1. PROJECT MANAGEMENT – ORGANIZATION & RESPONSIBILITIES

1.1 Title and Approval Page

Secondary Data Quality Assurance Project Plan (QAPP)
for the Palmer River Source Tracking, Water Quality Trends Summary, and Watershed Plan

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Nora Conlon, EPA QA Reviewer

Date: 2-7-2019
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Forrest Bell, FBE Principal

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1.3 QAPP Distribution List

The following distribution list is comprised of all personnel accountable for the outcome of the project, including those involved in gathering and evaluating secondary data and ultimately using the project results, who will receive the approved QAPP and any subsequent revisions or amendments (Table 1).

Table 1. Quality Assurance Project Plan (QAPP) distribution list. MassDEP = Massachusetts Department of Environmental Protection. RIDEM = Rhode Island Department of Environmental Management.

Name	Title / Project Role	Affiliation	Email	Phone
Ray Cody	Task Order Contracting Office Rep	USEPA - (Boston)	cody.ray@epa.gov	617-918-1366
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Tracey Orciuch	Project Support (Admin)	Horsley Witten Group	torciuch@horsleywitten.com	508-833-6600
Forrest Bell	Principal & Senior Scientist	FB Environmental Associates	info@fbenvironmental.com	207-650-7597
Laura Diemer	Project Manager	FB Environmental Associates	laurad@fbenvironmental.com	603-828-1456
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1.4 Project Organization

The Palmer River Source Tracking, Water Quality Trends Summary, and Watershed Plan project is being funded by US EPA Region 1 under BPA Contract No. 68HE0118A0002, Task Order No. 68HE0118F00010, which was awarded to Horsley Witten Group (HWG) and subcontractor FB Environmental Associates (FBE). The project will be completed by HWG and FBE project personnel, with collaboration from US EPA Region 1 (refer to Figure 1 for project personnel organization). The principal user of the project outputs will be US EPA Region 1, as well as state agencies and municipalities.

- Ray Cody (primary) and Karen Simpson (alternative) serve as the EPA Task Order Contracting Officer Representatives.
- Ian Dombroski serves as the EPA Project Officer and the primary EPA point of contact for the project.
- Nora Conlon serves as the EPA QA Reviewer and will be responsible for review of the QAPP.

- Other EPA, RIDEM, and MassDEP staff named in Table 1 serve as project support relevant to their individual expertise (e.g., PhyloChip) or knowledge of the Palmer River watershed.
- Richard Claytor serves as the HWG President and will be responsible for ensuring overall project completion.
- Jennifer Relstab serves as the HWG Project Manager and primary consultant point of contact for the project and will be responsible for completing HWG project tasks (Tasks 1, 5, 6) and overseeing FBE project tasks.
- Tom Noble serves as the HWG QA Officer and is responsible for independent QA review of all project deliverables prior to submittal to US EPA Region 1.
- Other HWG staff named in Table 1 serve as project support relevant to their individual expertise.
- Forrest Bell serves as the FBE Principal and will be responsible for ensuring completion of FBE project tasks.
- Laura Diemer serves as the FBE Project Manager and secondary consultant point of contact for the project and will be responsible for completing FBE project tasks (Tasks 2, 3, 4).
- Other FBE staff named in Table 1 serve as project support relevant to their individual expertise.

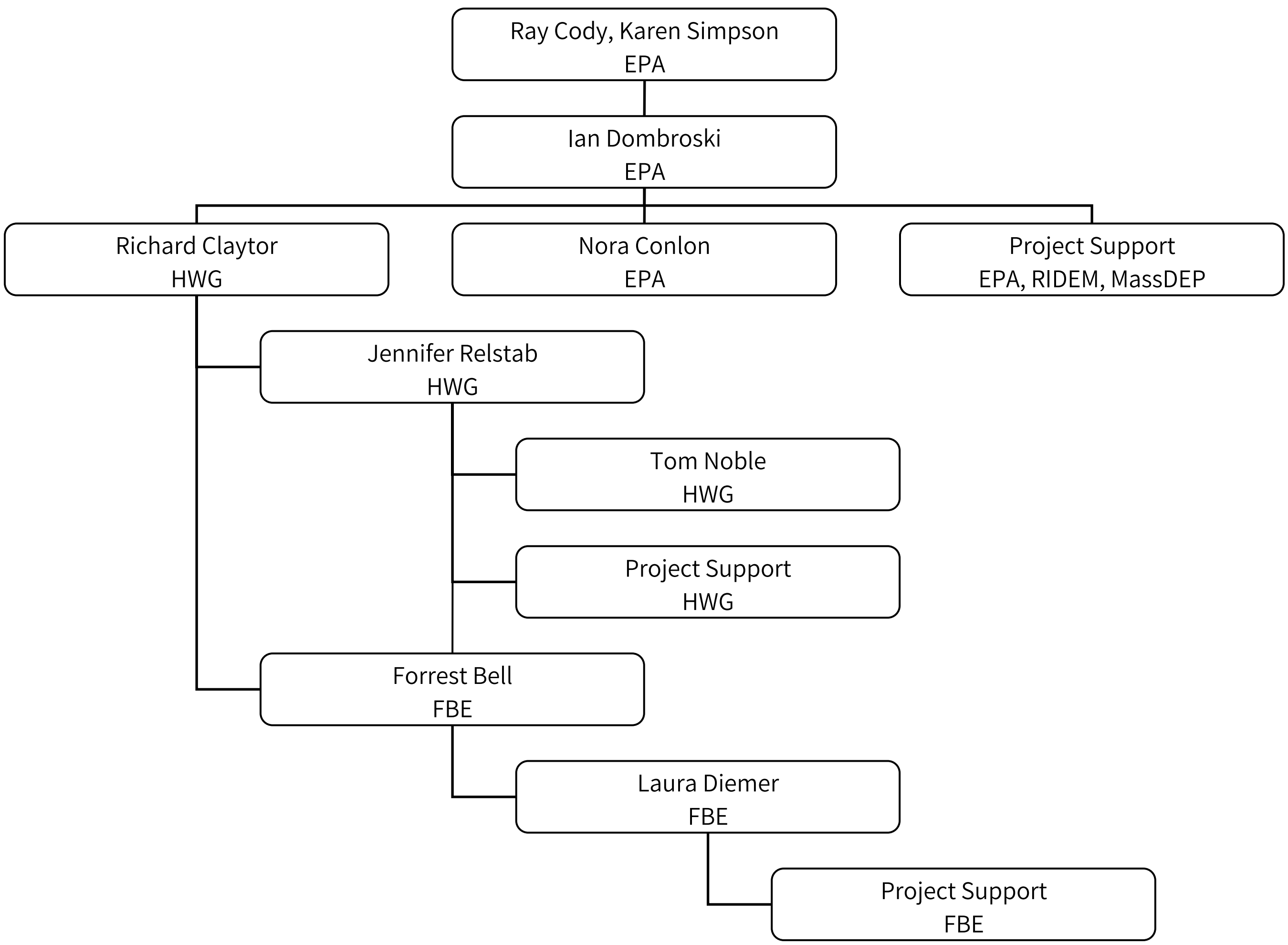

Figure 1. Organization Chart.

1.5 Purpose of Study, Background Information, and Problem Definition

The Palmer River, which flows across the Massachusetts (MA) and Rhode Island (RI) state border, is a major second order tributary in the Narragansett Bay watershed. The upper freshwater reaches of the Palmer River begin in Rehoboth, MA with the east and west branches of the river extending into Seekonk and Swansea, MA. Head of tide for the Palmer River is at the outlet of the Shad Factory Pond Dam, downstream of which the Palmer River joins with the Barrington River at Tyler Point in RI to form the Warren River before emptying into the Narragansett Bay. While still dominated by forest, the Palmer River watershed contains significant agriculture and development and faces increasing development pressure. In 1992, the Palmer River was listed as impaired by RIDEM for recreation and shellfish consumption due to elevated levels of fecal indicator bacteria. In 2002 and 2004, a total maximum daily load (TMDL) was approved for the Palmer River watershed in RI (fecal coliform) and MA (*E. coli*), respectively (RIDEM, 2002; ESS Group Inc, 2004). The 2004 MA TMDL study found that 33 out of 88 sampling stations along the Palmer River violated state criteria for fecal indicator bacteria. The Palmer River also exhibited elevated levels of total suspended solids (TSS) and nutrients (nitrogen and phosphorus). In 2010, RIDEM issued nitrogen permit limits to two point-sources in the Warren River to address nutrient and dissolved oxygen impacts to the Palmer River. The permit development document describes the methodology used (see Table 3 in Section 2.1). In response to the TMDL studies, a watershed management plan for the Barrington-Palmer-Warren Rivers was developed by FBE for US EPA Region 1 in 2012 (FBE, 2012).

Following these studies, the Palmer River watershed was included in the National Water Quality Initiative (NWQI) to abate fecal contamination through the installation of agricultural conservation practices or best management practices (BMPs). Since 2012, the Massachusetts Department of Environmental Protection (Mass DEP), the Rhode Island Department of Environmental Management (RIDEM), and US EPA Region 1 have collected monthly water quality samples at 12 fixed stations within the lower Palmer River watershed. These include four saline and eight freshwater stations, with three stations on Clear Run sampled for *E. coli*, three stations on the main stem sampled for Enterococci, and the remaining six stations sampled for both parameters. All sites were also sampled for TSS and nutrients. Beginning in 2017, samples were collected for ribonucleic acid (RNA) microarray analysis using PhyloChip[1] and are awaiting analysis. Correlating routine water quality monitoring with the installation of agricultural BMPs allows these agencies to monitor the effectiveness of remediation efforts. However, much of the water quality data collected since the 2004 TMDL study have yet to be evaluated for trends, and the current status of water quality and the effectiveness of agricultural BMP implementation work in the watershed are unknown.

The purpose of the project is to assist US EPA Region 1 with: (1) developing recommendations for use of the PhyloChip to maximize the ability to identify fecal contamination sources with limited resources; (2) analyzing water quality trends in the Palmer River watershed using existing water quality data, geospatial information, and summary papers; and (3) assessing the impact that changing land use is expected to have in the Palmer River watershed and providing recommendations for reducing the impacts of land development on water quality.

Results will be used by US EPA Region 1, state agencies, and local municipalities to 1) revise the current water quality monitoring program, including site selection and parameters (e.g., use of PhyloChip), 2) apply water quality monitoring strategies for use of PhyloChip as a source tracking method in other regional watersheds in the Southeast New England Program (SNEP), 3) determine the water quality status of the Palmer River (e.g., improving, degrading) and its relationship to agricultural BMPs on the landscape, 4) better inform future effectiveness and placement of agricultural BMP work in the watershed, and 5) revise local land use regulations to better protect water quality.

