Acid Rain Monitoring Project

FY23 Annual Report

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Bureau of Waste Prevention

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Front cover photo: Volunteer Caleb Walk sampling Underwood Brook in Heath, Massachusetts
April 2, 2023
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Executive Summary

- 2023 was the 22nd year of Phase IV of the Acid Monitoring Project, which started in 1983 to document the effects of acid deposition on surface waters in Massachusetts.
- The project, funded by the Massachusetts Department of Environmental Protection's Bureau of Waste Prevention, is run by the Water Resources Research Center at the University of Massachusetts Amherst, and relied on 57 volunteers from 34 Massachusetts towns to sample 144 water bodies across the state.
- Samples were analyzed for pH and alkalinity at the UMass Environmental Analysis Lab and at 10 labs staffed by volunteers, from Westfield to the Cape Cod National Seashore. Samples from 26 Long-Term Sites (having data dating back to at least 1985) are also analyzed for color and 11 ions (Cl, NO_3, SO_4, Mg, Mn, Fe, Cu, Al, Ca, Na, K).
- Trend analyses show that 40% of the water bodies surveyed show a significant increase in pH and 49% show a significant increase in alkalinity over the duration of the project. Only 4% show a decrease in pH and this year, no water body showed a significantly significant downward trend in alkalinity.
- Of the 26 Long Term sites, 20 show a significant increase in color, which is consistent with a recovery of natural alkalinity.
- Ions for the most part show no significant increase or decrease over the past 38 years. However, sulfate decreased significantly at all sites, an indication that the Clean Act Amendment of 1990 is having a positive effect on Massachusetts surface waters' water quality. Conversely, sodium and chloride increased for 20 and 17 sites, respectively, a likely result of road salting in the winter. This year again, potassium also increased significantly at 23 sites. The reason for this increase is unknown, though potassium chloride is sometimes used as a road salt as well.
- A program was written to extract needed data from the Database in order to format it for submission to the USEPA Water Quality Portal. The complete data set will be uploaded via WQX by the end of 2023.

Introduction
This report covers the period January 1, 2023 to June 30, 2023, the twenty-second year of Phase IV of the Acid Rain Monitoring Project. Phase I began in 1983 when around one thousand citizen volunteers were recruited to collect and help analyze samples from nearly half the state's surface waters. In 1985, Phase II aimed to do the same for the rest of the streams and ponds[1] in Massachusetts. The third phase spanned the years 1986-1993 and concentrated on a subsample of streams and ponds to document the effects of acid deposition to surface waters in the state. Over 800 sites were monitored in Phase III, with 300 citizen volunteers collecting samples and doing pH and ANC analyses. In 2001, the project was resumed on a smaller scale: about 60 volunteers are now involved to collect samples from approximately 150 sites, 26 of which are long-term sites with ion and color data dating back to Phase I. In the first years of Phase IV (2001-2003), 161 ponds were monitored for 3 years. Between Fall 2003 and Spring 2010, the project monitored 151 sites twice a year (April and October), mostly streams, except for the 26 long-terms sites that are predominantly ponds. Since 2011, reduced funding eliminated the October sampling and monitoring now occurs in April only. In 2011, we also stopped monitoring some of the streams in order to add and revisit ponds that were monitored in 2001-2003. This year is the eleventh year of monitoring for those added ponds. No collection took place in 2020 as the covid-19 pandemic prevented entry to many laboratories used in this project.

Goals
The goals of this project are to determine the overall trend of sensitivity to acidification in Massachusetts surface waters and whether the 1990 Clean Air Act Amendment has resulted in improved water quality.

Methods
The sampling design was changed in 2011 to monitor both streams and ponds, and that design continues to date. In 2001-2003 mostly ponds were monitored. In Fall 2003 the sampling scheme switched to streams to evaluate their response to air pollution reductions. In 2011 the site list was modified to include both ponds and streams. Half of the streams monitored since 2003 were kept, and half of the ponds monitored in 2001-2003 were added back. The streams that were removed were chosen randomly within each county. Ponds that were reinstated on the sampling list were chosen at random within those counties and by ease of accessibility to replace the removed streams. Because those sites were chosen without a preconceived plan, they can be considered picked at random.

One collection took place this year, on **April 2, 2023**.

Methods were unchanged from previous years: Volunteer collectors were contacted six weeks before the collection to confirm participation. Clean sample bottles were sent to them in the mail, along with sampling directions, a field sheet/chain of custody form, and directions including latitude and longitude coordinates along with maps to the sampling sites. Volunteers collected a surface water sample at their sampling sites either from the bank or wading a short distance into the water body. They collected water one foot below the surface, upstream of their body, after rinsing their sample bottle three times with pond or stream water. If collecting by a bridge, they collected upstream of the bridge unless safety and access did not allow it. They filled in their field data sheet with date, time, and site code information, placed their samples on ice in a cooler and delivered the samples to their local laboratory right away. They were instructed to collect their samples as close to the lab analysis time as possible. In

[1] Note: The term stream in this report refers to lotic waters (from creeks to rivers) and the term ponds refers to lentic waters (lakes and ponds, but not marshes)

a few cases, samples were collected the day prior to analysis because the lab is not open on traditional "ARM Sunday." Previous studies by our research team have established that pH does not change significantly in 24 hours when the samples are refrigerated and stored in the dark.

