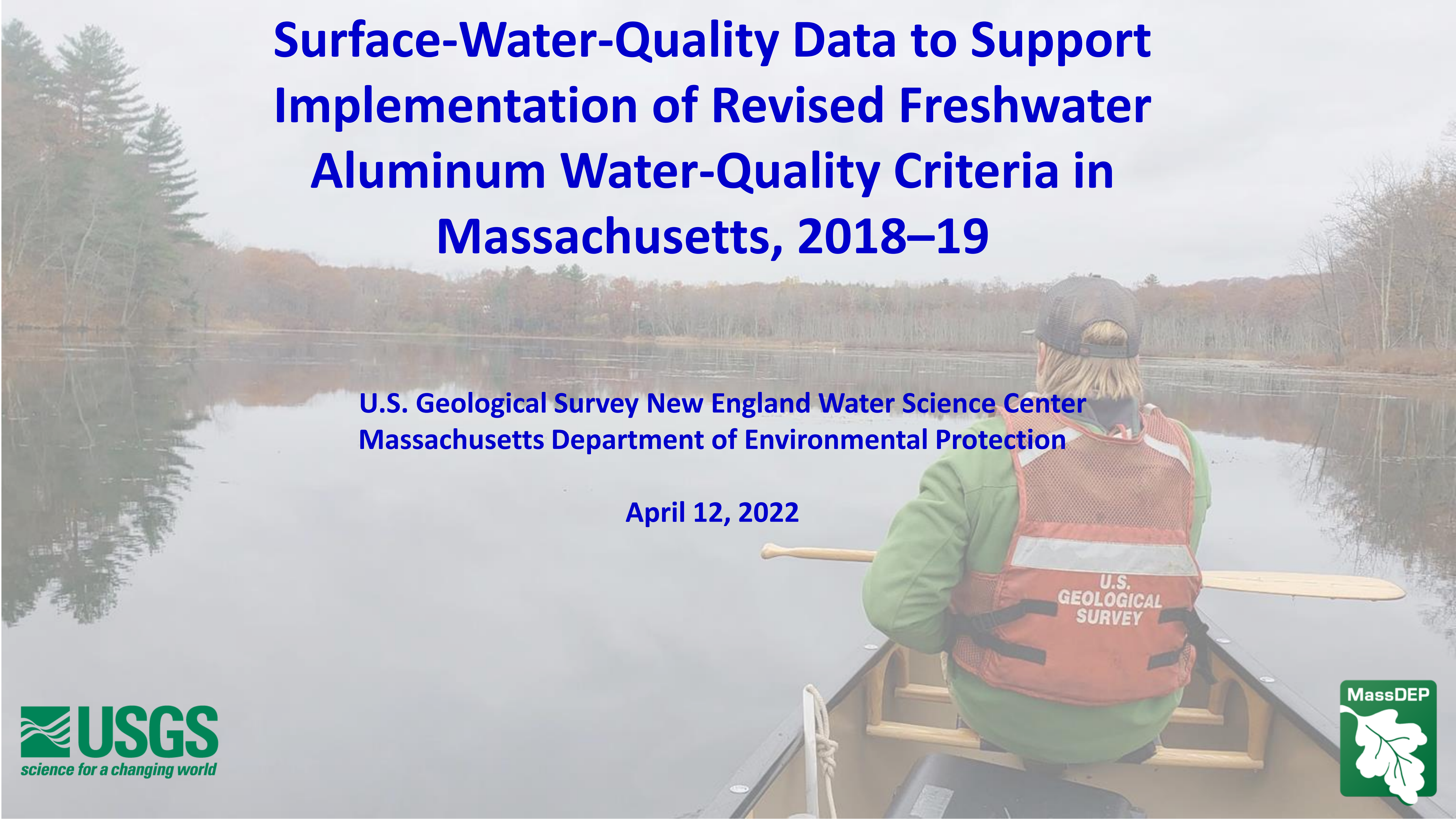
Surface-Water-Quality Data to Support Implementation of Revised Freshwater Aluminum Water-Quality Criteria in Massachusetts, 2018–19

U.S. Geological Survey New England Water Science Center
Massachusetts Department of Environmental Protection

April 12, 2022



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Massachusetts Surface Water Quality Standards and Freshwater Aquatic Life Aluminum Criteria

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Massachusetts Surface Water Quality Standards (314 CMR 4.00) – Overview

- The foundation of surface water quality programs in the Commonwealth under the federal Clean Water Act
- Provide the scientific and legal basis for controlling the discharge of pollutants into surface waters
- Define water quality goals for waterbodies and establish water quality criteria to enhance, maintain, and protect designated uses

314 CMR: DIVISION OF WATER POLLUTION CONTROL

314 CMR 4.00: MASSACHUSETTS SURFACE WATER QUALITY STANDARDS

Section

4.01: General Provisions

(1) Title. 314 CMR 4.00 shall be known as the "Massachusetts Surface Water Quality Standards".

(2) Organization of the Standards. 314 CMR 4.00 is comprised of seven sections: 314 CMR 4.01: *General Provisions*; 314 CMR 4.02: *Definitions*; 314 CMR 4.03: *Application of Standards*; 314 CMR 4.04: *Antidegradation Provisions*; 314 CMR 4.05: *Classes and Criteria*; 314 CMR 4.06: *Classification, Figures, and Tables*; and 314 CMR 4.07: *Severability*.

(3) Purpose. M.G.L. c. 21, §§ 26 through 53 charges the Department with the duty and responsibility to protect the public health and enhance the quality and value of the water resources of the Commonwealth. It directs the Department to take all action necessary or appropriate to secure to the Commonwealth the benefits of the federal Clean Water Act, 33 U.S.C. § 1251 *et seq*. The objective of 33 U.S.C. § 1251 *et seq*. is the restoration and maintenance of "the chemical, physical and biological integrity of the Nation's waters" 33 U.S.C. § 1251(a). To achieve the foregoing requirements the Department has adopted the Massachusetts Surface Water Quality Standards which designate the most sensitive uses for which the various waters of the Commonwealth shall be enhanced, maintained and protected; which prescribe the minimum water quality criteria required to sustain the Designated Uses, as defined in 314 CMR 4.02: *Designated Uses*; and which contain regulations necessary to achieve the Designated Uses and maintain existing water quality including, where appropriate, the prohibition of discharges.

4.02: Definitions

Aquatic Life. A native, naturally diverse, community of aquatic flora and fauna including, but not limited to, wildlife and threatened and endangered species.

Authorization. An approval granted pursuant to 314 CMR 4.04(5) for a discharge to High Quality Waters, Outstanding Resource Waters or Special Resource Waters.

Background Conditions. That water quality which exists or would exist in the absence of pollutants requiring permits and other controllable cultural factors that are subject to regulation under M.G.L. c. 21, §§ 26 through 53.

Best Available Treatment Technology. The technology-based standard of the Clean Water Act defined as Best Available Technology Economically Achievable (BAT) for privately-owned treatment works. BAT effluent limitation guidelines reflect the best performance technologies for a particular pollutant or group of pollutants, or for a category or class of point sources, that are economically achievable.

Massachusetts Surface Water Quality Standards (314 CMR 4.00) – Water Quality Criteria

- Examples of water quality criteria include aquatic life criteria that protect aquatic life from specific pollutants
- Aquatic life criteria typically contain three components:
  - Magnitude (concentration)
  - Duration (averaging period for concentration)
  - Frequency (allowable exceedances of average concentration)
- Usually include:
  - An acute criterion (for short-term, lethal exposures)
  - A chronic criterion (for long-term, sub-lethal exposures)
  - Different criteria for fresh and saltwater

Massachusetts Surface Water Quality Standards (314 CMR 4.00) – Site-Dependent Criteria

- **Site-specific criteria vs. Site-dependent criteria**
- **Site-specific criteria**: listed in Table 28 and apply to a particular surface water or segment
  - Based on a modification of generally applicable criteria (such as class-based criteria) that reflect local conditions
  - Implementation of new or revised site-specific criteria requires Table 28 revisions
- **Site-dependent criteria**: equation- and model-based criteria with inputs and outputs (criteria values) that will be different at each site
  - Implementation of site-dependent criteria does not require Table 28 revisions
  - Example: aluminum

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Massachusetts Surface Water Quality Standards (314 CMR 4.00) – Narrative Toxic Pollutant Standard

- 314 CMR 4.05(5)(e):

All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife.

Aluminum: Toxicity to Aquatic Life

- Produces harmful effects on fish and wildlife
- Accumulates on the gills of fish, and mussels are sensitive
- Acute toxicity can be noticeable (e.g., fish kills)
- Chronic toxicity reduces growth and reproduction

Healthy gills (left), Al-impacted (right) of Atlantic Salmon
Source: The Northeast Fisheries Science Center
www.nefsc.noaa.gov/salmon/factsheets/sss_factsheet.pdf

Dwarf Wedgemussel

Yellow Lampmussel

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EPA's Previous Aquatic Life Ambient Water Quality Criteria for Aluminum in Freshwater (1988)

- **<u>Fixed</u>** aluminum criteria values:
  - Acute = 750 μg/L
  - Chronic = 87 μg/L
- **<u>Criteria reflect scientific knowledge in 1988</u>**
  - Applicable only to a narrow pH range (6.5 to 9.0)
  - Excludes other influential factors (DOC and hardness)
  - Toxicity studies: 1972 – 1986
  - Did not account for freshwater mussel sensitivity to aluminum

EPA's Current Aquatic Life Ambient Water Quality Criteria for Aluminum in Freshwater (2018)

- **Variable** aluminum criteria values that are dependent on water chemistry
- **Criteria reflect the latest scientific knowledge**:
  - Aluminum toxicity to aquatic life increases as its bioavailability increases
  - pH, DOC, and hardness all affect aluminum bioavailability and toxicity
  - Updated toxicity studies: 1972 – 2018
  - Accounts for freshwater mussel sensitivity to aluminum
- Equation-based criteria using Multiple Linear Regression (MLR) models:
  - Uses concurrent pH, DOC, and hardness data to derive criteria

pH (SU) | DOC (mg/L) | Hardness (mg/L) → Aluminum Criteria Calculator → Aluminum Acute Criterion (CMC; µg/L) | Aluminum Chronic Criterion (CCC; µg/L)

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Massachusetts Surface Water Quality Standards (314 CMR 4.00) – Aquatic Life Ambient Water Quality Criteria for Aluminum in Freshwater

- Recent amendments to 314 CMR 4.00 adopt EPA's 2018 aluminum criteria
  - EPA approval is pending
- The amendments allow for **two approaches**:
  1) EPA's 2018 Aquatic Life Ambient Water Quality Criteria for Aluminum (MLR)
     - **Site-dependent aluminum criteria values**: variable aluminum criteria based on available water chemistry data (pH, DOC, and hardness)
  2) Default aluminum criteria values
     - **Default criteria for watersheds and watershed groups:** based on existing statewide water chemistry data (pH, TOC/DOC, and hardness)
- **Site-dependent criteria values supersede watershed default criteria**, regardless of whether they are more stringent or less stringent than the watershed default criteria

Data Collection to Support Implementation of Revised Freshwater Aquatic Life Aluminum Criteria

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USGS ALUMINUM STUDY - REPORTS

The study has 3 products:

- **A Scientific Investigations Report (SIR)**

(Armstrong and others, 2022)

Armstrong, D.S., Savoie, J.G., DeSimone, L.A., Laabs. K.A., and Carey, R.O., 2022, Surface-water-quality data to support implementation of revised freshwater aluminum water-quality criteria in Massachusetts, 2018–19: U.S. Geological Survey Scientific Investigations Report 2021-5144, 85 p., https://doi.org/10.3133/sir20215144

- **And two data releases:**

(Aluminum Data Release: Armstrong, DeSimone, and Savoie, 2022)

Armstrong, D.S., DeSimone, L.A., and Savoie, J.G., 2022, Surface-water-quality data and time-series plots to support implementation of site-dependent aluminum criteria in Massachusetts, 2018–19: U.S. Geological Survey Data Release, https://doi.org/10.5066/P95WCT5T

(TOC-DOC Data Release: DeSimone and Armstrong, 2022)

DeSimone, L.A., and Armstrong, D.S., 2022, Total and dissolved organic carbon for an assessment of aluminum in Massachusetts surface waters: U.S. Geological Survey Data Release, https://doi.org/10.5066/P9420WXU

(Armstrong and others, 2022)

STUDY OBJECTIVES

(1) Collect discrete water-quality data
(38 stations)

(2) Demonstrate the use of the EPA Aluminum Criteria Calculator
(at ambient upstream stations and selected pond stations)

(3) Collect continuous water-quality data
(11 stations - 1 per facility)

(4) Develop a relation between TOC and DOC in Massachusetts streams
(using historic data from sites in Massachusetts)

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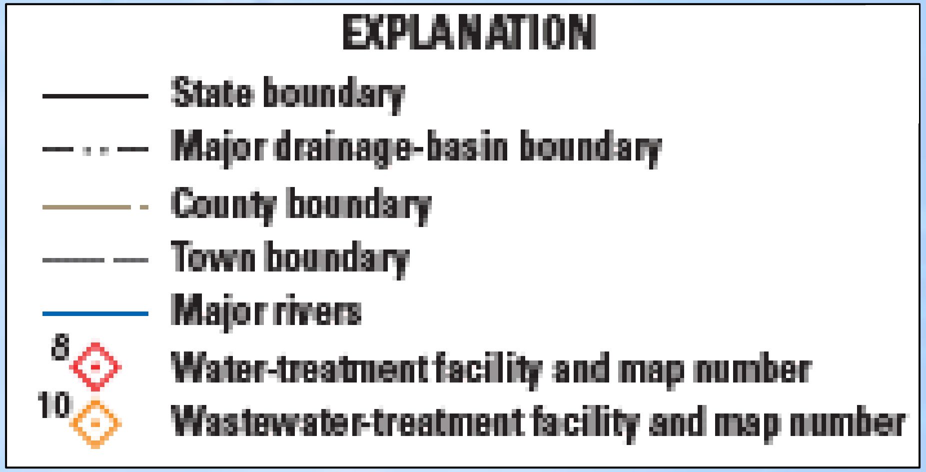
STUDY AREA

- Water-quality data were collected at 38 stations near 4 wastewater-treatment facilities (WWTFs) and 7 water-treatment facilities (WTFs) in central and eastern Massachusetts



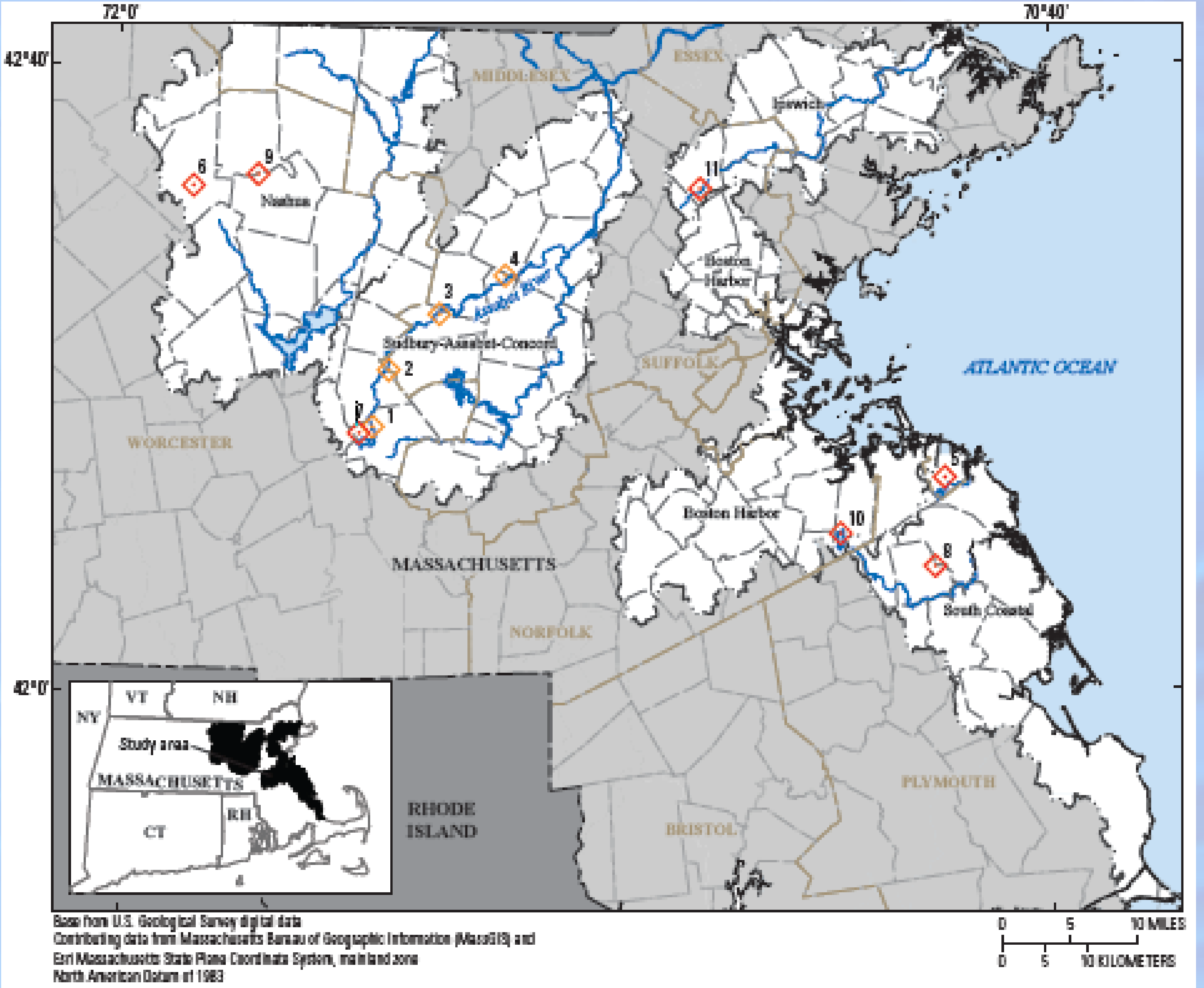


Figure 1. Locations of study-area major drainage basin boundaries and water-treatment and wastewater-treatment facilities in eastern and central Massachusetts. Facility information provided in table 1.

