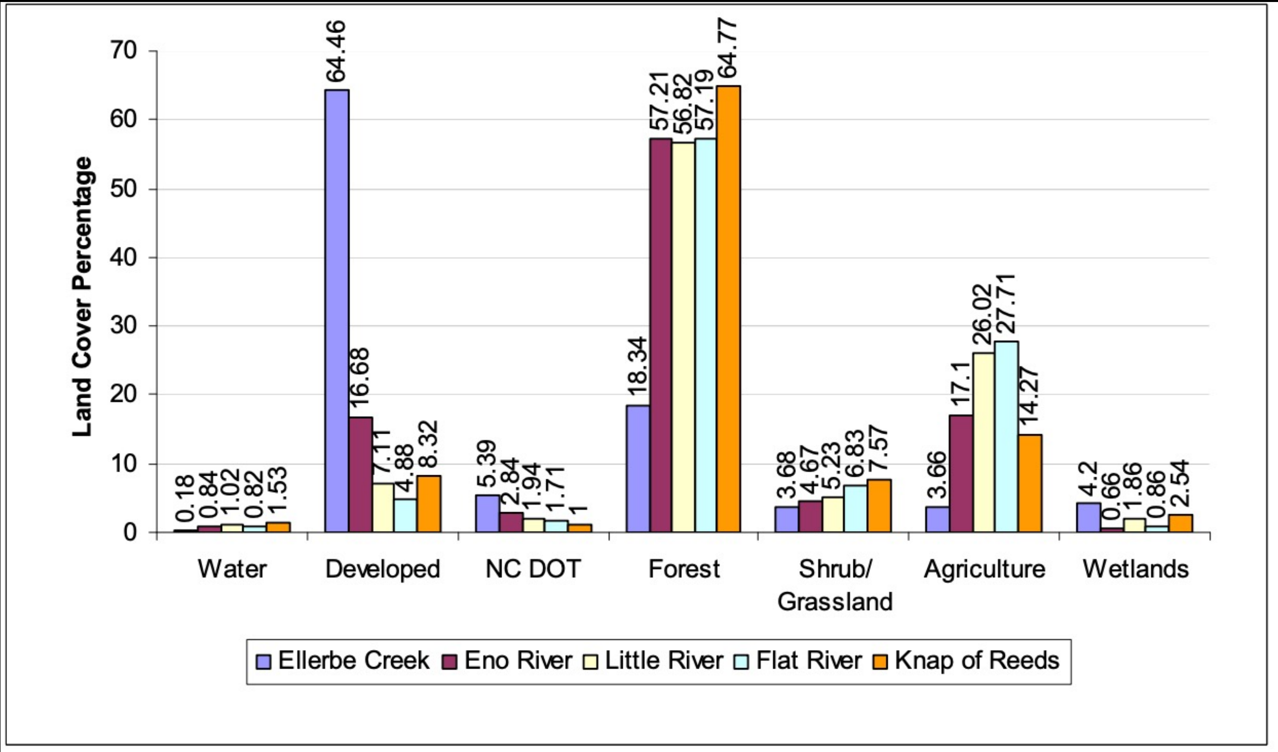
(2) To quantify rates of bottom sediment mixing and accumulation.

These are important processes parameters needed to quantify carbon and nutrient fluxes in bottom sediments.



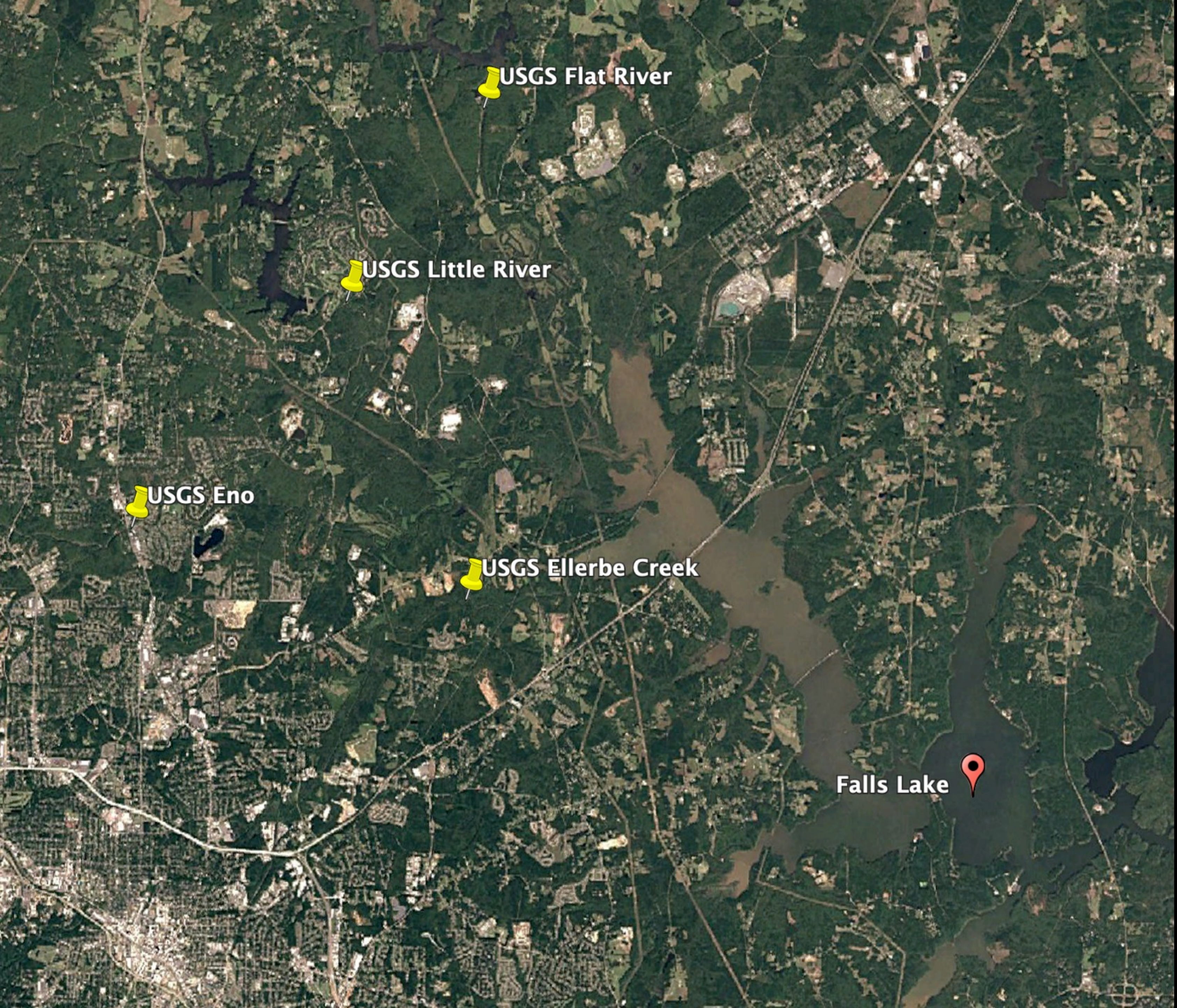
Watersheds monitored in this study (in yellow)

Upper Lake Watersheds



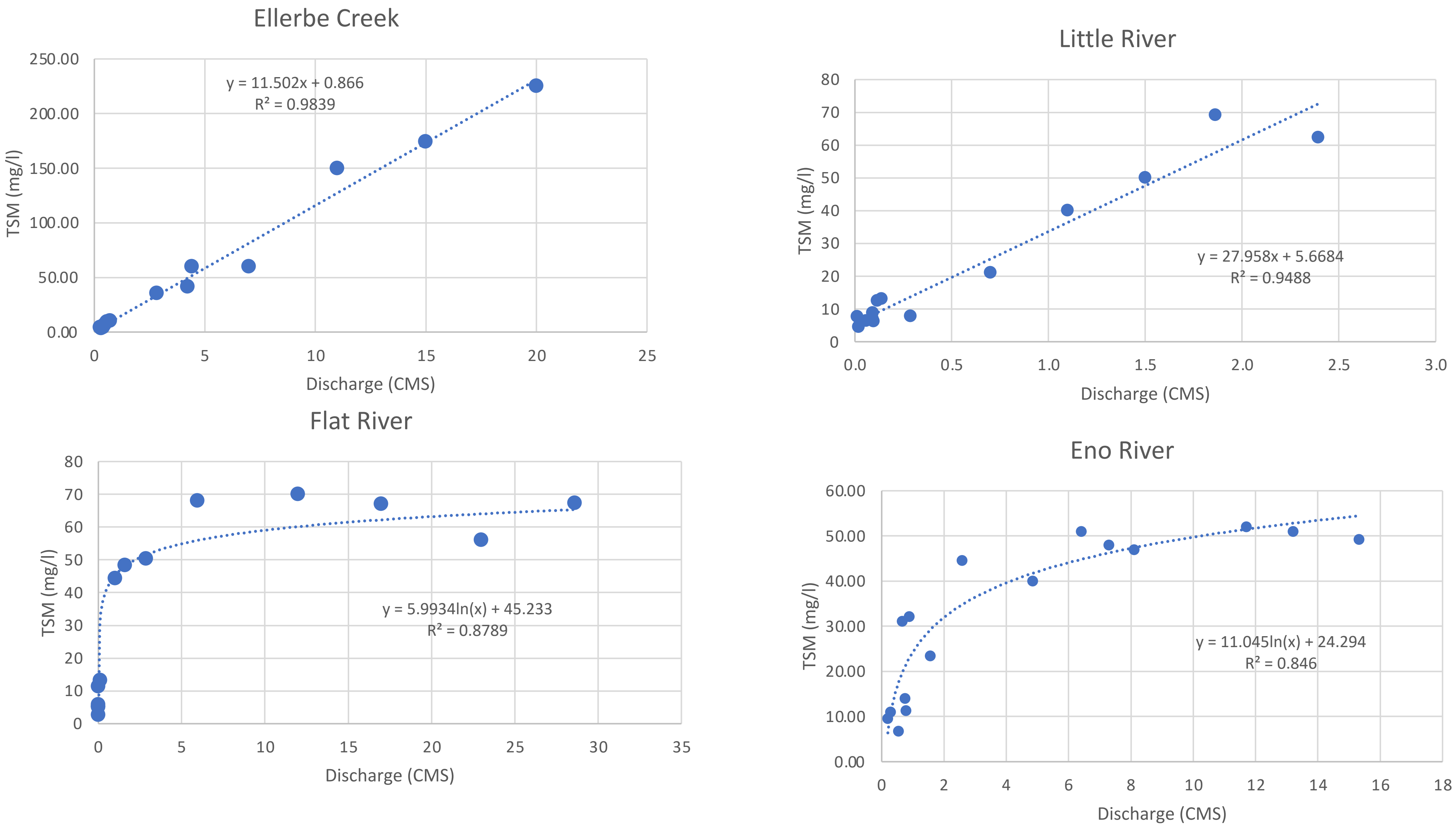
Department of Environment and Natural Resources

