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REPORT



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TOWN OF
Truro
MASSACHUSETTS

Truro Integrated Water Resources
Management Plan Phase II Report for
the Water Resources Oversight
Committee



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Truro Phase II Report

Prepared for

Town of Truro

Water Resources Oversight Committee**Introduction**

This is the second phase of the Truro Integrated Water Resources Management Plan for the Town of Truro, Massachusetts. The Town initiated the IWRMP because of its concern over long term ground water quality. Based on the Town's voluntary ground water quality testing, testing of surface water bodies and an evaluation of land uses and waste disposal, Phase I provided an assessment of ground water quality, focusing on the level of nitrate and its potential sources. The Phase II report summarizes public outreach efforts, provides a detailed assessment of ground water near East Harbor, discusses possible town-wide methods of controlling water quality and proposes development of storm water treatment measures as possible demonstration projects. The project was developed in collaboration with the Town Water Resources Advisory Committee (WRAC)

1.0 PUBLIC EDUCATION AND OUTREACH (TASK 1)

1.1 Purpose of Task

This task provided materials to the Town for increasing public awareness of the area's water supply and the need to protect its water quality from short and long-term impairments or sources of contamination. Although large scale municipal supplies exist within Truro (operated by Provincetown) the majority of Truro is served by private wells and septic systems. As a result, the long-term viability of water resources is dependent on public awareness and knowledge. Specifically, residential land use practices, private wastewater (septic system) management and a host of other small actions can pay long term dividends in protecting the water resources of Truro. However, without effective education and outreach material and ongoing efforts, beneficial public behavior and related management changes may not be realized. The materials discussed in this section, and contained in Appendices A and B were developed in consultation with the WRAC and were intended to be distributed through the Town.

1.2 Public Information Materials

1.2.1 *Public Meetings*

Presentation materials were prepared for the April 2015 Town meeting and a public workshop on August 13, 2016. These materials are Attached as Appendix A. The presentation at the April Town Meeting was cancelled due to conflicts with key WRAC presenters. It was not rescheduled. The August 13 Public workshop provided background on the region's hydrogeology and issues relating to Truro's ground- and surface water quality. The August 13 presentation was made by both members of the WRAC and Weston & Sampson; it was attended by 14 individuals.

1.2.2 *Presentation for Cable Broadcast*

In addition to the public meetings, materials were prepared for broadcast on local cable television. These materials consisted of two sets of slides with text for voice over recording (Appendix B). The first presentation was a series of three images in PowerPoint format listing steps individual home owners could take to protect and improve water quality. The second presentation was a 25-minute PowerPoint format presentation comprising 35 images with text for voiceover. The WRAC accepted the presentation materials and took responsibility for performing the voiceover and airing the materials.

Recommendations

The materials prepared for the WRAC should be updated from time to time and public meetings should be held at least annually. Broadcast materials should be repeated on the town cable channel and should be updated as new information becomes available.

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2.0 GROUNDWATER AND SURFACEWATER MONITORING (TASK 2)

2.1 Purpose of Task

Phase I of the IRWMA identified Beach Point and East Harbor as an area where development was relatively compact and that septic systems may have impacts to surface water (East Harbor). Although a prior study indicated that ground water flowed from East Harbor to the Ocean (Massachusetts Bay), Phase I recommended development of additional water level and water quality data to better evaluate transport and fate of nutrients. In this phase of work, monitoring wells were established along 4 transects to provide ground water quality and water level information between East Harbor and Massachusetts Bay as well as surface water quality data in East Harbor and Pamet River. The groundwater data are used to establish water quality and the direction of subsurface flow between East Harbor and the ocean (Massachusetts Bay). Surface-water sampling augments work performed under the Provincetown – Estuarine Water Quality Monitoring 604(b) Grant¹.

Water quality data were collected in June and July 2015 from East Harbor and all monitoring wells. Water samples were analyzed by both a commercial laboratory and by a Worcester Polytechnic Institute student as part of a senior Independent Study Project. Data results from both laboratories were comparable.

Water level data were collected using automated pressure transducers. Along each transect transducers were installed in 3 wells, a piezometer and staff gage. A Piezometer and staff gage were installed in the margin of East Harbor at the end of each transect under a permit from the Cape Cod National Seashore. Piezometers and staff gages in the margin of East Harbor allowed documentation of flow downward (from East Harbor into groundwater) or upward (from groundwater into East Harbor).

Wells were installed adjacent to Route 6 under permit from the Massachusetts Department of Transportation. Due to the environment and long deployment of transducers, some transducers failed to produce data. This resulted in the need for several deployments in summer, fall and spring over the course of 2 years to provide more complete data sets. Data collected are shown in the data summary tables. Initial data and other information was provided to the WRAC, BOH and BOS in 2016, and additional data collection was suggested by the WROC. In spite of the use of transducers to monitor water levels along the transects, collection and analysis of data were unusually labor intensive.

2.2 Well Installation

A series of shallow monitoring wells (12 wells and 4 staff gage/piezometers) were placed in the East Harbor area transecting the Rt. 6 and Beach Point area (Figure 1). The final locations were determined in consultation with the Truro Water Resources Oversight Committee. Water level measuring devices (Transducers and data loggers) were installed in all wells, staff gages and piezometer.

¹ Massachusetts DEP. 2010. Summary of Water Quality Monitoring Program for the Provincetown Harbor, East Harbor Lagoon, Pamet Harbor and Hatches Harbor Embayments Systems. Prepared by Coastal Systems Laboratory School of Marine Science and Technology (SMAST) University of Massachusetts – Dartmouth

All wells were installed using the direct push method with a Geoprobe 78220 rig. Wells were installed to a depth at least 10 ft. below the water table and finished in sandy soils. Each well comprised 1 inch PVC casing with 10 to 15 ft. of 1 inch slotted casing. Each well was finished below land surface and encased in a cylindrical road box with screw-down top. Well characteristics are summarized in Table 2-1.

Table 2-1. East Harbor Monitoring Well Installation Characteristics

Monitoring Well Specifications							
Well #	Well Location	Well Depth (ft.)	Well Screen (ft.)	Well Casing (ft.)	Water Level (ft.)	Time of Water Level Measurement	Top of Casing to Top of Box (in)
T1-A	Shoulder of Rt. 6 eastbound 38 ft. from curb	15	10	5	3.10	5/20 - 3:30 PM	2.25
T2-A	Shoulder of Rt. 6 eastbound 4 ft. from curb	20	10	10	9.65	5/20 - 3:45 PM	3.75
T3-A	Shoulder of Rt. 6 eastbound 11 ft. from curb	20	10	10	9.30	5/20 - 3:55 PM	4.75
T4-A	Shoulder of Rt. 6 eastbound 7.7 ft. from curb	20	10	10	7.50	5/20 - 4:20 PM	5.00
T1-B	Shoulder of Rt. 6 westbound ~10.5 ft. from curb	20	10	10	7.80	5/21 - 2:50 PM	2.50
T2-B	Shoulder of Rt. 6 westbound ~10.5 ft. from curb	20	10	10	9.20	5/21 - 2:35 PM	1.50
T3-B	Shoulder of Rt. 6 westbound ~10.5 ft. from curb	20	10	10	8.60	5/20 - 4:50 PM	6.50
T4-B	Shoulder of Rt. 6 westbound ~10.5 ft. from curb	20	10	10	6.80	5/20 - 4:40 PM	7.25
T1-C	Shoulder of Rt. 6A eastbound 4.5 ft. from curb	25	15	10	13.80	5/21 - 3:00 PM	3.75
T2-C	Shoulder of Rt. 6A eastbound ~8.5 ft. from curb	25	15	10	10.70	5/21 - 3:10 PM	3.50
T3-C	Shoulder of Rt. 6A eastbound ~7 ft. from curb	25	15	10	11.10	5/21 - 3:15 PM	2.50
T4-C	Shoulder of Rt. 6A eastbound 11 ft. from curb	25	15	10	7.00	5/21 - 3:20 PM	3.50

Each well was partially developed at the time of drilling. Additional development was performed on June 7 by hand pumping until the production water ran clear. The coordinates of each well location

were established using Trimble GPS Equipment. All wells were sampled On June 16 and July 22, 2016 for total dissolved solids (salinity) and nutrients (Table 2-2). Wells were sampled a second time on July 22, 2016 (Table 2-2).

Table 2-2. Ground Water Quality Sampling Results

Well ID	Well Construction	Date	Phosphate (Mg/L)	Nitrate + Nitrite (mg/L)	Ammonia Nitrogen (mg/L)	Salinity (ppt)	Conductivity (mS)	Distance Below Measuring Point (ft.)
T1-A	10' Screening 1" Diameter	6/16/2015	0.71	5.6	2.26	15.8	20.41	2.9
		7/22/2015	0.24	4.1	0.74	15.8	19.46	2.9
T1-B	10' Screening 1" Diameter	6/16/2015	0.08	1.7	1.34	7.9	10.12	7.2
		7/22/2015	0.12	1.0	0.73	5.6	7.33	7.2
T1-C	15' Screening 1" Diameter	6/16/2015	0.03	5.8	0.04	2.2	3.188	12.1
		7/22/2015	0.15	2.6	0.00	3.0	3.784	12.7
T2-A	10' Screening 1" Diameter	6/16/2015	0.06	2.1	3.10	16.5	18.90	9.2
		7/22/2015	0.09	0.7	1.56	15.6	18.54	9.5
T2-B	10' Screening 1" Diameter	6/16/2015	0.03	1.4	3.03	17.5	20.72	8.3
		7/22/2015	0.05	1.5	2.61	16.6	19.22	9.0
T2-C	15' Screening 1" Diameter	6/16/2015	0.07	0.8	2.91	16.2	18.68	8.7
		7/22/2015	0.09	1.4	1.22	14.8	17.64	9.6
T3-A	10' Screening 1" Diameter	6/16/2015	0.89	1.5	2.02	13.8	16.62	8.7
		7/22/2015	1.09	0.1	1.84	10.7	13.15	8.7
T3-B	10' Screening 1" Diameter	6/16/2015	0.90	2.4	1.23	7.7	9.260	8.1
		7/22/2015	0.96	0.1	1.37	6.1	8.45	8.3
T3-C	15' Screening 1" Diameter	6/16/2015	0.05	4.1	0.14	2.0	2.774	9.9
		7/22/2015	0.16	1.2	0.13	1.2	1.604	10.3
T4-A	10' Screening 1" Diameter	6/16/2015	0.16	ND	0.14	0.2	0.2706	7.0
		7/22/2015	0.06	0.2	0.09	0.2	0.2246	7.1
T4-B	10' Screening 1" Diameter	7/16/2015	0.25	0.6	1.79	0.1	0.2338	6.2
		7/22/2015	0.04	0.9	1.69	0.1	0.1447	6.2
T4-C	15' Screening 1" Diameter	7/16/2015	0.02	0.4	0.85	0.2	0.2883	6.6
		7/22/2015	0.05	0.2	0.56	0.1	0.2159	7.8

2.3 Water Level Monitoring

Water level measuring devices (Transducers and data loggers) were deployed three times in the Beach Point monitoring wells, Table 2-3. During the first deployment devices were installed in wells T1-A, T2-A, T2-B, T2-C and T4-A, and began recording data at 30 minute intervals on June 16, 2015. Transducers and data loggers were installed in the remaining wells as well as all staff gage and piezometers², and began recording data at 30 minute intervals on July 15, 2015. Transducers/dataloggers were recovered

² Staff gages and piezometers were installed in the margin of East Harbor with permission of the Cape Cod National Seashore. Wells along Route 6 were installed under permit from MassDOT.

from all wells and staff gage/piezometer locations on November 11, 2015. Data was successfully recovered from all transducers/data loggers except those installed in Well T1-C and piezometer PZ-4.

Water level measurement devices were deployed a second time in July 2016 and recovered in July 22, 2016. Data were recovered in all transducers except those in Staff gage T4-SG and Piezometer T4-PZ. Devices were deployed for the third time in August 2016 and were recovered August 17, 2017 with the exception of wells T4B and T4C that were recovered in in November 2917. While data were recovered from most monitored intervals, some devices malfunctioned creating gaps in the data set (Table 2-3).

Table 2-3. Data Recovery in Beach Point Transducers

	2015	2016	2016-2017
Well	Data Recovered		
T1-SG	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T1-PZ	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T1-A	6/12-12/1	05/13-07/21	9/8/2016-8/17/2017
T1-B	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T1-C	Data unrecoverable	05/13-07/21	9/8/2016-8/17/2017
T2-SG	7/15-12/1	05/13-07/21	Data unrecoverable
T2-PZ	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T2-A	6/12-12/1	05/13-07/21	9/8/2016-8/17/2017
T2-B	6/12-12/1	05/13-07/21	9/8/2016-8/17/2017
T2-C	6/12-12/1	05/13-07/21	Data unrecoverable
T3-SG	7/15-12/1	05/13-07/21	Data unrecoverable
T3-PZ	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T3-A	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T3-B	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T3-C	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T4-SG	7/15-12/1	Data unrecoverable	9/8/2016-8/17/2017
T4-PZ	Data unrecoverable	Data unrecoverable	9/8/2016-8/17/2017
T4-A	6/12-12/1	05/13-07/21	9/8/2016-8/17/2017
T4-B	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017
T4-C	7/15-12/1	05/13-07/21	9/8/2016-8/17/2017

2.4 Data Evaluation-Water Levels

Water level data from 2015, 2016 and 2017 were arranged by month and the percentage of time the gradients were from the beach toward East Harbor ("inland") were calculated as were the range and

average gradient (Table 2-4)³. Similar calculations were made using data from each piezometer and corresponding staff gage to measure direction of flow between underlying materials and East Harbor. Data were evaluated considering rainfall and tidal fluctuations. Unfortunately, water level data from the 4 transects is incomplete and does not allow direct comparison among transcripts during all data collection periods. However, sufficient data are available to draw conclusions as to horizontal and vertical movement of ground water. As discussed below, the data are not consistent with conclusions reached in the 2008 report Simulation of Groundwater Flow at Beach Point⁴.

Table 2-4. Summary of Groundwater Gradient Data, Beach Point Area

Period	Transect	Segment	Distance	Horizontal Gradient	
				Average	% Inland
6/12-12/1 2015	T1	C to B	202.9	equipment failure	
		B to A	102.76	0.0003	59.2
		A to PZ	134.21	0.0006	86.3
		A to SG	134.21	0.0008	92.5
6/12-12/1 2015	T2	C to B	172.42	-0.0029	35.3
		B to A	66.89	-0.0081	16.3
		A to PZ	69.19	0.0031	67.3
		A to SG	69.19	0.0053	77.8
6/12-12/1 2015	T3	C to B	163.83	0.0002	52.8
		B to A	71	-0.0014	7.5
		A to PZ	142.73	0.0000	48.7
		A to SG	142.73	0.0024	97.7
6/12-12/1 2015	T4	C to B	184.18	0.0007	100.0
		B to A	125.62	0.0008	99.8
		A to PZ	143.9	Optical Read Failure	
		A to SG	143.9	-0.0001	40.7

³ Water level data were collected at 30-minute (0.5 hour) intervals. Data are available in electronic form due to the magnitude of the data sets at each site.

⁴ Martin, L. 2008. Simulation of Groundwater Flow at Beach Point, Cape Cod, Massachusetts. Natural Resource Report NPS/NRPC/WRD/NRTR—2008/111

Period	Transect	Segment	Distance	Horizontal Gradient	
				Average	% Inland
5/13-7/22 2015	T1	C to B	202.9	0.0016	62.4
		B to A	102.76	-0.0007	28.6
		A to PZ	134.21	0.0013	100.0
		A to SG	134.21	0.0013	100.0
5/13-7/22 2015	T2	C to B	172.42	0.0003	52.0
		B to A	66.89	-0.0026	39.6
		A to PZ	69.19	-0.0045	15.4
		A to SG	69.19	0.0027	82.5
5/13-7/22 2015	T3	C to B	163.83	0.0028	100.0
		B to A	71	-0.0046	0.0
		A to PZ	142.73	0.0023	99.4
		A to SG	142.73	0.0009	67.3
5/13-7/22 2015	T4	C to B	184.18	0.0042	100.0
		B to A	125.62	-0.0048	0.0
		A to PZ	143.9	Optical Read Failure	
		A to SG	143.9	Optical Read Failure	

Period	Transect	Segment	Distance	Horizontal Gradient	
				Average	% Inland
9/8/16-8/17/17	T1	C to B	202.9	0.0063	79.9
		B to A	102.76	-0.0028	3.4
		A to PZ	134.21	0.0012	100.0
		A to SG	134.21	0.0011	97.1
9/8/16-8/17/17	T2	C to B	172.42	Battery Failure	
		B to A	66.89	-0.0037	32.3
		A to PZ	69.19	-0.0254	0.0
		A to SG	69.19	Battery Failure	
9/8/16-8/17/17	T3	C to B	163.83	0.0016	89.9
		B to A	71	-0.0010	24.8
		A to PZ	142.73	-0.0008	33.1
		A to SG	142.73	Battery Failure	
9/8/16-8/17/17	T4	C to B	184.18	0.0006	100.0
		B to A	125.62	0.0008	99.8
		A to PZ	143.9	-0.0006	55.1
		A to SG	143.9	0.0021	91.2

Period	Transect	Vertical Gradient	
		Average	% Upward
6/12-12/1 2015	T1	0.0120	83.8
	T2	0.0544	100.0
	T3	0.1327	99.6
	T4	Optical Read Failure	
5/13-7/22 2015	T1	0.0010	51.8
	T2	0.1538	96.8
	T3	-0.0585	0.2
	T4	Optical Read Failure	
9/8/16-8/17/17	T1	-0.0029	51.2
	T2	Battery Failure	
	T3	Battery Failure	
	T4	0.1741	100.0

First, in data collected from piezometers along the margin of East Harbor indicated an upward gradient (groundwater discharging to East harbor) during a majority of time, in both winter and summer. In some cases, upward gradient was measured in over 95% of the time monitored. This is inconsistent with the conclusion that subsurface flow moves from East Harbor toward Massachusetts Bay.

Second, while transects T2 and T3 (across narrower sections of Beach Point) show variation of horizontal gradient between inland and oceanward, the transects T1 and T4, show less variation and more consistent inland gradients (toward East Harbor). These data suggest that subsurface flow may flow toward East Harbor along a significant portion of the southwestern shoreline of East Harbor for most of the time. This is not consistent with the particle analysis in Martin (2008)⁵ which concluded that tidal fluctuation would reverse oceanward flow for relatively short periods of time. Therefore, the data in this study indicate that groundwater flow will carry nutrients from subsurface disposal of sewer effluent (septic systems) in the Beach Point area to East Harbor.

2.5 Surface Water Quality

In June and July 2015 surface water quality samples were collected by volunteers at locations in East Harbor and the Pamet River that had been sampled as part of prior studies⁶. Sample locations are shown in Figures 2 and 3. In locations where water was more than 1 meter in depth, a sample (“deep sample”) was taken approximately 0.1 meter above the bottom. Sample results are shown in Table 2-5 and are compared to average values reported by DEP (2010). Due to different laboratory techniques

⁵ Martin, L. 2008. Simulation of Groundwater Flow at Beach Point, Cape Cod, Massachusetts. Natural Resource Report NPS/NRPC WRD/NRTR—2008/111

⁶ DEP. 2010. previously cited.

used, some of the results are not directly comparable. However, there were notable changes between samples taken in East Harbor between June and July. In particular, nutrients, both Phosphate and Nitrate levels in July were higher in both surface and deep samples. In the Pamet River samples, a similar increase between June and July was found for Nitrate but not for Phosphate.

2.6 Conclusions and Recommendations

Where data allow comparisons to be made, surface water concentrations of Phosphate, Nitrate and Ammonia/nitrogen in both East Harbor and the Pamet River were higher in 2015 than in an average of 15 samples taken in 2007-2009.

Groundwater discharged to East Harbor upward from underlying materials along Beach Point a substantial majority of the period measured in 2015, 2016 and 2017.

Groundwater gradients were toward East Harbor a majority of the time and under a range of seasons along Transects 1 and 4. In transects 2 and 3, gradients were toward east harbor a majority of the time in some months, but not others but no seasonal correlation was apparent.

Groundwater gradients indicate that effluent from Beach Point septic systems are reaching East Harbor.

Truro should establish regular water quality monitoring of the monitoring wells along Beach Point road (Route 6A) which are nearest existing areas served by septic systems.

Alternatives for serving the Beach Point area with a centralized sewer collection system should be developed to remedy the water quality impacts associated with septic system discharges. The area evaluated for collection should be between the Provincetown line and Stott's Crossing.

TRURO PHASE II REPORT

Table 2-5. Surface Water Sampling Results

	Coordinates		Location	Sample Date	Phosphate (Mg/L)	Nitrate + Nitrite (mg/L)	Ammonia Nitrogen (mg/L)	NOX (mg/L)	TN (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)	Bromide (mg/L)	Salinity (ppt)	Conductivity (mS)
East Harbor	042° 03.9384' N,	070° 08.7092' W	EHL-1	Average	0.44		0.36	0.011	1.08					20.3	
	042° 03.9384' N,	070° 08.7092' W	EH1-S	6/22/2015	0.018	0.03	BRL			11,700	1,600	ND	34.9		
				7/22/2015	0.12	4.1	3.23							18.4	24.32
			EH1-D	6/22/2015	0.021	BRL	BRL			11,500	1,500	ND	42.7		
				7/22/2015	0.26	1.2	2.6							9.5	12.26
	042° 03.5210' N,	070° 07.8551' W	EHL-6	Average	0.01		0.018	0.006	0.779						24.2
	042° 03.5210' N,	070° 07.8551' W	EH6-S	6/22/2015	0.015	BRL	BRL			14,700	2,000	ND	51.8		
				7/22/2015	0.06	2.4	3.65							23.2	28.16
			EH6-D	6/22/2015	0.018	0.02	BRL			14,800	2,000	ND	57.2		
				7/22/2015	0.14	2.2	3.75							13.5	17.01
	042° 03.1616' N,	070° 07.0954' W	EHL-11	Average	0.017		0.031	0.008	0.55						27.8
	042° 03.1616' N,	070° 07.0954' W	EH11-S	6/22/2015	0.019	0.03	BRL			15,400	2,200	ND	53.5		
				7/22/2015	0.13	1.7	3.8							22.8	27.36
			EH11-D	6/22/2015	0.015	0.06	BRL			15,200	2,100	ND	46.3		
				7/22/2015	0.11	1.3	3.6							22.9	26.97
	042° 03.1786' N,	070° 07.7337' W	EHL-12	Average	0.005		0.013	0.005	0.384						30.7
042° 03.1786' N,	070° 07.7337' W	EH12-S	6/22/2015	0.023	0.03	BRL			18,700	2,600	ND	64.4			
			7/22/2015	0.2	2.6	4.34							12.2	15.38	
		EH12-D	6/22/2015	0.023	0.02	BRL			18,600	2,600	ND	61.5			
			7/22/2015	0.12	3.1	4.31							12.3	15.36	
			Sample ID		Phosphate (Mg/L)	Nitrate + Nitrite (mg/L)	Ammonia Nitrogen (mg/L)	NOX (mg/L)	TN (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)	Bromide (mg/L)	Salinity (ppt)	Conductivity (mS)
Pamet River	041° 59.6482' N,	070° 03.1339' W	PMH-1	Average	0.016	0.19	BRL			1,250	150	ND	ND		
	041° 59.6482' N,	070° 03.1339' W	PH1-S	6/22/2015	0.14	0.7	0.5							1.8	2.521
				7/22/2015	0.031		0.034	0.075	0.61						15.8
			PH1-D	6/22/2015	0.017	0.16	BRL			10,600	1,500	ND	28.5		
				7/22/2015	0.12	2.2	0.38							14.9	18.01
	041° 59.6773' N,	070° 03.7350' W	PMH-2	Average	0.023	0.08	BRL			16,600	2,300	ND	55.4		
	041° 59.6773' N,	070° 03.7350' W	PH2-S	6/22/2015	0.15	3.1	4.15							11	13.96
				7/22/2015	0.014		0.033	0.014	0.775						30.1
			PH2-D	6/22/2015	0.022	0.06	BRL			17,600	2,400	ND	51.9		
				7/22/2015	0.23	2.8	4.16							26.8	31.21
	041° 59.5859' N,	070° 04.2003' W	PMH-3	Average	0.02	0.02	BRL			18,600	2,600	ND	58.5		
	041° 59.5859' N,	070° 04.2003' W	PH3-S	6/22/2015	0.08	2.4	4.56							18.5	21.18
				7/22/2015	0.012		0.02	0.007	0.372						30.6
			PH3-D	6/22/2015	0.019	0.02	BRL			18,400	2,600	ND	57		
				7/22/2015	0.08	2.9	4.32							10.7	13.52
	041° 59.5173' N,	070° 04.6546' W	PMH-6	Average	0.012		0.02	0.008	0.357						30.6
041° 59.5173' N,	070° 04.6546' W	PH6-S	6/22/2015	0.019	BRL	BRL			18,600	2,600	ND	60			
			7/22/2015	0.06	2.6	4.62							20.2	22.36	
		PH6-D	6/22/2015	0.018	0.01	BRL			18,800	2,600	ND	157			
			7/22/2015	0.2	3.1	4.23							12	14.31	
			Notes:	East Harbor Average: 15 samples 2007-2009											
				Pamet River average: 15 samples 2007-2009											
				BRL= Below Reportable Levels ND = Not Detected											

3.0 STRATEGIC ANALYSIS (TASK3)

3.1 Purpose of Task

Phase I identified several areas of concern based on voluntary sampling that began in 2007. An incremental nitrogen control strategy was recommended based on these data and distribution of septic systems and impervious surfaces as well as the nature of development in the areas of concern. This section discusses existing conditions and outlines changes to septic system management and landscape fertilization that may be adopted to protect critical water/ecological resources and improve water quality for the protection of human health and the environment. Stormwater management is discussed in Section 4.

3.2 Background

This chapter discusses water resources within the Town of Truro focusing on factors that degrade water quality and potential approaches for addressing identified problems. As an introduction, we provide background on water supplies and wastewater discharge in Truro. Water supplies in the town are provided by an unconfined aquifer overlain by sandy soils typical to the Cape Cod region. Virtually all waste water in Truro is treated in individual septic systems with effluent flow contributing to aquifer recharge. In addition, surface water bodies (e.g. East Harbor, Pamet River, Little Pamet River, and Village Pond) are fed directly from groundwater.

Past studies indicate the aquifer has experienced increased levels of nutrients, particularly nitrogen compounds. Therefore, this chapter also includes a discussion of “innovative and alternative” (I/A) treatment systems and other methods that may, with time, reduce nitrogen entering the aquifer system. Controlling nutrients, particularly nitrogen compounds, has been recognized as an issue in the Cape Cod region for many years. As a result, a significant body of information is available and was used as a basis for discussion in this chapter (see the Bibliography).

3.3 Existing Conditions

The Town of Truro, incorporated in 1709, is located on the outer portion of Cape Cod between Provincetown and Wellfleet. Key attributes are summarized below.

3.3.1 *Truro Land Use and Lot Size*

Truro comprises an area of 26.3 square miles of which, 21.1 square miles is land and 5.3 square miles is water). The character of the Town is rural, with approximately 2,300 individual parcels of land. Roughly 67% of Truro is within the Cape Cod national seashore which is generally undeveloped. Most of the

remaining area is residential with residential lot size ranging from 0.5 to 1.5 acres.⁷ In addition, Truro has several areas of commercial development.⁸ These include:

- Beach Point Limited Business District
- Route 6A North Truro Limited Business District
- An Affordable Housing District
- Route 6 General Business District
- Truro Center Business District

Three relatively small agricultural areas occur within the Pamet and Little Pamet drainages; a fourth operation, a vineyard is located in an upland area along Rt. 6.

3.3.2 *Surface and Ground Water*

Most of the town is underlain by Carver soils except for marshy areas underlain by Freetown Muck, and Hooksan sandy soils that occur in dune areas and along the margins of beaches. The Carver and Hooksan soils are highly permeable resulting in rapid infiltration of storm runoff and downward percolation of subsurface discharges. Surface water occurs in lower areas of drainages and in depressed areas that are below the water table (kettle ponds).

