CHILMARK POND
Individual System Assessment

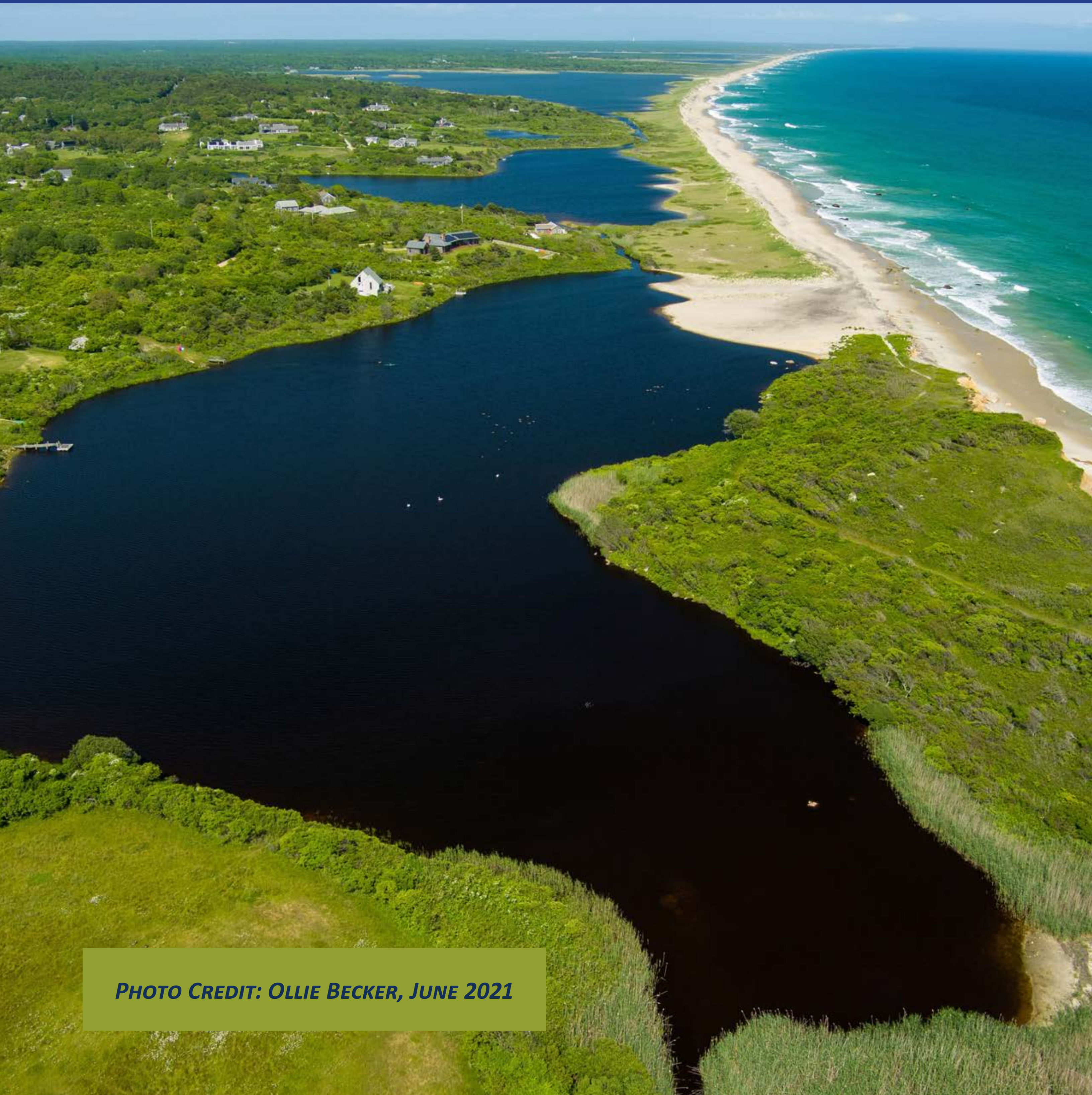

PHOTO CREDIT: OLLIE BECKER, JUNE 2021

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Martha's Vineyard Commission

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MassDEP

Acknowledgments:

The Martha's Vineyard Commission would like to acknowledge all the contributors to this detailed watershed assessment.

- *Chilmark Pond Working Group Members*
- *School for Marine Science and Technology the testing the MVC's water samples*
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- *The Trustees of Reservations*
- *Chris Murphy for his tireless dedication and contributions as the Chairman of the Up-Island Watershed Management Committee*

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RELEASE NOTES

Release of Chilmark Pond – Individual System Assessment Report

The Martha's Vineyard Commission, in partnership with MassDEP, Town Officials and the Up-Island Management Plan Chilmark Pond Working group, is developing a framework for up-island watershed management. The primary goal of this effort is to develop and implement water quality mitigation strategies that apply to all up-island ponds. Initial attention will be paid to: Chilmark Pond, James Pond, Menemsha Pond, Squibnocket Pond, and Tisbury Great Pond. The report you are receiving today, the Chilmark Pond Individual System Assessment, represents completion of the first of four "acts" that will help us achieve our primary goal, which is to clean our up-island ponds.

This Individual Assessment Report, "Act I", articulates environmental conditions found in Chilmark Pond and represents a multi-disciplinary approach to understanding many of the factors that contribute to impaired water quality in the Pond. Based on numerous studies completed in the past, as well 2021 data and analysis, this report describes the: Watershed, Physical Features, Water Quality, Biological Conditions, Socioeconomic Conditions and Land Conservation.

Although we hope you find the information presented in this report to be comprehensive and informative, it is important to note that ***the purpose of this assessment report is to inform strategic opportunities for restoring and protecting Chilmark Pond water quality and surrounding habitats.***

With the completion of Act I, we will move on to the remaining acts. Act II will identify and describe a variety of technologies and biological approaches to mitigating impaired waters and habitats. This will include researching the strengths and weaknesses of each option and quantifying the level of contaminant mitigation expected from technology when applied to specific circumstances.

Act III will focus directly on assessing technologies in terms of potential for mitigating contaminants in Chilmarks' ponds and coves. This phase will focus on analyzing the technologies that are most likely to reduce existing impaired conditions. This will include quantification of potential contaminant reduction impact relative to specific characteristics/situations found in the Pond.

Up-Island Watershed Management (208 Report) "Acts"

- **Act I – Individual System Assessment (see links below)**
- **Act II – Water quality mitigation technology and options**
- **Act III – Quantification of most appropriate technology for each unique challenge**
- **Act IV – Implementation strategies**

Act IV, the final act, will result in the management plan (208 Report) that direct how we clean our up-island ponds. Based on information gathered in Acts I-III the management plan will define implementation steps that effectively and efficiently reduce excess nutrients in Chilmark Pond. Each technology improvement and its process will be articulated alongside a cost/benefit analysis of each option. Additionally, potential funding sources and other requirements, such as permitting, will be illustrated.

In conclusion, please find the links to Act I: The Chilmark Pond Individual System Assessment and Annex below. This report was developed by MVC staff, an independent contractor from RJS Development Solutions, and the environmental consulting firm Horsley Witten. The draft was extensively peer reviewed by a variety of experts prior to release.

We look forward to sharing the Acts II-IV with you. If you have questions or comments, please direct them to: **Rachel Sorrentino** or **Sheri Caseau**

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Up-Island Watershed Management Plan (208 Report)

Important Links:

Chilmark Pond Individual System Assessment Report – prepared for the Up-Island 208 Watershed Management Plan: https://indd.adobe.com/view/3dbd6a5b-3ae0-4512-b876-4d1f400353b0

Chilmark Pond Individual System Assessment Appendix Document: https://indd.adobe.com/view/f6de9dc7-f616-45c7-a9d7-d6dfd6772dd5

MVC Virtual Pond Tour –Chilmark Pond: https://storymaps.arcgis.com/stories/65fd695b21514cada08b923281ca7cad

MVC Ponds of the Vineyard Web Page: https://storymaps.arcgis.com/stories/30dc099fffe749178b33b977c1606a8e

Photo documentation of Chilmark Pond (Ollie Becker): https://www.dropbox.com/sh/qpcuailsdz2pbga/AACB9jIriShCaL7_IoTxxTNGa/CHILMARK%20POND?dl=0&subfolder_nav_tracking=1

OVERVIEW

Chilmark Pond is a brackish estuary system formed by a barrier beach on the southern coast of Martha's Vineyard. The associated 3,400-acre watershed is located entirely within the Town of Chilmark[1].

Although once considered a single pond, "Chilmark Pond" is locally known as three separate ponds: "Upper", "Middle", and "Main" Chilmark Pond. The two areas known as Wade's Cove and Gilbert's Coves are located within the Main Chilmark Pond.

The three ponds drain from the Upper Pond to the Middle Pond, and finally, to the Main Chilmark Pond. The Main Pond periodically opens to the ocean through natural or managed breaches. Upper and Middle Chilmark Ponds are fed by freshwater streams, while the Main Pond is fed by the Upper and Middle ponds. All basins receive groundwater seepage.

It is important to note that although Upper, Middle, and Main Chilmark Pond areas are community names used to refer to the three basins, for the purposes of this report, local names will not be used to describe these areas. This report will rely on the formal names for each area: Lower Chilmark Pond (main pond, including Gilbert's and Wade's Coves) and Upper Chilmark Pond (Upper and Middle ponds).

The Chilmark watershed has areas of socioeconomic and biological importance, including critical habitat for species of conservation concern. Despite its watershed being mostly vegetated, the pond suffers from nutrient related impairments.

Report Highlights:

- **Limited tidal exchange between the Atlantic Ocean and the pond, soil characteristics, and watershed land cover and uses contribute to observed water quality issues in the pond.**
- **Lower Chilmark Pond currently has fair to moderate water quality. Water quality measures remain relatively constant with minor fluctuations in nitrogen levels; this finding is likely to be associated with little change in watershed nitrogen sources. Upper Chilmark (CHPUP) and Wade's Cove (CHP1) are key areas of concern.**
- **Water quality indicators suggest that watershed-derived nitrogen loads negatively impact critical habitats for benthic communities and inhibit eelgrass restoration.**
- **Existing infrastructure, population growth, and development pressures may exacerbate future water quality declines if appropriate nitrogen management efforts are not implemented.**

Note: all following figures and tables can be found in the appendix to this document. The appendix can also be found online at: https://indd.adobe.com/view/f6de9dc7-f616-45c7-a9d7-d6dfd6772dd5

Many of the physical, water quality, and biological features of this watershed have been described extensively in previous studies, such as the 2015 Massachusetts Estuaries Project (MEP) Report, 2019 Total Maximum Daily Load (TMDL) for Total Nitrogen, and Martha's Vineyard Commission (MVC) State of the Pond Reports. The existing conditions assessment report presented here consolidates key watershed information from these data sources, input from local experts, and updated information from publicly available sources (e.g., MassGIS, US Census, and town records). This report is organized in four parts to describe physical pond and watershed features, water quality, biological resources, and socioeconomic conditions.

Despite being in a mostly vegetated watershed, Chilmark Pond suffers from nutrient related impairments.

Middle Chilmark Pond at Fulling Mill Entrance: Ollie Becker, June 2021

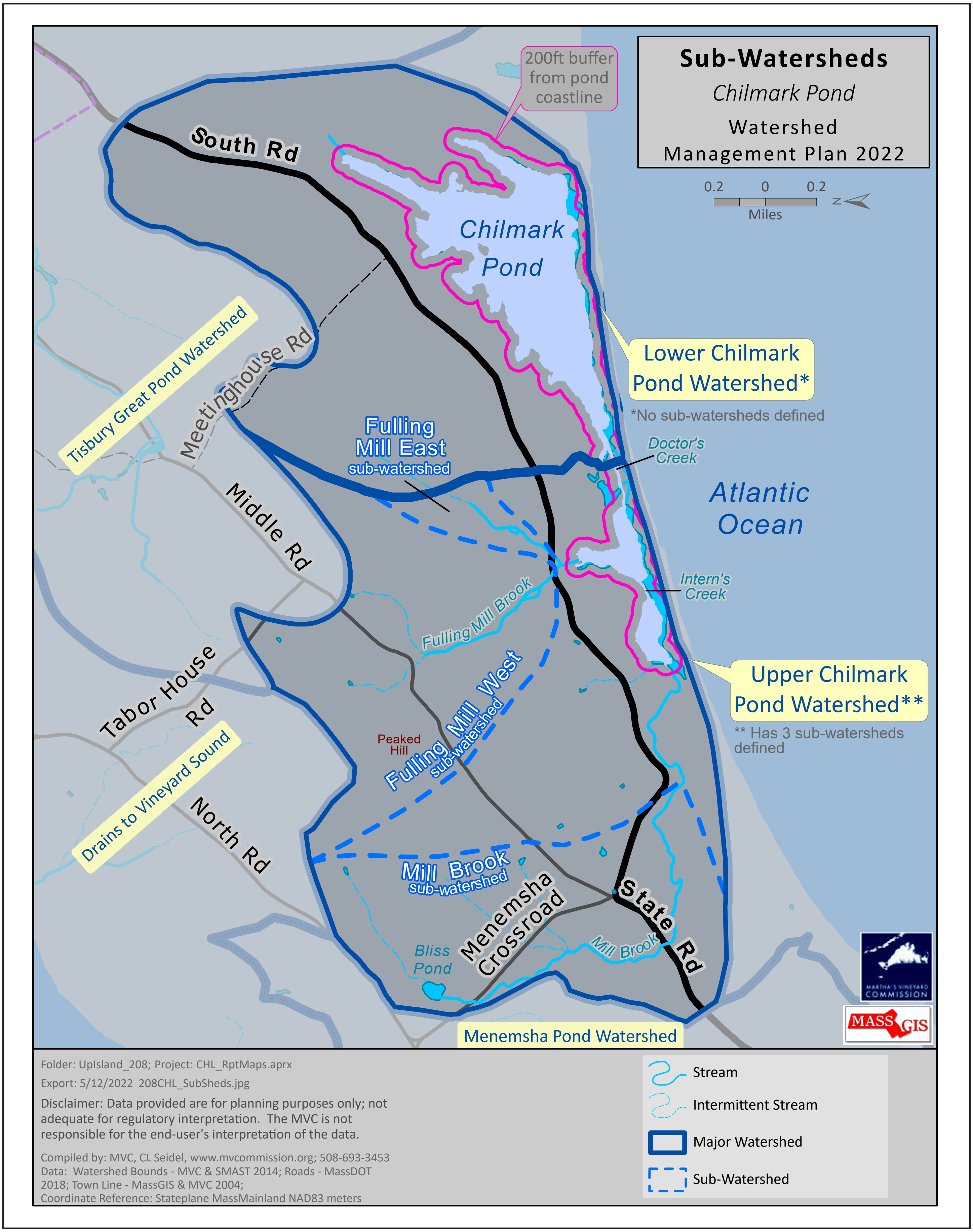


Figure 1. Watershed and Sub-watershed Boundaries for Chilmark Pond (Martha's Vineyard Commission, 2021)

THE WATERSHEDS

The Chilmark Pond Watersheds were delineated by the MEP and MVC based on the area's hydrology, geology, and topography[2], [3]. As depicted in Figure 1, the Chilmark Pond area includes two main watersheds (Upper and Lower).

Upper Chilmark includes three sub-watersheds (Fulling Mill East, Fulling Mill West, and Mill Brook-CHI). Lower Chilmark has a single watershed. The combined Upper and Lower Chilmark Pond watersheds are generally referred to as the "Chilmark Watershed" with distinctions made as appropriate. The sizes of watershed areas (acres) are outlined in Table 1. Chilmark Pond Watershed and Sub-watershed Area (acres)[4].

Sub-watershed Name	Watershed Area (acres)	Land Area (% of watershed)
Lower Chilmark Pond (including Wade's and Gilbert's Coves)	1467	43.0%
Fulling Mill East	61	1.8%
Fulling Mill West	605	17.7%
Mill Brook-CHI	617	18.1%
Upper Chilmark Pond (remaining area with unnamed sub-watershed)	662	19.4%
Total Watershed	**3411**	**100%**

Table 1. Chilmark Pond Sub-watershed Area (acres)

"Upper" and "Middle" Chilmark Pond, a.k.a Upper Chilmark Pond watershed Looking East: Ollie Becker, June 2021

The Chilmark estuarine system is characterized as a coastal open water embayment. The system is formed by a barrier beach known as South Beach. Lower Chilmark Pond is subject to occasional tidal flows due to periodic breaching of the barrier beach. Upper Chilmark Pond has fresh to slightly brackish water with surface water inputs from Mill Brook and Fulling Mill Brook which are primarily groundwater fed streams. The Chilmark watersheds are considered an enclosed embayment system which includes popular areas for recreation and land development[5].

Estimating pond size, depth, and water volume can be challenging given limited data and the impacts from barrier beach breaches. The pond's total surface area is approximately 257 acres with Lower and Upper Chilmark Ponds measured at 226 acres and 31 acres, respectively[6]. As the height of the pond changes, the pond's surface area can fluctuate by as much as 100 acres[7].

The pond's mean depth is 2.1 ft with an average tidal range of 0.5 ft when the pond inlet is open. The MEP evaluation of the pond's bathymetry estimated a maximum depth of 5.0 feet with the deepest parts in the middle and western portions of Lower Chilmark Pond, especially south of Wade's Cove and south of Long Point. The remaining areas are relatively shallow with a maximum depth of 2.0 ft. The average total volume of Chilmark Pond is estimated to be 30,013,150 cubic feet. The shallowness of the pond and flow dynamics of the barrier beach influence the ecological and biogeochemical structure of the pond water and its habitats[8] (Figure 2).

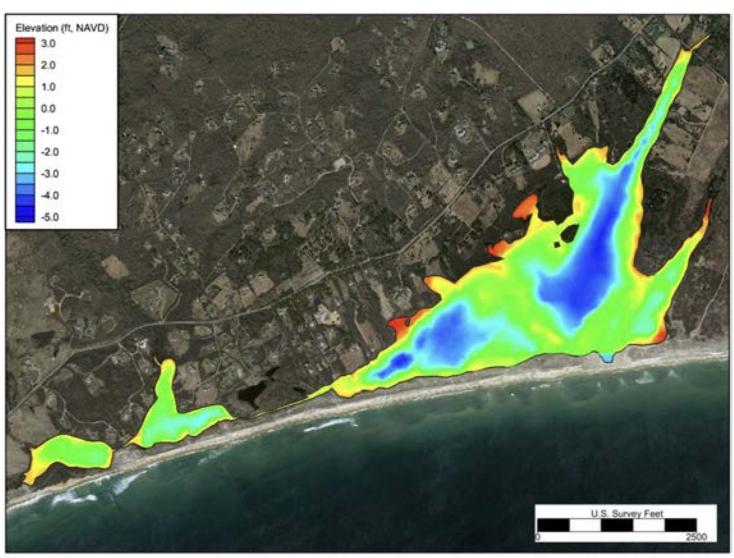


Figure V-9. Bathymetry data interpolated to the finite element mesh used with the RMA-2 hydrodynamic model. The elevations are relative to North American Vertical Datum 1988.

Figure 2. Chilmark Pond Bathymetry Map (MEP 2015)

Land Cover

Land use cover (also known as landscape patterns and conditions) within the watershed is a key component of determining the health of associated estuarine water quality. Undeveloped, forested lands and wetlands provide habitat and water quality benefits. Cultivated lands and impervious cover (and related commercial and residential development) often contribute pollutants through runoff to groundwater, receiving waters and alter natural hydrologic patterns (e.g., less recharge and evapotranspiration and more surface runoff). Information based on MVC's land cover data categories (as of 2016) is presented in the following paragraphs for all areas in the Chilmark Watershed[9] (Figure 3).

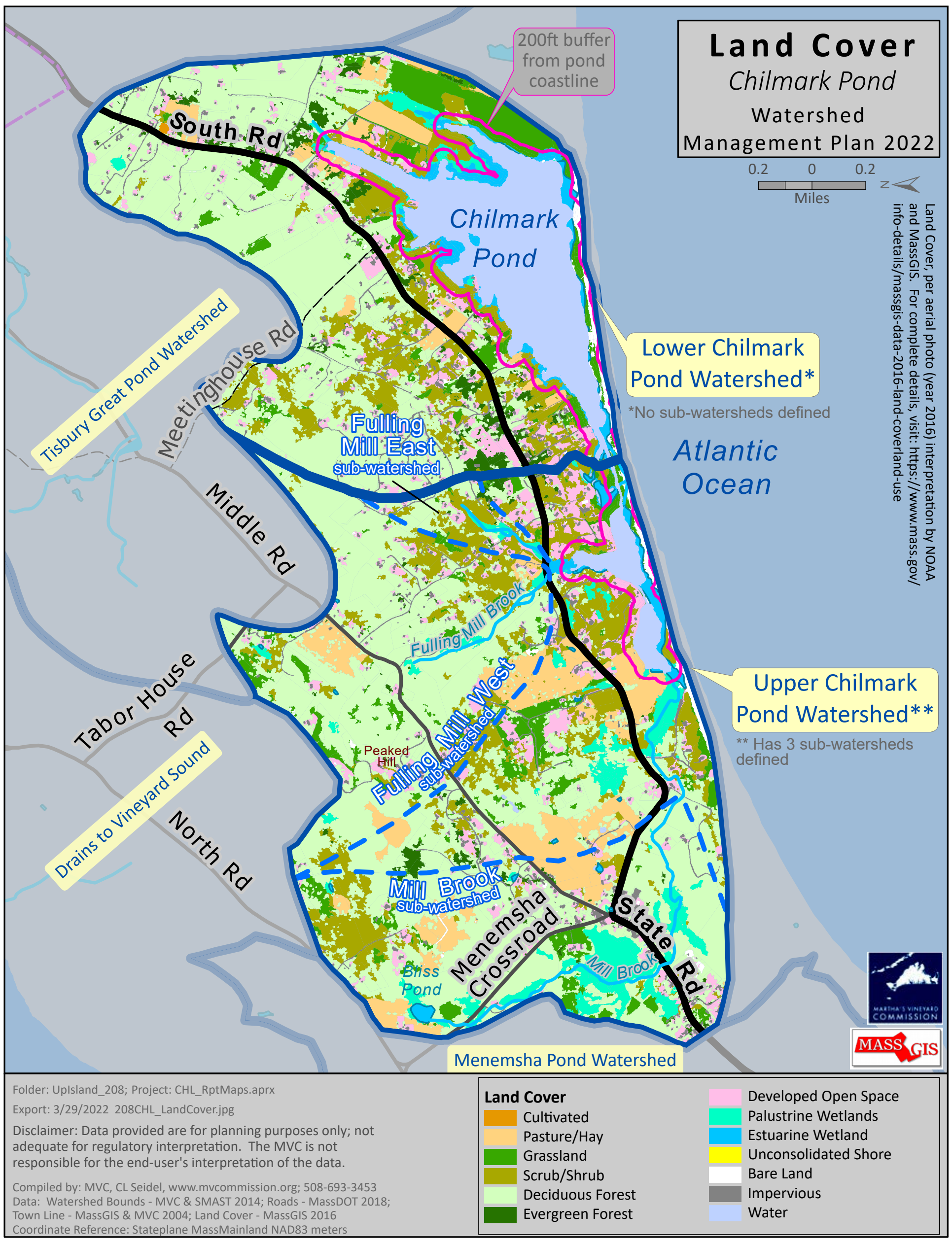


Figure 3. Chilmark Pond Land Cover Types

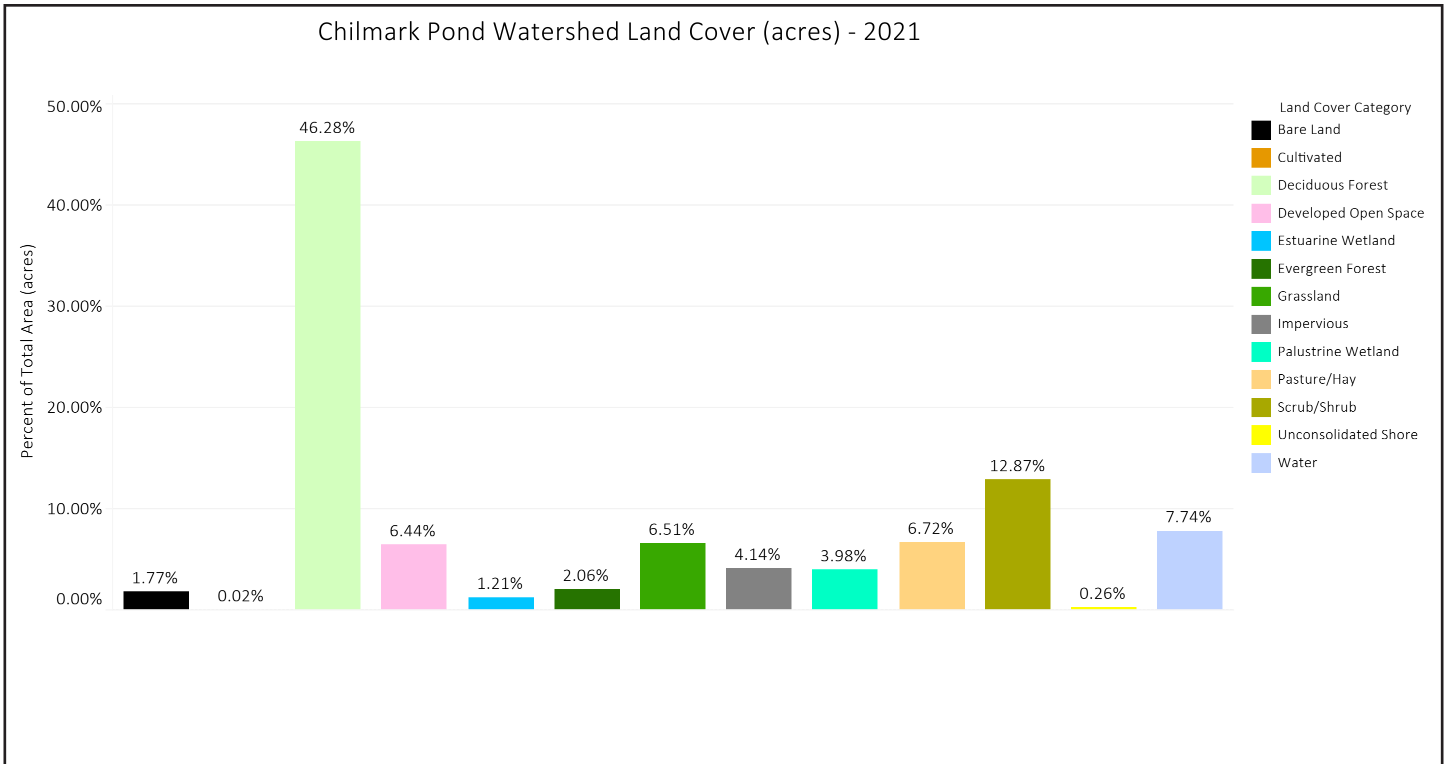


Figure 4. Chilmark Pond Land Cover Area (acres)

Most of the watershed is vegetated. Deciduous forest (46%), followed by scrub/shrub (13%) and water surface area (8%) are the three largest land cover types in the watershed. Developed open space, grassland, and pasture/hay all make up between 6 and 7% of the watershed. All remaining land cover types are 4% or less of the watershed (Figure 4).

One of the more *potentially* harmful land cover types, cultivated land, makes up less than 1% of the watershed. Another potentially impactful land cover type, impervious cover, makes up 4% of the watershed. Studies have shown that waterbodies can begin to experience adverse water quality impacts when impervious cover levels reach as little as 5% to 10%[10] of the watershed area. Additional management practices for impervious surfaces should be considered as development and/or additional impervious cover levels increase.

Pasture/hay land cover (7% of the watershed) can be indicative of animal grazing areas that *may* contribute pollutants to the watershed (e.g., nitrogen and/or bacteria from animal wastes). Further, legacy nutrients from historical agricultural uses can continue to contribute to water quality issues for long periods of time due to the travel time it takes for pollutants in groundwater to be carried through the watershed. Historic land use information prior to 1971 is not available at this time; however, there was likely extensive agriculture in the Chilmark Pond watershed, which included pasture, and perhaps cultivated, acreage[11].

Impacts from land cover must be carefully considered and conclusions drawn must reflect how various land cover types are managed. For example, depending on location and intensity of usage, even a few active agricultural acres can lead to adverse water quality impacts. However, not all agricultural land cover negatively influences the watershed. Agricultural land cover may, depending on the management practices employed by farmers, introduce fewer nutrients than one could find if the land is subject to onsite residential or commercial wastewater systems.

For the Chilmark Watershed, impervious cover does not exceed 6% in any of the sub-watersheds, with the highest value in Fulling Mill East (5%). Cultivated land cover is only present in the Lower Chilmark Pond sub-watershed and at very low levels (<1%), while pasture/hay is highest in Mill Brook-CHI and Upper Chilmark Pond sub-watersheds, 8% and 14%, respectively (Table 2). Given overarching nutrient concerns associated with agricultural practices, these sub-watersheds could be focus areas for agricultural management strategies, especially in locations with limited riparian buffers between agricultural land uses and waterbodies.

Sub-watershed Name	Pasture/Hay Land Cover (% of sub-watershed)
Lower Chilmark Pond	4% pasture/hay (54 acres)
Fulling Mill East	<1% (0.5 acres)
Fulling Mill West	6% (34 acres)
Mill Brook-CHI	8% (51 acres)
Upper Chilmark Pond (remaining area with no sub-watershed)	14% (89 acres)

Table 2. Agricultural Land Cover in Chilmark Pond Watershed

UPPER CHILMARK POND: OLLIE BECKER, JUNE 2021

Geology and Soils

The western portion of both watersheds fall in the western moraine. The eastern portion of Lower Chilmark watershed is in the sandy outwash plain; Wade's Cove serves as the dividing line[12]. The Natural Resources Conservation Service (NRCS) classifies predominant soils as Eastchop loamy sand, Haven very fine sandy loam, Nantucket sandy loam, Riverhead sandy loam, Chilmark sandy loam, and Pompton sandy loam[13]. Most watershed soils in Chilmark are classified in Hydrologic Soil Groups (HSG) A, A/D, B, and C. HSG A and B are generally suitable for infiltration (Figure 5)[14]. In other words, these soil types are likely to infiltrate (absorb) more rainfall than others. Although the characteristics of these soils may reduce stormwater runoff by filtering stormwater (and wastewater), the characteristics of these soil types can also increase the potential for pollutants to leach into groundwater.

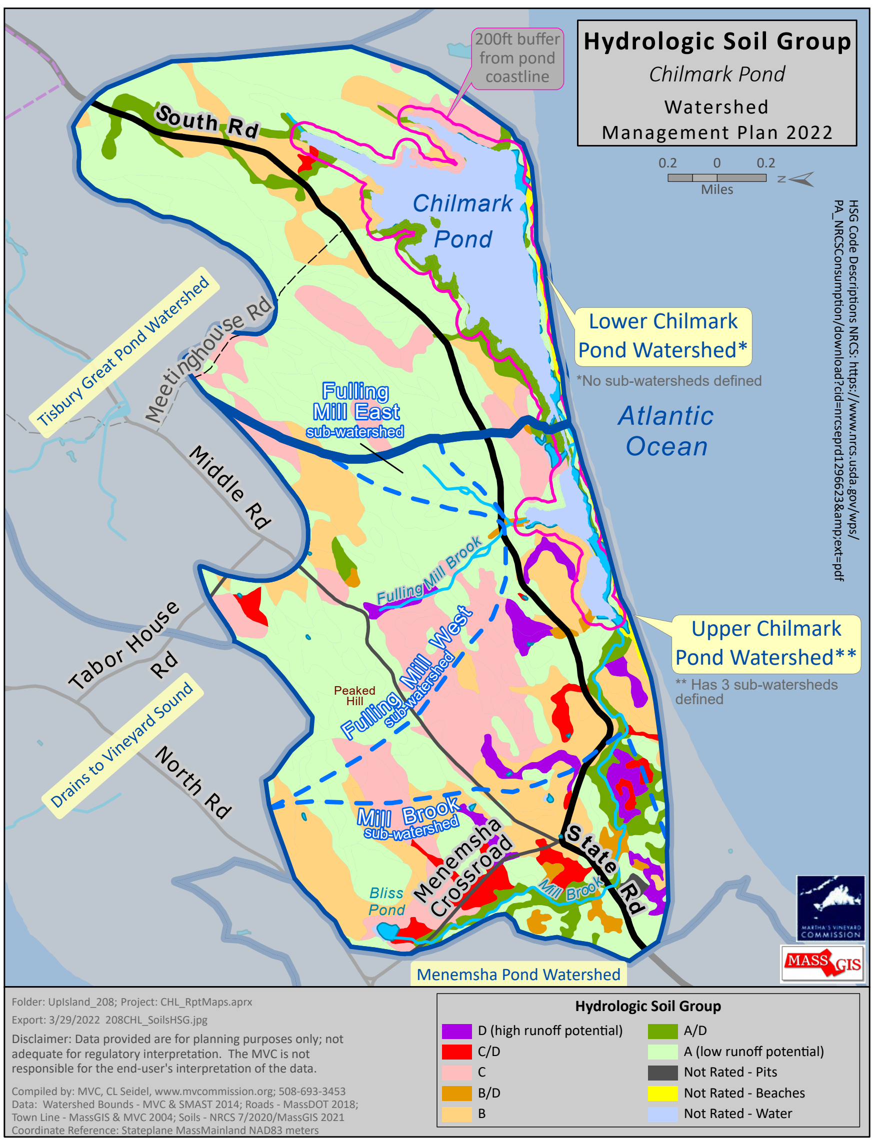


Figure 5. Chilmark Pond Hydrologic Soil Groups

Soluble nitrate is highly mobile and easily moves through the soil profile to groundwater, especially after heavy rainfall or with increased irrigation. The characteristics of soils in the Chilmark watershed are more likely to transport nitrogen to groundwater and are therefore associated with susceptibility to nitrogen pollution. Most (69%) of the Chilmark Pond watershed soils are categorized with a high potential for nitrate-nitrogen leaching[15, 16]. Upper Chilmark Pond and Mill Brook-CHI soil characteristics are less likely to transport pollutants and therefore have lower nitrogen-leaching potential than the watershed as a whole (Figures 6 and 7).

Soil types in the watershed highlight the importance of effective onsite wastewater system designs and fertilizer management. Nitrogen removal strategies could be prioritized in sub-watersheds with higher leaching and runoff potential.

The depth to groundwater in the area is estimated by NRCS to be within 2.0 ft below the surface[17, 18]. However, these estimates are not available for the western moraine and should be used for general planning purposes only[19]. More accurate groundwater elevation data could be found via monitoring wells, onsite soil evaluations, and local studies/records, if available. Depth to groundwater is important when considering stormwater and onsite wastewater management systems.

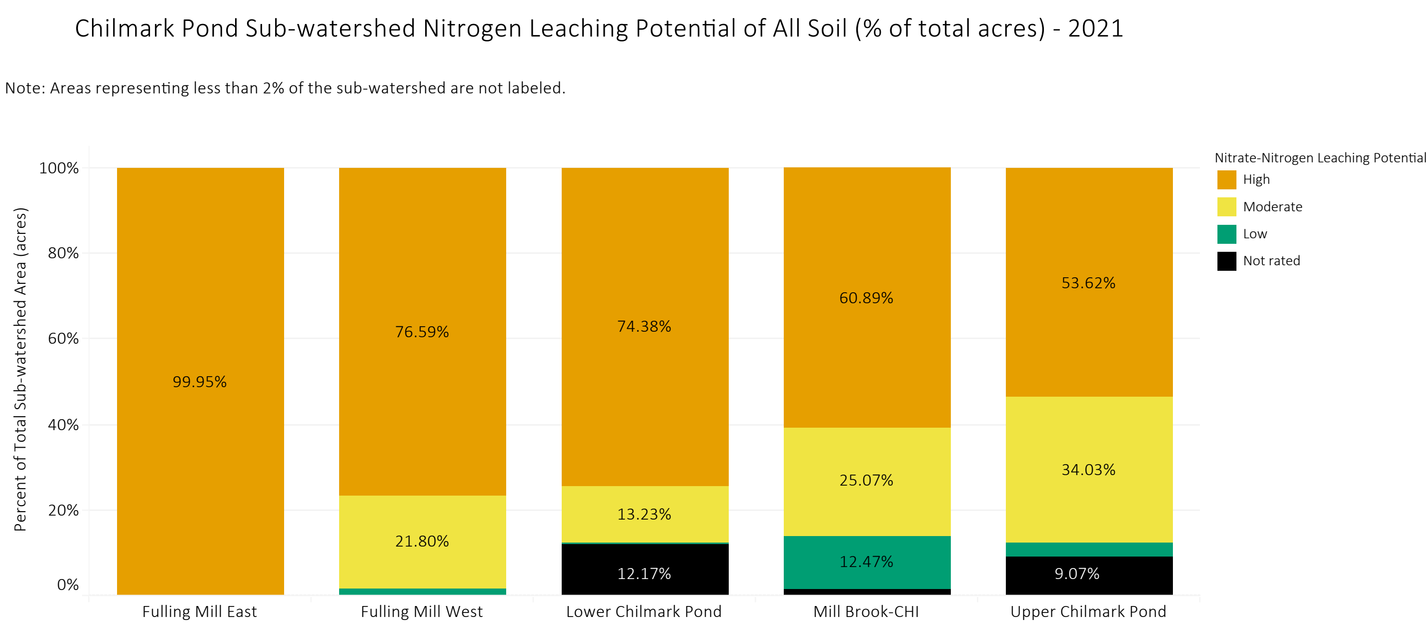


Figure 6. Chilmark Pond Nitrogen Leaching Potential by Sub-watershed

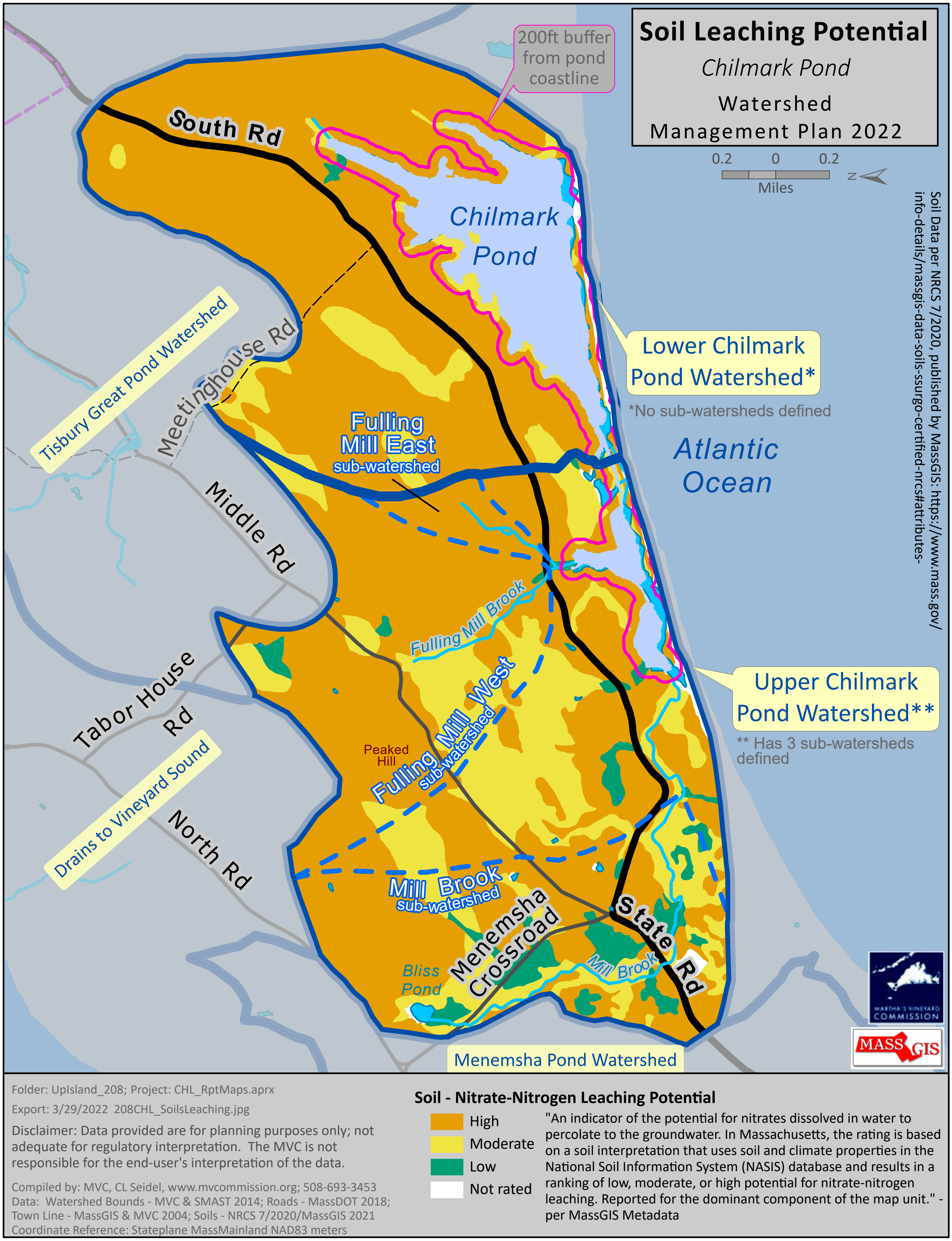


Figure 7. Chilmark Pond Soil Leaching Potential

Flows and Residence Time

Freshwater enters Chilmark Pond via precipitation, stream flows, and groundwater inflow. The eastern sub-watersheds receive freshwater via groundwater flows, while the western sub-watersheds receive freshwater to Upper Chilmark Pond via surface water from Mill Brook, Fulling Mill Brook, and groundwater discharge. There are no rivers or streams that provide water to Wade's Cove or Gilbert's Cove. Groundwater inputs to the Chilmark Pond system are estimated to total 895,355ft3/day; contributions from each sub-watershed are summarized in (Table 3).

Saltwater enters the pond through wave action washovers at the barrier beach[20]. And, even when there is no human-made channel, Chilmark Pond discharges some pondwater by seepage through the barrier beach[21].

Chilmark Pond has been managed by intentional breaching since colonial times to increase salinity and provide habitat for valued species of finfish and shellfish, especially oysters[22]. Today, the Chilmark Pond Association manages breaches to control salinity levels and flooding in adjacent areas[23]. The pond is opened approximately every four months when water depths reach one meter above mean sea level.

When open, ocean water enters the Lower Chilmark Pond main basin and flows into Wade's Cove. The length of time the inlet remains open varies based on weather, wind, and currents. The MEP noted that between 2011 and 2014, there were three or four openings each year, for an average duration of eight days (approximately 30 days per year), however at times, openings last less than a week[24]. Records provided by the Chilmark Pond Association indicate that from 2011 to 2021 there were three or four openings per year lasting an average of 19 days each (approximately 66 days per year), see Table 4[25].

Sub-watershed Name	Daily Input (ct/day)
Lower Chilmark Pond (estuarine)	353,430
Upper Chilmark Pond (freshwater)	175,922
Fulling Mill East (freshwater)	17,374
Fulling Mill West (freshwater)	172,659
Mill Brook (freshwater)	175,970
Total	**895,355**

Table 3. Chilmark Pond Sub-watershed Groundwater Input

Chilmark Pond Watershed - Number of Days Open (2003-2021)

	January	March	April	May	June	July	August	October	Novemb..	Decemb..	February	Septem..	Annual Days Open (total)
2003								20		10			30
2004			15			36							51
2011		11		22			8		8				49
2012		8								4		12	24
2013		3	3		24						4		34
2014	4	8								5			17
2015			12							83			95
2016			22										22
2017	23	18		20				28					89
2018		52							79		13		144
2019			2			26			10	20			58
2020			17		18					14	8		57
2021			17								3		20

Table 4. Number of Days Inlet Open - Chilmark Pond 2003-2021

When breaches close quickly, *the pondwater is not fully replaced with incoming offshore water, due to insufficient* tidal exchange and mixing of nutrient rich pond water with low nutrient ocean water. In these cases, pond water depths are lowered, but with *less than optimal* water quality improvements.

However, according to the MEP, the nature of water residence time in Chilmark Pond indicates that intentional breaching can permit enough water exchange to improve water quality during a breach when pond depth exceeds ocean water levels.

System residence time is the average time required for one unit of water (e.g., one water drop) to migrate from a point within the embayment to the entrance of the system (ocean). *Local residence* time is the average time needed for a water drop to migrate from inside a sub-basin of a pond to the outlet to the main basin. A lower residence time typically corresponds to better water quality. It is estimated that the Chilmark Pond has a residence time of approximately 2.3 days when the pond is open.

Although system and local residence times are common measures of how much time it takes for one unit of water to circulate in the estuary system, it can take up to three times longer for 90% of all the water within the entire system to circulate.

Summary

Chilmark Pond is particularly sensitive to nitrogen enrichment due to its limited tidal exchange. Residential watershed nitrogen inputs contribute to observed water quality issues in Lower Chilmark Pond main basin, coves, and Upper Chilmark Pond. Nutrients in groundwater and surface water flows, as well as atmospheric deposition are potential sources of excess nitrogen[26]. Furthermore, soil conditions within the watershed support groundwater transport of wastewater/residential nitrate to pond waters. And, while much of the watershed's land cover is vegetated, there are areas of impervious cover and agricultural land cover that can contribute to compromised water quality.

Managed breaches will continue to play a significant role in maintaining the nutrient related health of the pond in the future. Further study is needed to confirm impacts of breaches. Changing coastal conditions, such as sea level rise, are expected to affect these conditions and should be considered when evaluating the frequency and effectiveness of managed breaches in the future.

Lower Chilmark Pond (Open): Ollie Becker, June 2021

WATER QUALITY

Chilmark Pond is currently classified as an impaired saltwater body for enterococcus, estuarine bioassessments, fecal coliform, nitrogen, and nutrient/eutrophication. Biological indicators, such as chlorophyll-a and Total Pigment also suggest impairment. Possible sources of controllable nitrogen entering Chilmark Pond which may impact water quality include: wastewater, fertilizers, and agricultural activities and wildlife.

Relevant regulatory water quality standards and impairment thresholds are summarized in Table 5. These standards reflect the Massachusetts Surface Water Quality Standards (314 CMR 4.00), which designate uses and water quality criteria to support those uses, per the federal Clean Water Act[27] and the Massachusetts Integrated List of Waters[28] .

Water Quality Parameters	Regulatory Standards	MEP Status (2015)*	MVC Average (2016-2021)	Standard Sources
Nitrogen	0.50 mg/L	Impaired (0.61 mg/L)	Exceeds Standard (0.85 mg/L)	2015 Massachusetts Estuary Project, TMDL
Temperature	<85°F/29.4°C (At one time) <80°F/26.7°C (Max daily mean)	Status Not Reported	Meets Standard Requirements (74.9°F / 23.8°C)	Massachusetts Surface Water Quality Standards (314 CMR 4.00)
Dissolved Oxygen	6.0 mg/L	Most sampling sites were below standard requirements	Meets Threshold Requirements	Massachusetts Surface Water Quality Standards (314 CMR 4.00)
Total Pigment Gradient	10.0 µg/L	Above impairment threshold**	CHPUP (10.5) and CHP6 (25.6) exceed requirements. All other sampling sites meet threshold requirements.	2020 Martha's Vineyard Water Quality Technical Report

*** Values in this column represent the average of four samples collected from CHP1 in 2004 (Howes et. al2015, Table VI-1)**

**** MEP pigment data was based on chlorophyll-a only. The Total Pigment Gradient data referenced here is for "MVC Average (2016 - 2021)" is based on Total Pigment.**

Table 5. Chilmark Pond Water Quality Standards and Thresholds

Water quality samples are collected during the critical summer period by the MVC in Chilmark Pond at six locations (Figure 8). The MVC uses a variety of state and nationally adopted biological and chemical water quality indicators to monitor and assess ecosystem health, habitat suitability, potential stressors, and to develop management strategies including the following: salinity, conductivity, water temperature, nitrogen, dissolved oxygen, chlorophyll-a, total pigment, water clarity, and phosphorus.