	Land Use			
Input	**Developed**	**Forest**	**Agriculture**	**Shrub/Grassland**
Ellerbe Creek	64.46	18.34	3.66	3.68
Eno River	16.68	57.21	17.1	4.67
Little River	7.11	56.82	26.02	5.23
Flat River	4.88	57.19	27.71	6.83



Tributary	Percent Water Discharge to Falls Lake
Flat River	27
Eno River	25
Little River	10
Ellerbe Creek	9
Total	**71**

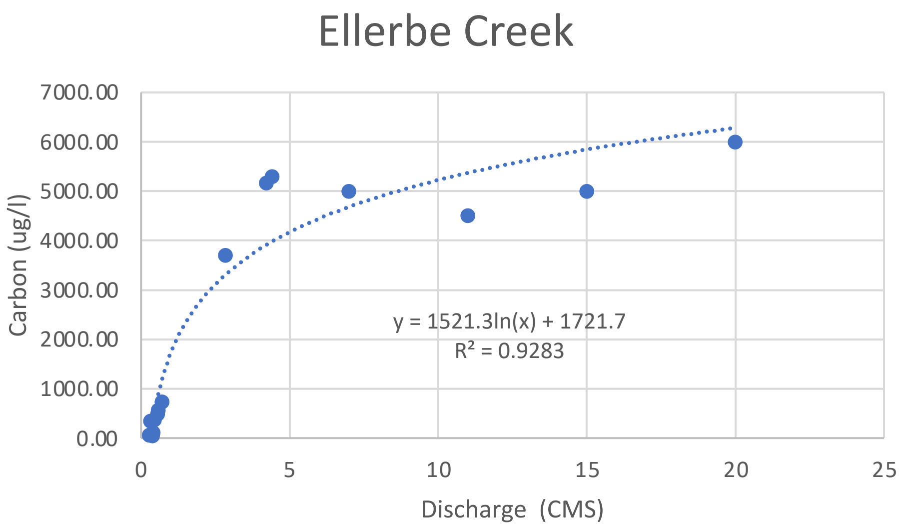
Establishing rating curves for total suspended matter (TSM)

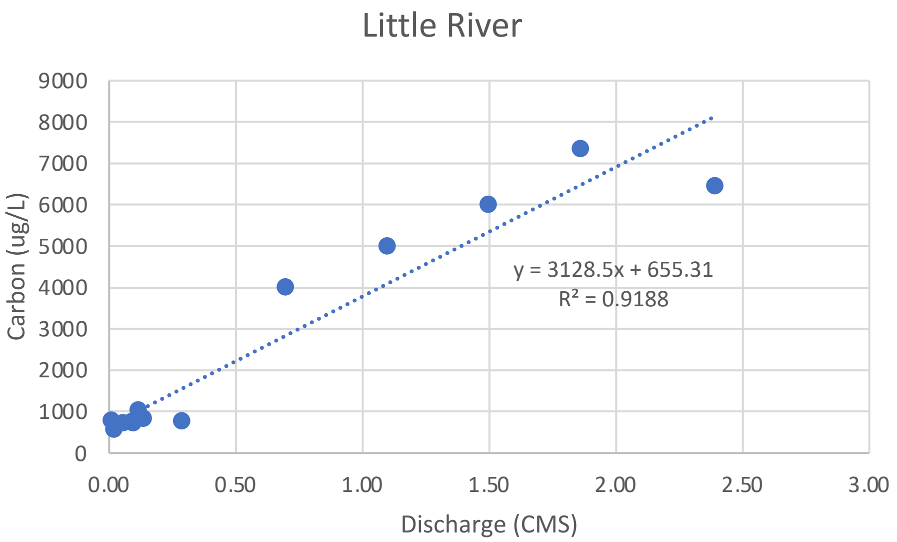


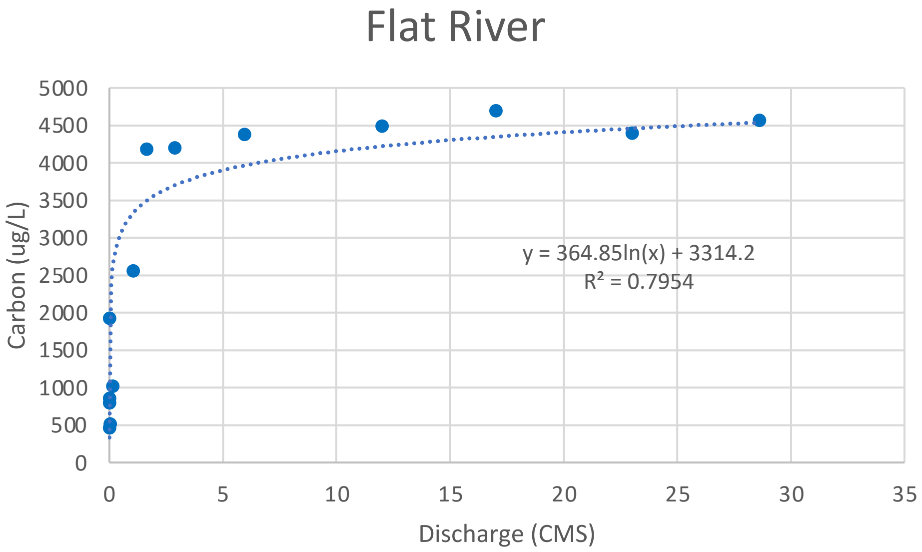
R^2 values between 0.8 and 0.9

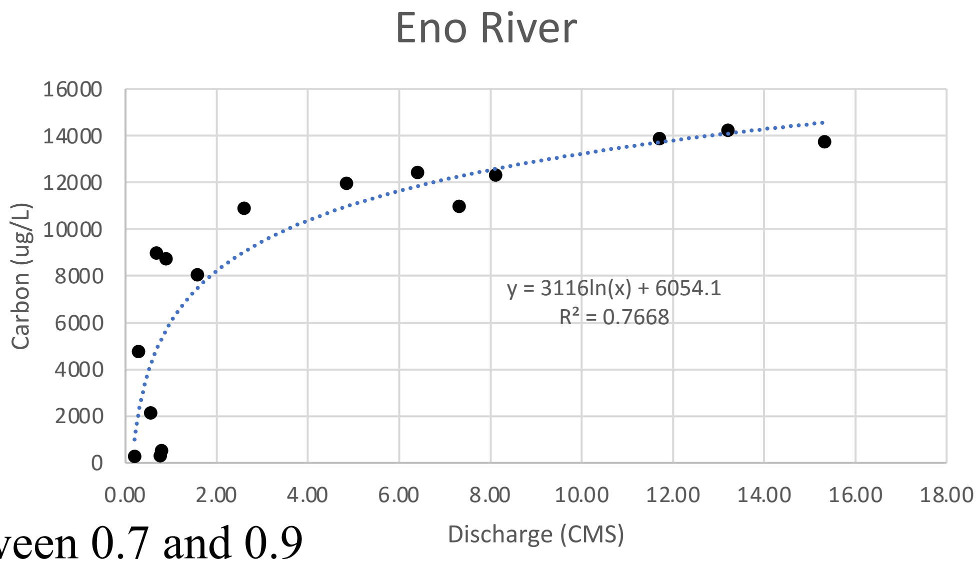
Water discharge (in CMS) which is readily available online at https://m.waterdata.usgs.gov/ from the US Geological Survey

