QUALITY ASSURANCE PROJECT PLAN

Optical Brightening Study-
Green Hill Pond, Ninigret Pond, Factory Brook, Teal Brook

Rhode Island Department of Environmental Management

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Table 2.1 Required Information Checklist

EPA Worksheet	*Section*	*Location*	*Comments*
1	1.0	Title Page	
2	2.0		
3	3.0	Table 3.1	Eliminated title of each recipient and document control number.
4	3.0	NA	All personnel in the organization chart will be given a copy of the QA plan
5a	4.0	Figure 4.1	
5b	4.0	Section 4.2	Narrative
6	4.0	NA	Personnel responsibilities and qualifications. Not needed for a project of this scope.
7	4.0	Section 4.3	Narrative information on training. Will keep a list of all trained individuals.
8a	5.0	Section 5.4	Scoping meetings were informal among RIDEM personnel.
8b	5.0	Section 5.0	Narrative
9a	6.0	Section 5.0	Narrative
9b	6.0	NA	TMDL dictates action limits have already been exceeded. Other information available in other tables.
9c	6.0	Tables 6.1, 6.1.1	Combined Tables 9c and 9d. Included only applicable information.
10	6.0	Table 6.3	
11a	7.0	Section 7.0	Narrative
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14	9.0	Table 9.2	No field equipment
15	9.0	Table 9.3	No field equipment
16	10.0	Table 10.2	
17	11.0	NA	No field analysis
18	11.0	NA	No field analysis
19	11.0	NA	No field analysis
20	12.0	Table 12.1	
21	12.0	NA	
22a	13.0	Table 13.1	
22b	13.0	NA	No multiple analytes for bacteria sampling.
23a	13.0	NA	No field analysis
23b	13.0	NA	No field analysis
24a	13.0	Table 13.2	
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25	14.0	Table 14.1	
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27a	16.0	NA	Assessment and Response Actions
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29a	19.0	Table 19.1	
29b	19.0	NA (Tables 7.1, 13.1, 13.2	
29c	19.0	NA	
30	20.0	NA (Tables 7.1, 13.1, 13.2)	

3.0 Distribution List

Table 3.1 Distribution List.

QAPP Recipient	*Organization*	*Telephone Number*	*Address*
Wayne Jenkins	RIDEM	401.222.4700 ext. 7272	235 Promenade Street Providence, RI 02908 wjenkins@dem.state.ri.us
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4.0 Project Organization

4.1 Project Organizational Chart

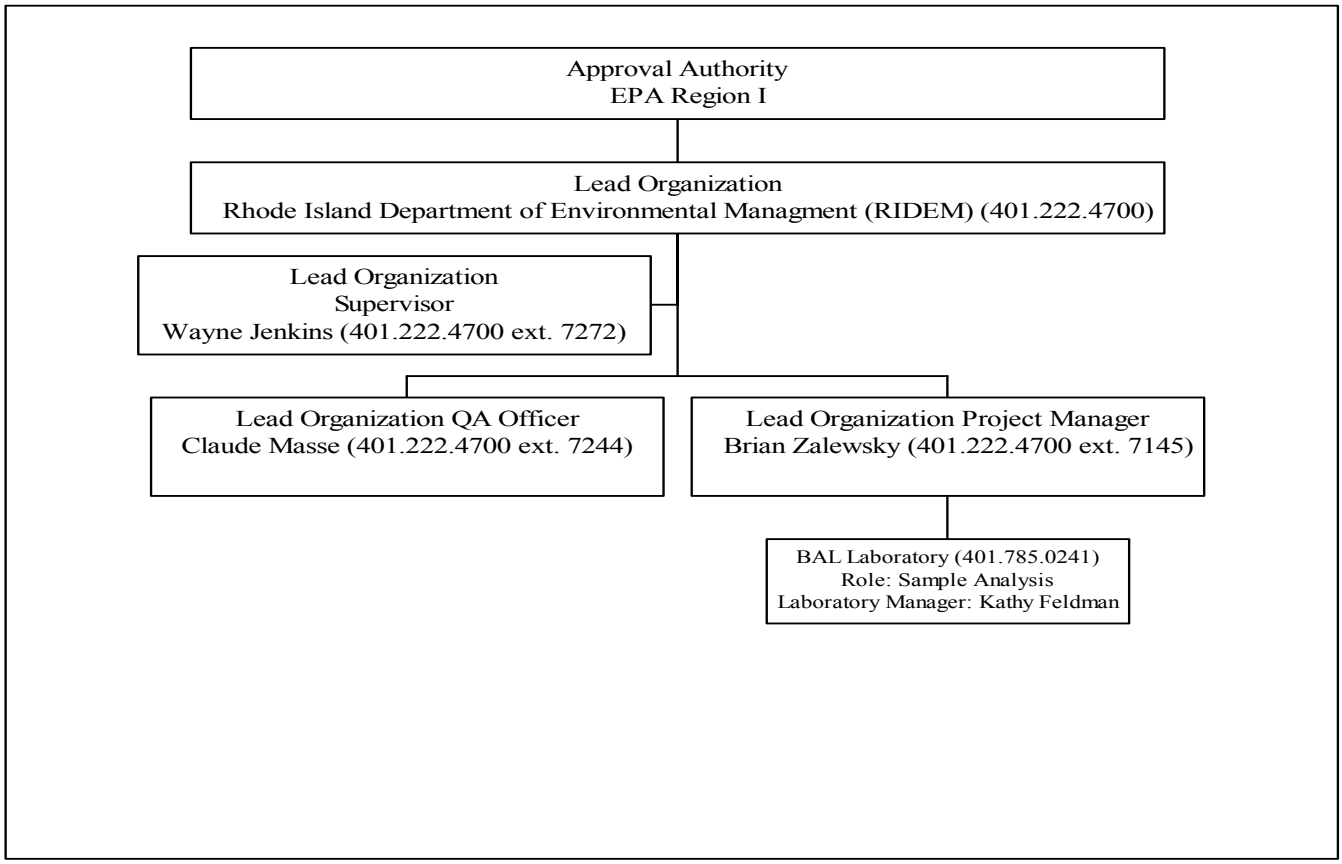


Figure 4.1 Project Organizational Chart.

4.2 Communication Pathways

An optical brightening study will be carried out in the summer of 2001. Dry and wet weather study criteria are discussed in Section 6.0 of this report. RIDEM staff will place and retrieve all optical brightening pads and collect concomitant fecal coliform samples. RIDEM staff will analyze all samples for the presence or absence of optical brighteners. Ten percent (10%) of the optical brightening pads will be sent to the Ozark Underground Laboratory for quality assurance analysis using a fluorescent black light and a Shimadzu RF-5000U Spectrofluorophotometer. BAL Laboratory will analyze all samples for fecal coliform bacteria.

In regards to wet weather sampling, the Project Manager will keep track of atmospheric conditions and notify one other staff member when conditions are favorable for a significant precipitation event to occur. When a potential storm is forecast, the Project Manager will inform that staff member that the study is underway. Preparations will then be made for pad placement and fecal coliform sampling. Before each study begins, the Project Manager will contact BAL Laboratory to arrange for sample bottles. Sample bottles will be picked up from BAL Laboratory prior to the surveys. These bottles will be kept at RIDEM and will be used for all sampling (during placement and retrieval).

Although it is not anticipated, changes to the study plan may occur over the course of the surveys. All changes made in the field by the field samplers will be documented in the field notes. The Project Manager will discuss these changes with the Project QA Officer within three days after sampling. In addition, it may become necessary to add and/or drop optical brightening placement stations prior to and/or during the survey. This decision will be made jointly by the QA Officer and the Project Manager. All changes to the QA Plan will be reported in each sampling event's Status Report and the Final Report.

4.3 Personnel Responsibilities and Qualifications

RIDEM personnel with surface water quality experience will conduct all bacteria sampling and will place, retrieve, prep, and analyze all optical brightening pads. Resumes of RIDEM personnel are on file at the RIDEM Office in Providence, RI. Kathy Feldman, Laboratory Manager at BAL Laboratory, will be responsible for the laboratory analysis of the surface water samples for fecal coliform bacteria. Her resume is on file at BAL Laboratory in Cranston, RI. Tom Aley, Director of the Ozark Underground Laboratory will be responsible for the analysis of the 10% of cotton pads sent as a QA-QC check.

The Project Manager will keep a list of all individuals trained. This list will include the names of the individuals trained, who trained them, and the date of training.

5.0 Problem Definition/Background

The Rhode Island Department of Environmental Management (RIDEM) is currently developing bacteria TMDLs for Green Hill Pond, eastern Ninigret Pond, Factory Brook, and Teal Brook. RIDEM is attempting to locate all sources of bacterial pollution to these waterbodies. Discerning between animal sources (wildlife, domestic animals, and waterfowl) and human sources (domestic sewage) of bacteria is a commonly encountered problem that cannot be resolved by sampling water quality parameters such as number of fecal coliform colonies per 100 ml, total organic carbon, ammonia nitrogen, nitrate nitrogen, ammonia nitrogen plus nitrate nitrogen, surfactants, and the ratio of fecal coliform colonies to fecal streptococcus colonies. None of these parameters are associated exclusively with sewage, and magnitudes and/or changes in magnitudes of the above parameters during differing temporal and spatial scales does not give insight as to whether the pollution source is anthropogenic or not. In addition, sampling for the above-mentioned parameters does not help with the identification of faulty septic systems, or storm drain cross-connections.

Reconnaissance sampling for optical brighteners is a simple and inexpensive tool for differentiating between human and non-human sources of bacterial pollution and detecting sewage contamination of waters in selected hydrologic settings.

Optical brighteners are fluorescent white dyes that are added to almost all laundry soaps and detergents. When optical brightener is applied to cotton fabrics, they will absorb ultraviolet rays in sunlight and release them as blue rays. These blue rays interact with the natural yellowish color of cottons and give the garment the appearance of being "whiter than white". Optical brightener dyes are generally found in domestic waste-waters that have a component of laundry effluent. Optical brighteners can therefore enter the subsurface environment as a result of ineffective sewage treatment.

Optical brighteners are removed from underground waters by adsorption onto soil and organic materials- they are removed from surface waters by adsorption and photodecay. Since adsorption is a critically important process in the performance of septic field systems, the recovery of optical brighteners in nearby waters (either surface or ground water) indicates ineffective natural cleansing of wastewaters.

Because optical brighteners are fluorescent white dyes that absorb ultraviolet "U.V." light and fluoresce in the blue region of the visible spectrum, they can therefore be detected by use of a long wave fluorescent "U.V." or a "black" light.

Bacterial sampling will be performed in conjunction with this study. Because optical brightener sampling only provides presence/absence data, bacterial sampling is necessary to provide quantitative results about a pollution source. Quantitative results are required to determine the concentration of pollutants in a water sample to evaluate the relative contribution of a pollution source to water quality problems and to help guide pollution remediation and enforcement decisions.

Currently, Green Hill Pond and the eastern section of Ninigret Pond (from the westernmost boundary of Tockwotten Cove to Heather Island) are closed to shellfishing because of elevated bacteria levels. Factory Brook and Teal Brook are currently listed on the States 303(d) List of Impaired Waterbodies for fecal coliform. The goal of this sampling program therefore, is to locate all sources of bacterial pollution, help identify faulty septic systems and storm drain cross-connections, and differentiate between human and animal sources of bacteria to the ponds and freshwater streams.

This sampling is being done in conjunction with a larger sampling program consisting of extensive dry and wet weather water quality monitoring in the ponds and freshwater streams. Both sampling programs support TMDL development in these waterbodies. The Quality Assurance Project Plan for the dry and wet weather sampling is available at the RIDEM Office in Providence, RI.

5.1 Green Hill-Ninigret Pond Watershed

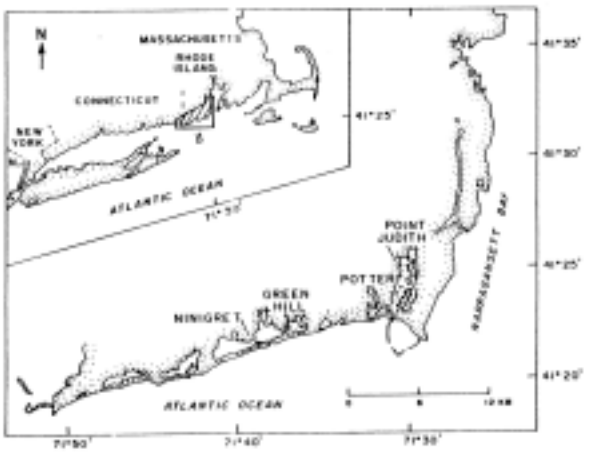
The Charlestown lagoon system, (Figure 5.1) located on the southern coast of Rhode Island, consists of two major basins, Ninigret Pond (6 km long and 1.4 km wide) and Green Hill Pond (1.5 km long and 1.4 km wide). Both of these shallow coastal lagoons are microtidal estuaries, receiving restricted tidal flushing through a narrow man-made breachway. The surface area of Ninigret Pond is $6.23 \times 10^6 m^2$ with a volume of $7.91 \times 10^6 m^3$ and an average depth of 1.27 m. Ninigret Pond is located entirely within the town of Charlestown and is bounded on its northern side by Route 1 and the Charlestown end moraine. The surface area of Green Hill Pond is $1.55 \times 10^6 m^2$ with a volume of $1.22 \times 10^6 m^3$ and an average depth of 0.79 m (Isaji et al 1985). Green Hill Pond is located primarily in the southwestern corner of the town of South Kingstown, with a small portion of the pond extending into southeastern Charlestown.

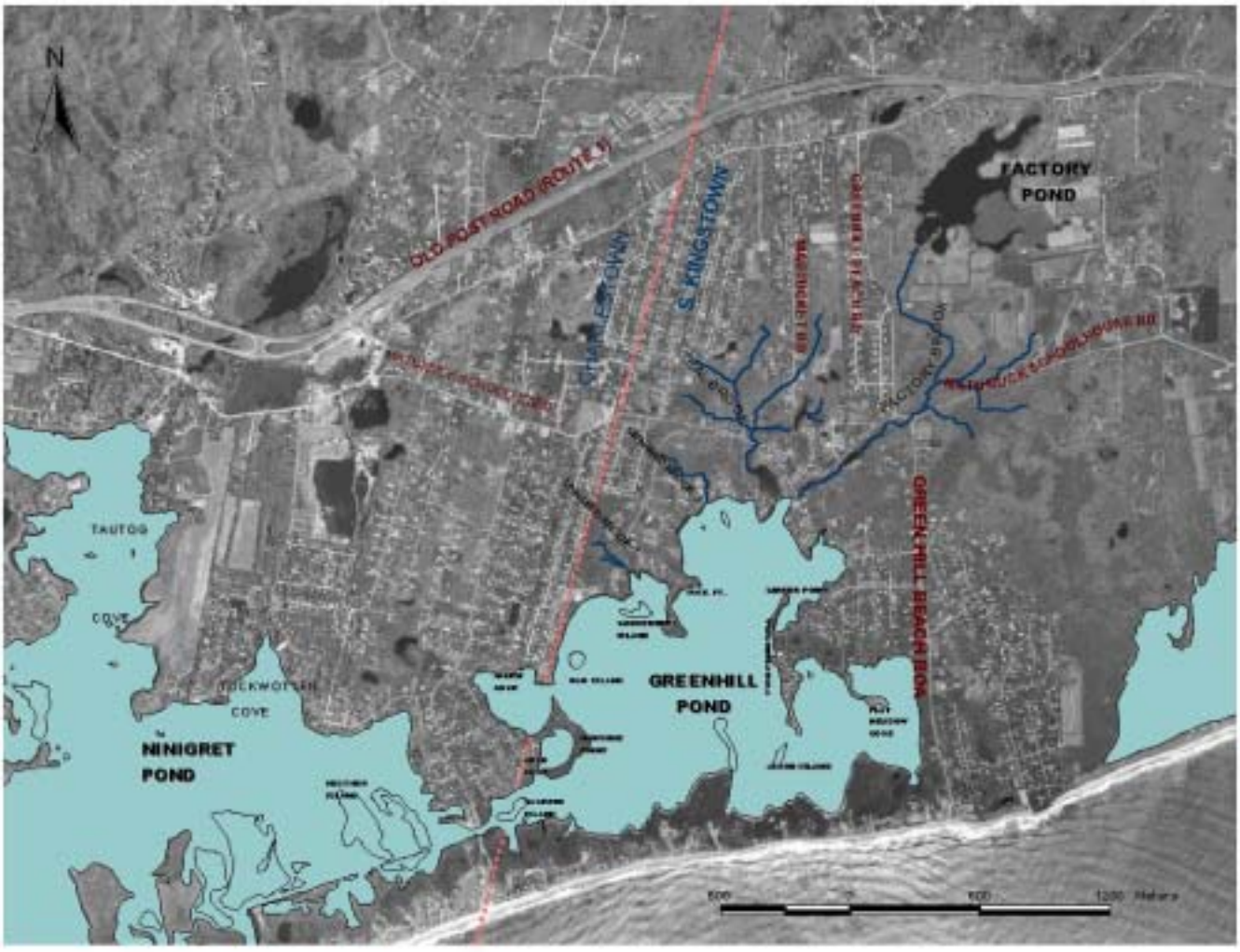
The Charlestown Lagoon watershed is approximately 10,154 acres in size (3,039 acres-Green Hill Pond watershed, 6,025 acres- Ninigret Pond watershed) and encompass the towns of South Kingstown and Charlestown. Green Hill and Ninigret Ponds lie on a low and level glacial outwash plain separated from the ocean by low narrow barriers.

The entire Salt Pond region is located in one of the fastest growing areas of the state and has experienced steady growth over the past forty years. Most of the existing residential and commercial development in the Green Hill and Ninigret Pond watersheds are not sewered and rely on Individual Sewage Disposal Systems (ISDS) for sewage disposal. The majority of the area surrounding the ponds is high density residential. Many of these houses which were originally constructed as summer cottages have since been converted to year-round residences without updating or replacing the existing ISDSs. In addition, to complete this worst case scenario, drinking water in the area is provided by individual, shallow dug wells.

Figure 5.1. Green Hill-Ninigret Pond study area.

Locus map





The watershed's population has increased dramatically since the 1950's and 60's when hundreds of vacation cottages were built on small lots clustered on the shores of Green Hill and Ninigret Ponds. During the 1980's, new construction spread throughout the watershed, and by 1997, residential development occupied about 37 percent of the watershed, with about 2,200 homes. Based on present zoning, approximately 600 additional homes could be built in the Green Hill Pond watershed. Most of this buildable land is in sensitive wellhead areas or close to the pond and its streams where the threat of water quality impact is the greatest.

RIDEM has concluded that Green Hill Pond and eastern Ninigret Pond are impaired due to fecal coliform concentrations, which exceed state water quality standards. RIDEM's Shellfish Growing Area Monitoring by RIDEM has shown that Green Hill Pond and eastern Ninigret Pond does not meet the National Shellfish Sanitation Program (NSSP) mandated statistical criteria for fecal coliform bacteria.

5.2 Factory Brook and Teal Brook Watershed

Teal Brook and Factory Brook are freshwater streams that flow into a small cove in the northwest corner of Green Hill Pond (Figure 5.2). Several small tributaries make up the headwaters of Teal Brook. The largest tributary originates in a small wetland area located east of Mautucket Road and west of Bedford Drive. As this stream crosses Matunuck Schoolhouse Road, it is joined by three smaller tributaries that originate in wetland areas between Mautucket Road and Hemlock Road. Teal Brook then flows south-southeast as a third-order stream approximately 0.6 kilometers before emptying into Teal Pond. Teal Pond drains directly to Green Hill Pond via a small rock lined channel approximately 1.5 meters in length and 1.0 meters in width. Teal Brook is a slow moving shallow stream ranging 1.0-1.5 meters in width.

Factory Brook originates in Factory Pond, a small pond approximately 10 ha in size, located just south of Route 1. At its outlet, Factory Brook flows south approximately 0.4 km before turning southeast and flowing into the northeast corner of Green Hill Swamp. Here, the mainstem is joined by three smaller tributaries that drain the middle and upper sections of the swamp. Factory Brook then continues through Green Hill Swamp for approximately 0.6 km before flowing into a small impoundment approximately 1.0 ha in size. The brook then flows SSE approximately 0.1 km and empties into Green Hill Pond as a second order stream approximately 10 meters east of Teal Brook.

The Factory Brook and Teal Brook watersheds are small- approximately 225 ha and 67 ha in size, respectively and consist of forestland, forested wetland, and swamp, with some low-density residential areas situated in the lower portion of the watershed. The watersheds rely on ISDS for the treatment of wastewater. Soils in the Factory Brook drainage are characterized as having rapid permeability, slow runoff, high water table, and a high susceptibility to flooding. The Soil Survey of Rhode Island (Rector 1981) describes these soils as having severe limitations for the placement of septic tank absorption fields.

Salt Pond Watcher monitoring data and RIDEM preliminary data have indicated that the two tributary streams, Teal and Factory Brooks, which enter Green Hill Pond exhibit elevated fecal coliform concentrations.

Figure 5.2. Factory Brook and Teal Brook study area.

5.3 Water Quality History

Public involvement has been very active concerning issues within Green Hill and Ninigret Ponds, as well as the entire Salt Pond Region. Public concern over deteriorating habitat and water quality- leading to the recent shellfish closures in Green Hill and Ninigret Ponds, has been the driving force behind much of the scientific research in this area. Numerous studies have been conducted in the ponds in an attempt to characterize water quality, understand changes in the ecology and cumulative impacts of development, and identify sources of pollution impacting the ponds.

As far back as 1981, studies conducted by the R.I. Department of Health (RIDOH) and University of Rhode Island (URI) researchers revealed that fecal coliform concentrations exceeded the Class SA shellfishing standard in Green Hill Pond.

The RIDEM Shellfish Growing Area Monitoring Program is part of the state of Rhode Island's agreement with the U.S. Food and Drug Administrations (FDA) National Shellfish Sanitation Program (NSSP). As part of this agreement, the state of Rhode Island is required to conduct continuous bacteriological monitoring of the shellfish harboring waters of the state, including the south shore

coastal ponds, in order to maintain certification of these waters for shellfish harvesting for direct human consumption. Since 1981, RIDEM's Shellfish Unit have sampled 12 stations in Green Hill Pond and Ninigret Pond. In 1994, based on composite bacterial monitoring results, Green Hill Pond's shellfishing status was reclassified from Conditionally Approved/Seasonal to Prohibited. In 1996, eastern Ninigret Pond (all waters east of a line from Tockwotten Cove (in its entirety) to a range marker located on the opposite side of the Pond) was reclassified from Approved to Prohibited based on elevated bacterial concentrations

Volunteers, known as the "Salt Pond Watchers" (SPW) began an annual monitoring program in the salt ponds in 1985 with funding from the Rhode Island Sea Grant Program, RIDEM, and the FDA. Under the direction of the URI Coastal Resources Center, a water quality monitoring program was established with sampling at 22 water chemistry and bacteria stations in Green Hill and Ninigret Ponds and 9 bacteria stations in Factory Brook and Teal Brook. The SPW dataset shows that the elevated in-pond bacteria concentrations are localized, and consistently occur in several isolated coves. SPW data have also shown that Factory and Teal Brook are a prime source of bacterial loading and that these streams are violating state water quality standards.

Historic data show bacteria violations in Green Hill Pond, Ninigret Pond, Factory Brook, and Teal Brook, however no information exists that definitively shows where the bacteria sources are, or whether or not they are of human or non-human origin. The objective of this study therefore is to provide some insight as to the origin of pollution sources in the study area.

A list of applicable studies appears in Table 5.1. More details about each study can be found in the Preliminary Data Report for the Green Hill-Ninigret Pond watershed (RIDEM 2001). Section 14.0 discusses data acquisition requirements.

Table 5.1 Water Quality Monitoring Programs in the Green Hill Study Area.

Organization	***Report/Monitoring***	***Date of Report***	***Approx. date of Study***
Salt Pond Coalition	SPW Technical Report 1985-1994; Ongoing Data Collection	1996	1985-1994, ongoing water quality monitoring
RIDEM-Shellfish Unit	Review: Shellfish Surface Water Monitoring Program	Yearly summaries	Ongoing water quality monitoring
RIDEM	Preliminary Data Report for Green Hill Pond, Ninigret Pond, Factory Brook, and Teal Brook	January 2001	Summary of previous water quality data

5.4 Project Planning

Informal project scoping meetings were held at RIDEM between the Project Manager, Brian Zalewsky and the Project Manager's supervisor, Wayne Jenkins. At these meetings, project goals were discussed, along with potential sampling locations and project action limits. The Project Manager also had detailed discussions with several other individuals who have completed studies of this nature.

In April, the Project Manager spoke at length, over the phone, with Tom Aley, Director of the Ozark Underground Laboratory, Inc., located in Protem, MO. During these conversations, project-specific details such as ideal optical brightener placement, retrieval, and analysis were discussed. In addition, Mr. Aley provided written material regarding successful optical brightener studies and some written instructions for optical brightener sampling.

In May, The Project Manager spoke at length, over the phone, with Bruce Lorentzen at the Glocester Shellfish Department in Gloucester, Mass. During these conversations, project-specific details such as optical brightener placement, retrieval, and analysis were discussed. The Gloucester Shellfish Department has performed hundreds of these studies in the past and their input proved very useful in designing this study.

In addition, the manual entitled "An Optical Brightener Handbook" is available over the internet at the following url: http://www.thecompass.org/8TB/pages/SamplingContents.html. This manual proved useful in helping the Program Manager design project action limits for this study.

6.0 Project Description and Schedule

A Total Maximum Daily Load (TMDL) report is required by the Clean Water Act for all waterbodies that do not meet their designated use. Green Hill Pond and eastern Ninigret Pond are currently closed to shellfishing due to elevated levels of fecal coliform bacteria. Factory Brook and Teal Brook are listed on the State's 303(d) list of water quality impaired waterbodies. The TMDL reports will include source identification and quantification of the dry and wet weather pollution sources to these waterbodies

In support of DEM's 2001 water quality monitoring studies, DEM will perform an optical brightening survey in the Green Hill-Ninigret Pond watershed, and Factory and Teal Brook watersheds. The purpose of the optical brightening study is to help locate sources of septic contamination in all discharge pipes, streams, and springs in the study area. The study will also be used, in conjunction with bacteria sampling, to help differentiate between human and non-human sources of contamination in the study area.

6.1 Tasks

The following tasks outline the steps needed to accomplish the objectives of the optical brightening survey. The tasks relate to both dry and wet weather optical brightening surveys.

Task 1 Water Quality Monitoring: Review Existing Water Quality Data

Table 5.1 lists the various water quality studies that have been completed in the watersheds over the last sixteen years, as well as those programs that currently collect water quality data. Table A.1 in Appendix A details water quality data from these programs. Since 1981, RIDEM's Shellfish Unit has sampled 12 stations in Green Hill Pond and eastern Ninigret Pond. A volunteer monitoring group called the 'Salt Pond Watchers' (SPW) have sampled Green Hill Pond, Ninigret Pond, Factory Brook, and Teal Brook from 1985 to present.

RIDEM and SPW data will be used to localize monitoring efforts and focus optical brightening surveys in areas of concern. Land use investigations and aerial photo analysis combined with fieldwork that included talking with local residents and walking up the length of channels looking for potential pollution sources have also helped RIDEM staff in the determination of station locations. In addition, other factors that influence the selection of sampling sites include accessibility to the site and tidal influences.

Task 2 Optical Brightening Study-Dry Weather

The purpose of the dry weather optical brightening survey is to differentiate between human and non-human sources of bacterial pollution, as well as to isolate bacterial pollution from failing septic systems. Optical brightening pads will be placed in all stream and spring sites, and discharge pipes (if they are flowing).

Two sampling devices will be placed at each station and allowed to remain on-site for approximately 5-7 days. Each sampling device consists of an untreated cotton pad measuring approximately 4" by 4". The untreated cotton pad is enclosed in a wire mesh cage consisting of two hinged pieces measuring approximately 5" by 5". This rigid sampling device will be placed so that it lies perpendicular to the flow but still allowed to move freely in the current. The device is secured by an attached monofilament fishing line that is tied at the other end to an aluminum spike. A total of 15 in-stream stations will be sampled during each dry weather survey. Two sampling devices will be placed at each station (1 is a replicate), so that the total number of sampling devices to be placed during the dry weather survey is 30.

After approximately 5-7 days the pads are retrieved and analyzed for the presence or absence of optical brighteners. Ten percent (10%) of these samples will be mailed to the Ozark Underground Laboratory for analysis.

Bacteria samples will be collected at each site twice during each survey- once during placement and once during retrieval. Replicate samples will be taken randomly at 5% of the stations for quality control purposes. BAL Laboratory will utilize the mTEC method when analyzing bacteria samples.

All fecal coliform samples will be collected following the field sampling Standard Operating Procedures (SOP) presented in Attachment A (S-1). All optical brightening devices will be placed, retrieved, and prepared for analysis following the field sampling SOP's presented in Attachment A (S-2).

Table 6.1. Analytical Services Table for Dry Weather Bacteria Sample Stations.

Medium/ Matrix	*Analytical Parameter*	*Analytical Method/ SOP*	*No. of Sampling Locations*[1]	*No. of Field Duplicates*	*Total No. Samples to Lab.*	*Data Package Turnaround*	*Laboratory Name*
Surface Water	Fecal Coliform	mTEC	30	5%	32	7 Days	BAL

[1] Number of Sampling Locations includes placement and retrieval.

Task 3
Optical Brightening Study-Wet Weather

The objective of the wet weather sampling program is to isolate the effect of a discrete rainfall event to permit source characterization of stormwater runoff, point source discharges, and in-stream stations during a high flow event. A total of 15 in-stream stations and 6 point source discharge stations will be surveyed during the wet weather study.

To be considered a storm event, the following precipitation characteristics must apply.

- Minimum rainfall of 0.5 inches in a 24-hr period
- Minimum duration of 5 hours
- Minimum antecedent dry period (ADP) of 3 days

Two sampling devices will be placed at each station and allowed to remain on-site for the duration of the event. Each sampling device consists of an untreated cotton pad measuring approximately 4" by 4". The untreated cotton pad is enclosed in a wire mesh cage consisting of two hinged pieces measuring approximately 5" by 5". This rigid sampling device will be placed so that it lies perpendicular to the flow but still allowed to move freely in the current. The device is secured by an attached 20 lb–test monofilament fishing line that is tied at the other end to an aluminum spike. A total of 21 stations will be sampled during the wet weather survey. Two sampling devices will be placed at each station (1 is a replicate), making the total number of sampling devices to be placed during the dry weather survey is 42.

Bacteria samples will be collected at each site twice during each survey- once during placement and once during retrieval. Replicate samples will be taken randomly at 5% of the stations for quality control purposes. BAL Laboratory will utilize the mTEC method when analyzing bacteria samples.

All fecal coliform samples will be collected following the field sampling Standard Operating Procedures (SOP) presented in Attachment A (S-1). All optical brightening devices will be placed, retrieved, and prepared for analysis following the field sampling SOP's presented in Attachment A (S-2).

Table 6.1.1 Analytical Services Table for Wet Weather Sample Stations.

Medium/ Matrix	*Analytical Parameter*	*Analytical Method/ SOP*	*No. of Sampling Locations*[1]	*No. of Field Duplicates*	*Total No. of Samples to Lab*[1].	*Data Package Turnaround*	*Laboratory Name*
Surface Water	Fecal Coliform	mTEC	42	5%	44	7 Days	BAL

[1] Number of Sampling Locations includes placement and retrieval.

6.2 Project Schedule

Table 6.3 Project Schedule.

		2001								
Task	***Deliverable***	***A***	***M***	***J***	***J***	***A***	***S***	***O***	***N***	***D***
Review Existing Data[1]	Monitoring Plan									
QAPP Preparation	QAPP Document									
Site Preparation	NA									
Sample Collection	NA									
Laboratory Analysis	Laboratory Report									
Final Data Report	Final Data Report									

[1]Section 14.0 of this report documents the existing data used to establish sampling stations and any data limitations.

7.0 Project Quality Objectives and Measurement Performance Criteria

Collecting high quality data is one of the most important goals of this project. Specific data quality objectives include method detection limits, precision, accuracy, representativeness, comparability, and completeness. All data quality objectives will be met if the data collected (optical brightening data in

combination with fecal coliform bacteria data) prove valuable by helping to differentiate between human and non-human sources of bacteria in the study area, as well as help locate any potential failing septic systems.

7.1 Measurement Performance Criteria

Representativeness

The selected stations were chosen for their representativeness of conditions during dry and wet weather. Wet weather optical brightening placement and concomitant fecal coliform sampling is important because this is when water quality in the ponds and streams is most frequently compromised. The extent to which the measurements represent actual environmental conditions will be somewhat restricted by the time of year the samples are taken and the overall weather conditions of that year (i.e. wet versus dry year).

Comparability

To maximize the quality of the data collected, and to collect data that is comparable with other studies, accepted sampling procedures will be used during this study. All samples collected will be sent to laboratories that use Standard Methods. The mTEC method will be used to analyze all bacteria samples. Optical brightening pads will be analyzed using techniques consistent with those utilized by the Ozark Underground Laboratory.

Sensitivity

Analytical methods for bacteria analysis were selected such that detection limits will not limit the usefulness of the data set. Analysis for the presence of optical brighteners on each sampling pad is performed in a qualitative manner. This data quality parameter will be fulfilled by sending 10% of the optical brightening pads to the Ozark Underground Laboratory for quality assurance analysis using the Shimadzu RF-540 Spectrofluorophotometer.

Completeness

If the data collected is sufficient to provide insight, in conjunction with concomitant bacteria sampling, as to help differentiate between human and non-human sources of bacteria-as well as to locate ISDS systems that are potentially failing, then the data is considered to be complete. Measurement performance criteria help determine the completeness of a data set. Table 7.1 documents the measurement performance criteria for fecal coliform bacteria for this project. Table 7.2 documents the measurement performance criteria for optical brightening analysis for this project.

Table 7.1 Measurement Performance Criteria for fecal coliform analysis.

Sampling SOP	S-1
Medium/Matrix	Surface Water
Analytical Parameter	Fecal Coliform
Concentration Level	<1

Data Quality Indicator	***Analytical Method/ SOP Reference/ Laboratory***	***Measurement Performance Criteria***	***QC Sample and/or Activity Used to Assess Measurement Performance***	***QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S/A)***
Precision	mTEC/ Standard Method 9213D/ BAL	Within 95% Confidence Interval	Field Duplicates/Split	S/A
Accuracy/bias Contamination	mTEC/ Standard Method 9213D/ BAL	Positive Growth (>2)	Method Blank	A
Accuracy/bias Contamination	mTEC/ Standard Method 9213D/ BAL	No Growth	Reagent Blank	A
Data - Completeness	mTEC/ Standard Method 9213D/ BAL		Anticipate 100%	A
Accuracy	mTEC/ Standard Method 9213D/ BAL	Within 95% Confidence Interval	Field Duplicates/Split	S/A

Table 7.2 Measurement Performance Criteria for optical brightening analysis.

Sampling SOP	S-2
Medium/Matrix	Surface Water-Storm Water
Analytical Parameter	Presence or absence of optical brighteners
Concentration Level	Qualitative Results (positive, moderately positive, weakly positive, non-detect)

Data Quality Indicator	***Analytical Method/ SOP Reference/ Laboratory***	***Measurement Performance Criteria***	***QC Sample and/or Activity Used to Assess Measurement Performance***	***QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S/A)***
Precision	Synchronous fluorescence scan using Shimadzu RF-540 Spectrofluorophotometer	Qualitative Results	Field Duplicate	S/A
Accuracy/bias Contamination	Reference pads; control	Qualitative Results	Method Blank	A
Accuracy/bias Contamination	Reference pads; control		Control	
Data - Completeness			Anticipate 100%	A
Accuracy		Qualitative Results	Field Duplicates/Split	S/A

8.0 Sampling Process Design

8.1 Sampling Design Rationale

Section 6.1 Task 1 describes the process for deciding the locations of the dry and wet weather optical brightening placement stations. Stations were chosen based on land use information, historic water quality data, and previous field investigations. Sample stations were selected with the intention of

quantifying pollution sources during dry and wet weather and differentiating between human and non-human sources of bacteria. In addition, some stations were selected as a "control" and will be confirmed as such using the optical brightening study in conjunction with bacteria analysis. These "control" stations are downstream of wetlands or forested wetlands where surface water is not likely to contain optical brighteners.

Tables A.2-A.5 in Appendix A describe the exact location and monitoring protocol for each station. A map showing station locations is provided in Figure A.1-Appendix A. BAL Laboratory will use the mTEC analysis method to analyze all bacteria samples. Table 8.1 contains information about sampling and analysis methods for fecal coliform bacteria. Table 8.2 contains information about sampling and analysis methods for the optical brightening portion of the study.

Table 8.1 Sampling and Analysis Method/SOP Requirements for fecal coliform collection.

Lab	*Medium/ Matrix*	*Depth*	*Analytic Parameter*	*SOP*		*Container*[1]			*Container*[1] *Requirements*	*Temperature*	*Holding Time*[2]
				Sampling	*Analytical*	*No.*	*Size*	*Type*			
BAL	Surface Water	6-12 inches	Fecal Coliform	S-1	mTEC	1	250 mL	Polyethylene	Ice	4°C	6 Hours

[1] The laboratory that completes the sample analysis will provide sterile bottles.
[2] Samples may be held for up to twenty-four hours before being analyzed, however most samples will be delivered to the laboratory within six hours.

Table 8.2 Sampling and Analysis Method/SOP Requirements for optical brightening study.

Lab	*Medium/ Matrix*	*Parameter*	*Sampling*	*Qualitative Quantitative*	*Sampling Medium*	*Medium Requirements*	*Temp*	*Holding Time*
Ozark Underground Laboratory	Surface or Storm Water	Optical Brighteners	S-2	Presence or Absence 10% of samples analyzed using Shimadzu SF-540 Spectro-photo-fluorometer	Untreated Cotton Pad	Cool, Dark	Cool	2-3 Days

9.0 Sampling Procedures and Requirements

9.1 Sampling Procedures

Standard operating procedures for field placement of the optical brightening devices during dry and wet weather are located in Attachment A of this report. Standard operating procedures for fecal coliform sampling during dry and wet weather are located in Attachment B of this QAPP.

Table 9.1 Project Sampling SOP Reference Table.

Reference Number /Title	*Originating Organization*	*Equipment Identification*	*Modified for Work Project*
Field Sampling SOP 2 (S-2) Optical Brightener Device Placement-Retrieval-Prep	RIDEM	Not Applicable	No
Field Sampling SOP 1 (S-1) Fecal Coliform Sampling	RIDEM	Not Applicable	No

9.2 Equipment Cleaning

BAL Laboratory will provide sterile bottles for bacteriological sampling.
RIDEM will provide untreated cotton pads, rigid sampling devices, and other placement equipment (i.e copper wire, 20-lb test monofilament fishing line bricks, tent stakes, etc.)

9.3 Field Equipment Calibration and Maintenance

The Project Manager will ensure that all field equipment is operating properly. The only equipment needed for sampling is any associated safety and maintenance gear, sampling sticks, and coolers.

10.0 Sample Handling, Tracking, and Custody Requirements

10.1 Field Notes & Sample Tracking

Task 1 Optical Brightening Sampling Device Placement and Bacteria Sampling
A two-person team will place the optical brightening sampling devices as well as collect samples for fecal coliform analysis. Detailed station locations are provided in Appendix A Tables A.6-A.9. A map showing station locations for both the dry and wet weather studies is provided in Appendix A Figure A.1.

Task 2 Field Notes & Sample Tracking
All sampling teams will be provided with a Nalgene field notebook. Each team member should ensure that a log of events is faithfully and articulately maintained in one of the Nalgene notebooks used to document field studies. A minimum log includes the date, samplers name, station (placement) location, sample name and run (wet weather), sample collection times, and any other significant information, including field observations such as:

1) Noting the presence of waterfowl or other animal activity.
2) Suspicious flows that might indicate surface outbreak of an on-site septic system.
3) Unusual growth of algae or other wetland plants that might indicate nutrient loading.

The proper identification of the collection bottle for the bacteria sample is important. Before it is filled, the sample bottle should be labeled with the following information: sample station, date of collection, time of collection, and the samplers initials. