MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Palmer River Watershed

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Prepared By:

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Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for “nine-element” watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Massachusetts Association of Conservation Districts (MACD) with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was prepared for the approximately 50-square mile Palmer River watershed, which is a tributary to Narragansett Bay. Major streams in the watershed include Bad Luck Brook (MA53-11); Beaverdam Brook (MA53-10); Clear Run Brook (MA53-13); East Branch Palmer River (MA53-08); Fullers Brook (MA53-12); Oak Swamp Brook (MA53-15); Palmer River (MA53-22); Rocky Run (MA53-16); Rumney Marsh Brook (MA53-09); Runnins River; Torrey Creek (MA53-14); and West Branch Palmer River (MA53-07). A major pond included in the watershed is Shad Factory Pond (MA53005).

Impairments and Pollution Sources: The Palmer River (MA53-22), Shad Factory Pond (MA53005), and Clear Run Brook (MA53-13) are category 5 water bodies on the Massachusetts Integrated List of Waters (303(d) list) due to *Escherichia coli* (*E. coli*) and nutrients impairments. Fullers Brook (MA53-12), Clear Run Brook (MA53-13), Torrey Creek (MA53-14), Oak Swamp Brook (MA53-15), and Rocky Run (MA53-16) are listed as category 4A waterbodies on the 303(d) list due to *E. Coli* impairment and are included in the Bacteria Total Maximum Daily Load (TMDL) that has been completed for the Palmer River watershed (MassDEP, 2004).

A ranking analysis was also conducted of recent water quality data at twelve core sampling sites within the watershed. Based on the ranking analysis which included data before BMP installation the most degraded water quality was identified at Clear Run Brook, followed by Rocky Run, the Palmer River mainstem, and Torrey Creek. It was concluded that the historic poor water quality at these locations was likely due to the dominance of agricultural landuses in these subwatersheds.

A microbial source tracking (MST) ribonucleic acid (RNA) microarray analysis was also completed to identify specific sources of fecal contamination in the Palmer River watershed. Human, bird, and cow waste were identified by PhyloChip® as the dominant sources of fecal pollution to the Palmer River, and several pathogenic bacteria strains associated with mammalian and bird intestinal tracts were present at all eight sites that were analyzed (see Figure A-2 and Table A-4). The human waste that was detected as a “strong” source at three of the eight sites (Clear Run Brook, Torrey Creek, and Palmer River mainstem downstream of Shad Factory Pond) indicated that septic systems are a suspected source of fecal contamination to the Palmer River. Cow waste was also prominent at Torrey Creek indicating cow farms are a source of fecal contamination in the Torrey Creek subwatershed. Bird waste was prominent in Clear Run brook and the Palmer River mainstem indicating bird waste is a source of fecal contamination in these areas.

Goals, Management Measures, and Funding: Water quality goals for this WBP are focused on addressing the Palmer River Watershed Bacteria TMDL, the listed *E. Coli* and nutrient impairments, and observed elevated concentrations of *E. Coli* and nutrients from ambient monitoring data. The goals are to reduce *E. coli* and Total Phosphorus (TP) loading to the Palmer River, eventually leading to delisting of impaired waterbodies in the study area from the 303(d) list. It is expected that these pollutant load reductions will result in improvements to other listed impairments throughout the study area as well.

It is expected that continued progress towards meeting these goals will be accomplished through development and implementation of farm conservation plans that address water quality impacts from agricultural activities in the Palmer River Watershed; continued implementation of agricultural best management practices (BMPs) building on efforts already completed; incorporating low impact development practices (LID) on new and existing development; and identifying and upgrading failing septic systems.

Farm conservation plans and agricultural BMPs have been implemented at numerous farms with funding from Fiscal Year 2014 and Fiscal Year 2017 Section 319 grants. Additional agricultural BMP planning and implementation may be also be performed in subsequent years, focusing on the most impaired waterbodies in the Palmer River watershed.

It is expected that future funding for management measures will be obtained from a variety of sources including Section 319 Grant Funding; the Environmental Quality Incentives Program (EQIP); Agricultural Management Assistance (AMA); the Agricultural Environmental Enhancement Program (AEEP); the Agricultural Produce Safety Improvement Program (APSIP); town capital funds; volunteer efforts; and other sources.

Public Education and Outreach: Goals of public education and outreach are to provide information about proposed stormwater improvements and to promote watershed stewardship. This will be achieved through continued outreach and dialogue with residents, businesses, schools, local government, farmers, and watershed organizations in the watershed to share what is being done by the agricultural community to preserve and protect the water quality of the Palmer River watershed using workshops, tours, web-based media, print media and local access TV.

Implementation Schedule and Evaluation Criteria: The implementation schedule includes milestones for BMP implementation; monitoring; public education and outreach; and periodic updates to the WBP. It is expected that continued water quality monitoring will enable direct evaluation of improvements over time. Other indirect evaluation metrics are also recommended, including quantification of potential pollutant load reductions from non-structural BMPs (e.g., street sweeping). The long-term goal of this WBP is to de-list the all waterbodies within the study area from the 303(d) list by 2040. The WBP will be re-evaluated and adjusted, as needed, once every three years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for “nine-element” watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop watershed-based plans only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs, so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

USEPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds, and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

Watershed-Based Plan Outline

This WBP for the Palmer River watershed includes nine elements (a through i) in accordance with USEPA Guidelines:

a) An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below.

b) An **estimate of the load reductions** expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).

c) A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e) An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g) A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h) A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the TMDL needs to be revised.

i) A **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Project Partners and Stakeholder Input

This WBP was developed by Geosyntec under the direction of the Massachusetts Association of Conservation Districts (MACD) with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP). This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool (WBP Tool). The MACD was a recipient of Section 319 funding in Fiscal Year 2020 to implement public outreach and education in the Palmer River Watershed.

Core project stakeholders include

- Jane Obbagy – MACD
- Matthew Reardon – MassDEP

This WBP was developed as part of an iterative process. The Geosyntec project team collected and reviewed existing data from the MACD. This information was then used to develop a preliminary WBP for review by core project stakeholders.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by information provided in MACD (2016a, 2016b) and FB Environmental and Horsley Witten (2019a, 2019b, 2019c).

Summary of Completed Work

The MACD's strategy has been to implement watershed-wide farm conservation practices and agricultural BMPs. The overarching methodology of the MACD includes the development and implementation of farm conservation plans that address water quality impacts from agricultural activities in the Palmer River Watershed. From 2015—2018, 28 agricultural BMPs (e.g., conservation tillage, prescribed grazing, critical area planting, litter storage and management, livestock exclusion fencing, and grass buffer) were successfully installed in the Palmer River watershed, 11 on cropland and 17 on pasture. Several sites included multiple BMP installations. These BMPs have resulted in an estimated total reduction of 528 lbs/yr of Total Nitrogen (TN), 149 lbs/yr of TP and 25 tons/yr of Total Suspended Solids (TSS) (FB Environmental & Horsley Witten, 2019a).

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

General Watershed Information

This WBP was prepared for the Palmer River watershed, which is in the towns of Attleboro, Dighton, Rehoboth, Seekonk, and Swansea, Massachusetts as well as Warren, Rhode Island. For this WBP, the delineation ends at the Massachusetts state line and does not include the Rhode Island portion of the watershed. The Palmer River is a tributary to the Narragansett and Mount Hope Bay; the total area of Palmer River watershed within Massachusetts is approximately 32,300 acres (approximately 50 square miles).

Table A-1 presents the general watershed information for the Palmer River watershed[1] and **Figure A-1** includes a map of the watershed boundary.

Table A-1: General Watershed Information

Major Streams (303(d) List Assessment Unit ID):	Bad Luck Brook (MA53-11); Beaverdam Brook (MA53-10); Clear Run Brook (MA53-13); East Branch Palmer River (MA53-08); Fullers Brook (MA53-12); Oak Swamp Brook (MA53-15); Palmer River (MA53-22); Shad Factory Pond (MA53005); Rocky Run (MA53-16); Rumney Marsh Brook (MA53-09); Runnins River; Torrey Creek (MA53-14); West Branch Palmer River (MA53-07)
Major Basin:	Narragansett and Mount Hope Bay
Watershed Area (within MA):	32,302 acres

[1] Watersheds are defined by the WBP-tool by utilizing MassGIS drainage sub-basins.

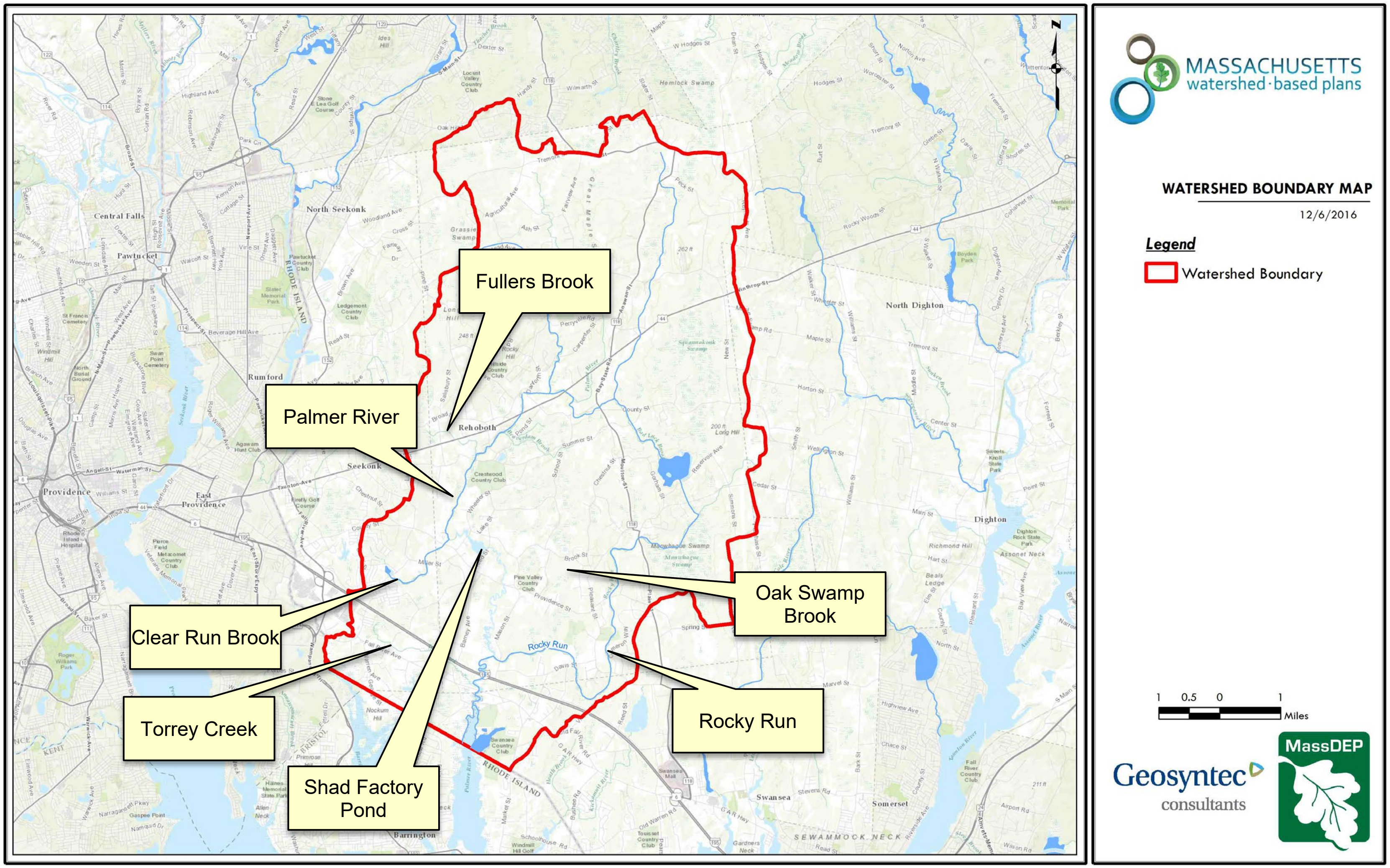

Figure A-1: Watershed Boundary Map
(MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

- Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MassDEP, 2009)
- BACTERIA TMDL FOR THE PALMER RIVER BASIN (MassDEP, 2004)

Appendix B includes select excerpts from the Water Quality Assessment Report (MassDEP, 2009) relating to aquatic life habitat and flow in Palmer River (MA53-04)[2], West Branch Palmer River (MA53-07), Rocky Run (MA53-16), Bad Luck Brook (MA53-11), and East Branch Palmer River (MA53-08); as well as information relating to primary and secondary contact recreation and aesthetics in Clear Run Brook (MA53-13).