Establishing rating curves for particulate organic carbon







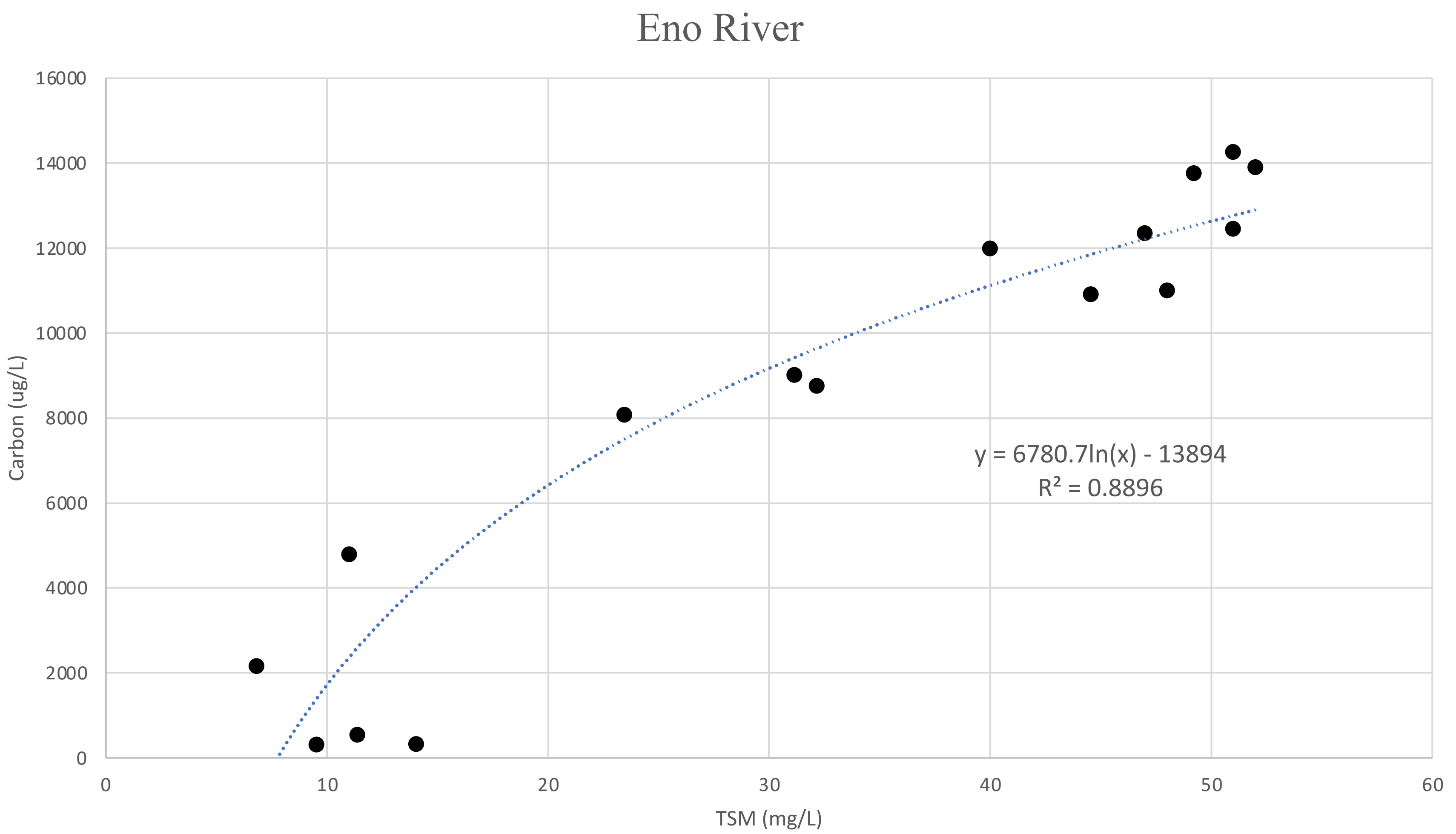


R^2 values between 0.7 and 0.9

Water discharge (in CMS) which is readily available online at https://m.waterdata.usgs.gov/ from the US Geological Survey

Good relationship between TSM and organic carbon concentrations in the tributaries

Rating curves can be compared to watershed simulations



Fate of particulate materials in Falls Lake sediments

(examples: Sediment and Organic Carbon)

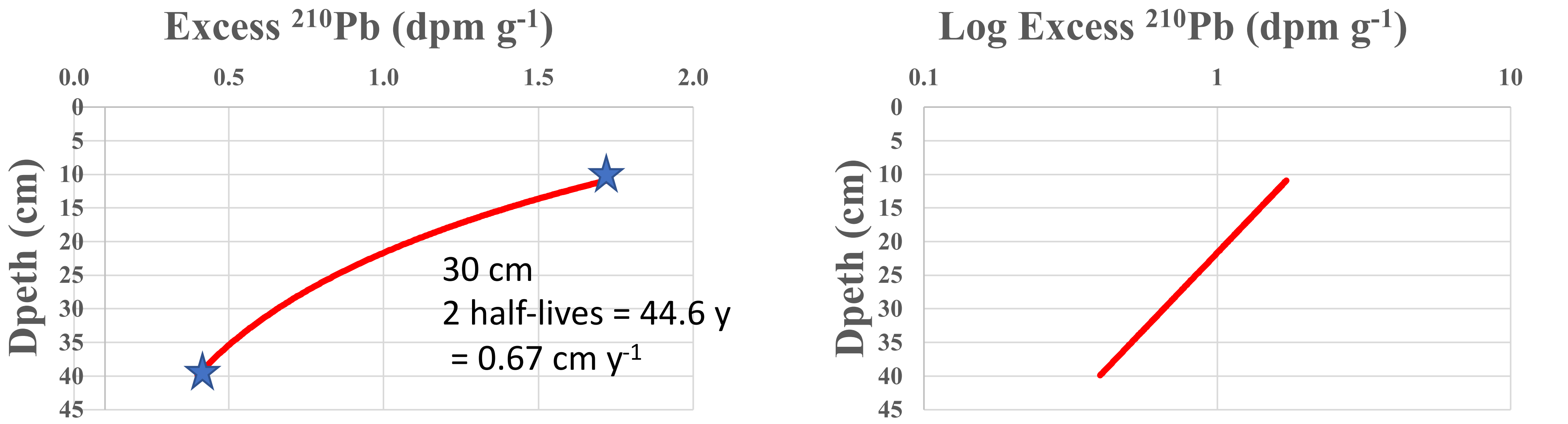
CO_2 emissions to the atmosphere have increased dramatically during past decades.

If carbon accumulation in reservoirs is an effective carbon sequestration strategy, then the storage of organic carbon must also increase substantially over time.

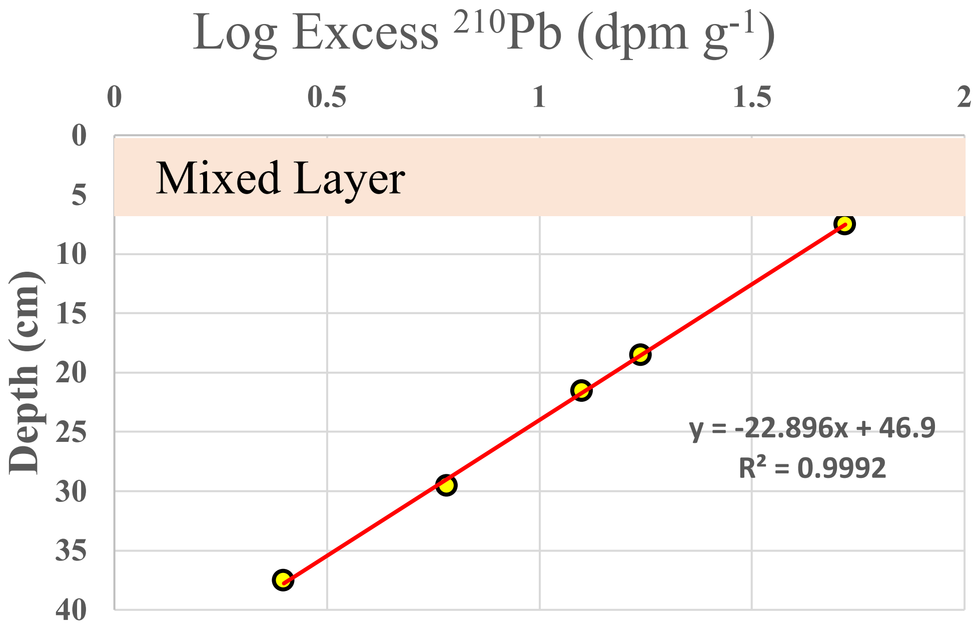
What are sediment and carbon accumulation rates in Falls Lake and how have they changed over the lifetime of the reservoir?