(Armstrong and others, 2022)

PARTICIPATING FACILITIES AND RECEIVING WATER BODIES

Table 1. Information on water-treatment and wastewater-treatment facilities in eastern and central Massachusetts.

[no., number; WTF, water-treatment facility; WWTF, wastewater-treatment facility; NA, not applicable]

Map no. (fig. 1)	Facility	Town	Facility type	Source of WTF water	Receiving-water body	Receiving-water body type
1	Westborough wastewater-treatment facility	Westborough	WWTF	NA	Assabet River	Stream
2	Marlborough wastewater-treatment facility	Marlborough	WWTF	NA	Assabet River	River
3	Hudson wastewater-treatment facility	Hudson	WWTF	NA	Assabet River	River
4	Maynard wastewater-treatment facility	Maynard	WWTF	NA	Assabet River	River
5	Cohasset water-treatment facility	Cohasset	WTF	Surface water	Lily Pond	Pond
6	Fitchburg water-treatment facility	Fitchburg	WTF	Groundwater	Wyman Pond	Pond
7	Westborough water-treatment facility	Westborough	WTF	Groundwater and surface water	Hocomonco Pond	Pond
8	Hanover water-treatment facility	Hanover	WTF	Groundwater	Third Herring Brook	Stream
9	Leominster water-treatment facility	Leominster	WTF	Surface water	Monoosnoc Brook	Stream
10	Weymouth water-treatment facility	Weymouth	WTF	Surface water	Mill River	Stream
11	Wilmington water-treatment facility	Wilmington	WTF	Groundwater	Maple Meadow Brook	Stream

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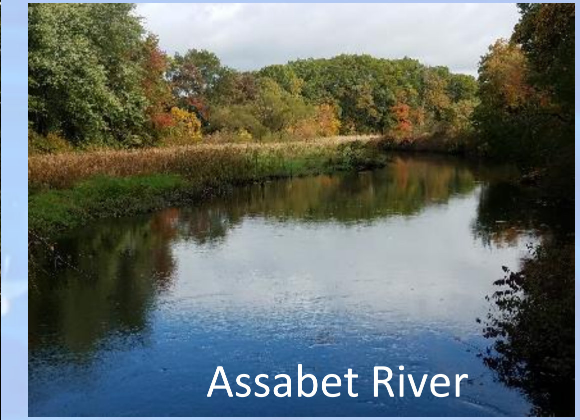
(Armstrong and others, 2022)

RECEIVING WATER BODIES

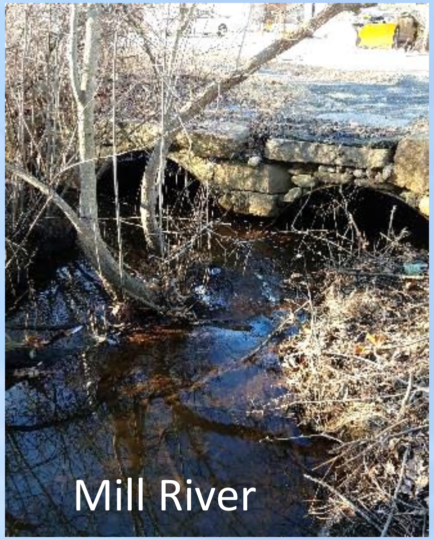
3 Rivers

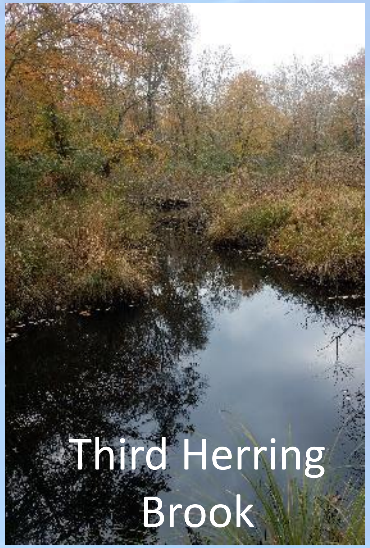
(35 – 117 mi^2)

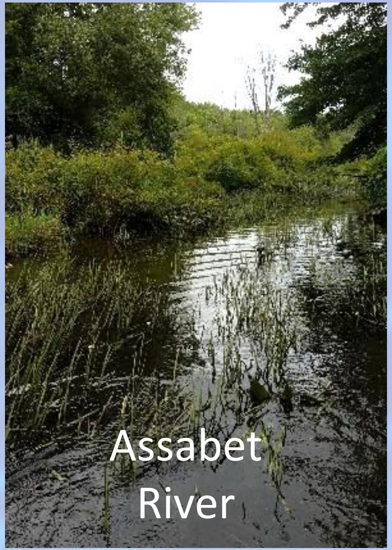


5 Streams

(2.7 – 8.4 mi^2)







3 Ponds

(28 – 117 ac)

Photographs by
D. Armstrong, USGS

STUDY DESIGN–STREAMS AND RIVERS

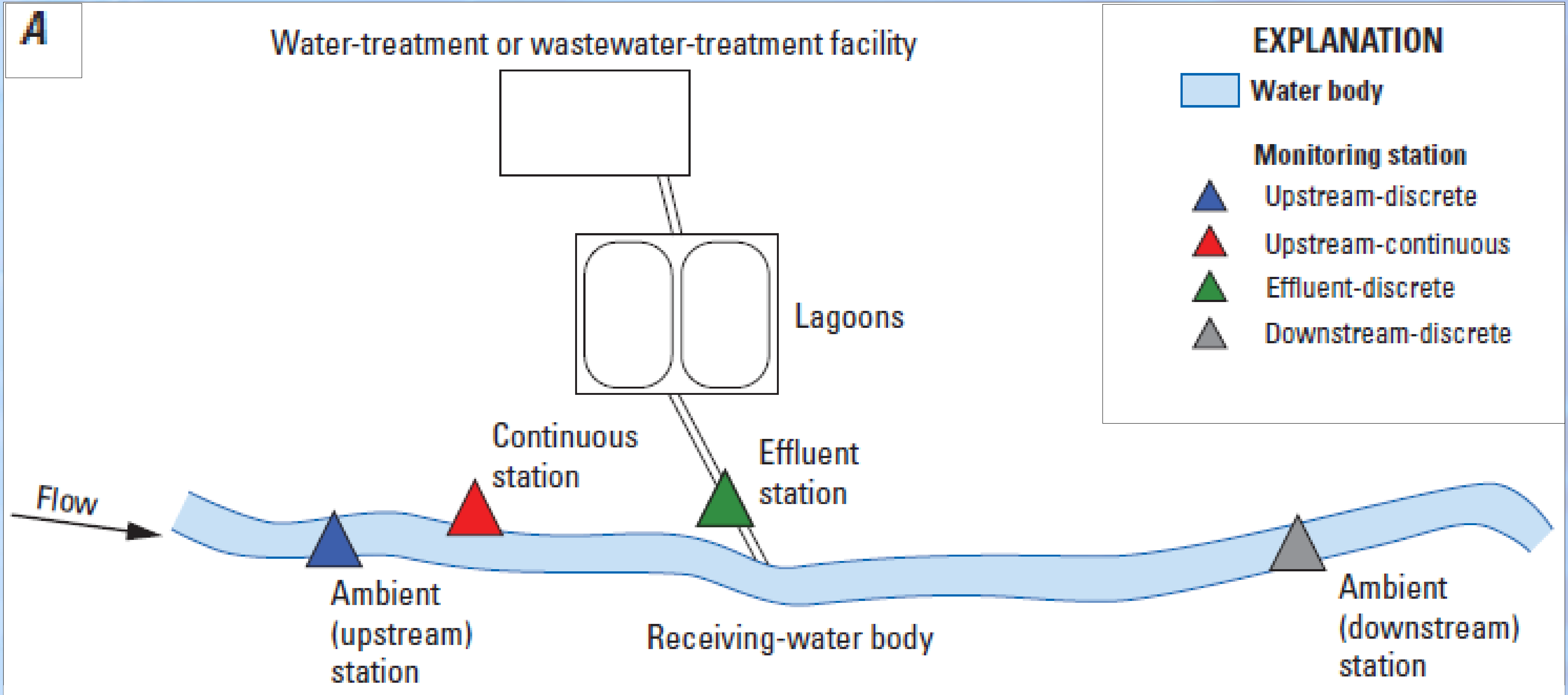


Figure 2. Schematic diagrams showing conceptual sampling designs for selection of water-quality monitoring stations *A*, on a stream or river and *B*, on a pond.

(Armstrong and others, 2022)

STUDY DESIGN–PONDS

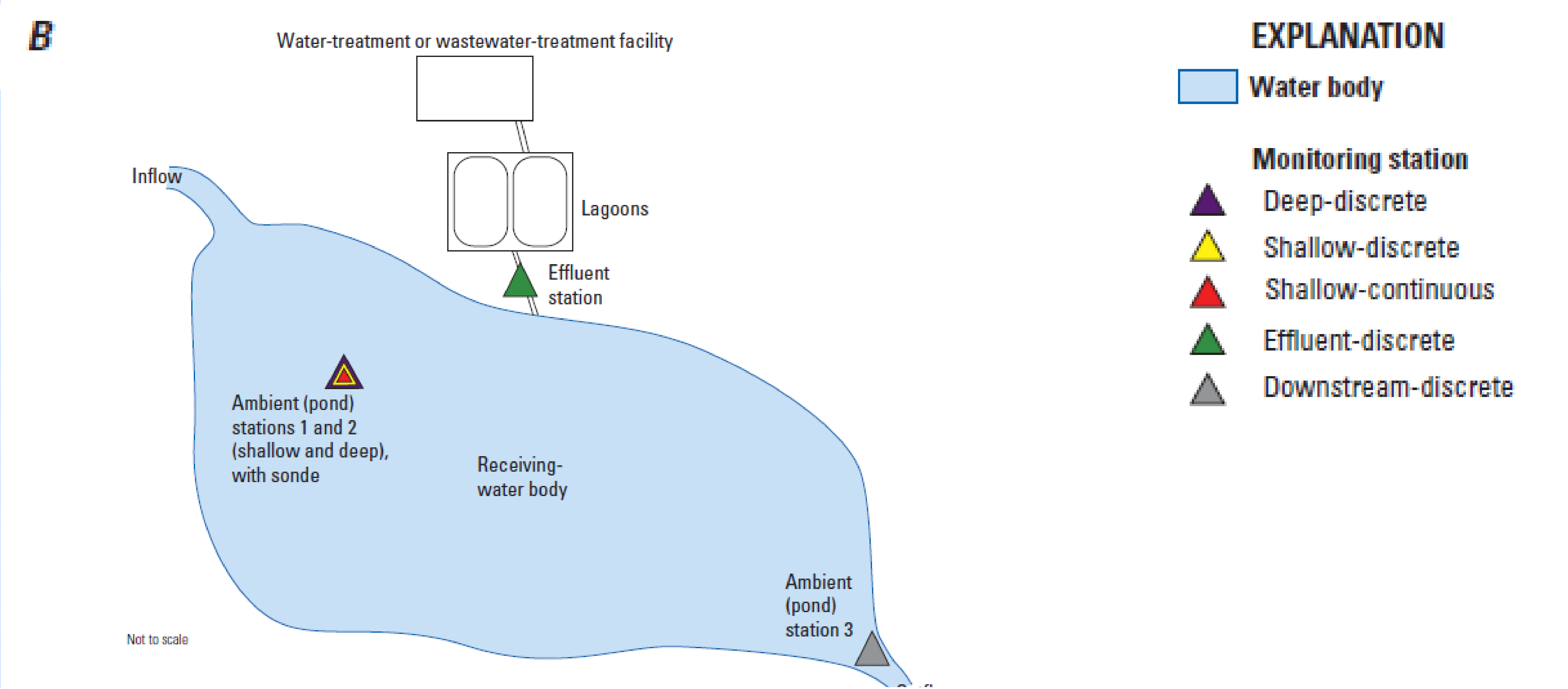


Figure 2. Schematic diagrams showing conceptual sampling designs for selection of water-quality monitoring stations *A*, on a stream or river and *B*, on a pond.

(Armstrong and others, 2022)

STUDY DESIGN–EFFLUENT

- The effluent was sampled at the effluent outfall (where possible)

Photographs by
D. Armstrong, USGS

WATER QUALITY

- Samples analyzed at the USGS National Water Quality Laboratory (NWQL) for 6 constituents.
- Field parameters were collected *in-situ* for each sample

Table 4. Water-quality analytes and minimum reporting levels for discrete samples collected at and near seven water-treatment and four wastewater-treatment facilities in Massachusetts, 2018–19.

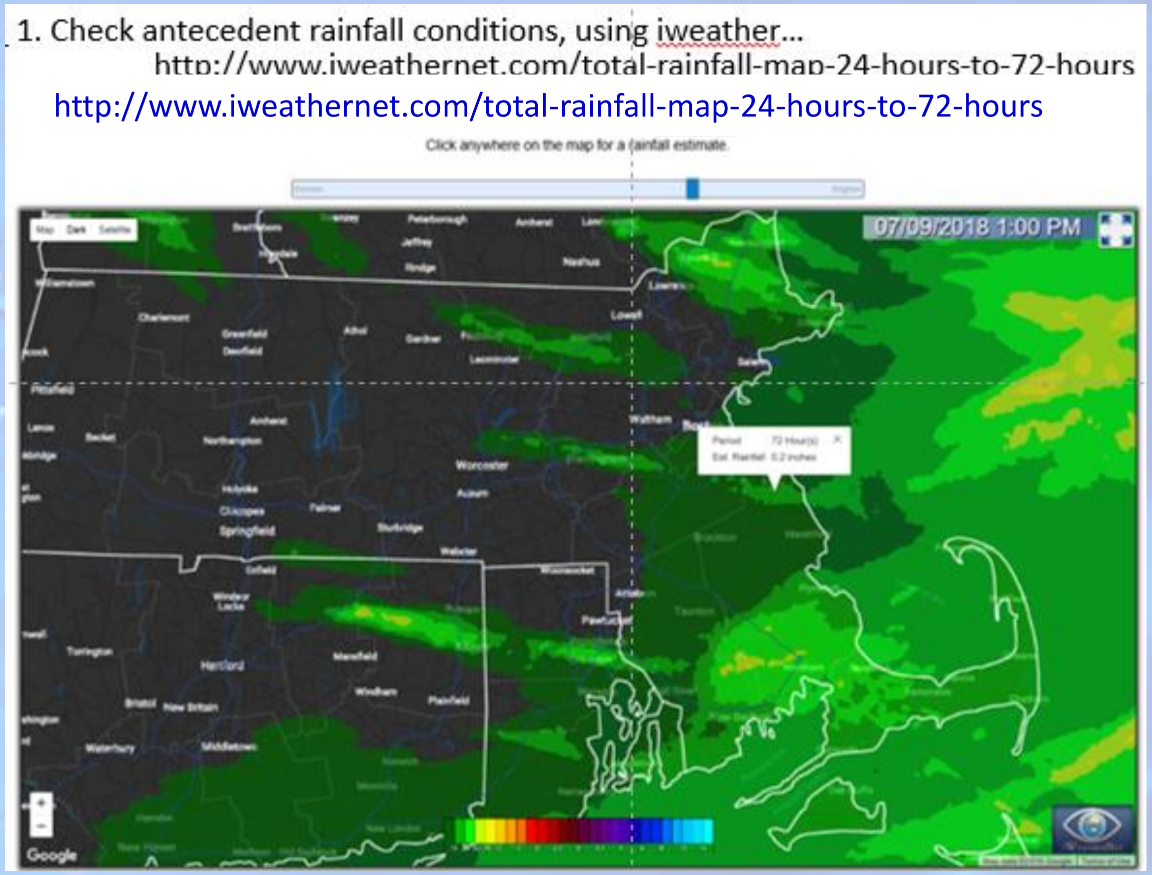
[Hardness is referred to in this report by its U.S. Environmental Protection Agency Substance Registry Services name of "total hardness." USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory; µg/L, microgram per liter; mg/L, milligram per liter; NA, not available; $CaCO_3$, calcium carbonate; NWIS, National Water Information System.]