Volunteer labs were sent any needed supplies (sulfuric acid titrating cartridge, electrode, buffers), two quality control (QC) samples, aliquot containers for long-term site samples, and a lab sheet one week to ten days before the collection. They analyzed the first QC sample (an unknown) in the week prior to the collection and called in their results to the Statewide Coordinator. If QC results were not acceptable, the volunteer analyst discussed possible reasons with the Statewide Coordinator and made modifications until the QC sample analysis gave acceptable results. On collection day or the day after, volunteer labs analyzed the second QC sample before and after the regular samples, and reported the results on their lab sheet along with the regular samples. Analyses were done on their pH-meters with KCl-filled combination pH electrodes. Acid neutralizing capacity (ANC) was measured with a double end-point titration to pH 4.5 and 4.2. Most labs used a Hach digital titrator for the ANC determination, but some used traditional pipette titration equipment. Aliquots were taken from 26 long-term sites to fill three 50mL tubes per site for later analysis of ions and color. These aliquots were kept refrigerated until retrieved by UMass staff. This year, 11 laboratories volunteered to analyze samples for pH and alkalinity on ARM Sunday. One lab, however, experienced issues with their pHmeter and had to back out at the last minute. We picked up the samples the next day and analyzed those samples at UMass.

This year all 26 long-term sites were sampled again. Aliquots, empty bottles, and results were collected by the ARM Statewide Coordinator and the Principal Investigator between one and three days after the collection.

The Principal Investigator reviewed the QC results for all labs and flagged data for any lab results that did not pass Data Quality Objectives (within 0.3 units for pH and within 3mg/L for ANC). pH and ANC data were entered by one ARM staff and proofread by another. Data were entered in a MS excel spreadsheet and uploaded into the web-based database at http://63.135.115.71/acidrainmonitoring/. pH and alkalinity data were also posted on the ARM web page at https://wrrc.umass.edu/research/projects/acid-rain-monitoring-project/arm-2023-results.

Water Resources Research Center's Cameron Richards, with the help of senior student Teresa Hachey, managed the Environmental Analysis Lab (EAL) and provided the QC samples for pH and ANC to all of the volunteer labs. EAL also provided analysis for color analysis for the long-term site samples. The UMass Extension Soils Laboratory analyzed the samples from the long-term sites for cations, and University of New Hampshire's Water Quality Analysis Laboratory, under the direction of Jody Potter, analyzed the samples from the long-term sites for anions.

Aliquots for the 26 long-term sites were analyzed for color on a spectrophotometer at UMass EAL within three days; anions within three months on an Ion Chromatograph at the University of New Hampshire; and cations within one month on an ICP at the UMass Extension Soils Laboratory on the UMass Amherst campus. The available data was sent via MS Excel spreadsheet to the Statewide Coordinator and uploaded into the web-based database.

The Project Principal Investigator plotted the data to check for data inconsistencies and gaps. She then analyzed the available April data from 1983 through 2022, using the statistical software JMP (http://www.jmp.com/software/) to run bivariate analyses of pH, ANC, color and ions against date. This yielded trends analyses with a fitted X Y line, using a 95% confidence interval.

Results

1. There are 149 water bodies on our list of sites, but only 144 sites --73 ponds and 71 streams-- were actually sampled by the volunteer collectors in 2023.

2. Of those, 19 ponds and 7 streams are "long-term" sites that are sampled every year and analyzed for color and a suite of ions in addition to pH and ANC.

3. There were some quality control problem this year. One lab was not able to pass the first (diagnostic) QC sample and did not perform any analyses this year. Another lab failed pH on the second Quality Control sample on the day of sampling, so those samples were re-analyzed at UMass when we retrieved the samples.

4. The network of volunteers was maintained and kept well informed on the condition of Massachusetts surface waters so that they would be able to participate effectively in the public debate. This was accomplished by e-mail and telephone communications, as well as through updates via an internet listserv. 57 volunteers from 34 towns in Massachusetts participated in this year's collection. Several new volunteer collectors were recruited to replace retiring volunteers via personal connections, participating professors recruiting students, and by word of mouth. There were 11 volunteer labs across the state, in addition to the EAL at UMass Amherst, in charge of pH and ANC analyses (Table 1), though one lab, at Fitchburg State University, ended up not doing analyses due to equipment malfunction (their samples were subsequently analyzed by the EAL at UMass).

Table 1: Volunteer Laboratories

Analyst Name	Affiliation	Town
Amanda Moulton	MDC Quabbin Lab	Belchertown
Talia Dell Angelo	Cushing Academy	Ashburnham
Robert Bentley	Analytical Balance Corp Laboratory	Middleborough
Dave Christensen	Westfield State University	Westfield
Ornela Piluri	Upper Blackstone Clean Water	Millbury
Sue Tower	Springfield Water and Sewer Commission	Westfield
Mary Rapien	Bristol Community College	Fall River
MF Hatte	Deerfield River Watershed Association	Greenfield
Cameron Richards	UMass Amherst Environmental Analysis Lab	Amherst
Carolina Bastidas	MIT	Cambridge
Aisling O'Connor	Fitchburg State University[1]	Fitchburg
Sophia Fox	Cape Cod National Seashore	Wellfleet

[1] This lab was unable to analyze samples on ARM Sunday. Their samples were brought to UMass and analyzed by EAL

5. The ARM web site and searchable database were maintained and updated. 2023 pH, ANC, color, and ion data were added to the web database via the uploading tool created in previous years.

6. The data collected was analyzed for trends in pH and ANC in April months (144 sites) and for color and ions (26 sites), using the JMP® Statistical Discovery Software (http://www.jmp.com/software/). Trend analyses (scatter plots, regression, and correlation) were run on pH, ANC, color, and each ion separately for each site, predicting concentration vs. time.