Coring Locations

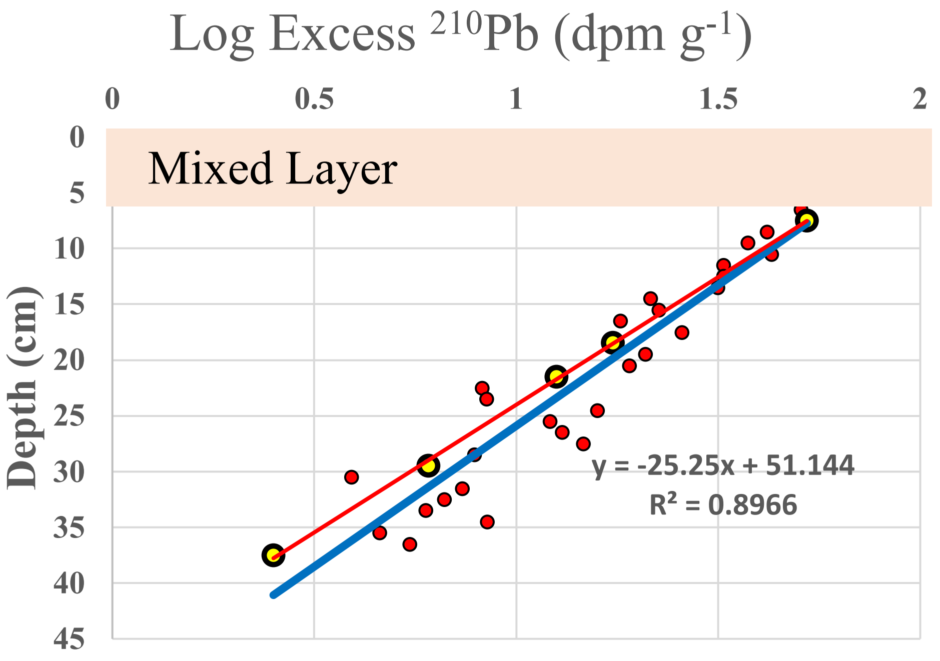
How Geochronologies (time histories) Work



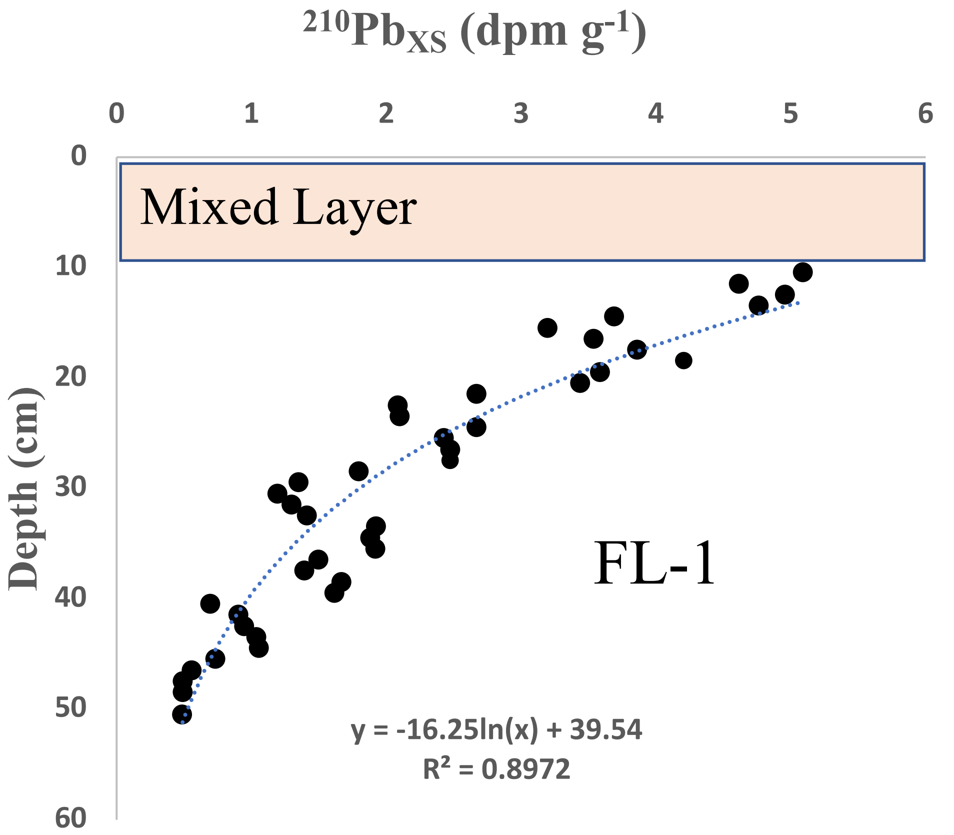
XS ^{210}Pb decays logarithmically with depth as sediment accumulates (Half-life 22.3 years)



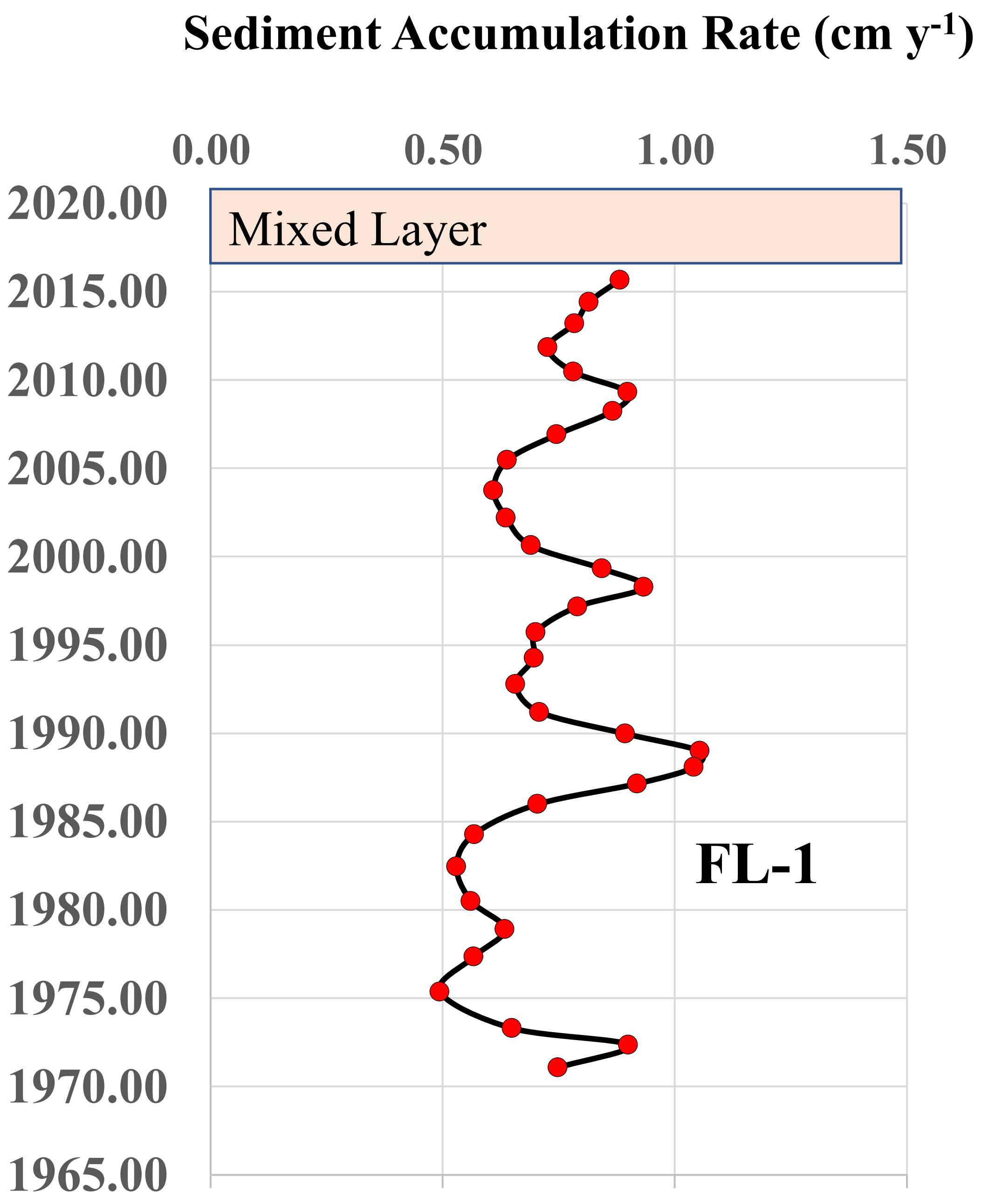
Five (5) intervals measured



Twenty-nine (29) intervals measured (every 1-cm interval)



Mean Sedimentation Rate: 0.56 cm y^{-1}



Properties of each 1 cm interval

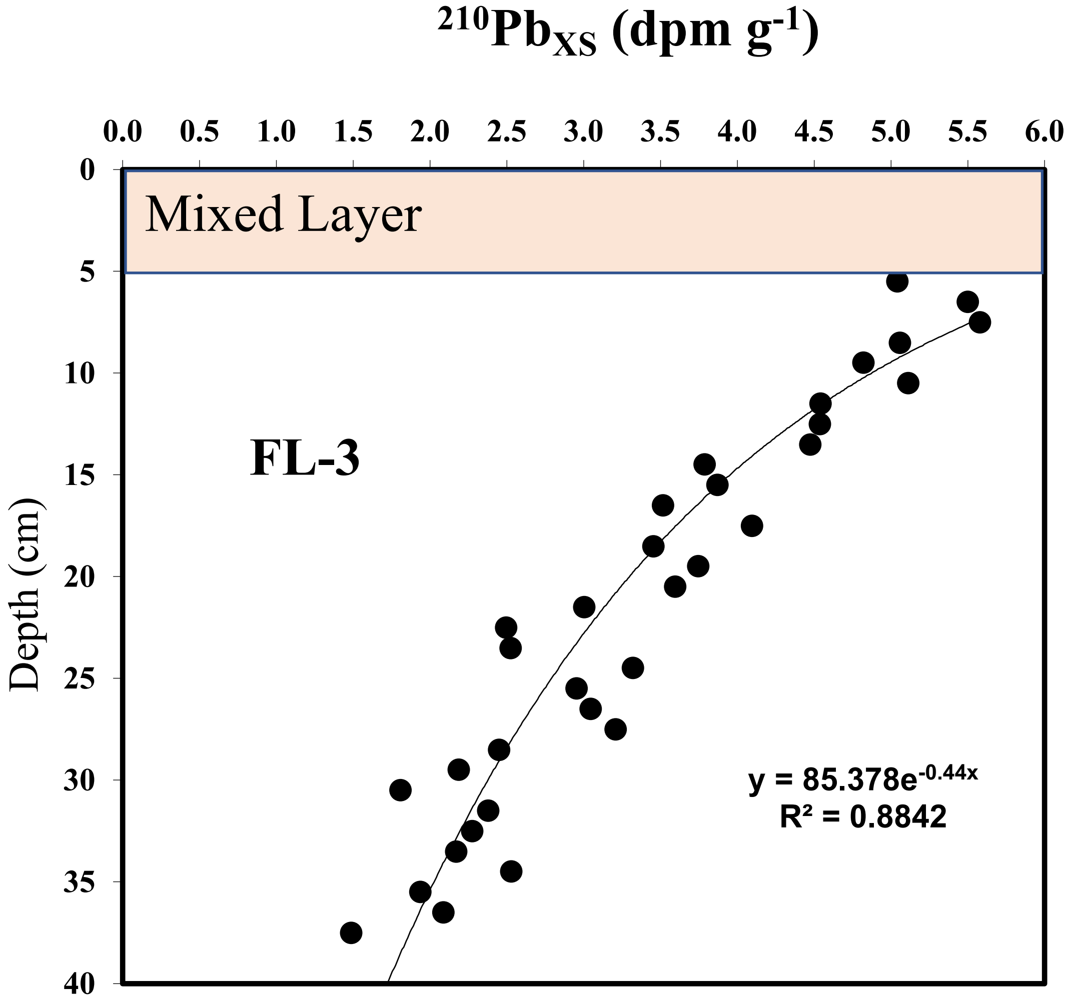
Other properties whose sediment histories can be quantified:

- Nitrogen
- Phosphorus
- Trace Metals and Contaminants
- Microplastics

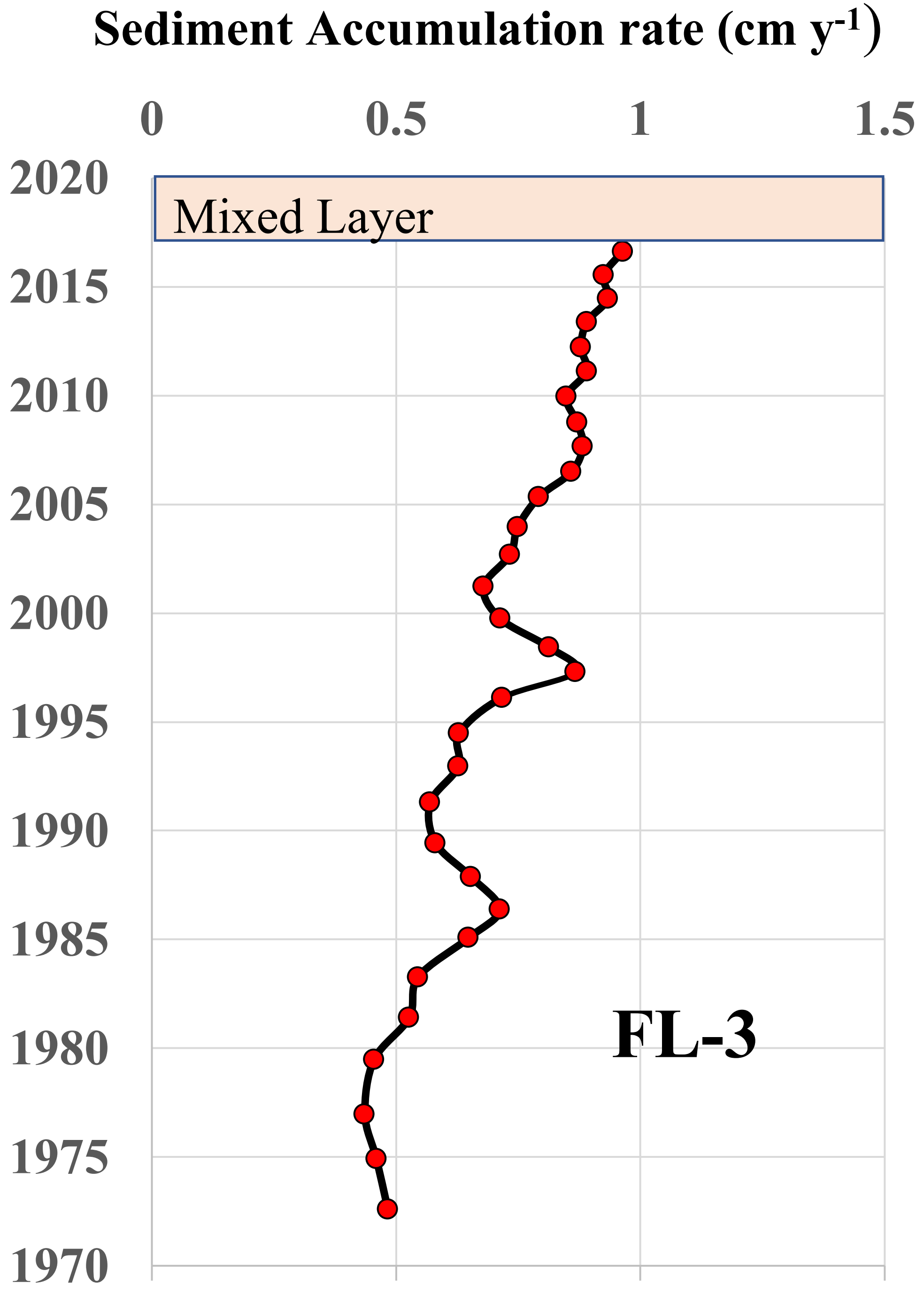
Depth (cm)	Years	DBD (g cm-3)	% C	C Burial ($gC\ m^{-2}$)	*Date*
0	0.62	0.24	5.58	196	2021.3
1	0.43	0.22	6.34	257	2020.7
2	0.74	0.25	6.97	307	2020.3
3	0.83	0.28	6.18	219	2019.5
4	1.20	0.29	5.75	167	2018.7
5	0.90	0.32	5.55	160	2017.5
6	0.97	0.33	5.97	211	2016.5
7	1.15	0.36	6.18	208	2015.6
8	0.88	0.38	5.16	192	2014.4
9	1.06	0.39	5.27	215	2013.5
10	1.04	0.41	4.95	267	2012.5
11	1.22	0.43	5.67	235	2011.4
12	0.71	0.43	5.87	171	2010.2
13	1.51	0.45	5.63	203	2009.5
14	1.17	0.46	4.88	204	2007.9
15	1.18	0.48	4.75	247	2006.8
16	1.59	0.50	5.37	211	2005.6
17	0.86	0.52	5.74	243	2004.1
18					2003.2