Data used to develop the Bacteria TMDL for the Palmer River Basin (MassDEP, 2004) were collected during sampling efforts mostly conducted in 2001 and 2002. An analysis of fecal coliform concentration sampling results from each sample location studied is included in Appendix C. The Table in Appendix C also includes target concentrations (based on the Massachusetts Water Quality Standards) and reductions necessary to meet these concentrations. Sample stations evaluated are also shown in the figure included in Appendix C. Sample stations within segment MA53-03 where violations of the Massachusetts bacteria water quality standard were observed included PM25 (Palmer Mainstem – unnamed salt marsh creek in Swansea) and PM11 (Palmer Mainstem – Bungtown Bridge in Swansea). Sample stations within segment MA53-04[2] where violations of the Massachusetts bacteria water quality standard were observed included PM14 (Palmer Mainstem – tributary below Shad Factory Pond). Sample stations within segment MA53-05 where violations of the Massachusetts bacteria water quality standard were observed included PM08 (Palmer Mainstem – outlet of Shad Factory Pond), PM26 (Palmer Mainstem in Rehoboth), and PM10 (Palmer Mainstem in Rehoboth). Numerous exceedances of this water quality standard were also observed in tributaries to this segment.

Water Quality Impairments

Known water quality impairments, as documented in the MassDEP 2016 Massachusetts Integrated List of Waters (303(d) list), are listed in **Table A-3**. Impairment categories from the Integrated List are listed in **Table A-2**.

[2] Palmer River was formerly identified with Assessment Unit ID MA53-04; in the 2016 revision of the 303(d) List, it was divided into two segments: MA53-22 and MA53005.

Table A-2: 2016 MA Integrated List of Waters Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

Table A-3: Water Quality Impairments

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA53-22 (formerly part of MA53-04)	**Palmer River**	**5**	Fish, other Aquatic Life and Wildlife	Low flow alterations	Source Unknown
MA53-22 (formerly part of MA53-04)	**Palmer River**	**5**	Fish, other Aquatic Life and Wildlife	Nutrient/Eutrophication Biological Indicators	Source Unknown
MA53-22 (formerly part of MA53-04)	**Palmer River**	**5**	Primary Contact Recreation	*E. Coli*	Source Unknown
MA53005 (formerly part of MA53-04)	**Shad Factory Pond**	**5**		Dewatering	
MA53005 (formerly part of MA53-04)	**Shad Factory Pond**	**5**		Nutrient/Eutrophication Biological Indicators	
MA53-12	**Fullers Brook**	**4A**		*E. Coli*	
MA53-13	**Clear Run Brook**	**5**	Primary Contact Recreation	Fecal Coliform	Source Unknown
MA53-13	**Clear Run Brook**	**5**		*E. Coli*	
MA53-13	**Clear Run Brook**	**5**		Dissolved Oxygen	
MA53-14	**Torrey Creek**	**4A**		*Alteration in stream-side or littoral vegetative covers*	
MA53-14	**Torrey Creek**	**4A**		Habitat Assessment	
MA53-14	**Torrey Creek**	**4A**		*E. Coli*	
MA53-15	**Oak Swamp Brook**	**4A**		*E. Coli*	
MA53-16	**Rocky Run**	**4A**	Primary Contact Recreation	Fecal Coliform	Source Unknown
MA53-16	**Rocky Run**	**4A**		*E. Coli*	

Additional Water Quality Data

A detailed water quality analysis was conducted in 2019 for the Palmer River Basin (FB Environmental & Horsley Witten, 2019). All water quality data for the Palmer River watershed were compiled into a database that included metadata, raw data, and site locations. Data came from a variety of federal, state, and local sources and were reviewed and validated for meeting data quality objectives outlined in the "Secondary Data Quality Assurance Project Plan (QAPP) for the Palmer River Source Tracking, Water Quality Trends Summary, and Watershed Plan" (FB Environmental & Horsley Witten, 2019c). **Figure A-2** identifies the 12 "core" sample sites and their respective drainage areas. Daily data for all twelve sites were summarized (median, average, minimum, and maximum) by site for application to state water quality criteria or natural background conditions (see **Table A-5** below). All sites exceeded state criteria for both *E. Coli* and *enterococci* for either the applicable geomean standard or single-sample standard or both. Most sites also had elevated nutrient levels compared to natural background levels for the coastal ecoregion (FB Environmental & Horsley Witten, 2019a).

Beginning in 2017, samples were also analyzed at eight of the twelve core sites for MST using the PhyloChip® to identify specific sources of fecal contamination in the Palmer River watershed. Human, bird, and cow waste were identified by PhyloChip® as the dominant sources of fecal pollution to the Palmer River, and several pathogenic bacteria strains associated with mammalian and bird intestinal tracts were present at all eight sites. PhyloChip® analysis results showed 5 of 8 selected sites had "strong" source signals for human, bird and/or cow (CR01, CR03, PM30, TC07, and PM43) corresponding to Clear Run Brook, Torrey Creek and the Palmer River mainstem. The strong source signal of human waste detected at three of the eight sites (Clear Run Brook, Torrey Creek, and Palmer River mainstem downstream of Shad Factory Pond) indicated that septic systems are a source of fecal contamination to the Palmer River. Cow waste was prominent at Torrey Creek (TC07) indicating cow farms are a source of fecal contamination in the Torrey Creek subwatershed. Bird waste was prominent in Clear Run brook (CR01) and the Palmer River mainstem (PM43) indicating birds are a source of fecal contamination in these areas. The PhyloChip® results compared to expected sources are summarized in **Table A-4** (FB Environmental & Horsley Witten, 2019a).

Table A-4: PhyloChip® Analysis Results

(Copied from FB Environmental & Horsley Witten (2019a))

Table 2. Identified sources of pathogen pollutants by site based on PhyloChip® analysis results, historic Microbial Source Tracking-DNA (MST-DNA) results, and anecdotal information. *NA* signifies that no samples for a site were analyzed using PhyloChip®. The ribotyping study data came from ESS Group Inc. (2003) and the Bacteroidetes data came from a prior study under the 2010-2015 Surface Water Monitoring & Assessment MassDEP Division of Watershed Management-Watershed Planning Program.

Site ID	PhyloChip® Strong Source	PhyloChip® Marginal Source	MST-DNA Results	Other Notes
CR01	Bird	Human		
CR02	*NA*	*NA*		
CR03	Human	Bird, Cow	Cow, pig isolates from ribotyping study	
PM31	*NA*	*NA*		
PM30	Human	Bird, Cow		
PM44		Human, Bird		
RR23	*NA*	*NA*		
RR22		Human, Bird, Cow	Cow, pig, horse, human, deer, rabbit, dog isolates from ribotyping study	Historic septic system failure at RR02 (upstream); remediated by 2015
TC07	Human, Cow	Bird, Pig, Dog, Horse	Cow, pig isolates from ribotyping study	Waterfowl identified in 2004 MA TMDL
TC08		Human, Bird, Cow	Weak human Bacteroidetes marker	
PM29	*NA*	*NA*		Major geese congregation
PM43	Bird	Human		Major geese congregation

Table A-5: Water Quality Statistics – Palmer River Core Sites

(copied from FB Environmental & Horsley Witten, 2019)

Summary statistics (median, average, minimum, maximum, number of samples (after duplicate days averaged), number of years, start year, and end year) by site and parameter for twelve "core" sites monitored in the Palmer River watershed. Values exceeding state criteria or natural background conditions are displayed as bold red or orange, respectively. Refer to the end of the table for a list of applied thresholds and other assumptions. *E. coli* for saline sites were greyed out because *E. coli* has been shown to result in false positives in marine waters (Pisciotta et al., 2002) and thus is not the preferred indicator for saline sites.

