School for Marine Science and Technology
706 South Rodney French Blvd.
New Bedford
Massachusetts 02744-1221
University of Massachusetts Dartmouth

Technical Memorandum

To: George Meservey, Director of Planning & Community Development, Town of Orleans

From: Ed Eichner, Principal, TMDL Solutions/Adjunct Professor, CSP/SMAST
David Schlezinger, Sr. Research Associate, CSP/SMAST, UMASSD
Micheline Labrie, Director/Assistant Professor, CSP/SMAST, UMASSD

Date: October 20, 2025

RE: Boland Pond YR1 2025 Management Plan Update

The Town of Orleans has been significantly investing in water quality management planning for several decades, including an effort to prioritize the identification of freshwater pond management options through the completion of diagnostic assessments/management plans for individual ponds. These efforts have been facilitated through the Town Marine and Fresh Water Quality Committee (OMFWQC) and completed in coordination with the Coastal Systems Program from the School for Marine Science and Technology at UMass-Dartmouth (CSP/SMAST). These assessments have been tailored to each pond and assessment results have been used to evaluate applicable management options and develop a set of recommended management steps to achieve acceptable water quality conditions. Working with Town staff and the OMFWQC, CSP/SMAST has completed pond diagnostic assessment/management plans for: Uncle Harvey's Pond (2018)[1], Pilgrim Lake (2019)[2], Crystal Lake (2021)[3], and Baker Pond (2022)[4]. In late 2024, the Town asked CSP/SMAST to complete a diagnostic assessment/management plan for Boland Pond.

Boland Pond is a 5 to 8 acre pond, located to the east of Route 6A, west of Route 28 and north of Eldridge Parkway with no formal public access, but it is adjacent to the Nauset Regional Middle School and Orleans Elementary School properties (**Figure 1**). The variation in its water surface area is due to fluctuating water levels and a large area of adjacent wetlands along its northwest side. Given that its area is less than 10 acres, it is not a Great Pond, so it is not publicly owned. Review of current Town Assessor parcels suggest the pond surface, especially the northwest

[1] Eichner, E., B. Howes, and D. Schlezinger. 2018. Uncle Harvey's Pond Management Plan and Diagnostic Assessment. Town of Orleans, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 106 pp.

[2] Eichner, E., B. Howes, and D. Schlezinger. 2019. Pilgrim Lake Management Plan and Diagnostic Assessment. Town of Orleans, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 114 pp.

[3] Eichner, E., B. Howes, and D. Schlezinger. 2020. Crystal Lake Management Plan and Diagnostic Assessment. Town of Orleans, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 101 pp.

[4] Eichner, E., B. Howes, and D. Schlezinger. 2022. Baker Pond Management Plan and Diagnostic Assessment. Town of Orleans, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 106 pp.

wetland-dominant area, is owned by multiple owners (**Figure 2**). The pond is estimated to have a maximum depth of 19 to 20 ft based on sample readings and a 2006 bathymetric map (**Figure 3**). Most of the pond watershed, which extends to the southwest towards the Lots Hollow Road and Eldredge Park Way intersection, is within later phases of the Town's current sewer scheduling plan (**Figure 4**). Previous evaluations of stormwater inputs identified discharge locations along the northern and western sides of the pond.[5]

Review of available historical Boland Pond water quality data in 2023[6] showed that the pond was impaired based on a number of characteristics, including:

- Average summer shallow (42 µg/L) total phosphorus (TP) level exceeded the regional 10 µg/L threshold. The deep summer average was approximately 6X higher, indicating notable sediment additions.
- Deep summer dissolved oxygen (DO) concentrations were all less than 1 mg/L (or anoxic), which would be consistent with summer release of sediment TP.
- Average shallow summer chlorophyll-a (CHL) concentrations were 8X the regional 1.7 µg/L threshold, indicating significant phytoplankton population growth.

As part of the current Boland Pond diagnostic assessment/management plan, which will be completed in 2026, CSP/SMAST proposed a number of tasks to be completed over two fiscal years, including the following:

- Collection and incubation of 8 sediment cores in late winter/early spring 2025 to measure sediment nutrient regeneration through oxic and anoxic conditions with accompanying water column sampling shortly before, during, and after core collection,
- Surveys of bathymetry, rooted aquatic plants, and freshwater mussels,
- Monthly water column sampling and measurements from April 2025 through October 2025 over the deep location in the pond,
- Monthly phytoplankton samples collected from April 2025 to October 2025 and assayed for cell counts and identification of all species,
- Collection of stormwater discharge during at least three storms at three locations previously sampled in 2017,
- Installation of two sondes at shallow and deep depths for continuous readings of temperature, conductivity, DO and chlorophyll a, and
- Estimates of watershed phosphorus inputs based on surrounding land uses.

Since March 2025 (YR1), CSP/SMAST staff have completed:

1) the collection and incubation of sediment cores:
   Cores were collected April 7 with water quality measurements before (4/4), during (4/7), and after (4/24) the core collection.
2) surveys of bathymetry, macrophytes, and mussels:
   Macrophyte and mussel video surveys were completed on June 13; bathymetric survey was completed on June 26.

[5] CSP/SMAST Technical Memorandum. May 12, 2017. Boland Pond Volunteer Stormwater Monitoring. From: B. Howes, CSP/SMAST and E. Eichner, TMDL Solutions. To: G. Meservey, Director of Planning & Community Development, Town of Orleans and C. Kennedy, Chair, Town of Orleans, Marine and Fresh Water Quality Task Force. 15 pp.

[6] CSP/SMAST Website water quality summaries completed for Orleans Marine and Fresh Water Quality Committee: https://www.town.orleans.ma.us/1654/NewWater-QualitySummaries-2002-2023 (accessed 10/15/25).

3) monthly water column samples and phytoplankton samples:
   Water column samples and readings and phytoplankton samples were collected on April 24, May 21, June 19, July 18, August 12, September 10 and October 9.
4) installation and stewardship of the sondes
   Sondes were deployed on April 4 at 2.5 m and 5.0 m depths.