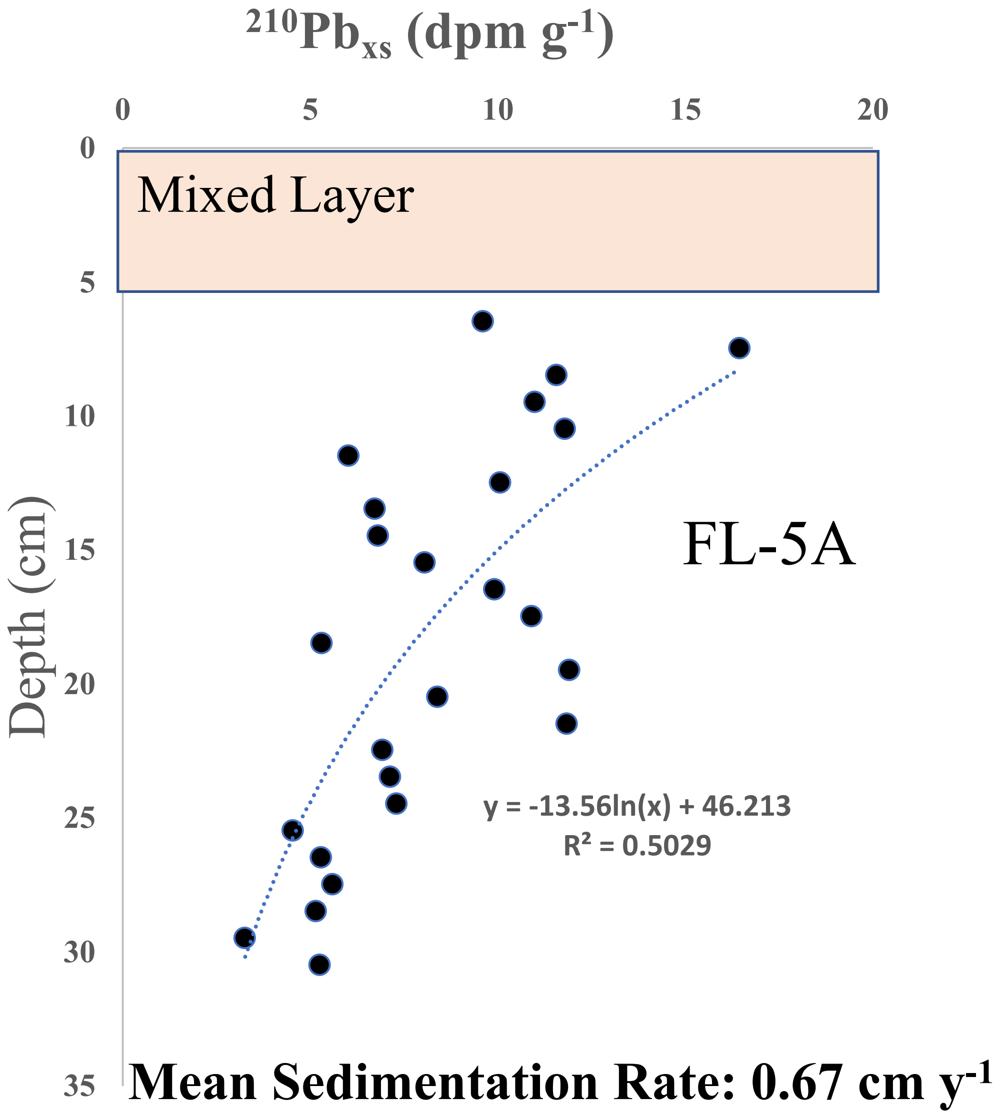
Measurements per Interval

18.1 years

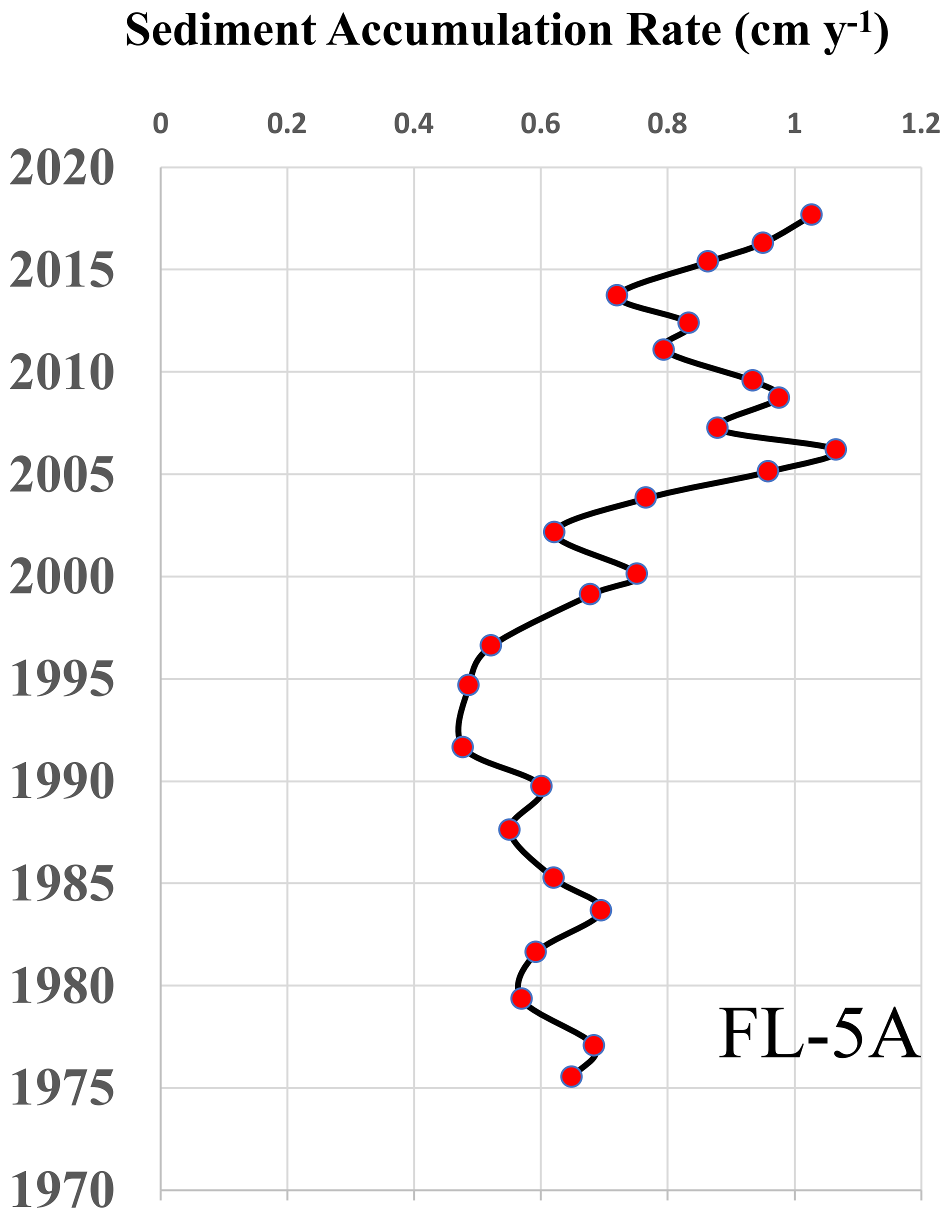


Mean Sedimentation Rate: 0.88 cm y^{-1}

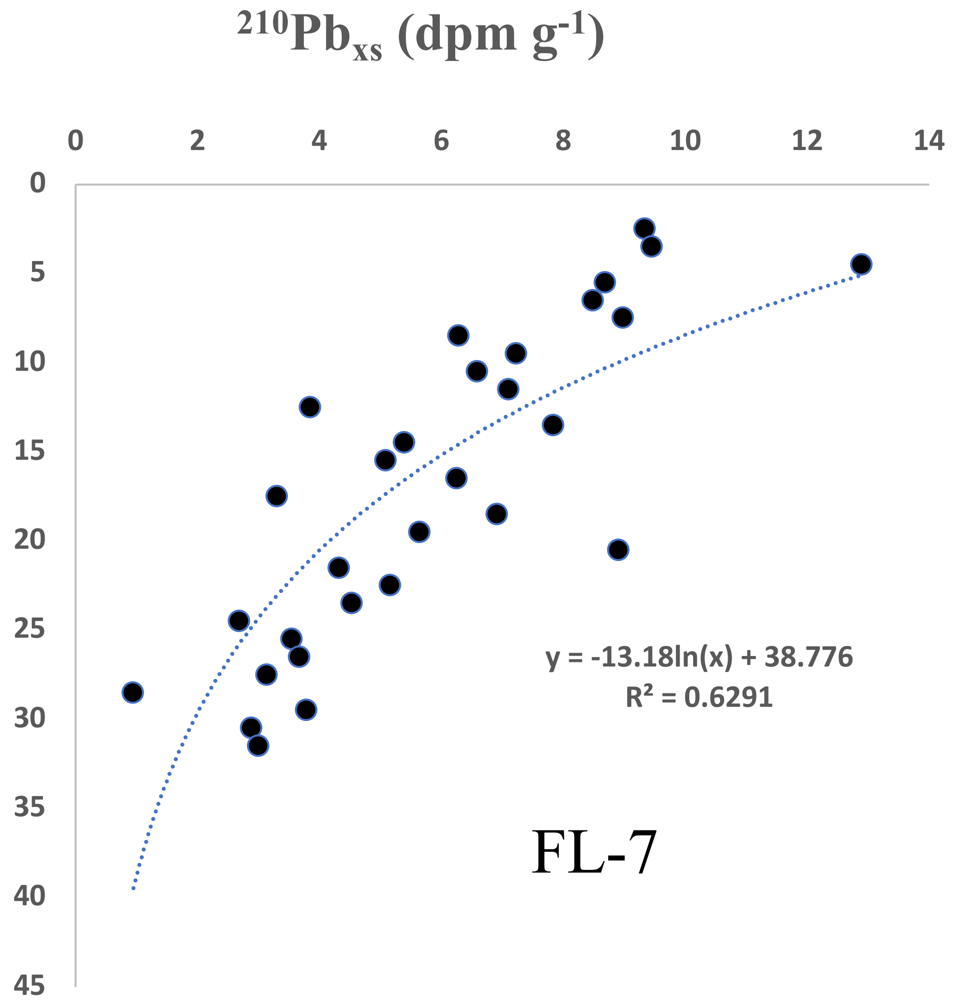




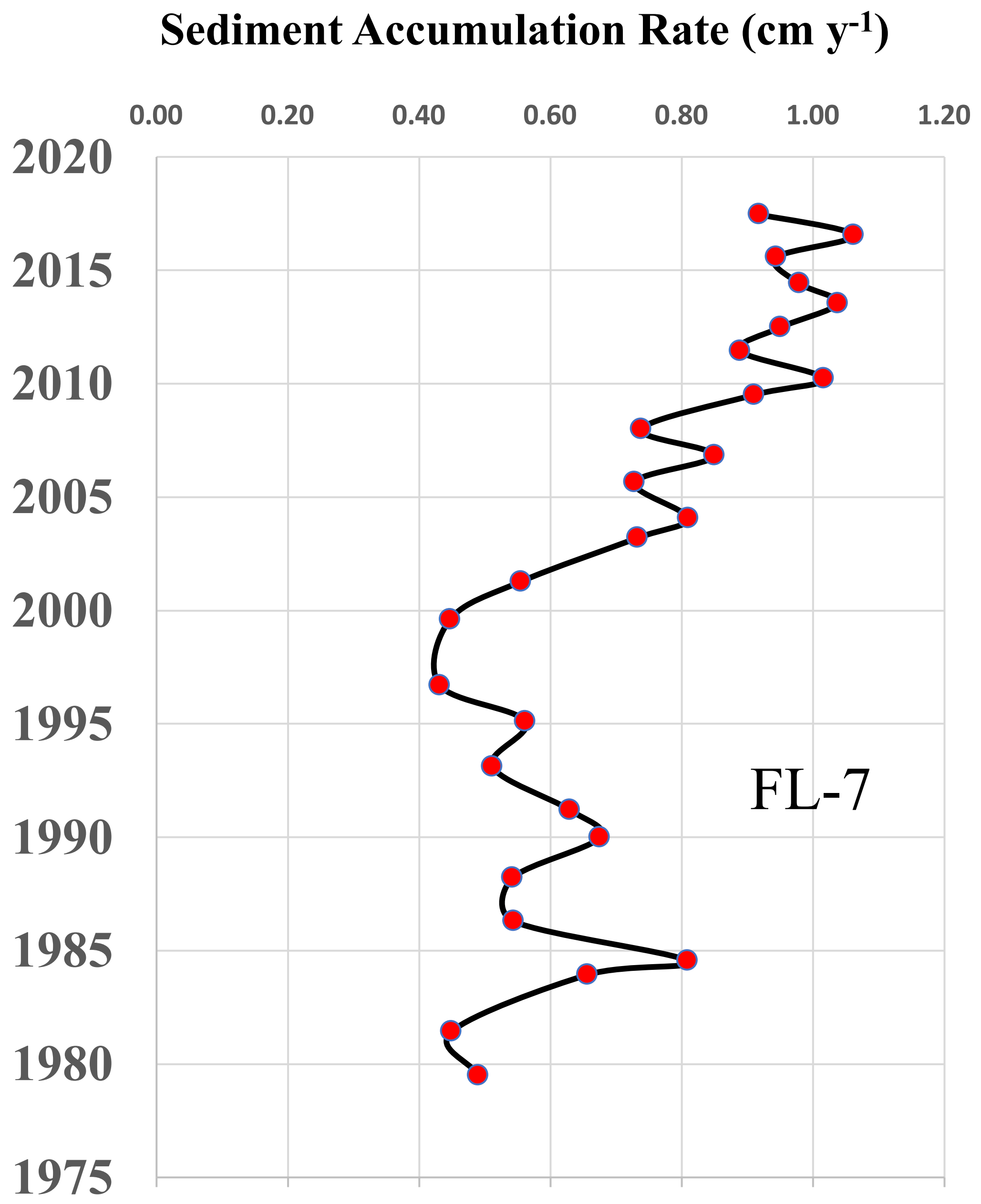
$^{210}Pb_{xs}$ (dpm g^{-1})
0
5
10
15
20
0
5
10
15
20
25
30
