MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Monitoring 3 Michigan Chloride Impacted Lakes

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*Yes, but getting saltier…
Lake Michigan 1800s chloride ~1-2 mg/l.
Lake Michigan 2020 chloride >15 mg/l (Dugan et al. 2021)

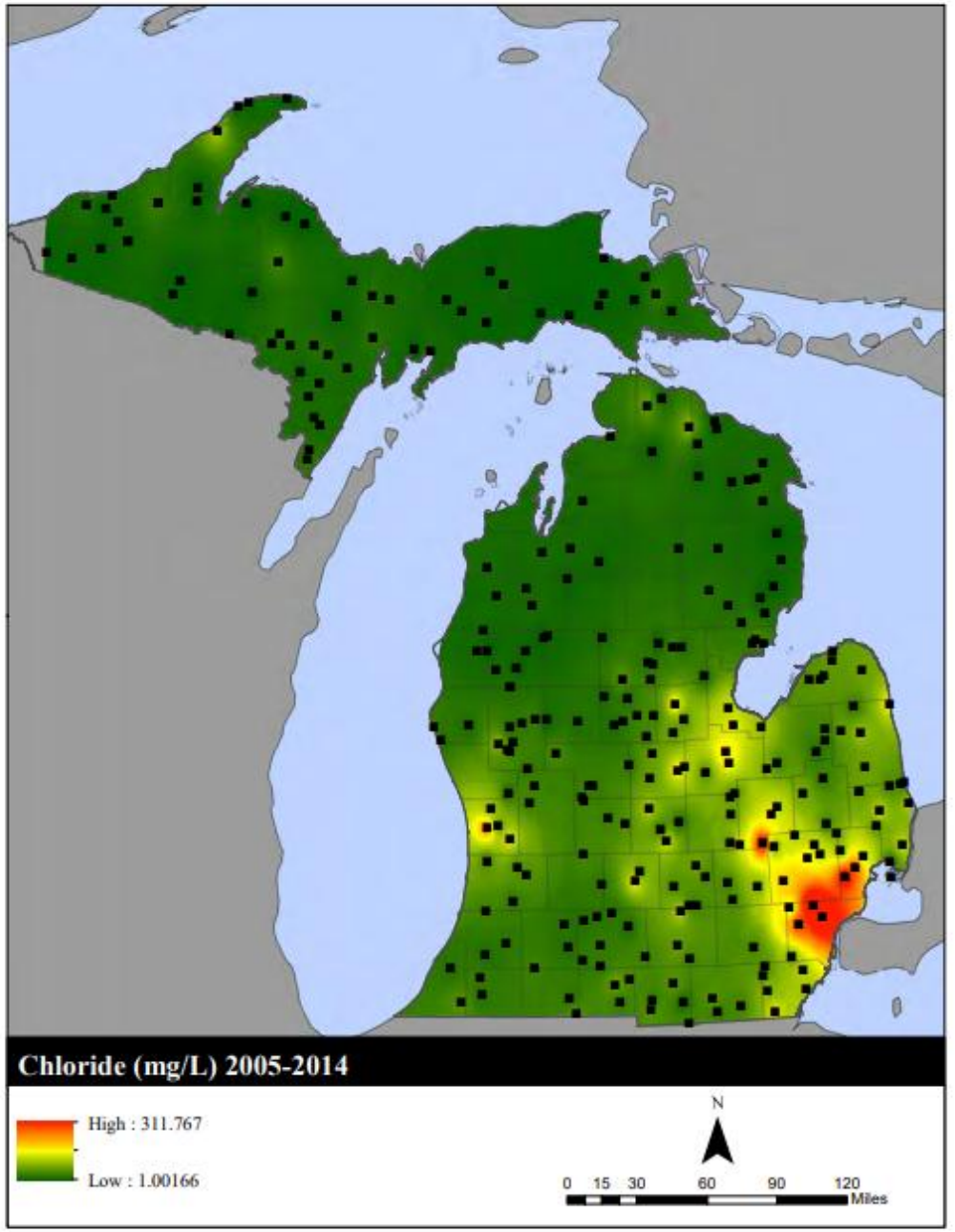


Figure 1-5. Inverse distance weighting interpolation image of median chloride concentrations (mg/L) from 2005-2014.

USEPA Region 5

CHLORIDE		
Agency	**Acute (µg/L)** (Ambient Surface Waters) AMV	**Chronic (µg/L)** FCV
USEPA	860,000	230,000
Minnesota	860,000	230,000
Wisconsin	757,000	395,000
Illinois	550,000*	340,000*
Indiana	550,000*	340,000*
Ohio	NA	NA
Michigan	320,000	150,000

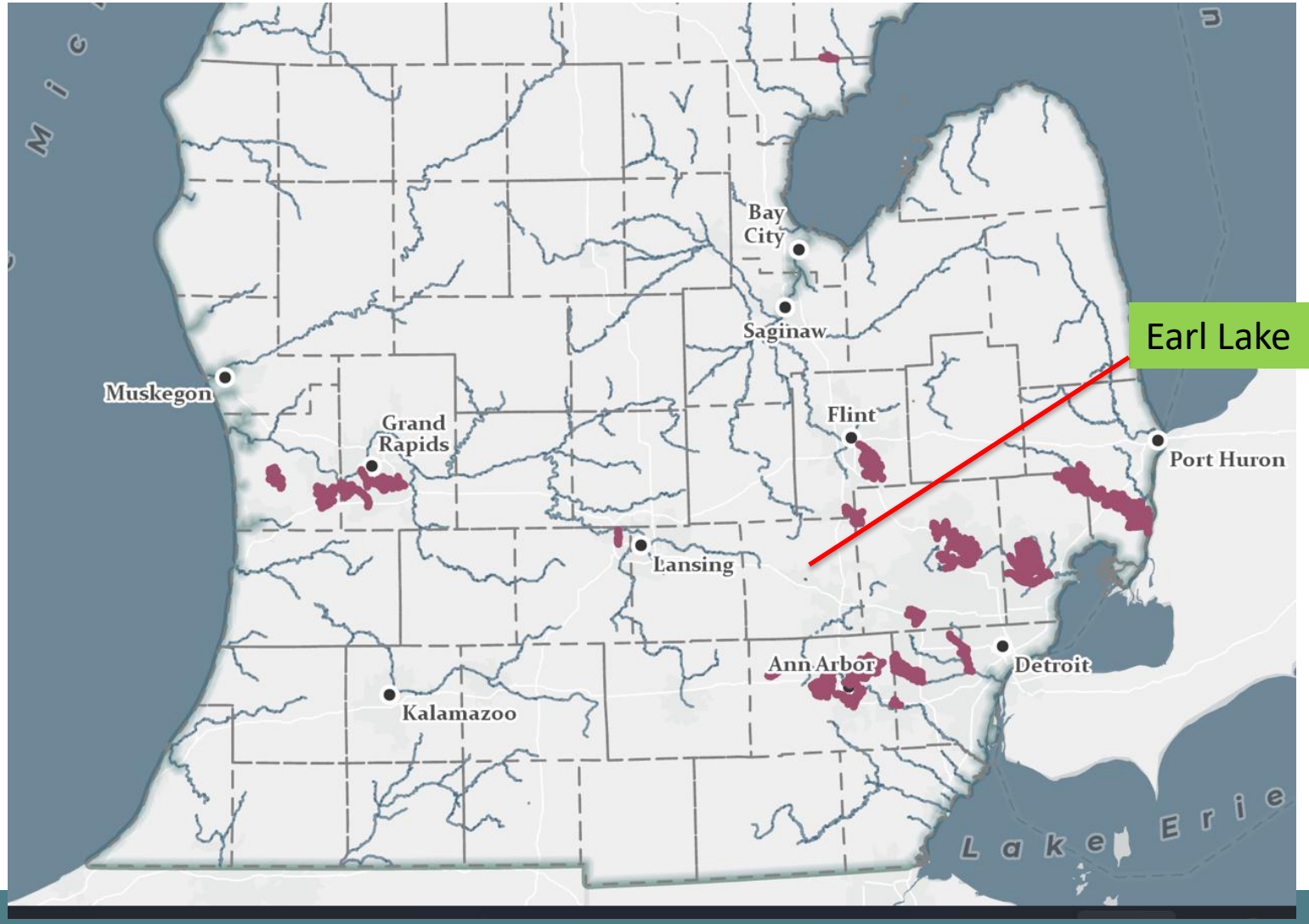
*hardness & sulfate-based value (Iowa equation); 100 mg/L hardness, 63 mg/L sulfate

Chloride-impaired waterbodies to date:

- Chloride Aquatic Life Values established in **2019**

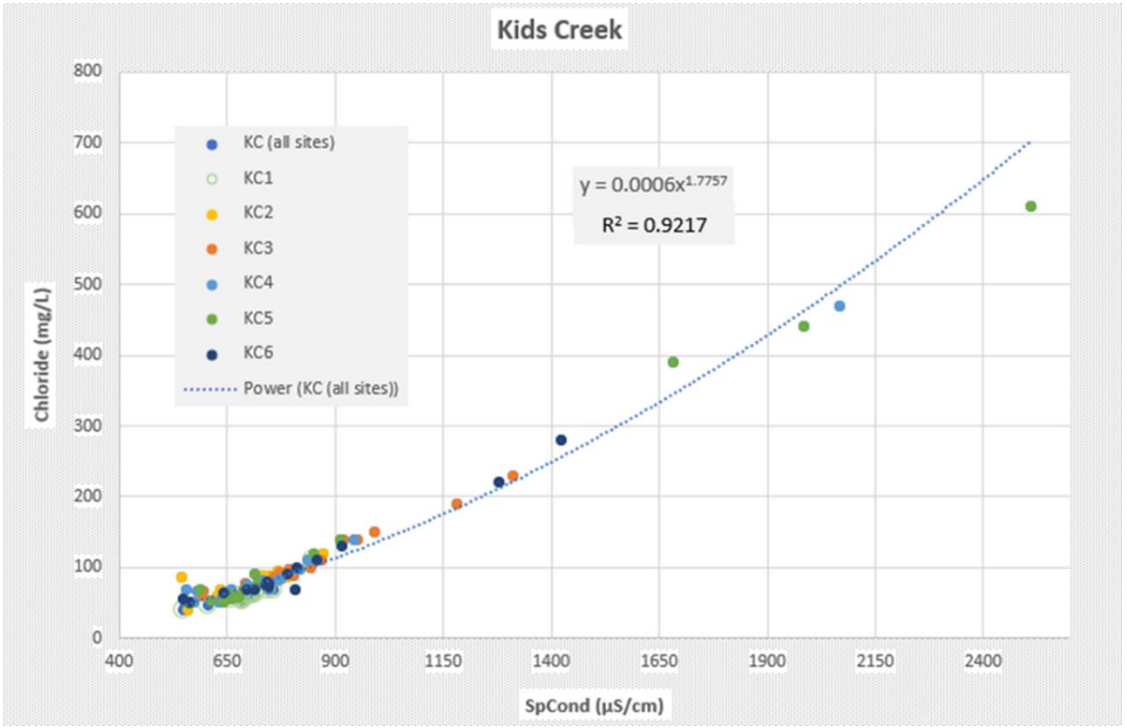
- Streams **303d** listings in
  - 2020(8)
  - 2022(10)
  - 2024(17)

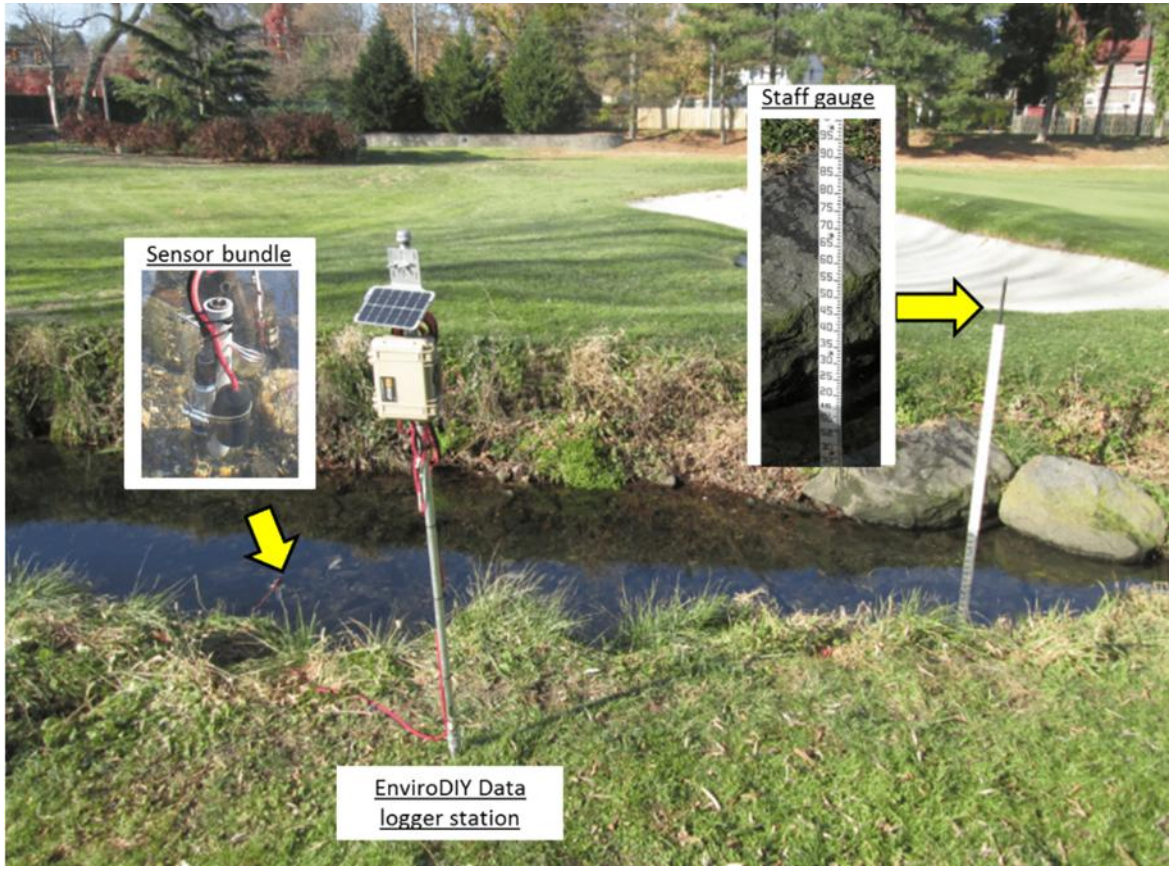
- Streams **305b** in
  - 2020(1)
  - 2022(10)
  - 2024(229)



Roll out...