Stormwater sampling has been delayed because of the drought during the summer, while watershed analysis was planned for YR2 with the synthesis of all data in the Management Plan.

Boland Pond water column measurements have been collected since 2001 by town volunteers (*i.e.*, OMFWQC members). All collected 2025 data will be reviewed with the historical data and summarized in the Boland Pond Management Plan. All available data will be synthesized with watershed information to provide an understanding of how water column conditions develop and are sustained, and which factors are key for managing water quality in Boland Pond.

Initial review of available Boland Pond historical water quality data (2001-2024) has shown that:

a) clarity tends to be relatively stable throughout the year and has not changed notably over the past 24 years (**Figure 5**).
b) the pond regularly stratifies during the summer, typically at a depth around 2 m and has a transition zone of approximately 2 m thick below that; stratification generally first occurs in May and typically lasts through September (**Figure 6**).
c) all historical spring and summer water column temperatures deeper than 2 m were sufficient for sustaining a cold water fishery based on the Massachusetts Department of Environmental Protection (MassDEP) upper limit of 20°C (314 CMR 4).
d) during the summer, waters at 3 m and deeper were regularly anoxic (*i.e.*, <1 mg/L DO), effectively eliminating a sustained cold water fishery (**Figure 7**). During April, anoxia generally only occurred just above the sediments (at 6 m and deeper). Average DO concentrations at 5 m depth and deeper in April and 2 m depth and deeper in August and September were less than the MassDEP 6 mg/L minimum for cold water fisheries. These summer averages also mean that hypoxia and anoxia regularly impact DO concentrations in the stratification transition zone between the warm upper and cold lower layers.
e) TP concentrations show excessive shallow and deep levels during both spring and summer. Spring and summer shallow average TP concentrations were similar (45.6 µg/L and 41.5 µg/L, respectively) with both more than 4X the regional 10 µg/L TP threshold (**Figure 8**). Spring deep average TP concentration (67.7 µg/L) showed the impact of sediment TP release, but deep summer average TP concentration showed more extensive impact of increased deep anoxia with an average TP of 265.9 µg/L.
f) Historical chlorophyll-a (CHL) concentrations showed increased phytoplankton growth in the summer and highly impaired conditions: average shallow April CHL concentration was 6.0 µg/L (>3X the regional threshold of 1.7 µg/L) and the late summer shallow average was approximately 2X higher (13.0 µg/L, n=27) (**Figure 9**). These concentrations were consistent with excessive TP concentrations and summer phytoplankton growth. Evaluations of the phytoplankton population in 2025 will provide insights into how the species change throughout the summer.

Project staff are available to discuss this Technical Memorandum if requested.

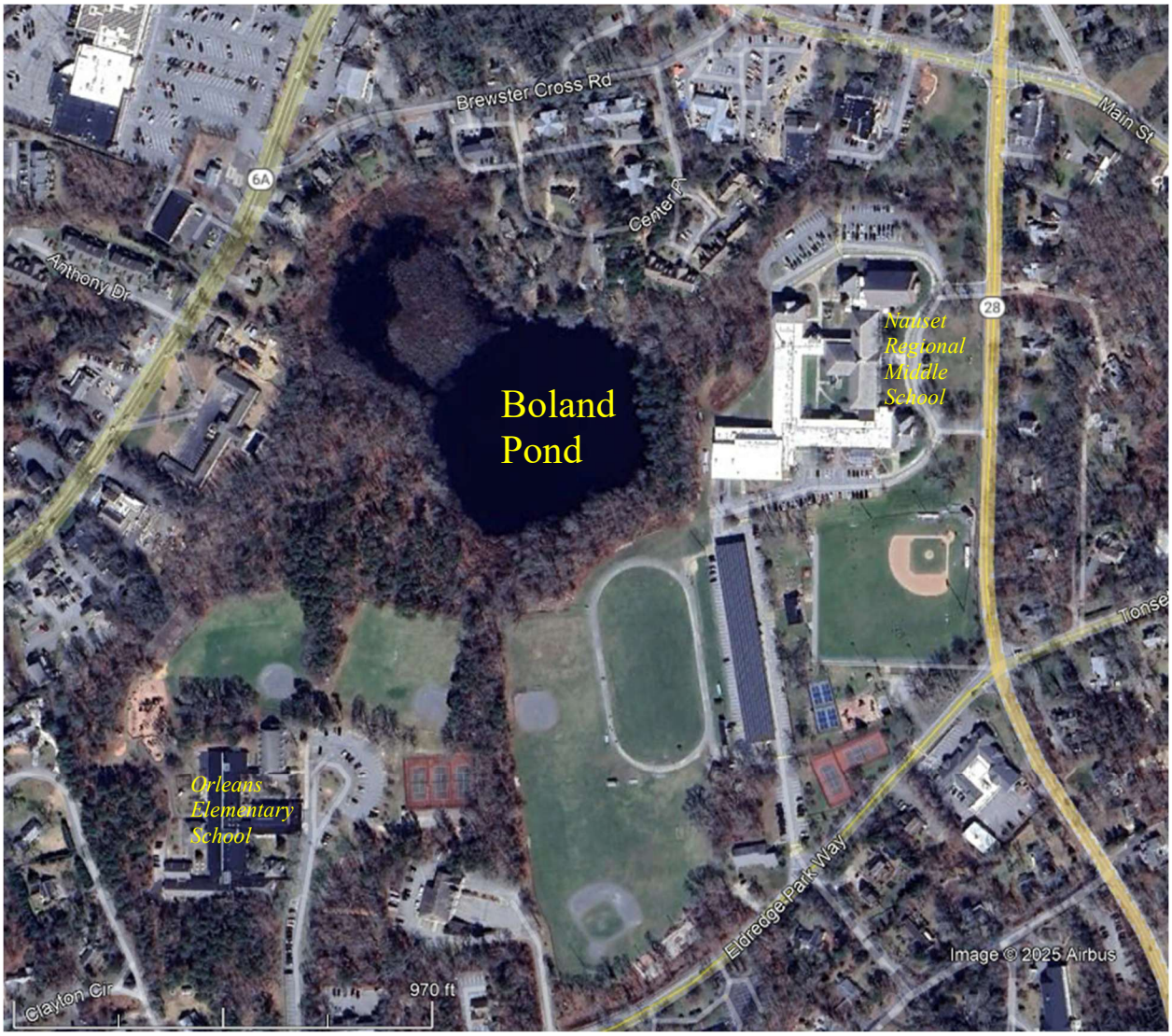

Figure 1. Boland Pond Locus. Boland Pond is east of Route 6A, west of Route 28, and north of Eldredge Parkway. The pond is adjacent to the parcels for Nauset Regional Middle School and Orleans Elementary School. Base map from Google Earth (3/21/24 aerial photograph).