35
Depth (cm)
Mixed Layer
FL-5A
y = -13.56ln(x) + 46.213
R² = 0.5029
Mean Sedimentation Rate: 0.67 cm y-1

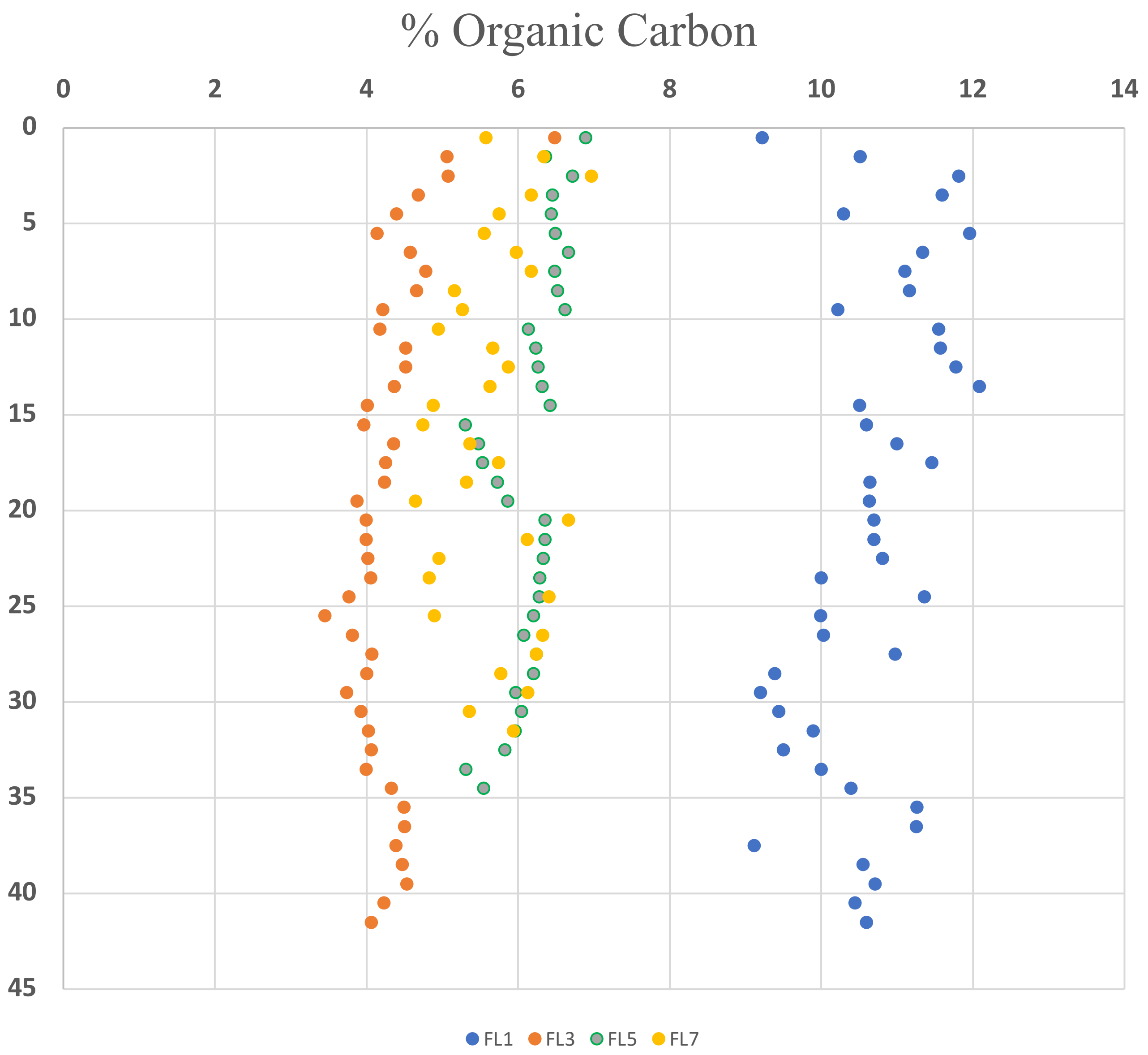


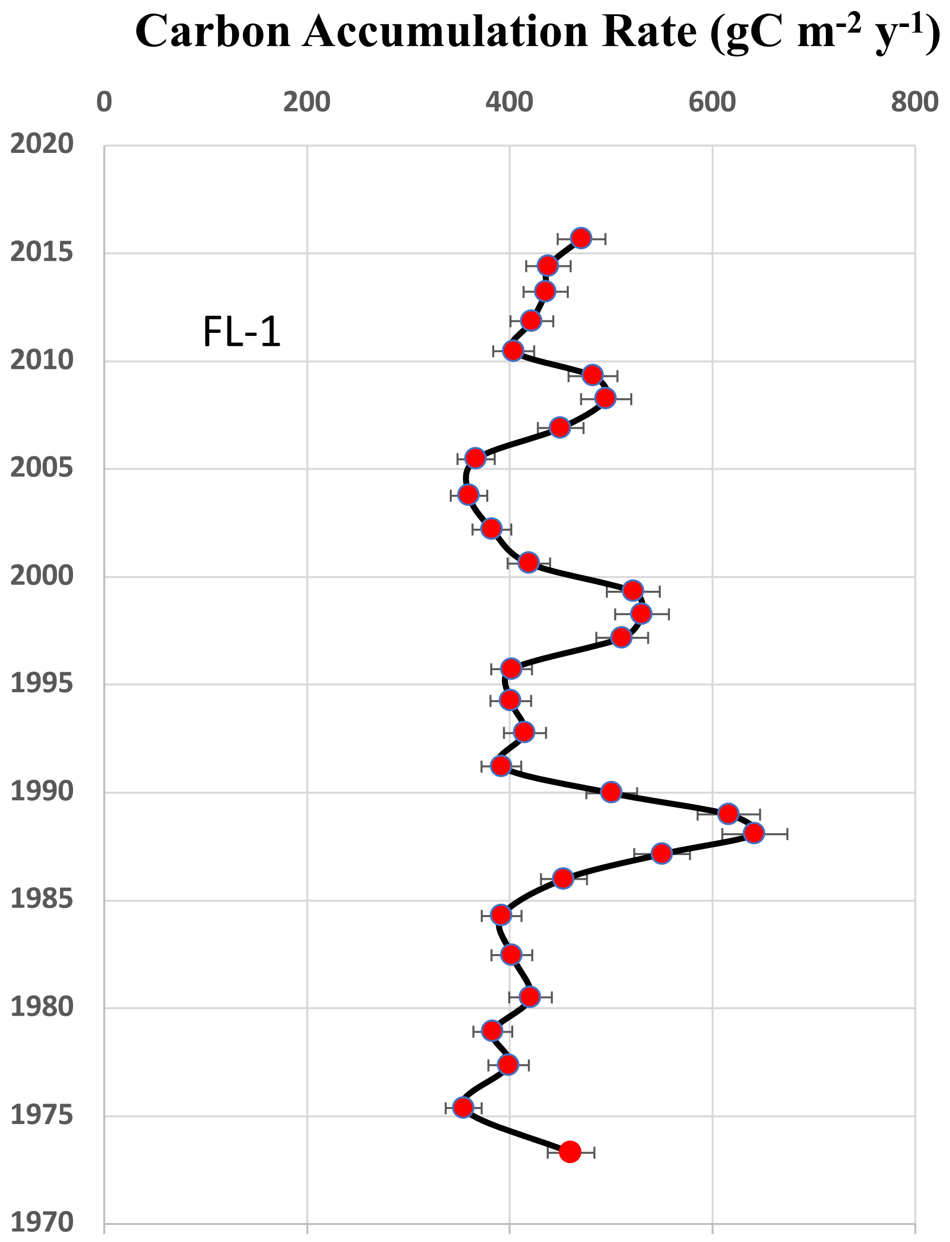
Sediment Accumulation Rate (cm y-1)
0
0.2
0.4
0.6
0.8
1
1.2
2020
2015
2010
2005
2000
1995
1990
1985
1980
1975
1970
FL-5A