- Stream monitoring program efforts: multiple targeted studies, statewide stream chemistry sampling





But Lakes....

MICHIGAN STATE UNIVERSITY

Salt runoff can impair lakes

Erick Elgin, Michigan State University Extension - June 02, 2024

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SALT STUDY: Researchers set to sample water from 50 West Michigan lakes

NEWS

Michigan lakes are getting saltier; road salt to blame

If trend continues, study predicts, salt levels will present risk to aquatic ecosystem in inland lakes

Keith Matheny Detroit Free Press

April 13, 2017 | Updated April 14, 2017, 1:16 p.m. ET

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Michigan's salty lakes

Road Salt, A Stealthy Pollutant, Is Damaging Michigan Waters

by CIRCLE OF BLUE

January 27, 2023

EGLE

Focus on two lakes (Woods and Asylum) with previously documented chloride impacts In Kalamazoo County.

Can conductivity loggers and periodic chloride sampling be used to model chloride exceedances in lakes as well?

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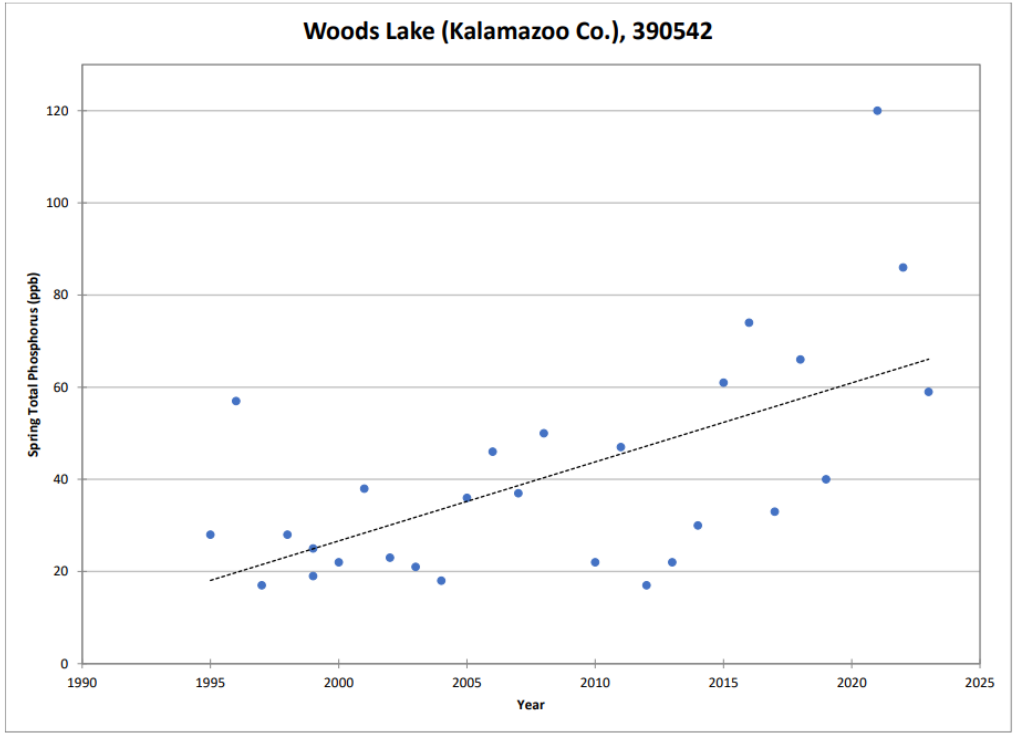
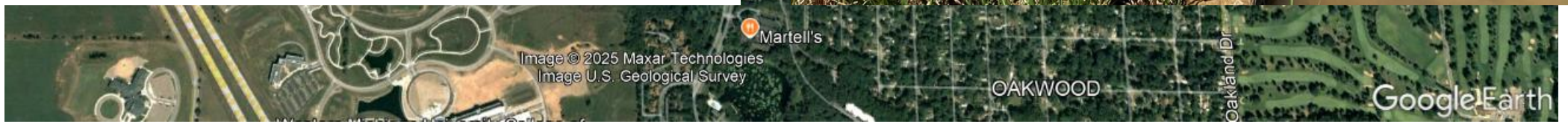
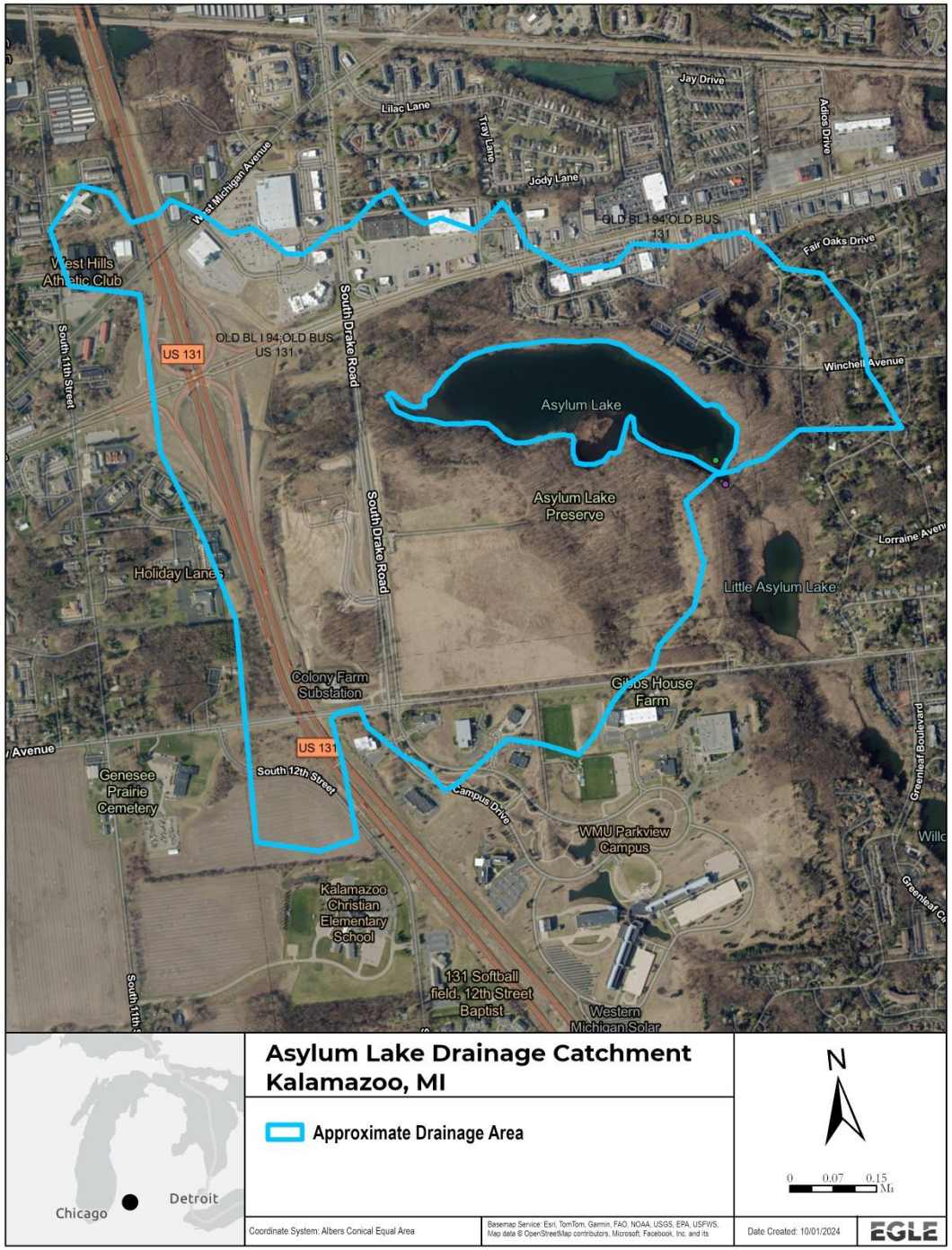
COOPERATIVE LAKES MONITORING PROGRAM
SPRING TOTAL PHOSPHORUS







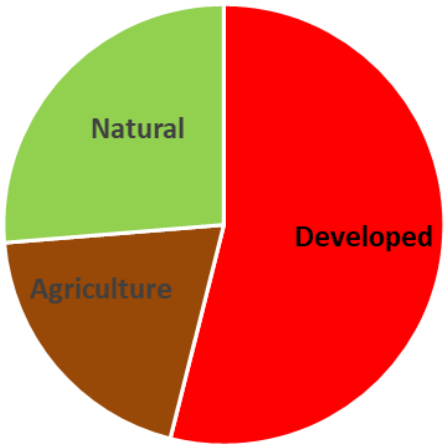
Asylum Lake

-Headwater lake, inlet, outlet with a dam

-Watershed: 0.8 mi^2, Surrounded by forest, main inlet largely developed.

-Lake size: 49 acres, 52 feet deep

-Documented chloride impacts; monomictic (mixes once/year; Koretsky et al. (2012); Wyman and Koretsky (2018); Dupuis et al. (2019); Kieser & Associates (2021))



Woods Lake

-Kettle lake: no natural inlet or outlet

-Watershed: 0.5 mi^2, watershed land use 94% developed

-Lake size: 24 acres, 43 feet deep

-Documented chloride impacts; meromictic (no spring or fall mixing; Koretsky et al. (2012); Sibert et al. (2015); Dupuis et al. (2019))

EGLE

Questions/Goals:

Are Woods and Asylum Lakes exceeding chloride aquatic life values; are they supporting relevant aquatic life Designated Uses?

What are the direct and indirect effects of excess chloride in these lakes (i.e., is it contributing to nutrient/algae issues)?

Explore conductivity loggers and logger array use for this kind of monitoring and data interpretation.

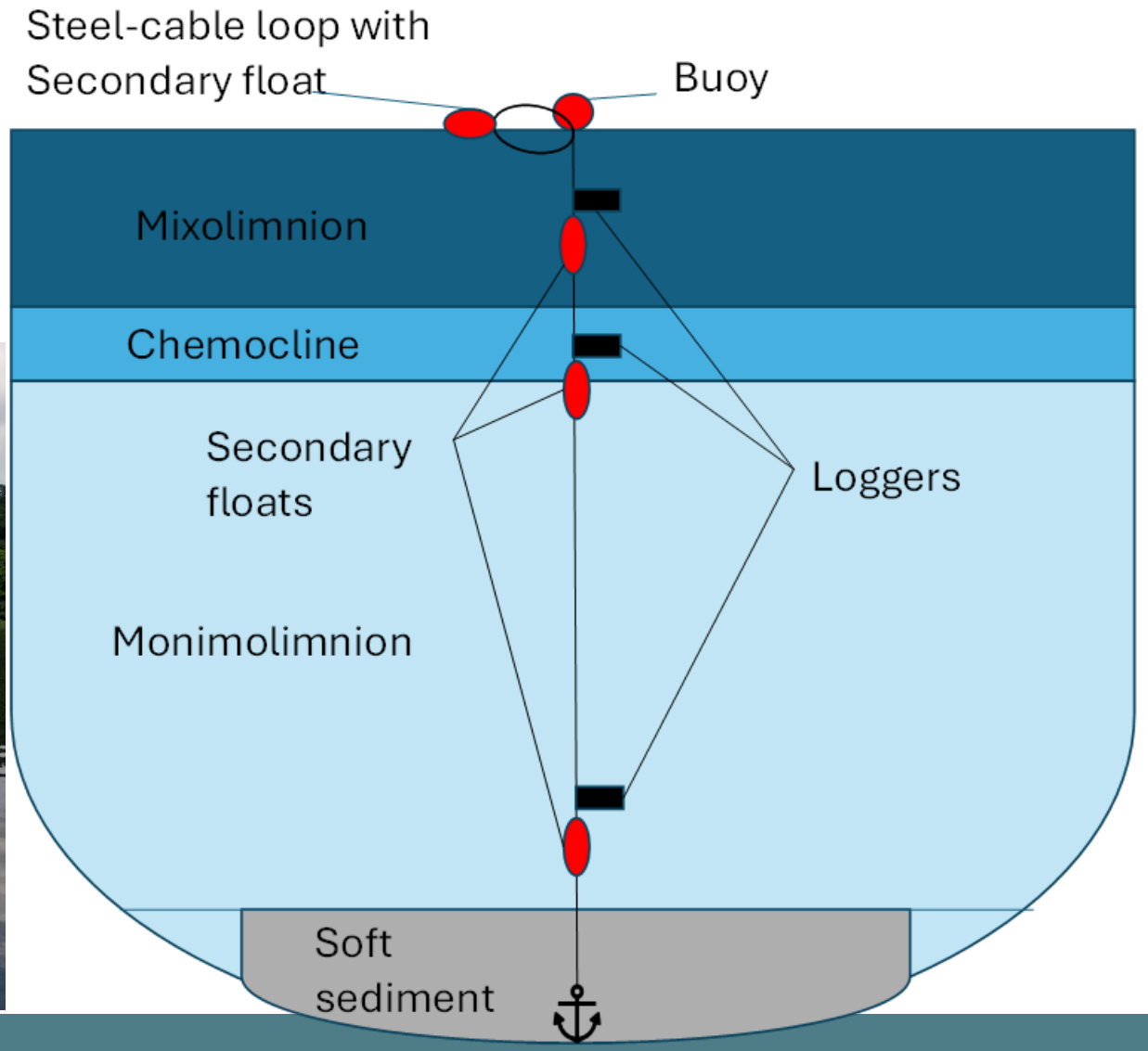
Explore chloride lab results with rapid test strips for reliable use in screening (at least)

Sampling plan

- Continuous logger arrays in each lake, inlets, outlets
- 15 visits per lake with profiles (YSI) and chloride grabs
- Chloride at surface, chemo/thermocline, bottom on each visit (as well as inlets/outlets)
- Trophic data collected 3x
- August 2023 – August 2024

8/2023-8/2024 – on each lake

Photo: Chris Bovid

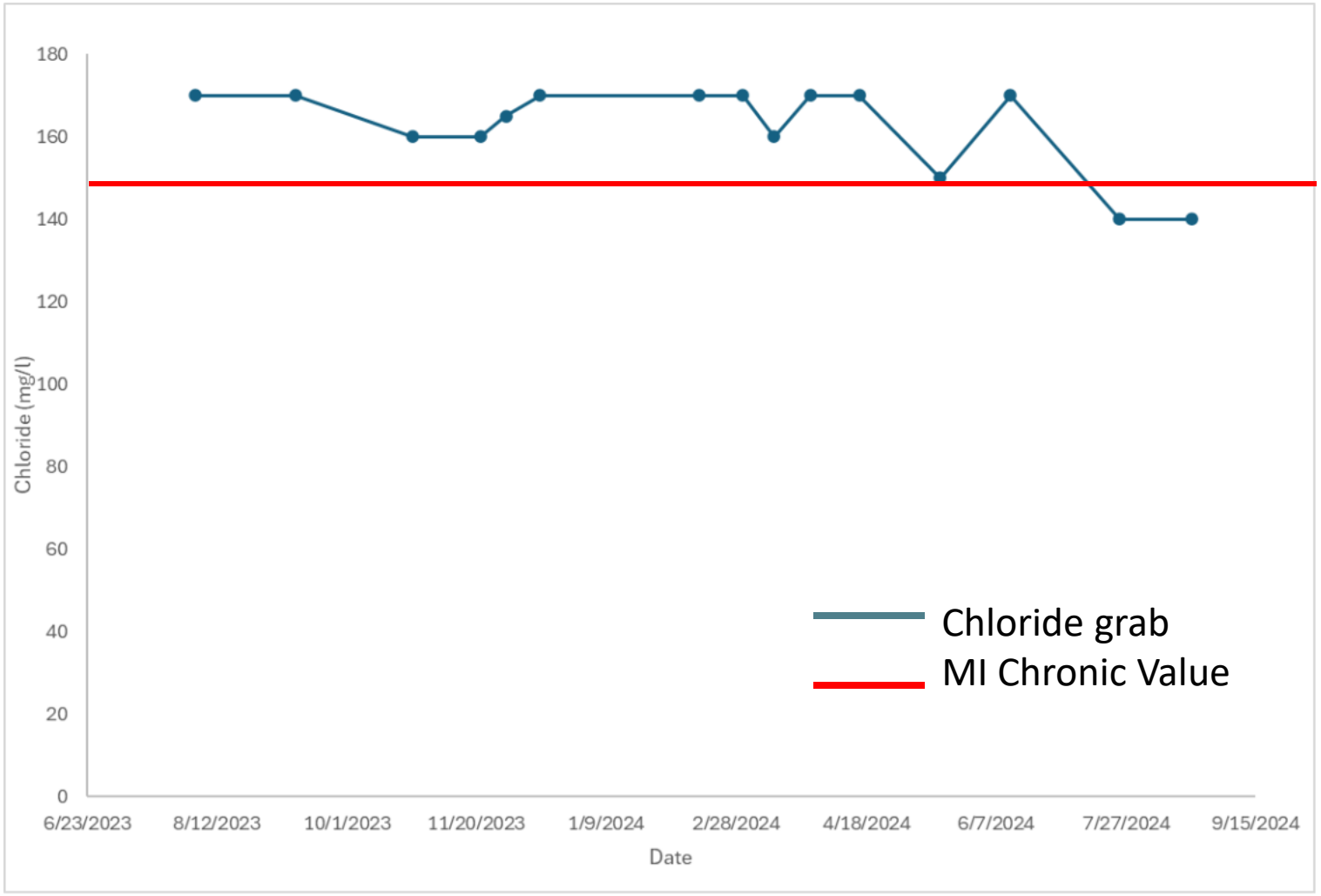


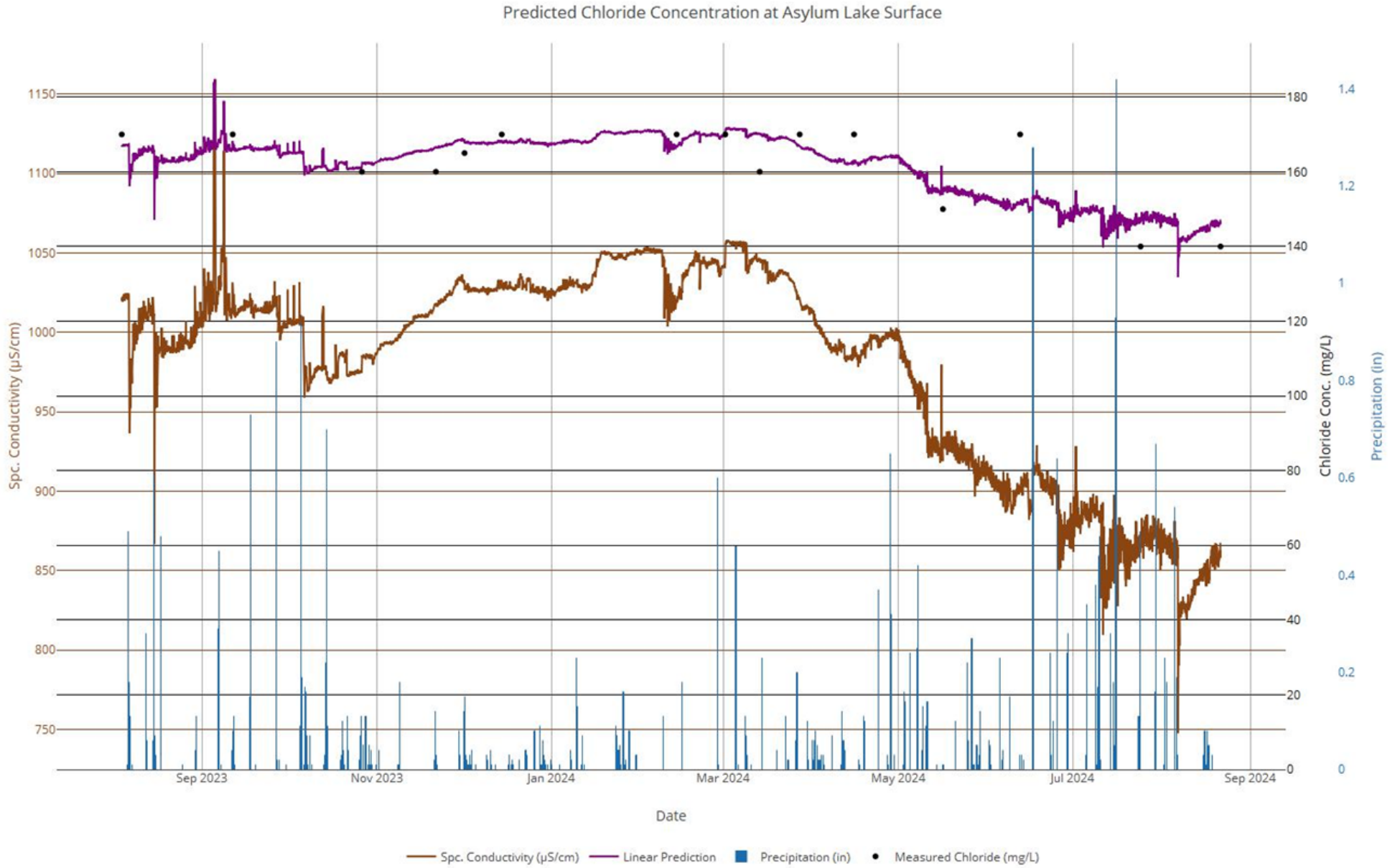
Results presented today:

- Lake chloride from August 2023 to August 2024
- Conductivity/chloride relationship
- Some lessons learned

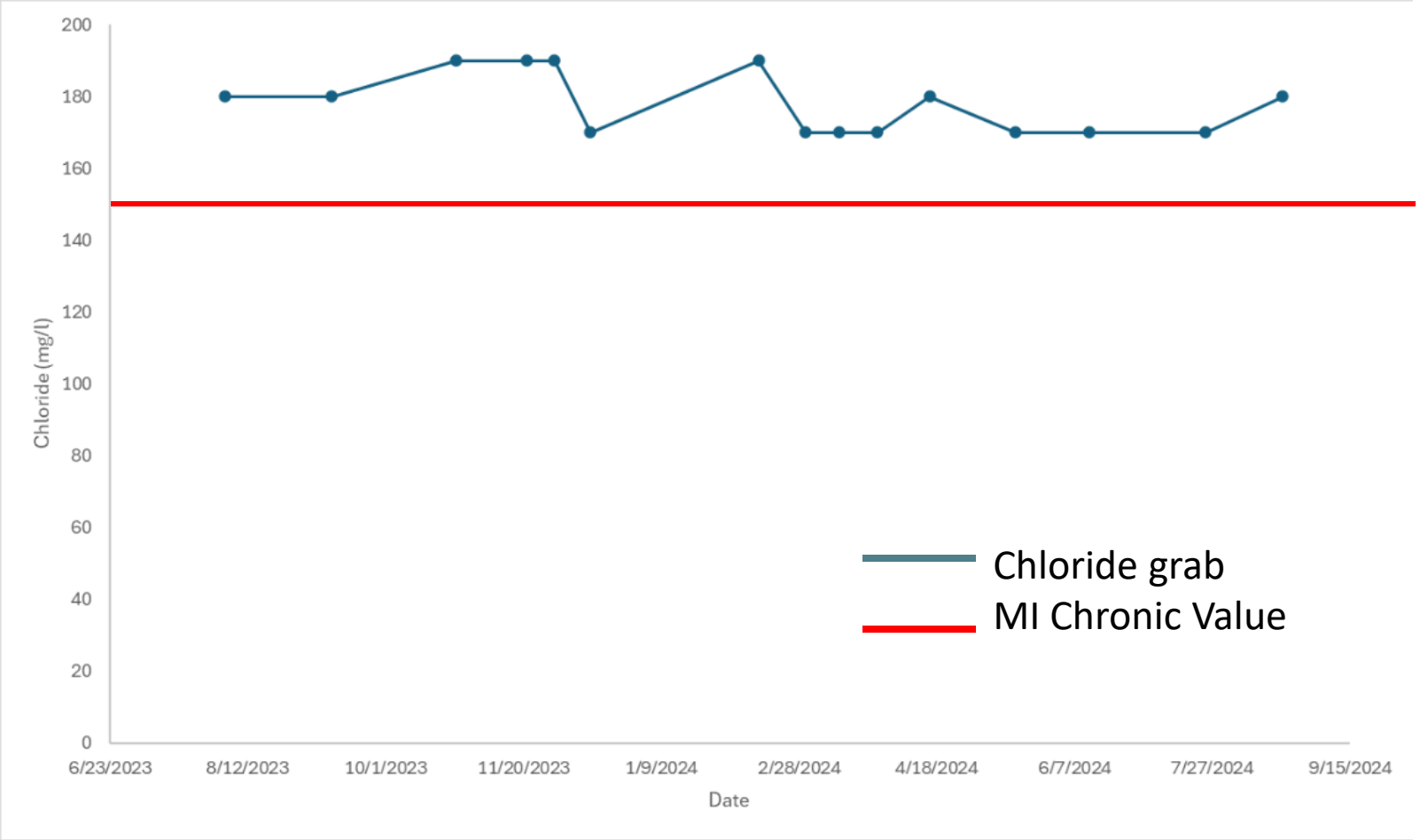
(NOT touching on profile info; nutrients/trophic info; tributaries)

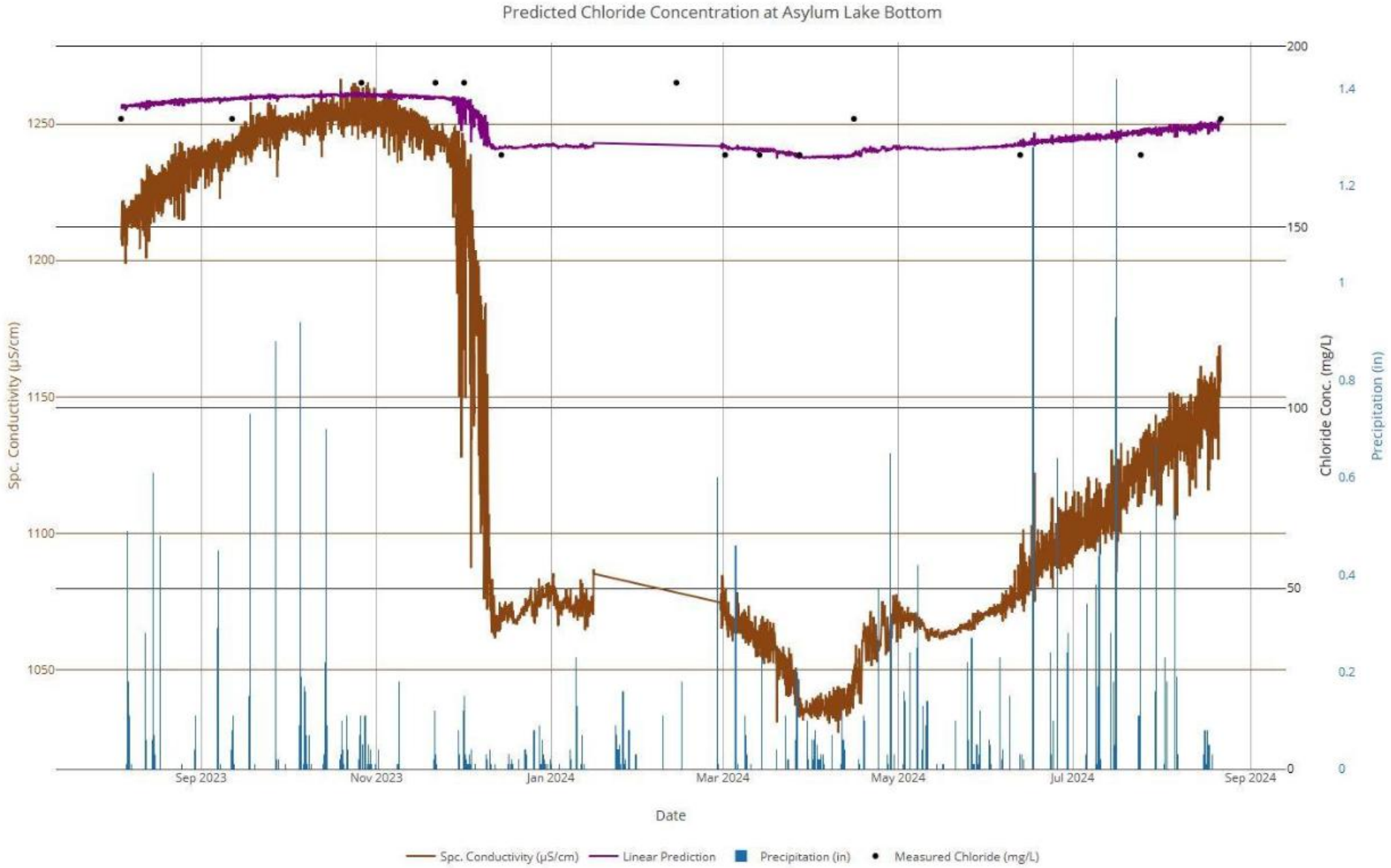
Asylum Lake: Surface chloride, 8/2023-8/2024



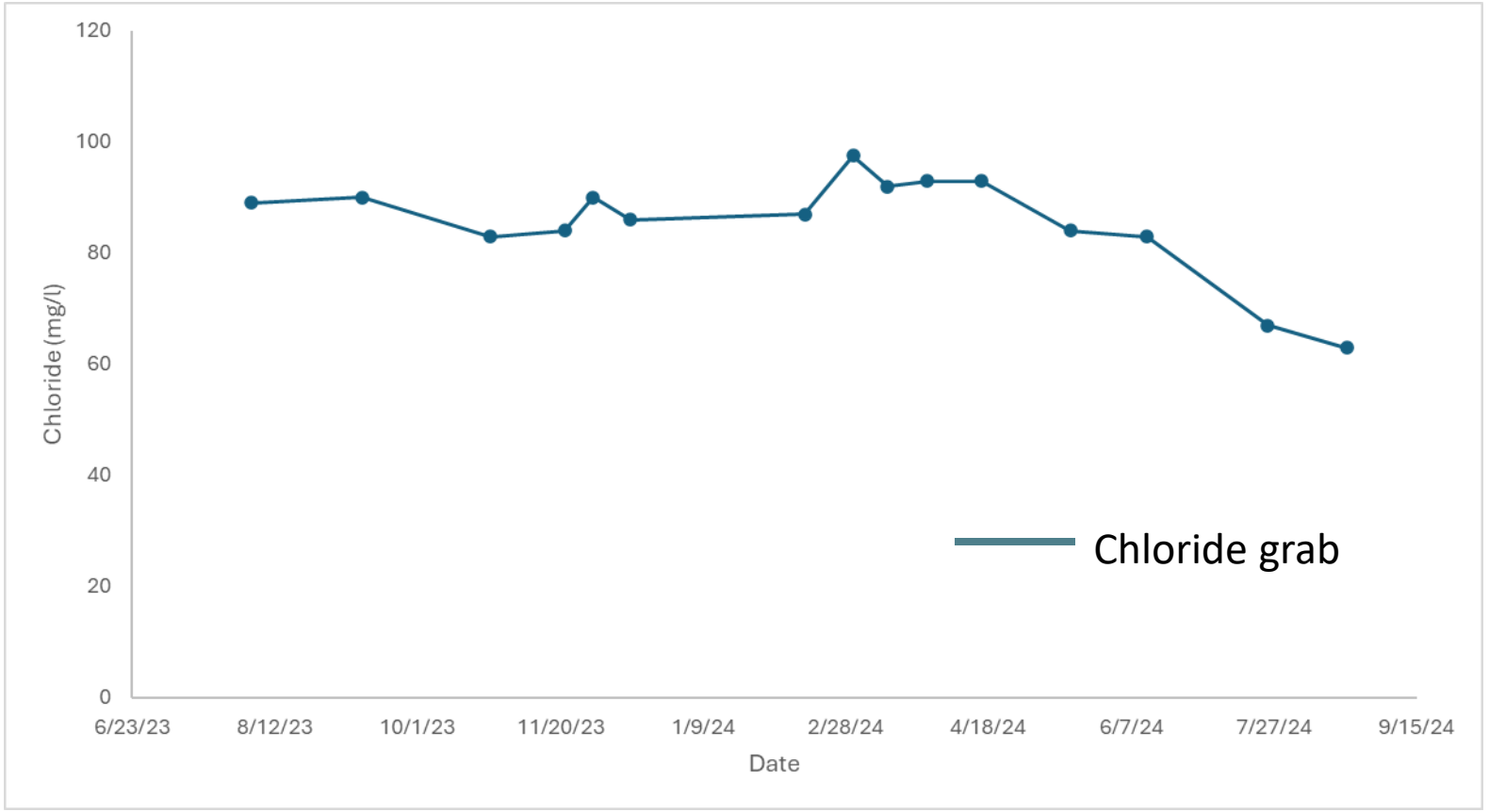

Predicted Chloride Concentration at Asylum Lake Surface
Spc. Conductivity (µS/cm)
Chloride Conc. (mg/L)
Precipitation (in)
1150
1100
1050
1000
950
900
850
800
750
180
160
140
120
100
80
60
40
20
0
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sep 2023
Nov 2023
Jan 2024
Mar 2024
May 2024
Jul 2024
Sep 2024
Date
Spc. Conductivity (µS/cm)
Linear Prediction
Precipitation (in)
Measured Chloride (mg/L)