Summary of naming conventions used for ponds in the Upper and Lower Chilmark Watersheds and notes on water quality sample stations:

- **"Upper Chilmark Pond" is a small pond that connects to "Middle Chilmark Pond" via Intern's Creek. It is especially important to note that there are no water quality stations in "Upper Chilmark Pond." The CHPUP sample station refers to water quality samples taken from the area informally known as "Middle Chilmark Pond".**
- **"Middle Chilmark Pond" connects to "Main Chilmark Pond" via Doctor's Creek. All water quality samples taken at this location are from the CHPUP sample.**
- **In this document, "Middle Chilmark Pond" and "Upper Chilmark Pond" are both referred to as Upper Chilmark Pond.**
- **"Main Chilmark Pond" is considered the main basin of the estuary system and, in this report, is referred to as Lower Chilmark Pond. Wade's Cove and Gilbert's Cove are both located in Lower Chilmark Pond. Water quality sample stations in the main basin include CHP1, CHP2, CHP4, CHP5, and CHP6.**

Water Quality Testing: Martha's Vineyard Commission

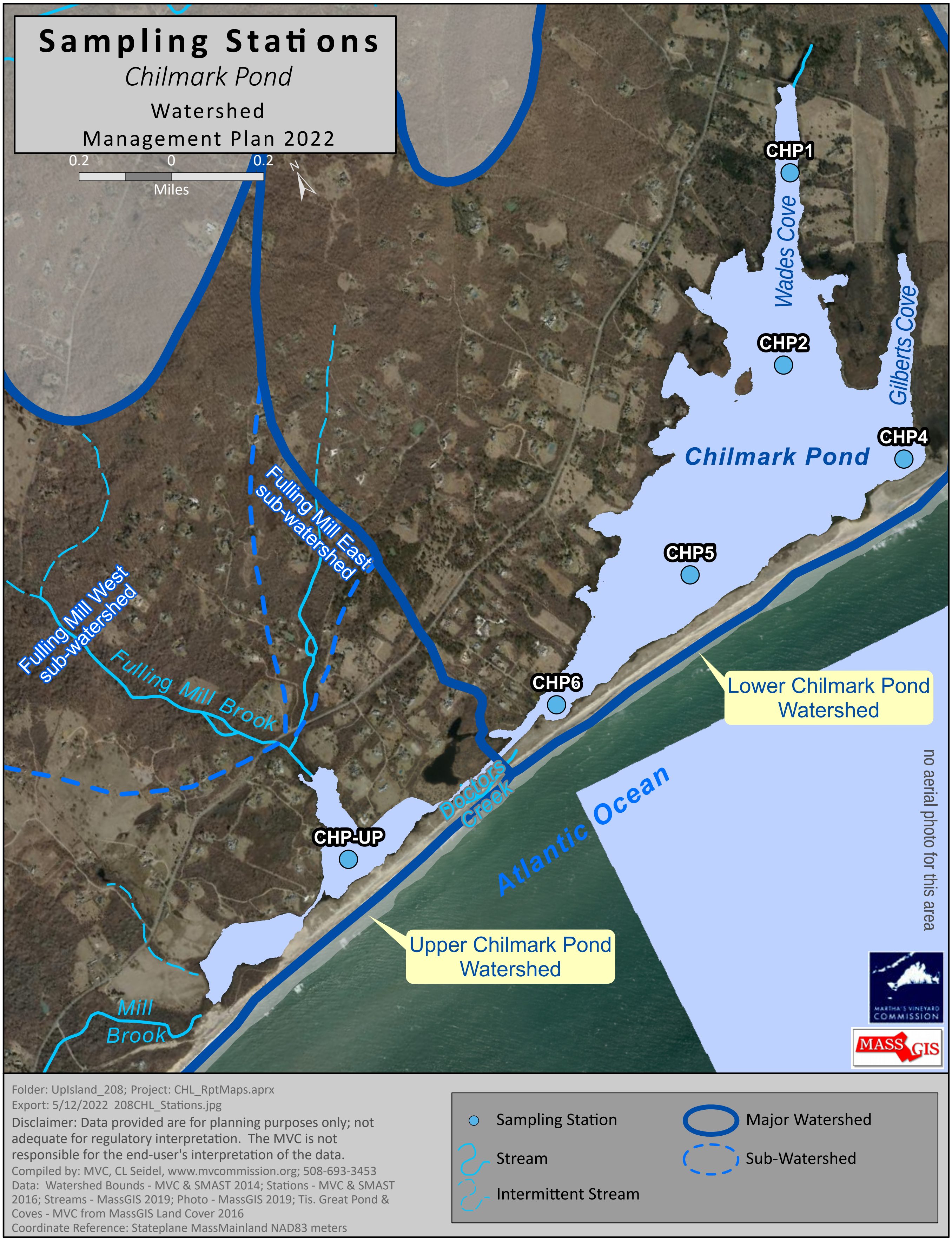


Figure 8. Chilmark Pond Water Quality Sampling Stations (2016-2021)

Salinity

Salinity is an important characteristic of a waterbody and can be an indicator of habitat quality for aquatic organisms, as well as an indicator of tidal influence. As seen in Figure 9, average salinity fluctuated at all sites over the past six years[29]. Prior to a managed breach, salinity levels are between 6-10 ppt. After a breach, salinity levels rise to greater than 20 ppt[30]. Note, Upper Chilmark Pond (CHPUP) consistently has lower average salinity values as compared to the other sampling sites. Lower values are expected due to the location of the CHPUP sampling site which receive a relatively high volume of freshwater inputs and relatively low tidal influence.

Changes in salinity, such as the increases observed in 2019 and 2021, may indicate changing conditions that impact ecosystem health and/or improved managed breaching. Accordingly, changes in salinity have important habitat implications for future managements strategies including managed breaches.

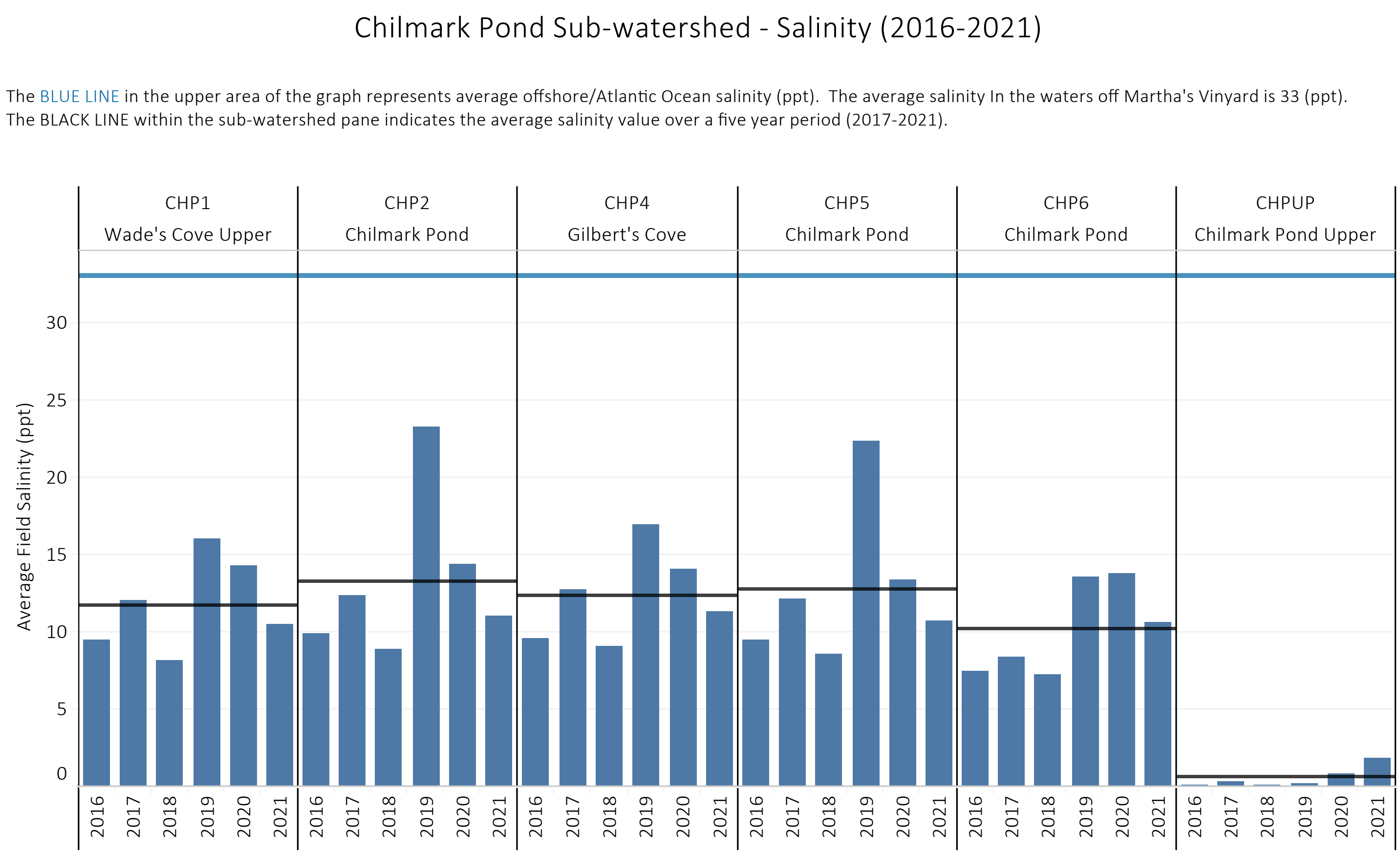


Figure 9. Chilmark Pond Salinity Data (2016-2021)

Water Temperature

Water temperature exerts a strong influence on biological activity, and dissolved oxygen levels (with lower solubility at higher temperatures). As required by 314 CMR 4.00, temperature must not exceed 85˚ F (29.4˚ C) nor a maximum daily mean of 80˚ F (26.7˚ C). As seen in Figure 10, average water temperature at all sites have been below 80 ˚F since 2016.

Chilmark Pond Sub-watershed - Water Temperature (2016-2021)

Massachusetts surface water quality standards state that coastal water temperature shall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C). The RED LINE indicates the 85°F (29.4°C) limit. https://www.epa.gov/sites/default/files/2014-12/documents/mawqs-2006.pdf

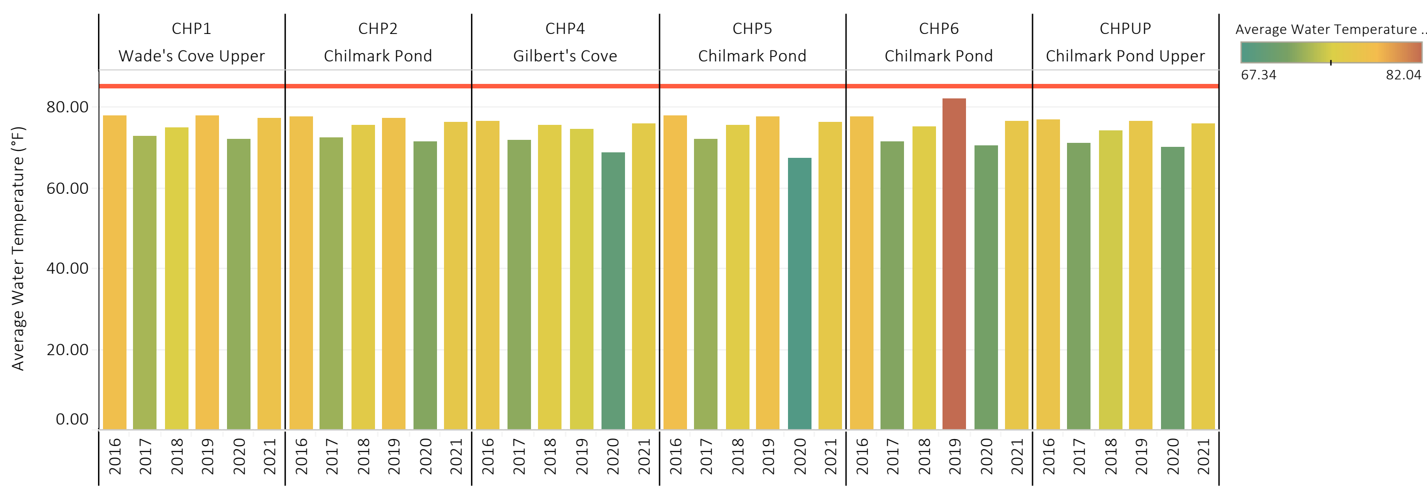


Figure 10. Chilmark Pond Temperature Data (2016-2021)

Nitrogen

Nitrogen is often the factor limiting plant, phytoplankton and algae growth in brackish coastal waters and therefore is often the target for management. It is the excess of nitrogen and resulting eutrophication of our estuaries and coastal waters world-wide, which is causing fish kills, loss of eelgrass, other seagrasses and benthic animal communities and significant habitat declines. While extremely low levels of nitrogen would negatively affect organisms in brackish water by limiting potential for growth, nitrogen in excess can be harmful to estuarine water and habitat quality.

The 2016 Massachusetts Integrated List of Waters identified Chilmark Pond (MA97-05) as impaired for total nitrogen. Based on the information contained in earlier studies, it is assumed that agriculture and wastewater are the two largest controllable sources of nitrogen in the Chilmark Pond watershed. Other sources of nitrogen include fertilizers, run-off from impervious surfaces, and direct atmospheric deposition to the waterbody surface area. The 2015 MEP analysis found in Table 6 summarizes the estimated nitrogen load to Chilmark Pond from each source[31].

Source	Nitrogen Load (kg/year)
Wastewater	2,560
Turf Fertilizers	264
Agricultural Fertilizers	253
Agricultural Animals	2.877
Impervious Cover	267
Water Surface (Atmospheric Deposition)	1.429
Natural Surfaces	1.337
Buildout*	271
* Buildout loads include wastewater disposal, fertilizer, and impervious surface additions from developable properties. .	

Table 6. Chilmark Pond Nitrogen Load Model Inputs (Howes, et. al, 2017)

The average total nitrogen (N) concentration in the Chilmark Pond estuarine system was 0.61 mg/L in 2004[32]. The MEP determined a nitrogen concentration of 0.50 mg/L as the threshold at which Chilmark Pond's benthic infauna habitat could be restored[33]. See Table 7 for watershed loads and targets, as well as the percent change required to reach the threshold loads (in kg/year).

Table 8 compares average water quality data in 2004 and in 2021. Note, the total nitrogen concentration data reported in the 2015 MEP represents an average of the data collected in 2004 (which was the only data available at that time)[34]. A six-year average (2016-2021) shows that total nitrogen concentrations have overall increased to levels above the 2004 values. However, samples from 2021 indicate lower nitrogen concentrations in all sampling locations, when compared to the six-year average.

Furthermore, nitrogen concentrations were variable in Chilmark Pond during the 2016-2021 time-period. Since 2016, data show that: A) a six-year average indicates that nitrogen levels are consistently above the applicable standard in all stations (Figure 11), and B) there was a substantial spike in total nitrogen concentration at all sites in 2020.

Moreover, CHP1, CHP5, and CHP6 have remained impaired for nitrogen since the 2015 MEP study was completed, a characteristic that is likely to negatively impact ecosystem health of the overall pond. Consistent load reductions can be achieved through a variety of strategies including better management of watershed nitrogen sources such as wastewater, stormwater, fertilizers, increasing the natural attenuation of nitrogen within the freshwater systems, and/or improving tidal exchange[35].

Sub-embayment	Present Load (kg/year)	Threshold Load (kg/year)	Threshold % Change
Chilmark Pond East	2002.0	1553.1	-22%
Chilmark Pond West	4239.1	3847.1	-9%
*Embayment and surface water loads used for total nitrogen modeling of threshold conditions for Chilmark Pond, with total watershed N loads, atmospheric N loads, and benthic flux.			
** Information published in Table ES-2 (Page 11) of the Chilmark Pond Embayment System Massachusetts Estuaries Project Report (2015).			

Table 7. Chilmark Pond TOTAL Nitrogen Load Reductions Required to Achieve Nitrogen Threshold (TMDL)

Sub-embayment	Sampling Station	MEP Observed Total Nitrogen Concentration (2013) (mg/L)	2016-2021 Average Total Nitrogen Concentration (mg/L)	2021 Observed Total Nitrogen Concentration (mg/L)	Threshold Total Nitrogen Concentration (mg/L)
Lower Chilmark Pond (including Wade's Coves)	CHP1	0.61	0.81	0.64	0.50
Lower Chilmark Pond	CHP2	-	0.75	0.63	0.50
Gilbert's Cove	CHP4	-	0.71	0.60	0.50
Lower Chilmark Pond	CHP5	-	0.97	0.64	0.50
Lower Chilmark Pond	CHP6	-	0.79	0.62	0.50
Upper Chilmark Pond	CHPUP	-	0.85	0.41	0.50
Total System		**0.61**	**0.71-0.97**	**0.41-0.64**	**0.50**

Table 8. Chilmark Pond Total Nitrogen Data Comparison

Chilmark Pond Sub-watershed - Total Nitrogen Concentration (mg/L) (2016-2021)

The RED LINES indicates concentrated total nitrogen target (mg/L) as established in the MEP (2013).

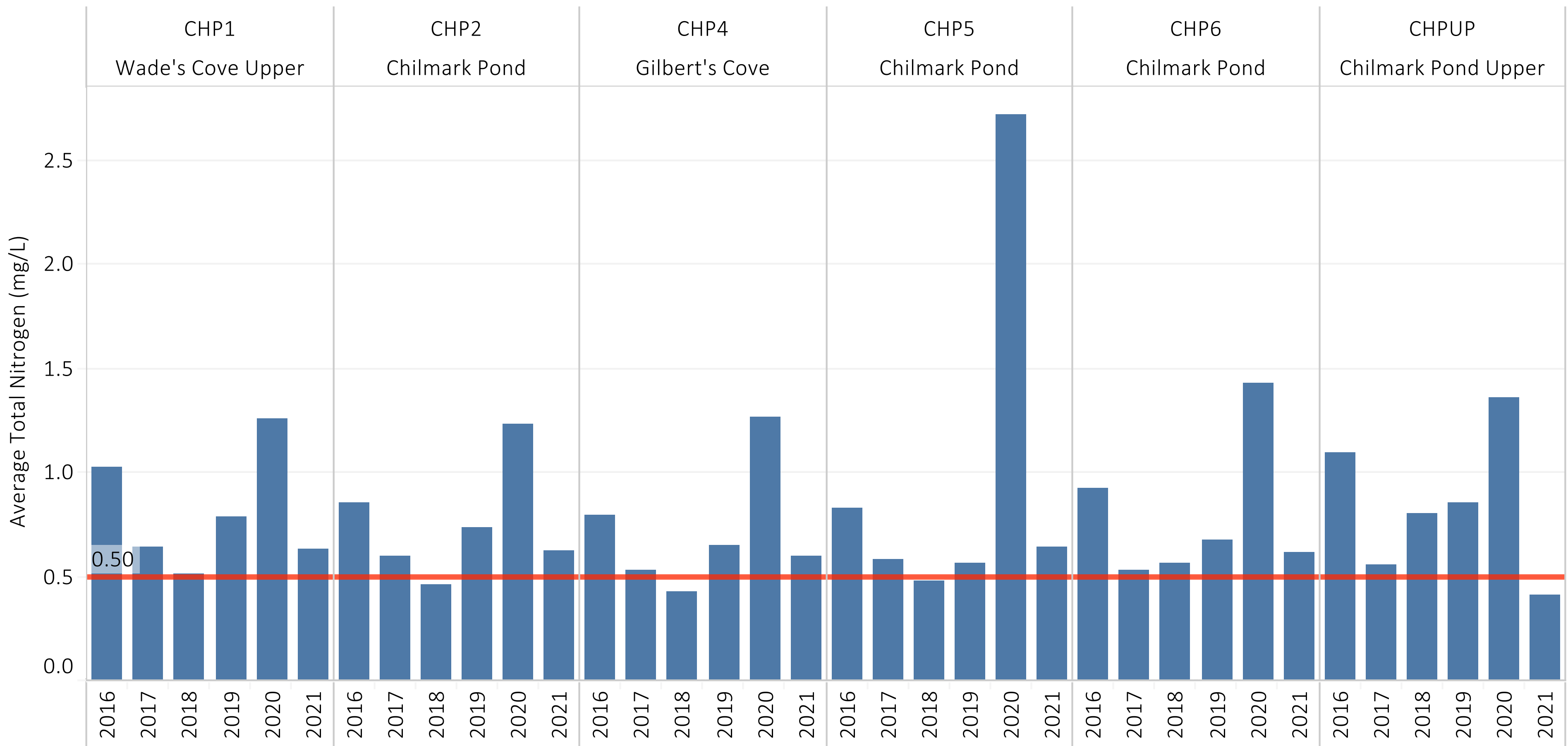


Figure 11. Chilmark Pond Total Nitrogen by Sub-watershed (2016-2021)

Dissolved Oxygen

Dissolved Oxygen (DO) levels are a good indicator of water quality conditions that may affect plant and animal habitat. Low DO concentrations may indicate excessive nutrient (eutrophic) conditions in Massachusetts estuaries. The DO threshold of 6 mg/L represents the amount of DO required for most organisms to thrive.

Despite the listed impairment, the DO values observed in 2021 were generally above 6 mg/L at all sites (samples taken near the bottom surface of the sample sites). The lowest observed DO was at CHP1 (Wade's Cove).

DO levels can widely fluctuate with photosynthesis and respiration of plants throughout the day and night. The quality of the habitat is determined in large part by the time periods in which water quality is at its worst, even if that is for a brief period of time. DO is likely to fall at night, therefore, in areas where the DO stays close to the threshold during the day, one could expect DO to drop below the threshold at night. This is likely to be true, especially at CHP1, where the DO stays close to the threshold during the day. Consequently, one could expect the benthic communities in these areas to be subject to stressful habitat conditions (Figure 12)[36].

Chilmark Pond Watershed - Dissolved Oxygen (2016-2021)

The RED LINE indicates the threshold dissolved oxygen level, values below this line are associated with stressful conditions in which aquatic species fail to thrive.

*All values represent dissolved oxygen levels taken at the BOTTOM surface of the pond.

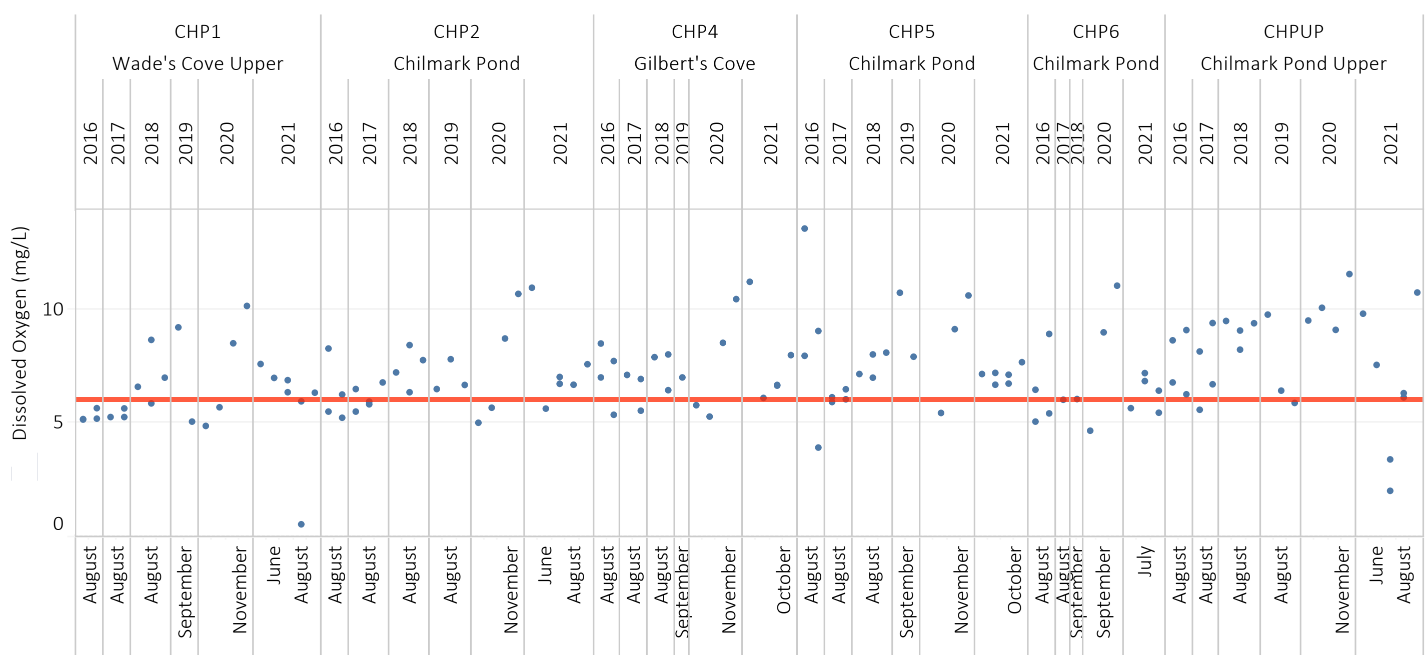


Figure 12. Chilmark Pond Dissolved Oxygen by Sub-watershed (2016-2021)

Chlorophyll-a and Total Pigment

Chlorophyll-a is a water quality indicator used to classify the trophic condition of a waterbody and is reflective of the amount of algae (in this case phytoplankton) present. Chlorophyll-a is the major chlorophyll in green plants and algae and therefore is naturally present in aquatic systems.