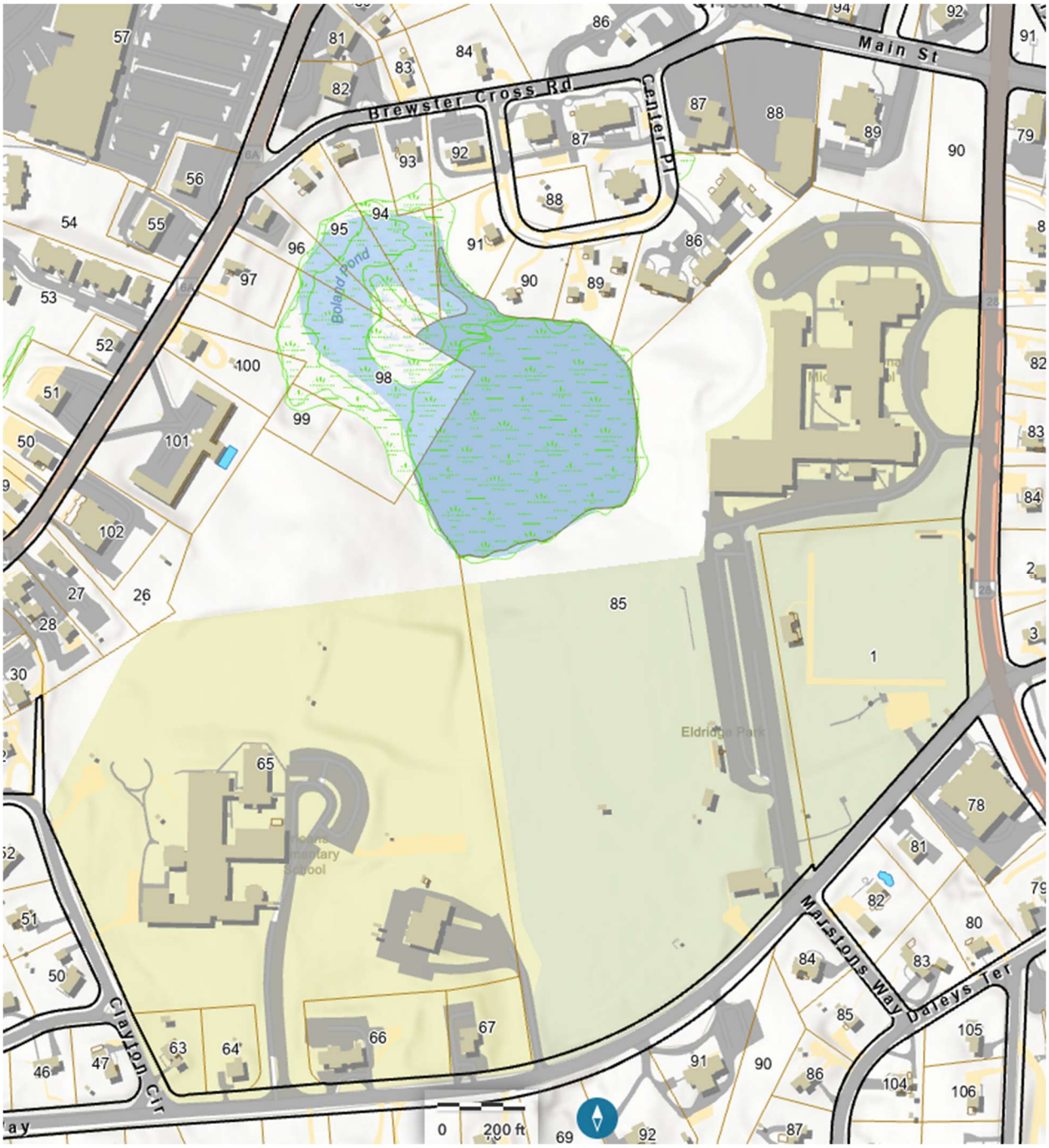

Figure 2. Town of Orleans Assessor GIS Parcels in Boland Pond area. The main basin of Boland Pond is identified as an individual parcel, but portions of the pond surface are divided among a number of private parcels, especially in the wetland-dominant northwestern portion. Map from online Town GIS: https://next.axisgis.com/OrleansMA (accessed 10/9/25).