1.6 Overview of Project Tasks

The full scope of work with detailed project task descriptions can be found in the HWG-FBE Response to Solicitation, dated September 25, 2018 (HWG & FBE, 2018). An overview of the project tasks with relevant details is provided below.

Task 1: Project Management and Administration: HWG and FBE will participate in regular conference calls with US EPA Region 1 to discuss project status.

[1] The PhyloChip is a rapid, high throughput, DNA microarray based on probing environmental samples for the 16S rRNA gene. The main benefits of using the PhyloChip over traditional culturing techniques are its speed, accuracy, and inclusivity of organisms that cannot survive culturing.

Task 2: Development of QAPP: FBE will develop a secondary data QAPP for the project based on EPA guidelines (US EPA, 2009; US EPA, 2002; TNC, 2011). HWG will provide QA review before submittal to US EPA Region 1 for final review and approval. FBE will incorporate any feedback given from HWG and US EPA Region 1.

Task 3: Source Tracking Sample Selection: FBE will select a subset of 50[2] (out of 96) samples collected in 2017 by the Mass DEP, RIDEM, and US EPA Region 1 for PhyloChip analysis to identify specific sources of fecal contamination. The selection will be based on the spatial and temporal representativeness of the watershed and sampling season, with priority for sampling sites with higher fecal indicator bacteria counts. The strategy for determining the most representative samples will be as follows (refer to Figure 2):

1. Review all existing fecal indicator bacteria, nutrient, and TSS data for the 12 sites sampled in 2017. See Task 4 for work related to compiling and validating for analysis all water quality data for the Palmer River watershed. Determine sites with elevated concentrations based on state water quality criteria (refer to Table 4). Determine sites with a statistically-significant improving, degrading, or no trend in water quality over time and/or before and after BMP installation in the subwatershed (hereafter referred to as water quality status). See Task 4 for work related to the water quality analysis. Potential progressive downstream improvements in water quality as a result of upstream installation of agriculture BMPs will be also considered in site selection.
2. Determine the number, type, and pollutant reduction potential of agricultural BMPs installed in the subwatershed to each site (see Task 4 for work related to compiling data on agricultural BMPs, see Task 6 for work related to delineating subwatershed areas to the 12 sites).
3. Prioritize the representativeness of sites, both spatially and in relation to water quality status and the types of installed agricultural BMPs, to assess the success of agricultural BMPs. Sites will be spatially representative by selecting samples for each major tributary (i.e., Clear Run, Rocky Run, and Torrey Creek) and significant reaches on the main stem of the river below Shad Factory Pond. Sites will also be representative of the different types of installed BMPs (to assess effectiveness) and water quality status (e.g., whether water quality is changing or not over time or before/after BMP installation). If possible, it is recommended that “reference” sites be selected (e.g., sites with elevated fecal indicator bacteria and/or similar water quality status such as improving trends but without installed agricultural BMPs in the subwatershed). FBE will create a map in ArcMap 10.6.1 highlighting the spatial representativeness of sites. Refer to Table 3 for a list of spatial data files to be used for the project. Local knowledge will also be consulted in the final selection process, which may de-prioritize certain spatially-representative areas.
4. Subsequent prioritization of sites will be based on the suspected types of fecal contamination (e.g., agriculture, wastewater, stormwater, wildlife). FBE will attempt to capture a variety of potential nonpoint sources to evaluate the effectiveness of PhyloChip across fecal source types. Percent land cover by general category (e.g., agriculture, developed, forest, water/wetlands) both before and after BMP installation will be calculated for each subwatershed to determine potential inputs from agriculture or urban stormwater/wastewater (see Task 6 for work related to land cover analysis). Stormwater runoff sources will also be identified through regulated MS4 areas. Areas on sewer or septic systems or both will also be mapped and assigned to each subwatershed, along with coarse estimates of the number of septic systems, the population per septic system, and septic failure rate in the subwatershed draining to each of the 12 monitoring stations (see Appendix A for work related to modeling the subwatersheds and agricultural BMPs). Note: the 12 sites were originally selected based on historic elevated fecal indicator bacteria levels, which coincide with the dominance of agricultural practices in this area. Possible confounding influences of non-agricultural fecal sources should be considered in determining water quality status (e.g., changing agricultural or developed land cover after installation of agricultural BMPs - see Task 6 for work related to assessing land cover change and Task 4 for work related to assessing land cover impact to water quality).
5. Samples will be further selected based on season and antecedent or at-collection conditions (e.g., precipitation, air/water temperature, salinity, time of day, time of year). Rainfall can have a dramatic influence on the flowpaths that deliver fecal waste to surface waters (e.g., surface runoff, shallow groundwater, deep groundwater). Human or agricultural sources of fecal pollution are activated during moderate precipitation events; thus, dry conditions would

[2] The US EPA Region 1 currently has funding for PhyloChip analysis of 50 samples collected in 2017. Additional funding may become available for PhyloChip analysis of the other samples collected in 2017 and 2018.

largely represent possible sources in baseflow from groundwater. Both can be important to understanding flowpaths of fecal sources.

6. FBE will develop and submit to US EPA Region 1 (following HWG review) a draft memorandum with rationale for sample selection for PhyloChip analysis. US EPA Region 1 will allow both RIDEM and MassDEP to review and approve the rationale for sample selection before selected samples are sent to the Lawrence Berkeley National Laboratory for analysis following protocols detailed in "July 25, 2016, Quality Assurance Project Plan (QAPP), 2016 US EPA Workforce Development Fund PhyloChip Microbial Source Tracking (MST) Project, RFA 16126, US EPA Office of Environmental Measurement and Evaluation, North Chelmsford, MA & OECA" (US EPA, 2016).
7. Following receipt of the quality-controlled and validated PhyloChip results from the Lawrence Berkeley National Laboratory, FBE will develop and submit a final memorandum with the final sample selection criteria and process, along with a discussion of PhyloChip results in the context of water quality status, installed BMPs, land cover change, and antecedent conditions to make recommendations for best practices when applying PhyloChip in sampling plans for other watersheds impacted by fecal contamination.

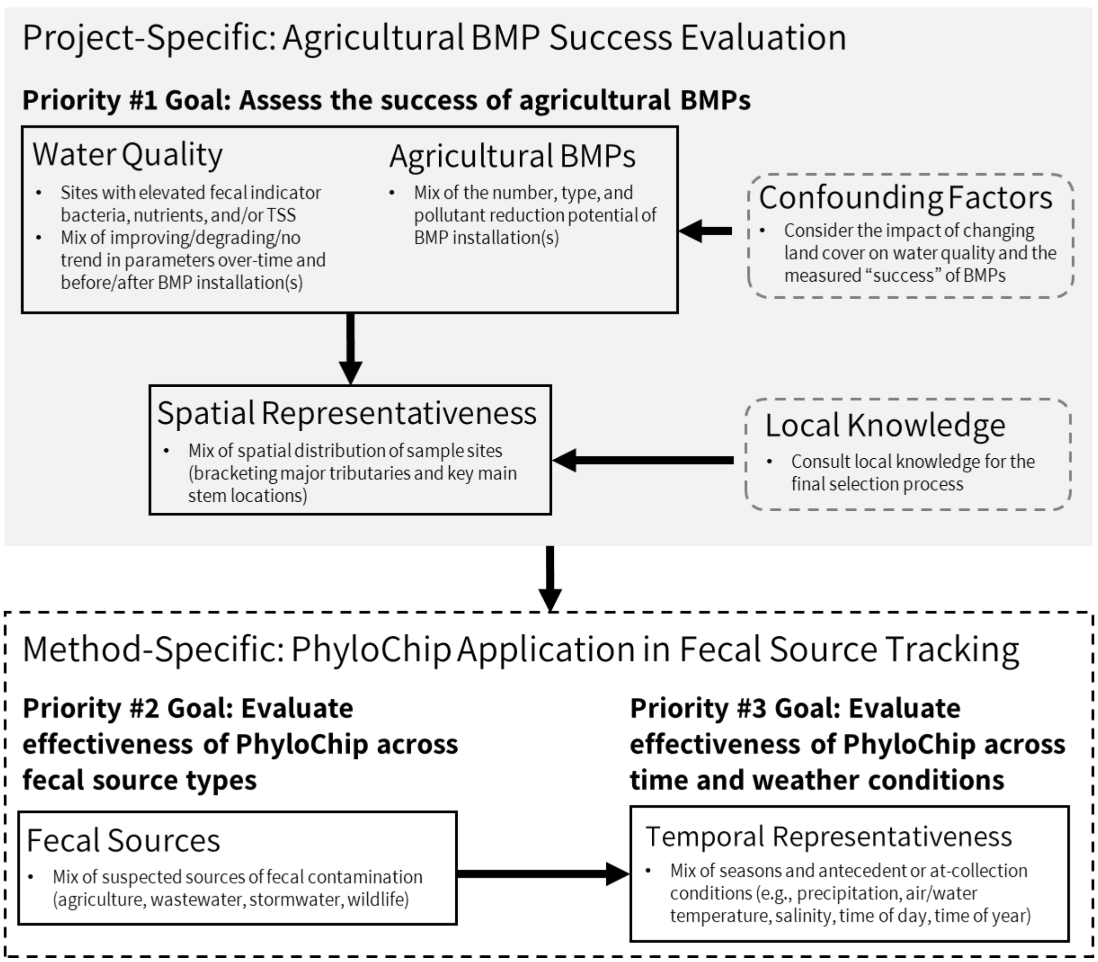

Figure 2. Decision matrix for prioritizing sample selection for PhyloChip analysis.

Task 4: Water Quality Trends Summary: FBE will perform a water quality analysis to better understand the status of water quality in the Palmer River watershed. The water quality analysis will be completed as follows:

1. Compile and validate for analysis all water quality data for the Palmer River watershed, including, at a minimum, all existing fecal indicator bacteria, nutrient, and TSS data (refer to Table 3 for a list of available water quality data sources). Attach weather data to each data entry; weather data will include at a minimum antecedent precipitation

(prior 24, 48, and 72 hours, days since last measurable precipitation) and air temperature (average, min, and max for both day of collection and 3-7 days prior to collection). PhyloChip results will be included upon receipt of the quality-controlled laboratory report. A database will be created in MS Excel 2016 that will include a tab with metadata, raw data, working data, and site locations. Refer to Section 4 for validation criteria.