Data Analysis Results

pH and ANC

Table 2 displays the number of sites that show a significant change over time for pH or ANC. If the difference was not statistically significant ($p>0.05$), the sites are tabulated in the 'No Change' category.

Table 2: Trend analysis results for pH and ANC, April 1983 – April 2023 (Number of sites)

	All sites		Ponds		Streams	
	pH	ANC	pH	ANC	pH	ANC
Increased	57	70	30	41	27	29
Decreased	6	0	2	0	4	0
No Change	81	74	41	32	40	42
Total	144	144	73	73	71	71

Those results are graphed as percentages of all sites in Figure 1.

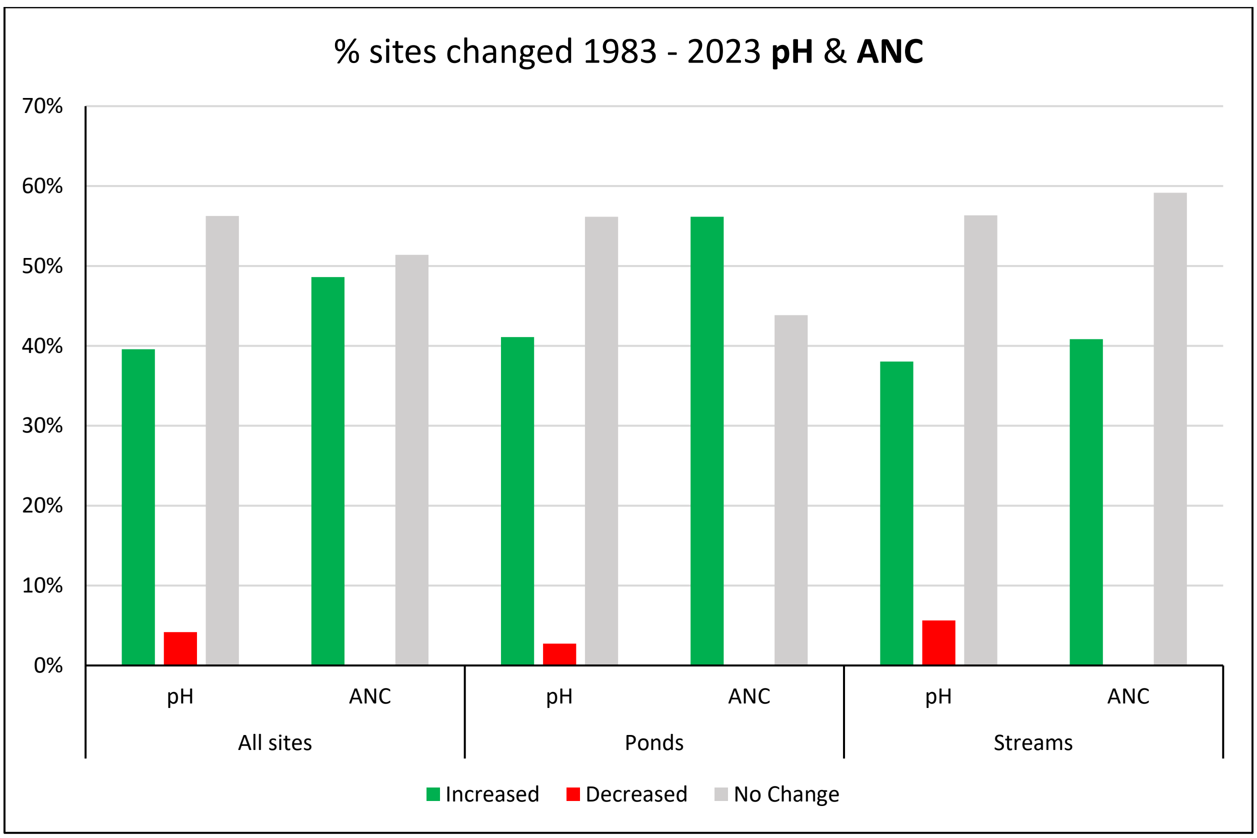

Figure 1. Percent change in number of sites for pH and ANC, from trend analysis, April 1983-2023

This trend analysis indicates that for most sites, neither pH nor ANC changed significantly over time. However, for those sites that show a significant change, many more show an increase than a decrease in value: 40% of the sites saw an increase in pH and 49% had an increase in ANC. It can be noted that more sites are exhibiting an increase in pH each year of the past 4 years.

We continue to see a much higher percentage of ponds exhibiting an increase in ANC compared to streams (56% vs. 41%). Streams continue to show more numbers increasing in pH. As far as decreases in pH are concerned, the situation is similar to the past two years: 6% of streams had a statistically significant decrease in pH this year (vs 7% the past two years). Again, no ponds had a statistically significant decrease in pH or ANC this year, and neither did streams this year.

The 2022-2023 winter preceding the sample collection did not have large amounts of snowfall, but it must be noted that we sampled earlier than in past two years (April 2^{nd}) and there was some snowpack left I higher altitude areas.

Ions and color

Trend analyses were run for 26 long-term sites that were analyzed for eleven ions and for color. Results are shown in Table 3 and Figure 2. Note that the trend period is 1985-2023.