Analyte	Parameter name	USGS parameter code	Analysis Type	Analysis method	NWQL minimum reporting limit
Aluminum, unfiltered	Aluminum, water, unfiltered, recoverable, µg/L	01105	NWQL	Method I–4471-97 (Garbarino and Struzeski, 1998; Garbarino and others, 2006)	3 µg/L
Total organic carbon	Organic carbon, water, unfiltered, mg/L	00680	NWQL	Method 5310B (Clesceri and others, 1998)	0.7 mg/L
Dissolved organic carbon	Organic carbon, water, filtered, mg/L	00681	NWQL	Method 5310B (Clesceri and others, 1998)	0.23 mg/L
Calcium, filtered	Calcium, water, filtered, mg/L	00915	NWQL	Method I–1472–87 (Fishman, 1993)	0.022 mg/L
Magnesium, filtered	Magnesium, water, filtered, mg/L	00925	NWQL	Method I–1472–87 (Fishman, 1993)	0.01 mg/L
Total hardness	Hardness, water, mg/L as $CaCO_3$ (calculated)	00900	Algorithm	Computation by NWIS algorithm	NA
Specific conductance	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	00095	Field	U.S. Geological Survey (2018)	NA
pH	pH, water, unfiltered, field, standard units	00400	Field	U.S. Geological Survey (2018)	NA
Water temperature, in degrees Celsius	Temperature, water, degrees Celsius	00010	Field	U.S. Geological Survey (2018)	NA

(Armstrong and others, 2022)

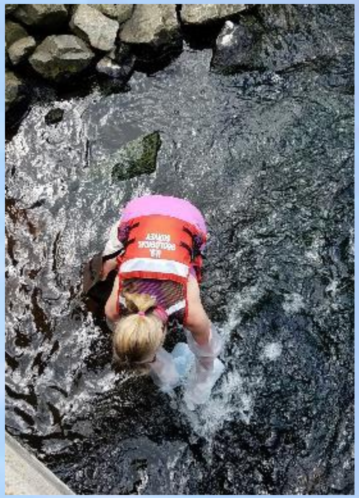
QUALITY ASSURANCE

- Monthly discrete samples and field parameters
- Monthly maintenance of continuous sensors
- Monitor antecedent rainfall conditions to minimize effects of stormwater runoff. Dry-weather conditions defined as antecedent dry periods that had less than 0.1 inch (in.) of rain during a 1- to 3-day period before sampling:
    - 1 day for ponds
    - 2 days for streams
    - 3 days for rivers.



- **QA/QC**

- Equipment blanks on bottles at start of study (4)
- Replicate samples (27) *6 % of environmental samples*
- Equipment blanks *(48) 11 % of environmental samples including Field blanks (15), Equipment blanks (33)*
- Laboratory spike samples (4)



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CONTINUOUS WATER QUALITY

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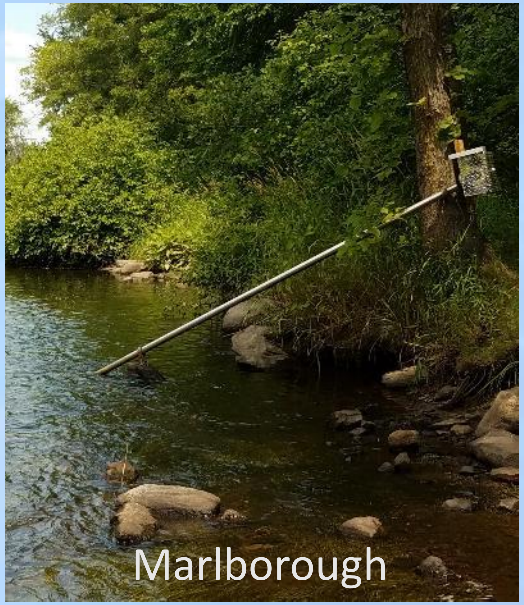
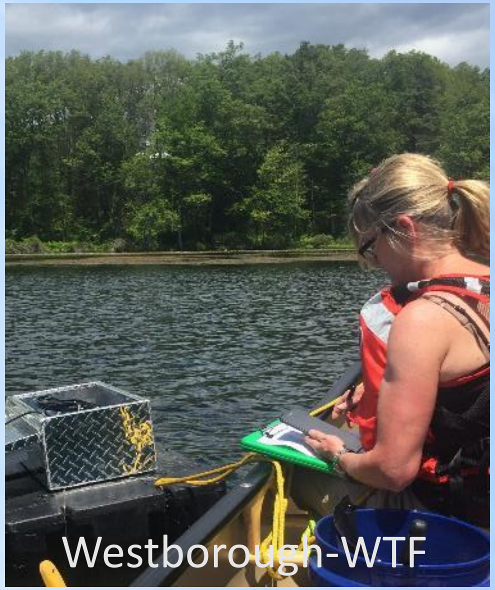
- Continuous (15 min) water quality data (pH and temperature) were collected at one station for each facility





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STATION SELECTION – Many factors influence selection of station locations

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Downstream dams

Upstream water diversions

Tributaries

Stormwater,
Abandoned landfill

flood-control dams

ground water withdrawals

Remote access (wetlands)

Superfund site

Images from Google Earth

STATION SELECTION

The report includes a table listing some factors to consider during selection of sampling locations

- Accessibility and logistics
- Safety considerations
- Receiving water bodies
- Channel conditions
- Water and land use
- Selection of stations
  - Upstream
  - Downstream
  - Pond
  - Effluent

Table 3. Factors to consider during selection of reaches and monitoring stations for collection of water-quality data to support aluminum criteria development in Massachusetts.

[MassDEP, Massachusetts Department of Environmental Protection; EPA, U.S. Environmental Protection Agency; NPDES, National Pollutant Discharge Elimination System]

Factor	Consideration
	Factors to consider for selection of reaches to sample
Accessibility and logistics	Parking—Is safe parking available near the water body?
	What is the distance and time from vehicle to stream?
	Will site accessibility be different in winter or wet weather?
	Access—Is access across wetlands or other sensitive habitats?
	Does access have obstructions such as fences, downed trees, or thick brush?
	Boat access—Is there a boat launch? Are there restrictions on the use of boat motors?
	Property ownership—Is the access through private property?
	Can landowner permission be obtained? Are keys needed to enter property?
Safety considerations	Traffic safety—Is off-road parking available? Is the site safe from high-speed traffic when unloading vehicles or crossing roads? Are traffic cones or police details needed? Is there a sidewalk on the bridge?
	Access safety—Does the access have steep banks, loose gravel, slippery rocks, or excessive poison ivy, green briar, or multiflora rose?
	Water quality—Is the water safe for contact?
	Winter safety—Are the parking areas and boat launches useable in winter? Can the site be sampled safely through ice?
	Wading safety—Does the channel have fast current, deep water, slippery rocks, or soft bottom?
	Boating safety—Are there high velocity currents, shallow water, rocks, or downed trees? Equipment safety—Is equipment safe from theft or vandalism?
	Personal safety—Is the site remote?
Receiving-water bodies	Confirm the identity of receiving-water body with MassDEP and with EPA permit writers.
	Mixing zone—What is the length or area needed for mixing of the effluent with receiving water?
	Is the length of mixing zone restricted by roads, tributaries, reservoirs, or other discharges?
	Is flow in the pond unidirectional toward the outlet?
Channel conditions	Streambed and stream banks—Do the streambed and stream banks support walking? Bank—Are there stone walls or riprap that make channel access difficult? Water depth—Is the channel wadable depth across the whole channel? Can the sample be collected at the same or nearby cross-section locations during all flow conditions?
	Is there groundwater discharge near the monitoring station?

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(Armstrong and others, 2022)

STATION SELECTION – worked closely with MassDEP to identify sampling locations

Example: Wilmington

- Challenge: Upstream tributaries and effluent join in large wetland; Solution: two upstream stations
- Challenge: Effluent combines with stormwater; Solution: Sample effluent at lagoon weir

Wetland

Upstream station 1: Maple Meadow Brook

Effluent discharge

Downstream station: Maple Meadow Brook

Upstream station 2: Sawmill Brook

Lagoon weir

Photographs by D. Armstrong, USGS

STATION SELECTION – Need to consider winter conditions

- Sample through ice, or if ice is not safe, at alternate location known to have similar conditions





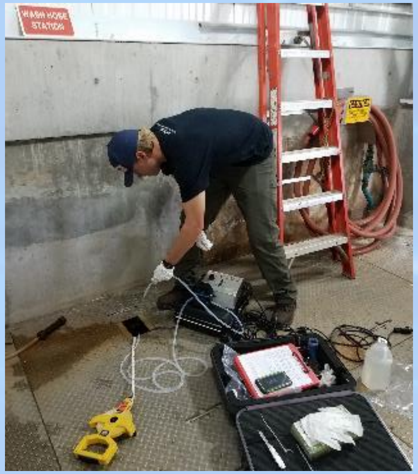



Photographs by D. Armstrong, USGS, and D. Davis, and D. Tympanick, MassDEP

STATION SELECTION–EFFLUENT

Some stations sampled at locations other than the outfall

- If effluent discharged below the water surface of receiving water



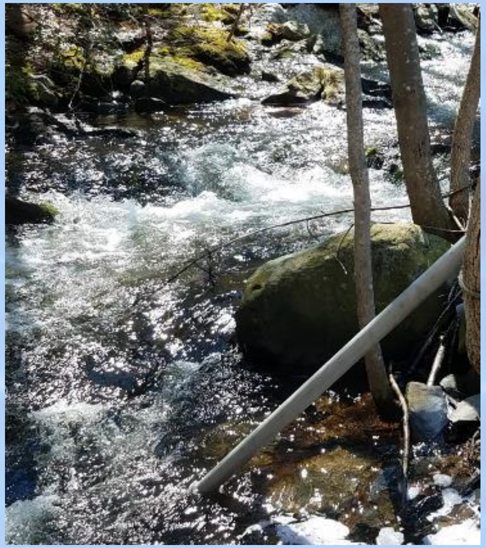
- If effluent combined with storm-water discharge before outfall

- Sampling locations at some stations varied depending on backwash conditions at time of sampling

Photographs by D. Armstrong, USGS

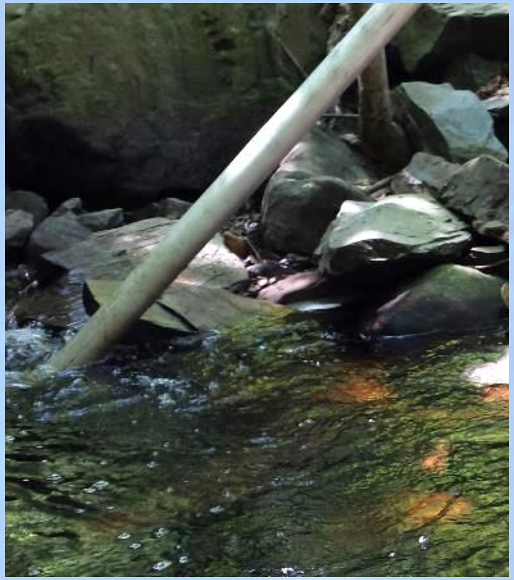
STATION SELECTION–CONTINUOUS

- Equipment needs to function over a range of flows and water quality conditions.



Flood

Low flows - changing water quality



Drought – dry stream

Photographs by D. Armstrong USGS

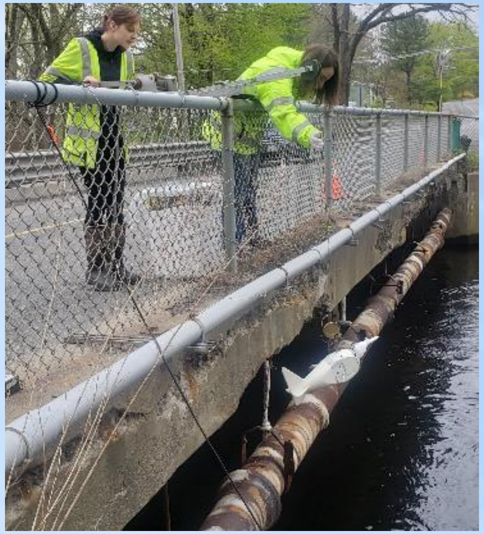
METHODS–DISCRETE SAMPLING

- Sampling methods varied by water-body type and with flow conditions

DH-81
in streams and rivers, while wading

Peristaltic pump –
In ponds, and rivers, from canoe, and for effluent

DH-95
in rivers, from bridges



Grab sample
in streams, while wading, and for effluent

Photographs by D. Armstrong, USGS

METHODS–DISCRETE SAMPLING

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- Clean sampling procedures used throughout all steps of the sampling and analysis using methods and procedures described in the USGS National Field Manual (NFM)

https://www.usgs.gov/mission-areas/water-resources/science/national-field-manual-collection-water-quality-data-nfm

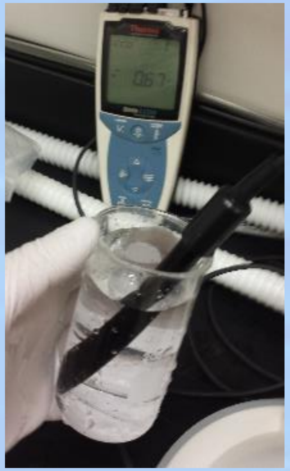
(1) equipment constructed of noncontaminating materials and that has been cleaned rigorously

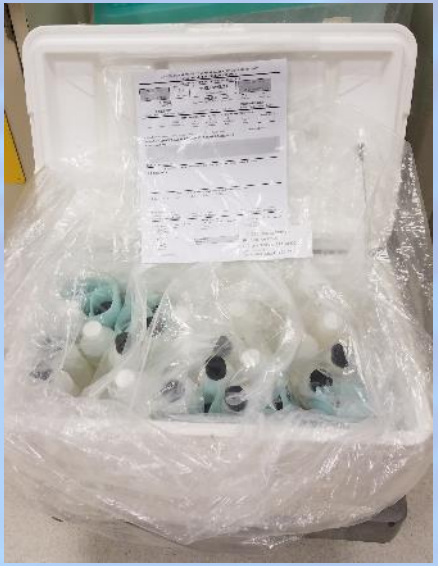
(2) handling equipment in a manner that minimizes the chance of altering sample composition;

(3) handling samples in a manner that prevents contamination;

(4) routinely collecting quality-control (QC) samples.