2. Import site location information to ArcMap 10.6.1 under "Add X Y Data" and export as a shapefile for mapping purposes.
3. Review literature sources for additional tabular or narrative data relevant to the study. Refer to Table 3 for a list of available literature sources. This preliminary list may expand during the review process as additional relevant sources are discovered and reviewed.
4. Determine the number and type of agricultural BMPs installed in the Palmer River watershed (refer to Section 2 for agricultural BMP data sources). Gather pertinent information about the installed BMPs to determine the potential magnitude of expected improvements to water quality (e.g., proximity to surface waters, pollutant reduction estimates, BMP types, number of BMPs, date installed). Note: we may not know the exact location of BMPs due to privacy laws, but we will generally assign BMPs to sites. If not already existing and sufficient information is available, HWG will calculate pollutant load reductions for each BMP to evaluate the efficacy of agricultural BMP installations. Appropriate models may include the Spreadsheet Tool for Estimating Pollutant Load (STEPL). Refer to Appendix A.
5. Review National Pollutant Discharge Elimination System (NPDES) discharge monitoring reports and data, as available, for facilities discharging to the Palmer River. Only one NPDES-permitted facility was identified in the Palmer River watershed – Swansea Water District Desalination Facility. Refer to Table 3 for NPDES data sources.
6. Perform water quality analysis. Validated data will be imported to R x64 3.5.1 / RStudio, an open source statistical program. All annotated R scripts or markdowns, csv file inputs and outputs, and exported figures will be made available to the end users.
    a. Key parameters (i.e., fecal indicator bacteria, nutrients, and TSS) will be summarized (by geomean for log-normalization for fecal indicator bacteria, median for all others) by day, month, and year. Sites with 10 or more years of annual data will be assessed for long-term trends using the Mann-Kendall trend test ($p < 0.05$).
    b. Monthly data will be summarized for an overall value by site for application to state water quality criteria (refer to Table 4).
    c. Monthly data for each site will also be separated by date into two categories: before and after agricultural BMP installation. Boxplots will be generated and one-way analysis of variance (ANOVA) will be performed to determine if there was a significant change in water quality before and after agricultural BMP installation ($p < 0.05$) at each site.
    d. Results of the trend analyses will be interpreted in the context of land cover changes (see Task 6) and installation of agricultural BMPs. Empirical analyses (e.g., multiple regression, receiver operating characteristics curve analysis, cumulative probability distribution) and/or model equations (e.g., logistic regression or classification and regression trees) may be performed to determine factors driving variation in and exceedances of fecal indicator bacteria and a yes or no "hit" for human or livestock fecal waste, as identified by PhyloChip.
7. Develop a Water Quality Trends Summary memorandum. The memorandum will include a list of available water quality data, BMP information, and land use data sources, along with both a written and visual summary of water quality status and trends in the context of land use change and BMP installation in the watershed (and whether BMPs were successful or require further data collection).
8. The RI Shellfish Program data from the estuarine portion of the Palmer River may also be analyzed for trends. If the data are analyzed for shellfish harvesting compliance, RIDEM will be consulted and will approve the methodology to ensure consistency with the FDA's National Shellfish Sanitation Program.

Task 5: Stakeholder Workshop: HWG will coordinate a stakeholder workshop to discuss priorities and concerns for the Palmer River watershed in the context of the key insights gained from the Water Quality Trends Summary memorandum (Task 4). FBE will attend the workshop in a supporting role. Stakeholders will discuss community land use goals and identify potential actions to achieve land use goals. HWG will develop a brief memorandum summarizing the results of the workshop for use in Task 6 deliverables.

Task 6: Land Use and Regulatory Analysis and Recommendations: HWG and FBE will assess the impact that changing land use has on water quality in the Palmer River watershed. HWG and FBE will make recommendations for regulatory amendments that support best land use practices for water quality protection. A summary of work tasks is as follows:

1. FBE and HWG will jointly review existing regulatory information, such as municipal ordinances, bylaws, and planning documents, to assess the strength of water quality protections and smart development practices. Municipalities include the towns of Rehoboth, Swansea, and Seekonk, MA, as well as the towns of Warren and Barrington, RI. Weak or missing land use regulations for water quality protection will be identified. Refer to Section 2 for municipal contacts and document sources.
2. FBE will auto-delineate subwatershed areas to the 12 sites using QGIS Desktop 3.4.1 and manually refine subwatershed areas in ArcMap 10.6.1 using the best-available topographic and elevation spatial data (Table 3). Refer to Appendix B for subwatershed delineation workflow.
3. FBE will perform a GIS-based analysis of land use changes over the water quality record. FBE will collect best-available land cover data for the Palmer River watershed (refer to Table 3) and reconcile land cover category differences among sources (MA and RI) and time periods (refer to Section 2.3). The magnitude of land use change (by major land use category such as agriculture, developed, forest, water/wetland) will be empirically related to long-term trends in water quality (to be included in Task 4 deliverable). The goal is to understand the impact that certain land cover types and the use of certain BMPs have on water quality. This will help to identify which areas are most vulnerable to land use changes and what BMPs are most effective at treating NPS pollution.
4. Based on this assessment, literature data, and professional experience, HWG and FBE will collaborate on developing a Land Use and Regulatory Analysis and Recommendations Summary for the Palmer River watershed that includes recommendations for regulatory amendments and best land use practices to support water quality protection.
5. HWG and FBE will present and discuss findings at a meeting with US EPA Region 1.

1.7 Quality Objectives and Criteria

Data quality objectives and criteria for the project will ensure that data used to support recommendations are scientifically valid and defensible, with a high level of transparency and data-sharing capabilities. The end users of the final products of the project are US EPA Region 1, state agencies, and municipalities who will use the results and recommendations to inform land management decisions and regulations at a local level, as well as apply innovative fecal source tracking methods (i.e., PhyloChip) at the regional level.

Water quality data will be gathered and assessed for inclusion in analyses based on the data quality criteria set in Table 2. Field and laboratory analysis methods used to collect existing secondary data should be based on approved sampling and analysis plans for comparability and representativeness. These methods should meet similar precision (field and lab), accuracy/bias, and sensitivity data quality indicators for water quality parameters. Field measurements (i.e., water temperature and salinity) should be collected with calibrated meters. Data sets will be considered complete when 90% of the data are collected, depending on equipment malfunctions or laboratory errors.

All other secondary data types will be gathered and assessed for inclusion in analyses based on the most recent, relevant files (see Table 3; see Section 4). Model selection for estimating pollutant load reductions from agricultural BMPs will be selected based on the best available model for the BMP type, such as STEPL, which can provide coarse estimates of pollutant load reductions based on information from personnel with knowledge of the BMPs (see Section 2.1); thus, model results will represent the relative (not absolute) magnitude of possible water quality improvements as a result of the BMPs (for use in empirical analyses).

Table 2. Data quality criteria for analytical water quality parameters. FIB = fecal indicator bacteria. Grey, italicized indicators will be satisfied if comparability indicators for laboratory methods are met.

Quality Indicators	Measurement Performance Criteria	Activity Used to Assess Measurement Performance
Comparability	Measurements should follow standard methods that are repeatable and have similar precision, accuracy/bias, and sensitivity: *E. coli* (Colilert) Enterococci (Enterolert) Fecal coliform (SM 9222D) Total Nitrogen (EPA Series Method 353.2/ EIASOP-INGNO2NO3) Nitrate-Nitrite (EPA Series Method 353.2/ EIASOP-INGNO2NO3) Total Organic Nitrogen + Ammonia (Calculation (TN-NO3-NO2)) Total Phosphorus (EPA Series Method 365.1 / EIASOP-INGTP11) Ortho-Phosphate (EPA Series Method 365.1 / EIASOP-INGTP11) Total Suspended Solids (Method SM2540D / INGTSS/TDS/VRES6)	Review Metadata for Comparable Methods
Precision-Field	*Relative percent difference (RPD) < 30% or Best Professional Judgment (BPJ) for FIB (e.g., low values can differ by 200% or more)* *RPD <20% for other analytes*	*Field Duplicates*
Precision-Lab	*RPD < 25% (low values) or 10% (high values) for FIB* *Relative standard deviation (RSD) < 15% for other analytes*	*Lab Replicates; Certified Reference Material, Laboratory Fortified Matrix Samples*
Accuracy/Bias	*Positive results with positive controls; negative results with negative controls for FIB* *RPD < 15% (between 85-115% recovery) for other analytes*	*Certified Reference Material, Laboratory Fortified Matrix Samples*
Sensitivity	Measurements should have similar reporting limits: *E. coli* (<4 to >24,196 MPN/100mL) Enterococci (<10 to >24,196 MPN/100mL) Fecal coliform (<10 to >24,196 MPN/100mL) Total Nitrogen (0.045 mg/L) Nitrate-Nitrite (0.023 mg/L) Total Organic Nitrogen + Ammonia (0.045 mg/L) Total Phosphorus (<0.005 mg/L) Ortho-Phosphate (<0.005 mg/L) Total Suspended Solids (<2.5 mg/L)	Review Lab Qualifiers (Based on Calibration Standards or Sterility Tests)
Representativeness	Measurements should be collected by trained personnel under an approved sampling plan	Review Data Sources & Documentation
Data Completeness	90% of collected samples and data (depending on equipment malfunctions or lab errors)	Perform Data Gap Analysis

2. DATA SELECTION AND MANAGEMENT

2.1 Sources of Existing Data

A variety of secondary data will be used for the project, including spatial files for mapping and analysis, water quality and agricultural BMP data for analysis, literature sources for reference, and municipal land use regulations data for review (Table 3). Much of these data were sourced directly from US EPA Region 1 and state agencies (Mass DEP and RIDEM) for QAPP development. Several additional literature sources will be obtained from Mass DEP (noted in Table 3).

Municipal land use regulations data (e.g., ordinances, bylaws, and planning documents) will be obtained directly from each of the five towns to ensure that the most relevant and up-to-date documents are secured for review:

- Rehoboth, MA: Stacy Vilao (Highway-Planning & Conservation Commission Office Administrator) – (508) 252-6891
- Swansea, MA: John P. Hansen, Jr. (Town Planner) – (508) 324-6730
- Seekonk, MA: John J. Aubin, III (Town Planner) – (508) 336-2962
- Barrington, RI: Phil Hervey (Town Planner/Administrative Officer) – (401) 247-1900
- Warren, RI: Bob Rulli (Director of Planning & Community Development) – (401) 289-0529

Weather data will be sourced from the NOAA National Centers for Environmental Information (NCEI) for quality-controlled, land-based stations in or near the Palmer River watershed. Weather data will include average, min, and max daily air temperature and total daily precipitation for the span of the water quality data record (1960-2018). Any data gaps will be filled in with data from the next nearest weather station and noted as such.