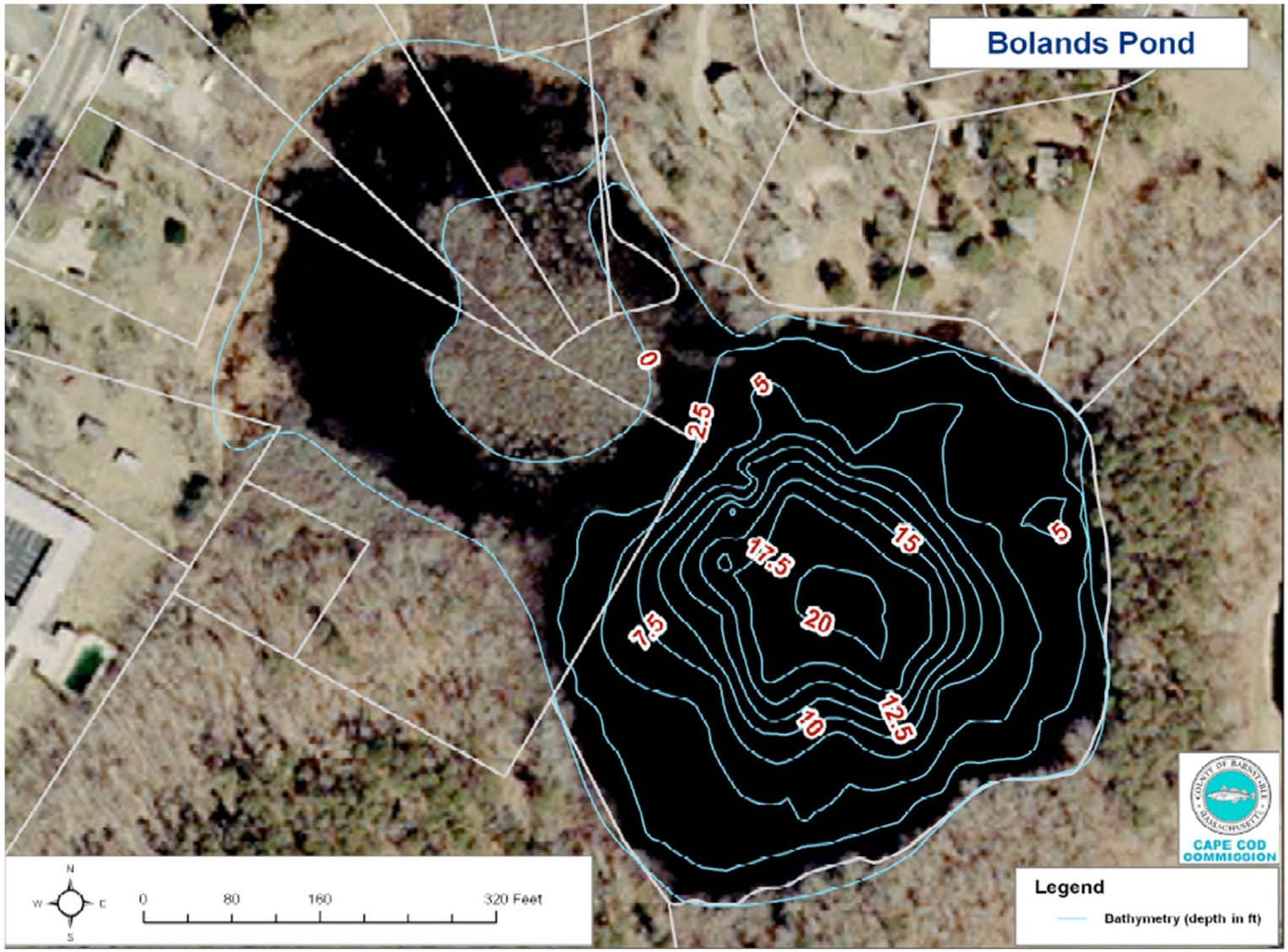

Figure 3. Boland Pond 2005/2006 bathymetry. Bathymetry data was collected by OMFWQC (née Orleans Marine and Fresh Water Quality Task Force) volunteers in 2005/2006 and synthesized into bathymetric contours by Cape Cod Commission staff (Eichner, 2007).