Previous studies by the USGS, National Seashore and Cape Cod Commission, summarized in the Phase I IRWMP, have identified watersheds draining into the Atlantic Ocean and Cape Cod Bay, and contributing to local surface water bodies (IRWM Phase 1, Figure 3-2). The most significant are Pilgrim Lake (East Harbor) to the north of Truro, Village Pond, the Pamet River and the Little Pamet River as well as the Herring River to the south. These surface water bodies are generally supported by inflow from groundwater. East Harbor is supported by groundwater and also is connected to Massachusetts Bay by a culvert that allows limited tidal flow. Other areas are drained by subsurface flow through sandy soils; the subsurface flow from these areas eventually discharges to the Atlantic Ocean or Cape Cod Bay.

The Town is underlain by two significant groundwater sources, the Pamet lens and the Chequesset lens. These lenses are distinct bodies of fresh water located under areas of higher terrain that essentially sit on top of more dense salt water. The lenses are recharged by precipitation and wastewater return flow. The highest elevation of the Pamet lens is typically 5 to 6 feet above sea level while the Chequesset is approximately 7 to 8 feet maximum elevation above sea level. Due to the density difference between freshwater and sea water the lenses are estimated to be 200 to 250 feet thick. Each lens naturally discharges to the ocean, and in some areas to streams and ponds. These lenses are the sole source of groundwater for Truro.

3.3.3 *Water Supplies*

Water in Truro is supplied by groundwater extraction from two sources: the Pamet Lens and the Chequesset Lens. Public water supply systems in Provincetown (including the Beach Point area of

⁷ <http://www.truro-ma.gov/assessors-office/pages/assessors-maps>

⁸ Phase I report, 2014, Weston & Sampson

Truro) and Wellfleet are supplied by wellfields in the Pamet Lens and Chequesset lens respectively. In addition, approximately 31 smaller public supply systems provide water to commercial and industrial operations that serve more than 25 people 90 days per year. The rest of Truro water users are supplied by individual wells. Presently each lens is sufficient to meet current and projected demand.

3.3.4 *Water Quality*

Both groundwater and surface water quality in Truro has been evaluated in a number of studies. Several surface water bodies have been found to have unacceptable levels of nutrients that may cause algal growth and other undesirable effects (Table 2-4). Although local ground water supplies are of generally of high quality, nutrients (particularly Nitrogen compounds like Nitrate) have increased over the years and are the focus of ongoing studies at the town level. In addition, the Town has adopted policies and regulations to protect ground water quality (Appendix C).

Three sources of nitrogen affect nutrient levels in Truro groundwater: onsite waste water disposal, fertilizer use and deposition of atmospheric nitrogen. While the results of the Phase I IWRMP suggest that onsite wastewater disposal contributed roughly 65% of the total N to local groundwater overall, in specific drainages the contribution of fertilizer and stormwater may be as significant. Due to the nature of development, the actual effects also vary by density of development and nature of waste disposal systems used.

Generally, fertilizer use is estimated to contribute 25% of total contribution of N to local groundwater. Since the nature of landscaping and its maintenance varies considerably within the Town, contribution by excess fertilization is highly localized and difficult to estimate precisely. However, surveys performed in July and October 2015 encountered a wide range of landscaping; some properties had no landscaping with accumulations of leaves and other vegetative material blanketing open areas. Other properties had extensive landscaping that remained lush into October.

Deposition from the atmosphere typically takes the form of wet and dry deposition of ammonia, nitrate and organic nitrogen and may be considered a “background” contribution. This deposition contributes to the nutrients available in vegetated areas. However, research indicates that the input from atmospheric sources (as precipitation) in the Cape Cod area is responsible for approximately 1ppm NO₃ level in groundwater. Much of this contribution is due direct runoff from impervious surfaces through sandy soils, which provide no opportunity for uptake of nutrients from vegetation. Methods for reducing the contribution from each of these sources are discussed in subsequent sections.

3.3.5 *Wastewater Disposal*

Virtually all wastewater in Truro is treated by individual on-site systems. These systems include cesspools, older (pre-1995) septic systems compliant to older standards, and newer Title 5 compliant septic systems, as well as few that are more technically advanced. These technically advanced systems are known as “innovative and alternative” (I/A) systems and typically employ one or more modifications to the current Title 5 design standards to increase nutrient removal. These onsite treatment systems

work by collecting and moving wastewater through a system that relies on microbes for treatment. The liquid wastewater is eventually discharged to subsurface soils leaving behind a small amount of solid waste. Depending on the design and operation of an individual system, the degree of treatment, particularly nitrogen removal, varies (Appendix D).

Cesspools are usually a lined pit with no bottom; in some cases, the bottom of the cesspool extends into the water table. Cesspools provide limited opportunity for microbial activity and therefore little nitrogen and phosphorus reduction prior to effluent entering the groundwater system.

Septic systems generally have two elements: 1) a large tank (septic tank) that removes solids and provides space for some microbial digestion and 2) a subsurface piping system that allows discharge of effluent (through a “leach field”) for additional treatment. Typically, as waste enters a septic tank, an equivalent amount of effluent discharges to the leach field. Nutrient reduction depends on several factors including residence time in the septic tank, the size of the leach field, nature of soils in and beneath the leach field and distance (separation) between the leach field and the water table. Older (pre-1995) septic systems were not constructed to the current standard that requires a minimum separation of 4 to 5 feet between the leach field and the water table. Title 5 systems are assumed by regional and State regulatory agencies to result in treatment leaving NO₃ levels of 26 ppm in effluent after treatment.

Several individual wastewater treatment systems capable of removing more nutrients from wastewater than Title V systems have been developed and installed on Cape Cod, some within Truro. These systems, known as innovative and alternative or “I/A” systems, are most effective in areas low density development, such as in much of Truro. However, they typically achieve no more than 50% wastewater nitrogen reduction compare to Title V systems. Interest (and regulatory pressure) in controlling nitrogen levels in groundwater has led to monitoring the effectiveness of many I/A systems throughout the Cape Cod area. The County of Barnstable has compiled a summary of these systems including data showing general performance in reducing nitrogen. (Appendix D,E)

3.3.6 *Fertilizer Management*

Fertilizer used on lawns and other landscaping contains nitrogen and phosphorus. Heavy rainfall or excess irrigation will readily transport nutrients through sandy soils below the root zone of plantings. Any nutrients transported beyond the root zone will reach the water table and enter local groundwater. Preventing nutrients from being transported below the root zone is a key objective of fertilizer management.

Techniques to reduce impacts from fertilizer use focus on the type, amount and timing of use. Fertilizer management efforts in other areas of Cape Cod have included public education, development of best management practices and use regulations, and certification of applicators (such as landscape maintenance companies). Public education brochures and other web based materials have been developed by the majority of towns in Barnstable County, the Cape Cod Commission and the University

of Massachusetts. Due to similarities in soil types and nutrient impact between Truro and these other areas, much of what has been done in these other areas appears to be relevant.

3.3.7 *Stormwater Treatment*

Stormwater runoff is affected by the porosity and slope of the area it falls upon. Pavement and other “hardscape (such as roofs) concentrate peak flow and allow stormwater to pick up pollutants such as oil and grease. Control of stormwater runoff generally comprises two objectives: 1) reduction of peak flow rate and 2) reduction of pollutants, particularly Nitrate. Stormwater control techniques include channeling runoff into retention basins or swales and exposing the water to biologically active media such as soils of other filters.

In Truro areas of hardscape include roads parking lots and roofs. Stormwater runoff is of concern because in some areas stormwater carries pollutants directly into surface water bodies. In other areas, the sandy native soils allow attenuation of peak flows, but promote infiltration at rates that reduce the effectiveness of pollution reduction. As discussed in Section 4.0, several sites have been evaluated for potential stormwater treatment facilities. Conceptual designs have been prepared for 3 of the sites for development as demonstration projects. A detailed design has been prepared for the site near the public library.

3.3.8 *Past Groundwater Sampling Results*

Groundwater sampling by the Town through its Water Resources Oversight Committee has occurred on a voluntary basis since 2007. This data suggests that there has been an increase above an assumed “background” of 0.5 to 1 part per million in much of the developed area of the town. In some areas, discussed in the Phase I report, NO₃ levels exceed 10 ppm.

3.4 **Critical Areas**

Three critical areas were identified in the Phase I report as containing sensitive resources and being susceptible to stormwater and other sources of contamination. The report suggested developing stormwater Best Management Practices (BMPs) to protect groundwater quality. These areas include Pilgrim Lake (East Harbor), Pamet River, and South Hollow/North Union Wellfield. These areas should be evaluated for potential BMP sites for stormwater treatment (Section 4.0 includes a discussion of potential BMPs). As discussed later in this section, control of Nitrate entering East Harbor and the Pamet River could be further improved by development of a sewer collection system in Beach Point and installation of I/A systems in the catchment of the Pamet River.

3.4.1 *Pilgrim Lake (East Harbor)*

The majority of impervious surface in draining to East Harbor comprises State Route 6. Stormwater control for Rt. 6 is the responsibility of MassDOT. A discussion of stormwater controls, including BMPs is included in Section 5 of this report. The US Army Corps of Engineers has prepared a report on the

modification of the opening between East Harbor and Cape Cod Bay⁹. Enlarging the opening between East Harbor and Cape Cod Bay would substantially increase tidal flushing.

Results of groundwater quality monitoring and water level measurements indicate that nutrients are being transported to East Harbor from subsurface waste disposal systems in the Beach Point area.

3.4.2 *Pamet River*

The Phase I report concluded “[t]he Pamet River drainage basin receives almost 2/3’s of its nutrient load from impervious areas. The majority of this impervious area is located west of Route 6 and is related to residential development, with an area of commercial development along Truro Center Road. A preliminary site visit to the lower Pamet River watershed area revealed a few possible areas for enhanced stormwater infiltration. While the area’s sandy soils offer good infiltration, their character provides minimal nutrient removal.¹⁰ Infiltration BMPs are in place at the small shopping center on Truro Center Road that includes the Post Office; over half the parking area is permeable material and infiltration trenches containing crushed stone are on the north and south edges. Further treatment may be possible by routing runoff to vegetated areas with augmented (less sandy) soils.

3.4.3 *South Hollow/North Union Wellfield*

The Phase I report identified the South Hollow/North Union Wellfield areas as sources of public water supply. The proximity of the South Hollow well field has resulted in elevated levels of salt, presumably from winter treatments to nearby Rt. 6. In addition, the wellfield is susceptible to contamination from accidental spills of fuels or other hazardous materials in the vent of traffic accident. Best Management Practices include alternative road treatment (such as CaCl or brine) and installation of stormwater runoff facilities that could capture and isolate potential liquid spills to facilitate cleanup and minimize the risk of groundwater contamination.

The Zone II area of the North Union wellfield includes residential developments that could be the source of salt from road treatments and nutrients, particularly Nitrate, from onsite waste disposal systems. Water quality in production well sin the North Union Well field should be closely monitored for any increases in Sodium or Nitrate with control measures implemented before water quality issues become problematic.

3.5 **Other Areas of Concern**

The Phase I IWRMP identified three areas of particular concern based on estimated Nitrogen loading, groundwater sampling and surface water quality (Figure 4). This study looked more closely at each of these areas, evaluating land use practices and DOH records of onsite disposal systems. In addition, potential stormwater control sites were identified and screened for further consideration.

⁹ USACE. 2011. Draft East Harbor Sediment Transport Modeling Study, New England District United States Army Corps of Engineers

¹⁰ USRCS 1993 Soil Survey of Barnstable County

3.5.1 Area 1

Area 1 includes the intersection of Highland Road and Route 6 and the vicinity of the Pond Road commercial district, and including approximately 128 residences. This area has a significant amount of impervious surface. In addition, DOH records indicate replacement of 4 cesspools with Title 5 compliant systems since 2004. Village Pond is downgradient of this area.

Opportunities for increased removal of nitrate include continued upgrading of onsite disposal systems and installation of Stormwater BMPs capable of removing N from storm water. Several of the parcels in Area 1 are relatively small and may be in areas of shallow groundwater. Improved N removal from onsite waste water systems could be accomplished by converting to I/A systems. Two potential sites for enhanced stormwater treatment are discussed in Section 4. Both sites would require plantings and soil amendment to improve N removal by native sandy soils.

3.5.2 Area 2

Area 2 includes the residential area along South Highland Road east of Rt. 6 and west of Hillbourne Terrace and North Union Field Road. Approximately 157 residences are within this area. Records for this area of the Town indicate that there are 4 pre-1995 Title 5 disposal systems and that two cesspools have been replaced.

Opportunities for increased Nitrate control include continued upgrade of onsite disposal systems to post 1995 Title 5 standards (or I/A nitrogen removing systems) and better control nutrients applied to landscaped areas.

3.5.3 Area 3

Area 3 includes the residential area east of Old Rt.6 and between Long Nook Road and Quail Ridge Road. Records for this area of the Town indicate that there are 4 pre-1995 Title 5 disposal systems and that one cesspool has been replaced. In addition, use of fertilizer is indicated by luxuriant landscaping on several properties and an agricultural operation occurs on Long Nook Road.

Opportunities for Nitrate control include continued upgrade of onsite disposal system to post 1995 Title 5 standards (or I/A nitrogen removing systems), better control of nutrients applied to landscaped areas, and evaluation of nutrient use in the agricultural operations.

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Table 3-1 Effects of Potential Nitrate Reduction

Effect of Potential Nitrogen Reduction					
Areas of Concern					
	Area Properties	Total Parcels	2.03 Persons/	Title V	40% N Reduction
	with high NO ₃	With Homes	House	N loading Lbs/yr	Lbs/yr
AREA 1	7	128	260	1,546	618
AREA 2	8	157	319	1,896	759
AREA 3	12	135	274	1,631	652
Notes:	N Loading	Assumes Title V 5.95 lbs/person/year			
	2010 Census		2.03 people/house		
	I/A loading		13-19 mg/l NO ₃		
	Average Septic Loading		26mg/l NO ₃ (Title V)		
	I/A NO ₃ reduction		27-50% compared to Title V		

3.6 Local Regulations and Options to Address Water Quality

Truro has several regulations and policies that directly or indirectly relate to the protection of water quality. These regulations and policies are found in the Local Comprehensive Plan (2008), the Health Department bylaws and in the Town's building codes (Appendix C). In general, the Town's regulations provide for the location, design and regulation of individual wastewater treatment facilities (septic systems) to protect public health as well as the quality of surface- and groundwater. In aggregate these regulations:

- Establish regulatory responsibility for review, permitting and enforcement,
- Provide design standards for wastewater disposal systems, including "innovative and alternative" designs to address specific water quality issues,
- Set standards for repair or replacement of older and nonfunctioning onsite waste disposal systems,
- Set setback requirements for septic system element from wells, property lines and sensitive resources, and
- Establish long term goals to protect groundwater quality in general and potential and existing public drinking water sources in particular.

These regulations and policies are intended to protect and improve surface- and groundwater quality. The Town may choose to clarify some of these regulations to make their application more predictable. In addition, there are additional measures the Town may consider that would help reduce the level of NO₃ entering the ground water. These potential changes are discussed below.

3.6.1 Improve Onsite Wastewater Disposal Systems

Approaches to reducing water quality impacts of onsite wastewater disposal systems include:

- improved onsite treatment,

- shared upgraded systems, and
- centralized collection and treatment.

The Cape Cod Commission has evaluated these options for the region. Based on their studies, for most of the residential areas of Truro, improved onsite treatment appears to be the most feasible. This would involve replacement or upgrading onsite wastewater disposal systems to reduce Nitrate levels in effluent reaching the ground water. For example, current Title 5 compliant systems are assumed to result in effluent containing 26.25 mg/l (ppm) NO₃ while I/A systems may reduce loading to 13 to 19 mg/l.

Replace older waste disposal systems

The Town currently requires replacement or upgrading of non-conforming or failing septic systems. Replacement of non-conforming disposal systems (cesspools or pre-1995 septic systems) is required upon sale or transfer of property under certain circumstances. In the three areas of concern shown in Figure 4 and identified in Phase I Report, several cesspools and pre-1995 systems have been replaced with Title 5 compliant septic systems. Accelerating this process throughout the Town to require replacement of all cesspools and older (pre-1978) septic systems will reduce nitrogen levels in treatment system effluent, and eventually result in lower NO₃ levels in local groundwater. This process should begin promptly since the benefits will manifest slowly because nutrients already in the aquifer will take some time to migrate.

Under current procedures, intergenerational transfer of properties may not trigger the inspection, and as needed, upgrading of onsite waste disposal systems. This may result in antiquated and ineffectual treatment systems remaining on place far longer than appropriate. This is a significant reason to replace cesspools and older septic systems on an established schedule rather than upon transfer of ownership.

In addition, in areas of relatively small average lot size, Title 5 compliant systems may not provide sufficient NO₃ removal to adequately control NO₃ levels in the aquifer on a long-term basis. In these areas, including the three areas of concern discussed above, the Town should require I/A treatment systems that meet NO₃ removal efficiencies that exceed typical Title 5 treatment. These types of systems are discussed below.

3.6.2 *Enhanced N removal through I/A Septic Systems*

There are numerous I/A system designs that are capable of reducing NO₃ resulting from onsite wastewater treatment systems. They are typically used within areas of low density and where wastewater nitrogen reduction is necessary.¹¹ MassDEP has an approval process that allows designs that are more effective than standard Title 5 treatment; MassDEP has approved I/A and enhanced I/A septic systems that are expected to achieve 19 and 13 mg/L, respectively in treated effluent. Other I/A systems may be installed for nitrogen reduction, but the system must go through an approval process at the local level. Barnstable County records indicate that 6 I/A systems have been installed in Truro. A summary of their

¹¹ DRAFT Cape Cod Area Wide Water Quality Management Plan Update Chapter 3

performance as well as other I/A system performance throughout Barnstable County is contained in Appendix B and C.

Generally speaking, I/A systems are more expensive to install and have higher annual operating costs. Installation costs include purchase and installation of system elements in addition to basic septic system design. The additional elements may include an additional tank, extra piping and treatment media (such as sand). Installation costs may range from \$3,000 to \$12,000 more than a simple septic system. Operation and maintenance costs include electricity, inspection (required by regulations) and cleanout if required. Typical operation maintenance costs can range from \$300 to \$400 per year.

Potential Implementation Options for Onsite Disposal Systems

In order to best protect the quality of the Town's water supply, several measures should be considered. These measures focus on improving the quality of effluent from onsite wastewater disposal systems.

1. All cesspools and septic systems constructed prior to implementation of the 1978 Title V standard should upgrade to current Title V standard upon property transfer or within 5 years, whichever occurs sooner. (intergenerational transfer or sale should not be exempt.) In areas of small lot size and in areas of concern, I/A systems should be required.
2. The Town should require upgrade or installation of or upgrade to I/A if:
 - a. Demolition of, or move, or upgrade to an existing building.
 - b. Current onsite system found not to have been constructed according to approved plan.
 - c. Bedrooms within a residence should be limited to 1995 regulation, even if approved capacity (for 1978 systems) allows more.
 - d. Variances to lot size, setback or grading regulations are part of an approval.
3. Upon property transfer, all septic systems must be inspected per state regulation. In addition, the Town should require the following for all septic systems, except for I/A: complete pumping of the system and photographs of the inside of the tank, pre- and post-pumping. At least one photograph of the filter/pipe to leach field must be taken.
4. All wastewater regulations should be revisited every 5 years. The review will include but not be limited to: ground water and surface water sample data, wastewater treatment technology, and county, state, and federal regulations.
5. The Town should consider adopting requirements that all septic systems should be converted to low NO₃ (< 15 ppm) effluent systems by 2035; an earlier compliance date should be considered in Pamet River Area.
6. The Town should distribute information about the need for (and benefits of) regular maintenance of septic systems, including regular pump-outs.
7. The Town should coordinate with Barnstable County for monitoring and reporting of performance of I/A systems.
8. The Town should prepare recommendations for State approved I/A systems for voluntary upgrade of onsite waste disposal systems in areas of less concern.

3.6.3 *Fertilizer Management*

Barnstable County has designated Cape Cod as a Fertilizer Management District of Critical Planning and Concern¹². This designation allows towns on Cape Cod to regulate the use of fertilizer. Several Towns have adopted regulatory mechanisms based on model regulations developed by the Cape Cod Commission. The model regulations include specific nitrogen-related limits and incorporate Turf Management Best Management Practices from the University of Massachusetts Extension.

Use of Nitrogen in Wells for Irrigation (“Fertigation”)

Fertigation means integrating fertilization and irrigation practices, basically measuring nutrients in irrigation water sources and reducing the amount of additional fertilizer used. Irrigation wells can capture nutrient-enriched groundwater, for example downgradient from areas of septic systems and recycle it back to turf grass areas (including golf courses, athletic fields and lawns). Depending on the nitrogen levels in the irrigation water, little or no fertilizer may be necessary to maintain healthy turf. In this manner, nitrogen is recycled as a resource (fertilizer). This can significantly reduce nutrient loads downgradient and reduce fertilizer costs.

The efficiency of this technology depends upon finding locations with relatively high nitrogen concentrations and vegetated areas that can receive fertilization and irrigation that are in close proximity. Unless a greenhouse is utilized, the technology is limited in application to the growing season. Estimated annualized load reductions must account for during this seasonal period. Potential locations include landscaped areas at the Cemetery, the Truro Central School, the Whitman House, Town Hall and Library.

Implementation Options for Fertilizer Management

1. The Town should consider requiring certification of landscape service providers.
2. The Town should consider adopting specific nitrogen-related limits for fertilizer application and incorporate Turf Management Best Management Practices as town policy.
3. The Town should distribute public outreach materials through nursery sales outlets.
4. The Town should develop a pilot project to demonstrate use of “fertigation” at a public site with turf area.

3.6.4 *Other Measures*

1. The Town has developed extensive water quality data through voluntary samples since 2007. Encouragement of voluntary sampling should continue.
2. The Town should establish one or more monitoring wells in the Pamet River drainage, Pond Road commercial district, Old Rt.6/Sylvan lane area and South Highland road area. Monitoring wells in these areas should be monitored twice a year in spring and fall.

¹² <http://www.capecodcommission.org/index.php?id=139>

Table 3-2. List of Potential Measures to Reduce Nutrients in Surface and Ground WaterOnsite Disposal Systems

1. Replace all cesspools by date certain.
2. Replace septic systems with I/A systems for facilities over 480 GPD of sewerage (peak daily) and built to 1978 standards when property transferred or additional capacity/demand added to residence or commercial building. (Intergeneration transfers or sales should not be exempt.)
3. Require all new construction to “offset” N loading by demonstrating actual reductions on/in other systems within the same watershed.
4. Adopt requirements that all septic systems be converted to low NO₃ (< 15 ppm) effluent systems by 2035. Adopt earlier compliance date in Pamet River Area.
5. Develop and distribute information about the need for (and benefits of) regular maintenance of septic systems, including regular pump-outs.
6. Cooperate with Barnstable County with monitoring and reporting of performance of I/A systems.
7. Prepare recommendations of State approved I/A systems for voluntary upgrade of onsite waste disposal systems.

Fertilizer Management

1. Require certification of landscape service providers.
2. Adopt specific nitrogen-related fertilizer limits and incorporate Turf Management Best Management Practices as town policy.
3. Develop aggressive public outreach materials to be distributed through nursery sales outlets.
4. Develop pilot project to demonstrate use of “fertigation” at a public site with turf area.

Water Quality Monitoring

1. The Town has developed extensive water quality data through voluntary samples since 2007. Encouragement of voluntary sampling should continue.
2. The Town should establish one or more monitoring wells in the Pamet River drainage, Pond Road commercial district, Old Rt.6/Sylvan lane area and South Highland road area. Monitoring wells in these areas should be monitored twice a year in spring and fall.

3.7 Beach Point

The Beach Point area is densely developed with visitor serving facilities and residences. Further development is possible on under- or undeveloped lots along Shore Road. The low elevation and sandy soils of the Beach Point area indicate that percolating sewage effluent receives minimal treatment as it passes to the water table. The data available on water levels and groundwater quality (discussed in Section 2) suggest that some of the nutrients discharged to the subsurface enter East Harbor, while the rest pass into Massachusetts bay. The density of development and subsurface conditions suggest that installation of I/A systems may not be sufficient to effectively address water quality problems in the Beach Point area. The Town should perform a study to evaluate alternatives including clustered

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treatment systems, installing a sewer collection system to connect with the Provincetown system, or to connect to a newly constructed wastewater treatment facility somewhere in Truro.

3.8 Other Recommendations

The Town has adopted a number of land use and other regulatory measures relating to protecting water quality. While these measures are generally applied, no systematic accounting of the measures or their effectiveness is performed. In addition, some additional measures have been adopted by other Cape Cod communities and may be applicable to Truro; they should be publicly vetted.

1. The Town should develop a data acquisition and reporting system for land use and health department requirements related to evaluation of waste disposal system adequacy and modification/replacement as a result of site development, land use changes or waste disposal system maintenance, or system failures.
2. The Town should develop educational materials for public workshops regarding potential changes to requirements for design of waste disposal systems, upgrading older systems, as well as maintenance and potential guidelines for fertilizer use.
3. The Town should hold public workshops to vet measures to provide additional protection of water quality.

4.0 EXAMPLE STORMWATER BMP'S (TASK 4)

4.1 Purpose of Task

Following up on Phase I's Stormwater Analysis, several recommendations were suggested for Phase II, these included bylaw revision, public outreach/education, identifying potential locations to implement stormwater best management practices (BMPs), the installation and monitoring of protection wells at key locations in Truro (public water supply wells, Pamet River, East Harbor, etc.), and a detailed assessment of land use practices in these same areas.

The purpose of Task 4 was to tackle one of these recommendations; the identification of potential locations to implement stormwater BMPs, the selection of one of those sites, and the development and eventual construction of that site. This recommendation was selected as a separate task for Phase II, as stormwater runoff from impervious surfaces carries a higher nutrient load than rainfall on vegetated areas, therefore, properly designed BMPs may reduce overall nutrient loading by removing nutrients, making these improvements a priority to improve conditions in Truro.

Phase I of the IWRMP identified stormwater as a significant source of nitrogen in both surface water and groundwater. Table 4-1 below shows the calculated annual nitrogen loads for each of the 19 recharge zones discussed in the Phase I report. As indicated, stormwater introduces an estimated 35,831 pounds of nitrogen per year to Truro's surface water and groundwater resources. Roughly 34% of the annual stormwater load is from impervious surfaces such as roads, parking areas and roofs.

Table 4-1. Nitrogen Loads Generated by Stormwater¹

Recharge Zone ID	Acreage	Annual Nitrogen Load (lbs.)				Total
		Impervious	Vegetation	Open Land	Lawn	
1	962	265	127	3,377	0	3,769
2	0	0	0	0	0	0
3 (Atlantic)	4,631	1,720	1,571	9,773	2	13,065
4	338	73	128	441	0	642
5	203	34	62	0	0	96
6	415	520	113	1,192	12	1,838
7	3,294	1,764	1,382	181	33	3,361
8	5	0	0	43	0	43
9	34	0	6	196	0	202
10	320	493	117	171	19	799
11	1,380	1,907	525	487	122	3,041

Recharge Zone ID	Acreage	Annual Nitrogen Load (lbs.)				
		Impervious	Vegetation	Open Land	Lawn	Total
12	645	1,397	211	579	55	2,242
13	150	265	38	351	12	666
14	268	601	87	214	42	943
15	334	587	128	2	29	747
16	158	405	53	28	30	516
17	128	89	54	0	0	144
18	52	30	20	17	0	67
19	779	1,861	210	1,501	75	3,648
Total less Atlantic		10,292	3,263	8,779	431	22,765
Total for All Truro		12,013	4,834	18,552	433	35,831

¹ Note: Stormwater is used to represent both runoff and direct infiltration from precipitation.

Source: IWRMP Phase 1 Report

Stormwater-related water quality impairments such as elevated levels of nitrogen are typically triggered by a disruption of the hydrologic cycle. In most cases, site development activity leads to changes in land cover in which vegetated areas are converted to impervious surfaces. In Truro, these changes in land cover result increases in surface runoff from impervious surfaces and/or reduction of soil contact due to removal of native vegetation and topsoil. Both the quantity and quality of water resources are affected by these hydrologic disruptions. In Truro, the ponds, streams, estuaries and groundwater resources are sensitive to the higher unit loads of nitrogen resulting from stormwater runoff from impervious areas. Most soils in Truro are highly permeable which allows disposal of stormwater without the need for collection and routing facilities. The use of this “country drainage” in Truro does a good job of mitigating some of the hydrologic effects of impermeable surfaces (such as higher surface water flows) by providing infiltration. However, the majority of the pervious areas where stormwater infiltrates comprise sandy material with little or no vegetation to provide an uptake of nitrogen. A number of techniques generally referred to as Best Management Practices have been developed in other areas to increase the amount of stormwater contact with vegetation.