Excess algae, which is often expressed as elevated Chlorophyll-a values, can be harmful to ecosystems because it often indicates high organic matter levels that can result in low oxygen levels at night or during the aging and decay after death of the algae. Elevated chlorophyll-a values, can be harmful to ecosystems as they indicate high organic matter levels which can ultimately result in low oxygen levels at night or during the aging and decay of the algae. Chlorophyll-a concentrations are highest at CHPUP (Chilmark Upper Pond (Figure 13).

Total pigment is a combined measure of Chlorophyll-a and Pheophytin-a that indicates the amount of microscopic living and expiring plant matter in the water. While this parameter is not a direct measure of phytoplankton biomass, total pigment is a commonly used indicator for assessing biological and habitat health. The MVC has been regularly analyzing Chilmark water samples for total pigment since 2016. Total Pigment concentrations have been variable in the past six years. It is unclear the extent that the observed fluctuations reflect whole pond levels or results from the sampling frequency that may allow blooms to be only partially captured before they settle.

Chilmark Pond Sub-watershed - Chlorophyll-a (2016-2021)

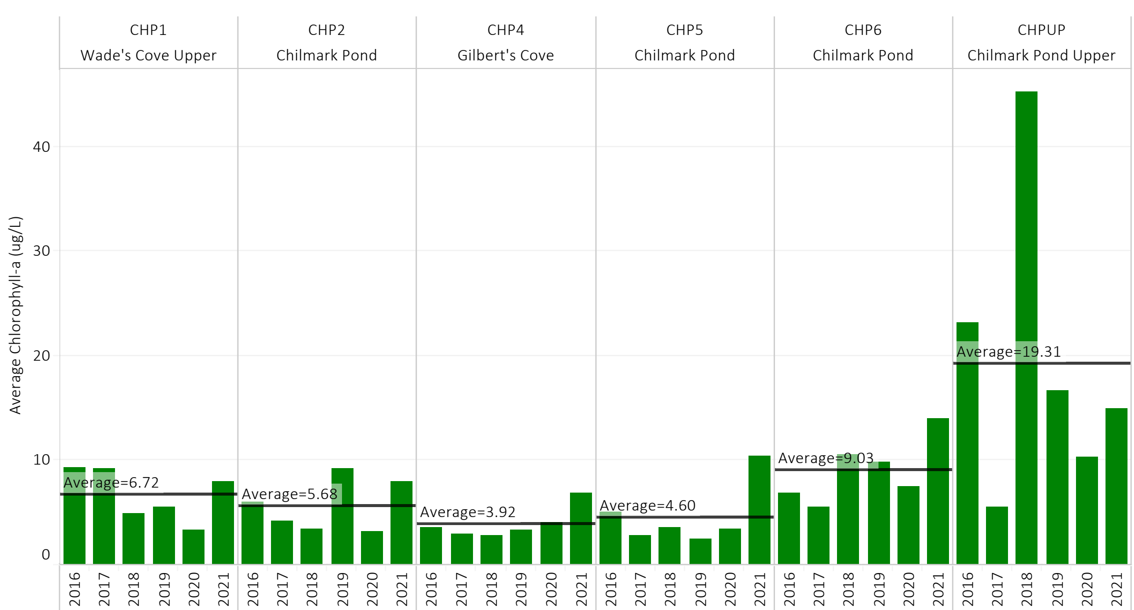


Figure 13. Chilmark Pond Chlorophyll-a (2016-2021)

Data from 2021 clearly indicated a blooms occurred that resulted in total pigment concentrations at or above the threshold of impairment of 10.0 µg/L at all but the CHP4 sampling location[37, 38].

Samples show that the highest pigment concentrations are from samples collected from CHPUP (Chilmark Upper Pond) (Figure 14). Based on these trends, nitrogen is likely taken up by plant matter at CHPUP (Chilmark Upper Pond), which is consistent with the fact that this sampling location has the second highest average total nitrogen concentration. There may be higher nitrogen inputs to this location contributing to the significantly high chlorophyll-a and total pigment concentrations, this is described further in the Socioeconomic section.

High pigment concentrations combined with high total nitrogen levels in the pond may indicate eutrophication.

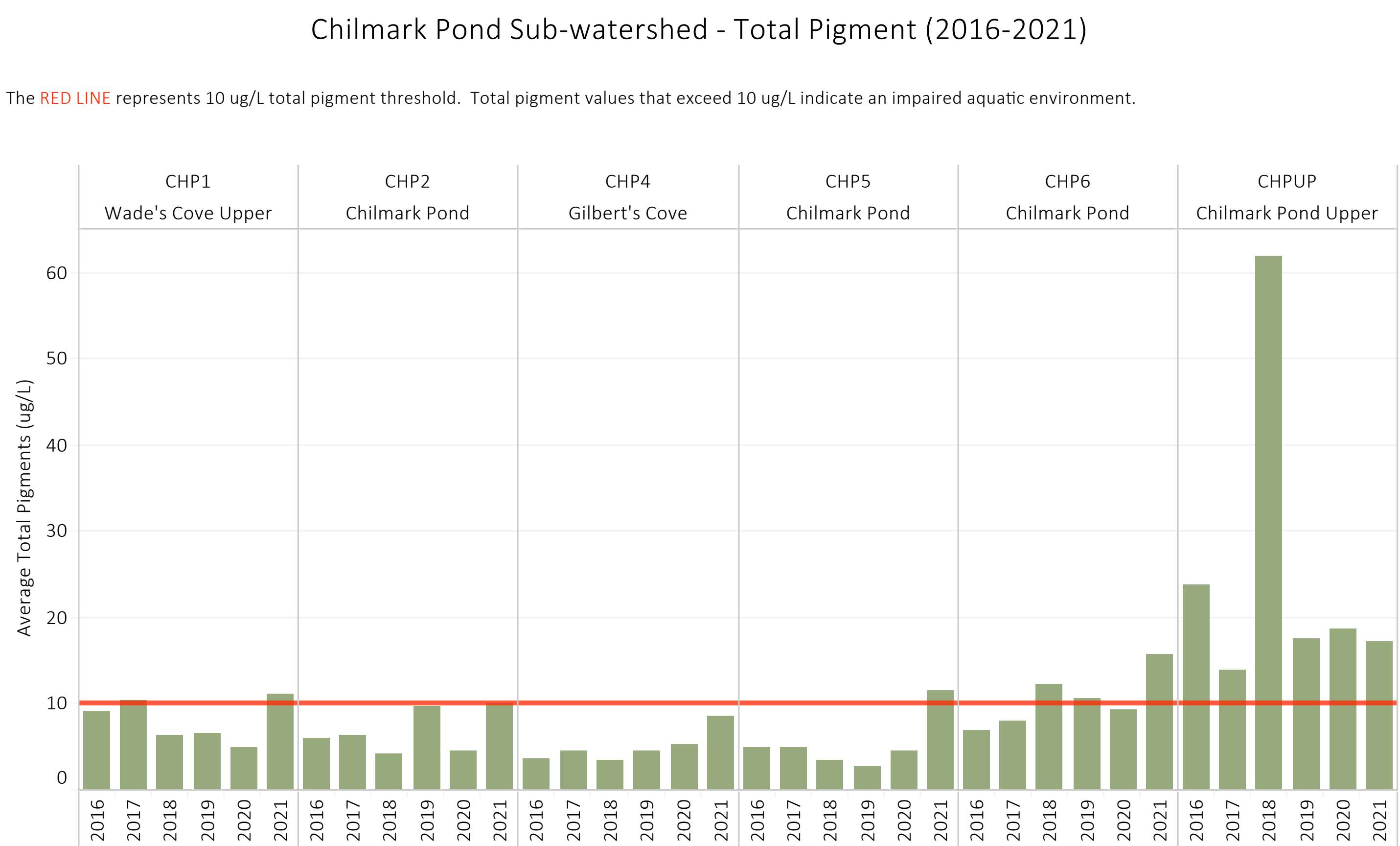


Figure 14. Chilmark Pond Total Pigment (2016-2021)

Phosphorus

Although nitrogen is generally the limiting nutrient in coastal and estuarine waters, phosphorus is still an important water quality parameter to monitor because phosphorus is also important for phytoplankton production. In river-dominated temperate estuaries, the upper relatively freshwater reaches are often limited by both nitrogen and phosphorus and sometimes with seasonal shifts[39].

Watersheds in Martha's Vineyard and Cape Cod release relatively small amounts of phosphorus to coastal waters in comparison to nitrogen[40]. Since 2018, phosphorous concentrations have been variable at some stations, fluctuating between 2 µM up to nearly 6 µM (Figure 15).

Phosphorus data was primarily collected for CHPUP (Chilmark Upper Pond), which has the least amount of tidal influence and the most direct surface water input from fresh water sources. Since 2018, data suggests that phosphorus levels are generally decreasing; however, there was a large spike in total phosphorus concentrations in 2020. Further data is needed – especially at sites other than CHPUP – to provide a more comprehensive analysis of phosphorous conditions in Chilmark Pond.

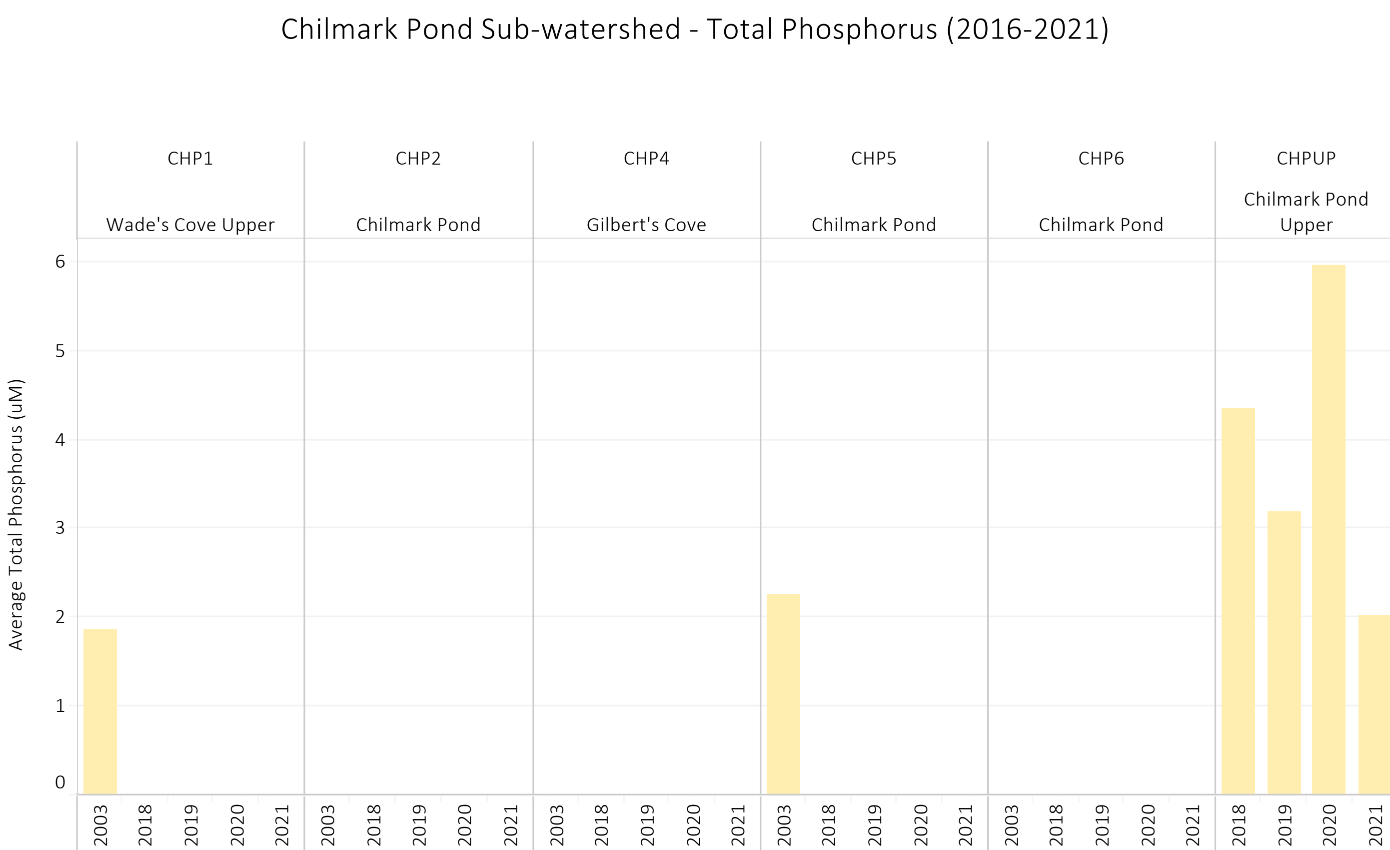


Figure 15. Chilmark Pond Total Phosphorus by Sub-watershed (2016-2021)

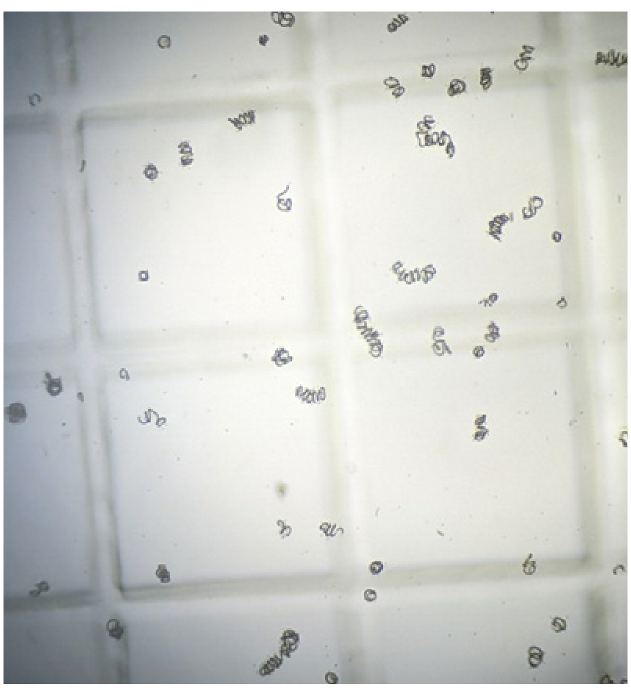
Cyanobacteria

In 2021, the MVC began an island-wide cyanobacteria monitoring project . In the first year of the study, MVC focused on establishing a baseline of cyanobacterial presence and abundance in Island ponds. Cyanobacteria, also known as blue-green algae, can cause harmful algae blooms. Cyanobacteria can produce cyanotoxins, which at certain concentrations can be dangerous to human and animal health.

Bloom-forming cyanobacteria tend to be found grouped together as large colonies and filaments, while picocyanobacteria tend to be found as single cells and sometimes small colonies. Both types of these cyanobacteria (bloom-forming and pico) are known to produce cyanotoxins.

Chilmark Upper and Lower watershed ponds were sampled every two weeks from June through September at the CHPUP, CHP6 and CHP2 sample sites. Bloom-forming cyanobacteria (those responsible for visible surface accumulations) were found at CHP-UP, CHP2 and CHP 6. Evidence of picocyanobacteria was also observed at all three sample sites.

In 2022, MVC will continue to monitor and research the bloom-forming cyanobacteria, picocyanobacterial populations and associated toxin levels in Chilmark ponds. MVC will also work with its partners to analyze eDNA samples of the bacteria in order to identify the cyanobacteria at the species level.



Cyanobacteria Samples: Sheri Caseau, Martha's Vineyard Commission, 2021

Summary

Although indicator values fluctuate from year to year, the six-year average demonstrates that Chilmark continues to have fair to moderate water quality. Water temperature and salinity are stable and generally show a consistent pattern. While still above or near the threshold at most stations, nitrogen concentration decreased in the 2021 samples. Note, drawing conclusions from annual data can be misleading and as one can see from the data, nitrogen concentrations are variable. However, it is clear that nitrogen trends are similar for most sampling stations.

Total pigment has been near or below the applicable standard requirements in the Lower Chilmark Pond for each of the past six years. However, CHPUP (Chilmark Upper Pond) remains substantially above the impairment threshold, and CHP6 has been slightly above the threshold. When comparing all sample sites, CHPUP (Chilmark Upper Pond) and CHP1 (Wade's Cove) are areas of concern.

Water quality data shows consistently elevated levels of nitrogen and the highest total pigment at CHPUP (Chilmark Upper Pond). Furthermore, water quality samples from CHP1 (Wade's Cove) indicate total nitrogen concentrations are consistently above standard and DO levels are often low. The area locally known as "Upper Chilmark Pond" does not currently have a regular sampling station. Future management plans should consider the value of adding a sample site at this location.

However, toxic cyanobacteria algae has been identified and documented in the Chilmark Pond system. It is recommended that future management plans address toxic algae blooms associated with these microorganisms.

As noted elsewhere, load reductions could be achieved through a variety of strategies including maximizing tidal exchange during openings and better management of watershed nitrogen sources (wastewater, stormwater, fertilizers, and agricultural practices), and increasing the natural attenuation of nitrogen within the freshwater systems[41].

Pond and Upland Habitat

Chilmark Pond and its surrounding watershed include critical areas for rare and other species of conservation concern. The Chilmark Pond Watershed includes areas designated by MassWildlife's Natural Heritage & Endangered Species Program as Natural Communities[42], Priority Habitats of Rare Species, Estimated Habitats of Rare Wildlife and State Protected Rare Species[43] (Figure 16).

Core Habitat (Figure 17) and Critical Natural Landscapes (Figure 18) are intended to protect the state's biodiversity and their habitats in the face of climate change, these areas are mapped under the BioMap2 (2010) project. Core Habitats include: Aquatic Core, Priority Natural Communities, and Species of Conservation Concern[44]. Critical Natural Landscapes include: Tern Foraging, Coastal Adaptation, Upland Buffer of Aquatic Core, and Landscape Blocks[45]. There are approximately seven endangered species, 21 threatened species, and 27 special concern species listed in the Chilmark Pond watershed in the Core area[46]. The Core area is also home to one imperiled natural community (Estuarine Subtidal: Coastal Salt Pond) and one critically imperiled natural community (Sandplain grassland)[47].

Gilbert's Cove, Lower Chilmark: Ollie Becker, June 2021

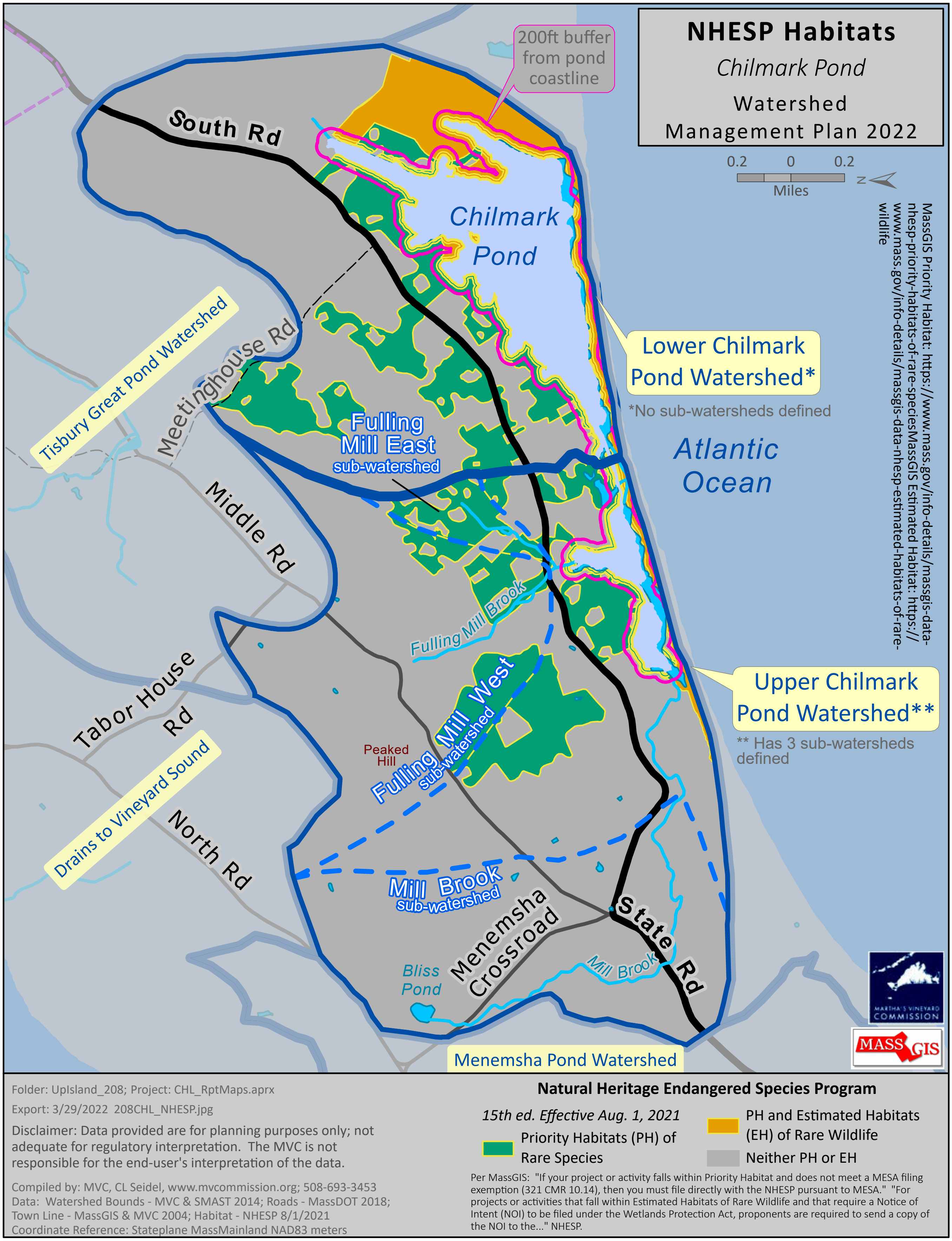


Figure 16. Natural Heritage & Endangered Species Program Map

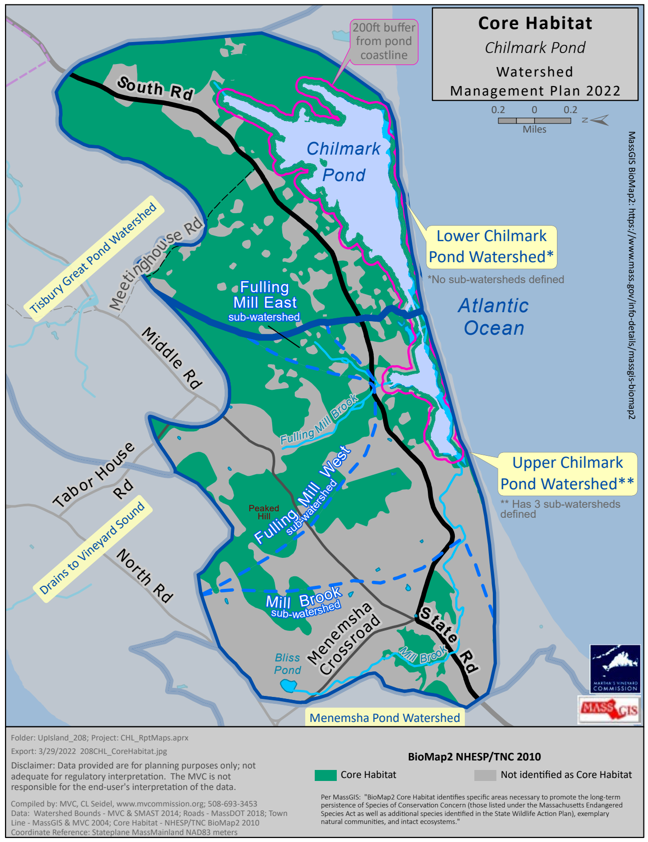


***Figure 17. BioMap2 Core Habitat Landscape** (Note Core IDs correspond with elements list)*

Figure 18. Critical Natural Landscape Map

Wetlands also provide valuable habitat benefits to a variety of wildlife species and to overall water quality in associated aquatic systems (Figure 19). While areas of the Chilmark watershed are under conservation protection, there are unrealized conservation opportunities remaining that could provide permanent protection for key habitat areas.