Table 3: Trends for number of sites with increases or decreases in ion concentration and color April 1985 – April 2023

	Increased	Decreased	No Change
Color	20	0	6
Mg	5	0	21
Mn	0	13	13
Fe	0	10	16
Cu	11	0	15
Al	1	4	21
Ca	4	1	21
Na	20	0	6
K	23	0	3
Cl	17	0	9
NO3	1	0	25
SO4	0	25	1

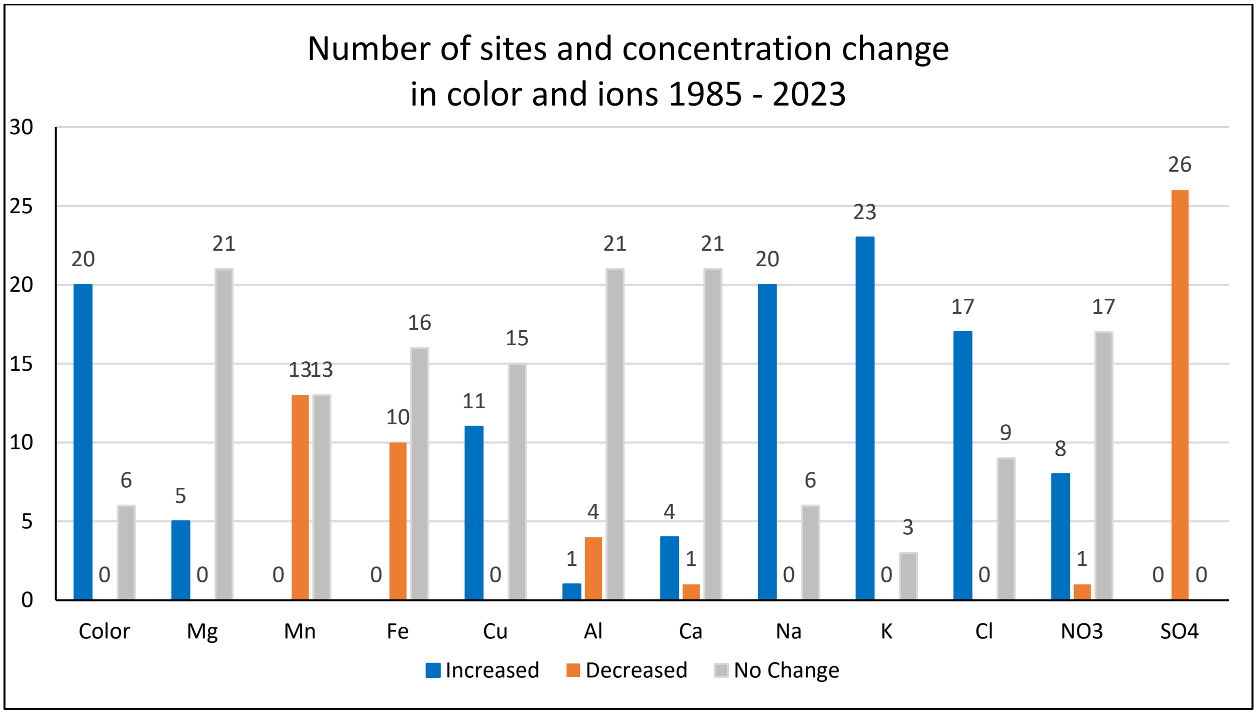

Figure 2: Results of trend analysis for ions and color at 26 long-term sites, April 1985-2023. The bars depict how many sites showed a statistically significant increase (blue), decrease (orange), or no significant change (grey) over the period 1985 – 2023.

Results are similar to last year.

While there are still more sites that show no significant change either up or down, some cations show significant increases or decreases over the years. Sodium (Na) and potassium (K) are the cations with the most increases (23 out of 26 for K again this year, a sizeable increase from 2021 when it was 16), with manganese and iron showing the most decreases. Sodium and chloride increases are usually associated with road salting in the winter. Potassium chloride is sometimes used to salt roads as well.

After double checking what looked like extreme outliers for nitrates in 2014, it was discovered that the 2014 NO3 and SO4 data had been entered incorrectly. The incorrect data were replaced with the correct data and the trend analyses run again. We now see that for sulfates, all sites show a significant decrease in concentration over the 38 years of the project. For nitrates, most sites show no trend, but 8 sites show an increase, and one site shows a decrease. Chloride has increased at 17 sites and decreased nowhere.

Color is still increasing in most of our sites, which is consistent with a recovery of natural alkalinity.

Discussion

The continued trend in decreasing sulfate confirms that the Clean Air Amendment of 1990 is having a positive effect in the quality of the Commonwealth's surface water quality. Road salting in the winter continues to affect the concentration of sodium and chloride in the water bodies. Continued monitoring will help determine whether nitrate pollution continues to increase, and if more sites are affected in the future.

Database

We proposed to download the ARM database from the private server where it has been stored, for a couple of reasons: Hosting the database on that server is not cheap (over $400/year), and it requires maintenance by a consultant who can program in ColdFusion. Our consultant, Bob English, is retiring, and there aren't many people locally who are able to fill in for him. Our plan is to convert the database to an excel spreadsheet and convert its format to one that is compatible with U.S.EPA's Water Quality database, where we will upload all of the ARM data via WQX, and where the data can be searched and downloaded via the Water Quality Portal.

The database, which is in Access format on the server, was downloaded to the UMass server, and a program was written to pull out the desired fields (Palsaris or Saris code, Sampling date, Water body name, Latitude, Longitude, pH, ANC, Mg, Mn, Fe, Cu, Al, Ca Na, K, Cl, NO3, SO4, Color). The program also re-organized the data to list one record per site per sampling date per parameter. The program is simple and can be found in Appendix Table A4.

We then must fill out many other fields required by WQX, such as Analytical Method ID, Detection Limit, Units, etc. before the file has the required parameters for upload.