Non-structural and structural stormwater Best Management Practices (BMPs) have been demonstrated to be an effective tool in mitigating not only the hydrologic and hydraulic impacts of increased impervious cover, but also the water quality impacts associated with the higher unit loads of nutrients in runoff from impervious cover. Non-structural stormwater BMPs include street sweeping, maintenance of

stormwater utilities, education and public outreach programs, land use planning, and impervious surface reduction and control. Structural stormwater BMPs include soil media filters, infiltration basins and infiltration trenches, constructed stormwater wetlands, extended dry and wet detention basins, etc. This discussion focuses on structural BMPs and the selection of potential sites that could be used to demonstrate the utility and aesthetics of BMP installation.

4.2 Demonstration Stormwater Best Management Practices

As part of Phase II of the IWRMP, Weston & Sampson performed a site screening analysis of more than 40 potential sites at 25 locations in Truro to identify areas suitable for the implementation of one or more structural stormwater Best Management Practices (BMPs) to reduce nitrogen loading from impervious areas (Appendix F). These locations were identified during the initial desktop stormwater recharge siting analysis performed during Phase I and focused on recharge areas with large annual nitrogen loads. Criteria used in the evaluation included the following:

- Ownership
- Contributing impervious area
- Available space
- Site grades
- Existing stormwater infrastructure
- Land cover
- Proximity to existing resource areas

Datasets used for the site screening analysis included assessor's data, aerial photography and a 2-foot contour dataset generated using LiDAR data from the Massachusetts Geographical Information System (MassGIS) website.

In addition, Weston & Sampson evaluated a number of structural BMPs that target nitrogen for use in each area. Technical resources for BMP types and anticipated removal rates included the Massachusetts Stormwater Handbook¹³ and the Cape Cod Commission's Section 208 Area-wide Water Quality Management Plan¹⁴. These two sources describe a number of BMPs that provide some level of nitrogen reduction, which are summarized in Table 4-2 below.

Table 4-2. Nitrogen-Removing BMPs in the Massachusetts Stormwater Handbook and the Cape Cod Commission's 208 Plan.

BMP Type	% Nitrogen Removal	Source
Rain Garden/Bioretention	30-50, 25-45	1,2
Extended Dry Detention	15-50	1

¹³ Undated. Volume 2, Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook at <http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html>

¹⁴ Cape Cod Commission. 2015. Cape Cod Area Wide Water Quality Management Plan Update (208 Plan)

BMP Type	% Nitrogen Removal	Source
Extended Wet Detention	15-50	1
Wet Pond	10-50	1
Constructed Wetland	20-55, 25-90	1,2
Infiltration Basin/Swale	50-60	1
Infiltration Trench/Bed	40-70	1
Organic/Sand Filter	20-40	1
Dry Water Quality Swale	10	1
Wet Water Quality Swale	10	1

References:

1. Massachusetts Stormwater Handbook
2. Cape Cod Commission's 208 Plan

As a result of the site screening analysis, Weston & Sampson selected seven sites at five locations that appeared to warrant additional evaluation for the implementation of a nitrogen-reducing BMP for demonstration purposes. These five locations include the following:

- Corn Hill Lane Parking Lot
- Public Library & Community Center Parking Lots
- Town Hall & DPW Driveways and Parking Lots
- Intersection of Castle Road and Truro Center Road
- Chamber of Commerce Office on Shore Road

Among these five sites, two types of BMPs stood out due to their relatively low cost, ease of implementation, low maintenance, high nitrogen removal rate, and comparatively small footprint. These BMPs were infiltration basins or infiltration swales both utilizing a soil media filter. Infiltration swales in particular appeared to be most suitable due to their linear shape because they are easy to construct along parking lots and roadways and have the ability to collect a significant amount of sheet flow runoff without the use of a piped collection system.

Truro has a relatively small impervious area throughout the town as a function of overall area. Most of the impervious areas in Truro comprise roads, roof areas and driveway/parking lots. The nature of development in the town has resulted in most roof and parking areas being modest in area. Due to the size and location of many of the impervious areas evaluated, the catchment and size of the potential BMPs are limited. Table 4-3 contains the catchment area and potential Nitrogen removal for each of the 7 BMP sites at the 5 locations recommended.

Table 4-3. Summary of Characteristics for Identified Potential BMP Sites

Appendix E Number/ Site Name	BMP Type	Catchment Area (Square Feet)	Annual N Removal (Pounds)	
1 Corn Hill Beach Parking Lot	Infiltration basin with soil media filter	90,444	28.0	
2	Town Library	Infiltration swale with soil media filter	17,518	5.4
	Community Center	Infiltration swale with soil media filter	27,971	8.7

Appendix E Number/ Site Name	BMP Type	Catchment Area (Square Feet)	Annual N Removal (Pounds)	
3	Town Hall Parking/Drive	Infiltration swale with soil media filter	3,565	1.1
	DPW Parking Area	Infiltration swale with soil media filter	11,995	3.7
4	Castle Road/Town Center	Infiltration swale with soil media filter	37,307	11.6
5	Chamber of Commerce	Infiltration swales with soil media filter		

The following sections describe each of the five sites and identify the level of potential nitrogen removal provided by each. More detailed assessment of each site would be needed as a basis for preliminary BMP design. Ownership and use of adjacent properties may affect the nature and size of potential BMPs.

4.2.1 *Corn Hill Lane Parking Lot*

Corn Hill parking lot is located at the western end of Corn Hill road at the access to Corn Hill Beach (Appendix E-1). The BMP would consist of an infiltration swale with soil media filter located along the south side of the paved parking area. The catchment would be 2.08 acres and could reduce N loading by 28 pounds per year.

4.2.2 *Public Library and Community Center Parking Lots*

The Library/Community Center is located Standish Way in North Truro just off Highway 6. A significant portion of the parking lot drains into a swale on the northwest side of the paved area. (Appendix E-2) and could be used to treat approximately 65 percent of the parking lot surface. Combined the catchment would be 1.04 acres and could reduce N loading by 14 pounds per year.

As discussed in a subsequent section, the Cape Cod Commission awarded Truro a grant to develop design and specification documents for a BMP to treat parking lot runoff at the Public Library. The design and specification documents are a basis for seeking funding from grants or other sources for actual construction.

4.2.3 *Town Hall and DPW Driveways and Parking Lots*

Two parking lots exist at the Town Hall/Public Works Department building along Town Hall road. Due to the configuration and slope of the parking lots and other paved areas, two BMP areas would be used to treat approximately 55 percent of the paved parking lot and road surface (Appendix E-3). Each BMP would consist of a narrow infiltration swale with soil media filter. One would be located on the south side of Town Hall road, the other along the south and east side of the town hall driveway. The slope immediately adjacent to the sites limits the area of each swale. Combined the catchment would be 0.36 acres and could reduce N loading up to 4.8 pounds per year. However, design of the existing drainage system appears to make a swale design BMP infeasible without substantial modification.

4.2.4 *Intersection of Castle Road and Truro Center Road*

The paved area at the Intersection of Castle Road and Truro Center Road slopes to the southwest. The BMP would consist to would consist of an infiltration swale with soil media filter capturing runoff from

the lower portion of Truro Center Road and the norther extension of Castle Road (Appendix E-4). Due to relatively high groundwater in the area, this swale may require some features of a constructed wetland. The catchment would be 0.86 acres and could reduce N loading by 11.6 pounds per year.

4.2.5 *Chamber of Commerce Driveway and Parking Lot*

The driveway and parking lot at the Chamber of Commerce office on comprises 0.14 acres of paved area. The BMPs would consist to would consist of infiltration swales with soil media filter capturing runoff from three separate areas of the paved area (Appendix E-5). Due to relatively high groundwater in the area, this swale may require some features of a constructed wetland. The swales at the Chamber of Commerce could reduce N loading by 2.0 pounds per year.

4.3 **Stormwater Best Management Practices for use Town-wide**

Given variation in topography and proximity to wetlands, several types of BMPs appear applicable in the Town of Truro; they are listed in Table 4-2. Selection criteria of BMPs for a particular site are discussed in Volume 1 of the Massachusetts Stormwater Standards and depend on the nature of resources potentially affected (such as wetlands, surface water bodies and ground water). Actual design parameters are highly site specific and depend on such factors as slope, soil type and catchment area. A detailed discussion of design parameters is provided in Volume 2, Chapter of the Massachusetts Stormwater Handbook.

The state standards for Stormwater BMPs address several factors including:

- Applicability for removal of specific pollutants
- Effectiveness for attenuation peak flow
- Physical site constraints
- Subsurface constraints (such as soil type and depth to groundwater)
- Proximity to septic systems and drinking water supplies
- Need for pretreatment
- Long term maintenance
- Overall cost effectiveness
- Aesthetics and Public acceptance

Because the sites have been selected to be demonstration projects, aesthetics are an important consideration. Experience in other communities has shown that BMPs can be seen by the public as to enhance or degrade the area in which they are located. Careful planning, landscaping and maintenance can make a BMP an asset to a site.

The Massachusetts Stormwater Management Standards have been incorporated in the Wetlands Protection Act Regulations, and the Water Quality Certification Regulations. This means that projects requiring State permits or Conservation Commission approval require some stormwater controls if the

project discharges water into wetlands of surface water body. This means that to some extent Truro already has the authority to require stormwater BMPs in some circumstances.

Additional stormwater controls may be adopted by the Board of Health (to protect groundwater) or by revisions to the Conservation Commission bylaws and/or Town building codes. Truro may choose to require stormwater BMPs for new development or redevelopment that create over a threshold area of “hardscape.” Hardscape is considered area that does not infiltrate rainfall, and would include roofs, walkways, driveways, parking areas and other impermeable surfaces. Depending on location, BMP design could focus on removal of pollutants of concern, such as Nitrate (to protect groundwater quality) or suspended solids (to protect surface water bodies). For example, Table 4-2 shows typical Nitrogen removal by BMP type. Table 4-4 summarizes some key considerations in BMP selection.

Table 4-4. Summary Comparison of Structural Control Best Management Practices

BMP Type	% Nitrogen Removal	Typical Site Use	Area Requirements compared to catchment	Notes
Rain Garden/ Bioretention	30-50,	Residential/Commercial	Small	Compatible with landscaping
Extended Dry Detention	15-50	Larger commercial sites	Large	Sandy soils may limit detention time
Extended Wet Detention	15-50	Larger commercial sites	Large	Sandy soils may limit detention time
Wet Pond	10-50	Larger commercial sites	Large	Sandy soils may limit detention time
Constructed Wetland	20-55,	Shallow water table	Large	Sandy soils may require liner
Infiltration Basin/Swale	50-60	Residential/Commercial	Large	Compatible with landscaping
Infiltration Trench/Bed	40-70	Residential/Commercial	Small	Compatible with landscaping
Organic/Sand Filter	20-40	Residential/Commercial	Small	Not compatible with high groundwater
Dry Water Quality Swale	10	Conveyance to BMP	Depends on catchment	Compatible with landscaping
Wet Water Quality Swale	10	Conveyance to BMP	Depends on catchment	Compatible with landscaping

1 Potential need for pretreatment depends on catchment.

4.4 Design of the Stormwater BMP at the Truro Library Site

At the recommendation of the WROC, the Town sought and received a grant from the Cape Cod Commission for development of a design and specifications for a BMP at the library site. Specifically, an engineered design for a stormwater rain garden adjacent to the Truro Library was prepared (Appendix G). Based on a topographic survey of the project area, a detailed base map of the site, and plans showing the layout and grading of the rain garden features on the site. The plans included a typical cross section of the rain garden and technical specifications for the grading, soils and planting for the rain garden features. The design and specification documents are intended to be used to seek funding from grants or other sources for actual construction.

4.5 Recommendations

1. Funding for construction of the storm water treatment project by the library parking lot should be pursued based on the existing design.
2. Costs of installing and maintaining additional BMPs identified in Task 4 and of interest to the WROC should be developed and potential funding mechanisms identified.
3. On the basis of the demonstration BMPs, the town should consider requiring storm water BMPs for new construction and development of new impervious surfaces in recharge zones with a high ratio of nitrogen contribution as a function of impervious surface (Table 4-1, Zones 6, 12, 13, 14, 15, 16, and 19).

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5.0 EVALUATE AND PREPARE CONCEPTUAL STORMWATER IMPROVEMENTS FROM RTE. 6 (TASK 5)

The Phase I IRWM report identified potential threats to water quality from Rte. 6. Unfortunately, turnover in the IRWM team hampered development of a working relationship with DOT, however, two issues in particular warrant discussion with MassDOT. First, the stormwater collected from the northbound lanes on Rte. 6 in the Beach Point area drain directly into East Harbor (Pilgrim Lake). A stretch of Rte. 6 in the “South Hollow” area drains into an area close to the public water supply well owned by Provincetown. The nature of intersections in the area may pose a risk of vehicular accident and attendant hazardous material spill. Use of salt for deicing may adversely affect groundwater quality in the long term.

5.1 Recommendations

1. Work with MassDOT to develop preliminary design for modification of Rte. 6 storm drains along the northbound lanes to prevent direct discharge to East Harbor.
2. Work with MassDOT to develop preliminary design of stormwater control facilities in the area of South Hollow that could also capture and contain spilled liquids in the event of an accident on Rte. 6, Rte. 6A or South Hollow road. These facilities would be intended to reduce the risk of spilled materials to the South Hollow public water supply well

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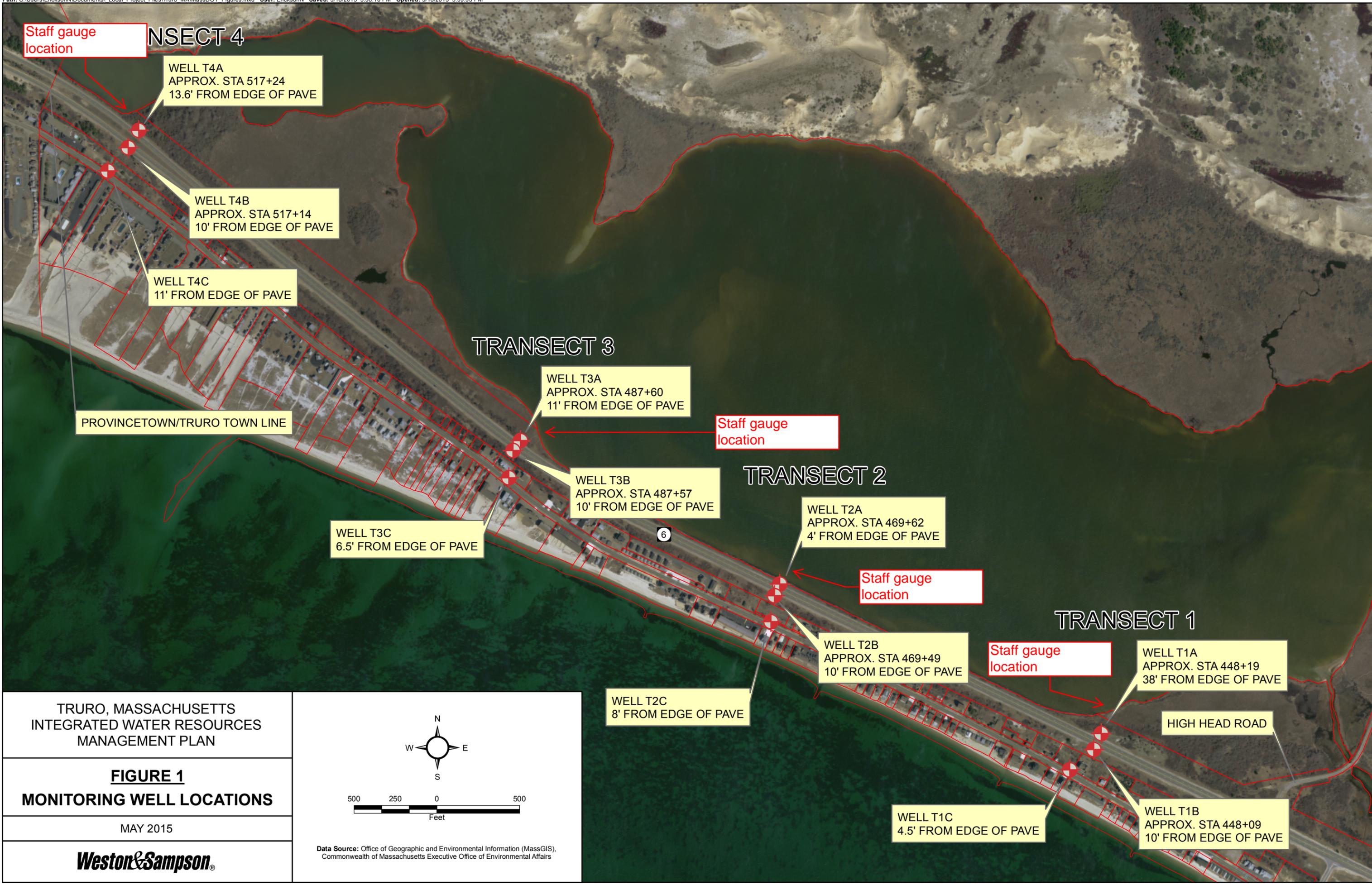
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FIGURES 1 - 4



TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES
MANAGEMENT PLAN

FIGURE 1
MONITORING WELL LOCATIONS

MAY 2015

Weston & Sampson

North arrow and scale bar (0 to 500 feet).

Data Source: Office of Geographic and Environmental Information (MassGIS),
Commonwealth of Massachusetts Executive Office of Environmental Affairs

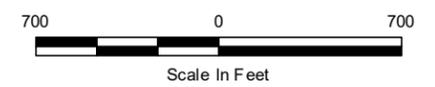
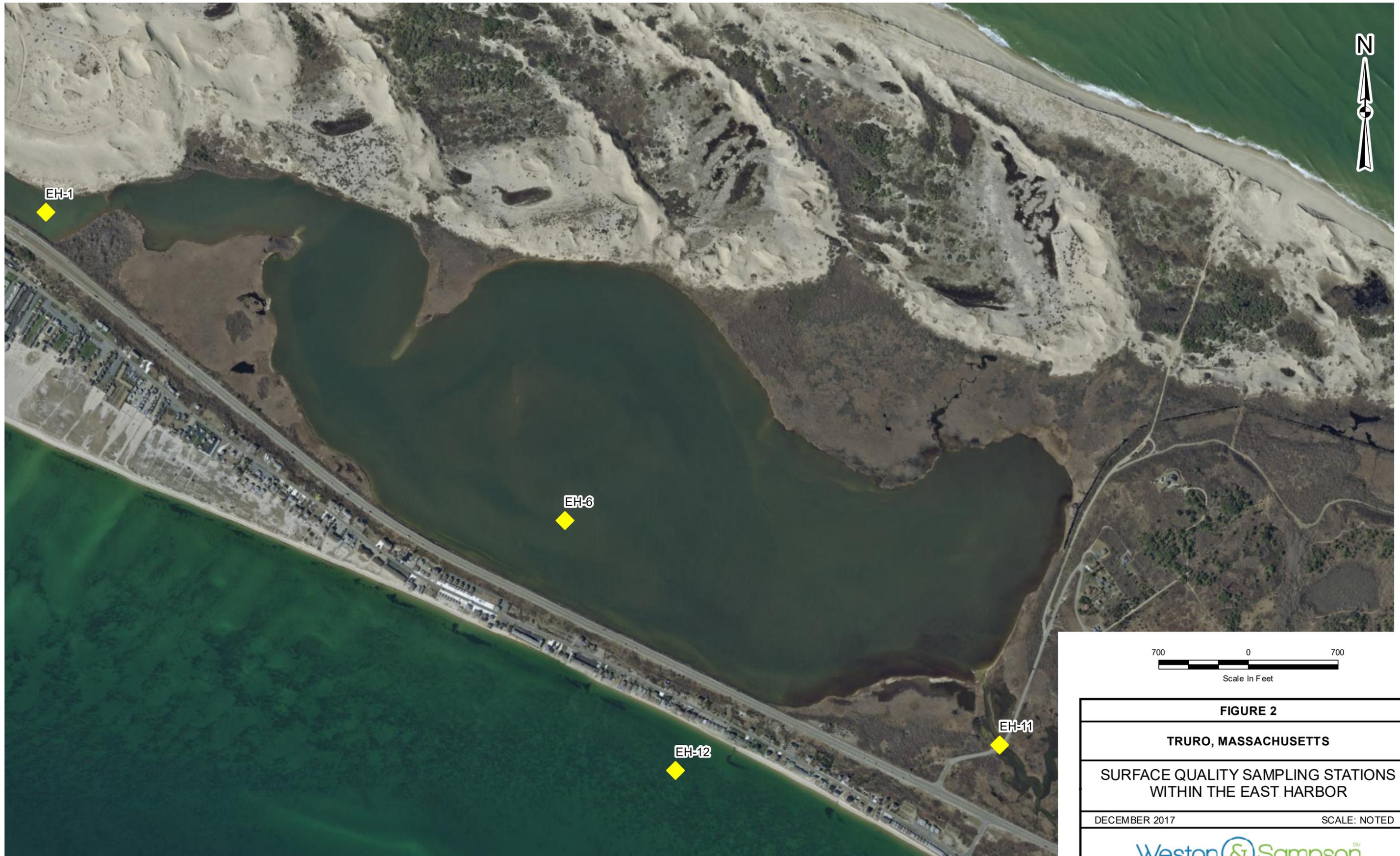


FIGURE 2	
TRURO, MASSACHUSETTS	
SURFACE QUALITY SAMPLING STATIONS WITHIN THE EAST HARBOR	
DECEMBER 2017	SCALE: NOTED

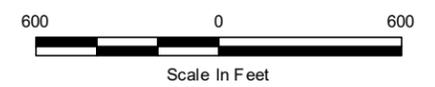
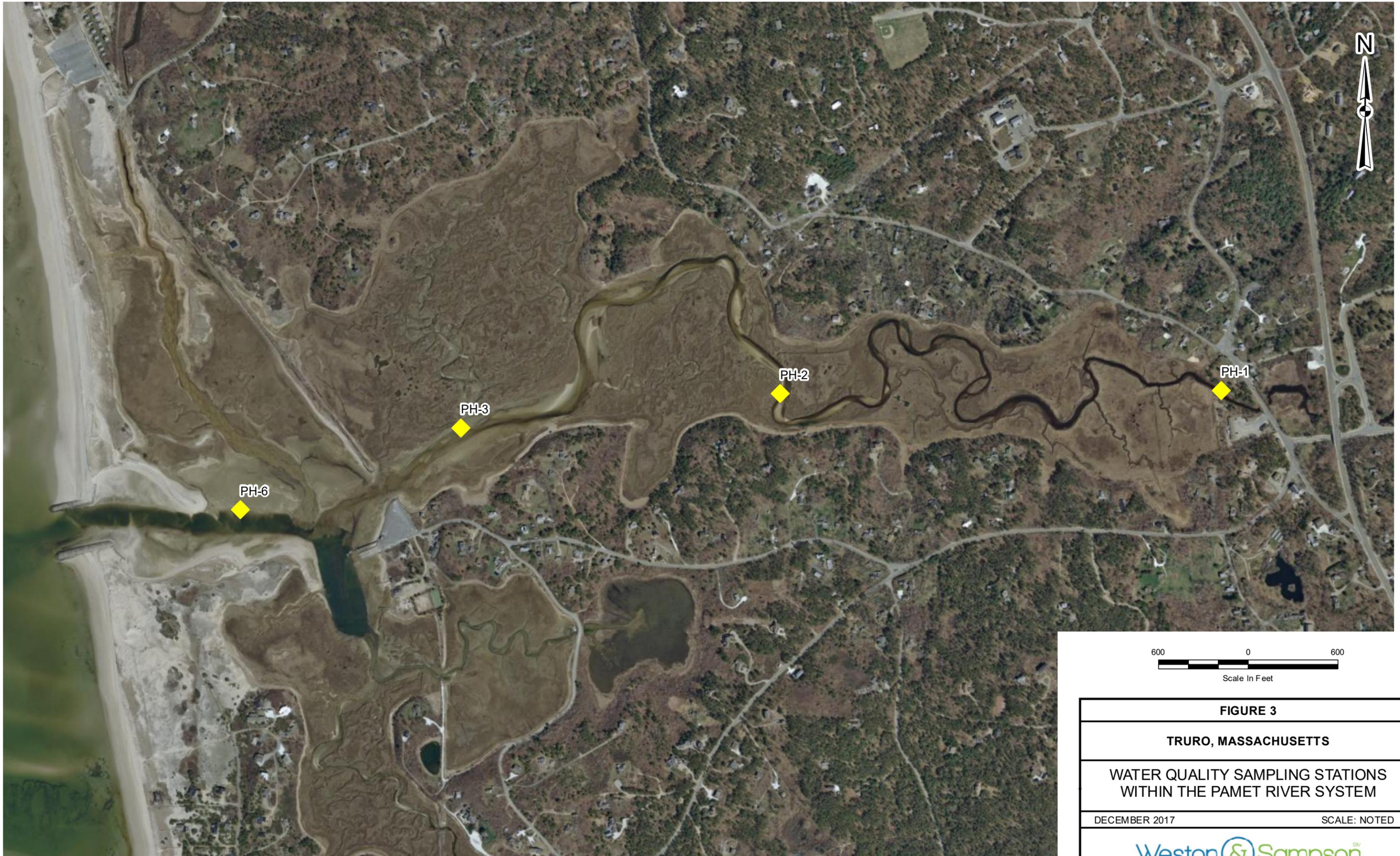


FIGURE 3	
TRURO, MASSACHUSETTS	
WATER QUALITY SAMPLING STATIONS WITHIN THE PAMET RIVER SYSTEM	
DECEMBER 2017	SCALE: NOTED