Site	Parameter	Median	Average	Min	Max	*n* (samples)	*n* (years)	Start Year	End Year
CR01	E. COLI	55	57	2	**4884**	41	9	2001	2018
CR01	NITRATE + NITRITE	**0.330**	**0.703**	0.023	**2.900**	23	3	2016	2018
CR01	ORTHOPHOSPHATE	0.014	0.020	0.005	**0.087**	20	3	2016	2018
CR01	TOTAL KJELDAHL NITROGEN	**0.425**	**0.474**	0.240	**0.889**	22	3	2016	2018
CR01	TOTAL NITROGEN	**0.890**	**1.118**	0.370	**2.500**	23	3	2016	2018
CR01	TOTAL PHOSPHORUS	**0.071**	**0.092**	0.018	**0.240**	23	3	2016	2018
CR01	TOTAL SUSPENDED SOLIDS	3.4	5.6	2.5	18.0	24	3	2016	2018
CR02	E. COLI	**471**	**414**	18	**24196**	44	10	1999	2018
CR02	NITRATE + NITRITE	**1.200**	**1.206**	0.200	**2.100**	23	3	2016	2018
CR02	ORTHOPHOSPHATE	**0.065**	**0.084**	**0.027**	**0.220**	20	3	2016	2018
CR02	TOTAL KJELDAHL NITROGEN	0.300	**0.354**	0.010	**0.800**	23	3	2016	2018
CR02	TOTAL NITROGEN	**1.600**	**1.560**	**0.640**	**2.500**	23	3	2016	2018
CR02	TOTAL PHOSPHORUS	**0.150**	**0.164**	**0.060**	**0.450**	23	3	2016	2018
CR02	TOTAL SUSPENDED SOLIDS	2.7	6.0	2.5	31.0	24	3	2016	2018
CR03	E. COLI	**315**	**324**	12	**24196**	52	11	1999	2018
CR03	NITRATE + NITRITE	**0.460**	**0.533**	0.023	**1.400**	23	3	2016	2018
CR03	ORTHOPHOSPHATE	**0.100**	**0.116**	0.005	**0.270**	21	5	2001	2018
CR03	TOTAL KJELDAHL NITROGEN	**0.370**	**0.411**	0.210	**1.100**	25	5	2001	2018
CR03	TOTAL NITROGEN	**0.840**	**0.986**	0.450	**2.310**	30	6	2001	2018
CR03	TOTAL PHOSPHORUS	**0.215**	**0.266**	**0.080**	**1.500**	30	6	2001	2018
CR03	TOTAL SUSPENDED SOLIDS	4.1	9.7	2.0	48.0	26	5	2001	2018
PM31	E. COLI	31	33	2	**2420**	35	10	1999	2018
PM31	ENTEROCOCCI	14	23	2	**426**	26	4	2015	2018
PM31	NITRATE + NITRITE	0.145	0.197	0.012	**1.965**	34	5	1996	2018
PM31	ORTHOPHOSPHATE	0.008	0.012	0.001	**0.031**	45	7	1996	2018
PM31	TOTAL KJELDAHL NITROGEN	**0.330**	**0.347**	0.200	**0.840**	27	5	2001	2018
PM31	TOTAL NITROGEN	0.515	**0.594**	0	**2.132**	38	7	1996	2018
PM31	TOTAL PHOSPHORUS	**0.039**	**0.038**	0.011	**0.066**	38	7	1996	2018
PM31	TOTAL SUSPENDED SOLIDS	2.5	4.7	1.0	24.0	28	5	2001	2018
PM30	E. COLI	**136**	**169**	16	**2420**	36	10	1999	2018
PM30	ENTEROCOCCI	**142**	**125**	10	**2910**	27	5	2014	2018
PM30	NITRATE + NITRITE	0.280	**0.333**	0.026	**1.000**	23	3	2016	2018
PM30	ORTHOPHOSPHATE	0.012	0.018	0.005	**0.123**	30	4	2001	2018
PM30	TOTAL KJELDAHL NITROGEN	**0.301**	**0.325**	0.220	**0.700**	23	3	2016	2018
PM30	TOTAL NITROGEN	**0.590**	**0.658**	0.320	**1.700**	23	3	2016	2018
PM30	TOTAL PHOSPHORUS	**0.042**	**0.046**	0.018	**0.099**	23	3	2016	2018
PM30	TOTAL SUSPENDED SOLIDS	2.5	3.3	2.5	9.8	24	3	2016	2018
PM44	*E. COLI*	*1230*	*957*	*95*	*6328*	*5*	*3*	*2013*	*2016*
PM44	ENTEROCOCCI	**426**	**326**	10	**7701**	26	4	2015	2018
PM44	NITRATE + NITRITE	0.210	0.182	0.023	**0.380**	23	3	2016	2018
PM44	ORTHOPHOSPHATE	0.015	0.018	0.005	**0.044**	16	3	2016	2018
PM44	TOTAL KJELDAHL NITROGEN	**0.449**	**0.489**	0.300	**0.879**	23	3	2016	2018
PM44	TOTAL NITROGEN	**0.650**	**0.669**	0.400	**1.100**	23	3	2016	2018
PM44	TOTAL PHOSPHORUS	**0.057**	**0.062**	**0.026**	**0.110**	23	3	2016	2018
PM44	TOTAL SUSPENDED SOLIDS	5.0	8.5	2.5	45.0	24	3	2016	2018
RR23	E. COLI	**154**	126	4	**1099**	42	11	2001	2018
RR23	ENTEROCOCCI	**95**	**90**	10	**776**	25	4	2015	2018
RR23	NITRATE + NITRITE	0.170	0.222	0.005	**0.802**	34	5	1996	2018
RR23	ORTHOPHOSPHATE	0.016	0.021	0.000	**0.120**	41	6	1996	2018
RR23	TOTAL KJELDAHL NITROGEN	**0.382**	**0.437**	0.271	**0.990**	25	4	2001	2018

Site	Parameter	Median	Average	Min	Max	*n* (samples)	*n* (years)	Start Year	End Year
RR23	TOTAL NITROGEN	0.655	0.769	0.360	1.424	40	7	1996	2018
RR23	TOTAL PHOSPHORUS	0.043	0.046	0.010	0.140	41	7	1996	2018
RR23	TOTAL SUSPENDED SOLIDS	2.5	4.3	1.0	44.0	26	4	2001	2018
RR22	*E. COLI*	*365*	*336*	*4*	*12997*	*43*	*12*	*1999*	*2018*
RR22	ENTEROCOCCI	**201**	**192**	10	**8160**	29	6	2013	2018
RR22	NITRATE + NITRITE	0.180	0.215	0.023	0.500	23	3	2016	2018
RR22	ORTHOPHOSPHATE	0.014	0.021	0.005	0.050	17	5	2001	2018
RR22	TOTAL KJELDAHL NITROGEN	0.490	0.571	0.300	1.020	27	5	2001	2018
RR22	TOTAL NITROGEN	0.810	0.808	0.410	1.400	27	5	2001	2018
RR22	TOTAL PHOSPHORUS	0.040	0.050	0.018	0.120	27	5	2001	2018
RR22	TOTAL SUSPENDED SOLIDS	2.9	5.8	1.0	51.0	28	5	2001	2018
TC07	*E. COLI*	*272*	*266*	*15*	*12033*	*39*	*9*	*2001*	*2018*
TC07	ENTEROCOCCI	**206**	**211**	10	**6488**	26	5	2013	2018
TC07	NITRATE + NITRITE	0.460	0.503	0.054	1.000	23	3	2016	2018
TC07	ORTHOPHOSPHATE	0.010	0.015	0.005	0.050	24	5	2001	2018
TC07	TOTAL KJELDAHL NITROGEN	0.360	0.414	0.240	0.900	27	5	2001	2018
TC07	TOTAL NITROGEN	0.940	0.993	0.400	1.930	27	5	2001	2018
TC07	TOTAL PHOSPHORUS	0.037	0.041	0.020	0.080	27	5	2001	2018
TC07	TOTAL SUSPENDED SOLIDS	2.9	4.0	2.5	18.0	28	5	2001	2018
TC08	*E. COLI*	*487*	*348*	*13*	*3873*	*37*	*8*	*2002*	*2018*
TC08	ENTEROCOCCI	**475**	**326**	10	**3873**	27	5	2013	2018
TC08	NITRATE + NITRITE	0.081	0.084	0.023	0.260	23	3	2016	2018
TC08	ORTHOPHOSPHATE	0.005	0.008	0.005	0.027	19	3	2016	2018
TC08	TOTAL KJELDAHL NITROGEN	0.559	0.569	0.339	0.919	23	3	2016	2018
TC08	TOTAL NITROGEN	0.610	0.650	0.350	1.000	23	3	2016	2018
TC08	TOTAL PHOSPHORUS	0.026	0.031	0.014	0.096	23	3	2016	2018
TC08	TOTAL SUSPENDED SOLIDS	2.5	5.4	2.5	45.0	24	3	2016	2018
PM29	*E. COLI*	*239*	*281*	*110*	*846*	*6*	*4*	*2012*	*2016*
PM29	ENTEROCOCCI	**216**	**177**	10	**3255**	29	6	2013	2018
PM29	NITRATE + NITRITE	0.120	0.132	0.023	0.300	26	4	1998	2018
PM29	ORTHOPHOSPHATE	0.023	0.025	0.005	0.056	17	4	1998	2018
PM29	TOTAL KJELDAHL NITROGEN	0.543	0.559	0.290	1.580	26	4	1998	2018
PM29	TOTAL NITROGEN	0.630	0.688	0.370	1.800	26	4	1998	2018
PM29	TOTAL PHOSPHORUS	0.054	0.060	0.027	0.130	26	4	1998	2018
PM29	TOTAL SUSPENDED SOLIDS	7.0	8.5	2.5	33.7	27	4	1998	2018
PM43	*E. COLI*	*100*	*91*	*15*	*820*	*8*	*5*	*2001*	*2016*
PM43	ENTEROCOCCI	**121**	**142**	10	**2755**	28	6	2013	2018
PM43	NITRATE + NITRITE	0.079	0.106	0.023	0.240	23	3	2016	2018
PM43	ORTHOPHOSPHATE	0.027	0.037	0.007	0.099	27	5	2001	2018
PM43	TOTAL KJELDAHL NITROGEN	0.554	0.616	0.300	1.430	27	5	2001	2018
PM43	TOTAL NITROGEN	0.730	0.742	0.350	1.600	27	5	2001	2018
PM43	TOTAL PHOSPHORUS	0.060	0.089	0.036	0.580	27	5	2001	2018
PM43	TOTAL SUSPENDED SOLIDS	7.4	8.9	3.0	32.0	28	5	2001	2018

E. coli	*126 mpn/100mL (geomean); 235 mpn/100mL (single)*
Enterococci	*35 mpn/100mL (geomean); 104 mpn/100mL (single)*
Nitrate + Nitrite	*0.31 mg/L*
Total Kjeldahl nitrogen	*0.30 mg/L*
Total Nitrogen	*0.57 mg/L*
Orthophosphate	*0.024 mg/L (used Total Phosphorus Reference Condition)*
Total Phosphorus	*0.024 mg/L*
Total suspended solids	*30 mg/L (30-day average), 58 mg/L (daily max)*

Note: both median and average *E. coli* and enterococci values were log-transformed before summarized (average represents true geomean)

Figure A-2: Sub-basin drainage areas to twelve "core" sample site locations in the Palmer River watershed

(copied from FB Environmental & Horsley Witten, 2019)

Water Quality Goals

Refer to **Table A-6** for a list of water quality goals. Element C of this WBP includes proposed BMPs to address these impairments.

The Palmer River does not have a Total Maximum Daily Load (TMDL) for nutrients (TP or TN). The water quality goal for nutrients is therefore based on target concentrations established in the Quality Criteria for Water (USEPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir, nor 25 ug/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 ug/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

As noted above, the Palmer River does have a Bacteria TMDL (MassDEP, 2004). The water quality goals in the Bacteria TMDL are based on the Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013). The Massachusetts Surface Water Quality Standards prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. The segments within the Palmer River watershed are designated as Class 'B'. The water quality goal for bacteria is therefore based on the current Massachusetts Surface Water Quality Standards.

Table A-6: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 ug/L in any stream --25 ug/L within any lake or reservoir	Quality Criteria for Water (USEPA, 1986)
Bacteria	**Class B Standards** • Public Bathing Beaches: For *E. coli*, geometric mean of 5 most recent samples shall not exceed 126 colonies/ 100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For *E. coli*, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

Land Use Information

Land use information and impervious cover is presented by the below tables and figures. Land use source data is from 2005 and was obtained from MassGIS (2009b).

Watershed Land Uses

As summarized by **Table A-7**, land use in the Palmer River watershed is mostly forested (approximately 66 percent); approximately 16 percent is residential; approximately 12 percent of the watershed is agricultural; approximately 4 percent of the watershed is open land or water; approximately 2 percent of the watershed is commercial or industrial; and approximately 1 percent is designated as highways.