Once the data was downloaded and sorted, we found that many of the sites that were sampled in the early phases of the Acid Rain Monitoring Project had missing latitude and longitude data. Out of 377,505 records with April data, only 366,107 have coordinates data. The database has data from 1983 through 2023, and contains 42,073 records with measurements data pH, ANC, color, and 11 anions on each record.

We are currently filling out the required information for all records (as partially listed above), which requires some research in old documents, particularly for the analytical methods used in the early phases of the project.

Because finding coordinates will involve some effort requiring GIS investigations, we propose to perform that task in the last quarter of this year, with the help of Natural Resources Conservation students taking an internship course with Dr. Randhir (WRRC's director and next year's ARM Project Principal Investigator).

We have uploaded the Access Database and the Excel spreadsheet on the WRRC Google Drive, and shared both documents with our sponsor at Mass DEP, Mark Wert. The Access Query program is also uploaded in that folder.

Acknowledgements

Thank you to all of the project's volunteers who make this project possible by collecting samples all over the state under any weather conditions, and who spend many hours in the lab analyzing samples.

Appendix

Table A-1: April 2, 2023 pH and Alkalinity Data

Name	Town	Palsaris	pH	ANC
Aldrich Brook	Millville	5131425	6.15	3.2
Angeline Brook	Westport	9560000	5.01	-0.4
Anthony Brook	Dalton	2105425	6.42	2.4
Ashby Reservoir	Ashby	81001	6.15	2.2
Ashfield Lake	Ashfield	33001	7.17	32.7
Babcock Brook	Tolland	3107625	5.69	4.0
Bagg Brook	West Springfield	3417750	7.65	74.0
Baker Brook	Gardner	3524050	5.31	1.6
Bartlett Pond Brook	Leominster	8146000	5.30	0.4
Barton Brook	Dalton	2105350	6.89	10.0
Bassett Brook	Raynham	6236100	6.31	8.4
Bassett Pond	New Salem	35002	5.88	0.9
Beagle Club Pond	Dartmouth	371	6.92	10.1
Beaman Brook	Winchendon	3523825	5.72	2.0
Belmont Reservoir	Hinsdale	21010	5.44	0.7
Benton Brook	Otis	3107375	6.30	9.2
Bickford Pond	Hubbardston	36015	6.39	3.3
Bilodeau Brook	Hinsdale	2105750	6.93	10.9
Black Brook	Hamilton	9253700	6.48	16.9
Black Brook	Warwick	3522675	6.36	1.9
Blossom Brook	Fall River	6134700	4.66	-1.4
Blue Hills Reservoir	Qunicy	73004	7.55	13.9
Bog Pond	Savoy	33003	6.13	3.8
Boston Brook	Middleton	9253925	6.86	17.5
Bozrah Brook	Hawley	3315325	7.07	8.1
Brass Mill Pond	Williamsburg	34011	6.70	12.0
Bread And Cheese Brook	Westport	9560150	6.16	3.1
Buck Pond	Westfield	32012	6.85	17.0
Bungay River	North Attleborough	5233750	6.70	22.3

Cadwell Creek	**Pelham**	**3626575**	**5.92**	**0.7**
Cady Brook	**Washingon**	**2105725**	**6.65**	**8.4**
Cheshire Reservoir North	**Cheshire**	**11002**	**8.18**	**94.7**
Clear Run Brook	**Seekonk**	**5334150**	**6.87**	**37.5**
Cloverdale Street Pond	**Rutland**	**36036**	**6.50**	**8.3**
Cobble Mountain Reservoir	**Blandford**	**32018**	**6.74**	**7.0**
Coes Reservoir	**Worcester**	**51024**	**7.02**	**19.3**
College Pond	**Plymouth**	**95030**	**6.48**	**2.5**
Cowee Pond	**Garner**	**35013**	**5.23**	**0.2**
Cronin Brook	**Grafton**	**5132625**	**6.73**	**7.1**
Crystal Lake	**Palmer**	**36043**	**5.99**	**1.0**
Dorothy Brook	**Worcester**	**5132700**	**6.74**	**20.2**
Duck Pond	**Groton**	**84083**	**6.67**	**6.7**
East Branch Swift River	**Barre**	**3627200**	**6.37**	**2.2**
East Brimfield Reservoir	**Brimfield**	**41014**	**6.26**	**5.2**
East Oxbow Brook	**Charlemont**	**3314925**	**6.52**	**2.9**
Ezekiel Pond	**Plymouth**	**95051**	**6.71**	**3.9**
Farm Pond	**Sherborn**	**72039**	**6.91**	**4.5**
Fiske Pond	**Wendell**	**34023**	**5.43**	**0.3**
Flat Brook	**Ware**	**3627500**	**6.85**	**7.9**
Fox Brook	**Granville**	**3106825**	**6.29**	**3.0**
French River	**Oxford**	**4230075**	**6.79**	**12.6**
Godfrey Brook	**Milford**	**7240375**	**7.45**	**26.2**
Great Pond	**Wellfleet**	**96117**	**6.23**	**1.0**
Greenwood Pond	**Templeton**	**35026**	**5.37**	**1.2**
Grove Pond	**Ayer**	**81053**	**7.02**	**17.2**
Gulf Brook	**Pepperell**	**8143675**	**7.00**	**11.2**
Hartwell Brook	**Charlemont**	**3315075**	**7.30**	**13.1**
Hatches Creek	**Eastham**	**9661525**	**6.33**	**8.2**
Hawley Reservoir	**Pelham**	**34031**	**6.17**	**1.5**
Heald Pond	**Pepperell**	**81056**	**7.10**	**15.6**
Hedges Pond	**Plymouth**	**94065**	**6.44**	**2.4**
Hinsdale Brook	**Shelburne**	**3313175**	**7.86**	**37.1**