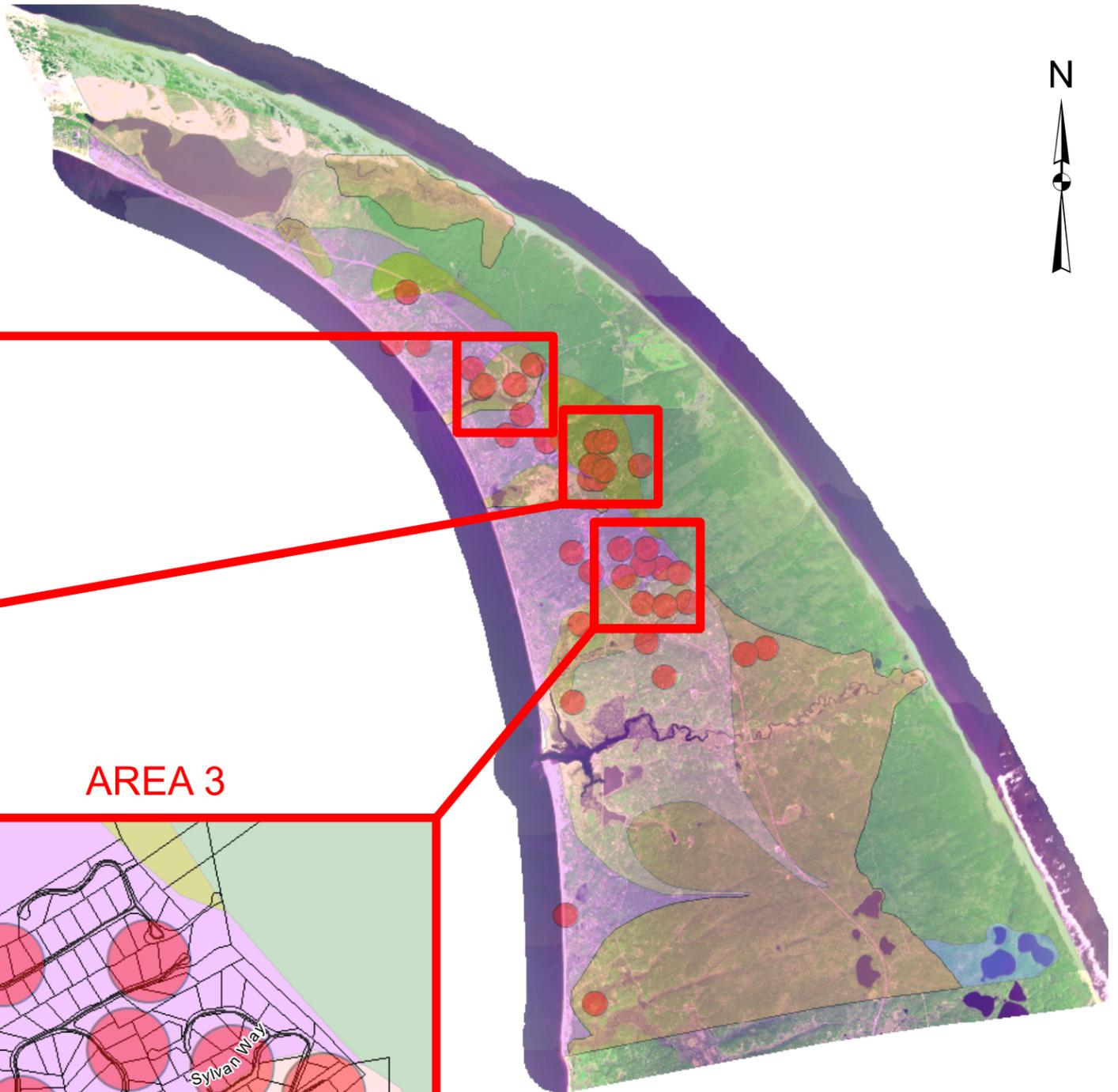
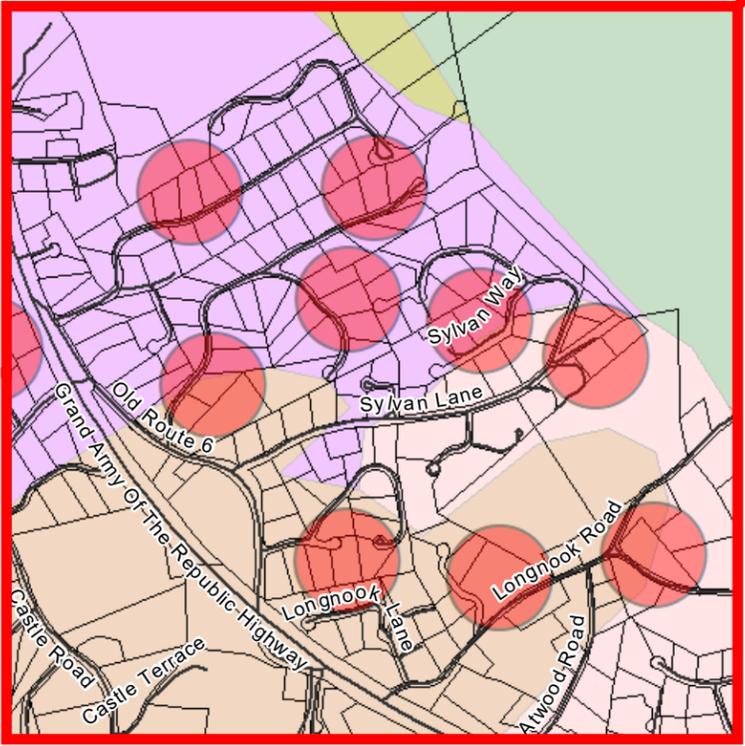
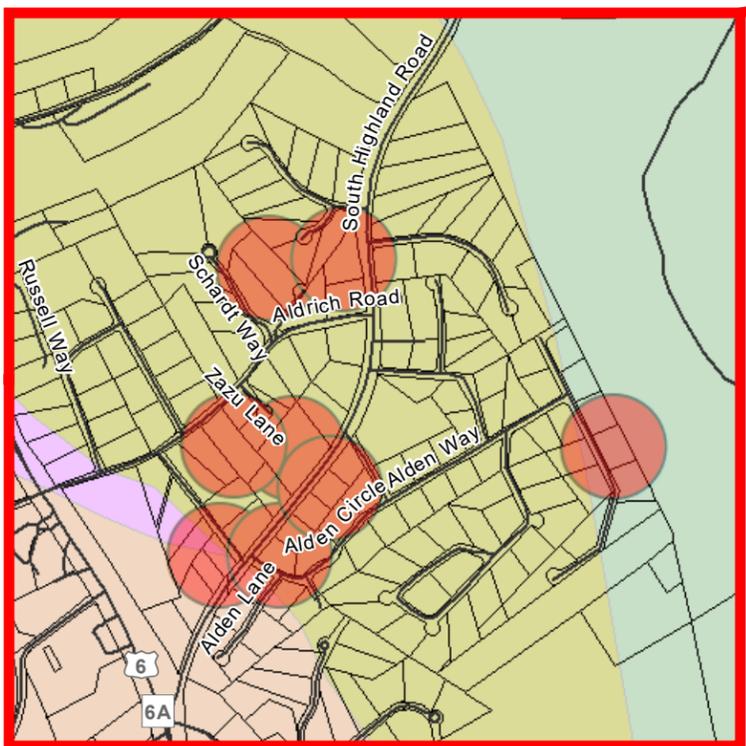
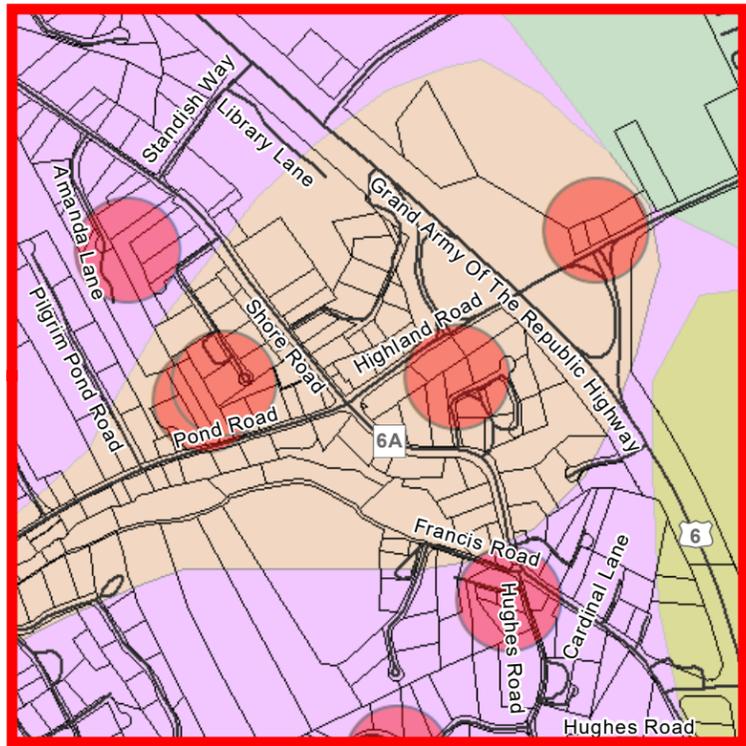


FIGURE 4

TRURO, MASSACHUSETTS

INTEGRATED WATER RESOURCES MANAGEMENT PLAN

AREAS OF CRITICAL INTEREST

DECEMBER 2017

Weston & Sampson

APPENDIX A

Materials Prepared for August 12, 2015 Workshop

Truro
Phase II
Task 1: Public Education and Outreach

First Newsletter: Handout at Town meeting, April 2015

Purposes:

- Summarize Phase I
- Provide Overview of Phase II activities

Proposed Text

Town Water Resources Advisory Committee Moves Forward to Protect Truro Water Quality

The Town has approved Phase II of the Integrated Water Resources Management Plan (IWRMP) to identify specific steps that landowners and the Town can take to protect local groundwater. Ground water is the sole source of drinking water in the town. The Town's Water Resources Advisory Committee (WRAC) is guiding the IWRMP process. Phase I evaluated water quality in the Town and identified potential problem areas. Phase II will define potential threats to ground water quality and ways to protect against these threats.

Summary of Progress to Date

Over the last two years the WRAC has guided Weston & Sampson Engineers in an evaluation of existing water use and water quality in the Town. Water supplies in the town are derived from wells, most of which serve individual homes. Wastewater is treated through septic systems that return water back to the aquifer. Unfortunately the septic systems tend to slowly increase nitrogen levels in the groundwater. Drinking water standards include standards for Nitrogen to protect against risk to human health. The Phase I report concludes that water samples from local wells show Nitrogen levels are below standards but levels roughly have the Town's 25 watersheds have increased over the past years.

The Phase I report (*Integrated Water Resources Management Plan, Phase I*) can be reviewed at the Town Hall during normal business hours. The Phase II work is intended to identify specific ways to keep the town's water supply safe, in particular keeping nitrogen levels as far below the drinking water standard as possible.

What Will Happen in Phase II

In the next year the WRAC and Weston & Sampson will complete Phase II of the IWRMP. Phase II has three basic objectives:

1. Better define the sources of nitrogen in certain areas of the Town.
2. Identify a range of nitrogen control options that may be applied to each of the sources.
3. Help residents understand the things they can do to protect ground water quality.

In the next year Weston & Sampson will install and sample wells at a number of key locations, evaluate sources of nitrogen in different areas of the Town and identify ways to control them, identify other threats to groundwater quality, and develop written guidance for Town residents, commercial establishment and government agencies (the Town and the State Department of Transportation). These written materials will contain best management practices that may be applied by septic system operators/owners, landscapers and homeowners and the Town and the State Department of Transportation.

A Brief Description of Water Supplies in the Town of Truro

Cape Cod is made up of sandy material that captures rainfall and snowmelt in a zone (or lens) that remains separate from sea water. The "Pamet Lens" lies under the Town and is the main source of the many individual wells that supply commercial establishments and residences. Rainfall and snowmelt are adequate to recharge the lens.

In order to protect water quality, all wastewater in the Town is treated by septic systems. After treatment, the water is leached back into the ground. Properly designed and maintained septic systems prevent harmful organisms and most chemicals from entering groundwater. However, typical septic systems will reduce, but not eliminate nitrogen, from leaching back into ground water. Depending on the spacing of septic systems, the volume of water treated and nature of groundwater movement, nitrogen can build up over the course of many years and may eventually reach or exceed drinking water standards. Although no exceedances have been found in the Town, high levels of nitrogen are a concern in other areas of the Cape.

Wastewater in Truro

A brief history and a look forward



Town of Truro

Water Resources Oversight Committee

August 13, 2015

Presenters

Robert Almy, Geologist
Senior Project Manager

Peter Romanelli, Geographer
Water Resources Oversight Committee

Purpose of Presentation

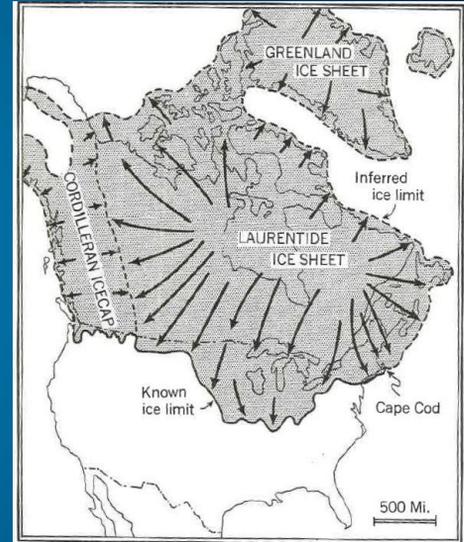
1. **Provide an understanding of Truro Water Resources**
2. **Give an overview of potential threats to our groundwater**
3. **Describe what is being done to protect water quality**
4. **Present options for the future**

Topics

- **Geologic History: Materials of the “Outer Cape”**
- **Ongoing Change: Natural processes and human interaction with the land**
- **Truro Water Supplies: A most precious asset**
- **Threats to water quality**
- **Approaches to protect water quality**

Geologic History: Materials of the “Outer Cape”

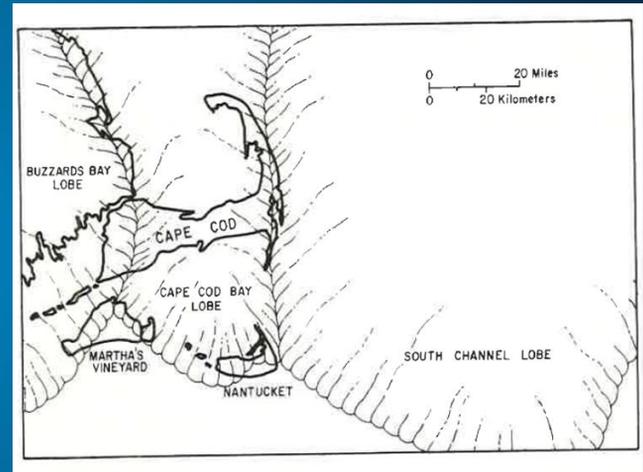
- Continental glaciation
- Thickness of 10,000 feet +
- Lower sea level (300+ feet)
- Large amount of material captured/carried by ice
- Outer Cape between ice lobes



From Strahler 1966

Geologic History: Materials of the “Outer Cape”

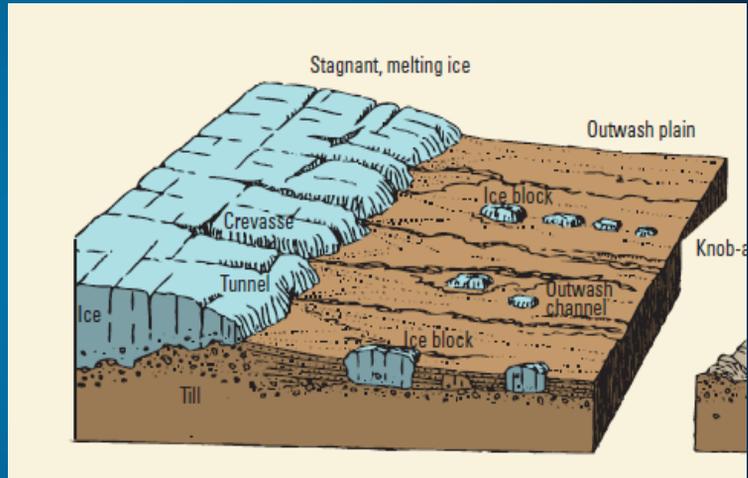
- Local “lobes” of ice
- South Channel Lobe retreated more slowly
- Material shed from the east
- Bedrock at great depth
- Initial deposits then shaped by wind and sea



From Strahler 1966

Deposits from the Channel Lobe

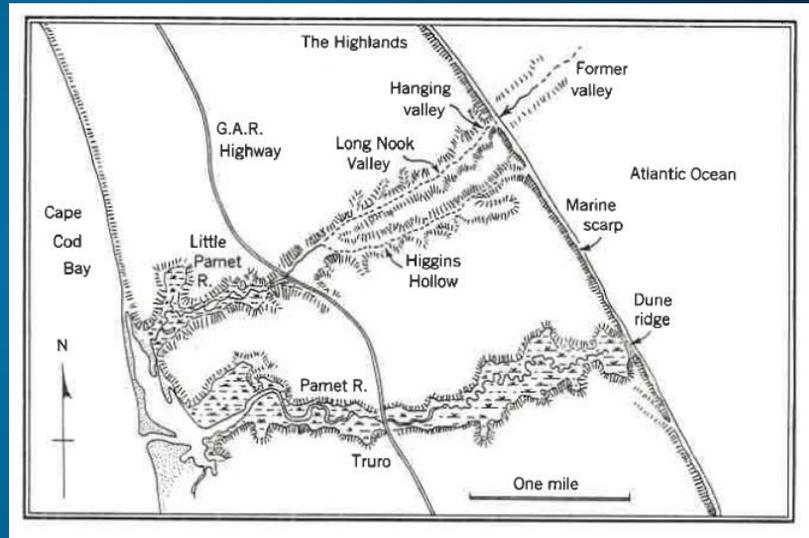
- East to west deposition
- Thicker deposits on east
- Outwash materials common



From Strahler 1966

After Deposition; Ocean Process

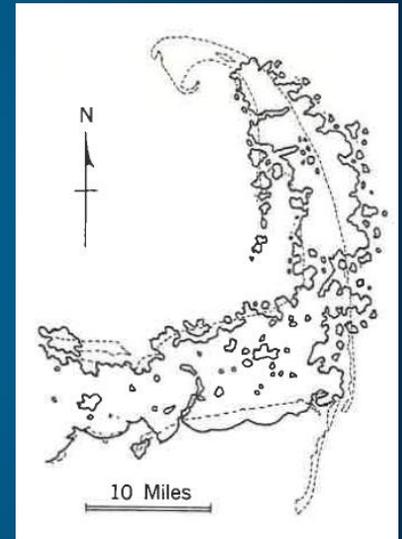
- Erosion along eastern side
- Distinctive Features
- “Hanging valleys”
- Pamet River



From Strahler 1966

After Deposition: Ocean Process

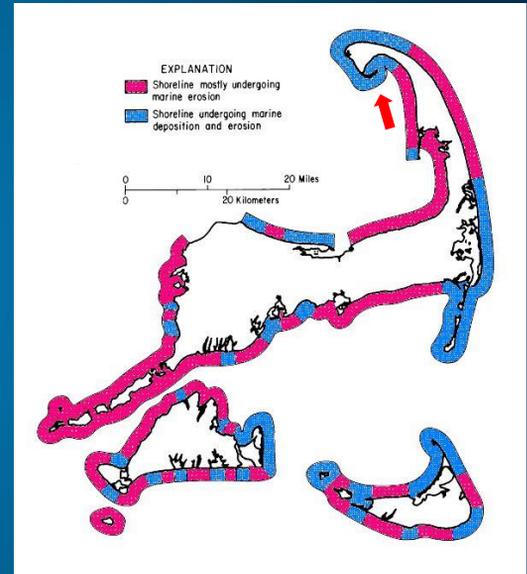
- Erosion and transport shape the outer Cape
- Formation of the Provincetown area
- Westward retreat of initial shoreline



From Strahler 1966

Coastal Erosion and Deposition

- Shapes the coastline
- Response to dominant wind/wave direction
- Typically to the North
- Shapes Truro and Provincetown



From Strahler 1966

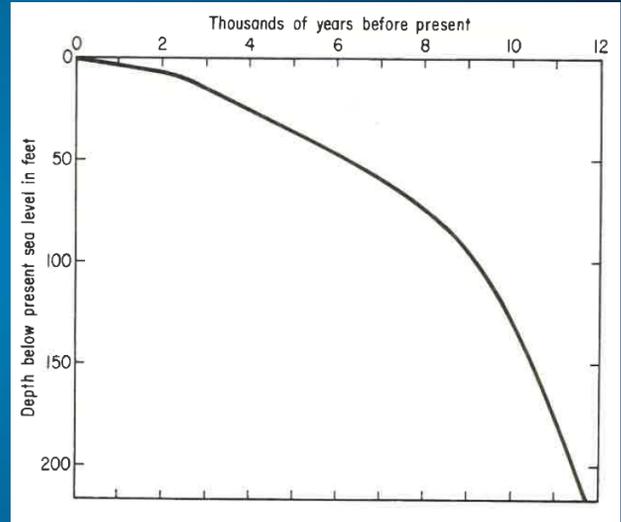
Deposits from the Channel Lobe

- Outwash materials common
- Sand and gravel common
- Excellent aquifers



Geologic History: Sea Level Rise

- **Sea level rise since glacial advance**
 - 300+ feet
- **Sea level rise continues**



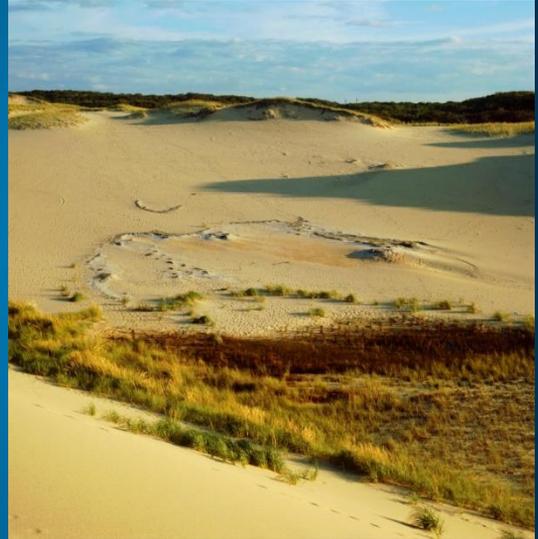
Natural Processes and Human Interaction with the Land

- Soil development and deforestation
- East Harbor
- Groundwater development
- Waste disposal

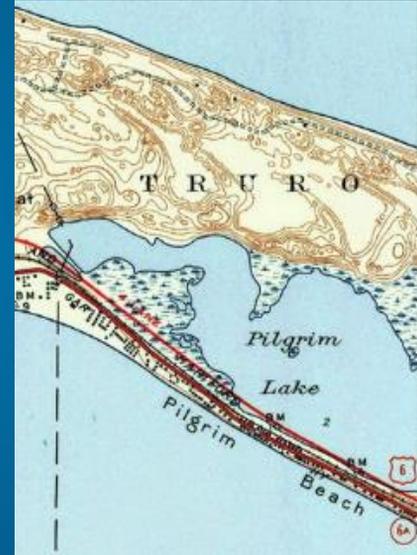
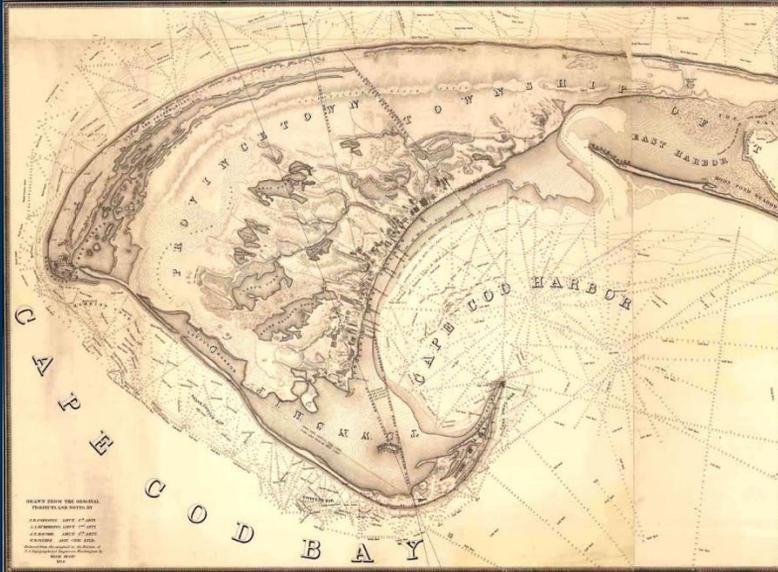
Sand Migration: Deposition and Erosion



Deforestation and Soils

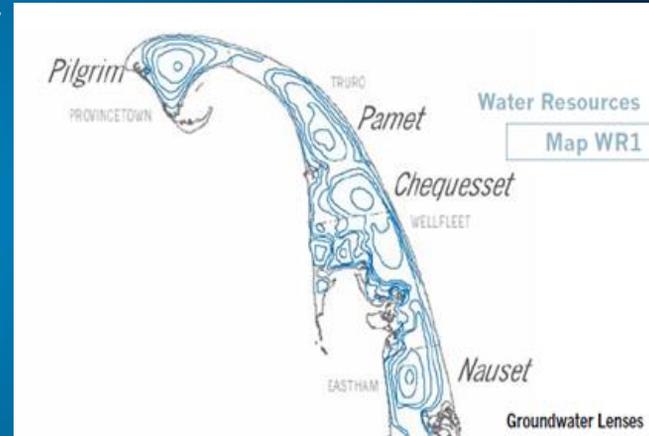


East Harbor 1836-2010: Human Influence



Groundwater of the Outer Cape

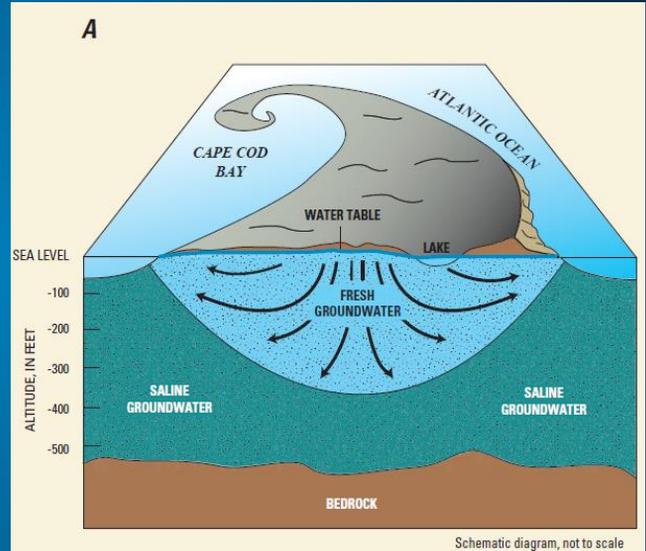
- Groundwater is virtually the only source of water on the Cape
- Developed by individual and municipal wells
- “Sole source “ aquifer; resource relied on by all
- Local “lenses” literally surrounded by salt water



From CCC 2012

Fresh Water “Floats” as a Lens

- Replenished by precipitation
- System in balance
- Sufficient supply
- A resource shared by all
- No fences underground



Hydrologic “Balance” of Cape Cod Aquifers

Cape Cod Flow Lenses	Flow in MGD	Discharge (percent)		
		To Coast	To Streams	To Wells
Pamet	12.4	71	22	7
Chequesset	24.2	49	51	0
Pilgrim	12.5	91	9	0
Nauset	19	74	26	0
Monomoy	110.6	77	16	7
Sagamore	269.2	66	28	6
Cape Cod Total	447.9	69	24	7

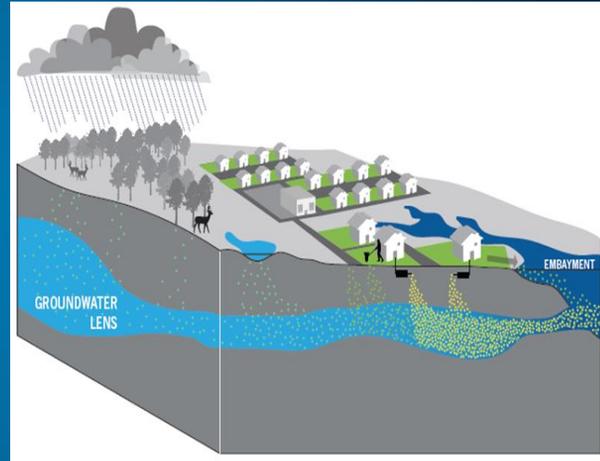
From 2002 data, increases to discharge to wells may have occurred

Truro Water Supplies: A Most Precious Shared Asset

- **Pamet lens; floats on top of sea water**
- **Sole source aquifer: the only source available**
- **Most water consumers depend on the Pamet and Chequesset lenses**
- **Recharge from precipitation and septic system return flows**
- **Septic systems contribute chemicals, including Nitrogen**
- **No fences underground: flow lines not property lines**

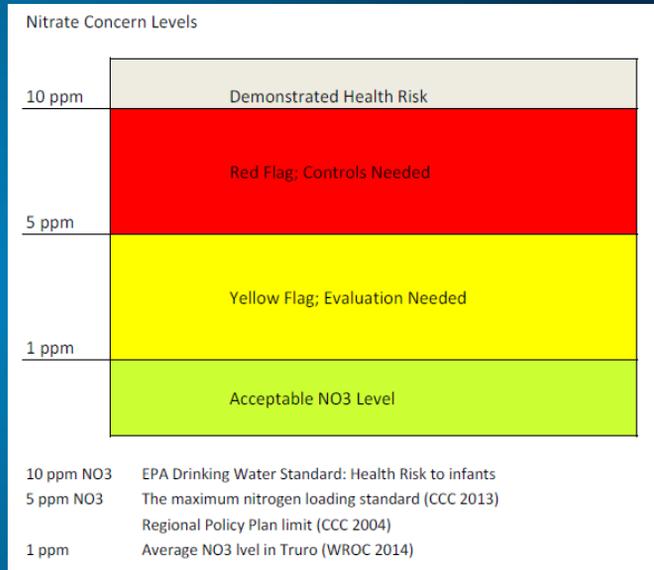
Nitrogen in the Environment

- **Nitrates (NO₃) and nitrites (NO₂)**
 - Nitrogen-oxygen chemical compounds
- **Threat to water quality**
 - Can be harmful to human health
 - Algal blooms in surface water bodies
- **Contained in:**
 - Septic system effluent (dominant source)
 - Fertilizers

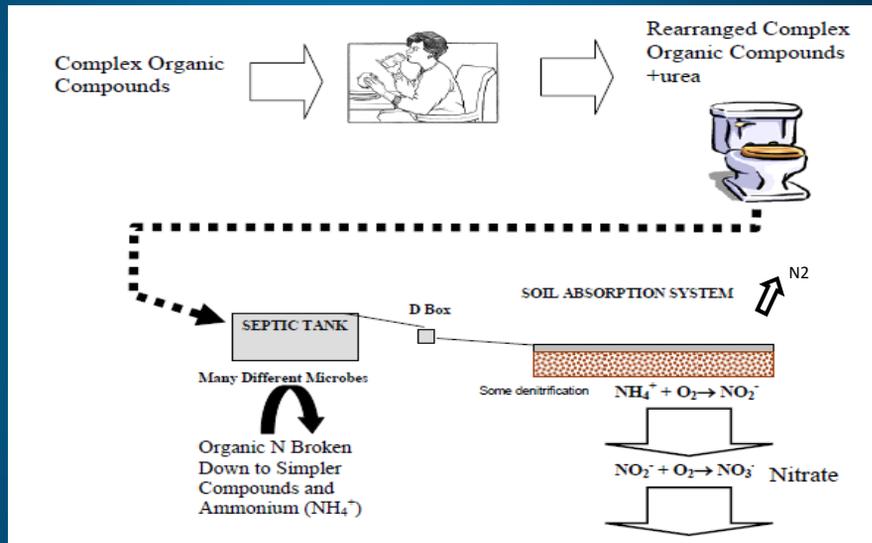


Nitrate Concern Levels

- **Voluntary Groundwater sampling**
 - 2008-2011
- **Average in Truro 1 ppm**
- **A few samples > 5ppm**



Nitrogen Travel Residential Systems



Note: Adapted from <http://buzzardsbay.org/etistuff/bched-alternative-septic-sytems-2007.pdf>

Existing Conditions

- Nitrogen enters Truro groundwater and surface water
- Main sources include cesspools, and septic systems
 - New systems take out 25% of N
- Some Nitrogen also results from
 - Over fertilized lawns
 - Stormwater runoff roads and other impervious surfaces



What is Being Done?

- **Board of Health oversight of Title 5 (septic systems)**
- **Integrated Water Resources Plan**
 - **Water Resources Oversight Committee**
 - **Phase I and II studies**
 - **Periodic sampling of Pamet estuary, East Harbor and Cape Cod bay (2007,-08,-09,-15)**
- **Stepwise analysis and development of approaches for the Town to consider**

Phase 1 Report available at the Town Hall

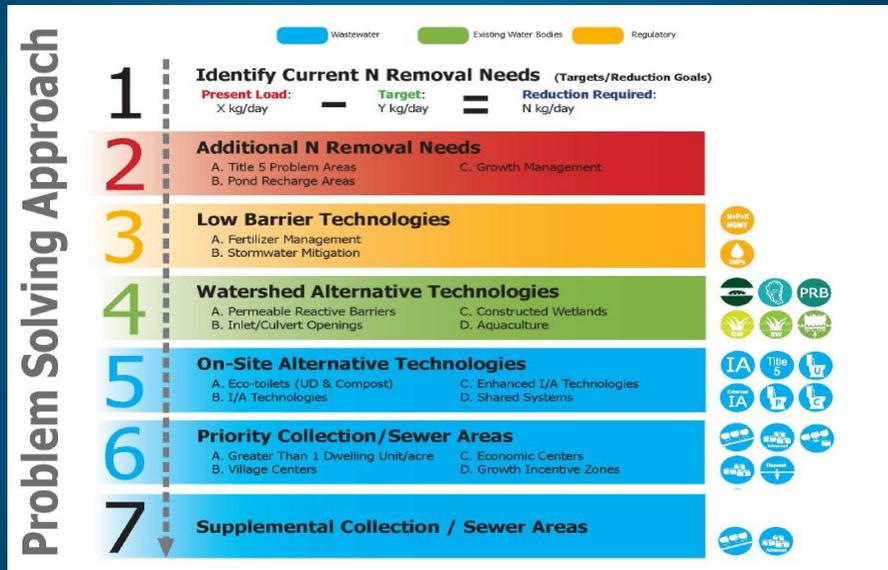
Current Progress

- WROC and Weston & Sampson have evaluated water use and quality in Truro.
- High nitrogen areas have been identified.
- Monitoring wells are being installed to provide long-term water quality analysis and quantification of septic system impacts.



Phase 1 Report available at the Town Hall

Consistent with Work by CCC



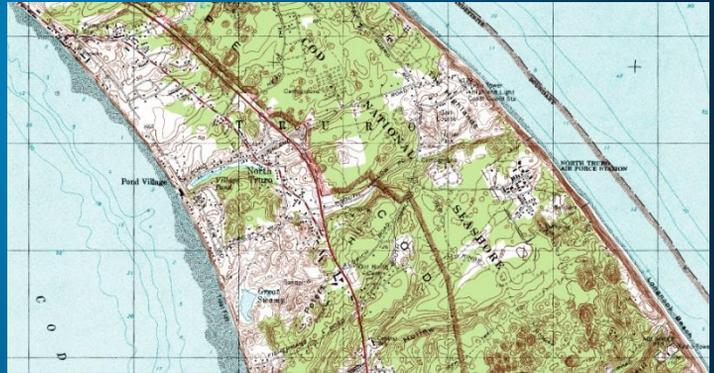
208 Plan Update Stakeholder Summit

What can you do to help?

- **Have your septic system pumped**
 - Septic tanks should be pumped every 3 years
 - Reduces the amount of nitrogen reaching groundwater
- **Replace cesspools and non-conforming systems**
 - Cesspools are no longer compliant with regulations
- **If fertilizer is necessary, avoid overuse**
 - If fertilizer is necessary, avoid overuse
 - Only use fertilizer when ground is above 50° F
 - Avoid applying fertilizer before rainfall

Potential Town-wide Options

- Overlay district to phase out cesspools



Example: Town of Dennis (Swan Pond)

Questions?

THANK YOU !

www.westonandsampson.com

Weston & Sampson®

Unused slides follow

Another Coastal Community on Septic Systems

Sand Point/Sandyland Cove
Santa Barbara, CA



Eventual Conversion to Sanitary Sewer

Sand Point/Sandyland Cove

Closely spaced homes
On septic systems
Water quality an issue



Available Alternative Septic System Options

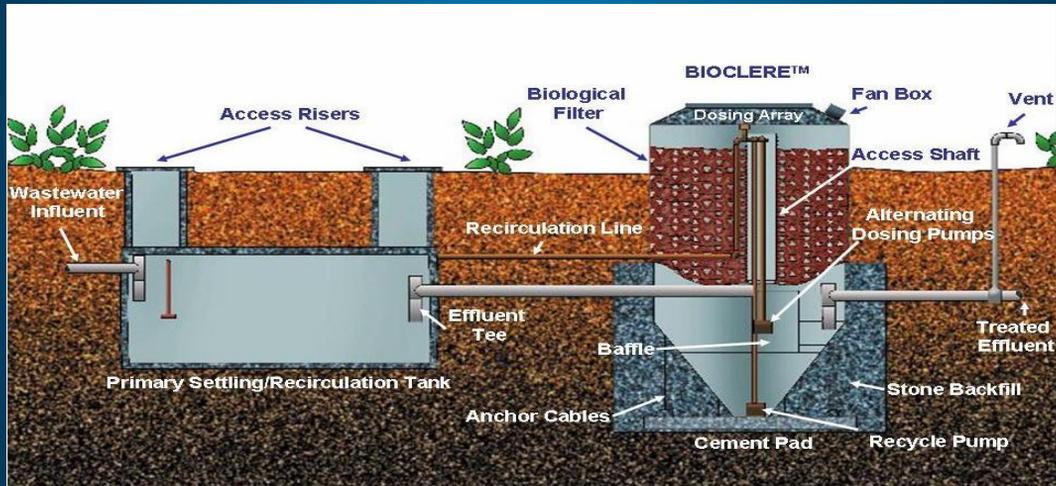
- **Examples of existing alternative systems**
 - Fixed Activated Sludge Treatment (FAST)
 - Bioclere
 - Recirculating Sand Filters
- **Systems in use**
 - Barnstable County, MA
 - Buzzards Bay, MA
 - Concord, MA
- **Cost of installation and maintenance an issue**
 - Consider when replacement/repair of existing system is needed

Being researched by County

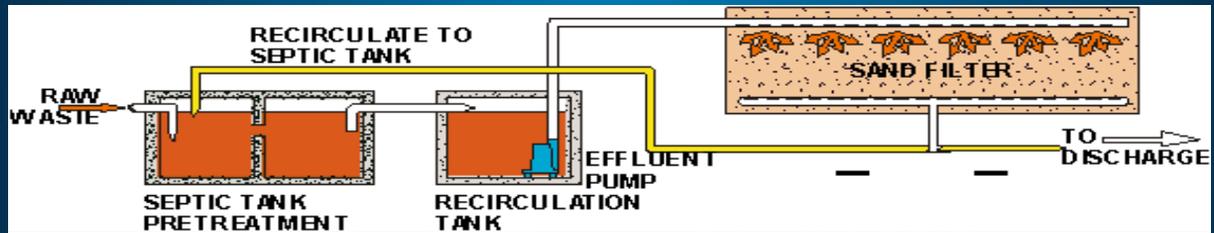
Fixed Activated Sludge Treatment



Bioclere

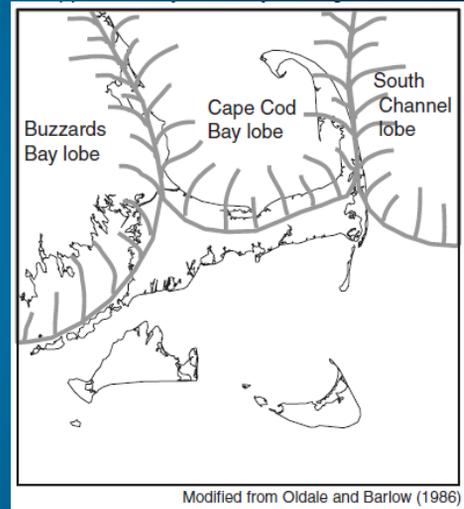


Recirculating Sand Filter

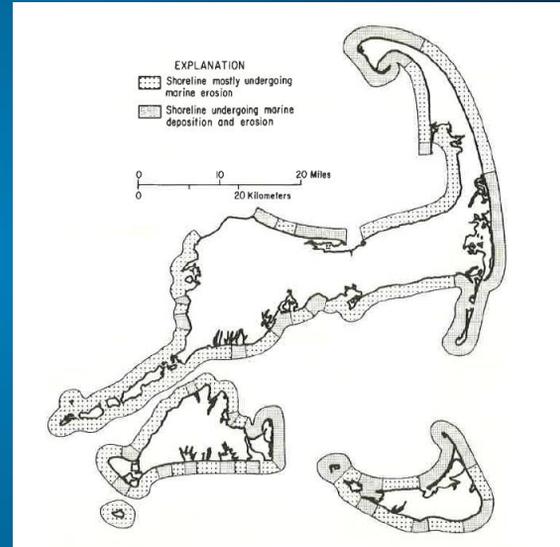
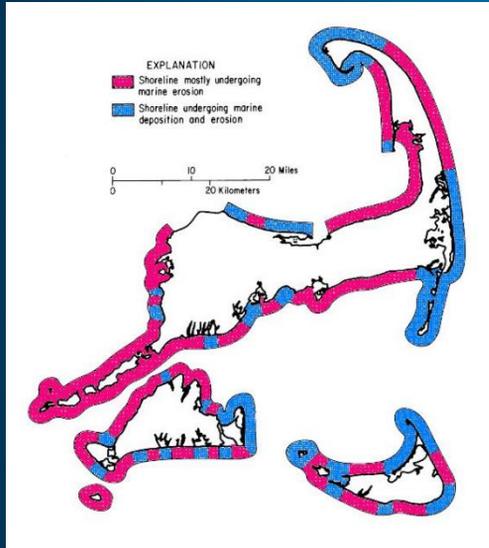


Geologic History: Materials of the “Outer Cape”

- Pleistocene ice lobes
- South Channel Lobe retreated more slowly
- Material shed from the east
- Bedrock at great depth
- Initial deposits then shaped by wind and sea



Coastal Erosion and Deposition



Geologic History: Materials of the “Outer Cape”

- Local ice lobes
- South Channel Lobe retreated more slowly
- Material shed from the east
- Bedrock at great depth
- Initial deposits then shaped by wind and sea



Nitrogen in the Environment

- **Nitrates (NO₃) and nitrites (NO₂)**
 - Nitrogen-oxygen chemical compounds
- **Threat to water quality**
 - Can be harmful to human health
 - Algal blooms in surface water bodies
- **Contained in:**
 - Septic system effluent (dominant source)
 - Fertilizers



APPENDIX B

Materials Prepared for Cable Broadcast

Water

Truro's most precious and shared resource



Town of Truro

Water Resources Oversight Committee

Weston & Sampson™

This Presentation is About Your Water

1. What is its source?
2. Do we have enough water?
3. Is the water quality safe?
4. What can we do to protect water quality?

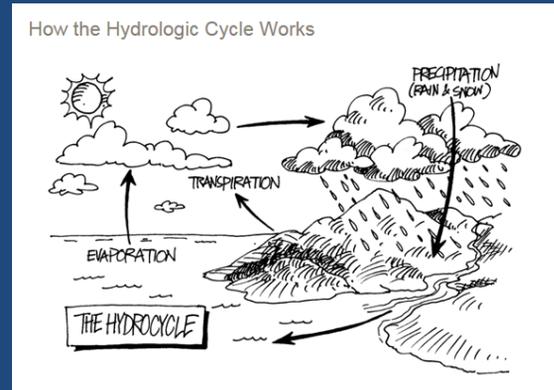


What is the source of Truro's water?

Rainfall and snow melt that soaks into the ground

Everyone in town uses
“groundwater”
pumped from wells...

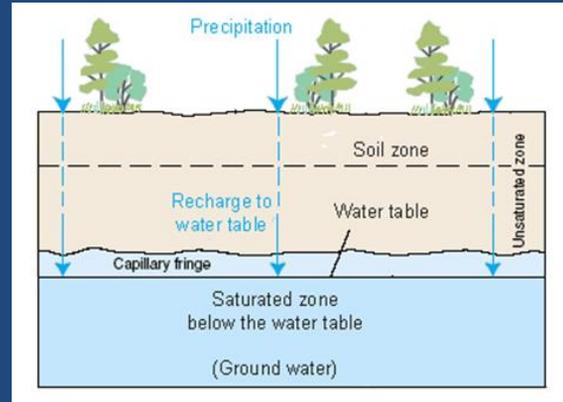
It is literally a shared
resource





Who relies on Groundwater?

- **Everyone in Town**
 - Homeowners
 - Businesses
 - Schools
- **Most from onsite wells**
- **The wells pump water from below the water table**

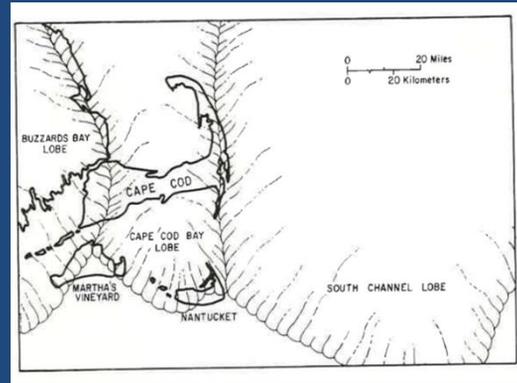


Where is Truro's Water?

Sandy glacial deposits form Cape Cod.

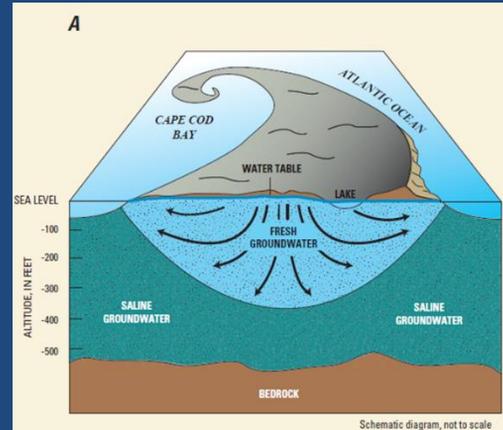
Truro's water is in these sandy materials.

Because Truro has ocean on two sides, our water floats on top of sea water.



Fresh Water “Floats” on top of Sea Water

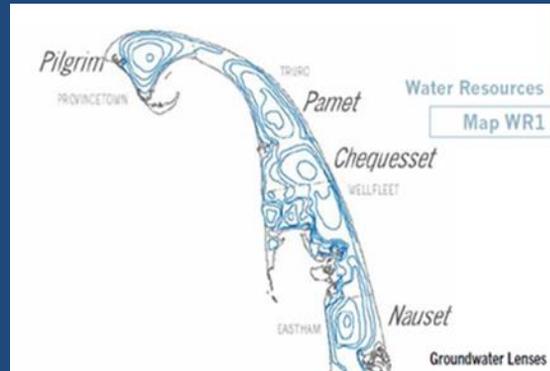
- Fresh Water lighter than Salt Water
- Constant slow flow
 - From inland areas (sources)
 - To ocean (discharge)
- “lens shaped”
 - Thicker under high elevations

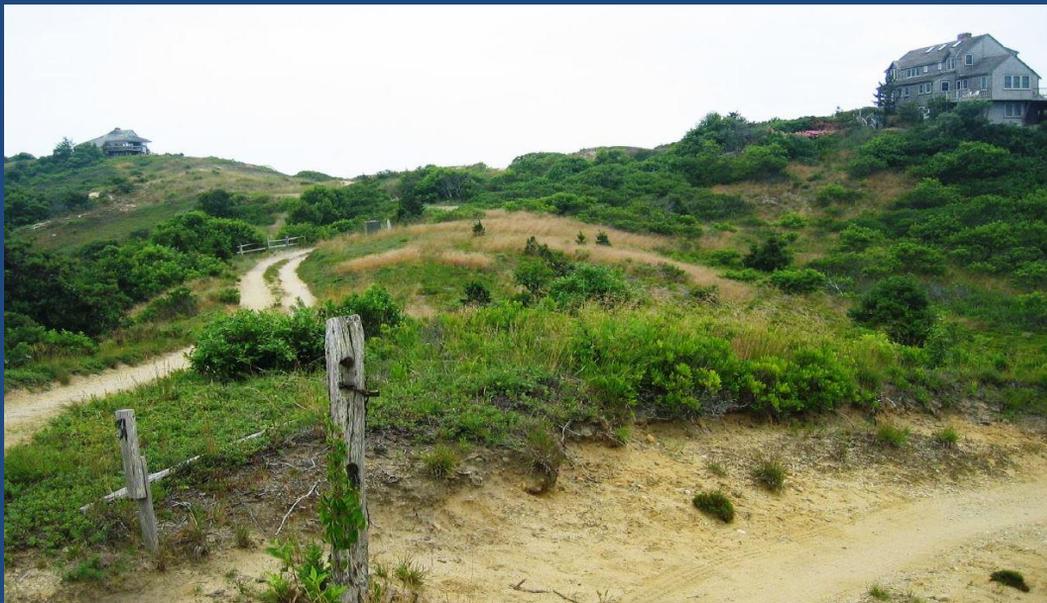


Two Major Lenses Under Truro

Under the highest areas in Truro

1. North of Pamet River
Pamet Lens
2. South of Pamet River
Chequesset Lens

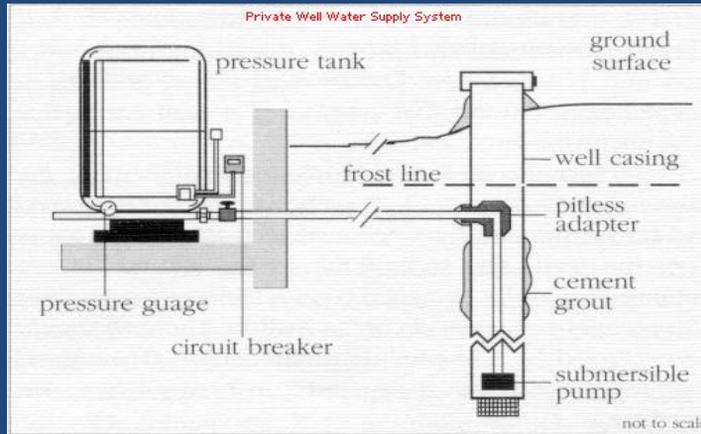




Why is Groundwater the Only Source?

- Groundwater requires little/no treatment
- Surface water is limited in Truro
- Surface water treatment is expensive

Groundwater is Easily Accessible



Does Truro Have Enough Water?

- Yes, only a small fraction is pumped.
- In fact, the Pamet Lens supplies Provincetown too!

Ground Water Lenses	Average Flow in MGD	Discharge (percent)		
		To Coast	To Streams	To Wells
Pamet	12.4	71	22	7
Chequesset	24.2	48	50	2
Pilgrim	12.5	91	9	0
Nauset	19	74	26	0
Monomoy	110.6	77	16	7
Sagamore	269.2	66	28	6
Cape Cod Total	447.9	69	24	7

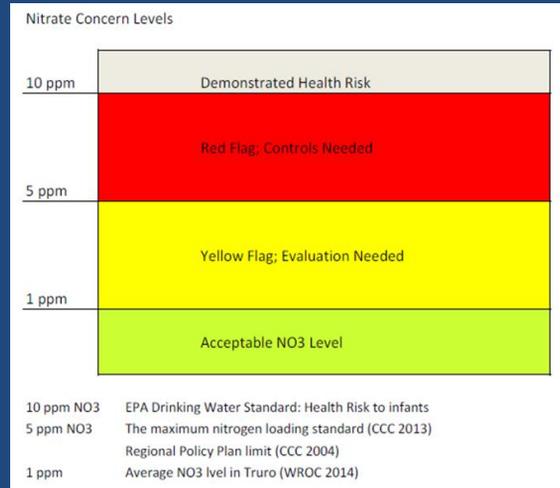
MGD: Million Gallons per day





What is the Quality of Truro's Water

- General good quality
- Nitrate in some areas
 - Nitrate levels in Truro usually below 5 ppm
 - A few areas have higher Nitrate



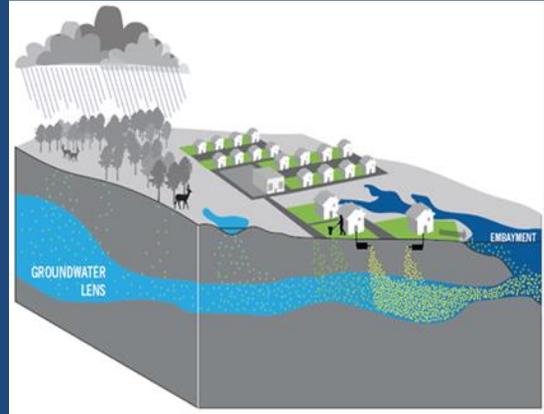
Why the Focus on Nitrate?

- **Health Effects**
 - “Blue Baby” syndrome
- **Environmental Effects**
 - Algae in ponds and wetlands
- **May mean incomplete treatment**
 - Other pollutants may reach groundwater



Why is there a question about Water Quality?

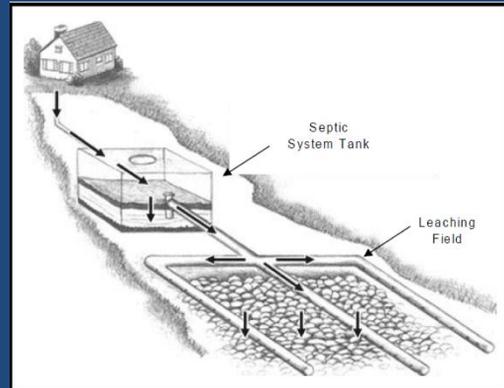
- Sandy soils not effective in removing Nitrate
- Contributing sources:
 - Septic systems
 - Fertilizer
 - Rainfall
- Nitrate does not break down in Groundwater



What is a Septic System?

Sewage disposal system

- On site tank + leach field
- Effective for bacteria and viruses
- Less effective for other pollutants
- Minimum design standards
- Require maintenance



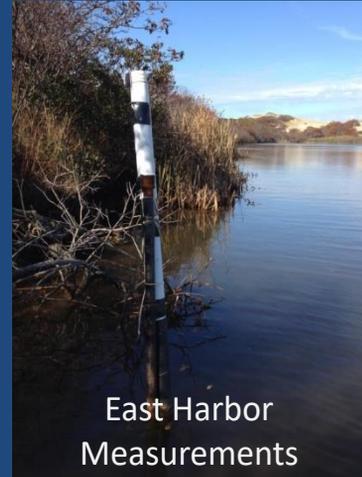
Is Water Quality being Studied?

Yes

- **The Town has established a Water Resources Oversight Committee (WROC)**
- **The Board of Health participates on the WROC**
- **Ongoing sampling since 2007**
 - **Groundwater, Pamet River, East harbor**
 - **Phase I Study 2014**

Studies Include

- Surface and groundwater sampling
 - Water quality
 - Flow direction
- Evaluation of Nitrate sources
- Stormwater control examples

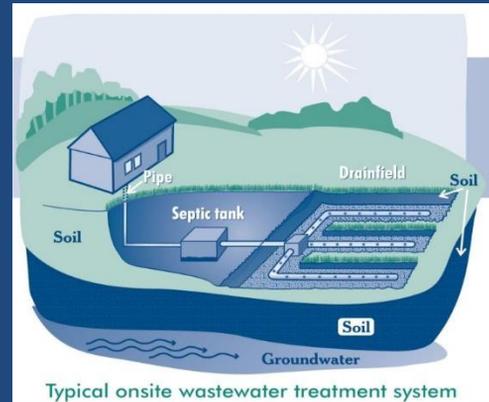




Do Septic Systems Make Sewage Safe?

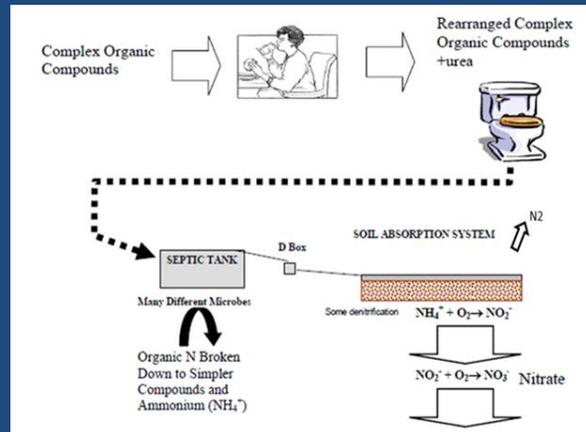
Generally yes:

1. Rely on bacterial action
2. Do a good job with harmful bacteria and viruses
3. **BUT Standard septic systems remove only a fraction of Nitrate**



What is the Source of Nitrate in Septic Systems?

Mostly human waste



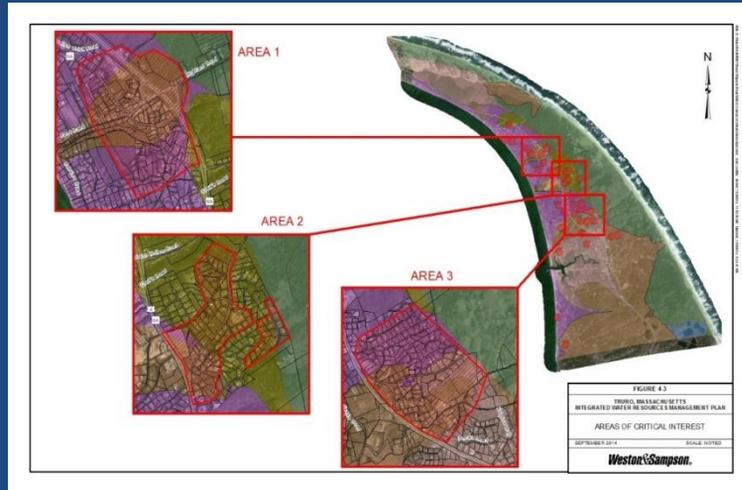
What are the trends?

1. Phase I Study by WROC identified areas of concern
2. Truro has several high Nitrate areas
3. Gradual increase shown by voluntary sampling (2007-2015)
4. Some areas have exceeded 5 ppm Nitrate
5. Reduce sources to stop Nitrate increases





Areas of Concern from Phase I Report



What are the Threats?

In Order:

1. Cesspools and Septic Systems
2. Over fertilization of landscaping
3. Stormwater runoff

Excessive Levels of Nitrate may lead to restrictions on development



No Treatment From Cesspools



What is Being Done?

- Board of Health oversight of Title 5 (septic systems)
- Integrated Water Resources Plan
 - Water Resources Oversight Committee
 - Phase I and II studies Report available at the Town Hall
 - Periodic sampling of Pamet estuary, East Harbor and Cape Cod Bay (2007,-08,-09,-15)
- Stepwise approach for the Town to consider

Nitrate is a Regional (Cape Cod) Challenge

Decades of Studies

Some Suggested Approaches Apply to Truro

- 1. Identify Current Nitrogen Control Needs**
- 2. Septic system Problem Areas**
- 3. Fertilizer management**
- 4. Better Septic System Technology**

Other Towns are Forced to Install Sewer Systems



What can you do to help?