Table A-7: Subwatershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	21,189	65.6
Low Density Residential	4,479	13.9
Agriculture	3,832	11.9
Open Land	817	2.5
Water	627	1.9
Commercial	489	1.5
High Density Residential	314	1
Medium Density Residential	239	0.7
Highway	202	0.6
Industrial	113	0.4

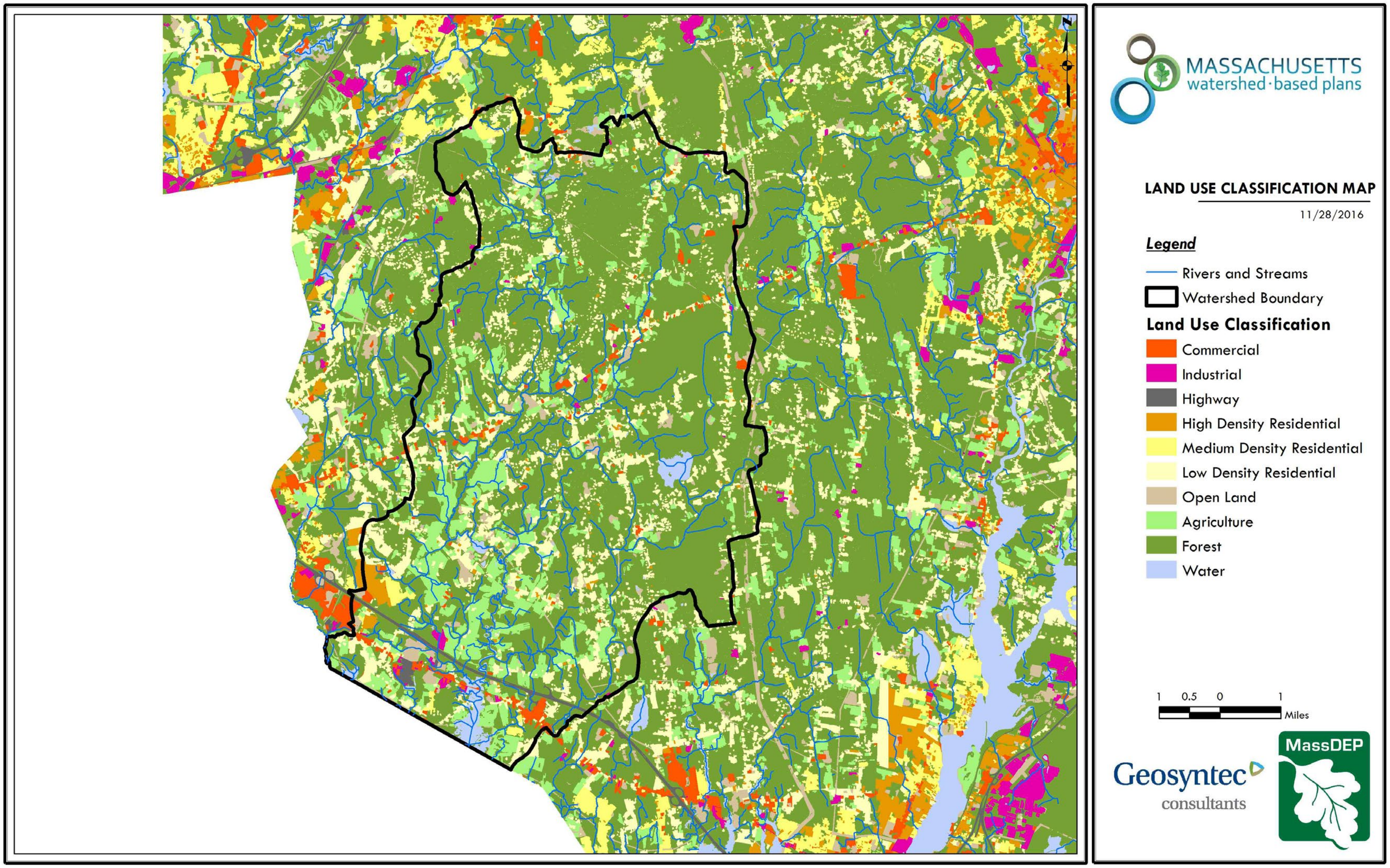

Figure A-3: Subwatershed Land Use Map

(MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc.

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with greater efficiency than disconnected impervious cover areas which are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. USEPA provides guidance (USEPA, 2010) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the **total impervious area (TIA)** of a watershed. Within each subwatershed, the total area of each land use was summed and used to calculate the percent TIA.

Table A-8: TIA and DCIA values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
Palmer River Watershed	7.3	5

The relationship between TIA and water quality can generally be categorized as listed by **Table A-9** (Schueler et al. 2009). The TIA value for the watershed range is 7.3%; therefore, the river and surrounding tributaries can be expected to show good to excellent water quality. It is likely there is a gradient of higher water quality in the upstream forested parts of the watershed while more downstream developed areas have more water quality stress.

Table A-9: Relationship between Total Impervious Area (TIA) and water quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0-10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of "urban drainage", with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

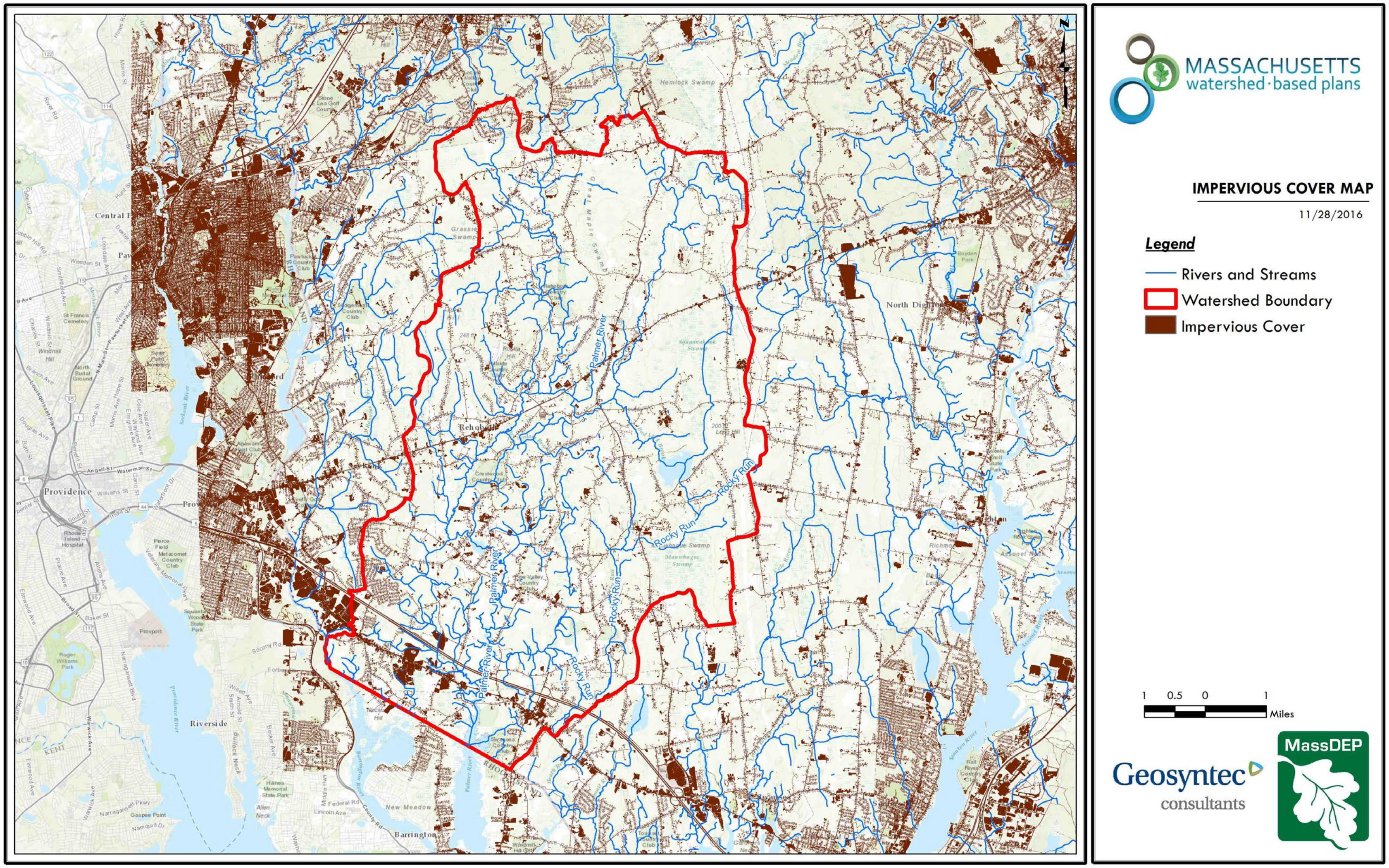

Figure A-4: Subwatershed Impervious Surface Map

(MassGIS, 2007; MassGIS 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Pollutant Loading

The land use data (MassGIS, 2009b) was intersected with impervious cover data (MassGIS, 2009a) and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data (USDA NRCS and MassGIS, 2012) to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

The amount of DCIA was estimated using the Sutherland equations as described above and any reduction in impervious area due to disconnection (i.e., the area difference between TIA and DCIA) was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER). The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (Voorhees, 2016b) (see documentation provided in Appendix A) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr); A_n = area of land use/cover type n (acres); P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

Table A-10 presents the estimated land-use based TP, TN and TSS within the Palmer River watershed. The largest contributor of the land use-based TP, TN and TSS load originates from areas designated as forested. TP and TN generated from forested areas is generally a result of natural processes such as decomposition of leaf litter and other organic material; the forested portions of the watershed therefore are unlikely to provide opportunities for nutrient load reductions through best management practices. Agricultural areas are the second and third largest contributors of land-use based TP and TN load in the watershed, respectively. Agricultural areas provide excellent opportunities for nutrient load reductions through agricultural BMPs.

Table A-10: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Forest	2,920	14,930	787
Agriculture	1,930	11,750	143
Low Density Residential	1,330	13,350	182
Commercial	543	4,665	58.4
Open Land	333	3,011	68.8
High Density Residential	214	1,489	21.9
Highway	168	1,359	77.9
Industrial	129	1,115	14.0
Medium Density Residential	79.0	650.0	9.30
TOTAL	7,650	52,310	1,360

[1]These estimates do not consider loads from point sources or septic systems.

It is important to note pollutant loads presented in **Table A-10** do not consider loads from point sources or septic systems. Additionally, in the Palmer River watershed, septic systems have been identified as a significant source of pollutant loading that is not accounted for in **Table A-10**. The 2019 Water Quality Analysis Report (FB Environmental & Horsley Witten, 2019) used the Spreadsheet Tool for Estimating Pollutant Load (STEPL) to estimate the existing TP, TN and TSS loads to the Palmer River of 21,561 lbs/yr, 79,391 lbs/yr, and 1,016 tons/yr, respectively. The STEPL model considers septic systems whereas the methodology presented above does not. Since septic systems are a significant source in the Palmer River watershed, the TP loading estimate from the 2019 Water Quality Analysis Report were used for estimating the loading reduction needed (**see Element B**).

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:

Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for TP, TN and TSS were previously presented in **Table A-10** of this WBP. *E. coli* loading has not been estimated for this WBP, because there are no known PLERs for *E. Coli*. As is explained in Element A, the loading estimates from the 2019 Water Quality Analysis Report (FB Environmental & Horsley Witten, 2019) were used for estimating the TP loading reduction needed (not the value presented in **Table A-10**. **Table B-1** presents the existing TP loading estimate (21,561 lbs/yr) from the 2019 Water Quality Analysis Report (FB Environmental & Horsley Witten, 2019).