Holden Reservoir	**Holden**	**51063**	**6.70**	**5.6**
Hop Brook	**New Salem**	**3627000**	**6.74**	**4.2**
Indian Pond	**Kingston**	**94072**	**6.48**	**11.2**
Ipswich River	**Ipswich**	**9253500**	**6.95**	**25.4**
Johnson Pond	**Raynham**	**62097**	**6.12**	**5.0**
Kenny Brook	**Royalston**	**3523750**	**6.01**	**1.4**
Kickamuit River	**Swansea**	**6134500**	**6.38**	**9.0**
Kilburn Brook	**Peru**	**2105700**	**6.64**	**4.1**
King Phillip Brook	**Fall River**	**6134725**	**4.65**	**-0.5**
Kinnacum Pond	**Wellfleet**	**96163**	**5.39**	**0.3**
Kinsman Brook	**Heath**	**3314450**	**6.90**	**6.5**
Lake Rohunta; South Basin	**Athol**	**35107**	**6.39**	**2.7**
Lake Denison	**Winchendon**	**35017**	**5.90**	**2.4**
Lake Garfield	**Monterey**	**21040**	**7.88**	**50.0**
Lake Lorraine	**Springfield**	**36084**	**6.55**	**10.0**
Lake Pearl	**Wrentham**	**72092**	**6.97**	**24.0**
Lake Wampanoag	**Ashburhnham**	**81151**	**5.09**	**0.4**
Lake Watatic	**Ashburnham**	**35095**	**6.12**	**3.4**
Lake Wyola	**Shutesbury**	**34103**	**6.39**	**1.8**
Little River	**Westfield**	**3208725**	**6.85**	**8.0**
Little Sandy Pond	**Plymouth**	**95092**	**6.74**	**5.2**
Long Pond	**Great Barrington**	**21062**	**8.02**	**79.0**
Lord Brook	**Rowe**	**3316550**	**6.35**	**1.6**
Lynde Brook Reservoir	**Leicester**	**51090**	**7.16**	**17.0**
Maynard Brook	**Oakham**	**3626475**	**5.63**	**1.1**
Mcgovern Brook	**Lancaster**	**8144725**	**7.31**	**15.3**
Mill River	**Conway**	**3419825**	**7.36**	**28.7**
Millham Brook	**Marlborough**	**8247475**	**7.26**	**24.3**
Moores Pond	**Warwick**	**35048**	**6.20**	**2.1**
New Long Pond	**Plymouth**	**95112**	**6.19**	**0.6**
Nipmuck Pond	**Webster**	**42039**	**5.74**	**1.6**
Noquockoke Lake	**Dartmouth**	**95170**	**6.24**	**3.8**
North River	**Colrain**	**3314100**	**7.05**	**9.9**

North Watuppa Lake	**Fall River**	**61004**	**6.16**	**1.6**
Phoenix Pond; Double Pd	**Shirley**	**81100**	**7.17**	**17.4**
Plain Street Pond	**Mansfield**	**52032**	**6.58**	**12.4**
Plainfield Pond	**Plainfield**	**33017**	**5.85**	**0.3**
Pleasant Street Pond	**Franklin**	**72095**	**7.06**	**20.9**
Quabbin Res.Station 202	**Belchertown**	**36129**	**6.74**	**3.8**
Rattlesnake Brook	**Freetown**	**6235125**	**5.36**	**0.5**
Robbins Brook	**Winchendon**	**3524250**	**5.75**	**1.3**
Robbins Pond	**Harvard**	**81111**	**7.77**	**55.4**
Robinson Brook	**Pepperell**	**8143825**	**7.38**	**21.7**
Rocky Run	**Rehoboth**	**5334100**	**6.60**	**10.8**
Round Meadow Brook	**Mendon**	**5131275**	**6.17**	**5.2**
Round Pond	**Brewster**	**96264**	**5.61**	**0.3**
Sandy Pond	**Ayer**	**81117**	**6.82**	**8.0**
Scarborough Pond	**Belchertown**	**34080**	**6.18**	**2.6**
Sewall Brook	**Boylston**	**5132600**	**6.94**	**16.6**
Shingle Brook	**Shelburne**	**3313850**	**7.72**	**50.5**
Shingle Island Brook	**Freetown**	**188**	**5.55**	**1.7**
Sleepy Hollow Brook	**Richmond**	**2104200**	**7.84**	**99.6**
Soda Creek	**Sheffield**	**2103725**	**7.24**	**31.0**
Spectacle Pond	**Warehem**	**95142**	**6.74**	**5.8**
Stony Brook Pond	**Norfolk**	**72113**	**6.99**	**23.7**
Storrow Pond	**Westwood**	**72115**	**6.42**	**4.3**
Stump Pond	**Gardner**	**35085**	**5.42**	**1.5**
Sucker Brook	**New Braintree**	**3625975**	**6.39**	**5.7**
Thompsons Pond	**Spencer**	**36155**	**6.67**	**6.5**
Todd Brook	**Charlemont**	**3316050**	**5.53**	**-0.2**
Torrey Creek	**Seekonk**	**5334075**	**6.35**	**17.1**
Towne Brook	**Royalston**	**3524200**	**5.41**	**0.8**
Trout Pond	**Tolland**	**31042**	**5.50**	**3.0**
Tully Pond	**Orange**	**35089**	**6.46**	**2.5**
Turner Pond	**New Bedford**	**95151**	**5.14**	**0.7**
Underwood Brook	**Heath**	**3314650**	**6.68**	**3.2**