Data on agricultural BMPs (e.g., proximity to surface waters, pollutant reduction estimates, BMP types, number of BMPs, date installed) will be obtained from the following individuals, in order of preference:

- Iain Ward (NRCS Consultant) – iain@neconsultingservices.com
- Thomas Akin (NRCS) – thomas.akin@ma.usda.gov
- Malcolm Harper (Mass State) – malcolm.harper@state.ma.us

Coarse estimates of pollutant load reductions for the agricultural BMPs will be generated by publicly-available models such as STEPL. STEPL estimates nutrient (nitrogen and phosphorus) loads, *E. coli*, 5-day biological oxygen demand (BOD), and sediment based on land use, number and type of livestock, and soil conditions; BMP reduction efficiencies can be applied to certain land cover types. Refer to Appendix A for work related to modeling pollutant load reductions for the agricultural BMPs.

Table 3. Sources of existing data.

Type [File Name]	Description / Title	Format	Source (Date)	Accessed	Intended Use	Limitations	QA/QC
			Spatial Data				
Aerial imagery [World_Imagery]	Satellite and aerial imagery	ArcGIS Layer	ESRI DigitalGlobe (9/13/2017)	11/2018	Spatial reference, data verification	NA	NA
Aerial imagery [Google Earth Pro Desktop]	Satellite imagery using Landsat 8; also available for 1995, 2000-2009, 2012-2016	Google Earth Pro Desktop	Google DigitalGlobe (2/28/2018)	11/2018	Spatial reference, data verification	Cannot use in ArcGIS for mapping	NA
Topography [World_Topo_Map]	USGS/ESRI digitized topographic basemap	ArcGIS Layer	ESRI DigitalGlobe (updated 11/2018)	11/2018	Spatial reference, data verification, manual sub-basin delineation checks	Citation date for study area unknown	NA
Topography [hp247, hp265, hp292]	3-m elevation contours	.shp	MassGIS (11/20/2017)	11/2018	Manual sub-basin delineation checks	Only for MA, not RI	NA
Topography [unknown]	2-ft elevation contours	Unknown	RIGIS (2/18/2018)	11/2018	Manual sub-basin delineation checks	Unable to download from RIGIS online	NA
Elevation [multiple Erdas images]	1-m resolution LiDAR terrain and elevation data for MA	.tif	MassGIS (12/8/2010)	11/2018	Reference for sub-basin delineations	Over 100 files to combine and convert to raster for use	NA
Elevation [grdn42w072_13]	USGS/NRCS 3DEP 10 m resolution (1/3 arc-sec), topographic bare-earth surface, seamless	.img	USGS/NRCS (1/1/2017)	11/2018	Automatic sub-basin delineations in QGIS	NA	NA
Sub-basins [SUBBASINS_POLY]	USGS topo drainage delineations	.shp	MassGIS (12/19/2017	11/2018	Manual sub-basin delineation checks	Delineated boundaries are from older USGS maps than those scanned, so sub-basins may not be positioned correctly	NA
Impervious cover [imp_se3, imp_se5]	Impervious cover	.img	MassGIS (12/7/2017)	11/2018	Land cover analysis	1-m resolution based on 2005 orthophotos, need to convert raster image to polygon for use (already completed for 2012 WMP)	NA
Roads [EOTROADS_ARC]	Roads in MA	.shp	MassGIS (12/31/2013)	11/2018	Spatial reference, general mapping, land cover analysis	Based on 1990's orthophotos, small private roads may not be well represented (but more detailed than 2010 Census TIGER)	NA
Roads [RIDOT_Roads_2016]	Roads in RI	.shp	RIGIS (2/23/2016)	11/2018	Spatial reference, general mapping, land cover analysis	Based on 1997 photography, small differences with e911_Road_centerlines file	NA
Land Cover [LANDUSE_POLY]	Historical land cover available for 1971, 1985, 1999 in 21 or 37 categories	.shp	MassGIS (11/16/2017)	11/2018	Land cover change analysis	NA	Need to reconcile land cover

Type [File Name]	**Description / Title**	**Format**	**Source (Date)**	**Accessed**	**Intended Use**	**Limitations**	**QA/QC**
Land Cover [LANDUSE2005_POLY]	Historical land cover, based on 0.5 m resolution digital ortho imagery captured in April 2005, used in 2012 WMP (no changes)	.shp	MassGIS (10/13/2017)	11/2018	Land cover change analysis	NA	categories among different time periods and different states
Land Cover [Land_Cover_1988]	Historical land cover interpreted from 1988 aerial photography	.shp	RIGIS (12/31/1992)	11/2018	Land cover change analysis	NA	
Land Cover [Land_Use_and_Land_Cover_1995]	Historical land cover, updated using 1995 USGS DOQs, edited in 2004	.shp	RIGIS (2/14/2005)	11/2018	Land cover change analysis	NA	
Land Cover [Land_Use_and_Land_Cover_20032004]	Historical land cover, based on 2003-2004 imagery, accurate to 1:5,000 scale	.shp	RIGIS (12/31/2006)	11/2018	Land cover change analysis	NA	
Land Cover [Land_Use_and_Land_Cover_2011__version_D]	Historical land cover, based on orthophotography taken in spring 2011, accurate to 1:5,000 scale	.shp	RIGIS (3/26/2014)	11/2018	Land cover change analysis	NA	
WQ Monitoring Stations [DWMWPP_WATER_QUALITY_STATIONS]	MassDEP water quality monitoring station locations (1994-2014)	.shp	MassGIS (3/28/2017)	11/2018	Spatial reference for water quality data; outlet locations for sub-basin delineations	Only accounts for 1994-2014 stations	Needs to be checked against Palmer River water quality data to ensure all stations accounted for
Surface waters [NHDFlowlines, NHDWaterbody]	USGS National Hydrography Dataset mapped at 1:24,000 scale	.shp	USGS (3/8/2012)	11/2018	Spatial reference	More detailed stream network compared to MassGIS versions	NA
Wetlands [HU8_01090004_Wetlands]	National Wetlands Inventory for the Narragansett R watershed, covers both MA and RI	.shp	USFWS (10/1/2018)	11/2018	Spatial reference	Planning level purpose only	NA
Watershed [WBDHU12]	USGS Watershed Boundary Dataset, used in the 2012 WMP	.shp	USGS (3/28/2016)	11/2018	Spatial reference, sub-basin delineation	Inconsistencies with MassGIS Sub-basins shapefile on western boundary	NA
Town/State [TOWNS_POLY]	Political boundaries for MA	.shp	MassGIS (1/1/1998)	11/2018	Spatial reference	NA	NA
Town/State [RITOWNS_POLY]	Political boundaries for RI	.shp	MassGIS (1/1/1998)	11/2018	Spatial reference	NA	NA
Impairment Status [IL_2014_Shapefile]	Mass DEP 2014 Integrated List of Waters 305(b) and 303(d)	ArcGIS Layer	MassGIS (2014)	11/2018	Priority ranking for PhyloChip	Newer 2016 assessment not available as spatial file	Compare differences to 2016 303(d) draft listing
Potential Pollutants [BWP_PT_UST, AUL_PT, C21E_PT]	Underground storage tanks, Oil and/or Hazardous Material Sites with Activity and Use Limitations (AUL) sites, Chapter 21E Tier Classified Sites	.shp	MassGIS (2016-18)	11/2018	Priority ranking for PhyloChip	May not be applicable for types of pollutants targeted in study	NA

Type [File Name]	Description / Title	Format	Source (Date)	Accessed	Intended Use	Limitations	QA/QC
Sewer [Sewered_Areas]	Sewered areas in RI	.shp	RIGIS (8/22/2012)	11/2018	Priority ranking for PhyloChip	NA	Determine whether sewered area stops at state boundary
Rehoboth.pdf, Swansea.pdf, Seekonk.pdf	Regulated MS4 in Massachusetts Communities (obtained from https://www.epa.gov/npdes-permits/regulated-ms4-massachusetts-communities)	.pdf	EPA (8/9/2013)	11/2018	Priority ranking for PhyloChip	Not readily available as shapefile, but may be able to request	NA
Soils [Soils]	Digital soil survey developed by the RI Soil Survey Program	.shp	RIGIS (12/7/2017)	12/2018	STEPL model input	NA	NA
Soils [soi_bris, soi_brisno]	Digital soil survey developed by the National Cooperative Soil Survey (NRCS SSURGO-certified) for Bristol County	.shp	MassGIS (11/1/2012)	12/2018	STEPL model input	NA	NA
			Water Quality Data				
1110636615.csv	Swansea Water District - Vinnicum Filtration Plant (NPDES Permit MA0103390)	.csv	ICIS (2018)	11/2018	Point source discharge data for PhyloChip sample prioritization	2018 data only, parameters may not be applicable to study	NA
1110639582-1.csv	Swansea Water District - Vinnicum Filtration Plant (NPDES Permit MA0103390)	.csv	ICIS (2018)	11/2018	Point source discharge data for PhyloChip sample prioritization	Duplicate of 1110636615.csv?	NA
Desal_DMR_1110648804.csv	Pollutant Loading Report (DMR) for Swansea Desalinization Project, Swansea, MA	.csv	DMR (2018)	11/2018	Point source discharge data for PhyloChip sample prioritization	No discharge monitoring data found for this facility.	NA
Desal_DMR_1110650635.csv	Pollutant Loading Report (DMR) for Swansea Desalinization Project, Swansea, MA	.csv	DMR (2018)	11/2018	Point source discharge data for PhyloChip sample prioritization	No discharge monitoring data found for this facility.	NA
PalmerData2010-2017_BACTERIA_ONLY.xlsx	Palmer River 2010-2017 Fecal Indicator Bacteria Data Only, multiple tabs with data by tributary	.xlsx	RIDEM, MassDEP (2012-17)	11/2018	Water quality data for Palmer River database	Minimal metadata, not from QA/QC'd database	Reconcile with 2016-2017 data spreadsheets (check for duplicate bacteria entries)
PalmerData2016Summary_all parameters_tables and graphs FINAL.xlsx	Palmer River 2016 All Data, multiple tabs with data by parameter	.xlsx	MassDEP (2016)	11/2018	Water quality data for Palmer River database	Minimal metadata, not from QA/QC'd database	Obtain metadata and review acceptance criteria