Water Quality Goals

There are many methodologies that can be used to set pollutant load reduction goals for a WBP. Goals can be based on water quality criteria, surface water standards, existing monitoring data, existing TMDL criteria, or other data. As discussed in Element A, water quality goals for this WBP are focused on addressing the Palmer River Watershed Bacteria TMDL, the listed *E. Coli* and nutrient impairments, and observed elevated concentrations of *E. Coli* and nutrients from ambient monitoring data. A description of criteria for each water quality goal is described by **Table B-1**. Since it is not practical to estimate *E. coli* in terms of loading, the pollutant load reductions needed to achieve water quality goals are focused on TP. It is expected that BMP efforts to reduce land-used based TP loading will also result in improvements to land-use based *E. Coli* and TN in the Palmer River watershed. Additional efforts that address septic system sources will also result in improvements to non land-use based *E. Coli* and TN in the Palmer River watershed.

The proposed management measures described in Element C of this WBP are expected to reduce *E. coli*, TP and TN loads to the Palmer River; however, additional load reductions will be required to meet the water quality goals. The following adaptive sequence is recommended to establish and track water quality goals.

1. Establish an **interim goal** to reduce land use-based TP to the Palmer River by 500 lbs/yr over the next 10 years (by 2030) within the watershed.
2. Continue to maintain and expand, as feasible, the water quality monitoring in the Palmer River watershed in accordance with recommendations with the existing quality assurance project plan (QAPP) (FB Environmental & Horsley Witten, 2019c) and from Elements H&I of this WBP. Use monitoring results to

perform a trend analysis to identify if proposed Element C management measures are resulting in improvements.

3. Re-evaluate the current long-term TP load reduction goal and the *E. Coli* goal included and **Table B-1** and establish a **long-term goal** to reduce land use-based TP and to meet the *E. Coli* water quality standards over the next 20 years, leading to the delisting of segments in the Palmer River watershed from the 303(d) list. Non land-use based (i.e., septic system) improvements should also be considered when re-evaluating the *E. Coli* goal.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus	21,561 lbs/yr[3]	8,708 lbs/yr[1]	500 lbs/yr (interim goal) 12,853 lbs/yr (long-term goal)
Bacteria (*E. Coli*)	*MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading. Available data from 2016-2018 indicated an E. Coli range of 2—24,196 colonies/100 ml.*	Class B Standards[2] • Public Bathing Beaches: For *E. coli*, geometric mean of 5 most recent samples shall not exceed 126 colonies/ 100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For *E. coli*, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	Concentration-based

1. *According to the USEPA Gold Book, TP should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir. The water quality loading goal was estimated by multiplying this target maximum TP concentration (50 ug/L) by the estimated annual watershed discharge for the Palmer River watershed. To estimate the annual watershed discharge, the mean flow was used, which was estimated based on United States Geological Survey (USGS) "Runoff Depth" estimates for Massachusetts (Cohen and Randall, 1998). Cohen and Randall (1998) provide statewide estimates of annual Precipitation (P), Evapotranspiration (ET), and Runoff (R) depths for the northeastern U.S. According to their method, Runoff Depth (R) is defined as all water reaching a discharge point (including surface and groundwater), and is calculated by: P - ET = R. A mean Runoff Depth R was determined for the watershed by calculating the average value of R within the watershed boundary.*
2. *The water quality goal in the Palmer River Watershed Bacteria TMDL (MassDEP, 2004) is based on the Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013) that apply to the Water Class of the selected water body. All of the segments in the Palmer River watershed are classified as "Class B" waterbodies. See Appendix C for additional information from the Palmer River Watershed Bacteria TMDL*
3. *The existing estimated TP total load is from the Spreadsheet Tool for Estimating Pollutant Load (STEPL) model estimate from the 2019 Water Quality Analysis Report (FB Environmental & Horsley Witten, 2019).*

Element C: Describe management measures that will be implemented to achieve water quality goals

Element C: A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

Existing Management Measures

Pollutant loading modeling presented in Element A (**Table A-9**) indicates that roughly one-quarter of the total land-use based nutrient (TP and TN) loading in the watershed originates from agricultural areas. The MACD's strategy has been to implement watershed-wide farm conservation practices and agricultural BMPs. The overarching methodology of the MACD includes development and implementation of farm conservation plans that address water quality impacts from agricultural activities in the Palmer River Watershed. FB Environmental and Horsley Witten (2019a) calculated the number, type and pollutant reduction potential of the agricultural BMPs installed in each sub-basin of the Palmer River watershed using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). From 2015—2018, 28 agricultural BMPs were successfully installed in the Palmer River watershed, 11 on cropland and 17 on pasture. Several sites had multiple BMPs installed. Based on the calculations, these BMPs have resulted in a total reduction of 528 lbs/yr of TN, 149 lbs/yr of TP and 25 tons/yr of TSS as presented in **Table C-1** (FB Environmental & Horsley Witten, 2019a). The sub-basin identification numbers in **Table C-1** correspond to the sub-basins identified in **Figure A-2** in Element A of the WBP.

Table C-1: Agricultural BMP types by sub-basin (non-cumulative) and total pollutant loads without BMPs and pollutant load reductions with BMPs by sub-basin (cumulative). Based on 2018 land use. N=Nitrogen; P=Phosphorus; Sed=Sediment; Red=reduction. Dates in brackets [] indicate the years when the BMPs were installed (copied from FB Environmental & Horsley Witten, 2019a)

Sub-basin	Agricultural BMP Types [implementation years]	N Load (lbs./yr)	P Load (lbs./yr)	Sed Load (tons/yr)	N Red (lbs./yr)	P Red (lbs./yr)	Sed Red (tons/yr)	N Red (%)	P Red (%)	Sed Red (%)
CR01	No BMPs	3,116	984	25	0	0	0	0%	0%	0%
CR02	Litter Storage and Management + Livestock Exclusion Fencing + Heavy Use Area Protection [2016, 2017]	7,028	1,866	68	46	4	0	1%	0%	1%
CR03	Litter Storage and Management [2016]	8,402	2,208	92	50	5	0	1%	0%	0%
PM31	Diverted Drainage + Grass Swale + Critical Area Planting + Litter Storage and Management [2016, 2018]	48,790	13,556	593	97	16	3	0%	0%	0%
PM30	Litter Storage and Management + Use Exclusion + Heavy Use Area Protection + Grass Swale [2017]	51,317	14,249	619	102	17	3	0%	0%	0%
PM44	Terrace + Conservation Tillage 2 + Prescribed Grazing [2015, 2016, 2018]	54,052	14,820	675	334	98	13	1%	1%	2%
RR23	Litter Storage and Management [2016]	11,662	3,374	134	1	0	0	0%	0%	0%
RR22	Livestock Exclusion Fencing + Grass Buffer + Prescribed Grazing + Use Exclusion [2016, 2018]	18,972	5,207	240	44	7	1	0%	0%	1%
TC07	Conservation Tillage 2 x3 + Prescribed Grazing x2 + Critical Area Planting [2015, 2016, 2018]	4,776	1,252	78	114	42	10	2%	3%	13%
TC08	No BMPs	309	40	6	0	0	0	0%	0%	0%
PM29	Conservation Tillage 2 + Prescribed Grazing [2016]	79,009	21,462	1,012	528	149	25	1%	1%	3%
PM43	No BMPs	79,391	21,561	1,016	528	149	25	1%	1%	2%

Future Management Measures

As discussed by **Element B**, it is recommended that future planning initially focus on water quality goals related to *E. coli* and nutrients in the Palmer River Watershed. The MACD technical providers will continue to work with farmers to develop and implement comprehensive farm conservation plans that outline a full suite of water quality BMPs necessary to prevent or remediate nonpoint source pollution generated by farm activities (see **Table C-1** for BMP examples). MACD will implement plans on each farm once the plan is completed and approved. Implementation of the plans may include construction of new BMPs and/or maintenance or renovation of existing BMPs. The farm conservation plans developed will be approved by the NRCS. The MACD has also added a wildlife assessment during the development of the plans since it has become evident that the presence of non-migratory Canadian geese may be contributing to water quality issues.

Based on the ranking analysis described in Element A, historically the most degraded water quality was identified at CR03, CR02, RR22, PM44, and TC07 (see **Figure A-2** for locations). It was concluded that the poor water quality at these locations was likely due to the dominance of agricultural landuse in these sub-basins. Significant work to remediate these sources has already been accomplished in many of the sub-basins to the twelve monitored sites as presented in **Table C-1**. Additionally, the 2019 Water Quality Analysis Report recommended that CR03, TC07, and RR22 be investigated further for septic system failures (FB Environmental & Horsley Witten, 2019).

Continuing to implement agricultural BMPs, along with incorporating structural BMPs (e.g. LID practices) on new and existing development, and investigation and remediation of potential human sources such as failing septic systems will be necessary to achieve a measurable and sustainable improvement in water quality in the Palmer River (FB Environmental & Horsley Witten, 2019). The following general sequence is also recommended to identify and implement future structural and agricultural BMPs. Note this approach applies largely to non-agricultural BMPs as MACD has significant local knowledge and relationships with the agricultural community which would guide any future agricultural BMP implementation.

1. **Identify Potential Implementation Locations:** Perform a desktop analysis using aerial imagery and GIS data to develop a preliminary list of potentially feasible implementation locations based on land use; soil type (i.e., hydrologic soil groups A and B); available public open space (e.g., lawn area in front of a police station); potential redevelopment sites where additional public-private partnerships may be leveraged; and other factors such as proximity to receiving waters, known problem areas, or publicly owned right of ways or easements. Priority should be given to the sub-basins noted above (i.e., CR03, CR02, RR22, PM44, and TC07).
2. **Visit Potential Implementation Locations:** Perform field reconnaissance, preferably during a period of active runoff-producing rainfall, to evaluate potential implementation locations, gauge feasibility, and identify potential BMP ideas. During field reconnaissance, assess identified locations for space constraints, potential accessibility issues, presence of mature vegetation that may cause conflicts (e.g., roots), potential utility conflicts, site-specific drainage patterns, and other factors that may cause issues during design, construction, or long-term maintenance.
3. **Develop BMP Concepts:** Once potential BMP locations are conceptualized, use the BMP-selector tool on the watershed-based planning tool to help develop concepts. Concepts can vary widely. One method is to develop 1-page fact sheets for each concept that includes a site description, including definition of the problem, a description of the proposed BMPs, annotated site photographs with conceptual BMP design details, and a discussion of potential conflicts such as property ownership, O&M requirements, and permitting constraints. The fact sheet can also include information obtained from the BMP-selector tool including cost estimates, load reduction estimates, and sizing information (i.e., BMP footprint, drainage area, etc.).

4. **Rank BMP Concepts:** Once BMP concepts are developed, perform a priority ranking based on site-specific factors to identify the implementation order. Ranking can include many factors including cost, expected pollutant load reductions, implementation complexity, potential outreach opportunities and visibility to public, accessibility, expected operation and maintenance effort, and others.