Asylum Lake: Bottom chloride, 8/2023-8/2024



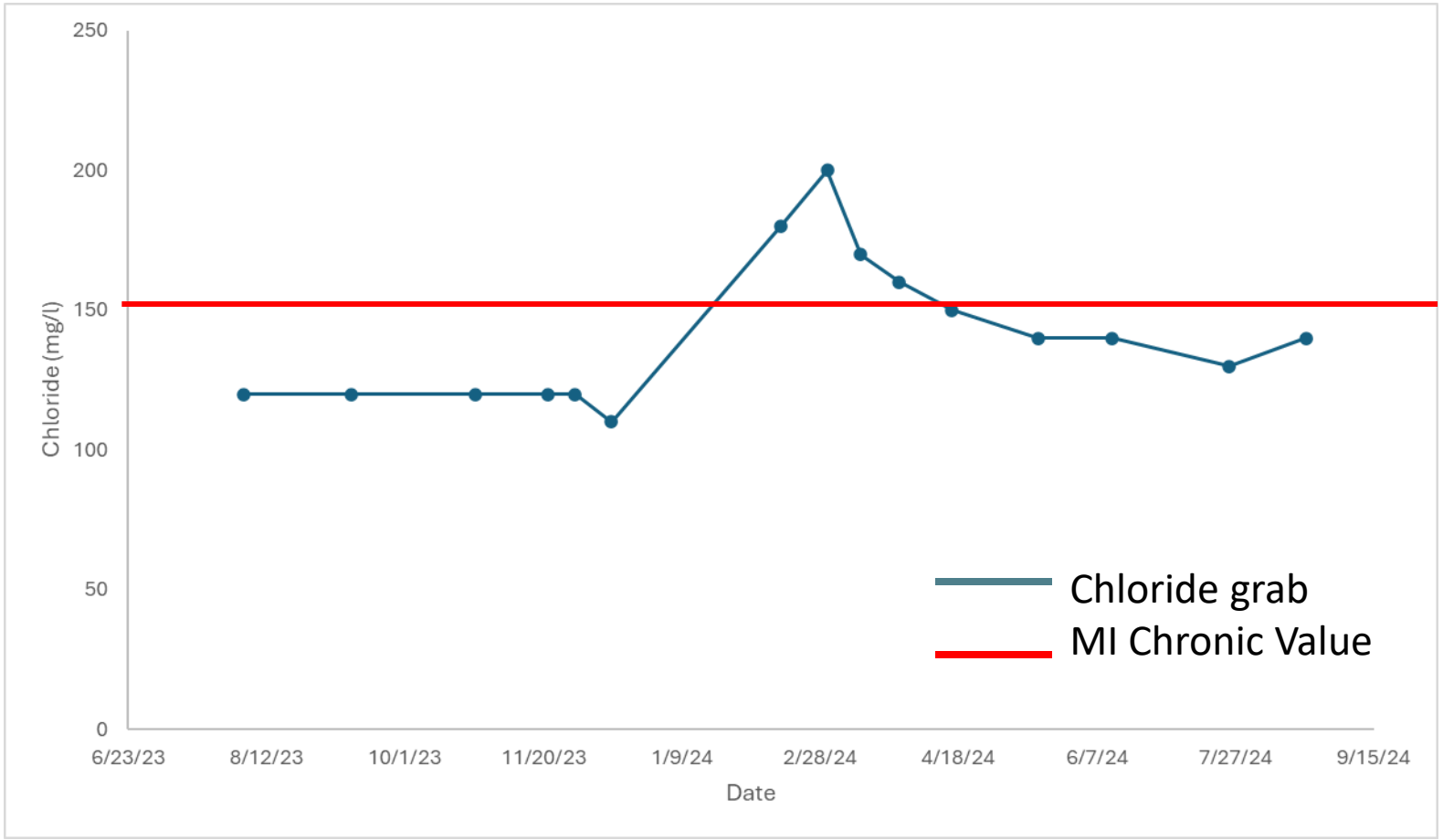

Predicted Chloride Concentration at Asylum Lake Bottom
Spc. Conductivity (µS/cm)
1250
1200
1150
1100
1050
Chloride Conc. (mg/L)
200
150
100
50
0
Precipitation (in)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sep 2023
Nov 2023
Jan 2024
Mar 2024
May 2024
Jul 2024
Sep 2024
Date
Spc. Conductivity (µS/cm)
Linear Prediction
Precipitation (in)
Measured Chloride (mg/L)

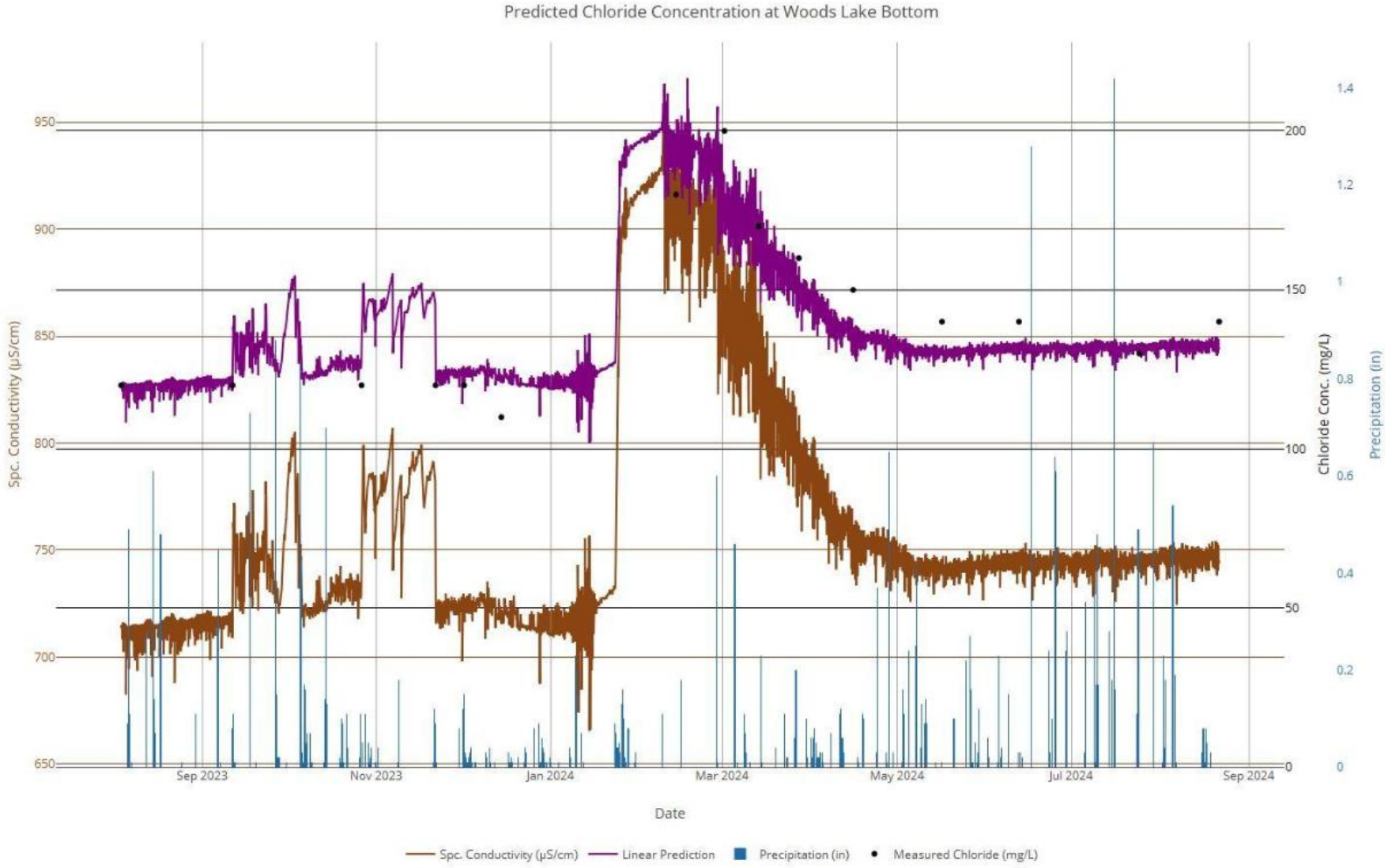
Woods Lake: Surface chloride, 8/2023-8/2024




Predicted Chloride Concentration at Woods Lake Surface
Spc. Conductivity (µS/cm)
550
500
450
400
350
Chloride Conc. (mg/L)
100
80
60
40
20
0
Precipitation (in)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sep 2023
Nov 2023
Jan 2024
Mar 2024
May 2024
Jul 2024
Sep 2024
Date
Spc. Conductivity (µS/cm)
Linear Prediction
Precipitation (in)
Measured Chloride (mg/L)

Woods Lake: Bottom chloride, 8/2023-8/2024




Predicted Chloride Concentration at Woods Lake Bottom
Spc. Conductivity (µS/cm)
950
900
850
800
750
700
650
Chloride Conc. (mg/L)
200
150
100
50
0
Precipitation (in)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sep 2023
Nov 2023
Jan 2024
Mar 2024
May 2024
Jul 2024
Sep 2024
Date
Spc. Conductivity (µS/cm)
Linear Prediction
Precipitation (in)
Measured Chloride (mg/L)

Findings

Good news:

- Woods and Asylum Lake chloride concentrations lower than expected (previous reported concentrations as high as 290 mg/l).

Bad news:

- Lower than expected, but still high, chloride concentrations remain in Asylum and Woods.

So…both lakes will be 303d listed, and some of the tributaries

Findings

Other news:

- Conductivity loggers were useful in a more complete picture of conductivity (and thus chloride) including spikes that would be missed by grab samples
- Loggers were small, minimal equipment needed to deploy, no incidence of vandalism or loss
- Some biofouling/occlusion issues particularly in inlet/outlet loggers (lotic)

- Real-time transmission options (e.g. Mayfly sensor) would be more useful in identifying rising/falling conditions to trigger sampling, and to indicate fouling issues
- Test strip correlation to lab analyzed chloride was strong and indicates a low-cost, simple option for monitoring, particularly screening-level studies

Findings

LOTS of Other news:

Monomictic, meromictic – chemoclines,

high phosphorus concentrations in monimolimnion,

interesting DO patterns possibly associated with methane at depth coming to surface when isothermal…

so much more!

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