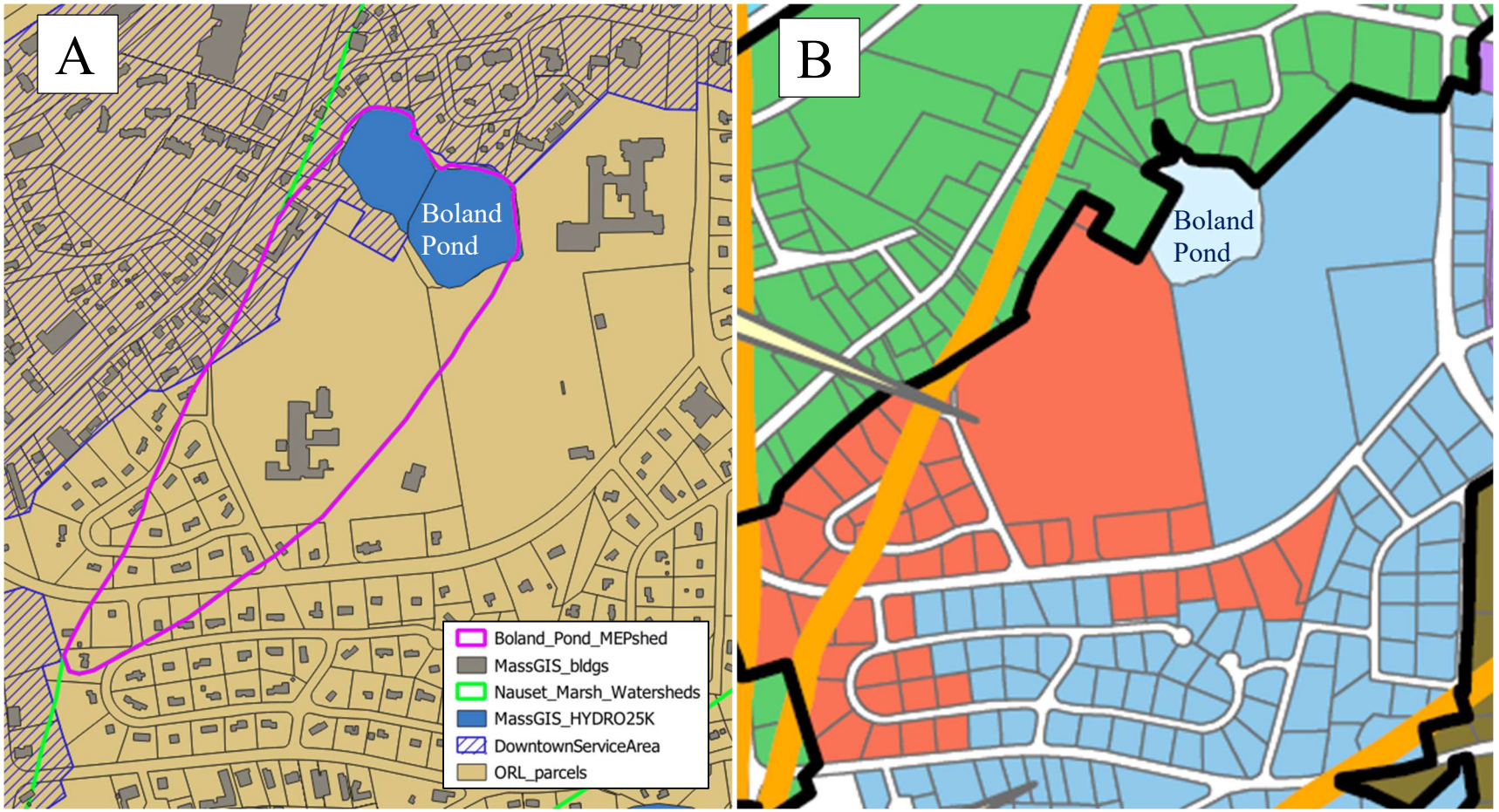

Figure 4. Boland Pond Watershed and 2024 Town Sewer Phases. Boland Pond watershed (pink outline in A) was delineated as part of the Massachusetts Estuaries Project (MEP) assessment of Nauset Marsh (Howes and others, 2012). Map A also includes downtown sewer area (blue diagonal lines) included in Phase 1 of the Town of Orleans Amended Comprehensive Wastewater Management Plan (AECOM, 2023). Map B shows the additional 2024 ACWMP sewer phases near Boland Pond including the downtown sewer area (green fill with a black outline) [AECOM map 8/21/25; https://town.orleans.ma.us/DocumentCenter/View/6168/Proposed-and-Approved-Service-Areas-2023 (accessed 10/14/25)].

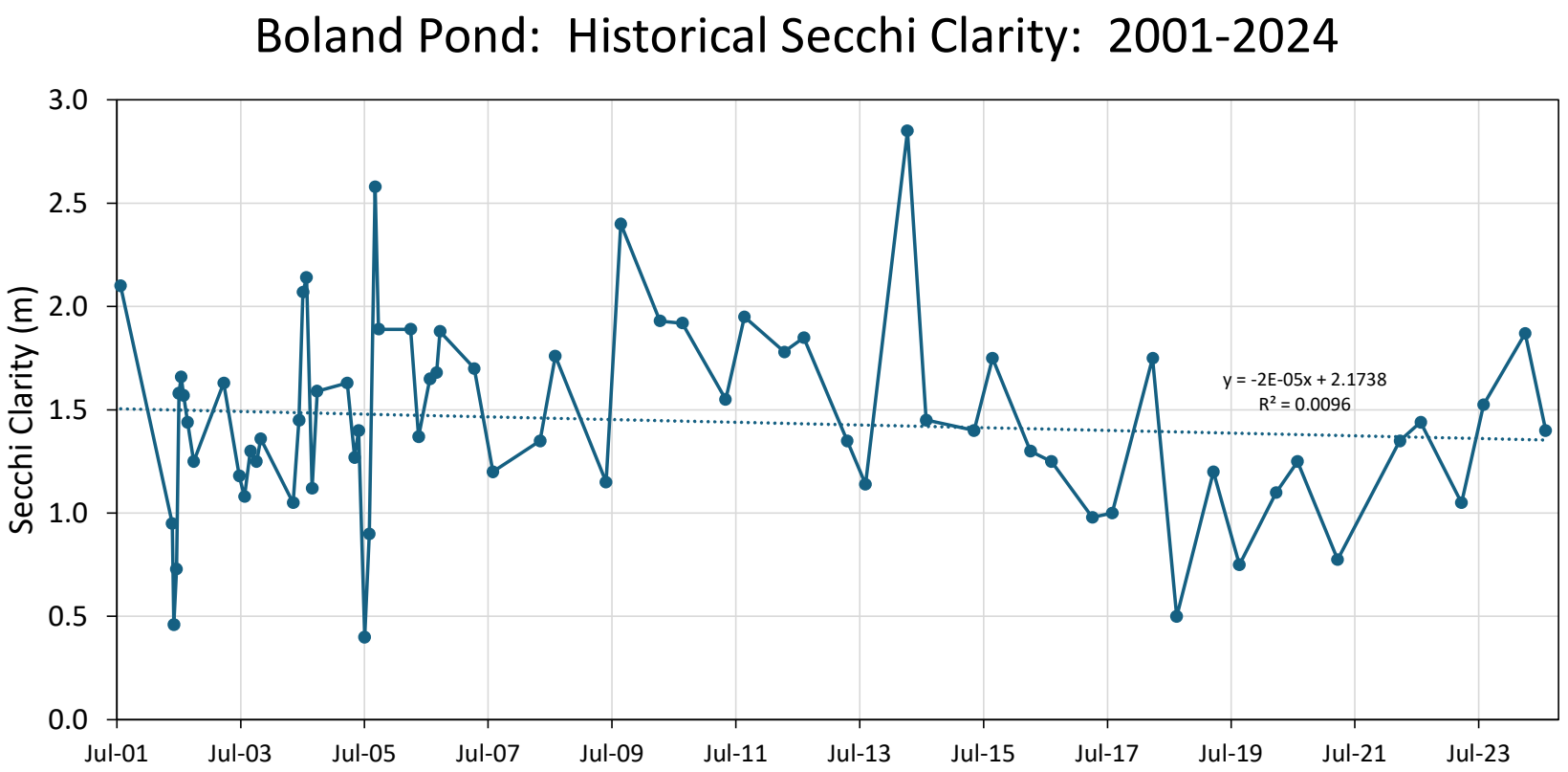

Figure 5. Boland Pond: Historical Secchi Clarity: 2001-2024. Longitudinal review of water clarity in Boland Pond has been relatively stable between 2001 and 2024 (n=68) with little difference between spring and summer clarity averages. The longitudinal record suggested a slight increase in clarity in 2007-2011 followed by decrease in 2015-2021, but the correlations even with a complex, multifactorial equation were poor (R-squared <0.22) which suggests that these multi-year changes were not significant.