- **Have your septic system pumped**
 - Every three years
- **Replace cesspools and non-conforming systems**
- **Fertilize only when necessary**
 - Don't waste money

| *Weston&Sampson*®

The Town of Truro
www.truro-ma.gov



Contact the Committee at:
KevinKuechler27@gmail.com

A photograph of a sunset over a body of water. The sun is low on the horizon, creating a bright orange and yellow glow. In the foreground, the silhouettes of two people are visible on a pier or dock. The sky is filled with soft, wispy clouds, and the water reflects the light from the sun.

Thank You for Watching

Many Thanks to

Lydia Mann

Karl Coleman

Tom Whitten

For the use of their Photographs

APPENDIX C

Existing Local Regulations

Appendix C Existing Local Regulations Pertaining to Water Quality

Selected Truro Land Use Policies and Water Quality Regulations

Areas for Action¹

A. Strengthen the zoning by-law relative to general business zoning and water resources.

Requirements for landscaping/stormwater treatment and upgrading Onsite Wasterwater treatment

B. Reduce public and commercial use of chemical fertilizers, herbicides and pesticides through a diligent information/education effort. In our very porous substrate these products can infiltrate areas of the aquifer and degrade groundwater quality.

Public outreach, use regulations, certification of applicators

C. Upgrade and eliminate substandard septic tanks.

Require replacement to I/A in instances of sale of properties with non-1995 standard systems or history of failures

D. Deter salts and other minerals from entering drinking water. Water becomes undesirable for drinking when the quantity of dissolved minerals exceeds 1,000 mg/L (milligrams per liter). Too much sodium may be harmful to people with heart problems.

Request use of CaCl deicing materials and use of other techniques on Rt 6

E. Reduce bacterial and viral pollution by identifying and addressing sources, and through homeowner testing of private wells.

Require replacement to I/A in instances of sale of properties with non-1995 standard systems or history of failures

F. Reduce nitrates in surface water and groundwater, and appropriately site and construct private wells.

Require replacement to I/A in instances of sale of properties with non-1995 standard systems or history of failures

Water Resource Policies²

11. In Impaired Areas, (areas where groundwater may have been degraded by point and non-point sources of pollution, including but not limited to areas with unsewered residential developments where lots, on average, are less than 20,000 sq ft; landfills, septage and wastewater treatment plant discharge sites; high density commercial and industrial areas and those down gradient areas where the groundwater may have been degraded by these sources) development shall generally meet a 5 parts per million nitrate/nitrogen loading standard for impact on groundwater, but may increase to 10 parts per million nitrate/nitrogen where it can be demonstrated to the permitting authority that such increase will cause no

¹ 2005-2010 Local Comprehensive Plan, Ch. 3 Water Resources, Page 38 et al

² 2005-2010 Local Comprehensive Plan, Ch. 3 Water Resources Page 42 et al

significant adverse impact on wetlands, water bodies, public or private drinking water supply wells and potential water supply wells.

12. In Impaired Areas, where existing development exceeds the 10 parts per million nitrogen loading standard, redevelopment of that property shall not increase existing levels of nitrogen loading.

13. In Impaired Areas, public and private sewage treatment facilities as well as other remediation measures such as community septic systems shall be used only when a public health hazard exists and to protect or remediate marine water quality, and when no other means of wastewater disposal is available.

14. In Impaired Areas, the development of public or community water supply systems shall be allowed for areas serviced by private wells or where necessary to accommodate cluster development with the provision that poor water quality shall be demonstrated before town funds are used to help alleviate the problem. The classification as an Impaired Area will not be, in and of itself, justification for public water supply system service.

15. In Water Quality Improvement Areas, (impaired areas that are located within wellhead protection areas, fresh water and marine water recharge areas) development shall not exceed a 5 parts per million nitrate/nitrogen loading standard or an identified marine water standard, whichever is applicable. Where existing development exceeds that identified loading standard, redevelopment shall improve existing levels of nitrate/nitrogen loading.

16. In Potential Public Water Supply Areas, no development shall be permitted in the well site area and in the area within 400 feet of the "potential well site", or an area equal to $150 \times \log$ of the pumping rate in gallons per day minus 350. Within the recharge areas, the same standards apply as in Wellhead Protection Areas above.

17. Development and redevelopment projects shall identify proposed wells and existing private wells on abutting properties within 400 feet, and assess the impact of the development on the water quality of these wells. Septic systems shall be sited so as to avoid contamination of existing or proposed wells....

21. The certification, development and use of appropriate new innovative technologies designed to improve wastewater treatment by reducing nutrient loading is encouraged, although such technologies shall not be the basis upon which to increase building density or change uses from those defined by the Town Zoning By-Law.

APPENDIX D

Summary of I/A System Performance Data

Appendix D

Summary of I/A System Performance Data¹

Total Nitrogen in Effluent, Systems Installed in Truro

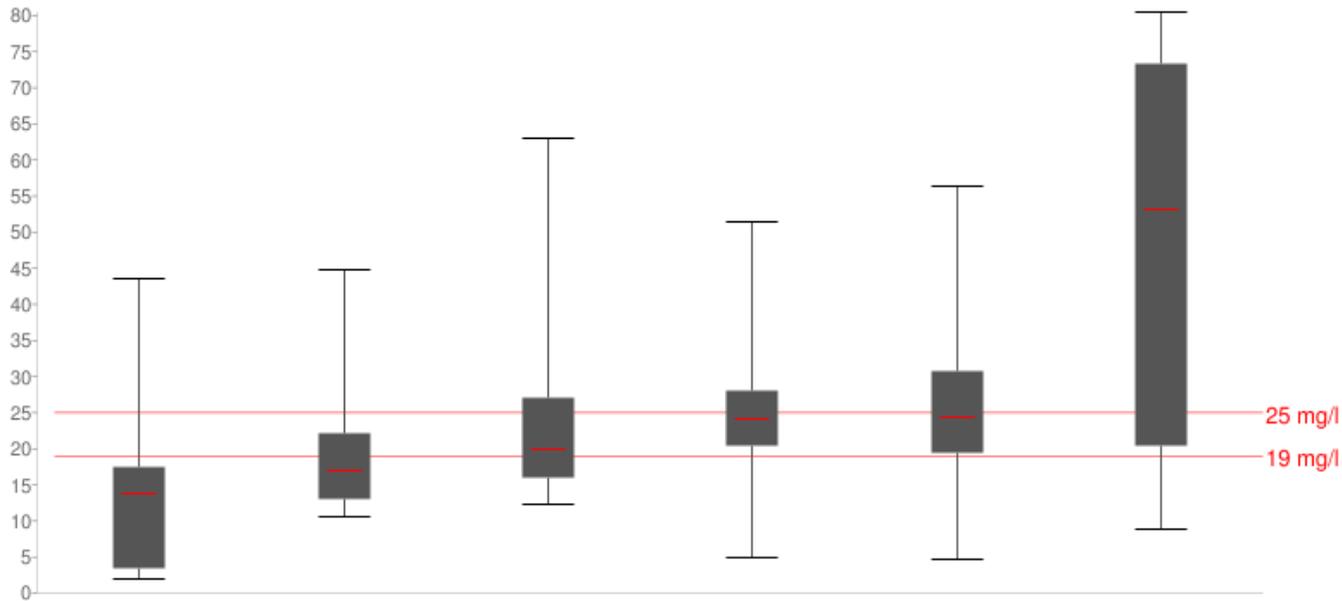
System	Minimum	Upper Quartile	Lower Quartile	Maximum	Median
Advantex	4.93	28	20.51	51.38	24.15
Bioclere	12.35	26.98	15.93	63	20
FAST	10.49	22.25	13.05	44.81	17
Septitech	4.77	30.85	19.39	56.46	24.45
Septitech	8.93	73.42	20.34	80.48	53.22
Waterloo	1.97	17.37	3.42	43.54	13.76

¹ Barnstable County at <https://septic.barnstablecountyhealth.org/>

Total Nitrogen in Effluent, Systems Installed in Truro

System	Minimum	Upper Quartile	Lower Quartile	Maximum	Median
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FAST	10.49	22.25	13.05	44.81	17
Septitech	4.77	30.85	19.39	56.46	24.45
Septitech	8.93	73.42	20.34	80.48	53.22
Waterloo	1.97	17.37	3.42	43.54	13.76

Single Family Total Nitrogen(in mg/l)
All Technologies in the town of Truro (6 systems)



Total Nitrogen in Effluent, Systems Installed in Truro

System	Minimum	Upper Quartile	Lower Quartile	Maximum	Median
Advantex	4.93	28	20.51	51.38	24.15
Bioclere	12.35	26.98	15.93	63	20
FAST	10.49	22.25	13.05	44.81	17
Septitech	4.77	30.85	19.39	56.46	24.45
Septitech	8.93	73.42	20.34	80.48	53.22
Waterloo	1.97	17.37	3.42	43.54	13.76

Systems in both the top 20 for total N removal (Multifamily) and top 50 N removal (Single Family) in Barnstable County data base:

Amphidrome, Bioclere, Singulair, FAST, OMNI RSF

Overall performance data available at: <https://septic.barnstablecountyhealth.or>

APPENDIX E

A/I Technologies Overview

Appendix E A/I Technologies Overview

I/A Onsite Wastewater Treatment Systems Summary

An I/A (innovative and alternative) septic system differs from a conventional system in that its design does not conform to the typical Title V septic system.

- I/A systems add an additional treatment step before wastewater is discharged to the surrounding soil.
- Many systems use pumps and timers to avoid overloading the treatment and dispersal components during peak flow times.
- Treatment from I/A systems further reduces the amount of solids in the effluent. Many treatment techniques also reduce the concentrations of pathogens and nutrients in wastewater effluent.

I/A septic systems include pretreatment technologies, compounding on the primary treatment included in conventional Title V systems.

- This pretreatment technology can be installed in a septic system by either adding an additional compartment within a single processing tank, or adding a separate component situated after the septic tank and before the drain field.
- Available technologies include aerobic treatment units, media filters, and sequencing batch reactors.

Aerobic Treatment Units (e.g. Fixed Activated Sludge Treatment)

- These systems utilize air injection systems that create an aerated environment suitable for bacteria growth.
- Bacteria break down organic material, contributing to lower total suspended solids and biochemical oxygen demand in the effluent.

Media Filters (e.g. Recirculating Sand Filters)

- These systems contain a watertight structure that houses one of several types of media. The media are used to grow bacterial populations and to facilitate biochemical and physical treatment.
- Bacterial organisms break down organic matter and consume nutrients in the effluent.

Final Dispersal Technologies

- Alternative drain field options for advanced systems can continue effluent treatment as it is discharged to the soil environment.
- Drip dispersal, low-pressure distribution, and media filter drain field options are available.

I/A Technologies with Nitrogen Reduction Credit from Massachusetts DEP (2015)

A number of the technologies have received nitrogen reduction credit as part of their technology approvals:

General Use Certification

Recirculating Sand Filters - Generic (25 mg/L TN) up to 10,000 GPD
Ruck (19 mg/L TN) up to 2,000 GPD
MicroFAST (19 or 25 mg/L TN) up to 2,000 GPD - residential flows only

Provisional Use Approvals

Advantex
Amphidrome
Bioclere for flows less than 2,000 gpd*
FAST
Mod FAST
SeptiTech
Singular
Waterloo Biofilter
Nitrex

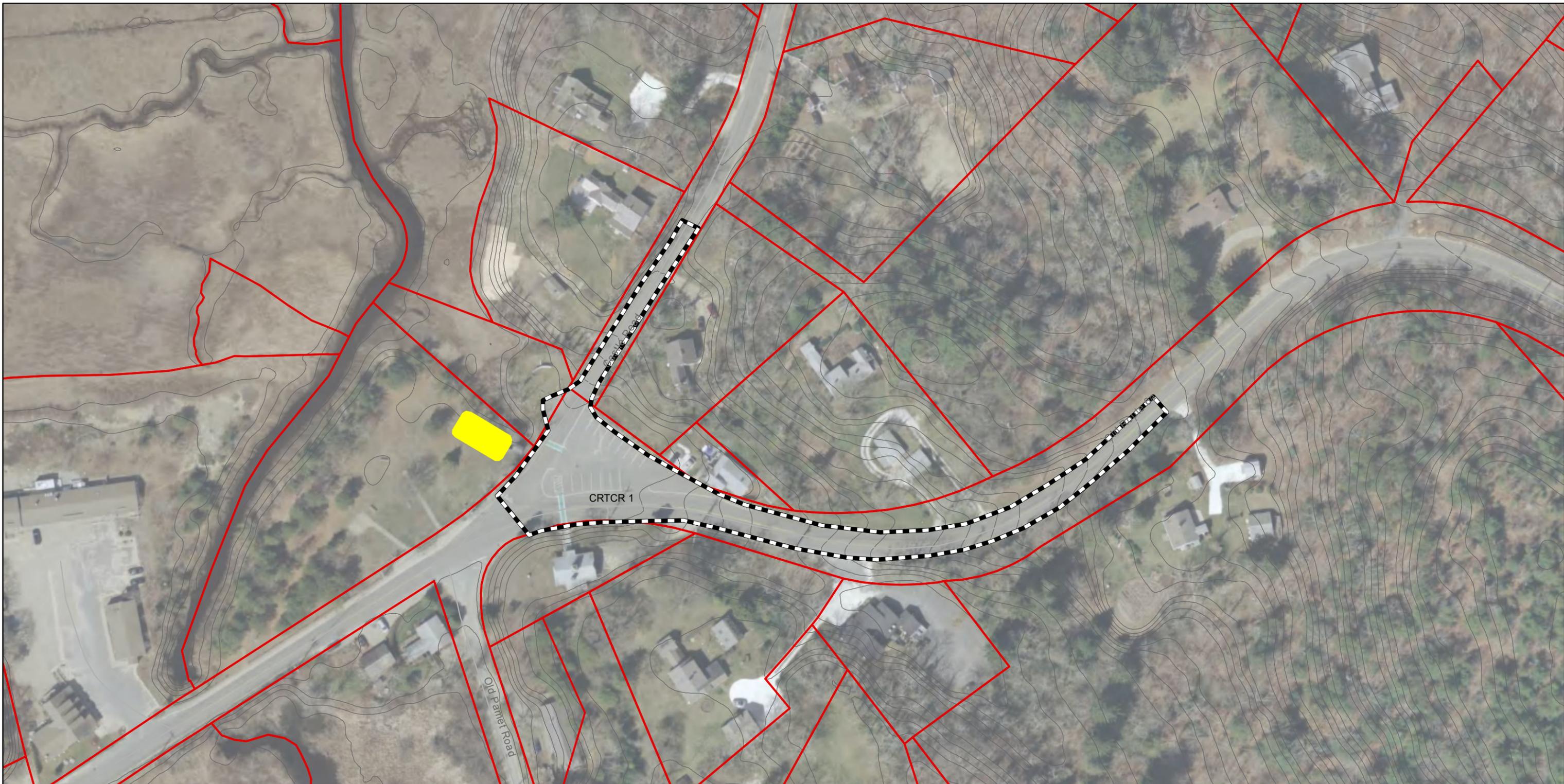
* Bioclere has reached limit for installed systems less than 2,000 gpd.

Piloting Use Approvals

Bio Barrier MBR WWT System
Nitrex Plus
OMNI-Cycle System
OMNI Recirculating Sand Filter System
RID Phosphorus Removal System
RUCK CFT

APPENDIX F

Sites Considered as Potential Locations for Stormwater Best Management Practices



CRTCR 1
 -Infiltration Basin with Soil Media Filter
 -Estimated Nitrogen Removal = 11.6 lbs/yr

Notes
 1. This potential BMP location needs to be investigated further for constructability, specifically the existing stormwater system in the area.
 2. A manhole is visible in the park area where the proposed BMP is shown. It may be possible to install a basin in this location depending on inlet and outlet pipe inverts.

Legend

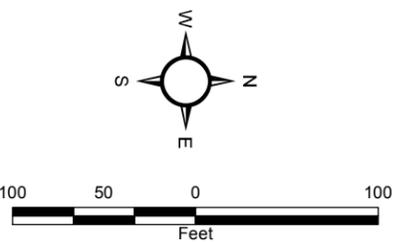
	Infiltration Swale w/ Soil Media Filter		Town Boundary
	Infiltration Basin w/ Soil Media Filter		Interstate
	Approximate Impervious Catchment Area		U.S. Highway
	2-Foot Contour		State Route
	Assessor's Parcels		Non-numbered Road

TRURO, MASSACHUSETTS
 INTEGRATED WATER RESOURCES
 MANAGEMENT PLAN

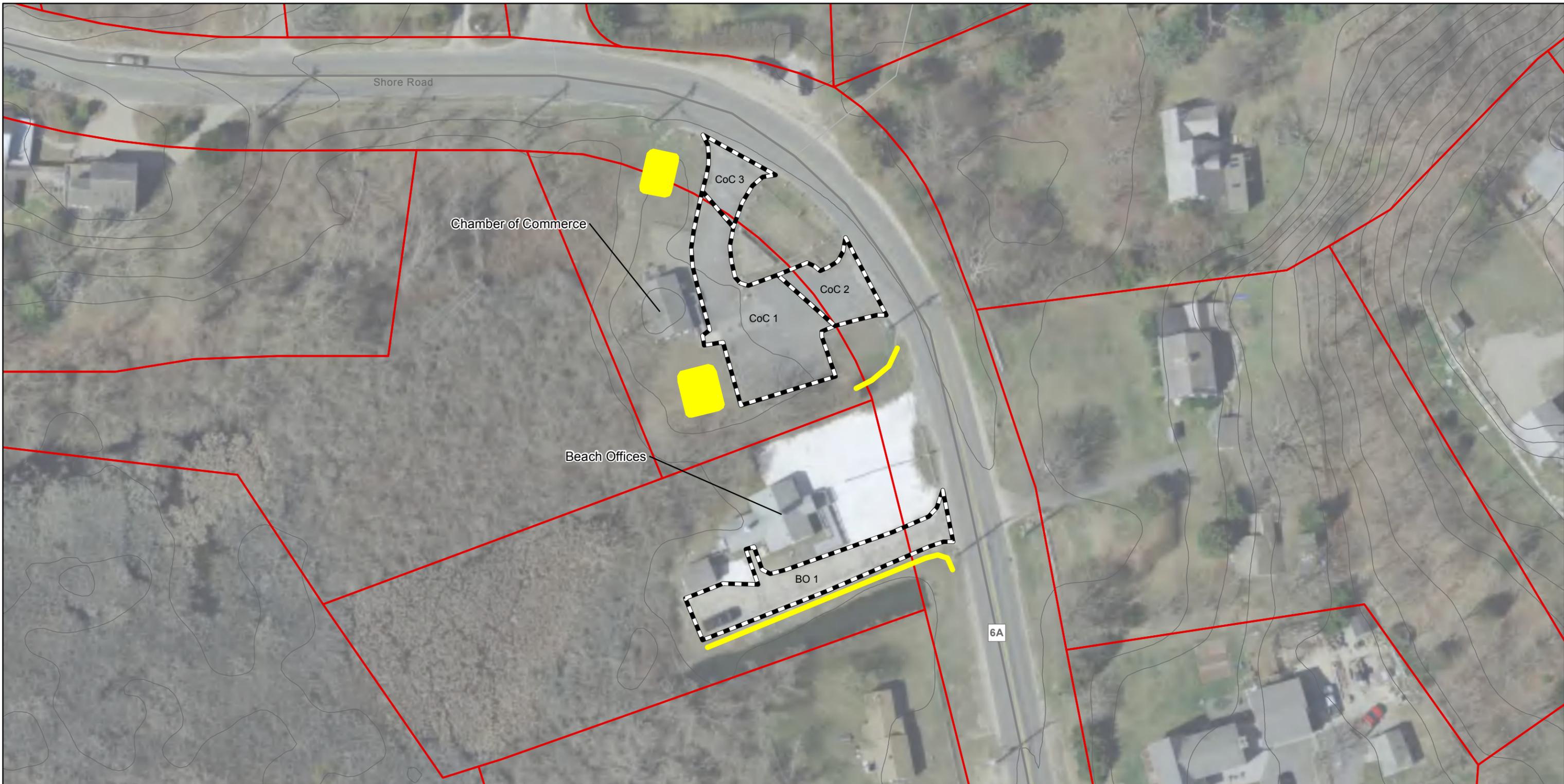
Potential BMP Locations
**Castle Road &
 Truro Center Road**

FEBRUARY 2016

Weston & Sampson



Data Source: Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs



<p>Catchment CoC 1 -Infiltration Basin with Soil Media Filter -Estimated Nitrogen Removal = 1.28 lbs/yr</p> <p>Catchment CoC 2 -Infiltration Swale with Soil Media Filter -Estimated Nitrogen Removal = 0.375 lbs/yr</p> <p>Catchment CoC 3 -Infiltration Basin with Soil Media Filter -Estimated Nitrogen Removal = 0.257 lbs/yr</p> <p>Catchment BO 1 -Infiltration Swale with Soil Media Filter -Estimated Nitrogen Removal = 0.855 lbs/yr</p>	<p>Notes 1. All four potential BMP locations need to be investigated further for constructability.</p>
---	--

Legend	
Infiltration Swale w/ Soil Media Filter	Town Boundary
Infiltration Basin w/ Soil Media Filter	Interstate
Approximate Impervious Catchment Area	U.S. Highway
2-Foot Contour	State Route
Assessor's Parcels	Non-numbered Road

TRURO, MASSACHUSETTS
 INTEGRATED WATER RESOURCES
 MANAGEMENT PLAN

**Potential BMP Locations
 Chamber of Commerce
 & Beach Offices**

FEBRUARY 2016

Weston & Sampson®

North arrow pointing North (N), South (S), East (E), and West (W).

Scale bar: 50, 25, 0, 50 Feet.

Data Source: Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs



CH 1

- Infiltration Swale with Soil Media Filter
- Estimated Nitrogen Removal = 28.0 lbs/yr

Notes

1. This potential BMP location needs to be investigated further for constructability, including parking lot grades.
2. The site may be in close proximity to dune habitat.

Legend

- Infiltration Swale w/ Soil Media Filter
- Infiltration Basin w/ Soil Media Filter
- Approximate Impervious Catchment Area
- 2-Foot Contour
- Assessor's Parcels
- Town Boundary
- Interstate
- U.S. Highway
- State Route
- Non-numbered Road

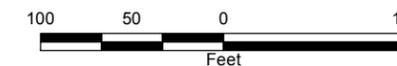
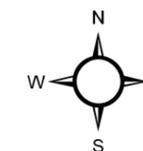
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES
MANAGEMENT PLAN

Potential BMP Locations

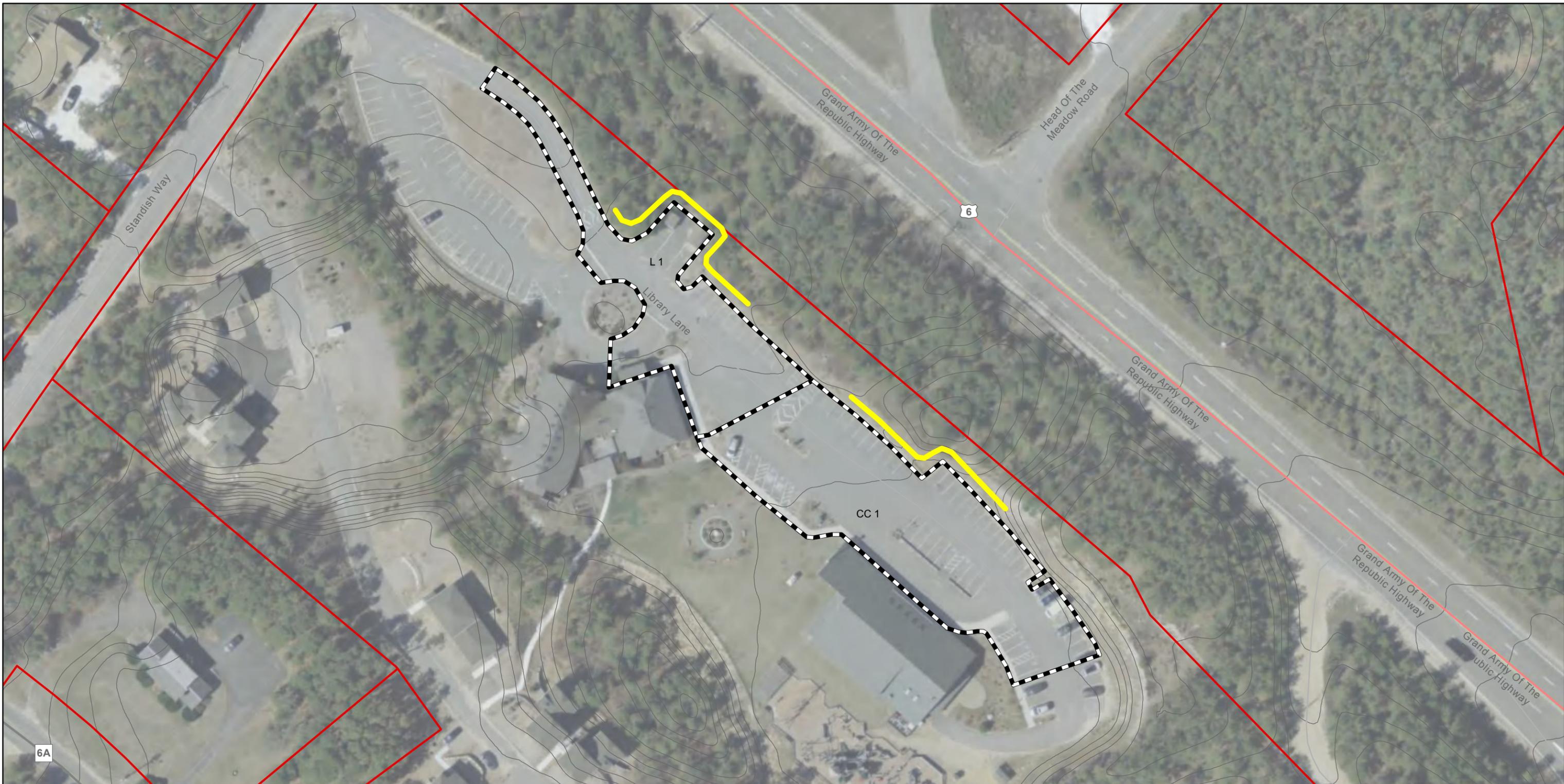
**Corn Hill Lane
Parking Lot**

FEBRUARY 2016

Weston & Sampson



Data Source: Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs



L 1

- Infiltration Swale with Soil Media Filter
- Estimated Nitrogen Removal = 5.43 lbs/yr

CC 1

- Infiltration Swale with Soil Media Filter
- Estimated Nitrogen Removal = 8.67 lbs/yr

Notes

- Both potential BMP locations need to be investigated further for constructability, specifically parking lot grades and existing stormwater systems.
- Some vegetation removal may be required.

Legend

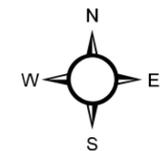
- Infiltration Swale w/ Soil Media Filter
- Infiltration Basin w/ Soil Media Filter
- Approximate Impervious Catchment Area
- 2-Foot Contour
- Assessor's Parcels
- Town Boundary
- Interstate
- U.S. Highway
- State Route
- Non-numbered Road

TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES
MANAGEMENT PLAN

Potential BMP Locations
Library & Community Center

FEBRUARY 2016

Weston & Sampson



Data Source: Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs



TH 1

- Infiltration Swale with Soil Media Filter
- Estimated Nitrogen Removal = 1.10 lbs/yr

TH 2

- Infiltration Swale with Soil Media Filter
- Estimated Nitrogen Removal = 3.72 lbs/yr

Notes

- Both potential BMP locations need to be investigated further for constructability.
- There appears to be an existing stormwater system on site, needs further investigation.