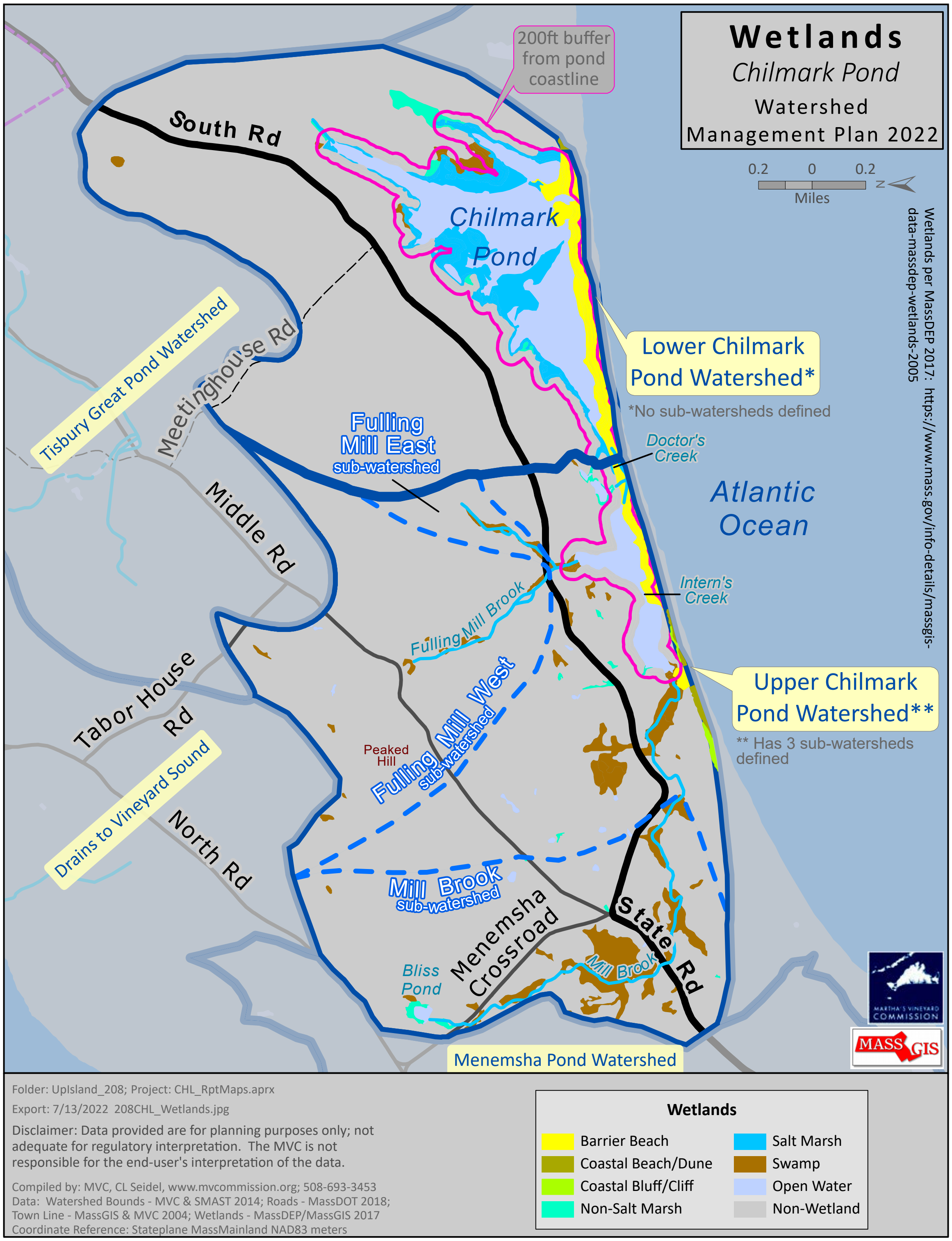


Figure 19. Chilmark Pond Watershed Wetlands Map

Benthic infauna and epifauna surveys

Benthic infauna are organisms that live within the bottom sediments, their presence (or absence) can reflect their habitat quality as well as conditions for other pond residents. The MEP study analyzed sediment samples at nine locations to characterize the benthic community[48]. The MEP used benthic animal communities to evaluate the response to nitrogen enrichment of the Chilmark Pond embayment since historically there is no clear evidence of eelgrass coverage in the Pond.

Excessive nitrogen in the pond can be indicated by low diversity of benthic animal communities[49]. The number of benthic species and counts of individuals in each species shows the general diversity and evenness of the benthic infauna community, this is combined with the observed species assemblages to classify benthic habitat health.

There are also certain benthic animals who can thrive in poor water quality conditions, their presence can be used to evaluate habitat health. Capitellids and Tubificids are examples of animals that thrive in nutrient and organic matter rich areas that would be stressful habitat environments for other benthic animals. Therefore, Capitellids and Tubificids are considered stress indicator species.

The MEP infauna survey sample analysis found that there were high numbers of individuals, little diversity of species and low counts of stress-tolerant species (Capitellids and Tubificids). The community diversity and evenness results indicate that the benthic communities in Chilmark Pond are under ecological stress and are moderately to significantly impaired but did not show any areas of severe degradation[50].

Finfish surveys

There are no documented finfish surveys of Chilmark Pond. Anecdotal evidence indicates that Chilmark Pond was used as a herring and perch fishery in the earlier part of the previous century[51]. More recently, local experts have reported the presence of Colonial Bryozoan and Pectinatella Magnifica[52]. The MVC recommended a finfish survey for Chilmark Pond in 2001, but as of today, no surveys have been completed.

Eelgrass mapping

There is no evidence of eelgrass beds in Chilmark Pond after the 1950s based on anecdotal information reported by residents, MVC, Chilmark Pond Association, and the Chilmark Shellfish Propagation Agent[53]. According to the MassDEP Eelgrass Viewer, there are no eelgrass beds currently mapped in Chilmark Pond[54]. Poor aerial imagery and lack of records make it challenging to determine the historic presence of eelgrass[55]. Eelgrass is sensitive to water quality degradation and as such, the loss of eelgrass beds is an indicator of habitat impairment. The MEP study did not find any evidence of eelgrass beds in the pond both historically and at the time of their study; the authors of the MEP concluded that nutrient loads and tidal exchange characteristics limit the capacity of Chilmark Pond to support eelgrass[56].

Although eelgrass does not play a significant role in the Chilmark Pond ecosystem, Widgeon Grass (genus Ruppia) is present and may be a good measure of water quality in addition to eelgrass.[57] Widgeon grass tolerates a wide range of lower salinities than eelgrass and its growth reflects water clarity. Furthermore, this type of seagrass attracts waterfowl often associated with increased bacteria in the pond.

Phytoplankton survey

There are no documented phytoplankton surveys of Chilmark Pond. However, other indicator parameters have been used to evaluate phytoplankton biomass. As described previously, several water quality indicators can be used to assess biological and habitat health: chlorophyll-a is a proxy indicator measure for phytoplankton biomass[58]; and total pigment measurements can indicate the amount of live and expired plant matter within a body of water. Periodic phytoplankton blooms have been observed in Chilmark Pond[59].

Summary

Chilmark Pond and its upland watershed supply critical habitat for species of conservation concern. Benthic infauna health and water quality are recognized as the primary indicators of the overall ecological health of the pond. The moderately to severely impaired benthic infauna communities, as well as patterns of elevated chlorophyll-a levels and oxygen depletion are indicative of excess nitrogen enrichment in the watershed[60]. More specifically, parts of Chilmark Pond, including Lower Chilmark Pond, Wade's Cove, and Gilbert's Cove, are classified as moderately to significantly impaired based on the characterization of its benthic infauna community[61].

Current studies show that there has been little substantial improvement in water quality since the MEP study was completed, therefore it is assumed that eelgrass and benthic infauna communities remain impaired. Despite recent water quality improvements, habitat impairments are likely to be consistent with the water quality information presented above that show high nitrogen and total pigment levels and potential DO stress levels. Reduction of nitrogen levels in the Pond will be required to restore eelgrass and infauna habitats.

Gilbert's Cove, Lower Chilmark: Ollie Becker, June 2021

Population and housing

The estimated year-round population of Chilmark has grown from 183 to 1,212 people between 1950 and 2020 (Table 9). Due to a large seasonal population, the town increases by approximately 5,000 residents each summer according to 2020 US Census Data[62]. Much like other towns with large summer residential populations, it is estimated that 62% of the parcels in Chilmark are owned by seasonal residents (Figure 20)[63].

Increased population, both year-round and seasonal, contributes to water quality stressors, along with the associated nutrient inputs from onsite wastewater systems and changes in land use from previously undeveloped land.

Town	Year-round Population 1950	Year-round Population 2020	Total Population % Increase 1950 - 2020	Peak In-season Population 2020
Chilmark	183	1,212	562%	6,530

*Population statistics reference **town-wide** data, these numbers are not limited to the Chilmark Upper and Chilmark Lower Watersheds.

Table 9. Chilmark Pond Watershed Population

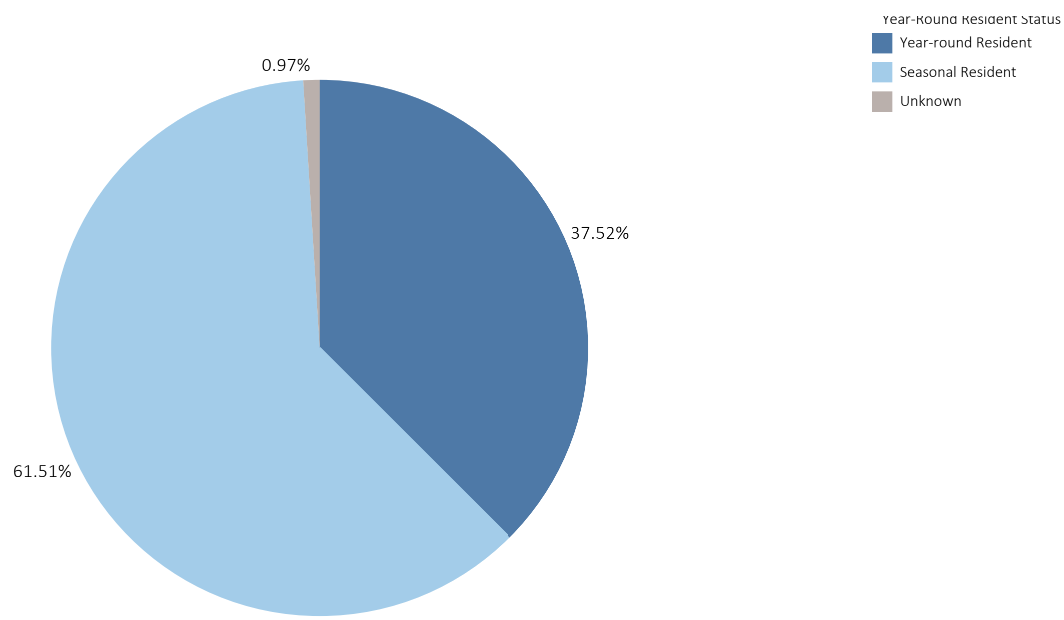


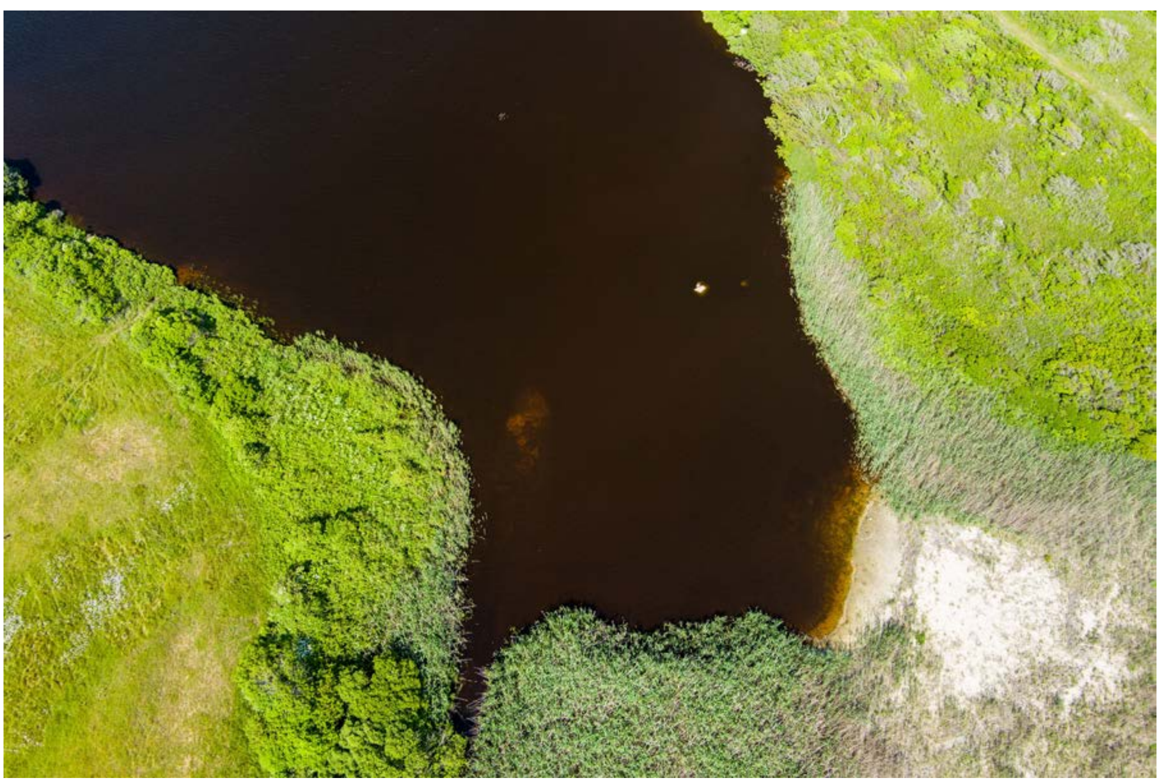
Figure 20. Housing and Residency Status (2021)

Land use and development

As noted previously, "Land Cover" refers to physical features and landscaping patterns/characteristics that exist in a particular area. For example, Land Cover can refer to the type of vegetation that exists in the watershed area (forests, pastures, wetlands etc.). "Land Use" refers to how the land is managed or used. Following this example, forested areas tend not to have large residential or commercial structures, agriculture land uses pastures to feed animals, and wetlands, like forests, are unlikely to be used for residential or commercial purposes.

In this section of the report, we limit our discussion to "Land Use". Changing land use patterns influence water quality in associated aquatic systems. For example, increased residential area, impervious surface, and cultivated agricultural land can contribute to higher nitrogen loading from watersheds to receiving waters.

While historic land use classifications differ from those used in 2021, changes in land use patterns are apparent when comparing 1971, 1985 and 1999 aerial photos. For example, in the Chilmark Pond Watershed, a conversion of forest and open land area to residential area is evident. The decrease in open space and forest has been roughly proportional to the increases in residential land use. Pasture land use has increased during this period, especially in Upper Chilmark Pond sub-watersheds, this may indicate changes in agricultural practices that could be associated with additional water quality stressors (Figure 21).



Upper Chilmark Pond Mill Brook: Ollie Becker, June 2021

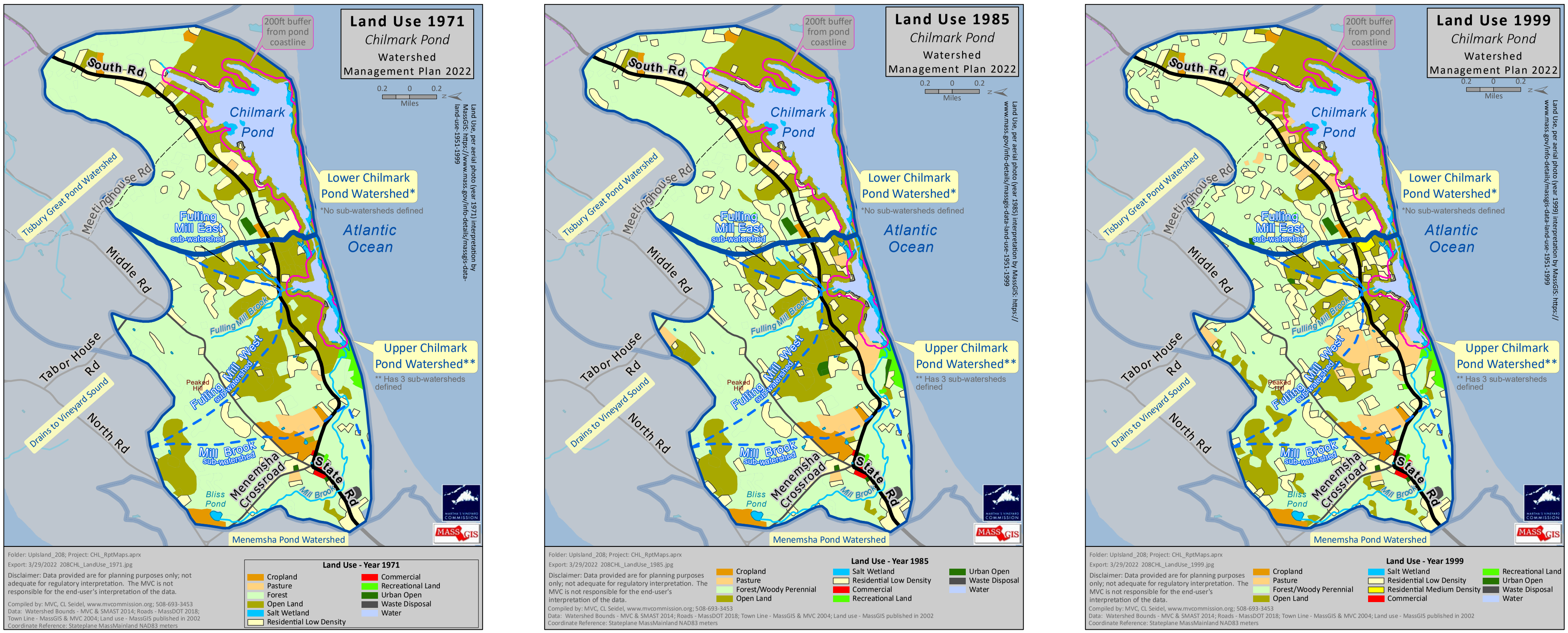
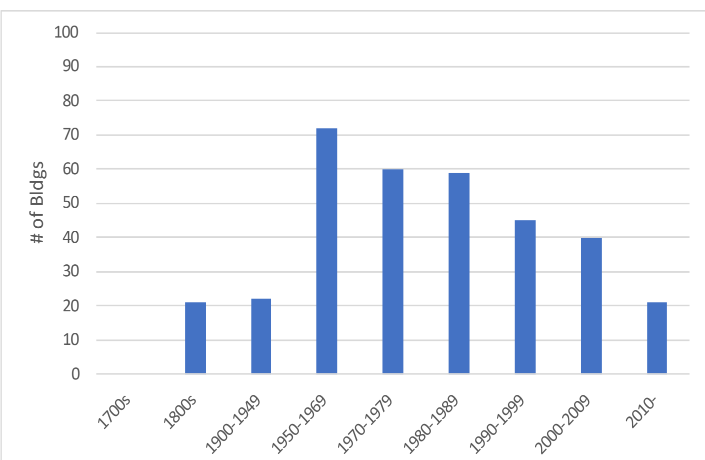


Figure 21. Land Use Map Comparison - 1971, 1985, 1999

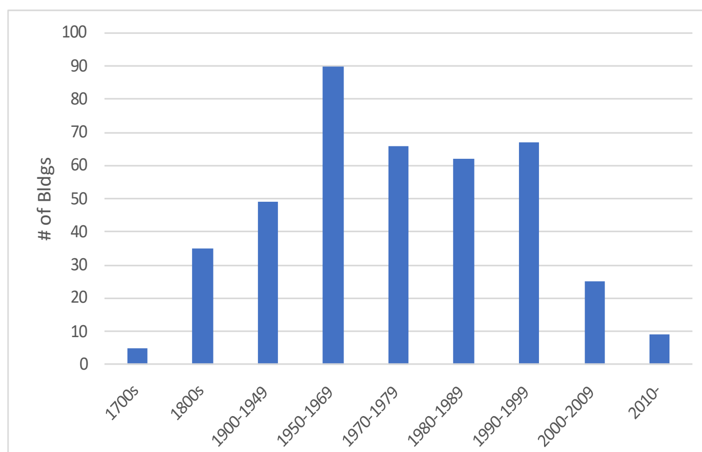
The MVC tracks development over time using year-built data from the towns' assessing records. Figures 22 and 23 highlight the growth in the number of buildings since the 1700s.

According to MVC data, in both the Upper and Lower Chilmark Pond watersheds, nearly half of existing development occurred between 1970 and 2000. The rate of development was fairly consistent each decade during that period. However, Lower Chilmark has experienced more development since 2000 than Upper Chilmark Pond[64]. In other words, the Lower Chilmark watershed is developing faster than the Upper Chilmark watershed. Although much smaller in scale, roughly one fifth of all watershed development occurred between 1950 and 1969, which has important implications on the impact of the wastewater systems put in place during that period.

Construction Year of Oldest Building on a Given Parcel in Lower Chilmark Pond Watershed



Construction Year of Oldest Building on a Given Parcel in Upper Chilmark Pond Watershed



* *Note: Time frames indicated on bar graph do not represent proportionate or equal time periods.:*

Figure 22. Construction Year of Oldest Building on a Given Parcel In Lower Chilmark Pond Watershed

Figure 23. Construction Year of Oldest Building on a Given Parcel In Upper Chilmark Pond Watershed

Current (2021) land use data for the Chilmark Pond Watershed is shown in Figure 24, the corresponding map is Figure 25. The majority (62%) of land in both Upper and Lower Chilmark Pond watersheds, combined, falls into the residential category. Undeveloped land represents 19% of the watershed area and agriculture accounts for less than two percent of both watersheds combined.