Prioritized BMP concepts should focus on reducing *E. coli* and nutrient loading to the Palmer River as summarized by **Element B.**

Note that planned BMPs can also be non-structural (e.g., street sweeping, catch basin cleaning). It is recommended that these municipal programs be evaluated and potentially optimized. First, it is recommended that potential pollutant load removals from ongoing activities be calculated in accordance with **Element H&I**. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Recently Completed Management Measures

The costs and funding sources used to implement the recently completed agricultural BMPs (2015—2018) in the Palmer River watershed are presented in **Table D-1**.

The Palmer River Watershed is designated as a Massachusetts' Priority Watershed under the National Water Quality Initiative (NWQI grant program). Through the NWQI, the Natural Resources Conservation Service (NRCS) offers financial and technical assistance to farmers, ranchers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams. NRCS helps producers implement conservation and management practices through a systems approach to control and trap nutrient and manure runoff. Qualified producers receive assistance for installing conservation practices such as cover crops, filter strips and terraces. NRCS conservation professionals provide technical assistance and planning tools to farm-owners to determine which conservation actions will provide the best results to improve water quality. Nutrient management systems, erosion control, conservation tillage, pest management, and buffers systems are just some of the practices being offered as part of the NWQI. To help install these conservation practices, financial assistance to share in the cost of these conservation practices is available through the Environmental Quality Incentives Program (EQIP). Between 2015—2018, approximately $1,592,000 in EQIP grant funding has been awarded to farms throughout the Palmer River watershed to implement agricultural BMPs (USDA, NRCS, 2020).

Other state and federal entities are engaging to support the NWQI effort, including the MassDEP and the MACD. MassDEP, through its 319 Nonpoint Source Program, has also provided technical and financial resources. MACD, through its Accelerated Conservation Planning Program (ACPP) has field staff who are engaged to work with Palmer River farmers to develop and implement conservation planning practices and nonpoint source BMPs to address NWQI goals (MACD, 2016a). Additional funding sources include the NRCS Agricultural Management Assistance (AMA) program; the Massachusetts Agricultural Environmental Enhancement Program (AEEP); and the Agricultural Produce Safety Improvement Program (APSIP).

Table D-1: Completed BMP Implementation Projects and Costs

Fiscal Year	Farming Operation Type	Funding Source[3]					Total Cost	Completed Practices
		EQIP	AMA	AEEP	APSIP	319		
2015	Dairy	$141,788				$3,500	$145,288	HUA roof, curbing, gutters, subsurface drain, fencing
	Mixed Vegetables	$10,102		$5,500	$15,810		$31,412	Grassed waterway, subsurface drain, vegetable washing
	Mixed Vegetables			$15,000	$7,500		$22,500	Fuel storage, vegetable packing bins
	Mixed Vegetables				$3,499		$3,499	Vegetable washing station
	Mixed Vegetables		$29,000		$12,375		$41,375	Irrigation pump, deer fencing
	Equine	$1,887					$1,887	Gutters, subsurface drain
2016	Dairy, Mixed Vegetables	$259,000		$10,999			$269,999	Fuel storage
	Cattle					$3,749	$3,749	Fencing
	Dairy	$143,000		$15,000		$14,250	$172,250	Manure storage, gutters, subsurface drains
	Dairy	$308,000		$15,000		$18,000	$341,000	Manure storage, leachate, and milk house waste filtering
	Cattle	$100,000				$28,000	$128,000	HUA pad, roof, gutters, subsurface drainage
	Equine	$50,000					$50,000	Subsurface drainage, fencing
	Mixed Vegetables				$20,000		$20,000	Washing and packing facility
	Mixed Vegetables	$12,000			$7,522		$19,522	Ebb and flow benches, subsurface drainage, bins, refrigeration
2017	Cattle	$271,284					$271,284	CNMP, roofed bedded pack, roof run-off, stream crossing, fencing
	Cattle	$131,485					$131,485	CNMP, roofed bedded pack, underground drainage, stream crossing
	Dairy	$91,755				$2,500	$94,255	Roofed bedded pack, roof run-off, microbes
	Dairy					$1,000	$1,000	Microbes
	Mixed Livestock	$69,990					$69,990	CNMP, roofed bedded pack, roof run-off, fencing
	Mixed Livestock	$11,122					$11,122	Fencing, stream crossing
2018	Dairy, Mixed Vegetables			$16,400	$13,000		$29,400	Reception pit, vegetable storage bins
	Mixed Vegetables				$20,000		$20,000	Vegetable refrigeration and processing area

[3] The following acronyms are funding sources for these implemented BMPs: EQIP is the Environmental Quality Incentives Program; AMA is the Agricultural Management Assistance; AEEP is the Agricultural Environmental Enhancement Program; APSIP is the Agricultural Produce Safety Improvement Program; 319 is the Massachusetts Department of Environmental Protection Section 319 Nonpoint Source Pollution Grant Program.

Future Management Measures

Funding for future BMP installations to further reduce loads within the watershed may be provided by a variety of sources, such as the EQIP, Section 319 Nonpoint Source Pollution Grant Program, town capital funds, or other grant programs. The MACD has previously been successful with and will continue to pursue securing grant funding through various sources. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts[4].

[4] Guidance on funding sources to address nonpoint source pollution:
http://prj.geosyntec.com/prjMADEPWBP_Files/Guide/Element%20D%20-%20Funds%20and%20Resources%20Guide.pdf

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Provide information about completed and proposed stormwater and agricultural BMPs and their anticipated water quality benefits.
2. Provide information to promote watershed stewardship.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. All watershed residents.
2. Businesses, schools, and local government within the watershed.
3. Farmers within the watershed.
4. Watershed organizations and other user groups, including the Rehoboth Agricultural Commission.

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Host workshops (examples include equine workshop, soil health workshop)
2. Host farm tours highlighting agricultural BMPs
3. Broadcast meetings with the Rehoboth Agricultural Commission on community television
4. Print and web-based fact sheets and media

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of workshops and farm tours and the attendance at each.
2. Track the number of materials and information, such as fact sheets and emails, and the size of the lists receiving these materials.
3. Track the farms who receive funding and from what sources.

As part of the Palmer River Project, the MACD created an educational video which demonstrates the benefits of implementing agricultural BMPs to preserve and protect the water quality of the Palmer River. In hopes of educating a broad audience, it shares what is being done by the agricultural community including information on agricultural BMPs. The video aids environmental regulators interested in understanding more about conducting farmer outreach, and targets farmers who may be hesitant about working with government agencies on the benefits of incorporating conservation practices on their farms. The video can be found online at: https://youtu.be/jrbtadraSyc.

Additional outreach products will be determined when future management measures and activities are planned for implementation in the watershed. This section of the WBP will be updated when the plan is re-evaluated in 2023 in accordance with Element F&G.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

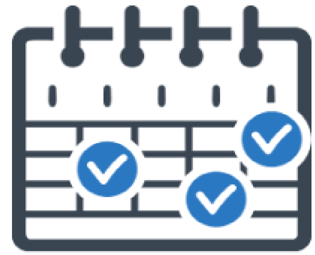

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2023, or as needed, based on ongoing monitoring results and other ongoing efforts. New projects for further implementation of the WBP will be identified through future data analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones

Category	Action	Cost Estimate	Year(s)
Monitoring	Evaluate success of BMP implementation through results of water quality data. MADEP and Rhode Island Department of Environmental Management (RIDEM) water quality monitoring of watershed provides baseline prior and during project implementation. MACD will continue to participate in the annual meetings of these two agencies to help pinpoint BMP implementation.	$5,000	2017-2020
Develop and Implement Farm Conservation Plans	MACD technical providers will continue to work with farmers to develop and implement comprehensive farm conservation plans that outline a full suite of water quality BMPs necessary to prevent or remediate nonpoint source pollution generated by farm activities. MACD will implement plans on each farm once the plan is completed and approved. Implementation of the plans may include construction of new BMPs and/or maintenance or renovation of existing BMPs. All farm conservation plans developed through this project shall be approved by the NRCS. MACD technical staff and subcontractors will develop overall baseline data on land use and status of farm conservation plans in the watershed. To the maximum extent possible, MACD providers will secure landowner permission to release project details for the purpose of project reporting.	$91,000	2017-2020
Provide Technical and Regulatory Support	Work with Agricultural Commissions in the Palmer River watershed to encourage and facilitate farmer participation in grant programs. Develop dialogue between and among farmers, federal, state, and local agencies to address agricultural water quality issues. Long term, this aspect of the project will provide government officials with a better understanding of how regulations help and/or hinder the ability of farmers to plan and implement conservation practices. This information will lead to Regulatory Certainty for farmers so that they know what they can/should do to implement BMPs and not trigger punitive action.	$30,900	2017-2020
Public Education and Outreach	Continue outreach and dialogue with residents, businesses, schools, local government, farmers, and watershed organizations in the watershed to share what is being done by the agricultural community to preserve and protect the water quality of the Palmer River watershed utilizing workshops, tours, web-based media, print media and local access TV.	$20,500	2017-2020
Access to Resources	Farmers often need assistance in obtaining bridge financing before BMP implementation can begin. They do not have the cash necessary to "front" the money for implementation and then wait for the reimbursement from the grant. MACD staff assists farmers in obtaining bridge financing, especially for projects with a total installation cost exceeding $100,000. This work took more MACD time than expected and will need to be factored in any future grant. MACD will continue to educate farmers about available financial and technical resources for enhanced water quality protection and will continue to assist the farmers with obtaining grant funding and implementing BMPs.	$380,000	2017-2020
Evaluation, reporting and oversight	Evaluate program successes and challenges, perform project oversight and reporting.	$19,000	2017-2020
Adaptive Management and WBP Updates	Establish working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.	--	2021
	Re-evaluate Watershed Based Plan at least once every three (3) years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, funding, etc.). – Next update, June 2023	--	2023
	Reach interim water quality goal	**--**	**2030**
	Reach long-term goal to de-list Palmer River from the 303(d) list	**--**	**2040**

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The interim loading reduction goal of 500 lb/yr of TP is presented in Element B of this WBP. Element C of this plan describes management measures that have been and will be implemented to help achieve this targeted load reduction. The evaluation criteria and monitoring program described below will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of the Palmer River and in making progress toward achieving the water quality goals.

Indirect Indicators of Load Reduction

Non-Structural BMPs

Potential load reductions from non-structural BMPs (i.e., street sweeping and catch basin cleaning) can be estimated from indirect indicators, such as the number of miles of streets swept or the number of catch basins cleaned. As summarized by Figure HI-1 and HI-2, Appendix F of the 2016 Massachusetts Small MS4 General Permit provides specific guidance for calculating phosphorus removal from these practices. As indicated by **Element C**, it is recommended that potential phosphorus removal from these ongoing actives be estimated. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

$$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{sweeping}} \times \text{AF} \qquad \textbf{(Equation 2-1)}$$

Where:

$\text{Credit}_{\text{sweeping}}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)

IA_{swept} = Area of impervious surface that is swept under the enhanced sweeping program (acres)

$\text{PLE}_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

$\text{PRF}_{\text{sweeping}}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-3).