(5) Clean sampling procedures
- separate field duties to dedicate one individual to tasks related to direct contact with the sample





Photographs by D. Armstrong, USGS

METHODS – FIELD PARAMETERS (pH, specific conductance, temperature)

- Field parameters were collected *in situ* at the same locations where samples were collected

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USGS ALUMINUM DATA RELEASE

- A total of 420 discrete water-quality samples were collected, including 306 ambient samples and 114 effluent samples
- The data are all available in the Aluminum Data Release, https://doi.org/10.5066/P95WCT5T, published on Sciencebase.gov
- Data are also available on the USGS National Water Information System (NWIS) database https://waterdata.usgs.gov/nwis

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Surface-Water-Quality Data and Time-Series Plots to Support Implementation of Site-Dependent Aluminum Criteria in Massachusetts, 2018–19

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Dates

Publication Date : 2022
Start Date : 2018
End Date : 2019

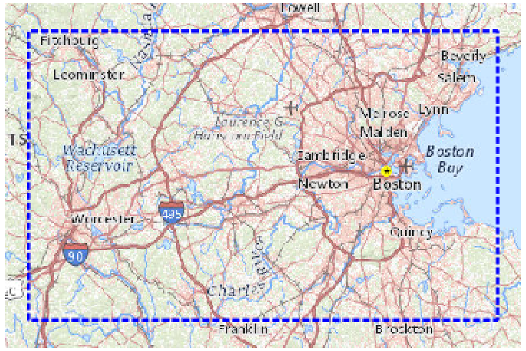
Citation

Armstrong, D.S., DeSimone, L.A., and Savoie, J.G., 2021, Surface-water-quality data and time-series plots to support implementation of site-dependent aluminum criteria in Massachusetts, 2018–19: U.S. Geological Survey data release, https://doi.org/10.5066/P95WCT5T.

Summary

This data release includes water-quality data collected at 38 sites in central and eastern Massachusetts from April 2018 through May 2019 by the U.S. Geological Survey to support the implementation of site-dependent aluminum criteria for Massachusetts waters. Samples of effluent and receiving surface waters were collected monthly at four wastewater-treatment facilities (WWTFs) and seven water-treatment facilities (WTFs) (see SWQ_data_and_instantaneous_CMC_CCC_values.txt). The measured properties and constituents include pH, hardness, and filtered (dissolved) organic carbon, which are required inputs to the U.S. Environmental Protection Agency's Aluminum Criteria Calculator version 2.0 (U.S. Environmental Protection Agency, 2018). Outputs from the Aluminum Criteria Calculator are also provided in that file; these outputs consist of acute (Criterion Maximum

Map »



Communities

- USGS Data Release Products

Associated Items

Associate an Item

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Aluminum Data Release: Armstrong, DeSimone, and Savoie, 2022

USGS ALUMINUM DATA RELEASE

The data release includes

- Plots showing station locations
- Discrete water-quality data
- Time-series plots of water-quality data (pH, DOC, Hardness, and aluminum) for each station
- Instantaneous monthly CMC and CCC values
- Plots of continuous and discrete pH data
- QAQC data (replicates, blanks)
- Metadata

EXAMPLE - HUDSON

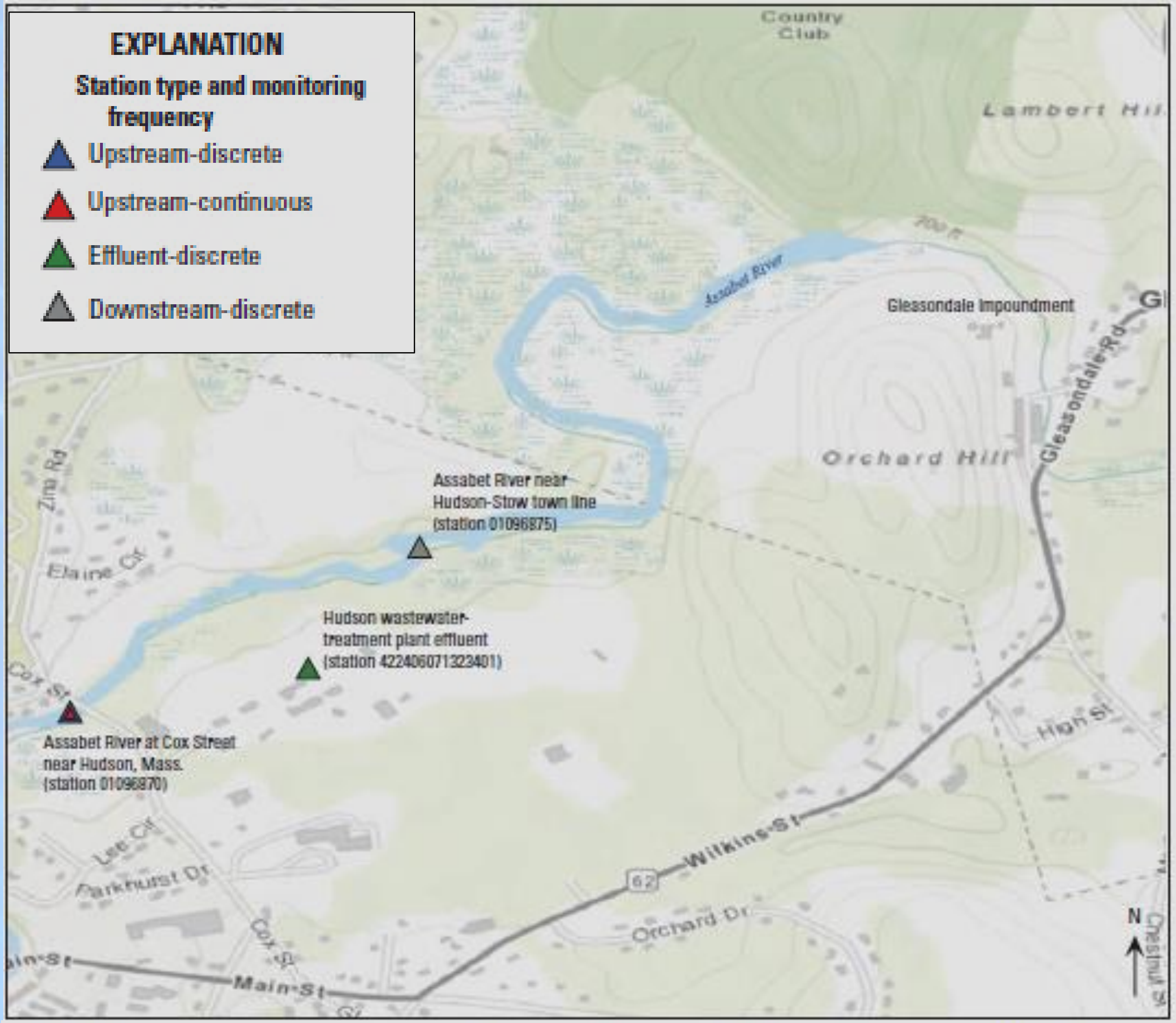


Figure 5. Locations of water-quality monitoring stations near the Hudson wastewater-treatment facility, Hudson, Massachusetts. Names of facilities and receiving water bodies are provided in table 1. Station monitoring frequency, station type, and identification of stations used in the Environmental Protection Agency Aluminum Criteria Calculator are provided in table 2.

Aluminum Data Release: Armstrong, DeSimone, and Savoie, 2022

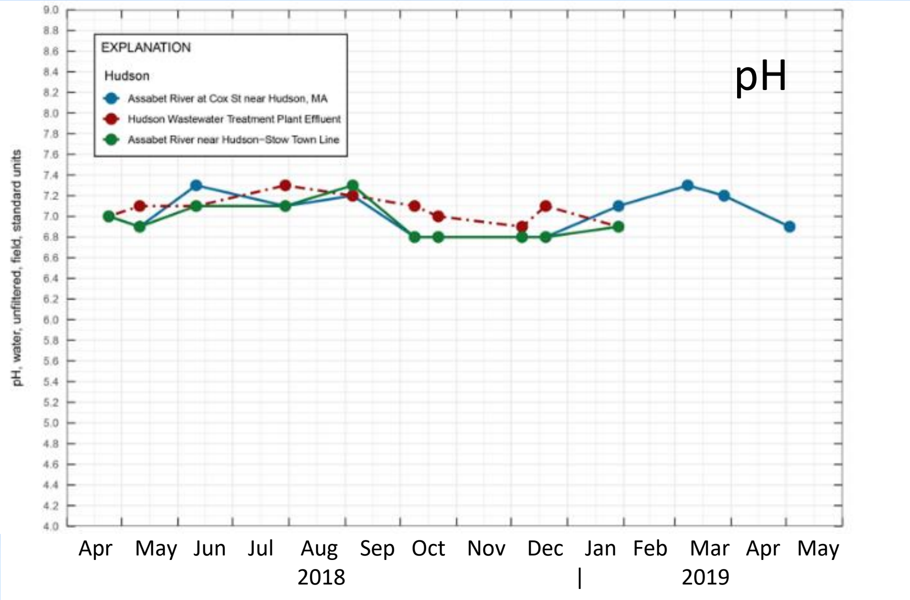
USGS ALUMINUM DATA RELEASE

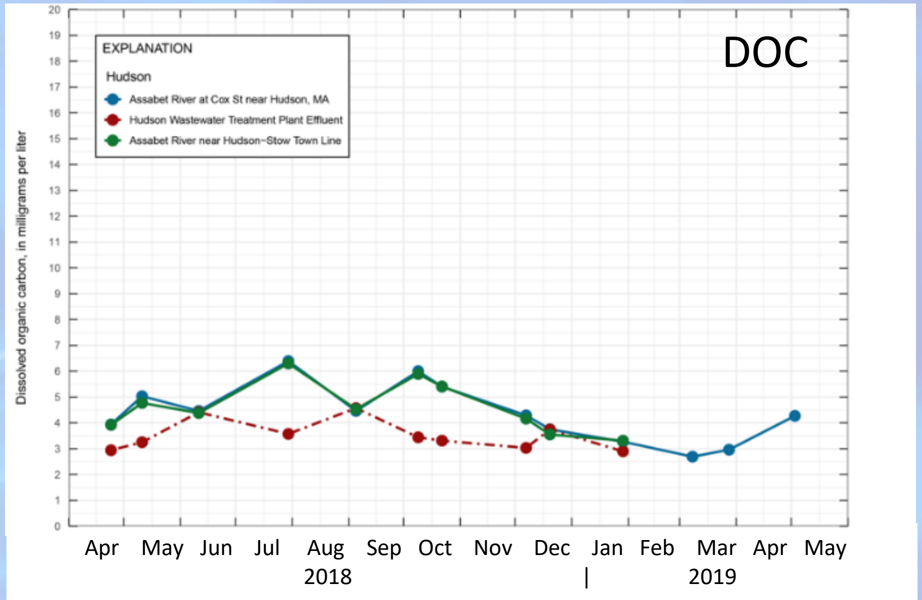
Example - Hudson

EXPLANATION

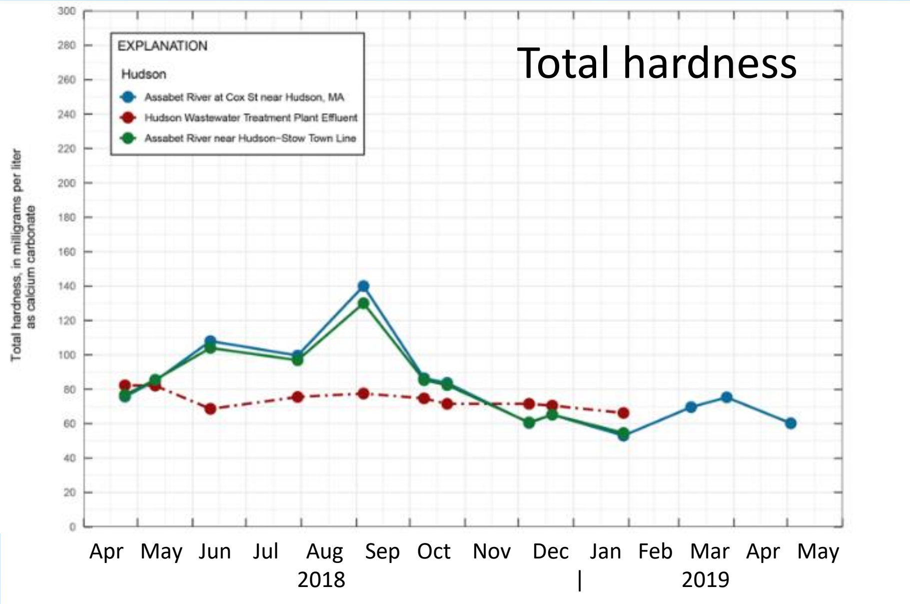
Hudson

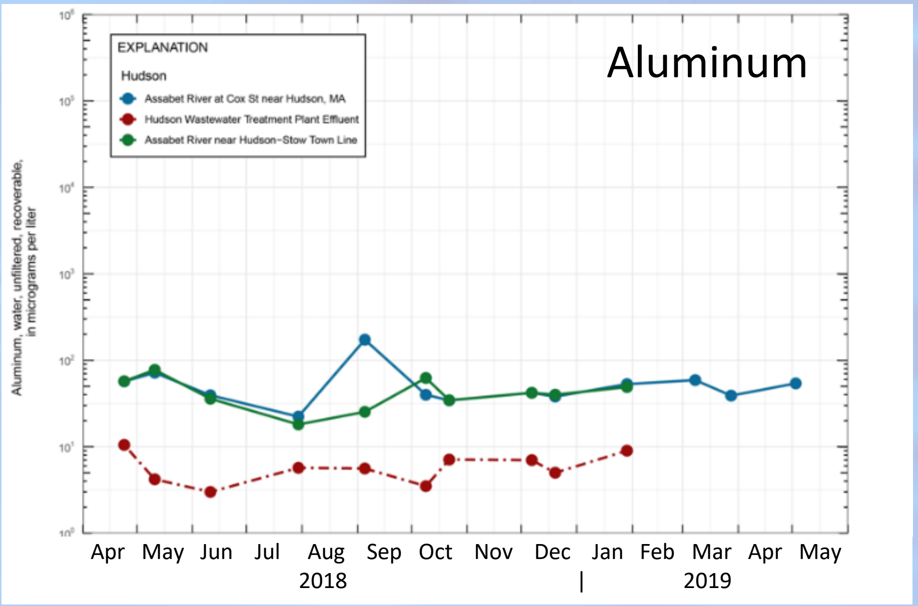
- Assabet River at Cox St near Hudson, MA
- Hudson Wastewater Treatment Plant Effluent
- Assabet River near Hudson–Stow Town Line





Total hardness





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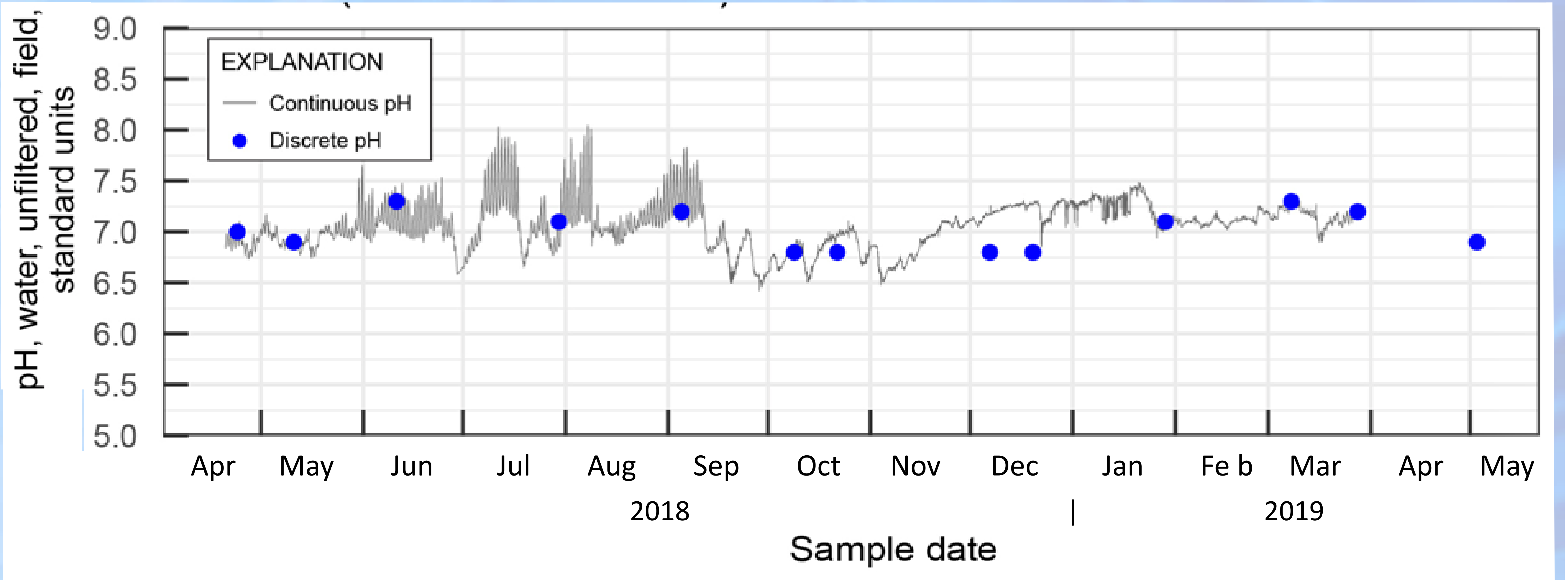
Aluminum Data Release: Armstrong, DeSimone, and Savoie, 2022