Legend

- Infiltration Swale w/ Soil Media Filter
- Infiltration Basin w/ Soil Media Filter
- Approximate Impervious Catchment Area
- 2-Foot Contour
- Assessor's Parcels
- Town Boundary
- Interstate
- U.S. Highway
- State Route
- Non-numbered Road

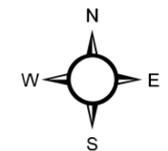
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES
MANAGEMENT PLAN

Potential BMP Locations

**Town Hall
& DPW**

FEBRUARY 2016

Weston & Sampson



Data Source: Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs

APPENDIX G

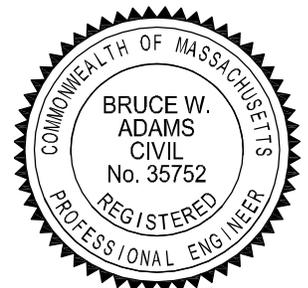
Plans and Specifications for a Stormwater Quality Demonstration Project

Site Work Technical Specifications

Stormwater Demonstration Project

Town of Truro, MA

August 4, 2016



Bruce W. Adams

8/4/2016

Weston & Sampson

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Peabody, MA 01960-7985

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TABLE OF CONTENTS

<u>Division</u>	Section Number
2 SITE WORK	
Clearing and Grubbing	02230
Earthwork	02300
Riprap	02371
Polyethylene Drainage Pipe (Perforated)	02622
Bioretention Rain Garden	02932
Planting	02950

END OF SECTION

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SECTION 02230

CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. The Contractor shall do all required clearing and grubbing as indicated on the drawings or herein specified in the area required for construction operations on the Owner's land or in the Owner's permanent or temporary easements and shall remove all debris resulting therefrom.
- B. Unless otherwise noted, all areas to be cleared shall also be grubbed.
- C. The Contractor shall not clear and grub outside of the area required for construction operations.

1.02 RELATED WORK:

Any trees and shrubs specifically designated by the Owner not to be cut, removed, destroyed, or trimmed shall be saved from harm and injury in accordance with Section 01570 - ENVIRONMENTAL PROTECTION.

PART 2 - PRODUCTS: NOT APPLICABLE

PART 3 - EXECUTION

3.01 RIGHT TO WOOD AND LOGS:

The Owner shall have the right to cut and remove logs and other wood of value in advance of the Contractor's operations. All remaining logs and other wood to be removed in the course of clearing shall become the property of the Contractor.

3.02 CLEARING:

- A. Unless otherwise indicated, the Contractor shall cut or otherwise remove all trees, saplings, brush and vines, windfalls, logs and trees lying on the ground, dead trees and stubs more than 1-foot high above the ground surface, trees which have been partially uprooted by natural or other causes (including their stumps), and other vegetable matter such as shags, sawdust, bark, refuse, and similar materials.
- B. Except where clearing is done by uprooting with machinery or where stumps are left longer to facilitate subsequent grubbing operations, trees, stumps, and stubs to be cleared shall be cut as close to the ground as practicable but not more than 6-inches above the ground

surface in the case of small trees, and 12-inches in the case of large trees. Saplings, brush and vines shall be cut close to the ground.

3.03 GRUBBING:

- A. Unless otherwise indicated, the Contractor shall completely remove all stumps and roots to a depth of 18-inches, or if the Contractor elects to grind the stumps, they shall be ground to a minimum depth of 6-inches.
- B. Any depression remaining from the removal of a stump and not filled in by backfilling shall be filled with structural fill and/or loam, whichever is appropriate to the proposed ground surface.

3.04 DISPOSAL:

All material collected in the course of the clearing and grubbing, which is not to remain, shall be disposed of in a satisfactory manner away from the site or as otherwise approved. Such disposal shall be carried on as promptly as possible and shall not be left until the final clean-up period.

END OF SECTION

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SECTION 02300

EARTHWORK

PART 1 - GENERAL

1.01 WORK INCLUDED:

The Contractor shall make excavations of normal depth in earth for trenches and structures, shall backfill and compact such excavations to the extent necessary, shall furnish the necessary material and construct embankments and fills, and shall make miscellaneous earth excavations and do miscellaneous grading.

1.02 RELATED WORK:

- A. Section 02230, CLEARING AND GRUBBING
- B. Section 02932, BIORETENTION RAIN GARDEN

1.03 REFERENCES:

American Society for Testing and Materials (ASTM)

ASTM	C131	Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
ASTM	C136	Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM	C330	Specification for Lightweight Aggregate for Structural Concrete.
ASTM	D1556	Test Method for Density of Soil in Place by the Sand Cone Method.
ASTM	D1557	Test Methods for Moisture-density Relations of Soils and Soil Aggregate Mixtures Using Ten-pound (10 Lb.) Hammer and Eighteen-inch (18") Drop.
ASTM	D2922	Test Methods for Density of Soil and Soil-aggregate in Place by Nuclear Methods (Shallow Depth).

Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges.

Code of Massachusetts Regulations (CMR) 310.40.0032 Contaminated Media and Contaminated Debris

Code of Massachusetts Regulations (CMR) 520 CMR 14.00 Excavation & Trench Safety Regulation

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

Samples of all materials proposed for the project shall be submitted to the Engineer for review. Size of the samples shall be as approved by the Engineer.

1.05 PROTECTION OF EXISTING PROPERTY:

- A. The work shall be executed in such manner as to prevent any damage to facilities at the site and adjacent property and existing improvements, such as but not limited to streets, curbs, paving, service utility lines, structures, monuments, bench marks, observation wells, and other public or private property. Protect existing improvements from damage caused by settlement, lateral movements, undermining, washout and other hazards created by earthwork operations.
- B. In case of any damage or injury caused in the performance of the work, the Contractor shall, at its own expense, make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing roads, sidewalks, and curbs damaged during the project work shall be repaired or replaced to at least the condition that existed at the start of operations. The Contractor shall replace, at his own cost, existing benchmarks, observation wells, monuments, and other reference points, which are disturbed or destroyed.
- C. Buried drainage structures and pipes, observation wells and piezometers, including those which project less than eighteen inches (18") above grade, which are subject to damage from construction equipment shall be clearly marked to indicate the hazard. Markers shall indicate limits of danger areas, by means which will be clearly visible to operators of trucks and other construction equipment, and shall be maintained at all times until completion of project.

1.06 DRAINAGE:

- A. The Contractor shall provide, at its own expense, adequate drainage facilities to complete all work items in an acceptable manner. Drainage shall be done in a manner so that runoff will not adversely affect construction procedures or cause excessive disturbance of underlying natural ground or abutting properties.

1.07 FROST PROTECTION AND SNOW REMOVAL:

- A. The Contractor shall, at its own expense, keep earthwork operations clear and free of accumulations of snow as required to carry out the work.
- B. The Contractor shall protect the subgrade beneath new structures and pipes from frost penetration when freezing temperatures are expected.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. GRAVEL BORROW:

Gravel Borrow shall satisfy the requirements listed in MassDOT Specification Section M1.03.0, Type b.

B. CRUSHED STONE:

Crushed stone shall satisfy the requirements listed in MassDOT Specification Section M2.01.

C. SAND BORROW:

Sand Borrow shall satisfy the requirements listed in MassDOT Specification Section M1.04.0.

D. PEASTONE:

Peastone shall be smooth, hard, naturally occurring, rounded stone meeting the following gradation requirements:

Passing 5/8 inch square sieve opening	-	100%
Passing No. 8 sieve opening	-	0%

E. BACKFILL MATERIALS:

1. Class B Backfill:

Class B backfill shall be granular, well graded friable soil; free of rubbish, ice, snow, tree stumps, roots, clay and organic matter; with 30 percent or less passing the No. 200 sieve; no stone greater than two-third (2/3) loose lift thickness, or six inches, whichever is smaller.

2. Select Backfill:

Select backfill shall be granular, well graded friable soil, free of rubbish, ice, snow, tree stumps, roots, clay and organic matter, and other deleterious or organic material; graded within the following limits:

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>
3-inch	100
No. 10	30-95
No. 40	10-70
No. 200	0-10

PART 3 - EXECUTION

3.01 DISTURBANCE OF EXCAVATED AND FILLED AREAS DURING CONSTRUCTION:

- A. Contractor shall take the necessary steps to avoid disturbance of subgrade during excavation and filling operations, including restricting the use of certain types of construction equipment and their movement over sensitive or unstable materials, dewatering and other acceptable control measures.
- B. All excavated or filled areas disturbed during construction, all loose or saturated soil, and other areas that will not meet compaction requirements as specified herein shall be removed and replaced with a minimum 12-inch layer of compacted crushed stone wrapped all around in non-woven filter fabric. Costs of removal and replacement shall be borne by the Contractor.
- C. The Contractor shall place a minimum of 12-inch layer of special bedding materials and crushed stone wrapped in filter fabric over the natural underlying soil to stabilize areas which may become disturbed as a result of rain, surface water runoff or groundwater seepage pressures, all at no additional cost to the Owner. The Contractor also has the option of drying materials in-place and compacting to specified densities.

3.02 EXCAVATION:

A. GENERAL:

- 1. The Contractor shall perform all work of any nature and description required to accomplish the work as shown on the Drawings and as specified.
- 2. Excavations, unless otherwise required by the Engineer, shall be carried only to the depths and limits shown on the Drawings. If unauthorized excavation is carried out below required subgrade and/or beyond minimum lateral limits shown on Drawings, it shall be backfilled with gravel borrow and compacted at the Contractor's expense as specified below, except as otherwise indicated. Excavations shall be kept in dry and good conditions at all times, and all voids shall be filled to the satisfaction of the Engineer.
- 3. In all excavation areas, the Contractor shall strip the surficial topsoil layer and underlying subsoil layer separate from underlying soils. In paved areas, the Contractor shall first cut pavement as specified in paragraph 3.02 B.1 of this specification, strip pavement and pavement subbase separately from underlying soils. All excavated materials shall be stockpiled separately from each other within the limits of work.
- 4. The Contractor shall follow a construction procedure, which permits visual identification of stable natural ground. Where groundwater is encountered, the size of the open excavation shall be limited to that which can be handled by the

Contractor's chosen method of dewatering and which will allow visual observation of the bottom and backfill in the dry.

5. The Contractor shall excavate unsuitable materials to stable natural ground where encountered at proposed excavation subgrade, as required by the Engineer. Unsuitable material includes topsoil, loam, peat, other organic materials, snow, ice, and trash. Unless specified elsewhere or otherwise required by the Engineer, areas where unsuitable materials have been excavated to stable ground shall be backfilled with compacted special bedding materials or crushed stone wrapped all around in non-woven filter fabric.

B. TRENCHES:

1. Prior to excavation, trenches in pavement shall have the traveled way surface cut in a straight line by a concrete saw or equivalent method, to the full depth of pavement. Excavation shall only be between these cuts. Excavation support shall be provided as required to avoid undermining of pavement. Cutting operations shall not be done by ripping equipment.
2. The Contractor shall satisfy all dewatering requirements specified in Section 02240 DEWATERING, before performing trench excavations.
3. Trenches shall be excavated to such depths as will permit the pipe to be laid at the elevations, slopes, and depths of cover indicated on the Drawings. Trench widths shall be as shown on the Drawings or as specified.
4. Where pipe is to be laid in bedding material, the trench may be excavated by machinery to, or just below, the designated subgrade provided that the material remaining in the bottom of the trench is not disturbed.
5. If pipe is to be laid in embankments or other recently filled areas, the fill material shall first be placed to a height of at least 12-inches above the top of the pipe before excavation.
6. Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed.
7. If, in the opinion of the Engineer, the subgrade, during trench excavation, has been disturbed as a result of rain, surface water runoff or groundwater seepage pressures, the Contractor shall remove such disturbed subgrade to a minimum of 12-inches and replace with crushed stone wrapped in filter fabric. Cost of removal and replacement shall be borne by the Contractor.
8. The Contractor shall obtain a trench permit from the municipality where the trench is located prior to making any excavations of trenches (any subsurface excavation

greater than three (3) feet in depth and fifteen (15) feet or less between soil walls as measured from the bottom).

9. All trenches required to be permitted must be attended, covered, barricaded, or backfilled. Covers must be road plates at least ¾-inch thick or equivalent, barricades must be fences at least 6-feet high with no openings greater than 4-inches between vertical supports and all horizontal supports required to be located on the trench-side of the fencing.

C. BUILDING AND FOUNDATION EXCAVATION:

1. Excavations shall not be wider than required to set, brace, and remove forms for concrete, or perform other necessary work.
2. After the excavation has been made, and before forms are set for footings, mats, slabs, or other structures, and before reinforcing is placed, all loose or disturbed material shall be removed from the subgrade. The bearing surface shall then be compacted to meet the requirements of this specification.
3. If, in the opinion of the Engineer, the existing material at subgrade elevation is unsuitable for structural support, the Contractor shall excavate and dispose of the unsuitable material to the required width and depth as required by the Engineer. If, in the opinion of the Engineer, filter fabric is required; the Contractor shall place filter fabric, approved by the Engineer, as per manufacturer's recommendations. Crushed stone shall then be placed in lifts and compacted to required densities. Backfill shall be placed to the bottom of the proposed excavation.

D. EXCAVATION NEAR EXISTING STRUCTURES:

1. Attention is directed to the fact that there are pipes, manholes, drains, and other utilities in certain locations. An attempt has been made to locate all utilities on the drawings, but the completeness or accuracy of the given information is not guaranteed.
2. As the excavation approaches pipes, conduits, or other underground structures, digging by machinery shall be discontinued and excavation shall be done by means of hand tools, as required. Such manual excavation, when incidental to normal excavation, shall be included in the work to be done under items involving normal excavation.
3. Where determination of the exact location of a pipe or other underground structure is necessary for properly performing the work, the Contractor shall excavate test pits to determine the locations.

3.03 BACKFILL PLACEMENT AND COMPACTION:

A. GENERAL:

1. Prior to backfilling, the Contractor shall compact the exposed natural subgrade to the densities as specified herein.
2. After approval of subgrade by the Engineer, the Contractor shall backfill areas to required contours and elevations with specified materials.
3. The Contractor shall place and compact materials to the specified density in continuous horizontal layers, not to exceed nine (9) inches in uncompacted lifts. The degree of compaction shall be based on maximum dry density as determined by ASTM Test D1557, Method C. The minimum degree of compaction for fill placed shall be as follows:

<u>Location</u>	<u>Percent of Maximum Density</u>
Below pipe centerline	95
Above pipe centerline	92
Below pavement (upper 3 ft.)	95
Embankments	95
Below pipe in embankments	95
Adjacent to structures	92
Below structures	95

4. The Engineer reserves the right to test backfill for conformance to the specifications and Contractor shall assist as required to obtain the information. Compaction testing will be performed by the Engineer or by an inspection laboratory designated by the Engineer, engaged and paid for by the Owner. If test results indicate work does not conform to specification requirements, the Contractor shall remove or correct the defective Work by recompacting where appropriate or replacing as necessary and approved by the Engineer, to bring the work into compliance, at no additional cost to the Owner. All backfilled materials under structures and buildings shall be field tested for compliance with the requirements of this specification.
5. Where horizontal layers meet a rising slope, the Contractor shall key each layer by benching into the slope.
6. If the material removed from the excavation is suitable for backfill with the exception that it contains stones larger than permitted, the Contractor has the option to remove the oversized stones and use the material for backfill or to provide replacement backfill at no additional cost to the Owner.

7. The Contractor shall remove loam and topsoil, loose vegetation, stumps, large roots, etc., from areas upon which embankments will be built or areas where material will be placed for grading. The subgrade shall be shaped as indicated on the Drawings and shall be prepared by forking, furrowing, or plowing so that the first layer of the fill material placed on the subgrade will be well bonded to the subgrade.
8. Where called for on the Drawings, Lightweight Fill shall be placed and compacted as recommended by the manufacturer. The exact number of passes shall be approved by the Engineer to insure stability of the layer. As soon as the compaction of each layer has been completed, the next layer shall then be placed. The Contractor shall take all necessary precautions during construction activities in operations on or adjacent to the Lightweight Fill to insure that the material is not over-compacted. Construction equipment, other than for compaction, shall not operate on the exposed Lightweight Fill. The top surface of the Lightweight Fill lying directly below the gravel course shall be chinked by additional rolling of the Lightweight Fill to prevent infiltration of fines.

B. TRENCHES:

1. Bedding as detailed and specified shall be furnished and installed beneath the pipeline prior to placement of the pipeline. A minimum bedding thickness shall be maintained between the pipe and undisturbed material, as shown on the Drawings.
2. As soon as practicable after pipes have been laid, backfilling shall be started.
3. Unless otherwise indicated on the Drawings, select backfill shall be placed by hand shovel in 6-inch thick lifts up to a minimum level of 12-inches above the top of pipe. This area of backfill is considered the zone around the pipe and shall be thoroughly compacted before the remainder of the trench is backfilled. Compaction of each lift in the zone around the pipe shall be done by use of power-driven tampers weighing at least 20 pounds or by vibratory compactors. Care shall be taken that material close to the bank, as well as in all other portions of the trench, is thoroughly compacted to densities required.
4. Class B backfill shall be placed from the top of the select backfill to the specified material at grade (loam, pavement subbase, etc.). Fill compaction shall meet the density requirements of this specification.
5. Water Jetting:
 - a. Water jetting may be used when the backfill material contains less than 10 percent passing the number 200 sieve, but shall be used only if approved by the Engineer.

- b. Contractor shall submit a detailed plan describing the procedures he intends to use for water jetting to the Engineer for approval prior to any water jetting taking place.
 - c. Compaction of backfill placed by water jetting shall conform to the requirements of this specification.
6. If the materials above the trench bottom are unsuitable for backfill, the Contractor shall furnish and place backfill materials meeting the requirements for trench backfill, as shown on the drawings or specified herein.
 7. Should the Engineer order crushed stone for utility supports or for other purposes, the Contractor shall furnish and install the crushed stone as directed.
 8. In shoulders of streets and road, the top 12-inch layer of trench backfill shall consist of processed gravel for sub-base, satisfying the requirements listed in MassDOT standard specification M1.03.1.

C. BACKFILLING UNDER BUILDINGS AND FOUNDATIONS:

Material to be used as structural fill under structures shall be special bedding material or gravel borrow, as shown on the Drawings or as required by the Engineer. Where gravel borrow fill is required to support proposed footings, walls, slabs, and other structures, the material shall be placed in a manner accepted by the Engineer. Compaction of each lift shall meet the density requirements of this specification.

D. BACKFILLING ADJACENT TO STRUCTURES:

1. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads to which they will be subjected. Excavated material approved by the Engineer may be used in backfilling around structures. Backfill material shall be thoroughly compacted to meet the requirements of this specification.
2. Contractor shall use extra care when compacting adjacent to pipes and drainage structures. Backfill and compaction shall proceed along sides of drainage structures so that the difference in top of fill level on any side of the structure shall not exceed two feet (2') at any stage of construction.
3. Where backfill is to be placed on only one side of a structural wall, only hand-operated roller or plate compactors shall be used within a lateral distance of five feet (5') of the wall for walls less than fifteen feet (15') high and within ten feet (10') of the wall for walls more than fifteen feet (15') high.

3.04 DISPOSAL OF SURPLUS MATERIALS:

- A. Surplus excavated materials, which are acceptable to the Engineer, shall be used to backfill normal excavations in rock or to replace other materials unacceptable for use as backfill. Upon written approval of the Engineer, surplus excavated materials shall be neatly deposited and graded so as to make or widen fills, flatten side slopes, or fill depressions; or shall be neatly deposited for other purposes as indicated by the Owner, within its jurisdictional limits; all at no additional cost to the Owner.
- B. Surplus excavated material not needed as specified above shall be hauled away and disposed of by the Contractor at no additional cost to the Owner, at appropriate locations, and in accordance with arrangements made by him. Disposal of all rubble shall be in accordance with all applicable local, state and federal regulations.
- C. No excavated material shall be removed from the site of the work or disposed of by the Contractor unless approved by the Engineer.
- D. The Contractor shall comply with Massachusetts regulations (310 CMR 40.0032) that govern the removal and disposal of surplus excavated materials. Materials, including contaminated soils, having concentrations of oil or hazardous materials less than an otherwise Reportable Concentration and that are not a hazardous waste, may not be disposed of at locations where concentrations of oil and/or hazardous material at the receiving site are significantly lower than the levels of those oil and /or hazardous materials present in the soil being disposed or reused.

END OF SECTION

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SECTION 02371

RIPRAP

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. This Section covers riprap for slope protection, drainage swales and pipe ends, complete.
- B. Grading and compaction of earth slopes and other slope preparation for the riprap are included under other sections of the specification.

1.02 RELATED WORK:

- A. Section 02300, EARTHWORK.

1.03 REFERENCES:

- A. The following standard forms a part of these specifications and indicates minimum standards required:

Massachusetts Department of Transportation (MassDOT) Standard Specifications for
Highways and Bridges.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. SLOPE PROTECTION:

Stone for slope protection shall be angular and shall be in accordance with MassDOT Specification Section M2.02.2 - Dumped Riprap.

B. PIPE ENDS:

Stone for pipe ends shall be angular and shall be in accordance with MassDOT Specification Section M2.02.3 - Stone for Pipe Ends.

C. DRAINAGE SWALES:

Stone for drainage swale ends shall conform to MassDOT Specification Section M2.02.3, and shall be not weigh less than 50 pounds or more than 125 pounds and least 75% of the volume shall consist of stones not less than 75 pounds each. The stones shall be so graded that when placed with larger stones, the entire mass will be compact.

D. GEOTEXTILE FABRIC:

Geotextile fabric shall be Erosion Control Fabric "A" as specified in Section 02071 - GEOTEXTILE FABRICS.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Geotextile fabric shall be installed where shown on the drawings, prior to placing the riprap.
- B. Riprap for slope protection and pipe ends shall be placed on the prepared slope or area in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids and a maximum void of 12-inches.
- C. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers or by dumping into chutes or by other similar methods likely to cause segregation will not be permitted.
- D. Riprap stones shall be placed and distributed such that there will be no large accumulation of either the larger or smaller stones in any given area.
- E. It is the intent of these specifications to produce compact riprap protection in which all required sizes of stone are placed in the proper proportions. Hand placing or rearranging of individual stones by mechanical equipment shall be utilized to the extent necessary to secure the desired results.

END OF SECTION

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SECTION 02622

POLYETHYLENE DRAINAGE PIPE
(Perforated)

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section includes furnishing all material, labor and equipment and installing polyethylene drainage pipe and fittings with synthetic protective wrap, as shown on the drawings and as specified herein.

1.02 RELATED WORK:

- A. Section 02300, EARTHWORK

1.03 REFERENCES:

- A. The following standards form a part of these specifications as referenced:

American Society for Testing and Materials (ASTM)

ASTM	D 1557	Standard Test Methods for Moisture-Density Relations of Soils and Soil - Aggregate Mixtures Using 10-lb. Rammer and 18-inch Drop.
ASTM	D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
ASTM	F405	Standard Specification for Corrugated Polyethylene Pipe and Fittings.
ASTM	F667	Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

American Association of State Highway and Transportation Officials (AASHTO).

AASHTO M252 Corrugated Polyethylene Drainage Tubing.

AASHTO M294 Corrugated Polyethylene Pipe, 12 to 36 inch diameter.

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

- A. Six sets of manufacturer's literature on the materials of this Section shall be submitted to the Engineer for review.
- B. Manufacturer's certification that the product was manufactured, tested, and supplied in accordance with this specification shall be furnished to the Engineer on request.

1.05 DELIVERY, STORAGE AND HANDLING:

Pipe shall be packaged to withstand shipment without damage and handled carefully on arrival at job site. Pipe shall be stored so that it is not exposed to sunlight.

PART 2 - PRODUCTS

2.01 GENERAL

- A. This Section applies to high density polyethylene corrugated pipe with an integrally formed smooth interior. It is applicable to nominal sizes 4- through 36-inch diameter.
- B. The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe.
- C. The pipe and fittings shall be free of foreign inclusions and visible defects. Fittings may be either molded or fabricated. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the Engineer. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining.
- D. When perforated pipe is specified, the perforations shall be cleanly cut so as not to restrict the inflow/outflow of water and uniformly spaced along the length and circumference of the pipe. Dimensions of the perforations shall be as stated in AASHTO M252.
- E. Joints shall be made with split couplings, corrugated to engage the pipe corrugations, and shall engage a minimum of 4 corrugations, 2 on each side of the pipe joint. Where required by the Engineer, a neoprene gasket shall be utilized with the coupling to provide a soil-tight joint.
- F. Pipe sizes 4- through 10-inches shall conform to AASHTO M252. Pipe sizes 12- through 36-inches shall conform to AASHTO M294.
- G. Pipe sizes 4- through 6-inches shall conform to ASTM F405. Pipe sizes 8- through 15-inches shall conform to ASTM F667.

2.02 SYNTHETIC PROTECTIVE WRAP:

- A. Provide a synthetic protective piping wrap that will admit fine silt and clay and retain sands and coarse silts.
- B. The synthetic protective wrap shall have the following characteristics:
 - 1. Non-toxic, non-irritating.
 - 2. Inert in soil.
 - 3. Non-biodegradable.
 - 4. Resist alkalis and acids.
 - 5. Not affected by freezing or thawing.
 - 6. Air permeability shall be a minimum of 500 cubic feet per minute per square foot.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. The pipe shall be installed as shown on the drawings and in accordance with the requirements of ASTM D2321.
- B. Installation of pipe and protective wrap shall be per the manufacturer's recommendations as approved by the Engineer.
- C. If protective wrap is not scheduled for immediate installation, the Contractor shall protect the pipe from sunlight ultra violet rays.
- D. Material for pipe support is specified under Section 02300 - EARTHWORK.
- E. Backfill shall be as shown on plans and specified in Section 02300.
- F. Backfill material shall be compacted to 95 percent of maximum density according to ASTM D 1557.

END OF SECTION

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SECTION 02932

BIORETENTION SOIL MIX FOR RAIN GARDENS

PART 1 – GENERAL

1.01 WORK INCLUDED:

- A. This section covers furnishing all materials, labor and equipment to construct individual rain gardens (bio-retention cells) as shown on the plans or as directed by the Engineer.

1.02 RELATED WORK:

- A. Section 02230, CLEARING AND GRUBBING
- B. Section 02300, EARTHWORK
- C. Section 02630, DRAINAGE PIPE (PERFORATED)
- D. Section 02950, PLANTING

1.1 SUMMARY

- A. This Section includes excavations of normal depth in earth; backfilling such excavations to the extent required; dewatering and control of groundwater and surface water; filling; rough grading; constructing embankments; miscellaneous earth excavation; the removal, hauling, and stockpiling of suitable excavated material for subsequent use in the work; all re-handling, hauling, and placing of stockpiled materials for use in refilling, filling, backfilling, grading, and such other operations; the excavation, removal, and stockpiling on-site; excavation and relocation of solid waste; compaction and testing of capping materials; and appurtenant work, complete, in accordance with the Drawings and Specifications, and as directed by Engineer.

1.2 SUBMITTALS

General: Submit the following in accordance with Division 1 Specification Sections.

- A. Filter Fabric: Submit the manufacturer's information and specified test results, and a one (1) square foot representative sample of the 16 ounce filter fabric material to the Engineer for review.
- B. Within one (1) week of a field change, re-submit revised working drawings as necessary to reflect changes required by field conditions.

- C. Submit the qualifications of the independent geotechnical testing laboratory performing soil testing and inspection services during earthwork operations. The geotechnical testing laboratory must demonstrate to the Engineer's satisfaction, based on evaluation of laboratory submitted criteria conforming to ASTM D3740, that it has the experience and capability to conduct required field and laboratory geotechnical testing. In addition, the laboratory shall be supervised by a geotechnical engineer who is a Registered Professional Engineer in the Commonwealth of Massachusetts.
- D. Submit the results of all geotechnical testing in accordance with the remainder of this section.
- E. Submit the methodology for handling and mixing the Bioretention Soil Mix

1.3 GROUNDWATER AND SURFACE RUNOFF CONTROL

- A. The Contractor shall provide, at his own expense, adequate pumping and drainage facilities to maintain the excavated area sufficiently dry from groundwater and/or surface runoff so as not to adversely affect construction procedures nor cause excessive disturbance of underlying natural ground. The drainage of all water resulting from pumping shall be managed so as not to cause damage to wetlands, the Site, or adjacent property. The groundwater collection system shall be designed to enable the sedimentation of fines, and discharge of water vertically within the groundwater retention area. The groundwater retention area shall be located within the limits of the geomembrane.
- B. Any damage resulting from the failure of dewatering operations of the Contractor, and any damage resulting from the failure of the Contractor to maintain all the areas of work in a suitable dry condition, shall be repaired by the Contractor, as directed by the Engineer, at no additional expense to the owner. The Contractor's pumping and dewatering operations shall be carried out in such a manner as to prevent damage to the Contract work and so that no loss of ground will result from these operations. Precautions shall be taken to protect new work from flooding during storms or from other causes. Pumping shall be continuous to protect the work and/or to maintain satisfactory progress.
- C. Water from the trenches, excavations and drainage operations shall be disposed of in such a manner as to avoid public nuisance, injury to public health or the environment, damage to public or private property, or damage to the work completed or in progress.
- D. The Contractor shall control the grading in the areas surrounding all excavations so that the surface of the ground will be properly sloped to prevent water from running into the excavated area. Where required, temporary ditches shall be provided for

drainage. Upon completion of the work and when directed, all areas shall be restored by the Contractor in a satisfactory manner and as directed.