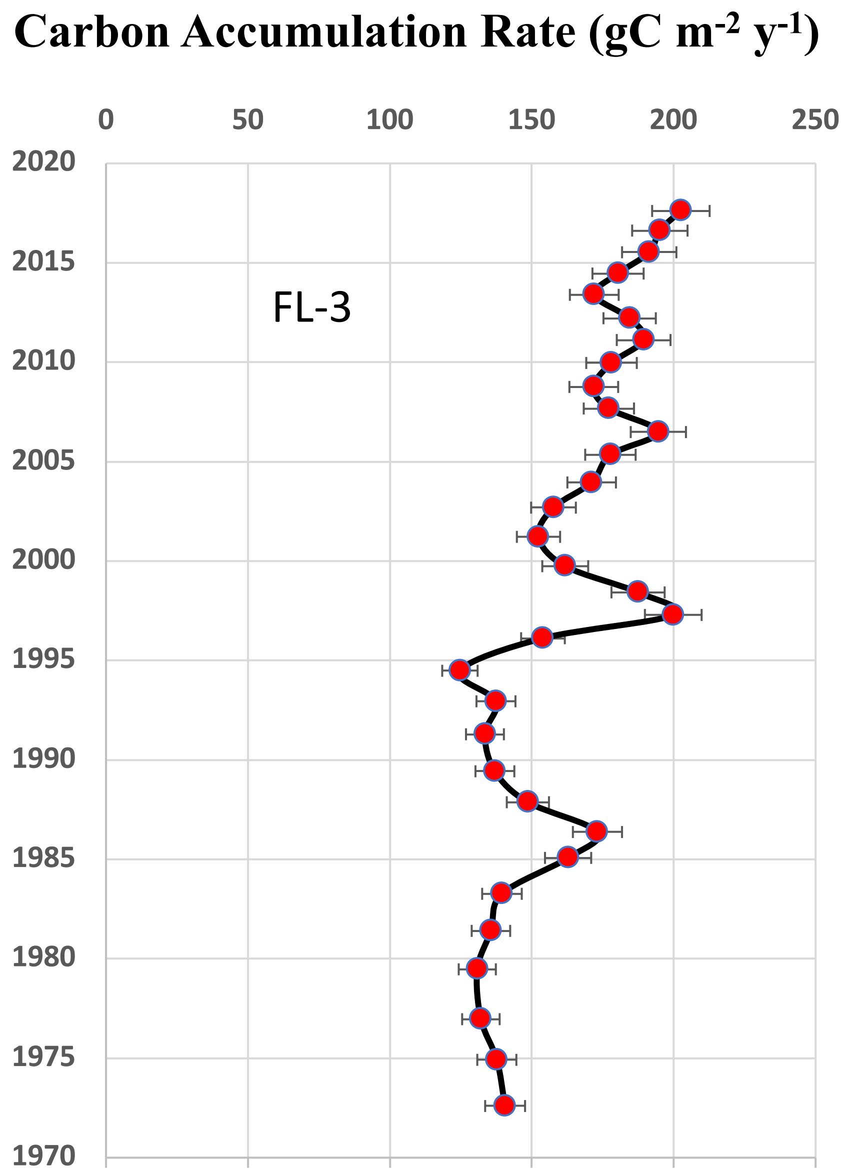


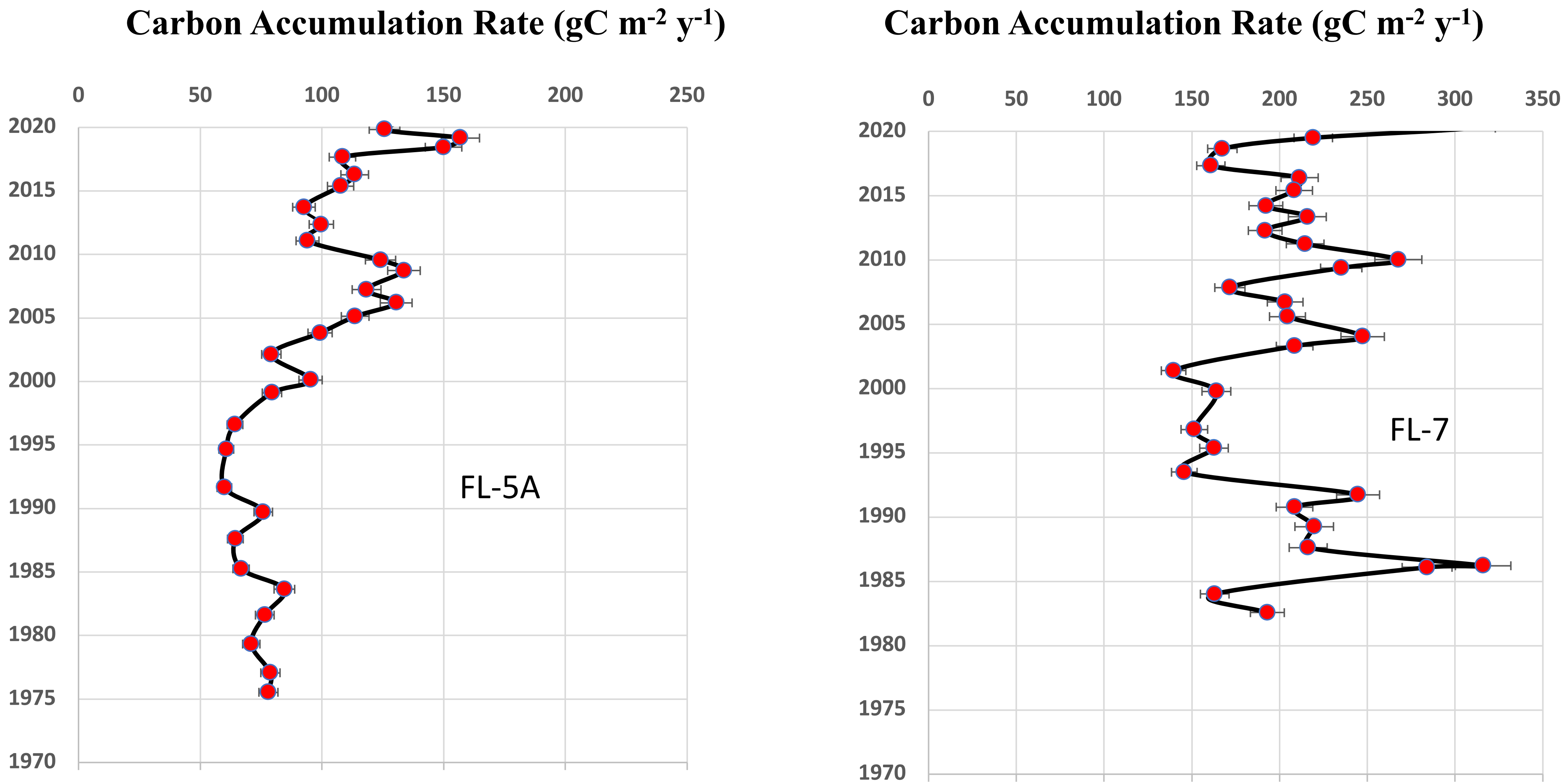
Mean Sedimentation Rate: 0.67 cm y^{-1}




% Organic Carbon
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
FL1
FL3
FL5
FL7


Carbon Accumulation Rate (gC m-2 y-1)
0
200
400
600
800
2020
2015
2010
2005
2000
1995
1990
1985
1980
1975
1970
FL-1


Carbon Accumulation Rate (gC m-2 y-1)
0
50
100
150
200
250
2020
2015
2010
2005
2000
1995
1990
1985
1980
1975
1970
FL-3



Carbon Accumulation Rate (gC m-2 y-1)
0
50
100
150
200
250
2020
2015
2010
2005
2000
1995
1990
1985
1980
1975
1970
FL-5A
Carbon Accumulation Rate (gC m-2 y-1)
0
50
100
150
200
250
300
350
2020
2015
2010
2005
2000
1995
1990
1985
1980
1975
1970
FL-7

Summary of Core Data

Sediment Accumulation Rates

Avg range (past 50 years) from 0.67 to 0.88 cm y^{-1}

Avg 1970: 0.59 cm y^{-1}

Avg Today: 0.98 cm y^{-1} **66% increase**

Carbon Accumulation Rates

Avg range (past 50 years) from 103 to 454 gC m^{-2} y^{-1}

Avg 1970: 137 gC m^{-2} y^{-1}

Avg Today: 284 gC m^{-2} y^{-1} **107% increase**

SUMMARY

Tributary rating curves can provide good estimates of sediment and carbon inputs to the lake using readily available water discharge data from the USGS

Geochronologies established in lake sediments provide a temporal framework to evaluate the timing and **fate of particulate materials** that enter the lake (nutrients, microplastics, and contaminants) and enable us to evaluate rates of sediment and carbon accumulation.


Thanks to all in the McKee Lab Group
Especially Sherif Ghobrial, Scott Booth, Mackenzie Wise, and Alyson Burch