Upper Attitash Pond	**Kingston**	**84072**	**7.35**	**17.2**
Upper Mystic Lake	**Winchester**	**71043**	**7.57**	**39.2**
Upper Naukeag Lake	**Ashburhnam**	**35090**	**6.00**	**1.8**
Upper Spectacle Pond	**Sandisfield**	**31044**	**6.21**	**6.0**
Valley Brook	**Granville**	**3107700**	**6.19**	**4.0**
Vincent Brook	**Colrain**	**3314550**	**7.11**	**9.0**
Walker Brook	**Becket**	**3210300**	**6.79**	**9.6**
Wallis Reservoir	**Douglas**	**51179**	**5.89**	**1.6**
Wellington Brook	**Oxford**	**4230325**	**6.90**	**17.8**
West Br Ware River	**Hubbardston**	**3628175**	**6.32**	**2.3**
West Branch Swift River	**Shutesbury**	**3626800**	**5.77**	**0.8**
Whitehall Reservoir	**Hopkinton**	**82120**	**6.50**	**5.5**
Wilder Brook	**Gardner**	**3523950**	**5.02**	**0.2**
Williams River	**West Stockbridge**	**2104100**	**7.89**	**118.8**
Winnecunnet Pond	**Norton**	**62213**	**6.81**	**10.8**
Wright Pond	**Ashby**	**81160**	**6.25**	**3.3**

Palsaris is a unique water body code based on the Massachusetts Department of Environmental Protection's inventory coding systems (SARIS for streams and PALIS for ponds).

Table A-2: April 2, 2023 color and ion concentration for 26 long term sites.
Ion concentrations are in mg/L, color in PCU

Site Name	Palsite	Date	Color	Mg	Mn	Fe	Cu	Al	Ca	Na	K	Cl	NO3	SO4
Shingle Island Brook	188	4/2/2023	258.05	1.32	0.00	0.26	0.03	0.19	3.16	10.29	1.99	15.56	0.20	1.75
Belmont Reservoir	20110	4/2/2023	24.38	0.67	0.03	0.01	0.04	0.04	2.48	0.67	2.18	2.78	0.04	0.66
Cobble Mtn Reservoir	32018	4/2/2023	46.95	1.22	0.00	0.05	0.03	0.01	2.74	9.86	1.61	14.83	0.05	1.02
Hawley Reservoir	34031	4/2/2023	40.29	0.74	0.00	0.01	0.03	0.01	2.55	8.43	1.53	12.63	0.05	1.57
Lake Wyola	34103	4/2/2023	43.12	0.60	0.00	0.02	0.03	0.01	1.98	4.98	1.39	7.24	0.04	1.30
Upper Naukeag Lake	35090	4/2/2023	41.70	0.54	0.00	0.01	0.03	0.01	1.52	10.97	1.40	15.71	0.01	0.82
Crystal Lake	36043	4/2/2023	34.50	0.38	0.00	0.01	0.03	0.01	0.73	0.67	1.03	3.30	0.00	0.08
Lake Lorraine	36084	4/2/2023	39.19	1.06	0.00	0.01	0.03	0.01	3.52	22.38	2.08	31.60	0.00	0.99
Quabbin Res Station 202	36129	4/2/2023	20.95	0.74	0.02	0.01	0.03	0.01	2.36	5.32	1.57	7.97	0.01	1.23
N Watuppa Lake	42039	4/2/2023	25.85	1.04	0.00	0.04	0.03	0.01	2.29	11.68	1.37	16.75	0.00	1.74
Nipmuck Pond	61004	4/2/2023	63.86	0.58	0.00	0.01	0.03	0.01	1.84	7.02	1.32	10.04	0.00	1.33
Ashby Reservoir	81001	4/2/2023	132.11	0.85	0.00	0.08	0.03	0.02	2.83	12.87	1.81	17.99	0.03	1.27
Wright Pond	81160	4/2/2023	72.38	0.79	0.00	0.29	0.02	0.01	2.33	15.86	2.32	24.86	0.01	0.85
Whitehall Reservoir	82120	4/2/2023	40.94	1.44	0.04	0.01	0.03	0.01	4.62	23.69	1.86	39.46	0.00	1.53
Hedges Pond	94065	4/2/2023	26.60	1.38	0.02	0.01	0.03	0.01	1.29	9.05	1.58	14.42	0.01	1.26
College Pond	95030	4/2/2023	20.63	0.97	0.00	0.01	0.03	0.01	1.11	4.49	1.40	7.34	0.00	1.11
Ezekiel Pond	95051	4/2/2023	28.72	1.43	0.00	0.01	0.03	0.01	2.29	18.31	1.59	28.65	0.06	1.46
Little Sandy Pond	95092	4/2/2023	31.03	1.33	0.00	0.01	0.03	0.01	1.86	16.99	1.92	25.78	0.47	1.29
Great Pond	96117	4/2/2023	22.49	2.06	0.00	0.01	0.03	0.01	1.24	14.95	1.74	24.93	0.00	1.45
Kinnacum Pond	96163	4/2/2023	65.36	1.59	0.00	0.01	0.03	0.01	0.94	10.49	1.61	17.47	0.00	0.73
Cadwell Creek	3626575	4/2/2023	42.75	0.61	0.00	0.01	0.03	0.04	1.59	5.65	1.18	8.38	0.00	1.36
West Br Swift River	3626800	4/2/2023	57.49	0.48	0.00	0.01	0.03	0.03	1.38	2.83	1.04	4.91	0.02	1.18
East Br Swift River	3627200	4/2/2023	80.76	0.75	0.00	0.06	0.03	0.01	2.54	6.34	1.49	9.25	0.03	1.29
Rattlesnake Brook	6235125	4/2/2023	179.50	0.93	0.02	0.16	0.02	0.18	2.21	5.76	1.40	8.46	0.03	1.94
Angeline Brook	9560000	4/2/2023	275.46	1.37	0.00	0.20	0.03	0.47	5.21	8.08	1.85	11.85	0.12	1.44
Bread and Cheese Brook	9560150	4/2/2023	291.88	1.65	0.00	0.27	0.03	0.19	4.51	24.28	2.32	36.42	0.43	1.94