Type [File Name]	Description / Title	Format	Source (Date)	Accessed	Intended Use	Limitations	QA/QC
PalmerData2017Summary_all parameters_tables and graphs FINAL.xlsx	Palmer River 2017 All Data, multiple tabs with data by parameter	.xlsx	MassDEP (2017)	11/2018	Water quality data for Palmer River database	Minimal metadata, not from QA/QC'd database	Obtain metadata and review acceptance criteria
Palmer_2018_EPA.xlsx	Palmer River 2018 Preliminary Data, single tab with data by parameter	.xlsx	EPA (2018)	11/2018	Water quality data for Palmer River database	Minimal metadata, not from QA/QC'd database, missing salinity and temperature data	Obtain updated (final) version from EPA
All_Palmer_watershed_data_DEP.docx	Palmer River WMP Data, includes site information and data in tables	.docx	MassDEP (2012-13)	11/2018	Water quality data for Palmer River database	WMP data, but marked as DRAFT	Check with Mass DEP on data validation, reconcile word data tables with spreadsheets
Bacteria by subbasin - rev 1.xls	Palmer River TMDL Data - FIB, multiple tabs with data by site	.xls	MassDEP (2001-02)	11/2018	Water quality data for Palmer River database	NA	NA
Field Data by subbasin - rev 1.xls	Palmer River TMDL Data - Field, multiple tabs with data by site	.xls	MassDEP (2001-02)	11/2018	Water quality data for Palmer River database	NA	NA
Nutrients by subbasin - rev 1.xls	Palmer River TMDL Data - Nutrients, multiple tabs with data by site	.xls	MassDEP (2001-02)	11/2018	Water quality data for Palmer River database	NA	NA
Palmer-PredawnDO for PM5,PM12,PM15.xls	Palmer River TMDL Data - Pre-Dawn DO, multiple tabs with data by site	.xls	MassDEP (2001)	11/2018	Water quality data for Palmer River database	NA	NA
SUMMARY Table A - Sub-Basin Priorities-rev3.xls	Palmer River TMDL Data - Sub-Basin Priorities, single tab with sub-basins ranked by priority for several categories	.xls	MassDEP (2001-02)	11/2018	Sub-basin ranking for PhyloChip prioritization	NA	NA
Summary Table B.xls	Palmer River TMDL Data - Sites Exceeding FIB Standard & Potential Sources, can use to compare to current suspected sources of FIB	.xls	MassDEP (2001-02)	11/2018	Pollutant sources by sampling site for PhyloChip prioritization	NA	NA
Table 1 - Screening Standards.doc	Palmer River TMDL Data - WQ Standards Table	.doc	MassDEP (2001-02)	11/2018	Water quality analysis	Water quality criteria used for TMDL, may be outdated	Check for any criteria changes since TMDL development
Table 2 - Palmer Bact R1 Locs.doc	Palmer River TMDL Data - Site Location Information	.doc	MassDEP (2001-02)	11/2018	Site information for Palmer River database	NA	NA
Table 3 - Palmer Bact R2 Locs.doc	Palmer River TMDL Data - Site Location Information	.doc	MassDEP (2001-02)	11/2018	Site information for Palmer River database	NA	NA

Type [File Name]	Description / Title	Format	Source (Date)	Accessed	Intended Use	Limitations	QA/QC
Table 4 - Palmer Nutrients Locs.doc	Palmer River TMDL Data - Site Location Information	.doc	MassDEP (2001-02)	11/2018	Site information for Palmer River database	NA	NA
Table 5 - Palmer Bact R3 Locs.doc	Palmer River TMDL Data - Site Location Information	.doc	MassDEP (2001-02)	11/2018	Site information for Palmer River database	NA	NA
Table 6 - Confirmatory Locs - TM-Palmer.doc	Palmer River TMDL Data - Site Location Information	.doc	MassDEP (2001-02)	11/2018	Site information for Palmer River database	NA	NA
USGS_Palmer_Results.xlsx	Query: Palmer HUC-12 (10900040701); all parameters; site data (for locations) and project data (for parameters) sample results (narrow)	.xlsx	USGS (1960-2006)	11/2018	Water quality data for Palmer River database	NA	NA
USGS_Palmer_StationLoc.xlsx	Station information	.xlsx	USGS (1960-2006)	11/2018	Site information for Palmer River database	NA	NA
USGS_Flow_Data_2006-2009.xlsx	Mean daily discharge from USGS Station # 01109220 Palmer River at South Rehoboth, MA	.xlsx	USGS (2006-2009)	11/2018	Water quality data for Palmer River database	Limited to only three years of the study period, all values approved by USGS for publication	NA
result.zip, station.zip, activity.zip, resdetectqntlmt.zip	Query results from EPA Water Quality Portal (identified 10 surface water sites - 9 NWIS, 1 STORET)	.zip	EPA (1965-2003)	11/2018	Water quality data for Palmer River database	NA	Check for duplicate entries from other query results
GA-2 BPW Shellfish Stations.doc	Palmer River Shellfish Program Data - Station Map	.doc	RIDEM (2007-08)	11/2018	Site information for Palmer River database	NA	NA
GA2 ShellfishData Palmer 1984-2018.xlsx	Palmer River Shellfish Program Data	.xlsx	RIDEM (1984-2018)	11/2018	Water quality data for Palmer River database	NA	Check for duplicate entries from other sources
Literature Sources							
2016 PhyloChip Project QAAP v3.pdf	Quality Assurance Project Plan (QAPP) 2016 USEPA Workforce Development Fund PhyloChip Microbial Source Tracking (MST) Project RFA 16126 (dated July 25,2016)	.pdf	USEPA (2016)	11/2018	Reference for PhyloChip methodology	NA	NA
MA BMP report 2013-2017.pdf	Project Summaries Section 319 NonPoint Source Competitive Grants Program	.pdf	MassDEP (2013-17)	11/2018	Reference for agricultural BMP data	NA	NA

Type [File Name]	**Description / Title**	**Format**	**Source (Date)**	**Accessed**	**Intended Use**	**Limitations**	**QA/QC**
MA Palmer Bacteria TMDL.pdf	Bacteria TMDL for the Palmer River Basin Final Report MA 53 03 2004-2 CN 182.0	.pdf	ESS Group Inc (2004)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
Min_Detectable_Change_Analysis.pdf	Minimum Detectable Change Analysis Palmer River, MA	.pdf	TetraTech (2014)	11/2018	Reference for agricultural BMP data	NA	NA
Narragansett Mt. Hope Bay TMDL.pdf	Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report (61/53-AC-2, CN 172.0)	.pdf	MassDEP (2004-08)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
NBEP-18-205.pdf	A strategy for monitoring and assessing the quality of Massachusetts' waters to support multiple water resource management objectives (CN 203.5)	.pdf	MassDEP (2016-2025)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
NWQI_Factsheet.pdf	National Water Quality Initiative Fact Sheet Massachusetts Overview	.pdf	NRCS (2012)	11/2018	Reference for agricultural BMP data	NA	NA
Palmer_BMP_report.pdf	ACPP Technical Providers for the Palmer River Watershed (13-08/319): Final Project Report	.pdf	Mass Association of Conservation Districts (2014-16)	11/2018	Reference for agricultural BMP data	NA	NA
Palmer_RI_TMDL.pdf	Fecal Coliform TMDL for Palmer River, RI	.pdf	RIDEM (2002)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
Palmer2012 WatershedPlan.pdf	Barrington-Palmer-Warren Rivers Watershed Plan: Barrington, Bristol, East Providence, and Warren, RI; Rehoboth, Seekonk, and Swansea, MA	.pdf	FBE (2012)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
Mailing Disc (Jennifer Sheppard)	Ten Mile River/Narragansett and Mount Hope Bays Watersheds Nonpoint Source Pollution Assessment Report	TBD	ESS Group Inc (2003)	TBD	Reference for water quality database and PhyloChip prioritization	Unavailable online	NA
Mailing Hardcopy (Jennifer Sheppard)	Septic System Impairment Assessment for the Palmer, Kickamuit, and Cole Watersheds	Hardcopy	ESS Group Inc (2003)	TBD	Reference for water quality database and PhyloChip prioritization	Unavailable digitally	NA
Request from MassDEP (Jennifer Sheppard)	Palmer River Basin Water Quality Data Collected by Massachusetts Division of Marine Fisheries	TBD	MDMF (1997)	TBD	Reference for water quality database and PhyloChip prioritization	Unavailable online	NA

Type [File Name]	Description / Title	Format	Source (Date)	Accessed	Intended Use	Limitations	QA/QC
01-06MWI PALMER RIVER MICROBIAL SOURCE TRACKING STUDY.pdf	Palmer River Microbial Source Tracking (MST) Study	.pdf	ESS Group Inc (2003)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
6153wqar1.pdf, 6153wqar2.pdf, 6153wqar3.pdf, 6153wqar4.pdf,	Narragansett/Mount Hope Bay Watershed 1999 Water Quality Assessment Report	.pdf	MassDEP (2002)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
6153ab08.pdf, 6153ac08.pdf, 6153aa08.pdf, 6153wq08.pdf	Narragansett/Mount Hope Bay Watershed 2004-2008 Water Quality Assessment Report	.pdf	MassDEP (2009)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
BPW TMDL Study 1996-98.pdf; BPW TMDL Study 1996-98 Appendices.pdf	Characterization studies to support TMDL development for the Barrington, Palmer, and Warren River watershed	.pdf	RIDEM (1999)	11/2018	Reference for water quality database and PhyloChip prioritization	NA	NA
Palmer River SAP 4 14 16 Final	Sampling and Analysis Plan (SAP) for the 2016 Palmer River Monitoring Project	.pdf	USEPA (2016)	11/2018	Reference for water quality database	NA	NA
Palmer River 2017 FINAL SAP	Sampling and Analysis Plan (SAP) for the 2017 Palmer River Monitoring Project	.pdf	USEPA (2017)	11/2018	Reference for water quality database	NA	NA
Palmer River SAP 4 19 18	Sampling and Analysis Plan (SAP) for the 2018 Palmer River Monitoring Project	.pdf	USEPA (2018)	11/2018	Reference for water quality database	NA	NA
ECA SOP Sondes 13.pdf, ECASOP-Ambient Water Sampling.pdf, EIASOP-INGAMMO0.pdf, EIASOP-INGNO2-NO30.pdf, EIASIPINGTP11.pdf, EIASOP-INGTSS-TDS-VRES6.pdf, Enterolert Revision 3.pdf, TC&EC _Colilert Revision 4.pdf	Various SOPs for the 2016-2018 SAP for the Palmer River Monitoring Project	.pdf	USEPA (2014-2017)	11/2018	Reference for water quality database	NA	NA

2.2 Intended Use of Existing Data

The intended use of existing data for each data file is summarized in Table 3. Water quality data and site location information files will be used to assemble a water quality database for the Palmer River watershed to be used in a water quality analysis. Literature sources, including some TMDL pollutant source data files and personal communications with individuals identified in Section 2.1, will be used as references to aid in PhyloChip sample prioritization, water quality data interpretation, agricultural BMP data assemblage, and municipal land use regulation review. Spatial data files (e.g., aerial imagery, topography, elevation, sub-basin/watershed boundaries, hydrology, roads, land cover/imperious cover, water quality monitoring stations, town/state boundaries, pollutant source locations, sewer areas, MS4 regulated areas, impaired segments, etc.) will be used for spatial reference, data verification, subwatershed delineation for land use change analysis, and PhyloChip sample prioritization.