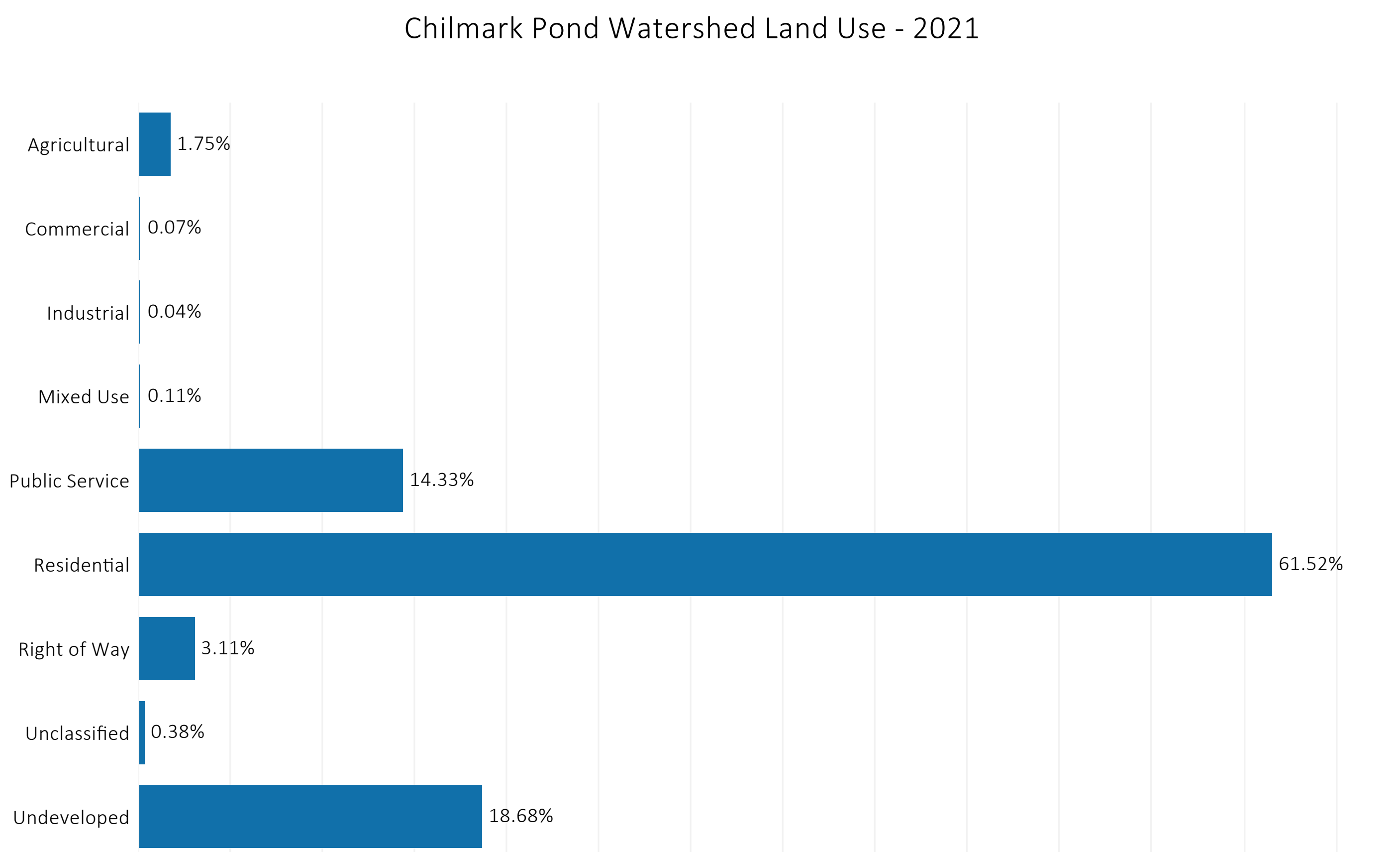


Figure 24. Land Use in Chilmark Pond Watershed (2021)

Figure 25. Chilmark Pond Watershed Land Use Map (2021)

Land use breakdown for each sub-watershed is shown in Figure 26. Residential land use represents more than half of every sub-watershed, with the highest percentage in the Mill Brook-CHI sub-watershed (73%). With the exception of Fulling Mill East and Mill Brook-CHI, undeveloped land accounts for 19 - 23% of sub-watersheds. Agriculture is only present in Fulling Mill West and Mill Brook-CHI and at relatively low levels, 5% and 4% respectively[65, 66].

Based on the use code assigned by the town assessor, land use in the Chilmark Pond Watershed remained relatively consistent from 2015 to 2021. Residential land use grew from 58% to 62%, public service/right of way slightly decreased from 16% to 14%, and undeveloped areas decreased from 24% to 19% of the watershed[67,68]. The continued increase in development with additional onsite wastewater systems and loss of forest and open space supports the contention that management actions are needed to prevent increased impairment to the Chilmark Pond Estuary.

Although land use remained relatively stable overall for the Chilmark Pond Watershed, Fulling Mill West and Mill Brook-CHI sub-watersheds experienced greater increases in residential land uses and decreases in undeveloped land than the watershed as a whole (Figure 27), which could be related to the water quality trends in those areas described previously. The presence of agricultural land in Fulling Mill

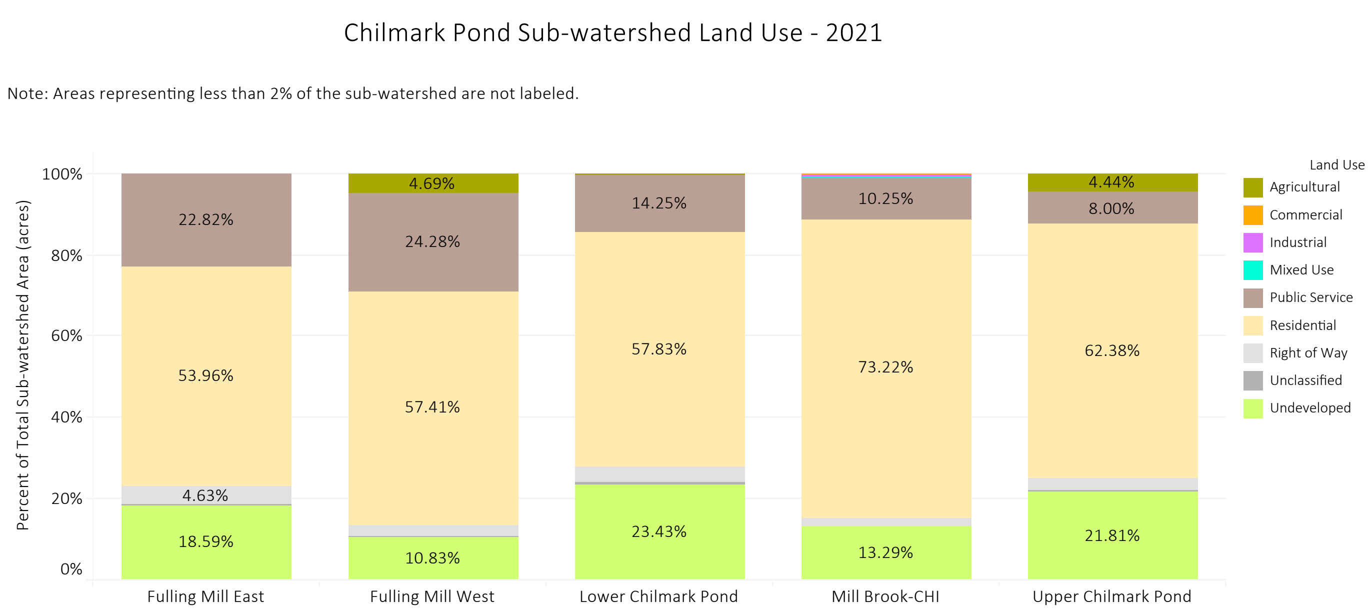


Figure 26. Chilmark Pond Land Use Categories by Sub-watershed

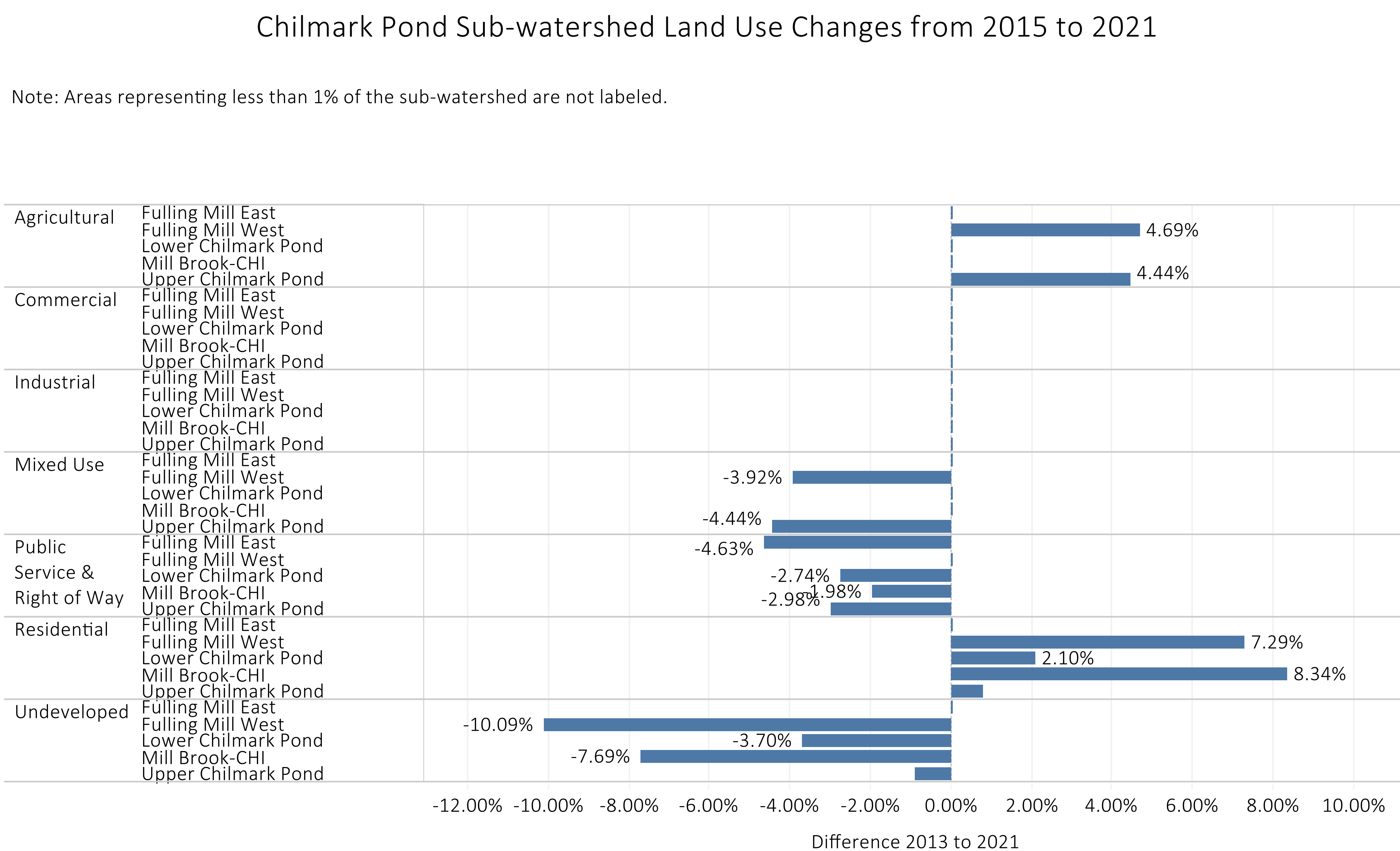


Figure 27. Chilmark Pond Land Use Changes from 2015 to 2021

West (5%) and Upper Chilmark (4%), although small relative to other use categories, may offer an opportunity to incorporate and/or expand "watershed friendly" agricultural practices. Given the overall trend of increasing developed land area throughout the Chilmark watershed since 1970, these values also highlight the potential for future development pressures, especially in those sub-watersheds with large areas of undeveloped land with the potential for future development.

Wastewater Management Systems

There are no centralized wastewater treatment facilities or decentralized package plants within the Chilmark watersheds[69]. Onsite septic treatment and disposal systems (OSDS) are a likely source of nitrogen loading to Chilmark Pond. It is estimated that there were 235 non-Title V systems built before 1978, 218 Title V septic systems built after 1978, and six innovative alternative systems currently in the watershed (Figures 28 and 29)[70].

It is estimated that nearly half (46%) of all OSDS are in Lower Chilmark Pond watershed. When considering the Non-Title V systems, we find that two-thirds (67%) of the non-Title V systems are located in the Lower Chilmark Pond watershed and the Mill Brook-CHI sub-watersheds.

Approximately 97% of all wastewater treatment systems are located more than 200 feet from the pond. Development within 100 feet of the pond edge is closely monitored and regulated to ensure proper setbacks from the pond. There are 15 onsite wastewater systems located within 200 feet of the pond's edge, including eight non-Title V systems. Of the non-Title V systems, six are in the Lower Chilmark Pond watershed and the remaining two are in the Upper Chilmark watershed[71].

Given the nitrogen load reduction targets, opportunities to improve wastewater management exist in the Lower Chilmark Pond and Mill Brook-CHI sub-watersheds. OSDS closest to the pond edge may present the greatest opportunities for immediate impact but given the nitrogen leaching potential of watershed soils, replacement of any low performance OSDS with enhanced nitrogen removal systems would be beneficial.

Septic loads documented in the MEP (kg/year), as well as the target thresholds are noted in Table 10.

Onsite disposal systems closest to the pond and stream edge may present the greatest opportunities for immediate impact but given the nitrogen leaching potential from more distant onsite wastewater systems, all septic systems will eventually impact the pond so any improvements could be beneficial.

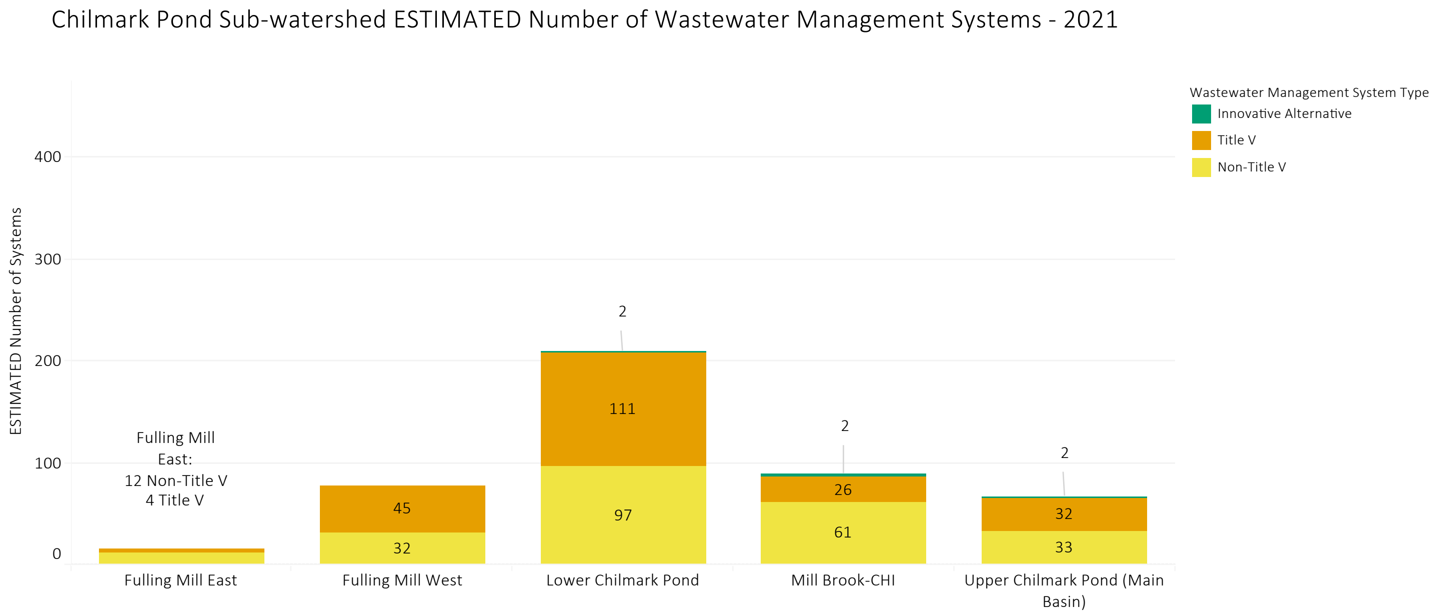


Figure 28. Wastewater Management Systems in Chilmark Pond Sub-watersheds

Sub-embayment	Present Load (kg/year)	Threshold Load (kg/year)	Threshold % Change
Chilmark Pond East	1122.0	687.7	-40%
Chilmark Pond West	1119.8	728.2	-35%
*Comparison of embayment attenuated **septic loads** used for modeling of present and threshold loading scenarios of Chilmark Pond. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.			
** Information published in Table VIII-2 (Page 121) of the Chilmark Pond Embayment System Massachusetts Estuaries Project Report (2015).			

Table 10. Chilmark Pond Total SEPTIC Nitrogen Load Reductions Required to Achieve Nitrogen Threshold (TMDL)

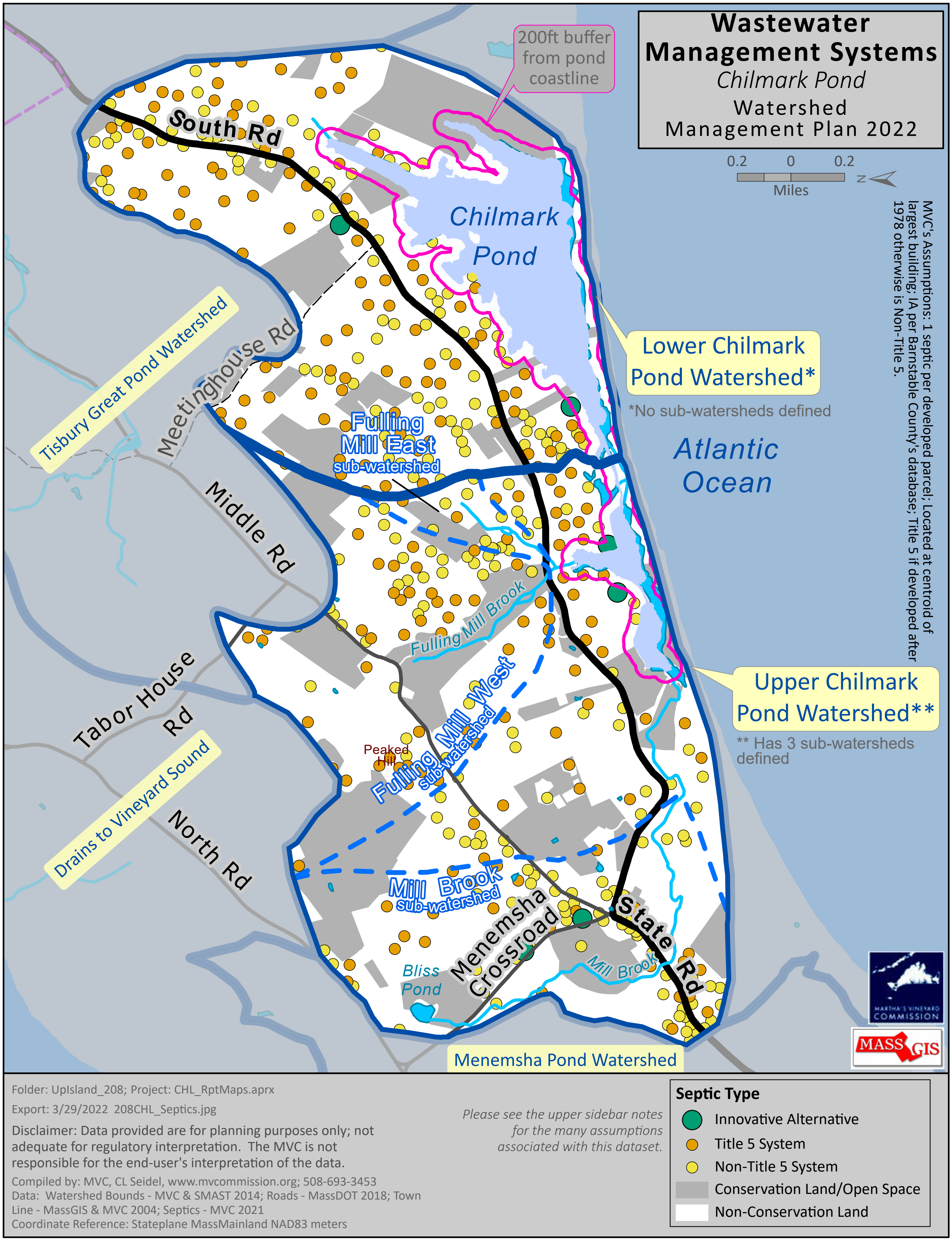


Figure 29. Wastewater Management Systems in Chilmark Pond Map

Stormwater Management

According to previous studies, most stormwater in Chilmark Pond Watershed percolates into the ground[72]. Chilmark is not considered an "urbanized area" under the 2010 U.S. Census, so it is not covered under the Massachusetts Municipal Separate Storm Sewer System (MS4) permit. It is, however, subject to the Massachusetts Stormwater Standards. The town of Chilmark cleans and maintains the infrastructure on town roads annually. The Massachusetts Department of Transportation (MassDOT) conducts similar maintenance on the Chilmark Watershed roads under its authority. Wastewater systems, development, fertilizer use, and agriculture are more likely to impact water quality than stormwater flowing in the Chilmark Pond Watershed, especially given the low amounts of impervious cover in the watershed. However, there may be targeted areas for improved stormwater management where there are direct discharges to pond waters, including the areas surrounding the Fulling Mill roadside in which there is limited vegetated buffer. Additional studies are warranted as they represent a potential nitrogen management solution.

Wade's Cove and Lower Chilmark Pond: Ollie Becker, June 2021

Buildout

Approximately 14% of the Chilmark watershed is available for development, with another 20% considered potentially available for development. Based on existing zoning and model projections, an additional 280 buildings could be developed in the Chilmark watersheds in the future: 127 buildings in the Lower Chilmark Pond Watershed and 153 buildings in the Upper Chilmark Pond Watershed[73]. A complete breakdown of watershed and sub-watershed land development status is shown in Figures 30 and 31[74]. A map depicting development status is found in Figure 32.