USGS ALUMINUM DATA RELEASE

- Time series of continuous pH readings from the Hudson station (01096870)



RESULTS–DISCRETE PH

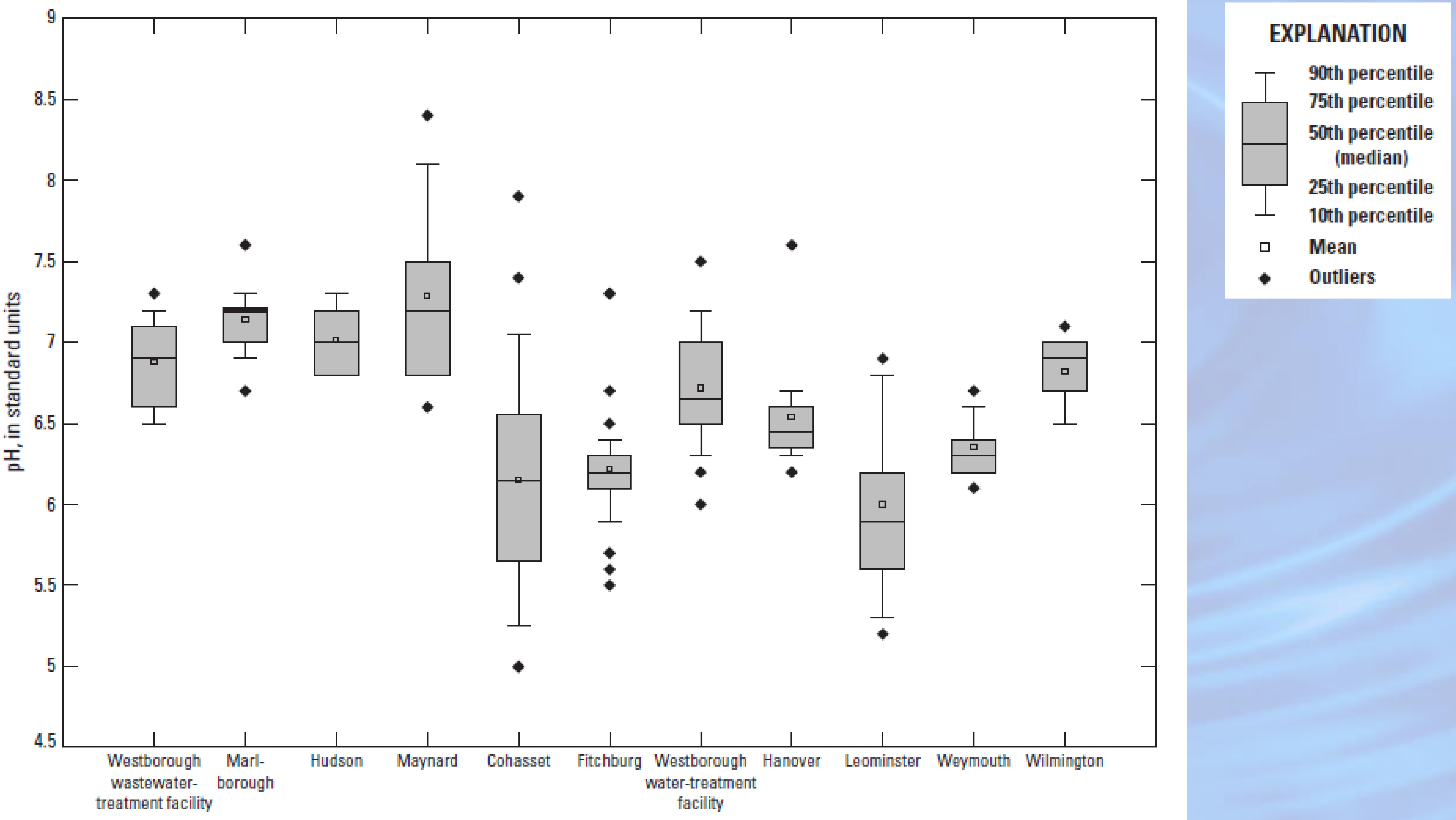


Figure 19. Distribution of pH measured as a field parameter during monthly sampling at selected ambient stations water-treatment facilities in eastern and central Massachusetts, 2018–19.

(Armstrong and others, 2022)

RESULTS–DISCRETE DOC

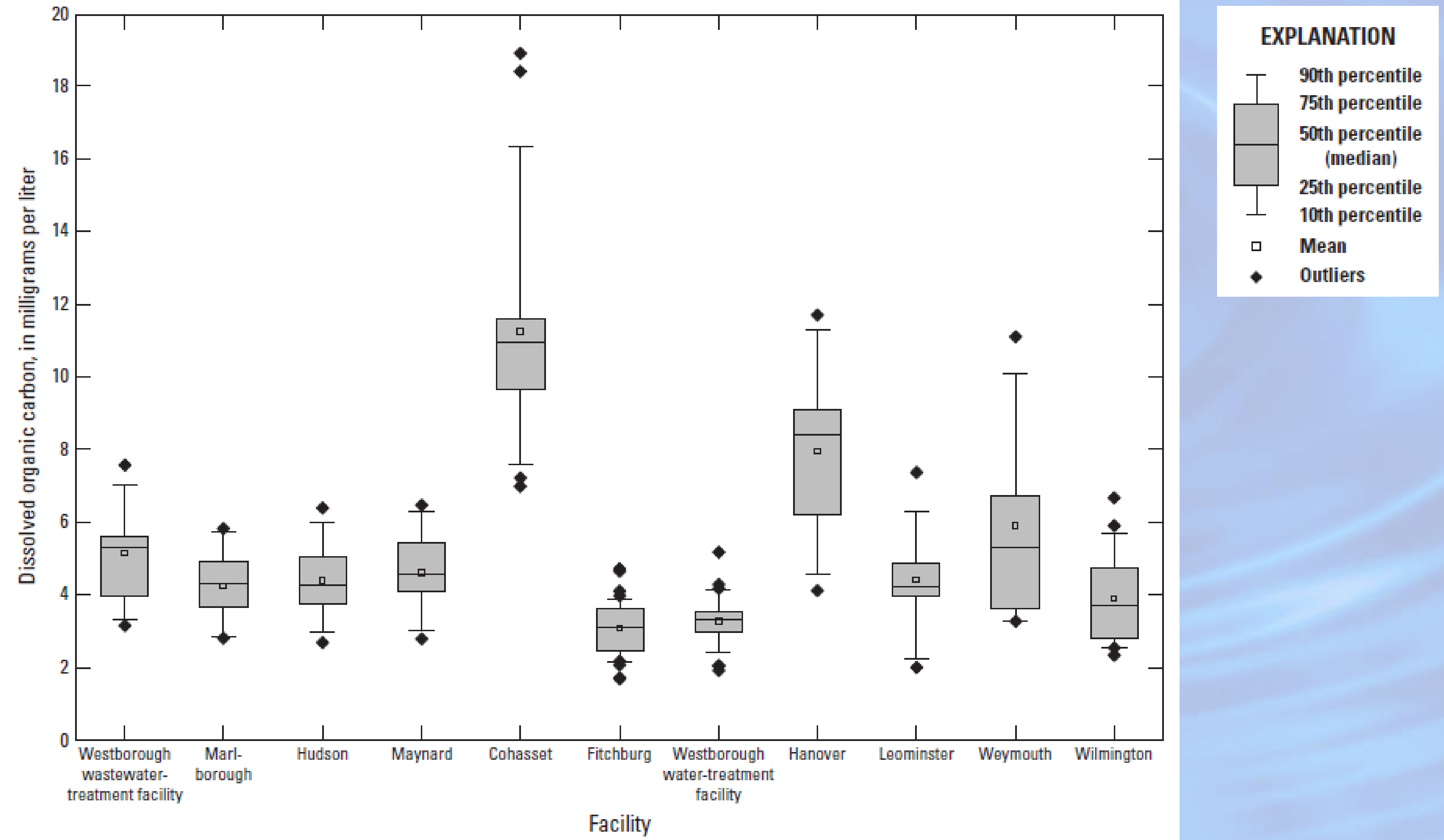


Figure 20. Distribution of concentrations of dissolved organic carbon measured in samples collected monthly at selected ambient stations near 11 water-treatment facilities in eastern and central Massachusetts, 2018–19.

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(Armstrong and others, 2022)

RESULTS–DISCRETE TOTAL HARDNESS

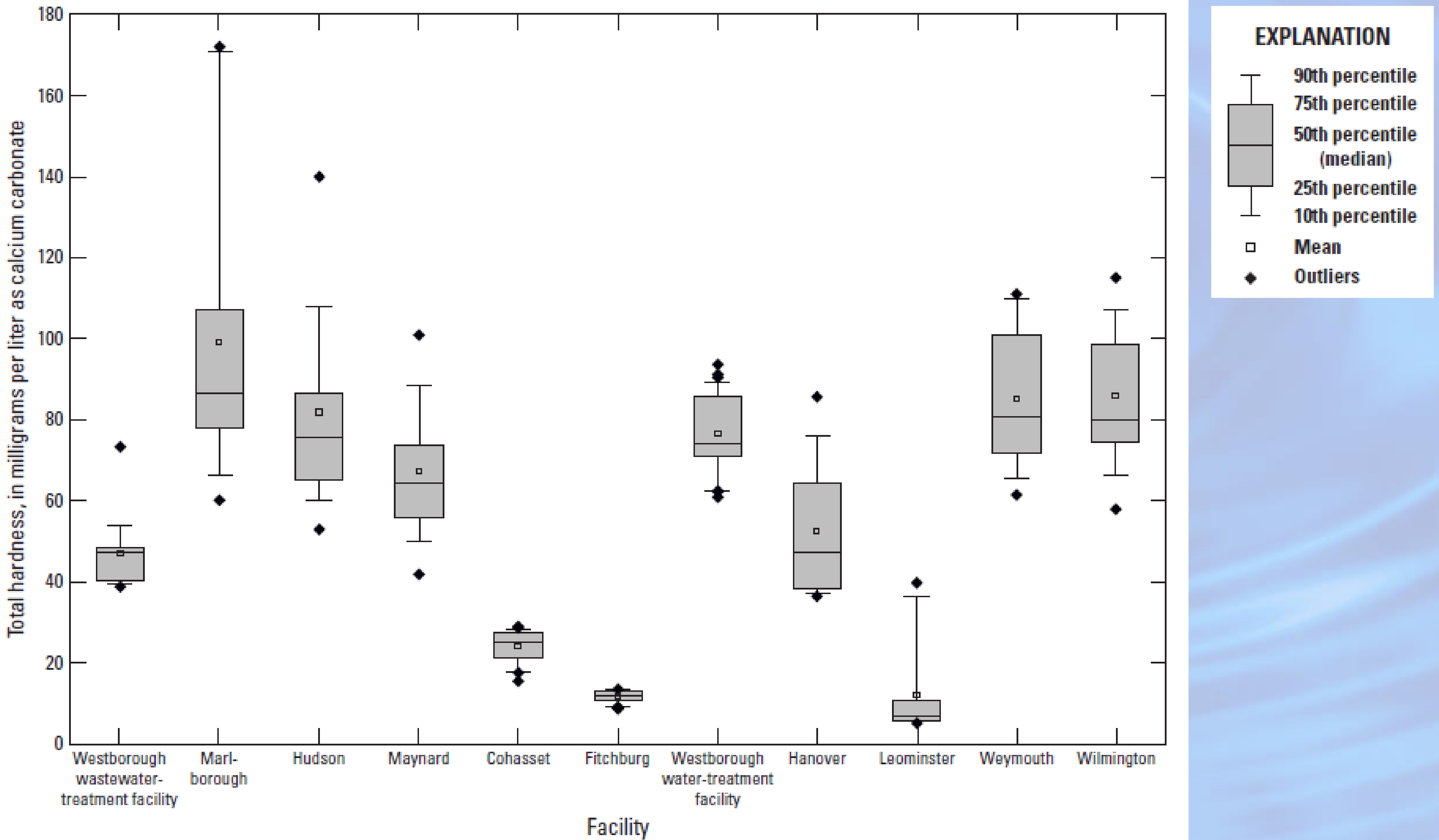

Figure 21. Distribution of concentrations of total hardness measured in samples collected monthly at selected ambient stations near 11 water-treatment facilities in eastern and central Massachusetts, 2018–19.

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(Armstrong and others, 2022)

RESULTS–DISCRETE ALUMINUM

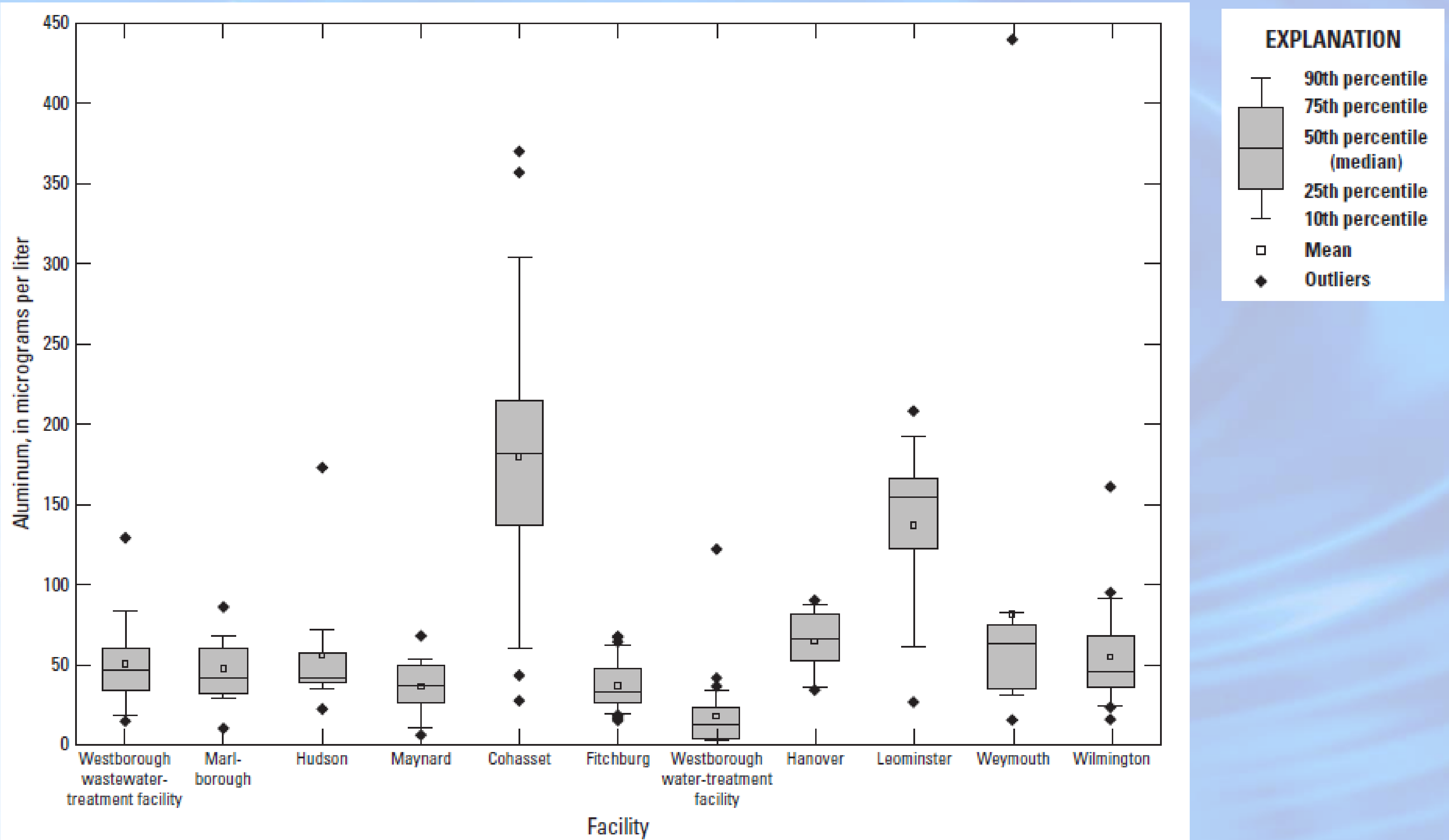

Figure 22. Distribution of concentrations of aluminum measured in samples collected monthly at ambient stations near four wastewater-treatment facilities and seven water-treatment facilities in eastern and central Massachusetts, 2018–19.