2.3 Limitations on the Use of Existing Data

The limitations on and quality control needed for the use of existing data are summarized in Table 3. Major limitations and quality control actions are described in greater detail below.

Water quality data will be compiled into a common database using MS Excel 2016. Validated data from federal and state quality controlled-databases will be selected for analysis. Parameters used in analyses (and reviewed for quality acceptance) will be limited to those collected most consistently in recent years and include *E. coli*, Enterococci, fecal coliform, nitrogen (total nitrogen, nitrite-nitrate, total Kjeldahl nitrogen), phosphorus (total phosphorus, ortho-phosphate), and total suspended solids, along with physical measurements of salinity and water temperature. Quality acceptance criteria will be based on the field sampling methods, laboratory analysis methods, and reporting limits of the parameters collected by US EPA Region 1, Mass DEP, and RIDEM from 2016-2018; thus, historical data collected by different agencies or under different projects must meet similar collection and analysis methods for the data to be comparable and used in analyses. All validated data obtained from publicly-available databases through US EPA, USGS, Mass DEP, and RIDEM will likely meet data quality objectives and criteria for the project, as outlined below.

- Samples must be collected by trained personnel under an approved QAPP or similar document to meet representative data quality criteria.
- Samples must be analyzed in accordance with approved laboratory methods to meet similar precision, accuracy, and comparability data quality criteria (see Table 2).
- Sample reporting values for each parameter must be equal to or less than the minimum reporting limits set in Table 2 and/or less than the water quality criteria used in assessing water quality status (Table 4).
- Dry weather data must be preceded by less than 0.1 inch of precipitation for each day within 72 hours of sample collection.

Since validated data obtained from publicly-available federal and state databases will likely meet quality acceptance criteria for field sampling and certified laboratory methods, any data exclusions will likely be due to reporting limit incompatibilities as a result of differing laboratory methods, dilution, or matrix interferences.

Geographic data must be available at a scale which will be useful at the smallest extent of project analysis. All MA spatial data files will be re-projected to match the projection of RI spatial data files. All maps generated for the 2012 Barrington-Palmer-Warren River Watershed Management Plan were projected in NAD 1983 State Plane Rhode Island FIPS 3800 feet.

We will use the USGS Watershed Boundary Dataset (WBD) HUC12 for the Palmer River as the best-available boundary for the Palmer River watershed (also used for the 2012 Barrington-Palmer-Warren River Watershed Management Plan). MassGIS offers sub-basins for MA, which were generated by digitizing delineations made on 1:24,000 USGS topographic quad sheets; metadata note that sub-basins may not be positioned correctly due to scanning errors. Close inspection of boundary discrepancies shows two major areas along the western boundary where the NHDFlowline conflicts with the WBD HUC12 boundary and better matches the MassGIS boundary. Approximately 377 acres (1%) of the MassGIS area and 336 acres (1%) of the WBD HUC12 area of the total area of the WBD HUC12 and MassGIS areas (overlapping areas in MA only) are larger than the other, respectively; the net difference is minimal at 42 acres. Using the WBD HUC12 boundary for consistency with the 2012 Barrington-Palmer-Warren River Watershed Management Plan results in a potential loss of 377 acres, which is acceptable at 1%, but may be more impactful at the subwatershed level. See Appendix C for a map comparing multiple watershed boundary sources.

Land cover data files will need to be reconciled among different time periods and different states. Historical land cover for MA is available for 1971, 1985, 1999 in 21 or 37 land cover categories. Historical land cover for RI is available for 1988, 1995, 2003-2004, and 2011. Common land cover categories among all data files will be carefully documented (as many categories will likely be assimilated into a single, more general category) and added as a new attribute field in each spatial data file. Data files for each state will be matched by time period: 1985 (MA) to 1988 (RI), 1999 (MA) to 1995 (RI), and 2005 (MA) to 2003-2004 (RI). The 2005 (MA) to 2003-2004 (RI) land cover file for the Palmer River watershed already exists as part of the 2012 Barrington-Palmer-Warren River Watershed Management Plan and will dictate the land cover categories used for other time periods. RI also has a 2011 land cover data file; it may be possible to create a land cover file for MA using 2012 Google aerial imagery. A 2017 land cover file (representing current conditions) could also be created by FBE for both RI and MA using ESRI World Imagery (dated 9/13/2017). Careful attention will be given to the resolution (1:5,000 scale) of existing land cover files so that they are comparable to created land cover files (2011 for MA and 2017 for MA and RI). The watershed boundary, most recent existing land cover file, and grid net for 1:5,000 scale viewing will be loaded into Google Earth Pro with the matching year of the most recent existing land cover file as the aerial background image. The watershed boundary, a copy of the most recent existing land cover file (renamed for new land cover year), and grid net for 1:5,000 scale viewing will be loaded into ArcMap 10.6.1 with the matching year of the new land cover file as the aerial background image. Zooming to each grid in Google Earth Pro and ArcMap 10.6.1, the two aerial images will be compared for changes in land cover and the new land cover file updated in ArcMap 10.6.1 to reflect changes.

The USGS also offers a National Land Cover Dataset (NLCD) for 2001, 2006, and 2011 that would provide seamless land cover data for the watershed in both MA and RI (not identified in Table 3). The spatial files are in raster format (.tif) and are mapped at a coarser resolution than those available through the individual state agencies.

Since field assessments are not part of the project, HWG will rely on gathering secondary information from personnel with knowledge of the agricultural BMPs for use in estimating pollutant load reductions. Information may be incomplete and default model values, literature values, or best professional judgement may be used. Refer to Appendix A.

Table 4. Water quality criteria used to assess water quality status.

Parameter	WQ Criteria/Reference Condition	Unit	Reference
E. coli	Class A/B (Freshwater) - 126 (geomean of 5 or more samples within 6 months), 235 (single sample)	MPN/100mL	Mass DEP, 2013
Enterococci	Class SA/SB (Estuarine, Marine) - 35 (geomean of 5 or more samples within 6 months), 104 (single sample)	MPN/100mL	Mass DEP, 2013
Fecal coliform	Class SA (Estuarine/Marine) - 14 (geomean); 28 (90^{th} percentile)	MPN/100mL	Mass DEP, 2013
	Class SB (Estuarine/Marine) - 88 (geomean); 260 (90^{th} percentile)	MPN/100mL	Mass DEP, 2013
	Class SA (Estuarine/Marine) - 14 (geomean); 49 (90^{th} percentile)[3]	MPN/100mL	RIDEM, 2018
	Class SA (Estuarine/Marine) - 14 (geomean); 31 (90^{th} percentile)[3]	cfu/100mL	RIDEM, 2018
Total Nitrogen	0.57	mg/L	US EPA, 2000
Nitrite-Nitrate	0.31	mg/L	US EPA, 2000
Total Organic Nitrogen + Ammonia	0.30	mg/L	US EPA, 2000
Total Phosphorus	0.024	mg/L	US EPA, 2000
Ortho-Phosphate	0.024 (used Total Phosphorus Reference Condition)	mg/L	NA
Total Suspended Solids	30 (30-day average), 58 (daily max)	mg/L	US EPA, 2003

[3] In August 2012, RIDEM Shellfish transitioned from MPN to mTEC analyses. The appropriate criteria are dependent on the analyses used. Data analyzed using MPN analysis requires that not more than 10% of the samples exceed 49 MPN/100 mL, while data analyzed using mTEC requires that not more than 10% of the samples exceed 31 cfu/100 mL.

3. ASSESSMENT AND OVERSIGHT

3.1 Project Oversight

The project team will meet monthly (as needed) throughout the project duration to assess project progress and ensure that data quality objectives are being maintained (see Task 1). Project tasks and associated products will be completed according to the schedule set forth in Section 5. Any changes to the schedule due to unforeseen challenges in completing project products will be immediately brought to the attention of the project team. A conference call at a frequency greater than one month may be scheduled to address any issues and potential changes to the schedule. HWG and FBE will set out specific project roles for Task 6 to avoid duplicate efforts.

The hierarchy of reporting within the project team, along with the project roles of key personnel, are identified in Section 1.4. Project products generated by FBE (and reviewed internally by the Project Manager) will be sent to HWG for review by the Project Manager and QA Officer prior to submission to the US EPA Project Officer. Project products generated by HWG will be reviewed internally by their QA Officer prior to submission to the US EPA Project Officer (who will be responsible for forwarding project products to other project team members). Any feedback from US EPA Region 1 will be incorporated by FBE and/or HWG to the final project products (depending on the task lead).

3.2 Project Documentation

Project progress will be documented by HWG through monthly performance reports detailing work completed in the reporting period and work to be completed in the next reporting period. Project status, project team updates, and key personnel follow-up actions (if necessary) will be documented by HWG in the minutes following each monthly (or as needed) conference call with the project team. Data collection and assessment will be reviewed weekly (or as needed) prior to analyses by the Project Manager of either FBE or HWG (depending on the task lead). Data quality review procedures will be documented in the draft and final project products (including metadata associated with the tabular and spatial databases), which will be reviewed by the Project Manager of either FBE or HWG (depending on the task lead) and then reviewed by the HWG QA Officer before sending to the US EPA Project Officer for final review. Any feedback from US EPA Region 1 will be incorporated by FBE and/or HWG to the final project products (depending on the task lead). The project products are identified in Section 1.6 and Section 5. Project files will be stored on the hard drives of individual personnel (including all files by the Project Managers) and will be backed up to an external hard drive daily.

3.3 Corrective Actions

Possible data problems that would require corrective actions include lack of appropriate or complete metadata, incomplete datasets, and data that conflicts with other quality-assured data sources. Corrective actions could include:

- Contacting the data originator for more complete metadata or explanation.
- Researching alternative data sources or formats that could be added to the incomplete dataset.
- Filtering out or discarding highly conflicting data with justification based on the metadata.