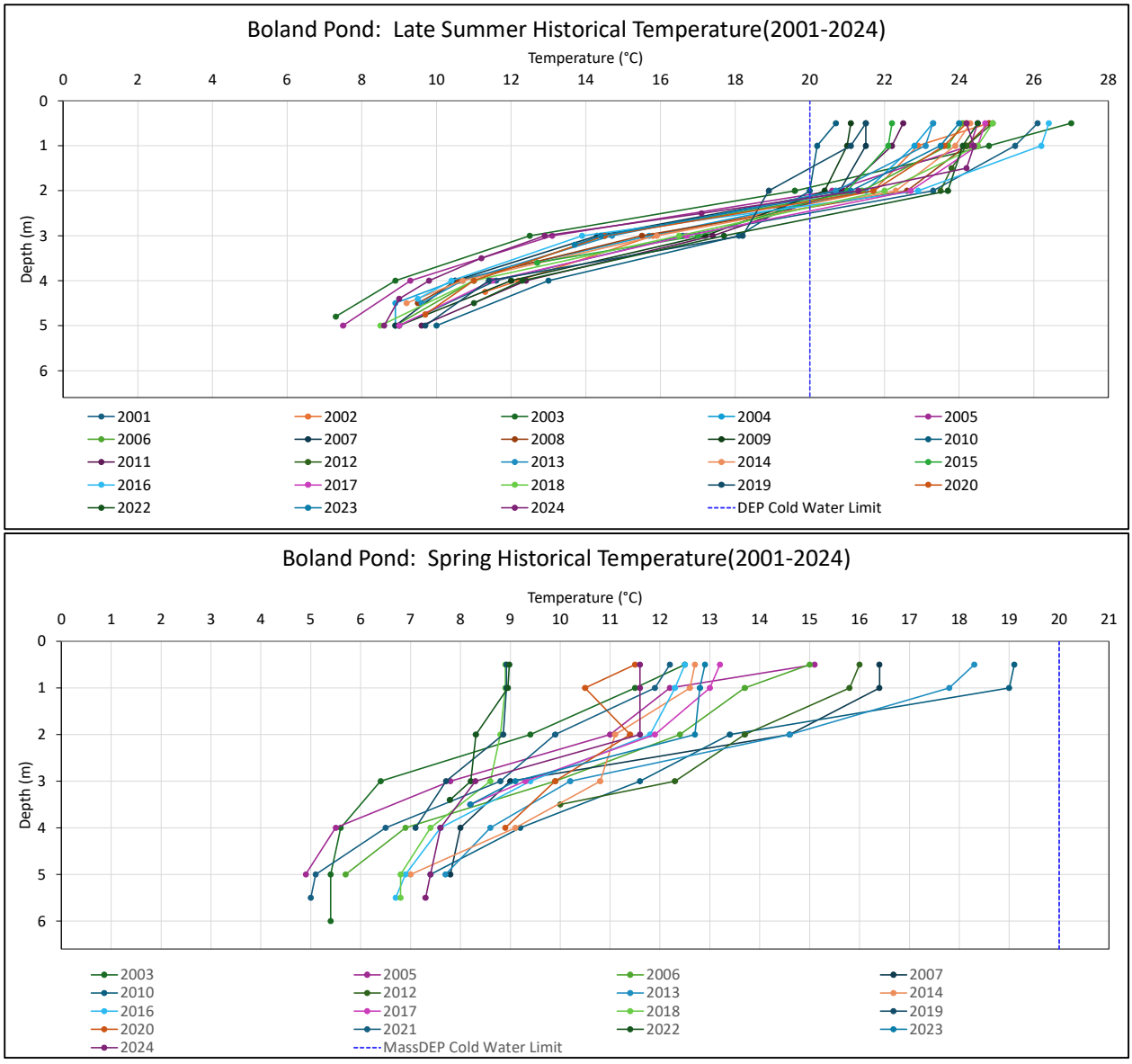

Figure 6. Boland Pond: Historical Water Column Temperature: 2001-2024. Spring and late summer water column temperatures generally show initial temperature stratification in May (infrequently in April) and strong stratification in late summer. On average during the summer, the upper 2 m of the water column is well-mixed with a ~2 m thick transition zone from warm to cold water below that and a cold bottom layer beginning at an average depth of approximately 4 m. Significant temperature differences in the transition zone would prevent mixing of the cold bottom layer water with the warm top layer. The depth of these layers in Boland Pond is not common in shallow Cape Cod ponds. Ponds that are ~6 m depth (like Boland) typically do not thermally stratify, and deeper ponds typically stratify at 8 to 9 m depth. All historical water column temperatures show that Boland Pond could support a cold water fishery in the deeper portions of the water column; all deep temperatures in spring and summer are less than the MassDEP maximum limit of 20°C for sustaining cold water fisheries.

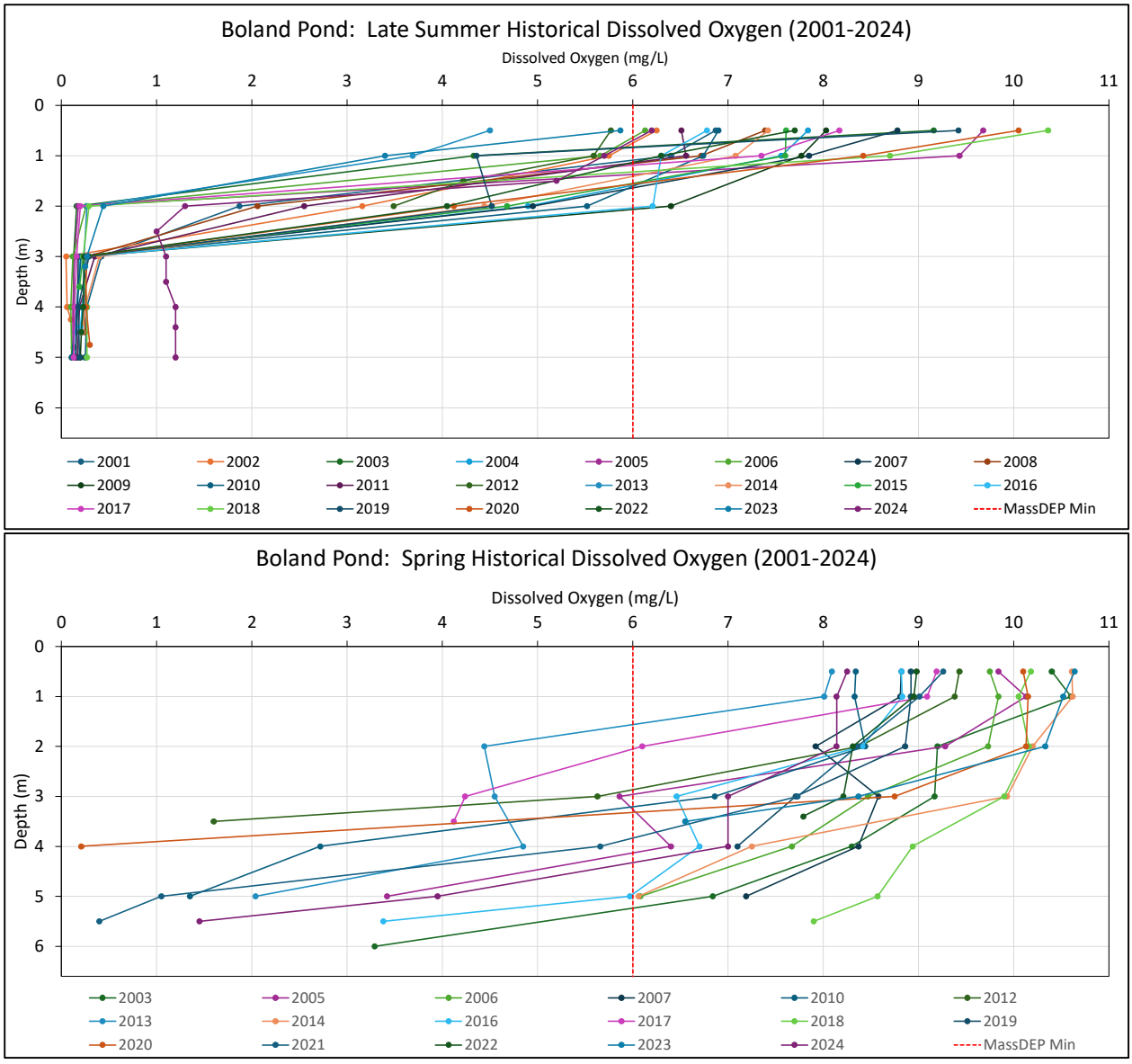

Figure 7. Boland Pond: Historical Water Column Dissolved Oxygen: 2001-2024. Late summer dissolved oxygen (DO) concentrations show the impact of sediment oxygen demand regularly removing most DO from the water column at 3 m and deeper. Spring water column DO concentrations were generally acceptable to 5 m depth, although sediment oxygen demand regularly causes the water column just above the sediments (*i.e.*, 6 m and deeper) to be anoxic. Comparison of DO concentrations to the stratification depths showed that reduced DO concentrations, including anoxia, regularly occur within the transition zone during the summer. Anoxia throughout the cold water layer would effectively eliminate the cold water fisheries habitat even though temperatures would support the fishery.