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(Armstrong and others, 2022)

RESULTS–EFFLUENT DISCRETE pH, DOC

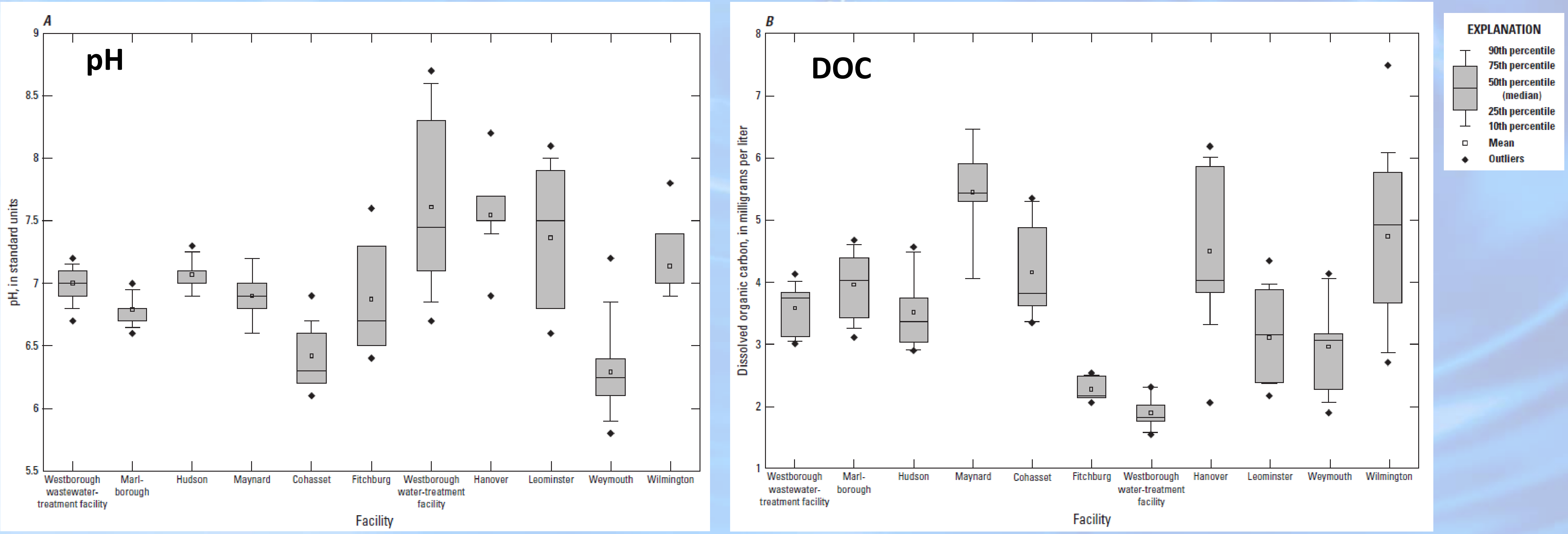

Figure 23. Distribution of pH measured as a field parameter and concentrations of dissolved organic carbon, total hardness, and total aluminum measured in samples collected monthly in effluent from four wastewater-treatment facilities and seven water-treatment facilities in eastern and central Massachusetts, 2018–19. *A*, pH; *B*, dissolved organic carbon; *C*, total hardness, and *D*, total aluminum.

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(Armstrong and others, 2022)

RESULTS–EFFLUENT DISCRETE TOTAL HARDNESS, AND ALUMINUM

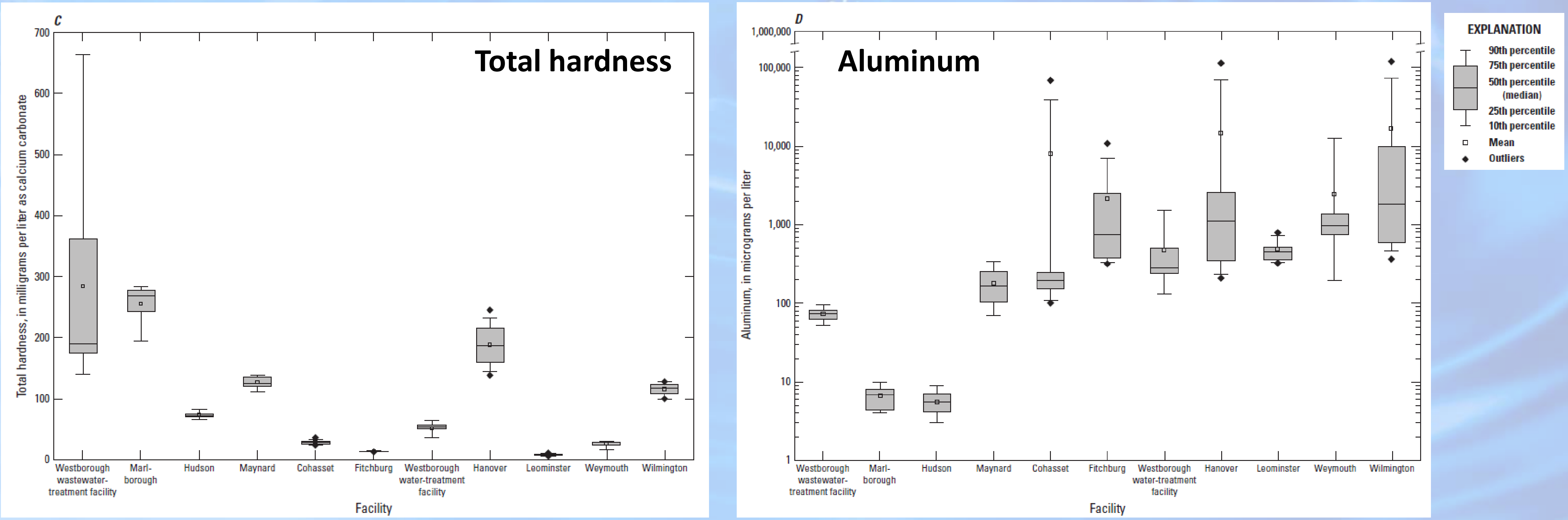

Figure 23. Distribution of pH measured as a field parameter and concentrations of dissolved organic carbon, total hardness, and total aluminum measured in samples collected monthly in effluent from four wastewater-treatment facilities and seven water-treatment facilities in eastern and central Massachusetts, 2018–19. *A*, pH; *B*, dissolved organic carbon; *C*, total hardness, and *D*, total aluminum.

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(Armstrong and others, 2022)

RESULTS–DISCRETE Aluminum concentrations for effluent stations

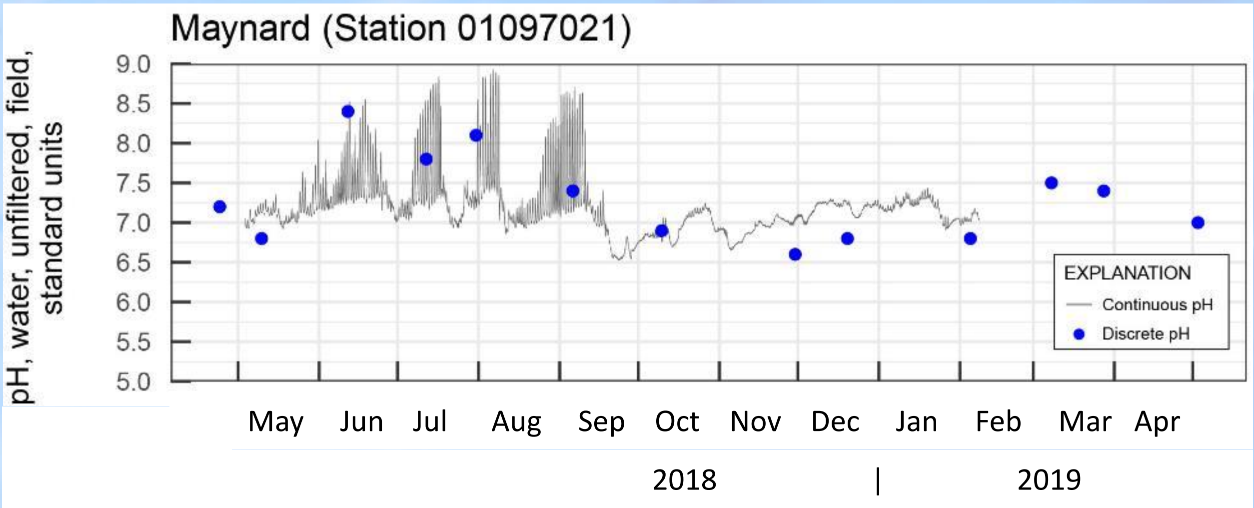
- Some effluent samples had high concentrations of aluminum (~ 10,000 – 100,000 µg/L)
- Most high aluminum concentrations were related to limited capacity of lagoons, clean-out of lagoons, collection of effluent samples leaking from lagoon weir as the lagoons refilled, or winter conditions.

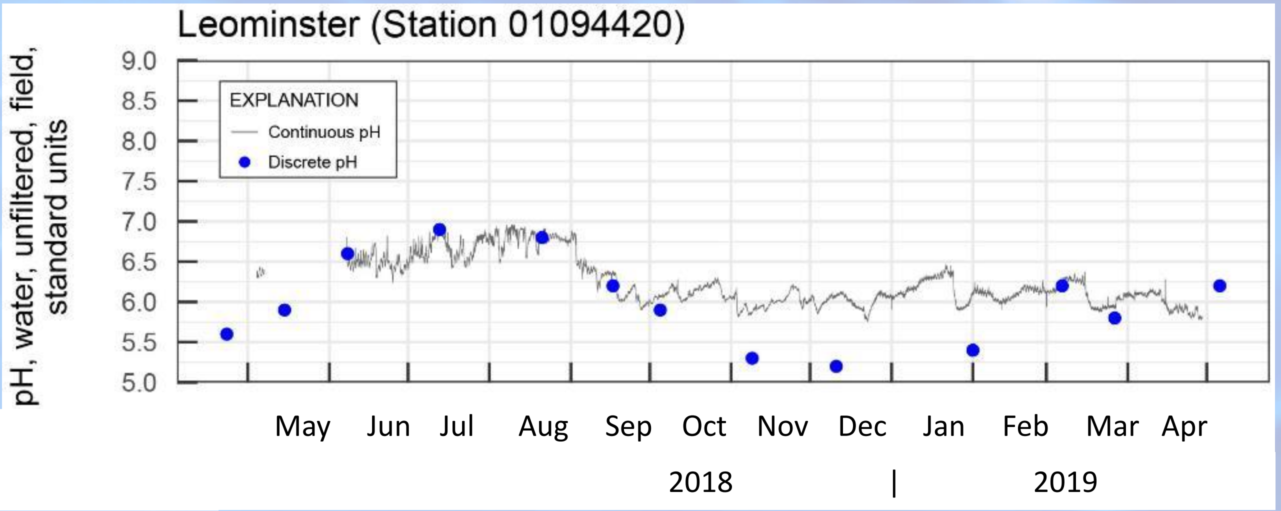


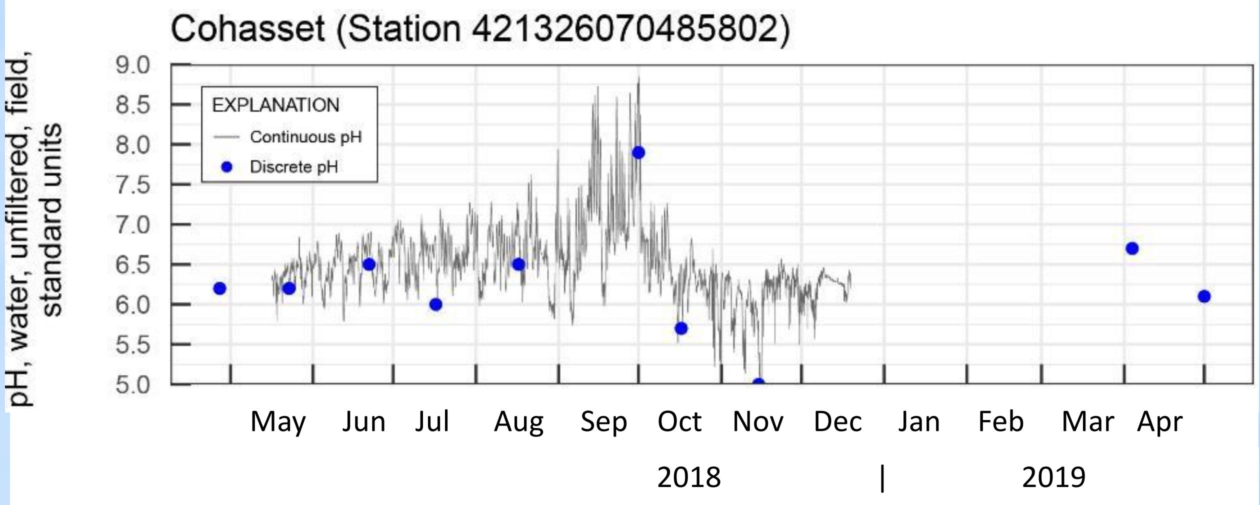

Photographs by D. Armstrong, USGS

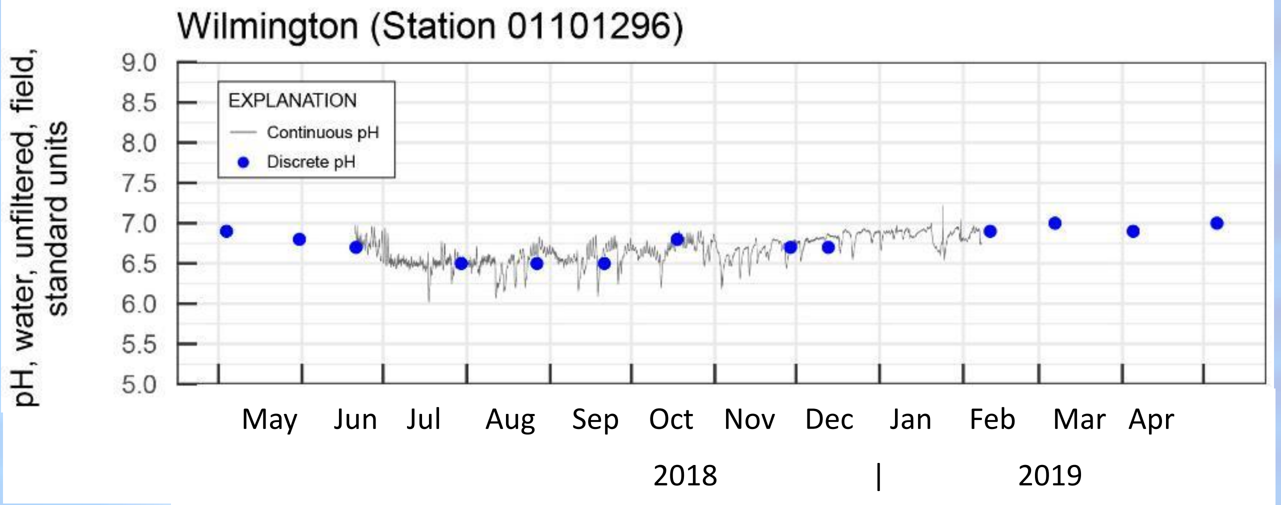
RESULTS–CONTINUOUS pH

- Diel variations in pH are caused by the effects of photosynthesis and respiration on carbon-dioxide concentrations in surface water.
- The greatest diel range in pH were measured in some of the pond and Assabet River stations with open canopies and large amounts of algae and aquatic vegetation.