In some cases, acceptance criteria may need to be lessened or altered to accommodate problematic data that is necessary for the project but are the only data source available. Any data limitations will be documented in project products. To avoid data loss or file corruption, working copies of each dataset will be created so that originals remain intact and the copies stored on primary and back-up hard drives.

4. DATA REVIEW – VERIFICATION, VALIDATION, AND EVALUATION

4.1 Data Verification and Validation

All secondary data will be reviewed to assess whether the data meet data quality acceptance criteria for use in analyses. The review process will include thorough metadata review, documentation, and investigation (as necessary). The methods and reporting limits of water quality data will be reviewed and validated for use in analyses if the data meet the data quality objectives and criteria set in Section 1.7 and Section 2.3. Any data not meeting the data quality criteria will be excluded from analyses or properly justified for use if certain approaches (such as taking half the reporting limit) are appropriate.

A summary of laboratory qualifiers and validation criteria are described as follows:

> J/E – estimated value above the reporting limit due to sample matrix or other issue; data should be acceptable unless otherwise justified for exclusion due to possible erroneous data bias or skew as a result of data point(s).
>
> R – field duplicate; data compiled in the water quality database will be assessed for duplicate entries; field duplicate samples will be averaged for a daily value.
>
> U/ND – below reporting limit. If the reporting limit meets the data quality criteria, then half the reporting limit will be taken. If the reporting limit is greater than the data quality criteria, then case-by-case assessments will be made as to whether the data should be excluded (such as for dilution increases in the reporting limit due to sample interference). Alternative approaches may be used if a significant portion (e.g., more than 25%) of the data are less than the reporting limit (and greater than the water quality criteria used for assessment).

Other secondary data such as spatial files and written documents will be selected for use based on relevance, completeness, accuracy, quality, and age of data (i.e., most recent available source that meet criteria). Data may be rejected for use if metadata are incomplete, data are outdated or incomplete, or data are redundant. Low quality data will not be used for analysis (except possibly as a supporting reference) unless it is the only available data; justification for use of and limitations to the low-quality data will be noted in project products. Any files with draft indication will be followed-up with the originator for the final version, if available.

4.2 Data Evaluation

Accurate and complete metadata are needed to ensure that the data source and collection/analysis methods are adequately defined and meet data quality objectives for comparability and representativeness. Metadata for all secondary data should include a data description, originator, source of access, publication date, time period and/or specific time and date collection information (for sampling data), and spatial domain information (such as projection/coordinate systems used; see Table 3). Additional metadata for sampling data sets should include the following: sampling and analysis plan, laboratory method, reporting limit, reporting units, field qualifiers or notes (e.g., missing values), and laboratory qualifiers.

Data and associated metadata will be evaluated to ensure data are complete and comparable for use in analysis based on the following procedure:

- Exclude data that have not been collected and analyzed using similar and approved field and laboratory analysis methods by trained personnel.
- Sort each parameter by value and assess laboratory qualifiers or other data flags. Add a new qualifier column that identifies the data qualifier or flag and either input a numeric value (such as half the reporting limit) or exclude the value from analysis in the parameter value column (with justification). There may be laboratory dilution issues that cause the reporting limits to increase for individual samples; in these cases, if the diluted reporting limit is more than double the typical reporting limit and does not impact more than 10% of samples, then the value will be discarded; otherwise, half the reporting limit will be input for analyses.
- Transform all data to a common measurable unit by parameter (e.g., mg/L).
- Average duplicate data entries for a single value.
- Review the distribution of values for each parameter to identify outliers and values less than the reporting limit (to determine if the data are skewed).
- Document justification and process for any data amendments, corrections, or exclusion.

Sites with 10 or more years of annual data will be assessed for long-term trends using the Mann-Kendall[4] trend test ($p < 0.05$). Qualifying annual data will have at least two data points per year and not have significant data year gaps (e.g., one or two non-consecutive missing data years are acceptable).

Monthly data for each site will also be separated by date into two categories: before and after agricultural BMP installation. Boxplots will be generated and one-way analysis of variance (ANOVA) will be performed to determine if there was a significant change in water quality before and after agricultural BMP installation ($p < 0.05$). The comparativeness of data (e.g., sample count, sample years, antecedent weather conditions) between the two time periods will be considered to determine whether a statistical test is appropriate.

5. PROJECT SCHEDULE

Table 5. Project Schedule.

Task / Deliverable	Date
Work Plan and Budget	10/9/18
Progress and Financial Reports	Monthly
Task 1: Project Management and Administration	
Subtask 1a: Kick-Off Call	
Kick-Off Conference Call	10/23/18
Call Summary	10/30/18
Subtask 1b: Conference Calls, Meetings, and Project Team Support	
Conference Calls & Summaries, Correspondence to Support Project	Monthly
Task 2: Development of QAPP	
Draft QAPP	11/30/18
Final QAPP	2/4/19
Task 3: Source Tracking Sample Selection	
Subtask 3a: Source Tracking Sample Selection and Lab Analysis by PhyloChip	
Draft Memo with Prelim. Subset of Samples for PhyloChip Analysis	Apr-19
Subtask 3b: Best Practice Recommendations for PhyloChip	
Final Memo with PhyloChip Results and Recommendations	Jun-19
Task 4: Water Quality Trends Summary	
Draft WQ Trends Summary Memo	Jun-19
Final WQ Trends Summary Memo	Jul-19
Task 5: Stakeholder Workshop	
Stakeholder Workshop	Jun-19
Workshop Notes and Action Plan	Jul-19
Task 6: Land Use and Regulatory Analysis and Recommendations	
Draft Land Use and Regulatory Analysis and Recommendations Summary	Aug-19
Review Meeting	Aug-19
Final Land Use and Regulatory Analysis and Recommendations Summary	Sep-19

6. PROJECT REPORTING

Final project reports will identify all sources of data used in the project. All sources of data used in or generated by the project will be either provided as attachments to final project reports or made available upon request. Draft and final project products will be generated in common or publicly-available programs that are compatible with end user systems for ease of maintenance or updates in the future such as MS Office 2016 (e.g., Word for written reports, Excel for

[4] A Mann-Kendall Trend Test is a non-parametric statistical test that determines if the central value (median) of a dataset has changed over time. A non-parametric test is appropriate here because it does not make assumptions about the normality or variability of the dataset; variation seen year-to-year or within seasons will not influence the results of non-parametric analysis the way that parametric tests can be influenced.

spreadsheets, CSVs for analysis), ArcMap Desktop 10.6.1 (e.g., geodatabase of spatial files and/or map packages of project maps), QGIS Desktop 3.4.1 (e.g., two vector files of automated subwatershed delineations to be included in a geodatabase and/or map packages), and R x64 3.5.1 / RStudio (e.g., R scripts or markdowns for statistical analyses, calculations, and data visualization). All MS Excel spreadsheets and/or model files will include metadata on data sources, corrections, and exclusions (by whom and on what date). All R scripts or markdowns will be annotated to ensure that the code for analysis can be easily reproduced and understood. All MS Word reports (as applicable) will document QA/QC procedures either within the report or as an attachment.

7. REFERENCES

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US EPA. (2016). Quality Assurance Project Plan (QAPP) 2016 US EPA Workforce Development Fund PhyloChip Microbial Source Tracking (MST) Project. RFA 16126. United States Environmental Protection Agency, Office of Environmental Measurement and Evaluation, North Chelmsford, MA & OECA. July 25, 2016.

APPENDIX A

Procedures for Model Application: Estimating Pollutant Load Reductions from Agricultural BMPs in the Palmer River Watershed

The following describes procedures for executing the Spreadsheet Tool for Estimating Pollutant Load (STEPL) model for the *Secondary Data Quality Assurance Project Plan (QAPP) for the Palmer River Source Tracking, Water Quality Trends Summary, and Watershed Plan*. Format follows EPA guidance on developing QAPPs for model applications (US EPA, 2010). Information redundant to the Secondary Data QAPP was not included. Because the project will use an existing model framework in the public domain, many of the requirements described in the EPA guidance were not necessary.

The latest model and documentation (STEPL 4.4, updated 3/15/18) will be used for estimating potential pollutant load reductions from installed agricultural BMPs in the Palmer River watershed (available at https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl). Model execution will follow recommendations and procedures outlined in the STEPL 4.4 User's Guide.

Data Generation and Acquisition

Data Acquisition Requirements (Non-Direct Measurements)

Since field assessments are not part of the project, HWG and FBE will rely on gathering secondary information from personnel with knowledge of the agricultural BMPs and agricultural operations in the watershed for use in estimating pollutant load reductions. Information may be incomplete and default model values, literature values, or best professional judgement may be used. The following describes the types and sources of information needed for model execution (see Table A1).

Model input selections:

- Select Massachusetts, Bristol County, Providence WSO Airport weather station.
- Keep Universal Soil Loss Equation (USLE) parameters associated with the county (Bristol, MA).

Data to gather at the sub-basin level for input to the model:

- 2017 land cover data for urban, cropland, pastureland, forest, and feedlots (if applicable). Urban land cover can be further defined as commercial, industrial, institutional, transportation, multi-family, single-family, urban-cultivated, vacant (developed), and open space. Land cover data will be analyzed under Task 6. Land cover categories will be reconciled with the general land cover categories assigned in STEPL. If feedlots exist, then enter the approximate percent paved of the feedlots.
- Number of agricultural animals (beef cattle, dairy cattle, swine (hog), sheep, horse, chicken, turkey, and duck).
- Number of months manure applied on cropland and pastureland. There is a manure application calculator available to deal with multiple farms within a sub-basin area.
- Septic system data, including the number of septic systems, the population per septic system, and the septic failure rate. In ArcMap 10.6.1 (using the most recent aerials available), estimate the number of primary dwellings in each sub-basin in non-sewered areas. Estimate the population per septic system using US Census 2010 demographic information on the average household size for the town with the largest coverage in the sub-basin. Estimate the septic failure rate by performing a brief literature search (typically 15-24% failure rates used) and contacting municipal health or code officers to identify any known or suspected trouble areas with failing or older septic systems.
- [Optional] Soil data, including the average soil hydrologic group (SHG). Soil information will be collected from Web Soil Survey (WSS) and GIS clearinghouses for MA and RI (refer to Table 3).

- [Optional] Irrigation area and irrigation amount, including the area of irrigated cropland, the depth of water per irrigation (before and after BMP), and irrigation frequency.