Table A-3: 2023 Sample Collectors

Henry	**Barbaro**	Newton	Gabriel	**Kornilovicz**	N/A
Hayley	**Benoit**	Northampton	Sophia	**Kostoulas**	Worcester
Bob	**Bentley**	Carver	Glenn	**Krevosky**	Boxford
Sophie	**Brown**	Milton	Bill	**Lafley**	New Salem
John	**Burns**	Cummington	Debra	**Lavergne**	N/A
Cindy	**Carvill**	Winchendon	Joy	**Livergood**	Ashburnham
Amanda	**Coffuire**	Douglas	Trouble	**Mandeson**	Greenfield
Dan	**Crocker**	Jefferson	Adam	**McLaughlin**	Merrimac
Eric	**Decker**	Sunderland	Steven	**Peterson**	Winchendon Springs
Travis	**Drury**	Greenfield	Cathy	**Pierce**	Ashburnham
Victoria	**Dumont**	Athol	Denise	**Prouty**	Douglas
Nick	**Duncan**	N/A	Matthew	**Richards**	Shirley
Bill	**Eykamp**	Arlington	Peter	**Richards**	Rutland
Bill	**Frenette**	Dighton	Theresa	**Richards**	Shirley
Lauren	**Gaherty**	Dalton	Colman	**Richards**	Shirley
Eloida	**Georgadarellis**	Dartmouth	Albert	**Rosati**	Rehoboth
Gina	**Georgadarellis**	Dartmouth	Sheila	**Russell**	Rehoboth
Paul	**Georgadarellis**	Dartmouth	Ryan	**Santos**	New Bedford
Beth	**Grady**	Belchertown	Jerry	**Schoen**	New Salem
Gail	**Gray**	Belchertown	Wendy	**Smith**	Shirley
Ken	**Guertin**	Grafton	Michael	**Sperry**	Bellingham
Nicholas	**Guidi**	Greenfield	Chloe	**Stevens**	N/A
Eileen	**Hachey**	Mashpee	Jenny	**Sullivan**	Greenfield
Tess	**Hachey**	Mashpee	Tom	**Trainor**	Sherborn
Marie-Françoise	**Hatte**	Greenfield	Caleb	**Walk**	Greenfield
Jim	**Hoberg**	Plymouth	Ellen	**Weeks**	Colrain
Mark	**Hoechstetter**	Cummington	Rob	**Whitaker**	Cataumet
Cathryn	**Humphery**	N/A	Joyce		N/A
Rory	**Kallfelz**	North Easton			

Table A4: Program to extract data from Access database and reformat to WQX requirements

```
In MS Access navigate to 'External Data' tab, then click 'New Data
Source'.

Select MS Excel file containing ARM data including mDate, SITE (renamed
from NAME since NAME is a reserved SQL word), COUNTY, LAT, LONG,
along with associated values of PH, ALK, Color, CL, NO3_N, SO4, Mg, Si,
Mn, Fe, Cu, Al, Ca, Na, K, and TP.

When it is imported, rename the table 'Measurements'.

Open the table and re-name the NAME column as SITE.

Navigate to the 'Create' tab, and click 'Query Design'.

When the new Query window pops up, right click then click 'SQL view'.

Paste the following text, then right click the window to save the query
with your desired name:

SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'PH' as DataType, PH as
Result FROM Measurements WHERE NOT PH IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'ALK' as DataType, ALK
FROM Measurements WHERE NOT ALK IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Color' as DataType, Color
FROM Measurements WHERE NOT COLOR IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'CL' as DataType, CL FROM
Measurements WHERE NOT CL IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'NO3_N' as DataType, NO3_N
FROM Measurements WHERE NOT NO3_N IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'SO4' as DataType, SO4
FROM Measurements WHERE NOT SO4 IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Mg' as DataType, Mg FROM
Measurements WHERE NOT Mg IS NULL
UNION
```

```
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Si' as DataType, Si FROM
Measurements WHERE NOT Si IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Mn' as DataType, Mn FROM
Measurements WHERE NOT Mn IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Fe' as DataType, Fe FROM
Measurements WHERE NOT Fe IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Cu' as DataType, Cu FROM
Measurements WHERE NOT Cu IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Al' as DataType, Al FROM
Measurements WHERE NOT Al IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Ca' as DataType, Ca FROM
Measurements WHERE NOT Ca IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'Na' as DataType, Na FROM
Measurements WHERE NOT Na IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'K' as DataType, K FROM
Measurements WHERE NOT K IS NULL
UNION
SELECT PALSITE, mDate, SITE, COUNTY, LAT, LONG, 'TP' as DataType, TP FROM
Measurements WHERE NOT TP IS NULL
ORDER BY PALSITE, mDate;
```

Right click the query on the left navigation bar under 'Queries', and hit 'Open'. Once the query runs, check the output to make sure it is as desired.

Right click the query in the left navigation bar under 'Queries' again, and click Export, then Excel, and save in desired location with desired name.