Aluminum Data Release: Armstrong, DeSimone, and Savoie, 2022

RESULTS
CONTINUOUS pH and DISCRETE pH

Some differences were observed, possibly because discrete and continuous pH were measured at slightly different locations

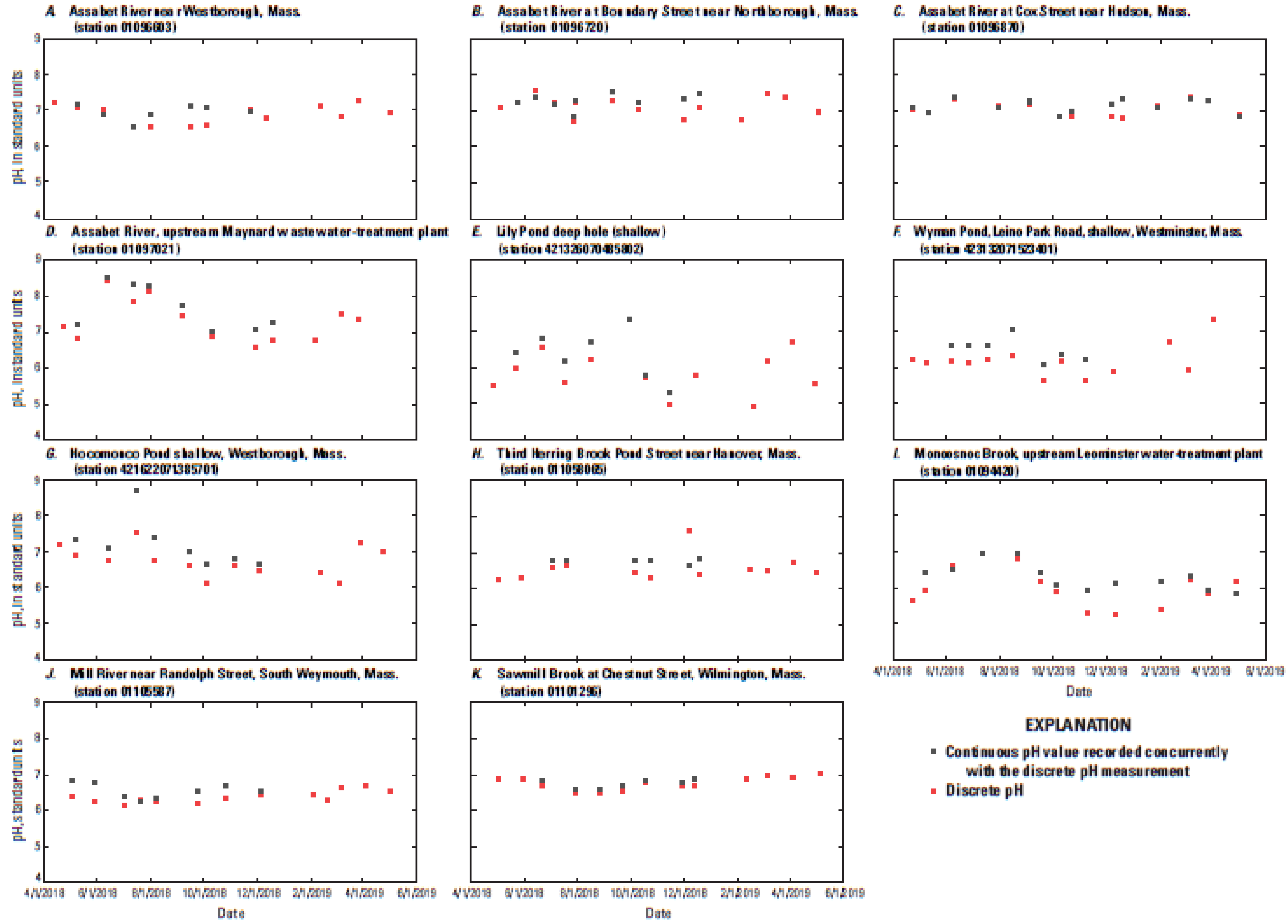


Figure 25. Comparison of pH values collected as continuous (15-minute interval) and discrete water-quality field parameters at selected stations near four wastewater-treatment facilities and seven water-treatment facilities in eastern and central Massachusetts, 2018–19. *A*, Fitchburg; *B*, Cohasset; *C*, Hanover; *D*, Leominster; *E*, Weymouth; *F*, Wilmington; *G*, Westborough Water-Treatment Facility; *H*, Westborough Waste-Water Treatment Facility; *I*, Marlborough; *J*, Hudson; *K*, Maynard.

(Armstrong and others, 2022)

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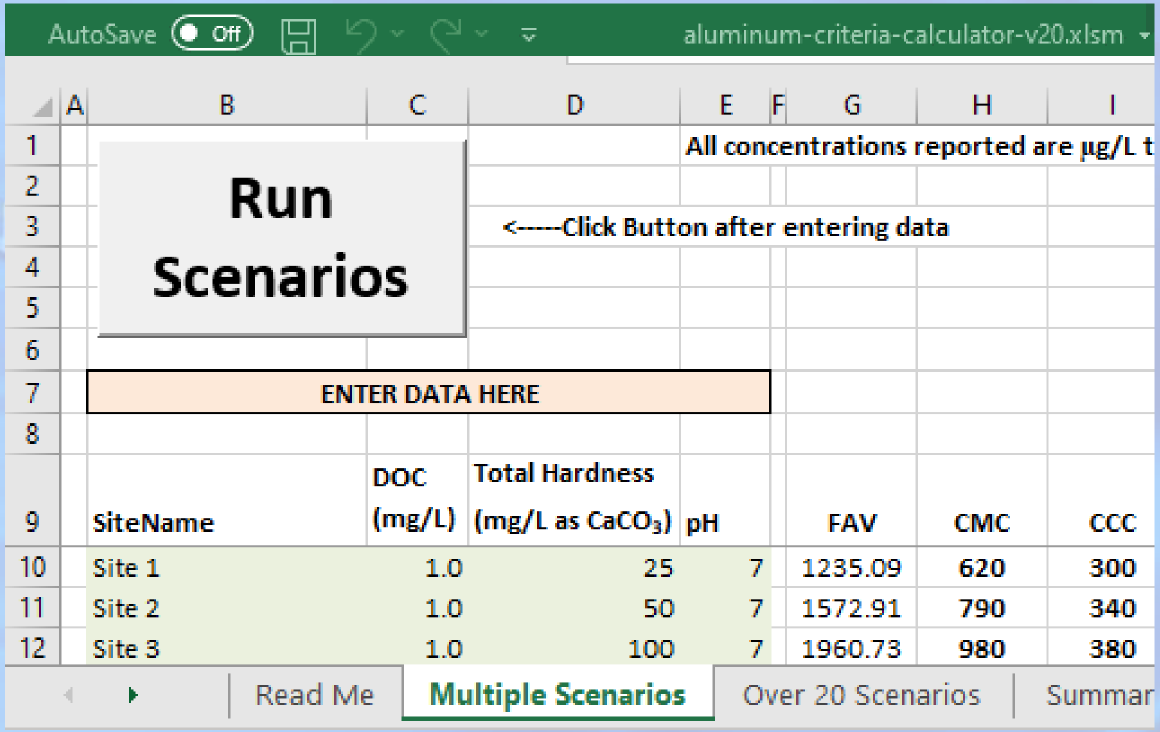
EPA ALUMINUM CRITERIA CALCULATOR

- EPA (2018) guidance included multiple linear regression equations to estimate aluminum concentrations that – if not exceeded – would be expected to protect aquatic life from acute and chronic aluminum exposures.



SiteName	DOC (mg/L)	Total Hardness (mg/L as $CaCO_3$)	pH	FAV	CMC	CCC
Site 1	1.0	25	7	1235.09	620	300
Site 2	1.0	50	7	1572.91	790	340
Site 3	1.0	100	7	1960.73	980	380

Model inputs:

- pH, DOC, and total hardness.

https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater

Model outputs:

- Criteria Maximum Concentration (CMC)
  An estimate of the highest aluminum concentration in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

- Criteria Continuous Concentration (CCC)
  An estimate of the highest aluminum concentration in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

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RESULTS CMC and CCC

- The report includes a table showing minimum values and the 5th percentile and 10th percentile statistics for CMC and CCC aluminum calculations
- The instantaneous CMC and CCC values determined by the EPA Calculator indicate toxic endpoints for the water quality conditions at the time of sampling

Table 6. Minimum, 5th percentile, and 10th percentile statistics for aluminum calculations made with the U.S. Environmental Protection Agency Aluminum Criteria Calculator for stations near seven water-treatment and four wastewater-treatment facilities in eastern and central Massachusetts, 2018–19.

[µg/L as Al, microgram per liter as aluminum; CMC, criterion maximum concentration; CCC, criterion continuous concentration; WWTF, wastewater-treatment facility; Mass., Massachusetts; WTF, water-treatment facility; —, not applicable; US, upstream]

Station identification number	Town and facility type	Station name	Upstream or pond	Minimum (µg/L as Al)		5th percentile (µg/L as Al)		10th percentile (µg/L as Al)	
				CMC	CCC	CMC	CCC	CMC	CCC
01096603	Westborough WWTF	Assabet River near Westborough, Mass.	Upstream	1,100	430	1,100	442	1,100	450
01096720	Marlborough WWTF	Assabet River at Boundary Street near Northborough, Mass.	Upstream	1,300	460	1,300	466	1,380	486
01096870	Hudson WWTF	Assabet River at Cox Street near Hudson, Mass.	Upstream	1,300	470	1,360	476	1,420	486
01097021	Maynard WWTF	Assabet River, upstream Maynard wastewater treatment plant	Upstream	1,000	420	1,060	420	1,140	428

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(Armstrong and others, 2022)

RESULTS CMC and CCC

- The report includes a table showing minimum values and the 5th percentile and 10th percentile statistics for CMC and CCC aluminum calculations

- For facilities when more than one station was selected, results are shown for each station and for combinations of stations (shallow, deep, etc.)

Table 6. Minimum, 5th percentile, and 10th percentile statistics for aluminum calculations made with the U.S. Environmental Protection Agency Aluminum Criteria Calculator for stations near seven water-treatment and four wastewater-treatment facilities in eastern and central Massachusetts, 2018–19.

[µg/L as Al, microgram per liter as aluminum; CMC, criterion maximum concentration; CCC, criterion continuous concentration; WWTF, wastewater-treatment facility; Mass., Massachusetts; WTF, water-treatment facility; —, not applicable; US, upstream]

Station identification number	Town and facility type	Station name	Upstream or pond	Minimum (µg/L as Al)		5th percentile (µg/L as Al)		10th percentile (µg/L as Al)	
				CMC	CCC	CMC	CCC	CMC	CCC
421622071385701	Westborough WTF	Hocomonco Pond shallow, Westborough, Mass.	Pond station 1	720	340	795	345	870	350
421622071385702	Westborough WTF	Hocomonco Pond deep, Westborough, Mass.	Pond station 2	620	340	735	345	850	350
421628071384501	Westborough WTF	Hocomonco Pond near Otis Street, Westborough, Mass.	Pond station 3	690	290	722	308	753	326
—	Westborough WTF	—	Pond stations 1 and 2 combined	620	340	726	340	852	350
—	Westborough WTF	—	Pond stations 1, 2, and 3 combined	620	290	706	336	769	341

(Armstrong and others, 2022)

RESULTS–ALUMINUM CRITERION MAXIMUM CONCENTRATION

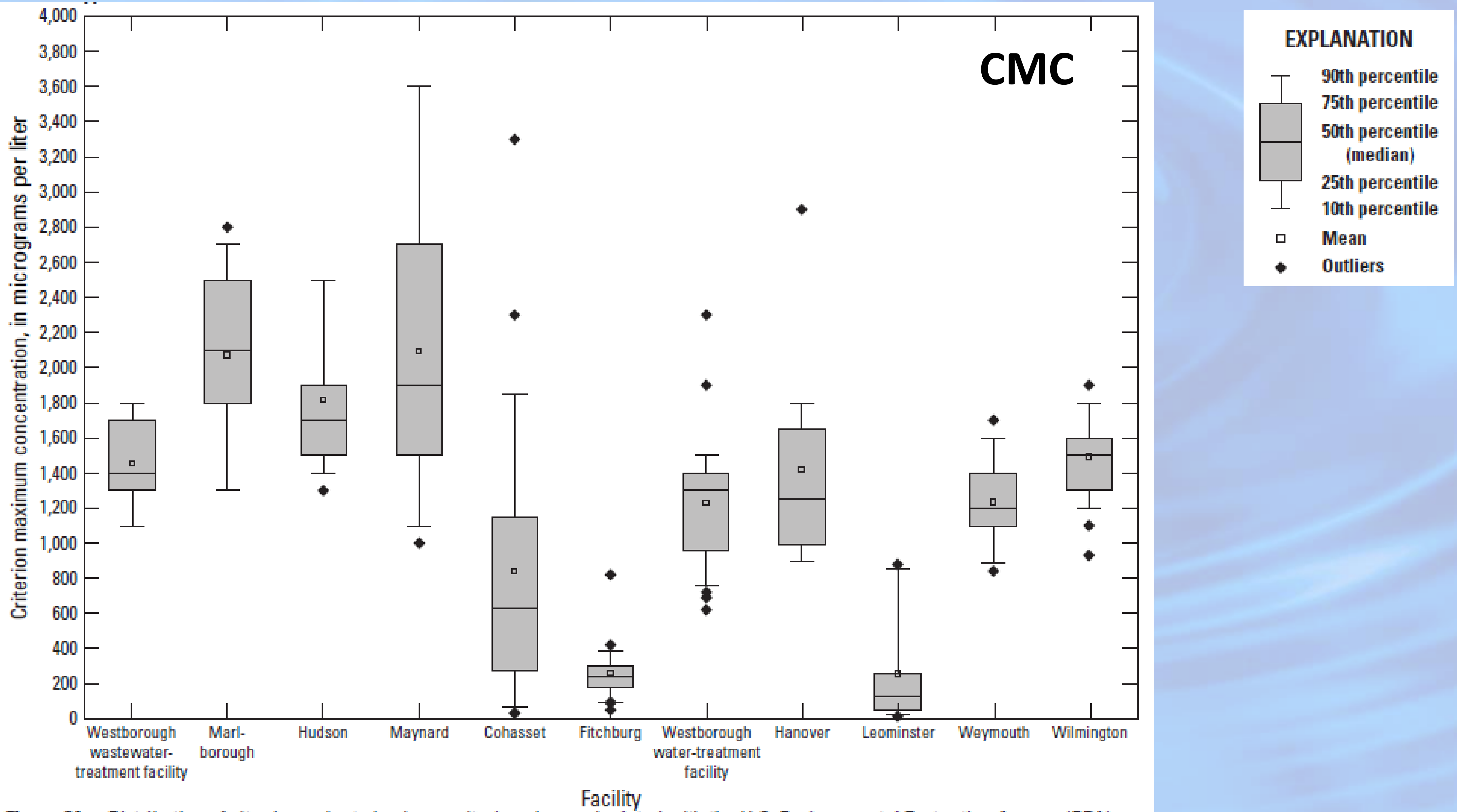

Figure 24. Distribution of site-dependent aluminum criteria values calculated with the U.S. Environmental Protection Agency (EPA) Aluminum Criteria Calculator for monthly pH, dissolved organic carbon, and total hardness data collected at selected stations

(Armstrong and others, 2022)