Data to gather at the BMP site level for input to the model:

- Compile information on the BMP type, location, and treatment area by land cover type.
- Assign BMPs to a sub-basin.
- Determine if BMPs are in a series (meaning one flows into another or to a common point) or different BMPs are used on the same general land cover type within a sub-basin and use the BMP Calculator to estimate a single reduction value from the BMP series (input as Combined BMPs-Calculated).
- Determine if any BMPs are gully or streambank erosion controls, and if so, then compile information on the width, depth, length, soil textural class, and years to form (input using the Gully and Streambank Erosion worksheet).
- Determine the direct discharge point from the BMP to the nearest surface water and whether there are further treatments to runoff (adjust reduction to account for additional treatments; for instance, through a forested area).
- For each general land cover type by sub-basin, select the BMP type from the STEPL menu and input the percent area that the BMP treats out of all the cropland within that sub-basin.

Table A1. Model data inputs and data sources.

Model Input	Source
Land Cover	2017; created under Task 6
Feedlots	NRCS; see Section 2.1
Animals	NRCS; see Section 2.1
Manure Application	NRCS; see Section 2.1
Septic Systems	2010 US Census; Aerial Counts; Literature; Municipal Contacts
Soils	Web Soil Survey; see Table 3
Irrigation	NRCS; see Section 2.1
BMPs	NRCS; see Section 2.1

Data Management

STEPL 4.4 is a simple spreadsheet model generated in MS Excel. A separate database spreadsheet will be generated in MS Excel 2016 to document and compile input data for the model (and be shared with the NRCS contacts for direct data entry and/or review and approval of information). Information from the database will be input to STEPL for load calculations. Metadata will be housed in the database spreadsheet. Multiple versions of the database will be generated if significant changes are made or added and both the database and STEPL will be backed-up to a secure external hard-drive to protect from possible data loss or file corruption.

Model Application

Model Parameterization (Calibration)

No observed or measured pollutant load reductions from installed agricultural BMPs are available to compare to modeled STEPL outputs; thus, no calibration procedure or sensitivity analysis will be completed.

Model Corroboration (Validation and Simulation)

The reasonableness of STEPL model results will be evaluated in the context of the best professional judgement of both the NRCS contacts (with local knowledge) and HWG/FBE technical staff (with regional knowledge). Data inputs will be checked for transcription errors and default assumption errors and reviewed by NRCS, HWG, and FBE personnel.

Reconciliation with User Requirements

STEPL provides coarse estimates of pollutant load reductions at a resolution deemed acceptable for project objectives; thus, model results will represent the relative (not absolute) magnitude of possible water quality improvements as a result of the BMPs (for use in empirical analyses).

Reports to Management

All model spreadsheets and documentation will be provided in final format upon request by project partners. Model results will be used in empirical analyses under Task 4 to determine the efficacy of agricultural BMPs in the Palmer River watershed.

APPENDIX B

Subwatershed Delineation Workflow in ArcMap 10.6.1 and QGIS Desktop 3.4.1

Download USGS/NRCS 3DEP 10 m resolution (1/3 arc-sec), topographic bare-earth surface, seamless image file (grdn42w072_13) from https://www.usgs.gov/core-science-systems/ngp/tnm-delivery/gis-data-download?qt-science_support_page_related_con=0#qt-science_support_page_related_con

Add grdn42w072_13 raster data file to **ArcMap 10.6.1**
Add the WBD HUC12 Palmer River watershed boundary and zoom to layer.
Right click on layer in the table of contents and click Data > Export Data.
Check Data Frame (Current) Extent, keep Raster Dataset (Original) Spatial Reference, specify save location folder, select TIFF format, and leave all else the same. Click Save.

Specify projection for project in **QGIS Desktop 3.4.1**
Go to bottom right corner and click on globe symbol (EPSG:4326 (OTF)) with default EPSG # to open Project Properties window for CRS (or click Project > Project Properties > CRS)
Select desired Coordinate Reference System
EPSG: 102730 – NAD 1983 State Plane Rhode Island FIPS 3800 ft

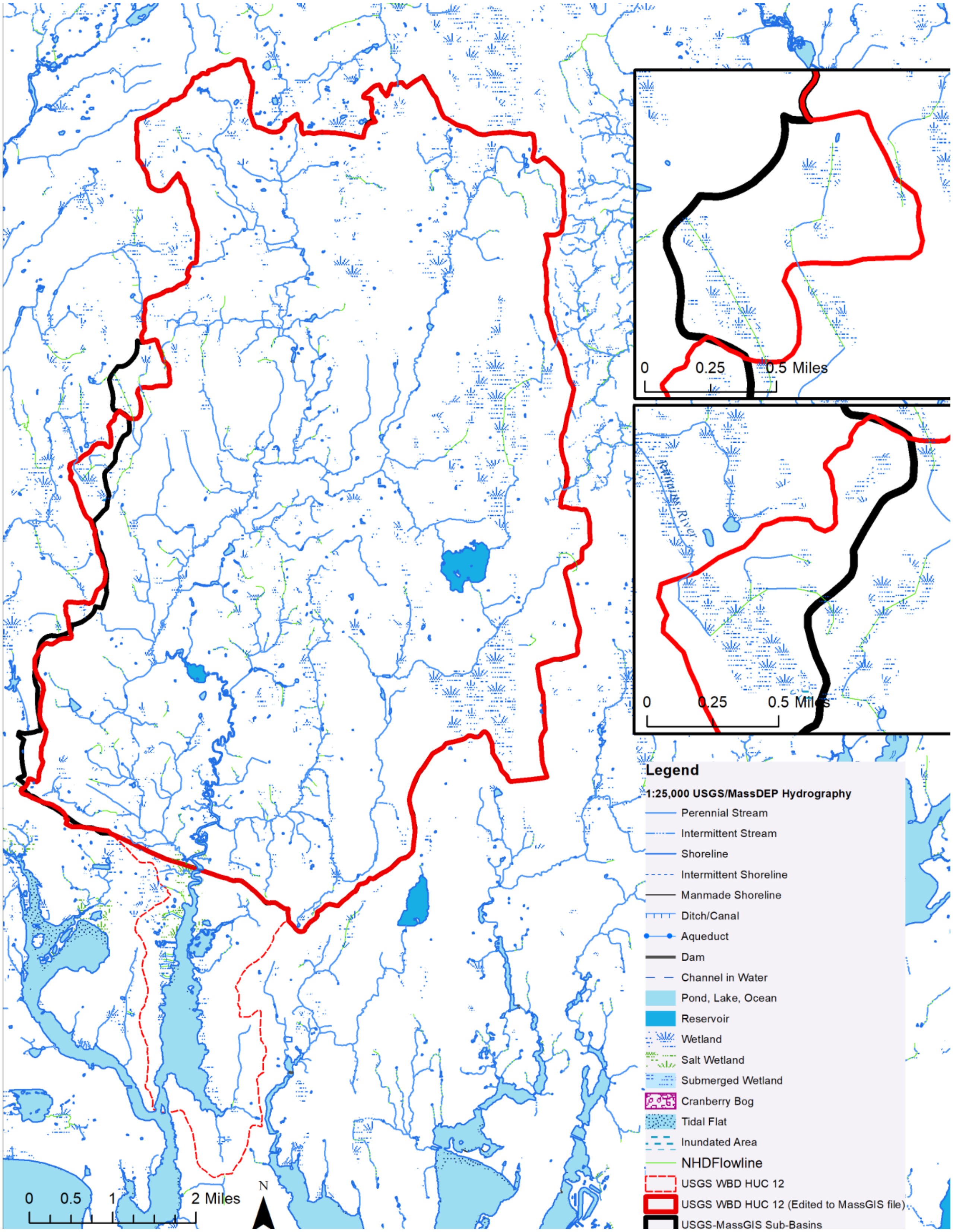
Add grdn42w072_13 TIFF file
Layer > Add Layer > Add Raster Layer (or click on left hand toolbar)
Navigate to TIFF file. Click Add, then Close.
Check that CRS for both TIFF file and project map are set to
EPSG: 102730 – NAD 1983 State Plane Rhode Island FIPS 3800 ft

Processing > Toolbox > GRASS commands [161 geoalgorithms] > Raster (r.*)
r.fill.dir
Input TIFF file. Keep everything else the same.
Check Open output file after running algorithm for Depressionless DEM.
Uncheck Open Output File after running algorithm for others.
Click Run. Click Close.
Check that CRS for output file and project map are set to
EPSG: 102730 – NAD 1983 State Plane Rhode Island FIPS 3800 ft
r.watershed
Input Depressionless DEM layer.
Skip down to Minimum Size of Exterior Watershed Basin and choose a value of 5000.
Check Open Output File after running algorithm for Number of cells that drain through each cell, Drainage direction, and Half-basins.
Click Run. Click Close.
Check that CRS for output files and project map are set to
EPSG: 102730 – NAD 1983 State Plane Rhode Island FIPS 3800 ft
r.water.outlet
Input Drainage Direction layer.
To enter coordinates of watershed outlet, click "…" to the right of the text box.
Click on map area on a stream network cell defined by the Number of cells that drain through each cell.
Save file to project folder.
Click Run. Click Close.
Check that CRS for output files and project map are set to

EPSG: 102730 – NAD 1983 State Plane Rhode Island FIPS 3800 ft
Above process could be repeated for individual sampling stations and combined in ArcMap 10.6.1.
r.to.vect
Input Output Basin layer.
Change Feature type to Area and check box to Open Output File after running algorithm.
Click Run. Click Close.
Repeat for Output Half-Basins layer.

Import to **ArcMap 10.6.1**.
Use Data Management Tools > Projections and Transformations > Project to set projection on vectorized files.
Use Editor and other basic tools to select and edit sub-basins within the Palmer River watershed.
Use ESRI World Topo Map and MA/RI elevation contours to manually edit automatic delineations.

APPENDIX C


0
0.25
0.5 Miles
Palmer River
0
0.25
0.5 Miles
Legend
1:25,000 USGS/MassDEP Hydrography
Perennial Stream
Intermittent Stream
Shoreline
Intermittent Shoreline
Manmade Shoreline
Ditch/Canal
Aqueduct
Dam
Channel in Water
Pond, Lake, Ocean
Reservoir
Wetland
Salt Wetland
Submerged Wetland
Cranberry Bog
Tidal Flat
Inundated Area
NHDFlowline
USGS WBD HUC 12
USGS WBD HUC 12 (Edited to MassGIS file)
USGS-MassGIS Sub-Basins
0
0.5
1
2 Miles
N