PART 2 – MATERIALS

2.1 BACKFILL MATERIALS

- A. **Bioretention Soil Mix (BSM)** shall consist of a homogeneous mixture (by volume) of 50% Coarse Sand, 25% Topsoil, and 25% wood chips. The BSM shall be a uniform mix, free of stones, stumps, roots or deleterious materials. No other materials or substances shall be mixed with the BSM.

The BSM shall conform to the following:

Parameter	Limit	Test Method
pH	5.5 – 7.5	ASTM D4972
Magnesium	> 32 ppm	
Phosphorous (as Phosphate P ₂ O ₅)	< 69 ppm	
Potassium (K ₂ O)	> 78 ppm	
Soluble Salts	< 500 ppm	

- B. **Coarse Sand:** Coarse sand shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings or other deleterious material. Coarse sand shall conform to the following gradation:

SIEVE SIZE	NOMINAL PERCENT PASSING BY WEIGHT
½-inch	100
3/8-inch	100
No. 4	80-100
No. 16	50-85
No. 50	5-30
No. 100	0-10
No. 200	0-5

- C. **Common Fill:** Common fill shall be soil containing no stone greater than 2/3 loose lift thickness. The materials shall be free of trash, ice, snow, tree stumps, roots and other organic and deleterious materials. Common fill shall not contain more than 30 percent by weight of soil material passing the number 200 sieve. It shall be of such a nature and character that it can be compacted to the specified densities in a reasonable length of time. Topsoil and subsoil shall not be considered common fill.

Common fill used as general backfill, daily cover, or final cover shall have a maximum particle size of 3 inches. Nesting of larger particles within common fill layers shall be prevented.

- D. Woodchips shall be from hardwood trees and consist of 2-inch maximum particle size and provide a uniform texture free from sawdust, foreign materials, twigs, leaves and any artificially introduced chemical compounds. Wood chips shall have been stockpiled outside for at least six months prior to uses.
- E. Peastone: shall conform to the Massachusetts Highway Department's Material Specification M2.01.6.
- F. Crushed Stone: Crushed stone shall consist of hard durable crushed rock or durable crushed gravel stone, free from ice and snow, roots, sod, rubbish, and other deleterious or organic matter. Crushed stone shall be washed so it is free of any materials passing the No. 200 sieve.
 - 1. Crushed Stone: The material shall be used in locations specified in plans and details, and will conform to the following gradation requirements:

SIEVE SIZE	PERCENT FINER BY WEIGHT
5/8-inch	100
1/2-inch	85-100
3/8-inch	15-45
No. 4	0-15
No. 8	0-5

G. Filter Fabric: 16 ounce Filter Fabric shall consist of a non-woven fabric made from polypropylene or polyethylene filaments or yarns. The fabric shall be inert to organic chemicals commonly encountered in the soil. The fabric shall conform to the following:

PROPERTY	UNIT	TEST METHOD	MINIMUM VALUE
Weight	ounce/s.y.	ASTM D-3776-84	4.5
Grab Strength	lbs.	ASTM D-4632-86	120
Grab Elongation	percent	ASTM D-4632-86	55
Trapezoid Tear Strength	lbs.	ASTM D-4533-85	50
Mullen Burst Strength	psi	ASTM D-3786-80	210
Puncture Strength	lbs.	ASTM D-4833-88	70
Apparent Opening Size (AOS)	U.S. standard size sieve	ASTM D-4751-87	70

Edges of filter fabric shall overlap a minimum of one (1) foot.

H. Hardwood Mulch: shall consist of the wood from hardwood trees which has been milled and screened to a maximum 4 in. particle size and provide a uniform texture free from sawdust, foreign materials, and any artificially introduced chemical compounds that would be detrimental to plant or animal life.

I. Rip Rap for Rain Gardens: Stone for Rain Gardens shall be angular and shall be in accordance with MHD Specification Section M2.02.3, Stone for Pipe Ends.

PART 3 - EXECUTION

3.1 EXCAVATION

A. The Bioretention facility shall be excavated to the dimensions, side slopes and elevations shown on the Drawings. The method of excavation shall minimize compaction of the bottom of the bioretention facility. Equipment or workers shall not be allowed on the exposed bottom of the bioretention facility.

B. Immediately prior to placing the underdrain and the BSM, the bottom of the Bioretention facility shall be roto-tilled to depths between 3 and six inches

3.2 SOIL AMENDMENTS

- A. Should the pH fall outside the acceptable range, the Contractor may, upon approval of the Engineer, modify the BSM with lime (to raise) or iron sulfate plus sulfur (to lower). The lime or iron sulfate shall be mixed uniformly into the BSM prior to placement.
- B. Should the magnesium content of the BSM be lower than the specified amount, it may be modified with magnesium sulfate, which shall be mixed uniformly into the BSM prior to placement.
- C. Should the potassium content of the BSM be lower than the specified amount, it may be modified with potash, which shall be mixed uniformly into the BSM prior to placement.

3.2 FILLING AND BACKFILLING

- A. Stockpiles shall be neatly trimmed and graded to provide drainage from surfaces and to prevent depressions where water may become impounded. Stockpiles shall be protected and shall not be disturbed
- C. Backfill Material Selection: Unless otherwise specified or directed, material used for filling and backfilling shall meet the requirements specified under Section 02300 - EARTHWORK. In general, the material used for backfilling shall be material removed from the excavations, provided that the reuse of these materials meets the requirements of common fill.
- D. Bioretention Facility Backfilling: Skip items 1 through 5 for bioretention facilities without an underdrain.
 - 1. A (3) three-inch layer of crushed stone shall be placed on the bottom of the Bioretention Facility excavation.
 - 2. The 4-inch underdrain pipe and cleanout shall be placed on top of the crushed stone.
 - 3. A (6) six-inch layer of crushed stone shall be placed over the crushed stone bedding and underdrain pipe, resulting in a nine inch layer of crushed stone.
 - 4. A (3) three-inch layer of pea stone shall be placed over the crushed stone.
 - 5. A (1) one inch layer of coarse sand shall be placed over the crushed stone.
 - 6. The BSM shall be placed in horizontal twelve-inch loose lifts to the elevations shown on the drawings. The BSM shall be compacted by saturating the entire area of the bioretention facility after each lift of BSM is placed until water

flows from the underdrain. The water for saturation shall be applied by spraying or sprinkling. Saturation of each lift shall be performed in the presence of the Engineer.

7. If the BSM becomes contaminated during the construction of the bioretention facility, the contaminated BSM shall be removed and replaced at no additional cost to the Town.
 8. Final elevations of the BSM shall be performed after a 24-hour settling period. Final elevations shall be within two-inches of the elevations shown on the Drawings.
 9. Heavy equipment shall not be used within the perimeter of the bioretention facility before, during or after the placement of BSM.
 10. See Section 02950 - PLANTING for planting specifications. Once the plants are in place, the entire bioretention facility shall be mulched to a uniform thickness of 3 inches. Well aged (minimum age of 6 months) shredded hardwood bark mulch is the only acceptable mulch.
- F. After backfilling, the Contractor shall maintain the surfaces of backfill areas in good condition so as to present a smooth surface at all times level with adjacent surfaces. Any subsequent settling over backfilled areas shall be repaired by the Contractor immediately, in a manner satisfactory to the Engineer, and such maintenance shall be provided by the Contractor for the life of this Contract, at no additional expense to the Town.
- G. The finished subgrade of the fills and filled excavations upon which topsoil is to be placed, shall not be disturbed by traffic of other operations and shall be maintained in a satisfactory condition until the finished courses are placed. The storage or stockpiling of materials on finished subgrade will not be permitted.
- H. Uniformly smooth grading of all areas to be graded, as indicated and as directed, including excavated and filled sections, embankments and adjacent transition areas, and all areas disturbed as a result of the Contractor's operations, shall be accomplished. The finished surfaces shall be reasonably smooth, compacted and free from surface irregularities.

3.4 BIORETENTION SOIL MIX MANUFACTURE AND STOCKPILING

- A. The components for the Bioretention Soil Mixture (BSM) shall be stored and stockpiled at a location within the Project Area to be provided by the Town.

- B. Upon acceptance by the Engineer the BSM shall be manufactured in accordance to the procedure submitted and accepted by the Engineer.
- C. The BSM shall be stored in a designated stockpile at the site. Only BSM from this designated stockpile shall be used in the Bioretention Cells (Rain Gardens).

3.5 RIP RAP:

- A. Geotextile fabric shall be installed where shown under rip rap and as shown on the drawings, prior to placing the riprap.
- B. Riprap for slope protection and pipe ends shall be placed on the prepared slope or area in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids and a maximum void of 12 inches.
- C. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers or by dumping into chutes or by other similar methods likely to cause segregation will not be permitted.
- D. Riprap stones shall be placed and distributed such that there will be no large accumulation of either the larger or smaller stones in any given area.
- E. It is the intent of these specifications to produce compact riprap protection in which all required sizes of stone are placed in the proper proportions. Hand placing or rearranging of individual stones by mechanical equipment shall be utilized to the extent necessary to secure the desired results.
- F. All proposed riprap areas shall be a minimum 8" deep.

END OF SECTION

SECTION 02950

PLANTING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. Include GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS as part of this Section.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with trades affecting, or affected by, work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 WORK INCLUDED

- A. Perform all work required to complete the work of the Section, as indicated. Such work includes, but is not limited to, the following:
 - 1. Planting of trees, shrubs, vines and groundcovers
 - 2. Maintenance and guarantee

1.2 RELATED WORK UNDER OTHER SECTIONS

- A. EARTHWORK

1.3 QUALITY ASSURANCE

- A. All plant materials shall be true to name according to "Standardized Plant Names", published by the American Joint Committee on Horticulture Nomenclature, 1942 edition. Each plant or bundle shall be tagged with the name and size of plants in accordance with the standards of the American Association of Nurserymen (AAN). In all cases, botanical names shall take precedence over common names.
- B. Quality and size shall conform to the current edition of "Horticultural Standards" for number one grade nursery stock as adopted by the AAN.
- C. All plants and plant materials shall comply with all Federal, State and local laws and regulations requiring inspection for plant disease and insect control.

1.4 SUBMITTALS

- A. Submit a complete list of all materials proposed for use in this work, demonstrating complete conformance with the requirements specified. Submissions must include:
1. Soil analysis results for review by the Landscape Architect.
 2. List of plant nurseries to the Landscape Architect for approval of selected plant material species.
 3. Manufacturer's certificate of compliance for controlled release fertilizer issued by the manufacturer only, showing quantity of material ordered and specific job application.
 4. For all plant materials not selected in the field by the Landscape Architect, submit a complete list showing each type, each source of materials, and the measured size of each.

1.5 PRODUCT HANDLING

- A. Delivery and Storage:
1. Deliver all items to the job site in their original containers with all labels intact and legible at time of Owner's Representative inspection.
 2. Immediately remove from the site all plants which are not true to name, and all materials which do not comply with the specified requirements.
 3. Use all means necessary to protect plant materials before, during, and after installation and to protect the work and materials of all other trades.
 4. Replacements: in the event of damage, immediately make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

1.6 JOB CONDITIONS

- A. Utilities: Determine location of underground utilities and perform work in a manner which will avoid possible damage. Hand excavate as required. Maintain grade stakes set by others until removal is mutually agreed upon by all parties concerned.
- B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Landscape Architect before planting.

PART 2 - PRODUCTS

2.2 GENERAL

- A. Loam - friable, typical of local cultivated topsoil containing 5% (min.) decayed organic matter (humus), no toxic materials, from well drained, arable site, reasonably free of subsoil, stones, earth, clods, sticks, roots or debris.
 - 1. Test for acidity, fertility and general texture by a recognized commercial or government agency. Report findings and recommendations to the Landscape Architect. Add soil conditioners as per testing agency's report and recommendations.
 - 2. Deliver no topsoil in frozen or muddy condition.
- B. Superphosphate - finely ground phosphate rock with eighteen percent (18%) minimum available phosphoric acid.
- C. Bone Meal - commercial raw bone meal, finely ground, 1% nitrogen and 18% phosphorus acid (min.).
- D. Manure - well rotted, unleached, cattle manure, reasonably free of wood shavings, sawdust or other litter and no chemicals or other ingredients harmful to plants. Dehydrated manure (Bovung or equal) is acceptable.
- E. Fertilizer - All plants will be fertilized with a controlled release 16-8-16 analysis fertilizer contained in polyethylene perforated bags with micropore holes. The bag shall contain 4 ounces minimum of water soluble fertilizer to be effective for 8 years. Pills, spikes, tablets and injections are not considered controlled release packets.
 - 1. Deliver as specified in standard containers, showing weight, analysis and manufacturer. Store in a weather-proof place.
- F. Peat - domestic or imported, of partially decomposed vegetable matter of natural occurrence, brown, clean, low in content of mineral and woody material; mildly acid, granulated or shredded, free from weedy grasses, sedges or rushes.
- G. Lime - ground, dolomite limestone, 95% passing 100 mesh screen.
- H. Planting mixture - topsoil thoroughly incorporated with well rotted manure or equivalent dehydrated manure or bone meal and peat proportioned 1 c.y. to 7 c.y. topsoil.
- I. Mulch - aged pine bark consisting of the outer bark of pine trees with minimum hardwood bark. Bark shall be thoroughly mixed and aged in stock piles a minimum of 6 months, partially decomposed, dark brown in color, and generally free of chunks of wood thicker than 1/4". Aged pine bark containing an excess of fine particles will not be acceptable.
- J. Water - The Contractor will furnish hose and connections required for watering all plant materials until completion of the project.

- K. Tree Staking - Hardwood Stake - for tree guying - 30" long (min.). For tree staking - 8' long (min.). Install as detailed on the Drawings.
- L. Wire - pliable No. 12 to 14 gauge galvanized soft steel wire with rubber hose or Chain Lock brand plastic tree tie or approved equivalent.
- M. Wrapping material - first quality, heavy, waterproof crepe paper manufactured for this purpose; not less than 4" wide.

2.2 PLANT MATERIALS

- A. Furnish and install all plants as per Drawings in quantities listed on plant materials list. If there is any discrepancy between quantities listed and shrubs shown, notify the Landscape Architect. Contractor shall be responsible for quantity of shrubs graphically shown on plans.
- B. All plants shall be nursery grown unless authorized to be collected.
- C. Plants - in accordance with USDA Standard for Nursery Stock, latest edition, hardy under climatic conditions similar to locality of project, typical of species or variety, normal habit of growth, sound, healthy, vigorous, well-branched, densely foliated when in leaf, free of disease, insect pests, eggs, or larvae, with well developed root systems.
- D. If plants of specified kind or size are not available within a reasonable distance, substitutions may be made upon request, if approved by Landscape Architect.
- E. Plant Dimensions - conform to USDA Standard for Nursery Stock, latest edition, as specified. Exceptions as follows:
 - 1. Plants larger than specified may be used if approved by Landscape Architect at no increase in contract price. Increase spread of roots or earth ball in proportion to size of plant.
 - 2. Undersize plants (10% max.) in any one variety or grade may be used if approved by the Landscape Architect. Provide sufficient plants above size to make average equal to or above specified grade. Undersize plants shall be larger than average size of next smaller grade.
- F. Balled and burlapped (B & B) plants - dig with firm natural earth roots. Made balls are unacceptable.
- G. Container grown plants - grown in container long enough for root system to have developed sufficiently to hold its soil together firm and whole. Plants loose in container will not be acceptable.

- H. Protect B & B plants not planted immediately upon delivery with soil, wet moss, or other acceptable material. Prevent voids among roots with careful filling. Bind no plants with wire or rope so as to damage bark or break branches.
- I. Plants are subject to inspection and approval at place of growth for conformity to specifications as to quality, size, and variety. The expenses incurred by the Landscape Architect for such inspections shall be born by the Contractor. Landscape Architect reserves right of inspection upon delivery at the site or during progress of work or right of rejection due to damage suffered in handling or transportation. Remove defective plants immediately from site. Plants to be accompanied by State Nursery inspection certification, if required.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PLANTING OPERATIONS

- A. Plant nursery stock immediately upon delivery to the site and approval by the Landscape Architect. Layout individual tree and shrub locations and areas for multiple plantings. Stake locations, outline plant beds and obtain the Landscape Architects approval before proceeding with planting work.
- B. Planting may be done whenever weather and soil conditions are favorable or as otherwise authorized by Landscape Architect. If this is not feasible, heel-in material with damp soil or mulch to protect from sun and wind.
- C. Notify Landscape Architect at least one week prior to beginning planting operations.
- D. Excavate tree pits 2'-0" diameter (min.) and shrub pits 12" diameter (min.) greater than ball of earth or spread of roots and sufficiently deep to allow for 4" thick layer of compacted planting mixture beneath ball or roots.
- E. Locate pits prepared and backfilled with planting mixture to grade prior to planting by staking and recording on plans for location when planting proceeds.
- F. Set plants in center of pits, plumb and straight, with crown of plant 1" higher, after settlement, than surrounding finished grade.
- G. When B & B trees are set, compact topsoil mixture around bases of balls to fill all voids. Remove burlap, ropes or wires from top one third (1/3) of balls before filling in with planting mixture.
- H. Thoroughly compact planting mixture around roots or balls and water immediately after plant pit is backfilled. Form a shallow basin slightly larger than pit with a ridge

of sod to facilitate and contain watering. Cultivate soil in shrub beds, rake smooth and neatly outline after planting. Provide 12" (min.) of loam between all shrubs and 6" (min.) between all ground covers.

- I. Distribute controlled release fertilizer packets equidistant within the planting pit adjacent to the root ball but not in direct contact with the roots. Placement depth shall be 6 to 8 inches. Packets shall not be cut, ripped or damaged.

- 1. Application rates as follows:

Planting Item	Size	No. of Packets
Deciduous Trees:	1-3" cal.	3
	4-6" cal.	4
Shrubs:	2-3'	2
	over 3'	3
Evergreen Trees:	5-10'	4
	over 10'	5
Vines:	1 gal.	1
Groundcover:		packet per four plants

- J. Stake or guy trees as detailed on the Drawings and as directed by the Landscape Architect.
- K. Wrap all deciduous trees immediately after planting. Wrap spirally from bottom to top and adequately secure. Overlap wrapping approximately 2" and entirely cover trunk from ground to height of second branch.
- L. Prune each plant in accordance with AAN standards to preserve natural character. Remove all dead wood, suckers, broken or badly bruised branches and approximately 1/4 of wood. Prune with clean, sharp tools.
- M. Cover all tree and shrub pits immediately after planting with 3" (min.) layer of specified mulch. Limit of mulch for trees shall be area of pit; for shrubs in beds, entire area of shrub bed.
- N. Refer to Section 02300 - EARTHWORK, if rock or underground obstructions are encountered in plant pit excavation.
- O. Contractor shall furnish plans showing locations of underground utilities encountered, as required.

3.3 MAINTENANCE - PLANTING

- A. Planting Maintenance

1. Maintenance shall begin immediately after each plant is planted and shall continue for a minimum of ninety (90) days following final acceptance of all planting.
2. Maintenance shall consist of keeping the plants in a healthy growing condition and shall include but is not limited to watering, weeding, cultivating, re-mulching, tightening and repairing of guys, removal of dead material, resetting plants to proper grades or upright position, and maintaining the planting saucer.
 - a) Plants shall be inspected for watering needs at least twice each week and watered as necessary to promote plant growth and vitality.
 - b) Stakes shall be kept plumb and neat in appearance. Guys, wires and anchoring cables shall be tightened and repaired weekly.
 - c) Planting beds and individual plant pits shall be kept free of weeds, and mulch shall be replaced as required to maintain the specified layer of mulch. Beds and individual pits shall be neat in appearance and maintained to the designed layout.
 - d) Plants that die during the maintenance period shall be removed and replaced at once, unless designated otherwise by the Owner's Representative.
 - e) Spraying for both insect pests and diseases shall be included during the maintenance period as required and as directed.
3. During the maintenance period, any decline in the condition of plantings shall require the Contractor to take immediate action to identify potential problems and undertake corrective measures. If requested by the Landscape Architect, the Contractor shall engage professional arborists and/or horticulturalists to inspect plant materials and to identify problems and recommend corrective procedures.

3.4 ACCEPTANCE STANDARDS FOR PLANTING

- A. Following the completion of all planting, the Contractor shall request, from the Landscape Architect in writing, a formal inspection of the completed work. If plant materials and workmanship for the site are acceptable, written notice will be given to the Contractor stating that the work has received acceptance and that the ninety (90) day maintenance and the one year guarantee period has commenced from the date of acceptance.
- B. If a number of plants are sickly or dead at the time of inspection, or if, in the Landscape Architect's opinion, workmanship is unacceptable, written notice will be given by the Landscape Architect to the Contractor in the form of a punch list, which itemizes necessary planting replacements and/or other deficiencies to be remedied. The Contractor's responsibility for maintenance of all the plants shall be extended

until replacements are made or other deficiencies are corrected. All dead and unsatisfactory plants shall be removed promptly from the project. Replacements shall conform in all respects to the Specifications for new plants and shall be planted in the same manner.

3.5 GUARANTEE FOR PLANT MATERIALS

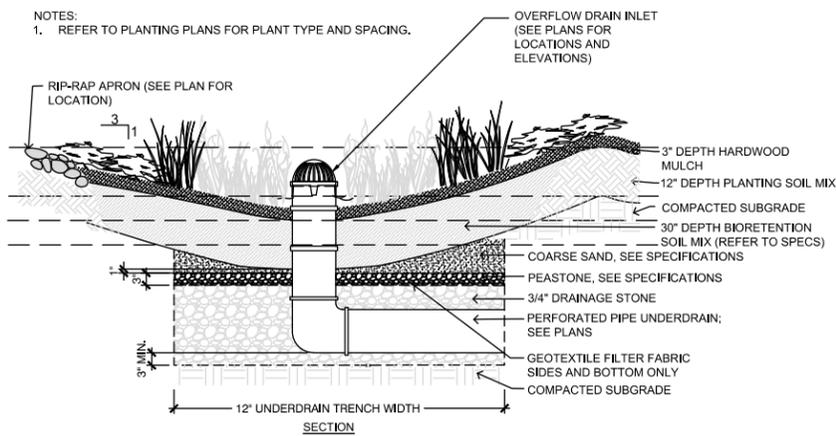
- A. Plants shall be guaranteed for a period of one (1) year after written notification of acceptance and shall be alive and in satisfactory growth at the end of the guarantee period.
- B. At the end of the guarantee period, a final inspection will be held to determine whether any additional plant material replacements are required. Each plant shall show at least 75% healthy growth and shall have the natural character of its species as determined by the Landscape Architect. Plants found unacceptable shall be removed promptly from the site and be replaced during the normal planting season, until the plants live through one year.
- C. Replacement plants shall have a one (1) year guarantee from time of planting.

END OF SECTION



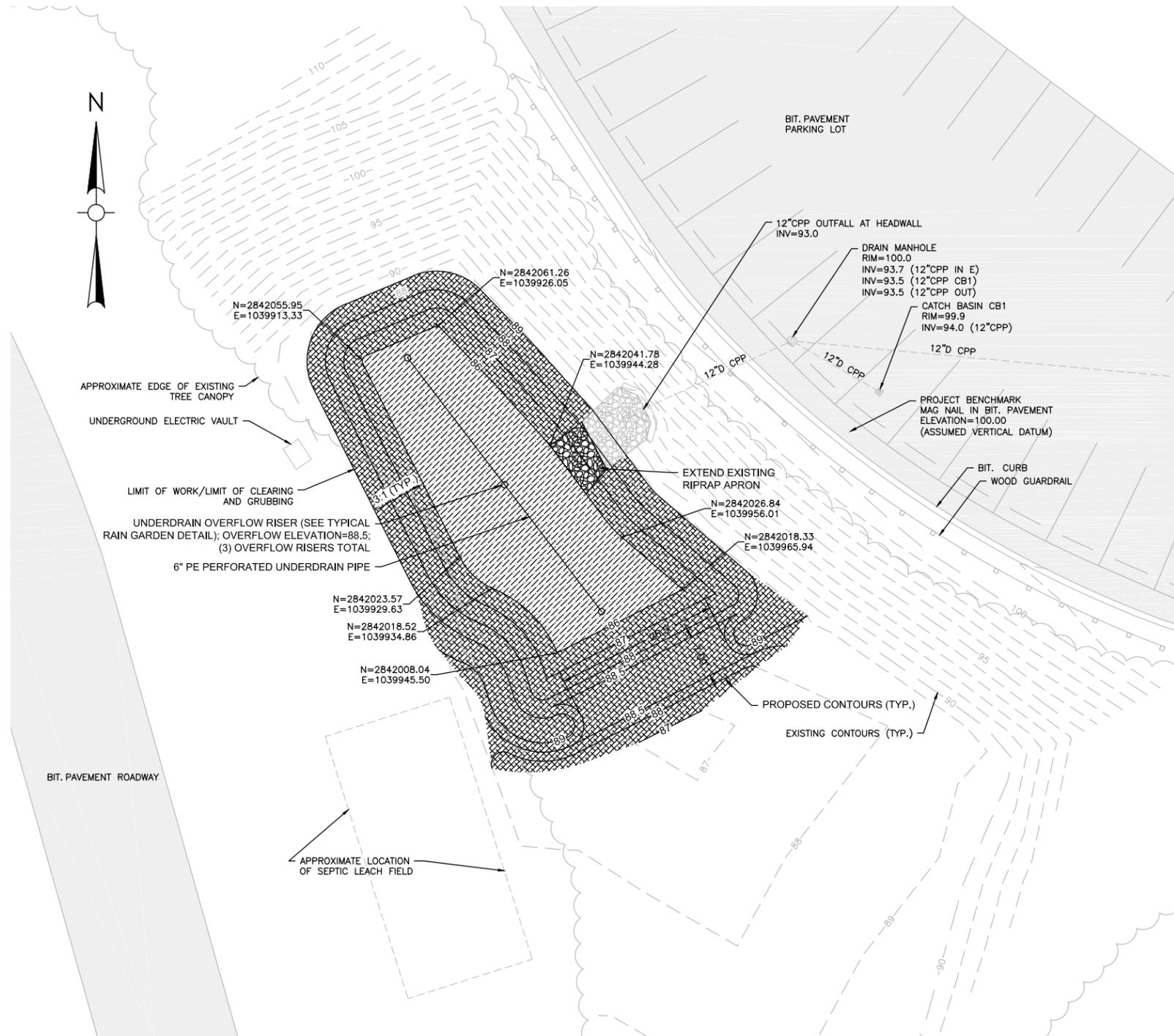
PROJECT LOCUS MAP

- RAIN GARDEN PLANTS LEGEND**
- EQUAL PARTS OF THE FOLLOWING:
 LITTLE BLUE STEM- SCHIZACHYRIUM SCOPARIUM
 LIRIOPE- LIRIOPE MUSCARI 'BIG BLUE'
 PURPLE CONE FLOWER- ECHINACEA PURPUREA
 SMOOTH ASTER- ASTER LAEVIS
 SIBERIAN IRIS- IRIS SIBERICA
 DAYLILY- HEMEROCALLIS SP.
 - NEW ENGLAND COMMON RAIN GARDEN SEED



TYPICAL RAIN GARDEN DETAIL

NOTE:
1) HORIZONTAL DATUM: MASSACHUSETTS STATE PLANE COORDINATES, NAD83 (MA83F)



PLAN



No.	Date	Dr. By	Ch. By	App. By	Description
A					P R O V E D

8/4/2016 DATE

Brian W. Adams
 REGISTERED PROFESSIONAL ENGINEER



TOWN OF TRURO, MA WATER RESOURCES OVERSIGHT COMMITTEE STORMWATER DEMONSTRATION PROJECT	CONTRACT:	2160455
RAIN GARDEN PLAN	SCALE:	AS NOTED
CADD NO. 02-PLANS	DR. BY:	JIP
	CHK. BY:	RA
	APP. BY:	BWA

FILE NO. **C-7**