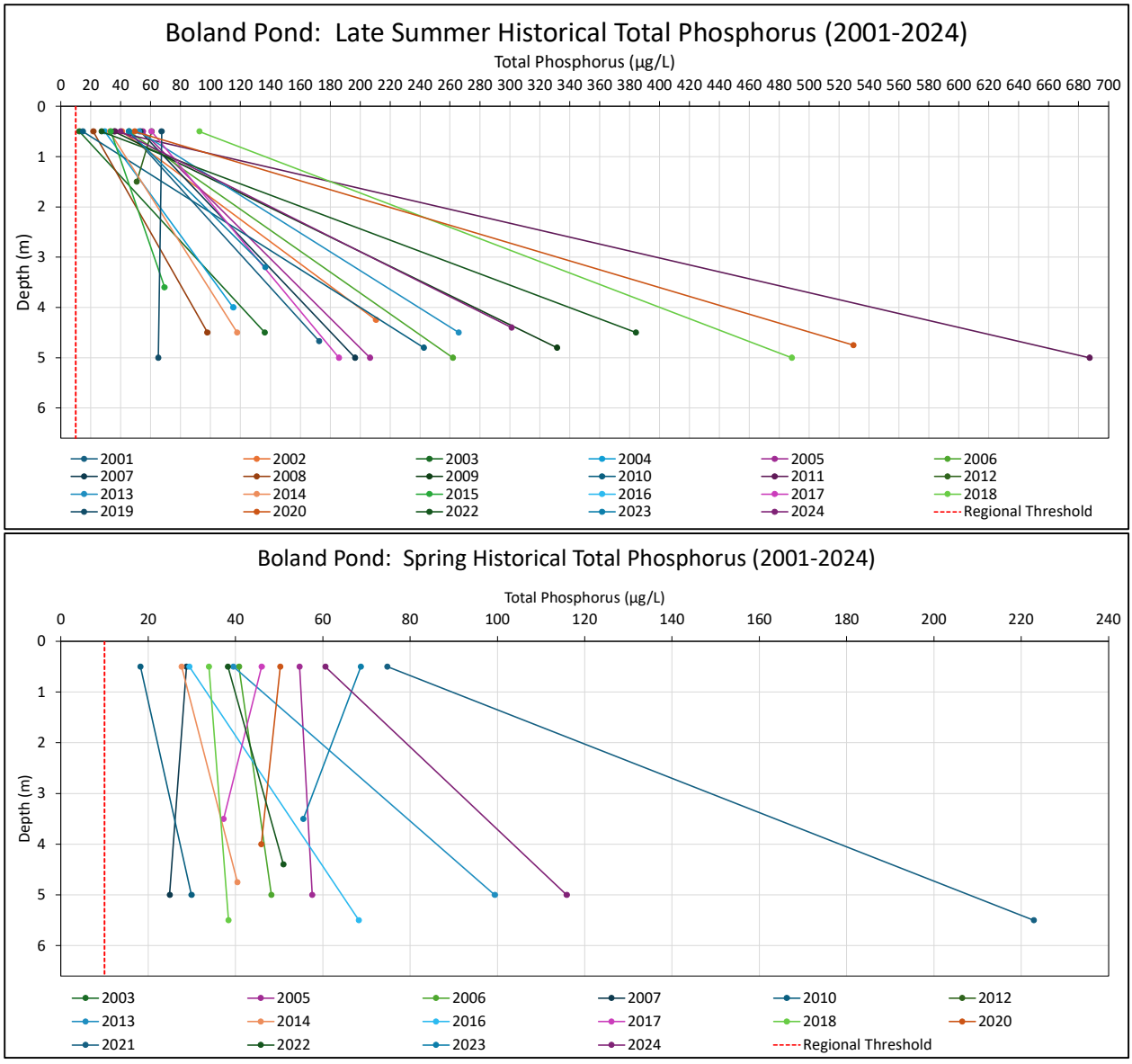

Figure 8. Boland Pond: Historical Water Column Total Phosphorus: 2001-2024. Average shallow spring and late summer historical total phosphorus (TP) concentrations tended to be similar and significantly greater than the Cape Cod regional threshold of 10 µg/L: late summer average was 41.5 µg/L (n=28), while the spring average was 45.6 µg/L (n=11). Deep TP concentrations showed the impact of deep water column anoxia in both spring and summer, but greater impacts in the summer: Deep spring average TP was 67.7 µg/L (n=11), while late summer average was 265.9 µg/L (n=27). The summer increase in deep TP concentrations would be consistent with prolonged anoxia in the deep, temperature stratified layer.

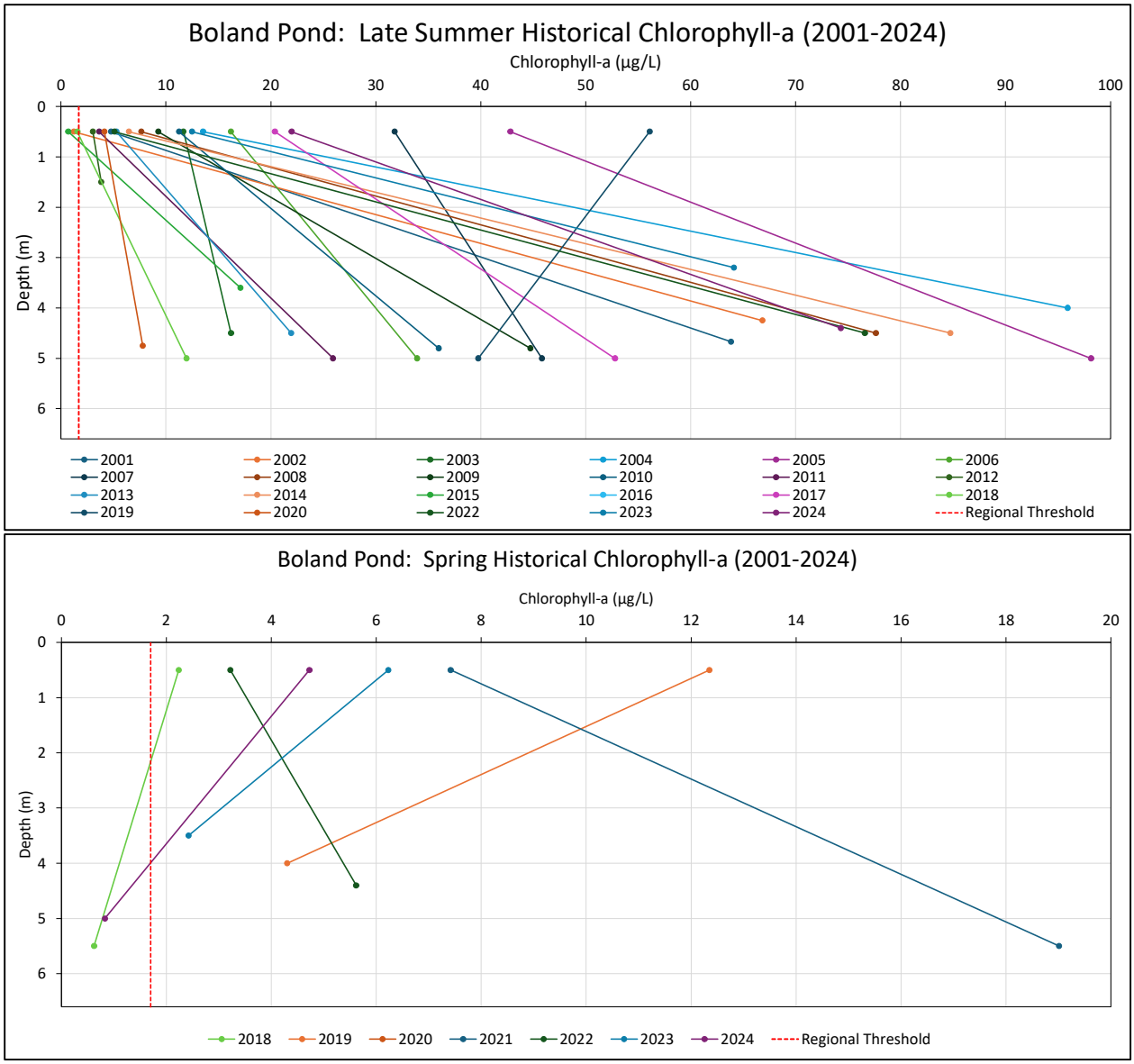

Figure 9. Boland Pond: Historical Water Column Chlorophyll-a: 2001-2024. Average spring shallow and deep historical chlorophyll-a (CHL) concentrations tended to be similar, but with both averages exceeding the Cape Cod regional threshold of 1.7 µg/L: shallow = 6.0 µg/L (n=6), deep = 5.5 µg/L (n=6). Late summer averages show the impact of higher TP concentrations with average shallow summer CHL concentrations more than 2X average shallow spring concentrations (13.0 µg/L, n = 27) and an average deep concentration more than 9X the average deep spring concentration (50.8 µg/L, n=24).