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Table 2-3: Phosphorus reduction efficiency factors ($\text{PRF}_{\text{sweeping}}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	$\text{PRF}_{\text{sweeping}}$
2/year (spring and fall)[2]	Mechanical Broom	0.01
2/year (spring and fall)[2]	Vacuum Assisted	0.02
2/year (spring and fall)[2]	High-Efficiency Regenerative Air-Vacuum	0.02
Monthly	Mechanical Broom	0.03
Monthly	Vacuum Assisted	0.04
Monthly	High Efficiency Regenerative Air-Vacuum	0.08
Weekly	Mechanical Broom	0.05
Weekly	Vacuum Assisted	0.08
Weekly	High Efficiency Regenerative Air-Vacuum	0.10

Figure HI-1. Street Sweeping Calculation Methodology

$$\text{Credit}_{\text{CB}} = \text{IA}_{\text{CB}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{CB}} \qquad \textbf{(Equation 2-2)}$$

Where:

$\text{Credit}_{\text{CB}}$ = Amount of phosphorus load removed by catch basin cleaning (lb/year)

IA_{CB} = Impervious drainage area to catch basins (acres)

$\text{PLE}_{\text{IC-and use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

PRF_{CB} = Phosphorus Reduction Factor for catch basin cleaning (see Table 2-4)

Table 2-4: Phosphorus reduction efficiency factor (PRF_{CB}) for semi-annual catch basin cleaning

Frequency	Practice	PRF_{CB}
Semi-annual	Catch Basin Cleaning	0.02

Figure HI-2. Catch Basin Cleaning Calculation Methodology

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates:

Anticipated pollutant load reductions from existing, ongoing (i.e., under construction), and future BMPs will be tracked as BMPs are installed. For example, the agricultural BMPs that were implemented between 2015—2018 have an estimated TP load reduction of 149 lbs/yr.

TMDL Criteria

The Bacteria TMDL encouraged continued water quality monitoring in the Palmer River basin in order to help monitor trends in bacteria concentrations and verify that implementation of controls is leading to compliance with water quality standards. The Bacterial TMDL recommendation states that the monitoring "could be conducted on a seasonal basis, structured to include at high-flow and one low-flow periods. These programs would best be implemented by town conservation and health agents, with assistance from the Palmer River Watershed Alliance, Save the Bay, and MADEP. MADEP will also continue to monitor water quality in the watershed through its rotating basin assessment cycle" (MassDEP, 2004).

Direct Measurements

Direct measurements are generally expected to be performed in accordance with the existing QAPP for the Palmer River watershed (FB Environmental & Horsley Witten, 2019c) and as described below.

River Sampling

Regular sampling will continue to understand the water quality in the Palmer River Watershed, including determining sources for pollution and tracking achievements toward water quality goals, including analysis of *E. coli*, TP, and TN. Additional parameters such as chlorophyll-a, dissolved oxygen, temperature, conductivity, pH, and flow rate could provide additional data for consideration. If possible, obtain sampling at locations directly downstream of implemented BMPs to determine the impact of implemented BMPs within the watershed. Monitoring locations should be selected based on accessibility and representativeness and shall be appropriate to quantify water quality improvements in the watershed.

Adaptive Management

As discussed by Element B, the baseline monitoring program will be used to evaluate and establish a long-term (i.e., 20-year) *E. coli* and TP load reduction goal (or other parameter(s) depending on results). Long-term goals will be re-evaluated at least **once every three years** and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the *E. coli* and TP concentrations and other indicators (e.g., chlorophyll-a) measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

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Appendix

Appendix A – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27
INDUSTRIAL, HSG B	0.12	29.4	1.16

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			

Appendix B – Select Excerpts from Water Quality Assessment Report (MassDEP, 2009)

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-04 - Palmer River)
Aquatic Life Habitat and Flow The new fishway at Shad Factory Pond Dam was completed in December 2007 after seven years of planning, design, and fundraising (Save The Bay 2007). Low flows have been raised as a concern for the Palmer River from the confluence of the East and West Branches of the Palmer River to Route 6 in Rehoboth by the Narragansett Bay Estuary Program (NBEP 2008). Biology The Palmer River supports one of the few small stream American shad (Alosa sapidissima) fisheries in the Commonwealth and the only one south of Cape Cod. In addition, an increasingly important river herring (Alosa sp.) fishery exists here as do rainbow smelt (Osmerus mordax) and white perch (Morone americana) populations. While herring utilize the fishway to spawn above the Shad Factory Pond dam, the other species successfully spawn in the section of river below the dam. Too limited data are available so the Aquatic Life Use in not assessed. **Report Recommendations:** Monitoring (fish counts and observations) should be conducted to evaluate the success of the new fish ladder at Shad Factory Pond. Flow monitoring should be conducted to define NBEP concerns about low flows.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-07 - West Branch Palmer River)
Aquatic Life Habitat and Flow The Perryville Dam is the one obstruction to fish passage on the West Branch Palmer River. According to DMF there is little value in providing fish passage at the Perryville Dam due to the lack of significant upstream habitat (Reback et al. 2004). The Aquatic Life Use is not assessed (too little data). **Report Recommendations:** Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-16 - Rocky Run)

Aquatic Life
Habitat and Flow
There are no obstructions to fish passage along Rocky Run (Reback et al. 2004).

Biology
River herring and rainbow smelt have been observed in Rocky Run; however no significant spawning area exists for either species (Reback et al. 2004).

Too limited data are available so the Aquatic Life Use is not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-11 - Bad Luck Brook)

Aquatic Life
Habitat and Flow
There are two obstructions to fish passage along Bad Luck Brook, the Upper Warren Reservoir Dam and Bad Luck Brook Dam. The reservoir, which offers a substantial potential spawning area, is owned by the Anawan Club and leased to the Bristol County Water Authority for an auxiliary water supply (Reback et al. 2004).

The Aquatic Life Use is not assessed (too little data). This use is identified with an Alert Status because of the impediments to fish passage.

Report Recommendations:
The need to improve passage at the Village Dam on the East Branch Palmer River, install fishways at a private dam on County Street (Bad Luck Brook Dam), and at the Upper Warren Reservoir Dam, in addition to insuring outflow from the reservoir during migration periods, make development of this system difficult and costly despite the substantial potential spawning area (Reback et al. 2004).

Conduct water quality monitoring (physico-chemical and bacteria) to evaluate the status of the Aquatic Life, Recreational and Aesthetics uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-08 - East Branch Palmer River)

Aquatic Life
Habitat and Flow
There is one obstruction to fish passage along the East Branch Palmer River. Village Dam at Bay State Road may be passable under some flow conditions due to a bypass channel on its east side (Reback et al. 2004).

The Aquatic Life Use is not assessed (too little data). This use is identified with an Alert Status because of the impediments to fish passage.

Report Recommendations:

According to DMF there is little spawning habitat available above Village Dam at Bay State Road and further development is a low priority (Reback et al. 2004). However, if passage into the substantial potential spawning area of Upper Warren Reservoir ever ensues, passage at Village Dam will need to be improved.

Conduct water quality monitoring (physico-chemical and bacteria) to evaluate the status of the Aquatic Life, Recreational and Aesthetics uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-09 - Rumney Marsh Brook)

No data are available so all uses are not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-10 - Beaverdam Brook)

No data are available so all uses are not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-12 - Fullers Brook)

No data are available so all uses are not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-14 - Torrey Creek)

No data are available so all uses are not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-15 - Oak Swamp Brook)

No data are available so all uses are not assessed.

Report Recommendations:
Monitoring to evaluate designated uses.

Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (MA53-13 - Clear Run Brook)

Primary and Secondary Contact Recreation and Aesthetics
Bacteria source tracking work was conducted in Clear Run Brook in 2006 (Sheppard and Meek 2007). From upstream to downstream three locations were sampled:
CR01 - Below pond at Miller Street crossing nearest Fieldwood Avenue, Seekonk
CR02 - Miller Street crossing (nearest the Rehoboth town line), Seekonk
CR03 - Providence Street, Rehoboth

[See table on page 14 of Water Quality Assessment Report]

Screening level bacteria data indicates one or more dry and wet weather sources of bacteria in the Clear Run Brook watershed between sites CR01 and CR02 (Table12). The increase in bacteria concentrations between CR01 and CR02 during dry weather was not tracked to any specific source(s). Due to the lack of storm drains and septic systems located adjacent to the brook, agriculture practices and wildlife appear to be the most likely sources. The dominant land use in this section of the watershed is cropland and forest. Cows were observed in the field southwest (upstream) of Miller Street and site CR02.

No objectionable odors were noted in Clear Run Brook at any of the three bacteria source tracking sampling locations on any of the surveys (11 May, 8 June, 18 July, 3 and 21 August and 25 September 2006 (MassDEP 2006a). The brook was noted as being either clear or slightly turbid with the exception of CR02 in September when it was described as moderately turbid. No objectionable growths of aquatic plants were observed at the most upstream sampling location and while dense/very dense growths were noted downstream (both sampling locations CR02 and CR03) these conditions are considered to be naturally occurring associated with the low gradient nature of this brook.

The Primary and Secondary Contact Recreational uses are not assessed since data validation procedures still need to be conducted on the *E. coli* dataset. These uses are both identified with an alert status, however, because of reportedly elevated *E. coli* bacteria in Clear Run Brook (Sheppard and Meek 2007). Although specific source(s) were not identified, agriculture practices (cows) appear to be the most likely source. The Aesthetics Use is assessed as support.

Report Recommendations:
Implement recommendations of Palmer River TMDL for Bacteria (Murphy 2004 and MassDEP 2004) that are appropriate to Clear Run Brook.

Data validation procedures should be conducted for the bacteria source tracking work conducted in 2006.

Conduct water quality monitoring (physico-chemical and bacteria) to evaluate the status of the Aquatic Life, Recreational and Aesthetics uses.

Appendix C – Select Excerpts from The Palmer River Bacteria TMDL (MassDEP, 2004)