RESULTS–ALUMINUM CRITERION CONTINUOUS CONCENTRATION

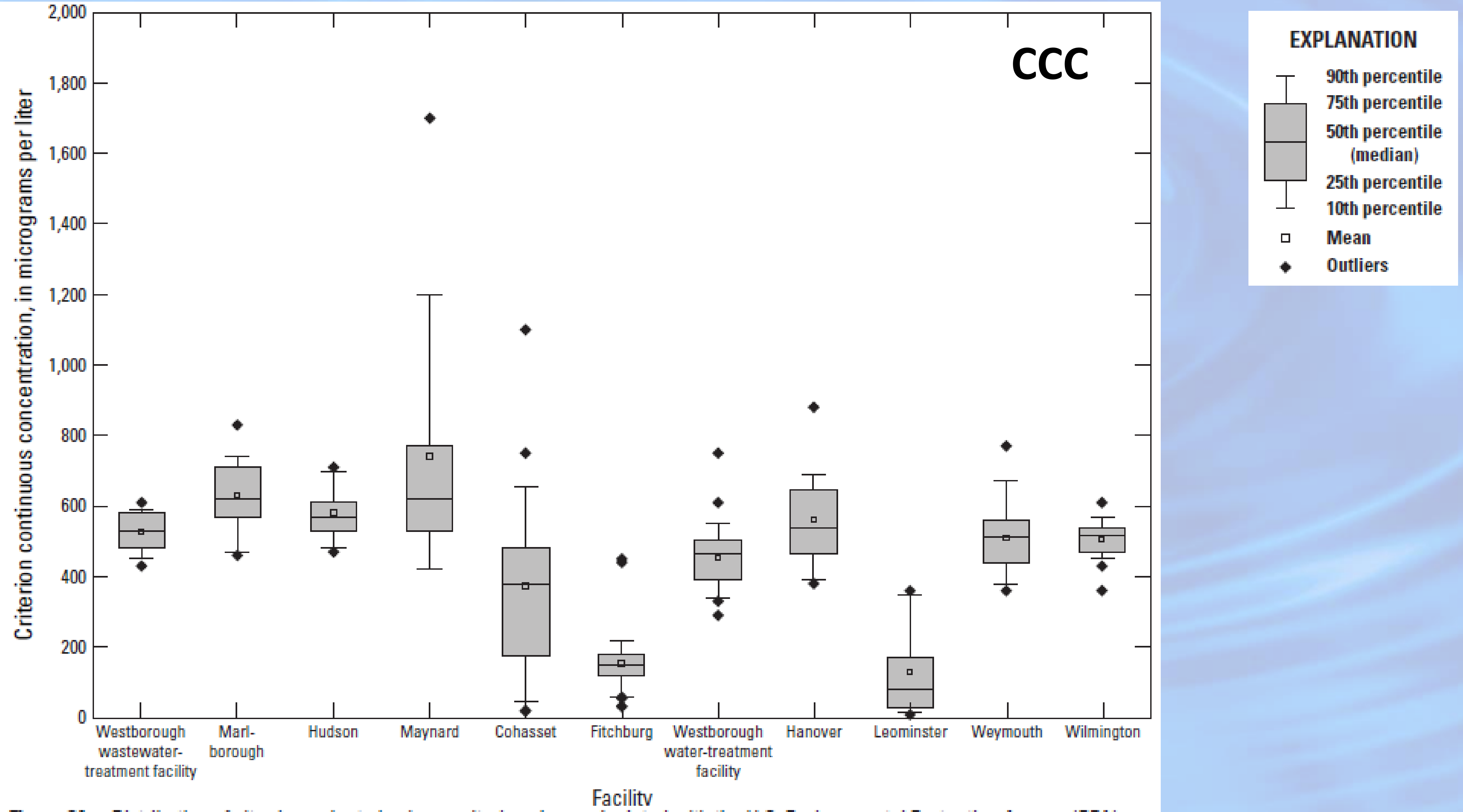

Figure 24. Distribution of site-dependent aluminum criteria values calculated with the U.S. Environmental Protection Agency (EPA) Aluminum Criteria Calculator for monthly pH, dissolved organic carbon, and total hardness data collected at selected stations

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(Armstrong and others, 2022)

RESULTS TOC-DOC REGRESSION EQUATION

- Paired values of DOC and TOC were available from 223 samples collected at 52 stations,

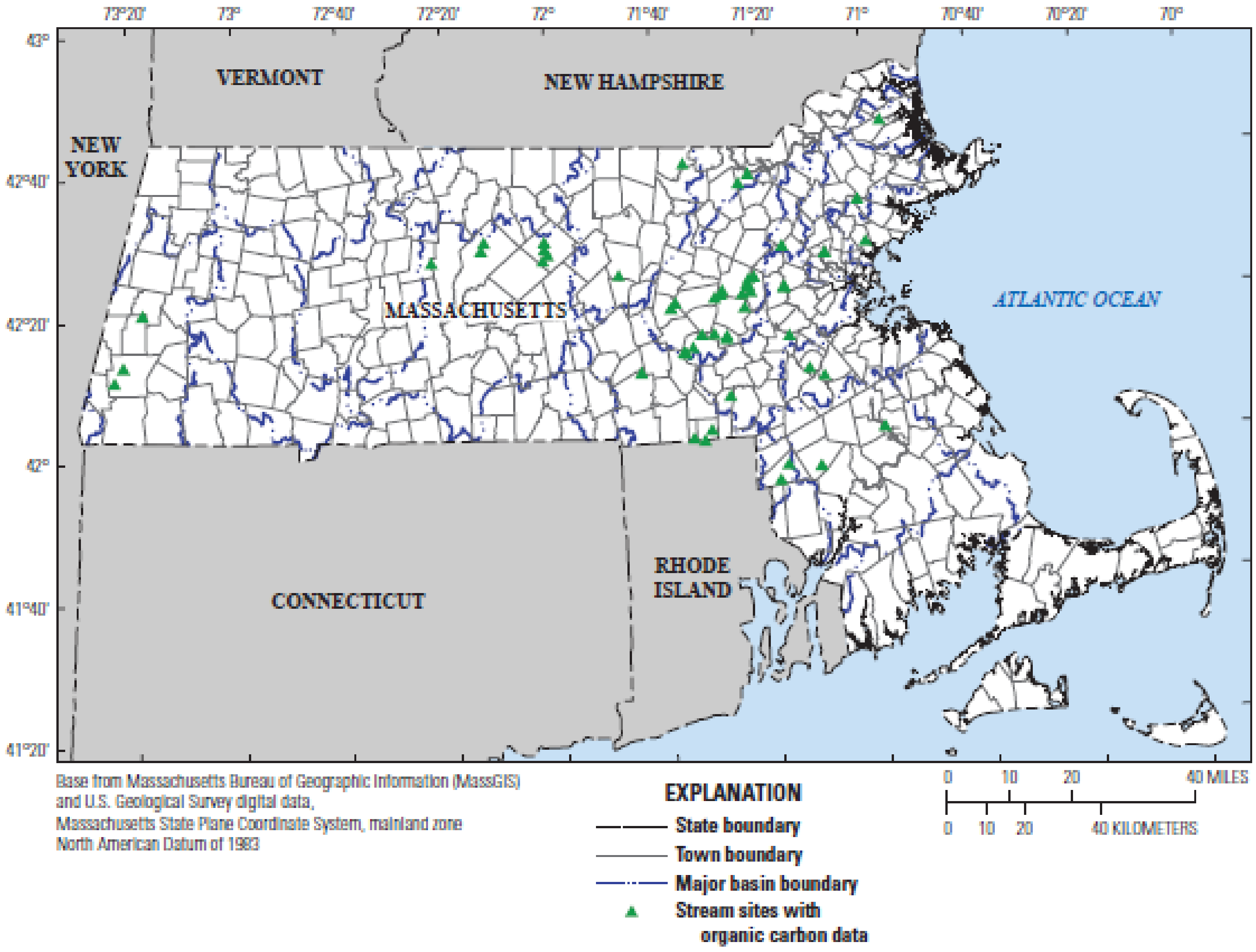

Figure 26. Historical data (1978–2001) showing organic carbon in 223 samples from 52 stream stations in Massachusetts.

(Armstrong and others, 2022)

RESULTS–TOC-DOC REGRESSION EQUATION

- DOC and TOC were well correlated in the 223 samples
  Pearson's r = 0.96, R^2 = 0.93

$$DOC = 0.858\ TOC - 0.196, \qquad (1)$$

where
DOC is dissolved organic carbon (in milligrams per liter), and
TOC is total organic carbon (in milligrams per liter).

- The equation enables MassDEP to use available water-quality data to evaluate water-quality conditions at additional sites across Massachusetts where only pH, hardness, and TOC data are available.

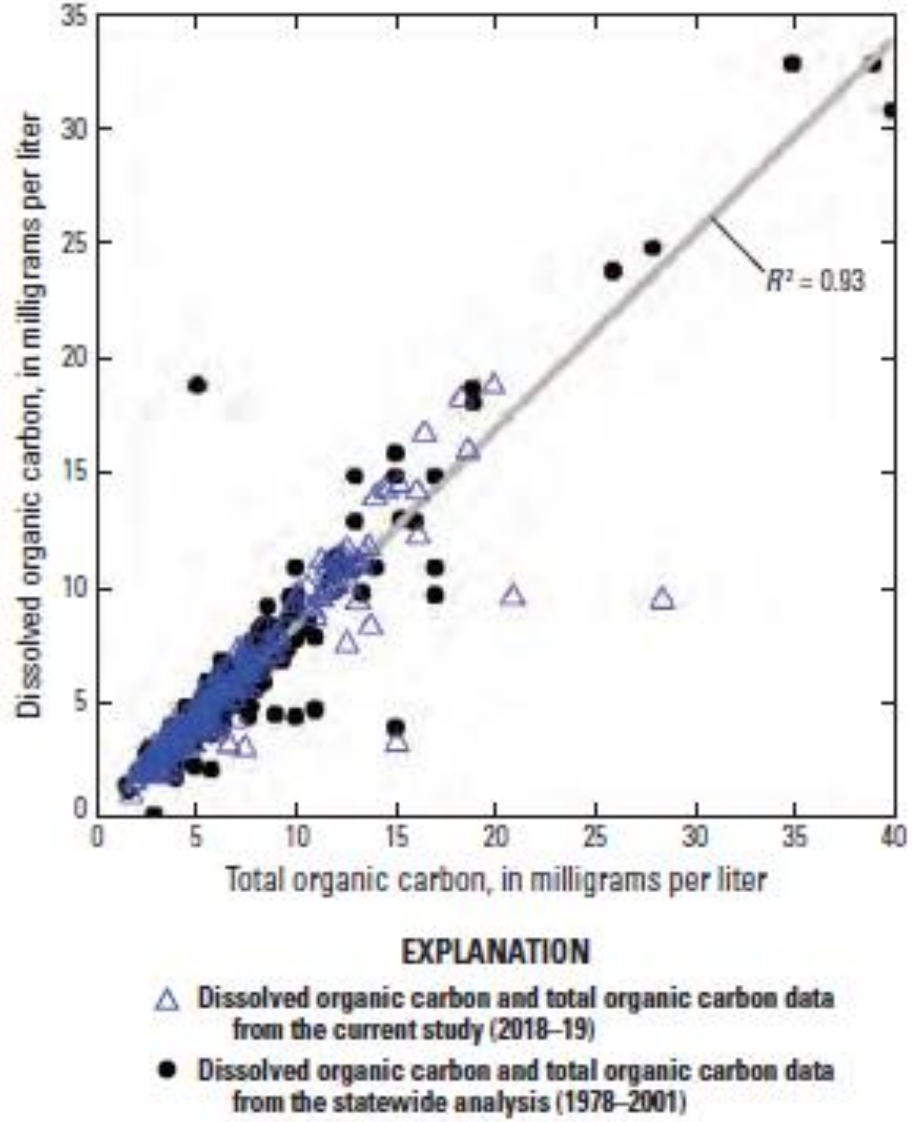

Figure 27. Correlation of dissolved organic carbon and total organic carbon from the current study (2018–19) and statewide analysis (1978–2001) in Massachusetts.

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(Armstrong and others, 2022)

TOC-DOC DATA RELEASE

https://doi.org/10.5066/P9420WXU

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Total and dissolved organic carbon data to support implementation of revised freshwater aluminum water-quality criteria in Massachusetts

View

Dates

Publication Date : 2021
Time Period : 2021

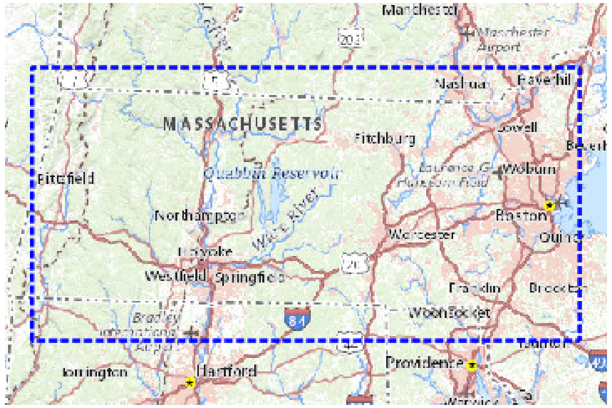
Citation

DeSimone, Leslie A., and Armstrong, David S., 2021, Total and dissolved organic carbon data to support implementation of revised freshwater aluminum water-quality criteria in Massachusetts: U.S. Geological Survey, https://doi.org/10.5066/P9420WXU.

Summary

This data set contains historical data on concentrations of total and dissolved organic carbon in Massachusetts streams from the U.S. Geological Survey National Water Information System (NWIS) database. The data were compiled from NWIS using site and sample selection criteria to retrieve all publicly available data from surface-water samples that contained analysis of both total and dissolved organic carbon. The data set was screened, as much as possible from the site and sample description information in NWIS, to retain only routine environmental samples from stream sites. The final data set consists of 223 samples from 52 sites and were collected from 1978 to 2007.

Map »



Communities

- USGS Data Release Products

Associated Items

Implementation of Freshwater Aquatic Life Aluminum Criteria in NPDES Permitting

Susy King
Chief, National Pollutant Discharge Elimination System Section
Massachusetts Department of Environmental Protection

Implementation Guidance

- Specifies how criteria should be applied in determining NPDES permit limits
- Includes data requirements for developing site-dependent criteria

**Fresh Water Aquatic Life Water Quality Criteria for Aluminum:
Application of the Aluminum Criteria Calculator for
National Pollutant Discharge Elimination System (NPDES) and
Massachusetts Surface Water Discharge (SWD) Permits**

MassDEP

Massachusetts Department of Environmental Protection

Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Kathleen Theoharides, Secretary
Massachusetts Department of Environmental Protection
Martin Suuberg, Commissioner

December 2021

CN 560.0

MassDEP

Data Requirements for Site Dependent- Criteria

- Existing Data
  - Data no older than 10 years, only 5 most recent years of data used
  - At least 5 continuous years of concurrently measured pH, DOC, hardness data
  - At least 20 sampling events in 5 most recent years of data

- New Data Collection
  - Minimum of 20 sampling events over two years, spaced at least monthly

Current Status of NPDES Permits

- Wastewater Treatment Plants
  - Individual permits
  - 3 of 4 have aluminum limits with 3-year compliance schedule, opportunity for permit modification
- Water Treatment Plants
  - Coverage under 2009 Potable Water Treatment Facility General Permit (PWTF GP)
  - No aluminum limits yet

MassDEP

Addressing Aluminum in Permit Reissuance

- Evaluate available data for calculating site-dependent criteria
  - Existing data
  - New data
  - USGS data do not meet requirements for new data collection (i.e., not enough data)
- If insufficient data for site-dependent criteria, use watershed default values for determining aluminum limits
- Anti-backsliding must be considered in setting permit limits

Hudson and Maynard WWTFs

- Currently have individual permits, proposed to be covered under Medium WWTF General Permit
- GP likely to be issued after water quality criteria approved, limits based on watershed default values
- 3-year compliance schedule will end prior to effective date of final GP, will need permit modifications
  - Evaluation for modification will be based on watershed default values
- Current individual permit and medium WWTF GP require pH, hardness, and DOC/TOC monitoring
  - Expect when medium WWTF GP is renewed, will have sufficient data to calculate site-dependent criteria, which will be basis of future limits

Marlborough and Westborough WWTFs

- Individual permits recently renewed
  - Westborough has aluminum limit, Marlborough does not
- Westborough will need modification once water quality criteria approved
  - Aluminum limit in modification will be based on watershed default values
- Permits require pH, hardness, and DOC monitoring
  - Expect when permits are reissued, will have sufficient data to calculate site-dependent criteria
  - Site-dependent criteria will be used to determine limits/if limits necessary in the future

Water Treatment Facilities

- PWTF General Permit due for renewal
- Facilities will be covered under the GP renewal or new individual permits
  - Limits to be based on watershed default values
  - Anticipate including requirements for ambient pH, hardness, and DOC monitoring
- For future permit reissuances, anticipate will have sufficient data to calculate site-dependent criteria, which will be the basis of future limits

Thank you!
Questions ?

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MassDEP:

- Richard O. Carey, Ph.D., richard.carey@mass.gov
- Susy King, susannah.king@mass.gov

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MassDEP