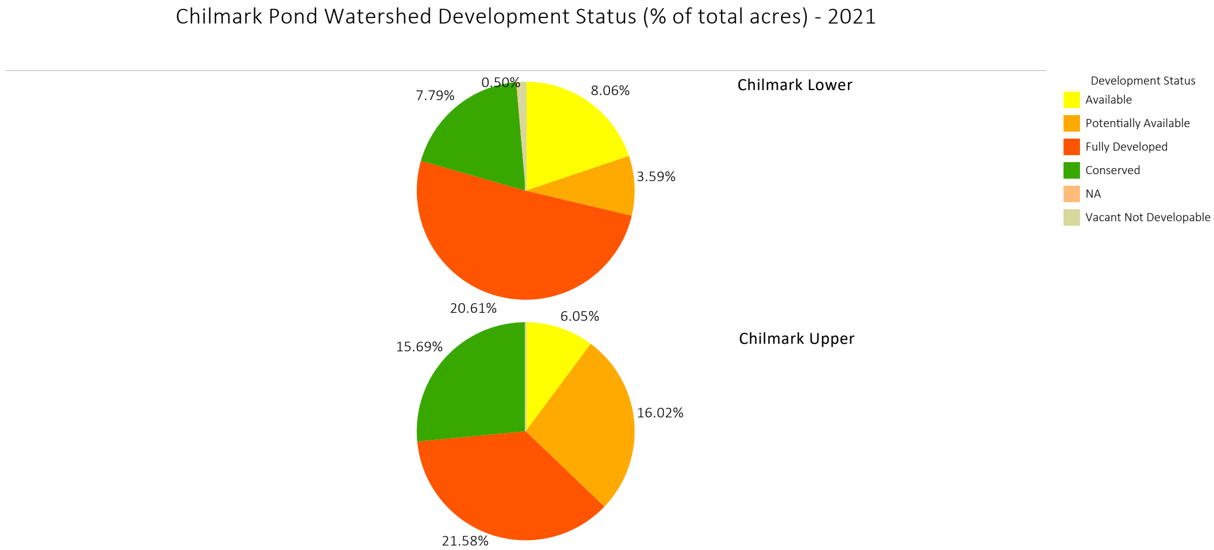


Figure 30. Chilmark Pond Watershed Development Status/Land Availability

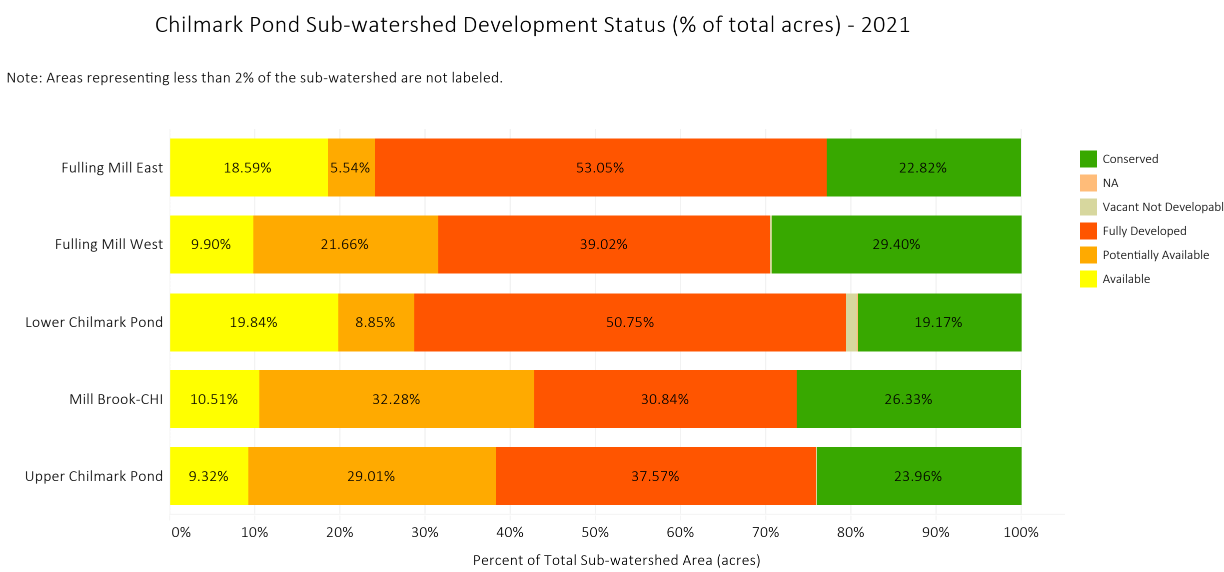


Figure 31. Development Status/Land Availability for Chilmark Pond Sub-watersheds

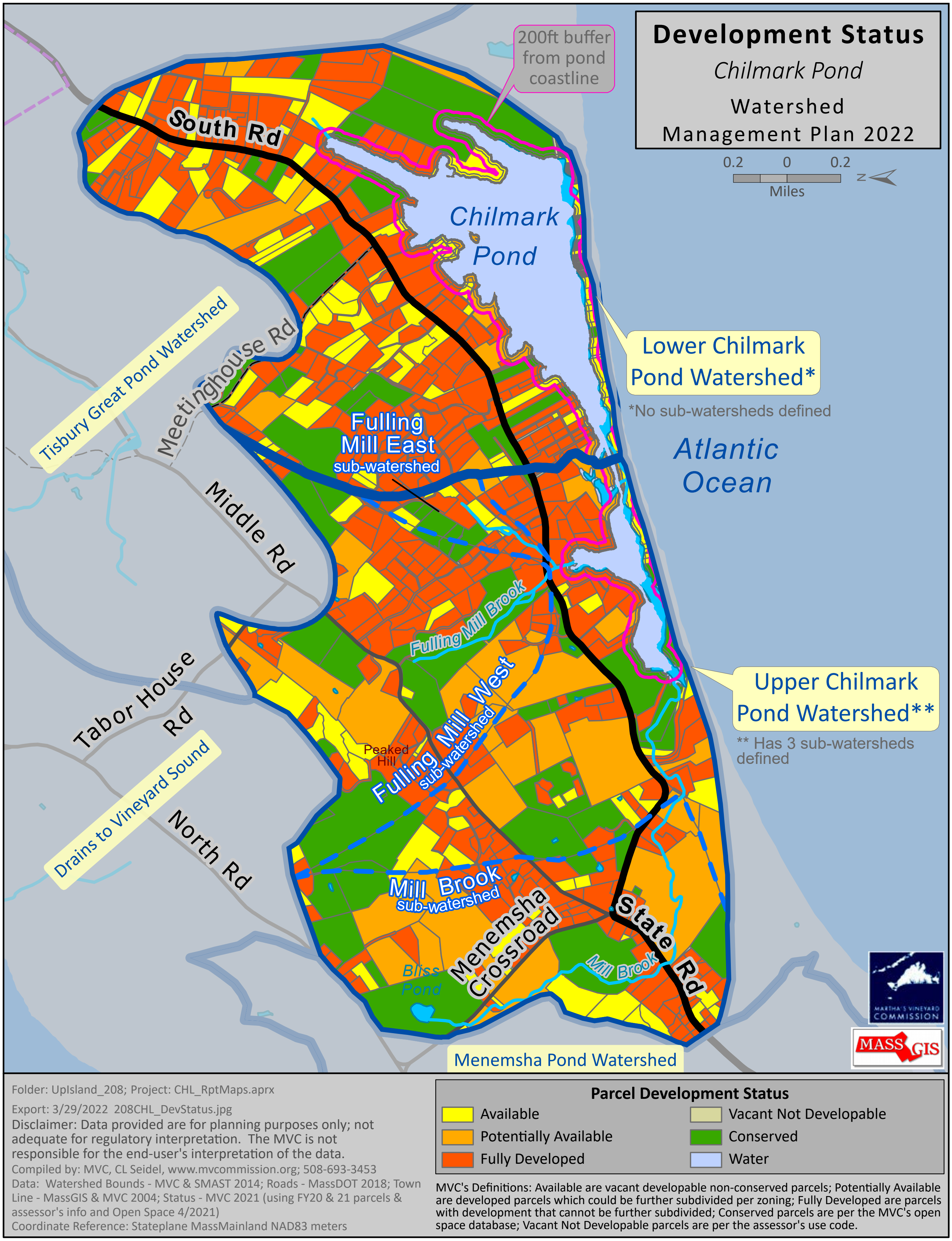


Figure 32. Chilmark Pond Development Status Map

Just under one quarter (24%) of the watershed area is currently conserved. Conserved land exists in all sub-watersheds, each has 19-29% of their area conserved. Conserved land in sub-watersheds is as follows: Fulling Mill West (29%), Mill Brook-CHI (26%), and Lower Chilmark Pond (19%). Mill Brook-CHI and Upper Chilmark Pond have the most land available or potentially available for development.

The two sub-watersheds with the largest increases in residential development since 2015 (Fulling Mill West and Mill Brook-CHI) also have more land that could be developed or conserved in the future than the Chilmark Pond Watershed as a whole. These values may be representative of development pressures or conservation opportunities that could impact future water quality issues in those sub-watersheds.

According to current regulatory guidelines, the maximum number of dwellings allowable within the Chilmark Pond Watershed is 1,037, with 468 in Lower Chilmark Pond sub-watershed and 569 in Upper Chilmark Pond sub-watershed. As noted above, 757 (73%) buildings have been built and another 280 could be built in the future. When taking proximity to the pond into consideration, there are 476 structures within 200 feet of the edge of the pond, with an additional 55 that *could* be built in the future (Figure 33).

Middle Chilmark Pond: Ollie Becker, June 2021

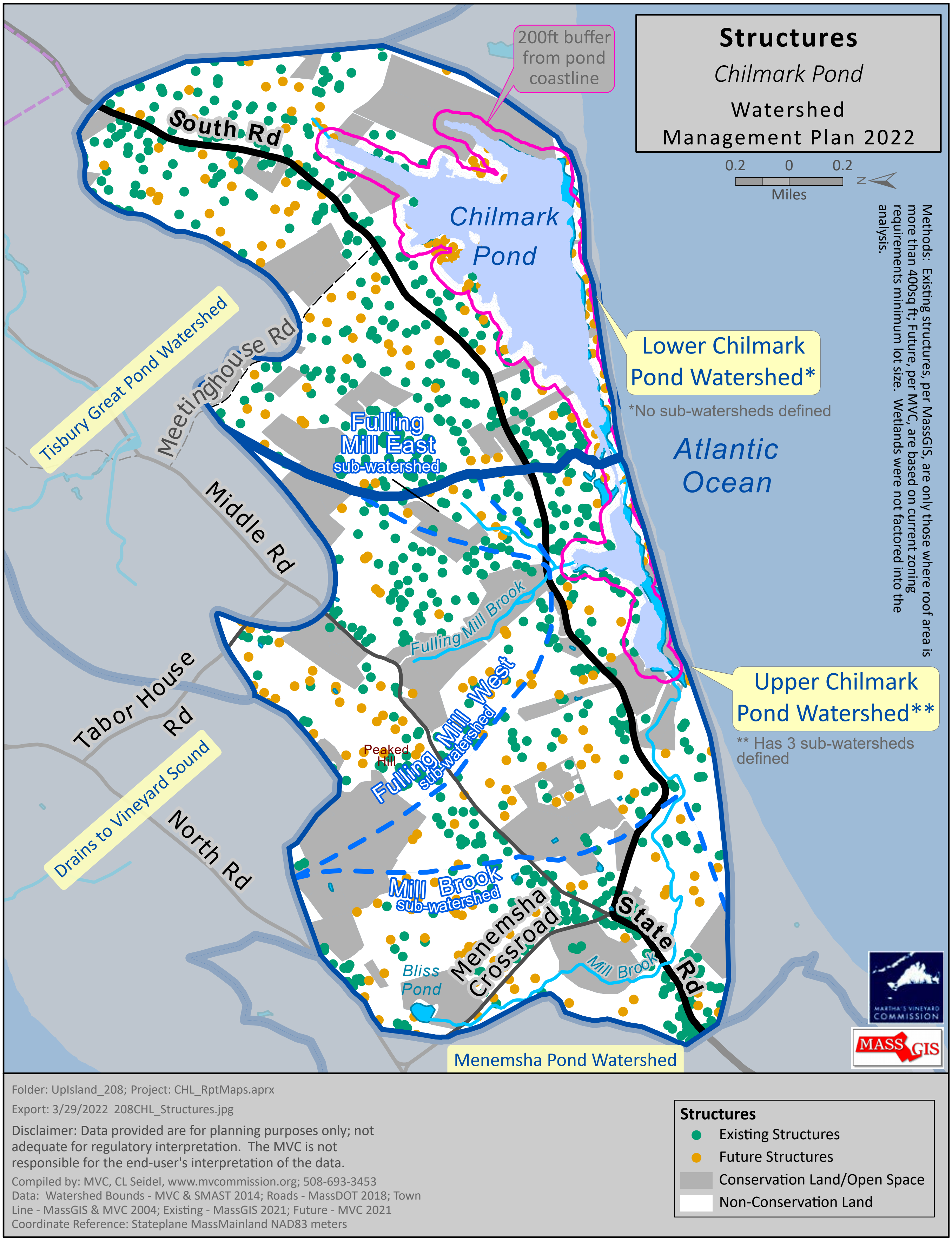


Figure 33. Existing and Potential Structures in Chilmark Pond Watershed

All development within the watershed, regardless of proximity to water surface areas, directly impacts water quality in the pond. Development closer to the pond edge has short term impacts, while development on parcels farther away from the pond edge impact water over a longer period of time.

Current (2021) regulatory guidelines address the density of residential structures within the Town of Chilmark. Structure density within each sub-watershed is fairly consistent, ranging from 0.20 to 0.30 buildings per acre (Figure 34).

Chilmark Pond Watershed Existing Building Density (Number of Existing Buildings/Acre) - 2021

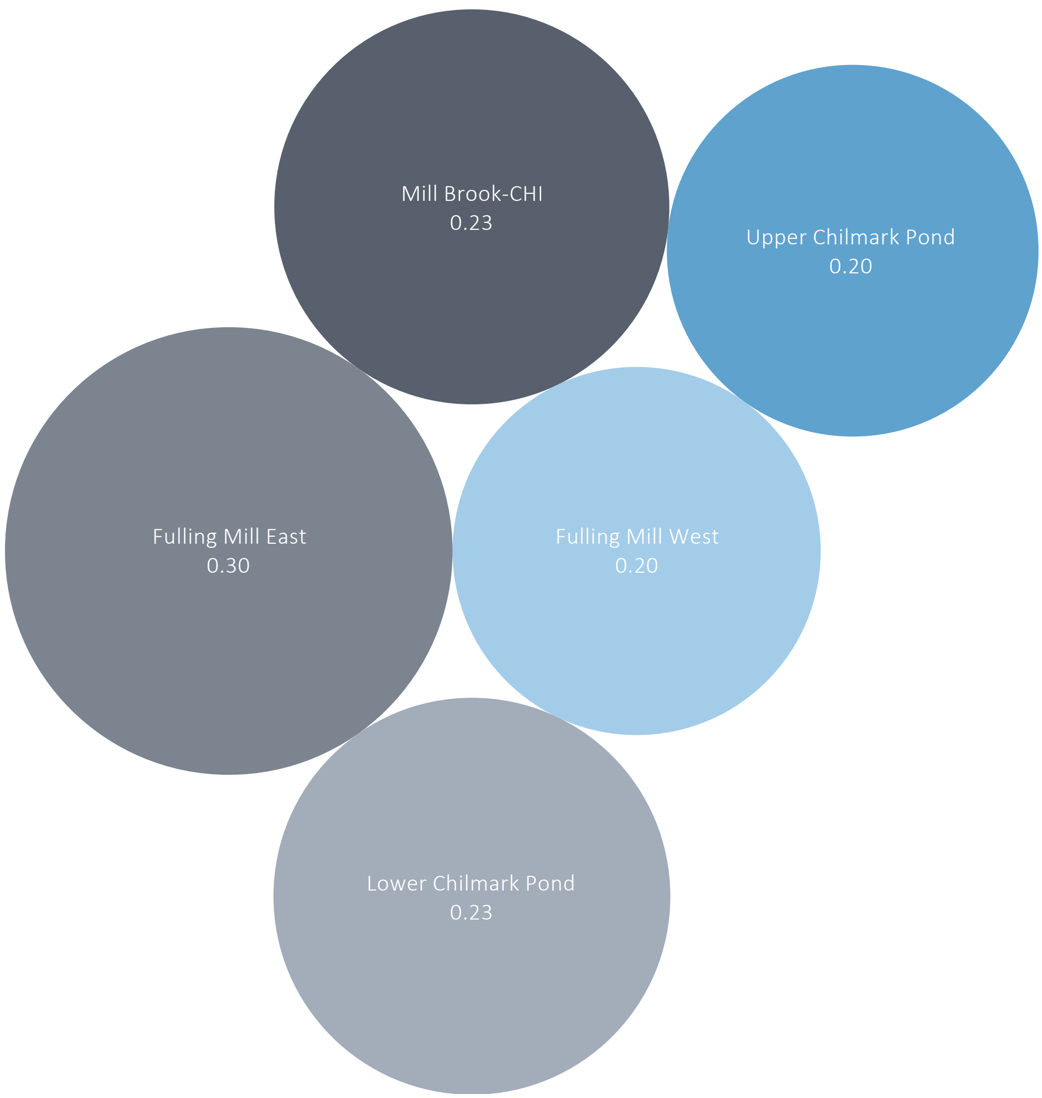


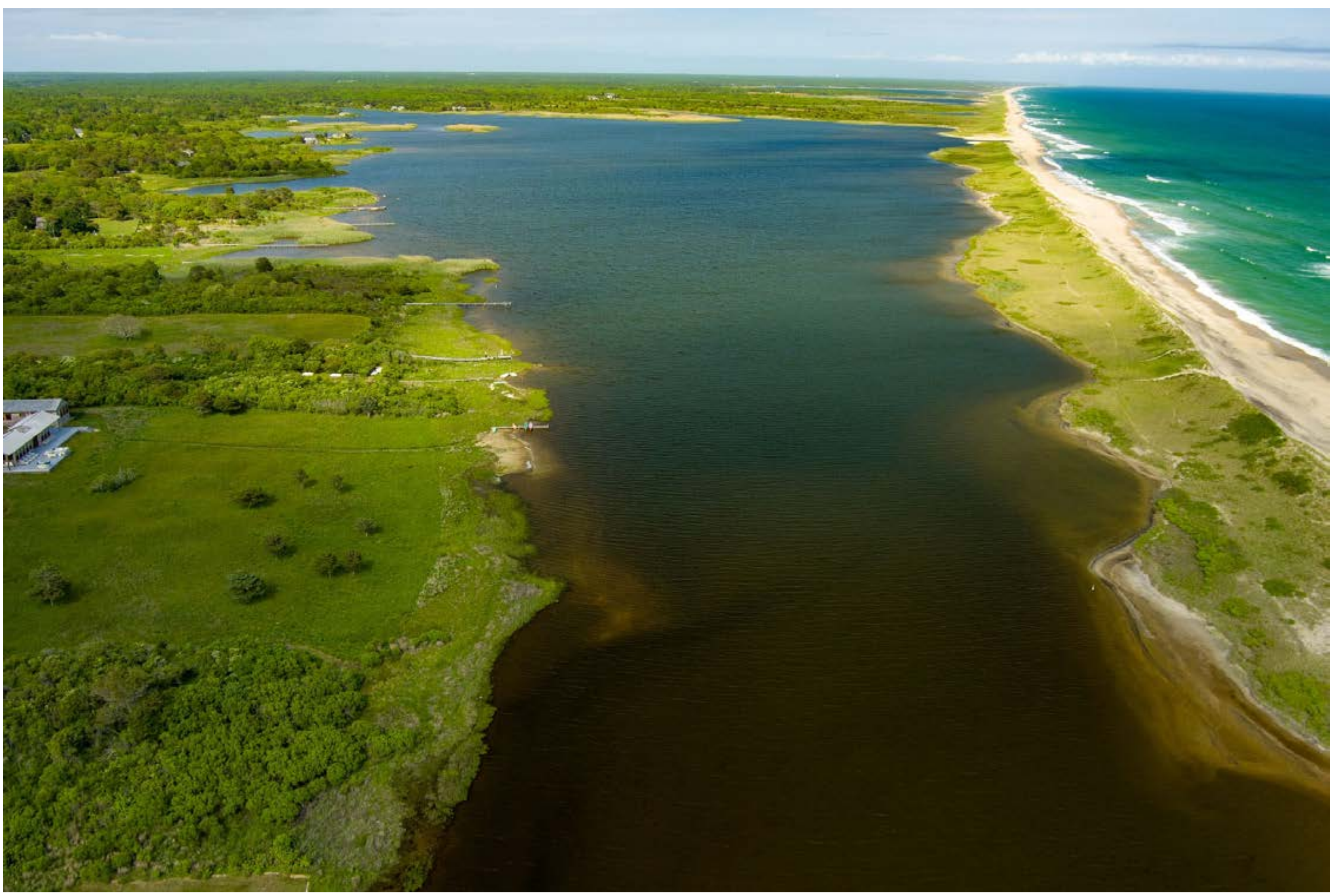
Figure 34. Existing Building Density (# Existing Buildings/Acres)

Other Uses

No golf courses, active cranberry bogs, or active landfills have been present in the watershed as of 2015. Chilmark capped its landfill in 2004[75]. Although the Chilmark Landfill was located in the town of Chilmark, it was not sited within the boundaries of Chilmark Pond watersheds and groundwater from the Chilmark Landfill flowed into the Tisbury Great Pond watershed and coastal zone.

Historically, there are many signs that show Native American occupation of the land around Chilmark Pond. Furthermore, there is evidence that the pond and marshy uplands were harvested during the 19th and 20th centuries. Salt hay was a cash crop, fin fish were seined, eels were potted and shellfish were regularly harvested. Local experts point to a considerable take of oysters and steamer clams in the 1960s. Continuing the longstanding tradition, clams, eel and perch were commercially harvested during the 70s, 80s and 90s from the lower pond[76].

As is noted elsewhere, at this time (2022) per Mass DEP guidelines, there is no shellfishing in Chilmark Pond due to human health concerns.



Lower Chilmark Pond: Ollie Becker, June 2021

Livestock

The town of Chilmark is home to longstanding, well established agricultural community. Accordingly, the Chilmark Pond watershed includes an ever-changing number and type of livestock (Table 11). The number of animals decreased between 2015 – 2021, across all animal types[77]. These decreases may be reflective of recent reductions in livestock, even though agricultural land use values did not change much during this period. The impact of fluctuating livestock numbers is an important area to be considered for future watershed management practices, especially because waste management practices for livestock operations impact nutrient loads to Chilmark Pond.

	Cattle	Equines	Pigs	Sheep	Goats	Poultry	Total
2015 MEP Survey	77	37	39	119	24	213	509
2021 Town Survey	20	19	0	114	2	120	275
Percent Change	-74%	-49%	-100%	-4%	-92%	-44%	-46%
Nitrogen Load Change (kg/year)	**-233.3**	**-1,272.2**	**-14.6**	**-226.2**	**-14.9**	**-64.2**	**-1,825.4**

Table 11. Animal Count (2015 &2021) for Chilmark Pond Watershed

Land Conservation

Land conservation areas protect water quality lowering future N loading and by holding and filtering water and associated pollutants before they reach downstream waterbodies. In general, predominantly forested watersheds with limited developed or cultivated land alterations tend to have better water quality due to very low nutrient output from these areas when compared to developed land. Protecting additional acres of undeveloped land can be an effective management strategy to prevent further degradation of water quality.

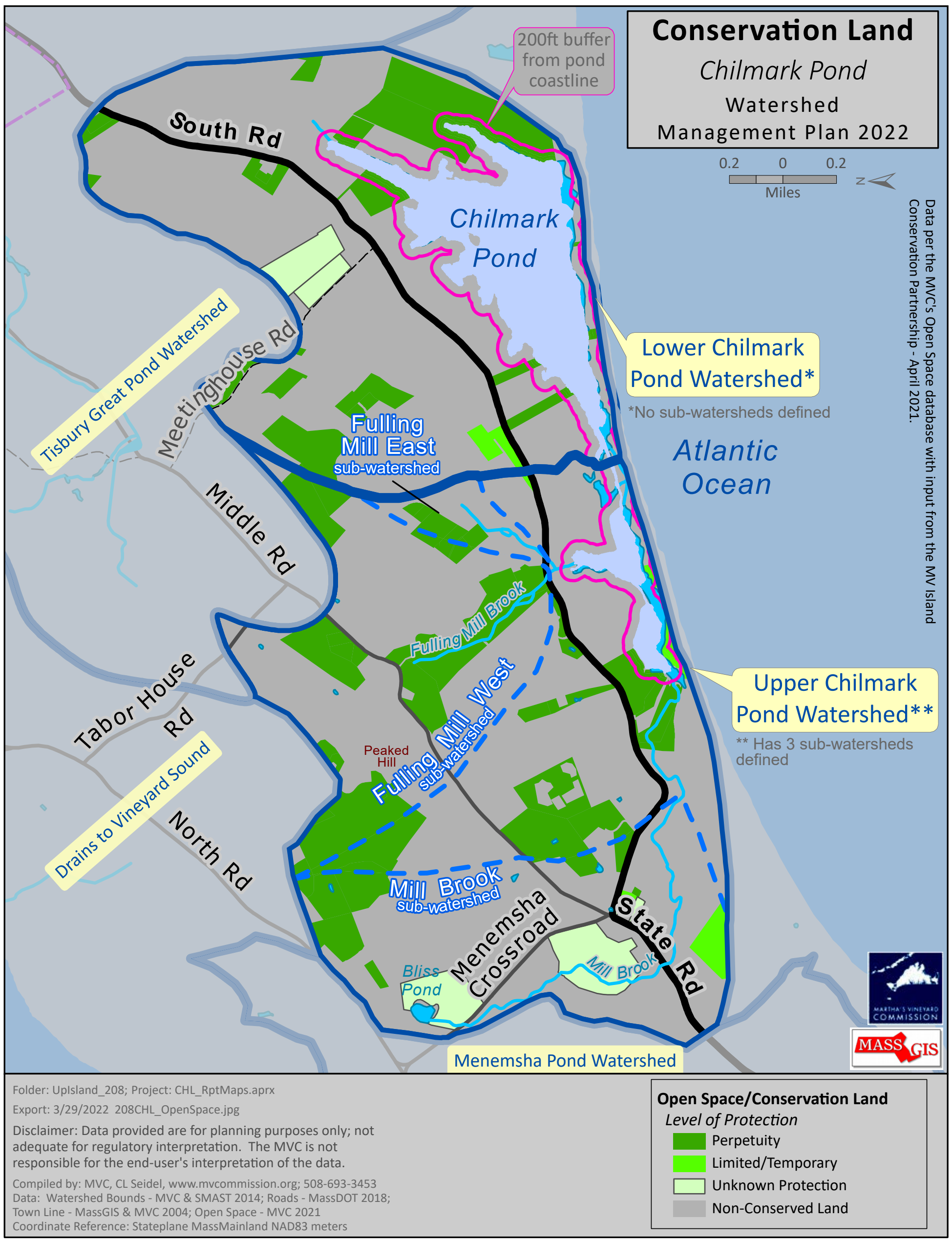


Figure 35. Chilmark Pond Watershed Conservation Land Map

Approximately 22% (745 acres) of the Chilmark Pond Watershed is conserved with some type of legal protection in place. Protections can be based on agricultural, conservation, or easement restrictions (Figure 35).

Most (80%) of conserved land is preserved in perpetuity and excluded from future development through legal restrictions. Unlike the other sub-watersheds, the majority of Mill Brook-CHI conserved land is tied to agricultural use, 58% of the conserved open space in this sub-watershed is protected by agricultural preservation restrictions (Figure 36)[78].

Chilmark Pond conservation areas include both publicly accessible recreation areas and non-publicly accessible areas managed by a variety of entities, including the Martha's Vineyard Land Bank Commission, Sheriff's Meadow Foundation, and the Town of Chilmark. Fulling Mill Brook Preserve and Middle Road Sanctuary in the upland areas of the watershed all allow public trail access, while Wade's Field and Priscilla Hancock Meadow, located adjacent to Gilbert's Cove, do not allow public access [79, 80]. In addition, the Town of Chilmark manages Lucy Vincent Beach on the edge of Upper Chilmark Pond watershed[81].

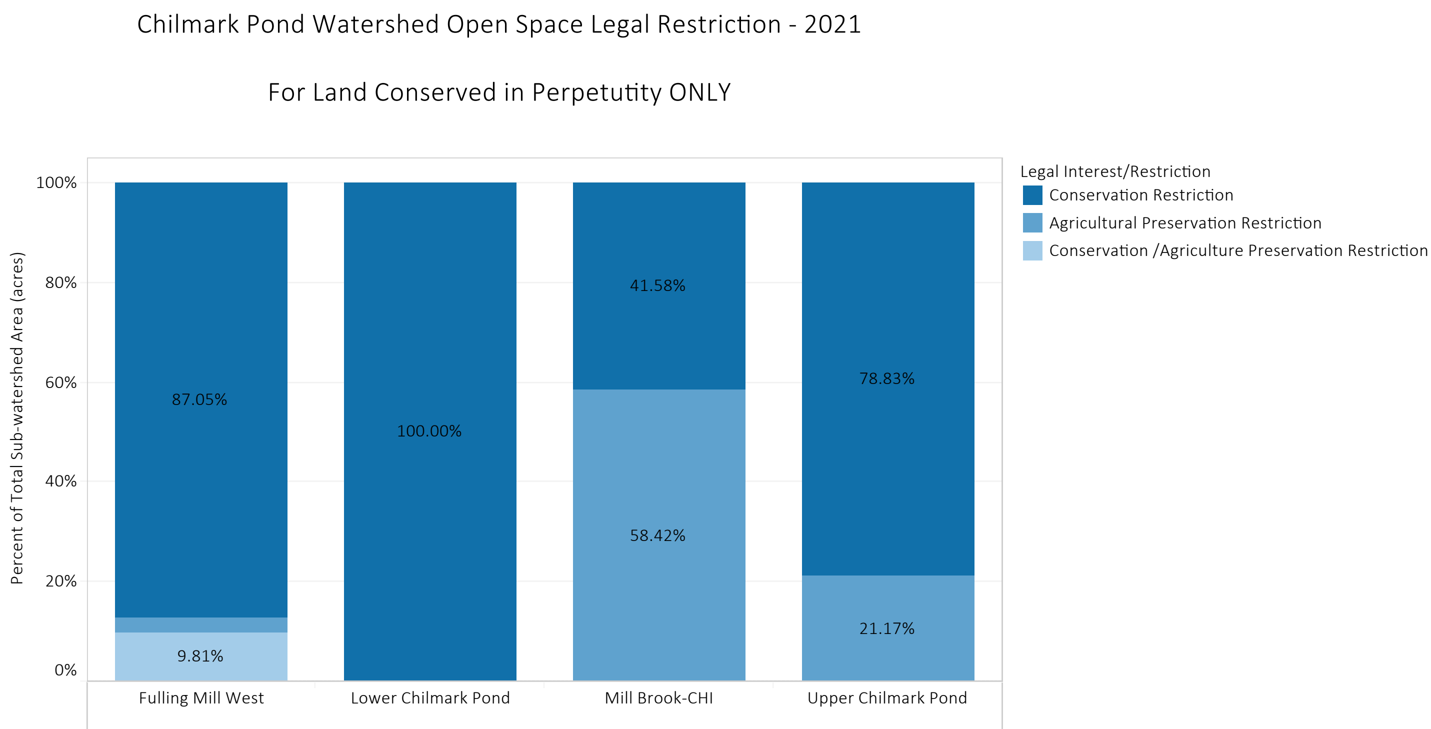


Figure 36. Legal Restrictions for Conservation Land in Chilmark Watershed

Pond uses

Chilmark Pond and surrounding areas have valuable recreational, cultural, and economic resources that rely on clean water and healthy pond ecosystems. Pond uses include recreational boating, swimming, and fin fishing. There are no large mooring areas, marinas, or public boat launches in the pond. There are private docks, many of which are in Lower Chilmark Pond.

Shellfish Areas

Despite having areas of Chilmark Pond are suitable for growing shellfish, the entire pond system is closed to shellfish harvesting due to high bacteria counts. The Department of Marine Fisheries (DMF) maintains shellfish sampling stations in Chilmark Pond as part of the Shellfish Project[82]. Although the DMF has identified Chilmark Pond as suitable for growing soft shelled clams, American Oyster, and Ribbed Muscles[83], shellfish are not a management option at this time due to the health risks associated with consuming shellfish grown in the pond[84]. Per the MEP, the most likely sources of bacteria are wildlife and surface water inflows (Figure 37)[85].

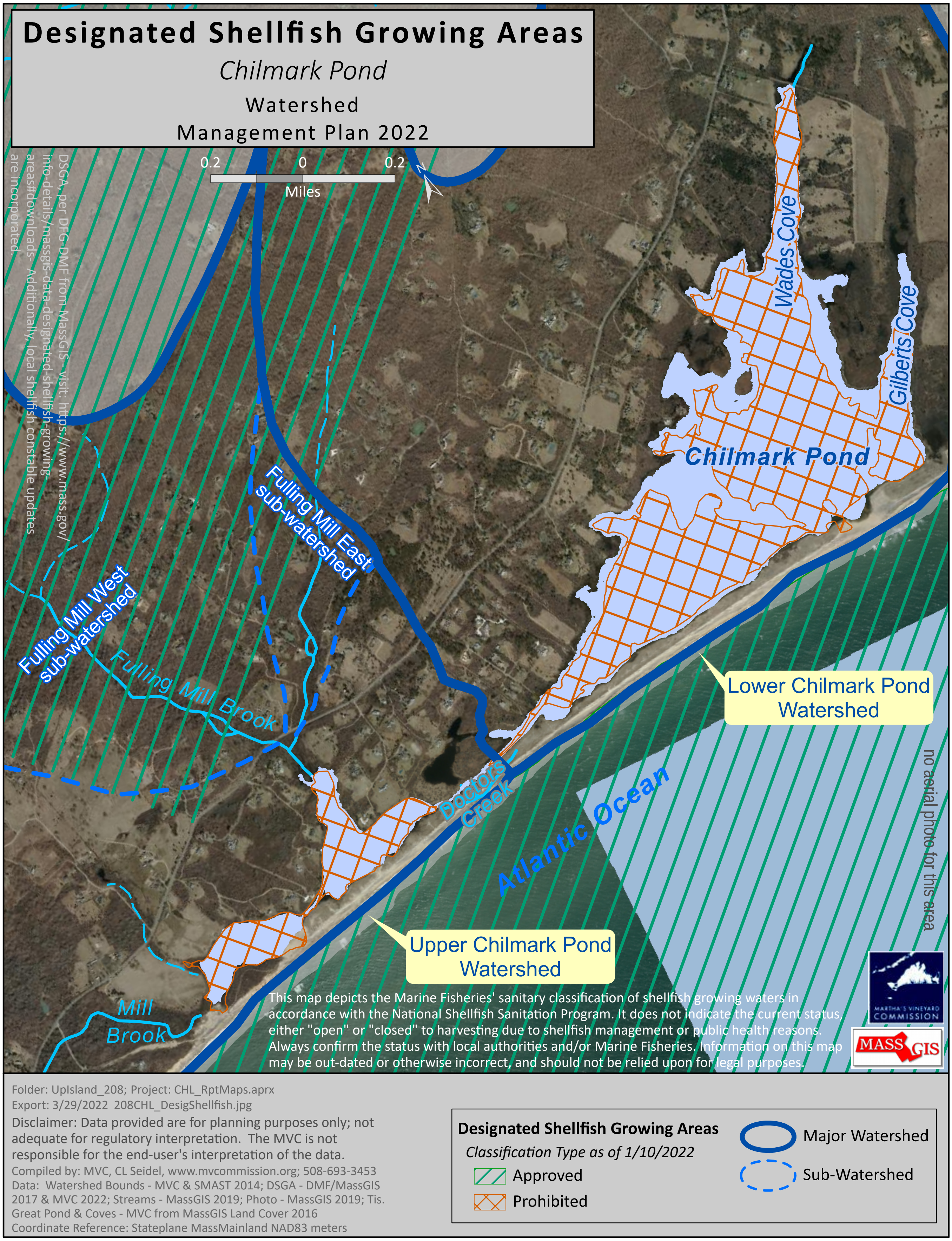


Figure 37. Chilmark Pond Designated Shellfish Harvest Area

Local Regulations

In Chilmark, the Conservation Commission implements the MA Wetlands Protection Act; the Planning Board oversees development under its jurisdiction; the Board of Health regulates wastewater systems; and other relevant town bodies influence pond management and water quality. Conservation Commission authority includes wetland resource areas and associated buffer zones, as defined by the Wetlands Protection Act and the town's bylaws and regulations. These regulations shape the form, density, and location of development, with implications for water quality.

East of Wade's Cove, the watershed area immediately around the pond is zoned as Agricultural-Residential District I. West of Wade's Cove, the watershed area immediately around the pond and south of South Road is zoned as Agricultural-Residential District II-B. North of South Road are areas of Agricultural-Residential District I and Agricultural-Residential District II. The far western edge of the watershed around the town center of Chilmark is zoned as Agricultural-Residential District VI. These zoning districts all have detached one-family dwelling, farm, barn, or silo, riding stable, or nursery uses permitted on minimum lot sizes of three acres[86], a policy that generally limits development density and maintains the rural character of the area.

Chilmark has a Coastal District Special Overlay District in its Zoning Bylaw that includes areas around Chilmark Pond and forbids almost all development in the "Shore Zone"[87], development is restricted in the "Inland Zone"[88], [89]. These regulations are intended to protect the areas immediately adjacent to the pond and reduce direct surface discharges to pondwaters.

The Chilmark Board of Health[90] regulates fertilizer use on residential lawns. Language for this regulation is found in the "The Content and Application of Fertilizer for Turf on Martha's Vineyard" policies. This policy articulates best practices and standards related to timing, concentration, location, and processes for fertilizer application. The policy also addresses nitrogen and other water quality impacts from residential fertilizer application. Fertilizer can be a source of nitrogen to Chilmark Pond, so by controlling fertilizer use, the town contributes to protecting Chilmark Pond.

Summary

Above all, Chilmark Pond's socioeconomic conditions reflect a watershed that has areas of long-established and newer development likely associated with population increases since the 1950s, as well as some areas of conservation land. Existing infrastructure (e.g., septic systems) and development pressures have the potential to amplify water quality stressors, especially in areas with existing water quality challenges presented in the Water Quality section above.

Finally, given the water flow patterns from Upper to Lower Chilmark Pond ("Upper" to "Middle" to "Main" ponds), management plans should reflect that water quality improvements in the Lower Chilmark Pond watershed will not significantly impact water quality in the Upper Chilmark Pond watershed.

Dr. Creek Looking East: Ollie Becker, June 2021

ENDNOTES

1 Data provided by the Martha's Vineyard Commission March 2022.

2 Martha's Vineyard Commission, (2015). Major Watersheds of Martha's Vineyard Map. Accessed March 3, 2022 from https://www.mvcommission.org/document/major-watersheds-marthas-vineyard-map.

3 These boundaries derive from various data sources, including those from MVC, SMAST modeling, and MEP, variation in calculated watershed size.

4 Data provided by the Martha's Vineyard Commission March 2022. Note: These values are slightly different than sub-watershed values presented by MEP, due to differences in methodology.

5 Howes B.L., E.M. Eichner, R.I. Samimy, D.R. Schlezinger, J. S. Ramsey, (2015). Linked Watershed-Embayment Model to Determine the Critical Nitrogen Loading Threshold for the Chilmark Pond Embayment System, Chilmark, Massachusetts. SMAST/DEP Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

6 Data provided by the Martha's Vineyard Commission March 2022.

7 Martha's Vineyard Commission, (2022). Chilmark Pond. Accessed March 1, 2022 from https://www.mvcommission.org/chilmark-pond.

8 Howes et al., (2015).

9 These categories are provided for areas delineated within 200 feet of the pond edge and beyond 200 feet from the pond edge.

10 NOAA, (2021). How to Use Land Cover Data as a Water Quality Indicator. Accessed December 27, 2021 from https://coast.noaa.gov/howto/water-quality.html.

11 Data provided by the Martha's Vineyard Commission March 2022.

12 Howes et al., (2015).

13 Data provided by the Martha's Vineyard Commission March 2022.

14. Note: 'Not Rated' is a group of soil types that do not fit the criteria to be assigned to a specific rating category. In the up-island area, the 'not rated' category appears to be soil types of water and beaches. The Up-Island 208 maps show two soil survey interpretations (1. Hydrologic Soil Group; & 2. Nitrate-Nitrogen Index). The respective "[s]oil survey interpretations assign ratings to soil types based on their properties…" These "…interpretations are developed by soil scientists within the state to provide information specific to the state of Massachusetts."

15 Data provided by the Martha's Vineyard Commission March 2022.

16. The Nitrate-Nitrogen Leaching Index (NLI) is an indicator of the potential for nitrates dissolved in water to percolate to the groundwater. In Massachusetts, the NLI is based on a soil interpretation that uses soil and climate properties in the National Soil Information System (NASIS) database and results in a ranking of low, moderate, or high potential for Nitrate-Nitrogen leaching." Source: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ma/soils/?cid=nrcseprd1371099

17 Data provided by the Martha's Vineyard Commission March 2022.

18. Note: Soil Data is a subset attribute fields from the MassGIS (11/21) SSURGO Certified 'Top20' Soils data from NRCS Database (6/20) . To fully understand these attributes please read the metadata: https://www.mass.gov/info-details/massgis-data-soils-ssurgo-certifie) .

19 Howes et al., (2015).

20 Howes et al., (2015).

21 Howes et al., (2015).

22 Howes B.L., E.M. Eichner, R.I. Samimy, H.E. Ruthven, D.R. Schlezinger, J. S. Ramsey, (2017). Linked Watershed-Embayment Model to Determine the Critical Nitrogen Loading Threshold for the Menemsha-Squibnocket Pond Embayment System, Chilmark/Aquinnah, Massachusetts. SMAST/DEP Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

23 Chilmark Pond Association, (2022). About Us. Accessed March 29, 2022 from https://www.chilmarkpond.org/about-us.

24 Howes et al., (2015).

25 Records provided by Martha Cottle, Head Commissioner, Chilmark Pond Association, September 2021.

26 Howes et. al, (2015).

27 https://www.mass.gov/regulations/314-CMR-4-the-massachusetts-surface-water-quality-standards.

28 https://www.mass.gov/lists/integrated-lists-of-waters-related-reports.

29 UMass Dartmouth's School for Marine Science & Technology (SMAST), (2016-2021). Data provided by the Martha's Vineyard Commission 2022.

30 Howes et al., (2015).

31 Howes et. al, (2015).

32 Howes et al., (2015).

33 Commonwealth of Massachusetts, (2019). Final Chilmark Pond Estuarine System Total Maximum Daily Load For Total Nitrogen.

34 Howes et al., (2015).

35 Howes et al., (2015).

36 Martha's Vineyard Commission, (2020). Chilmark Pond 2020 M.V.C. Sampling Summary. Accessed December 2021 from https://www.mvcommission.org/sites/default/files/docs/chilmark-pond-2_55349405%20%281%29.pdf.

37 UMass Dartmouth's School for Marine Science & Technology (SMAST), (2016-2021). Data provided by the Martha's Vineyard Commission 2022.

38. Total Pigment threshold is a well established parameter as described by Brian Howes in an email correspondence with Rachel Sorrentino on 9/30/2022.

39 U.S. EPA, (2001). Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters.

40 Howes et al., (2015).

41 Commonwealth of Massachusetts, (2019).

42 Priority Natural Communities include natural communities with limited distribution. Natural communities are interacting assemblages of plant and animal species that share a common environment and occur together repeatedly on the landscape.

43 Massachusetts Natural Heritage and Endangered Species Program (NHESP) (http://maps.massgis.state.ma.us/dfg/biomap2.htm)and Howes et al., (2015).

44 http://maps.massgis.state.ma.us/dfg/biomap2.htm. For definitions of these categories, visit the BioMap2 website.

45 http://maps.massgis.state.ma.us/dfg/biomap2.htm. For definitions of these categories, visit the BioMap2 website.

46 https://www.mass.gov/service-details/biomap2-town-reports, see Chilmark report.

47 https://www.mass.gov/service-details/biomap2-town-reports, see Chilmark report.

48 Sampling locations were in Upper Chilmark Pond (3), Chilmark Pond (3), Wade's Cove (2) and Gilbert's Cove (1). Howes et al., (2015).

49 DEP (2019).

50 Howes et al., (2015).

(Geukensia demissa) are found in Chilmark Pond. Ribbed muscles provide filtration services and are food sources for predators like the Blue Crab, however, Ribbed muscles can be toxic and are not considered a human food source.

51 Wilcox et al., (2001). Chilmark, Menemsha and Squibnocket Ponds: Nutrient Loading and Recommended Management Program. January 2001. https://www.mvcommission.org/sites/default/files/docs/Finl_MEnSqbChp_10edited.pdf.

52 Reported by Rick Karney, Director Emeritus and Shellfish Biologist, Martha's Vineyard Shellfish Group, Inc., 2022.

53 DEP (2019).

54 The MassDEP Eelgrass Viewer shows mapping project years from 1195, 2001, 2006/2007, 2010-2013, 2015-2017, and 2019-2022. The viewer is available here: https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=07f8d48c714f4f81bec49864ecf252da.

55 Howes et al., (2015).

56 Howes et al., (2015).

57 Green Beach, Emma (2022), Email correspondence with Rachel J. Sorrentino.

58 Howes et al., (2015).

59 Howes et al., (2015).

60 Howes et al., (2015).

61 Howes et al., (2015).

62 U.S. Census Bureau (2019). American Community Survey (ACS) Five-Year Estimates 2015-2019 and U.S. Census Bureau (2020). 2020 Census. Data provided by the Martha's Vineyard Commission 2022.

63 U.S. Census Bureau (2019) and U.S. Census Bureau (2020). Data provided by the Martha's Vineyard Commission 2022.

64 Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures. Data provided by the Martha's Vineyard Commission March 2022. Subsequent data summaries compiled by Horsley Witten Group 2022.

65 Howes et al., (2015).

66 Data provided by the Martha's Vineyard Commission 2022.

67 Howes et al., (2015).

68 Town of Chilmark, (2020), Assessors Databases. Data provided by the Martha's Vineyard Commission March 2022.

69 Howes et al., (2015)

70 Existing Septics: The Structure roofprints from MassGIS were used to determine which parcels were developed at the time MassGIS data was collected (data accessed 2022). The septic numbers represent an approximate count of parcels containing a septic system. It is assumed only one septic per parcel. It is assumed that Non-title V septics are parcels that were initially developed prior to 1978; parcels initially developed in 1978 or later are assumed to have a Title V septic. Parcels with Innovative Alternative systems were identified & geolocated based on info provided by the Barnstable County Innovative/Alternative Septic System Tracking Program. The IA data only included info for Active IA systems in Chilmark & West Tisbury as of June 2nd, 2021. The initial year built is based on the Assessor's year built data per their detailed building info export. If a parcel didn't have building info in that table, then the MVC consulted the town's Assess Table in their parcel geodatabase or the town's AxisGIS website. For parcels with multiple buildings, the earliest year built was used to classify Non-Title V vs Title V septic. Therefore, if the parcel's initial building was developed in 1965 but a second structure was built in 2000, then the type of septic assigned to that parcel is Non-Title V (since the Title V regulations went into effect in 1978). Finding developed parcels vs vacant parcels was identified by analyzing the MassGIS Structures data along with the Assessor's use code and assessed building value for the parcel.

71 Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures, with support from Barnstable County. Data provided by the Martha's Vineyard Commission March 2022.

72 Commonwealth of Massachusetts, (2019).

73 Future Buildings: The future building analysis, performed in the Spring of 2021 by the MVC, incorporated the most currently available parcel boundary, structure, zoning data, and open space/ Conservation land available. These data will not reflect the reality of the current moment as there is always a delay between obtaining data, processing, and then dissemination. The future buildout only considers minimum lot size per town zoning. Meaning, if a 9 acre parcel in a 3 acre minimum zoning area has one existing structure, then the model will determine that 2 future buildings could be developed on this parcel. The analysis does not restrict building on wetlands nor does it incorporate Town Board of Health regulations or special housing association or deed restrictions. The model did restrict future development on land that is protected as conservation land (as of April 2021). This methodology results a maximum future buildout.

74 Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures. Data and analysis provided by the Martha's Vineyard Commission March 2022.

75 Howes et al., (2015).

76 Murphy, Chris, (2022), email correspondence with Rachel J. Sorrentino

77 Martha's Vineyard Commission, (2022). Farm Animal Reports. Data provided by the Martha's Vineyard Commission January 2022.

78 MVC & MV Island Conservation Partnership, (2021). Data provided by the Martha's Vineyard Commission 2022.

79 Sheriff's Meadow Foundation, (2022). Lands and Trails. Accessed March 1, 2022 from https://sheriffsmeadow.org/lands/#map-trigger.

80 Mass Trails. Chilmark Open Space Property Map. Accessed March 1, 2022 from https://www.mass-trails.org/towns/Chilmark/OpenSpacePropertyMap_.html.

81 Town of Chilmark, (2022). Beach Information. Accessed March 1, 2022 from https://www.chilmarkma.gov/beach-committee/pages/beach-information.

82 https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html, Shellfish Growing Areas datalayer.

83 Green Beach, Emma (2022) email correspondence with Rachel J. Sorrentino indicating that Atlantic Ribbed Muscles

84 https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html, Shellfish Growing Areas datalayer.

85 Howes et al., (2015).

86 Martha's Vineyard Commission, (2015). Chilmark, MA Zoning. Accessed March 1, 2022 from chi_zn_current.pdf (mvcommission.org) and Martha's Vineyard Commission (2022). Up-Island Watershed Land Use. Accessed March 1, 2022 from https://www.arcgis.com/apps/mapviewer/index.html?webmap=ab3dcefe9ebe40cbb7902d1de39dcb59.

87 "Shore Zone" includes area "from mean low water to one hundred (100) feet inland of the inland edge of any beach or marsh grasses, and one hundred (100) feet inland of the crest of any bluff exceeding a height of fifteen (15) feet."

88 "Inland Zone" refers to the area other than the Shoe Zone and "below the ten (10) foot elevation above mean sea level, or within five hundred (500) feet of mean high water of a coastal water body exceeding ten (10) acres in size, or the ocean; all of Noman's Island; all land within one hundred (100) feet of streams and wetlands draining into the Coastal Great Ponds"

89 Town of Chilmark, MA, (2019). Town of Chilmark Zoning Bylaws 2019. Accessed March 1, 2022 from https://www.chilmarkma.gov/sites/g/files/vyhlif2951/f/uploads/chilmark_zoning_bylaws_article_11.pdf.

90 Town of Chilmark, (2019). Town of Chilmark Board of Health Regulations. Accessed December 27, 2021 from https://www.chilmarkma.gov/sites/g/files/vyhlif2951/f/uploads/boh_regulations_dec_2019.pdf.