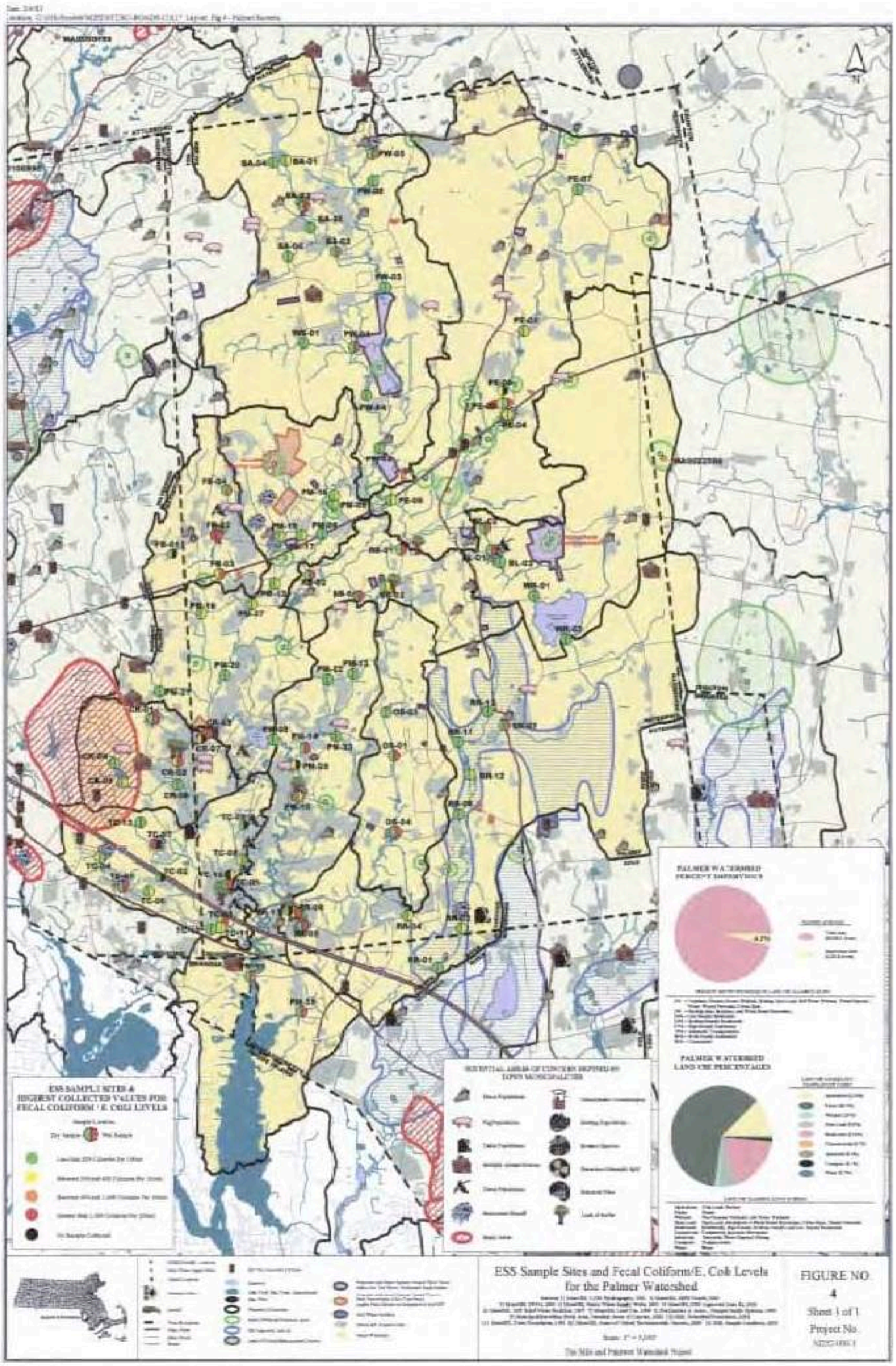
ESS Sample Sites and Fecal Coliform/E. Coli Levels
for the Palmer Watershed
FIGURE NO.
4
Sheet 1 of 1
Project No.
PALMER WATERSHED
PERCENT IMPERVIOUS
PALMER WATERSHED
LAND USE PERCENTAGES
ESS SAMPLE SITES &
HIGHEST COLLECTED VALUES FOR
FECAL COLIFORM / E. COLI LEVELS

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002) (cfu/100ml)

NOTES:
Shading indicates Massachusetts Water Quality Standards (DEP, 1996) exceeded and/or extremely high count.
[1]Geometric mean to be less than or equal to 200 organisms/100 ml (Class B)
[2]No more than 10% of the samples shall exceed 400 organisms/100 ml (Class B)
[3]Geometric mean to be less than or equal to 14 organisms/100 ml (Class SA)
[4]No more than 10% of the samples shall exceed 43 organisms/100 ml (Class SA)

Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Palmer River - West Branch	PW01	ESS	335	40%	170	660	70%	50%	660	39%
	PW02	ESS/DEP	44	0%	37	75	0%	0%	130	0%
	PW03	ESS	137	0%	110	170	0%	0%	170	0%
	PW04	ESS	19	0%	8	44	0%	0%	44	0%
	PW05	ESS	119	0%	19	740	73%	50%	740	46%
	PW06	ESS	3	0%	1	7	0%	0%	7	0%
	WB01	ESS	1	0%	1	No sample	NA	0%	1	0%
	BA01	ESS	55	0%	7	430	53%	50%	430	7%
	BA02	ESS	66	0%	1	8,800	98%	50%	8,800	95%
	BA03	ESS	189	0%	54	660	70%	50%	660	39%
	BA04	ESS	1	0%	1	4	0%	0%	4	0%
	BA05	ESS	18	0%	21	16	0%	0%	21	0%
	BA06	ESS	1	0%	1	1	0%	0%	1	0%
Palmer River - East Branch	PE03	ESS	186	0%	302	70	0%	0%	380	0%
	PE04	ESS	320	37%	369	240	17%	0%	390	0%
	PE05	ESS	48	0%	9	260	23%	0%	260	0%
	PE06	ESS/DEP	179	0%	125	370	46%	33%	1,300	69%
	PE07	ESS	6	0%	2	19	0%	0%	19	0%
	PE08	ESS	24	0%	10	57	0%	0%	57	0%
	PE09	ESS	390	49%	390	No sample	NA	0%	390	0%
Rumney Marsh Brook and Beaver Dam Brook	RB01	ESS	107	0%	6	1,900	89%	50%	1,900	79%
	RB02	ESS	832	76%	77	9,000	98%	50%	9,000	96%
	BB01	ESS	438	54%	16	12,000	98%	50%	12,000	97%
	BB02	ESS	76	0%	22	260	23%	0%	260	0%
Bad Luck Brook and Warren Upper Reservoir	BL01	ESS	464	57%	1	1,667	88%	67%	42,000	99%
	BL02	ESS	125	0%	33	470	57%	50%	470	15%
	BL03	ESS	150	0%	No sample	150	0%	0%	150	0%
	WR01	ESS	21	0%	21	21	0%	0%	22	0%
	WR02	ESS	No Flow	NA	No Flow	No Flow	NA	NA	No Flow	NA
	WR03	ESS	6	0%	12	3	0%	0%	12	0%
Fullers Brook	FB01	ESS	56	0%	56	No sample	NA	0%	56	0%
	FB02	ESS	85,337	100%	36,641	95,917	100%	100%	220,000	100%
	FB03	ESS	40,000	100%	310	22,000	99%	50%	22,000	98%
	FB04	ESS	64	0%	10	415	52%	50%	500	20%
Clear Run Brook	CR01	ESS	512	61%	12	3,341	94%	67%	18,000	98%
	CR02	ESS	759	74%	282	2,040	90%	50%	3,200	88%
	CR03	ESS/DEP	1,186	83%	455	13,000	98%	50%	13,000	97%

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002)(cfu/100ml)

NOTES:
Shading indicates Massachusetts Water Quality Standards (DEP, 1998) exceeded and/or extremely high count.
[1]Geometric mean to be less than or equal to 200 organisms/100 ml (Class B)
[2]No more than 10% of the samples shall exceed 400 organisms/100 ml (Class B)
[3]Geometric mean to be less than or equal to 14 organisms/100 ml (Class SA)
[4]No more than 10% of the samples shall exceed 43 organisms/100 ml (Class SA)

Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Clear Run Brook	CR04	ESS	95	0%	57	160	0%	0%	160	0%
	CR05	ESS	65	0%	19	120	0%	0%	270	0%
	CR06	ESS	72	0%	76	68	0%	0%	76	0%
	CR07	ESS	320	38%	320	No sample	NA	0%	320	0%
Palmer River-Main Stem	PM05	ESS	92	0%	61	210	5%	0%	210	0%
(Upstream of Shad Factory Pond Outlet)	PM06	ESS	79	0%	59	140	0%	0%	140	0%
	PM07	ESS	136	0%	87	330	39%	0%	330	0%
	PM12	ESS	85	0%	47	280	29%	0%	280	0%
	PM16	ESS	66	0%	17	260	23%	0%	260	0%
	PM17	ESS	49	0%	12	200	0%	0%	200	0%
	PM18	ESS	164	0%	73	370	46%	0%	370	0%
	PM19	ESS	83	0%	37	185	0%	0%	210	0%
	PM20	ESS	65	0%	30	140	0%	0%	160	0%
	PM21	ESS	47	0%	25	87	0%	0%	87	0%
	PM24	ESS	No Flow	NA	No Flow	No Flow	NA	NA	No Flow	NA
Torrey Creek	TC01	ESS	317	37%	70	524	62%	67%	24,000	98%
	TC02	ESS	10	0%	10	No sample	NA	0%	10	0%
	TC03	ESS	296	33%	84	1,050	81%	25%	3,800	89%
	TC04	ESS	99	0%	200	49	0%	0%	200	0%
	TC05	ESS	257	22%	110	1,100	82%	33%	1,100	64%
	TC06	ESS	100	0%	36	280	29%	0%	280	0%
	TC07	ESS	263	24%	263	No sample	NA	50%	1,000	60%
	TC08	ESS	89	0%	200	40	0%	0%	200	0%
	TC09	ESS	10	0%	10	No sample	NA	0%	10	0%
	TC10	ESS	200	0%	No sample	200	0%	0%	200	0%
	TC11	ESS	273	27%	340	220	9%	0%	340	0%
	TC12	ESS	138	0%	100	190	0%	0%	190	0%
	TC13	ESS	3	0%	1	11	0%	0%	11	0%
Oak Swamp Brook	OS01	ESS	542	63%	140	2,100	90%	50%	2,100	81%
	OS03	ESS	41	0%	42	40	0%	0%	42	0%
	OS04	ESS	140	0%	15	1,300	85%	50%	13,000	97%
Rocky Run	RR01	ESS	35	0%	20	60	0%	0%	60	0%
	RR02	ESS	144	0%	80	260	23%	0%	260	0%
	RR04	ESS	90	0%	28	290	31%	0%	290	0%
	RR05	ESS/RIDEM	552	64%	366	5,254	96%	69%	1,280	69%
	RR06	ESS/RIDEM/ DEP/DMF	422	53%	331	822	76%	50%	0	0%
	RR07	ESS	23	0%	1	520	62%	50%	520	23%

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002)(cfu/100ml)

NOTES:
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Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Rocky Run	RR08	ESS	11	0%	1	130	0%	0%	130	0%
	RR10	ESS	11	0%	33	4	0%	0%	33	0%
	RR11	ESS	15	0%	74	3	0%	0%	74	0%
	RR12	ESS	179	0%	140	230	13%	0%	230	0%
	RR13	ESS	130	0%	130	No sample	NA	0%	130	0%
Palmer - Tributary to Mainstem	PM14	ESS	96	0%	63	142	0%	25%	3,100	87%
(Downstream of the Shad Factory Pond Outlet)	PM22	ESS	11	0%	56	2	0%	0%	56	0%
	PM23	ESS	25	0%	26	24	0%	0%	30	0%
Water Body (Class SA)	**Station**	**Collecting Agency/ Organization**	**Geometric Mean (overall wet and dry) (cfu/100 ml)**	**% Reduction (overall wet and dry)[3]**	**Dry Weather Geometric Mean (cfu/100 ml)**	**Wet Weather Geometric Mean (cfu/100 ml)**	**Wet Weather % Reduction**	**% of Samples > 43 cfu/100 ml[4]**	**90% Observation (cfu/100 ml)**	**% Reduction for 90% Observation[4]**
Palmer River - Main Stem	PM08	ESS/RIDEM/ DEP/DMF	173	92%	195	155	91%	91%	957	96%
(Downstream of the Shad Factory Pond Outlet)	PM26	ESS	230	94%	230	No sample	NA	100%	230	81%
	PM10	ESS/DMF	188	93%	140	315	96%	100%	450	90%
	PM11	ESS/DEP/DMF	180	92%	126	444	97%	71%	1,600	97%
	PM25	ESS	278	95%	145	406	97%	100%	1,100	96%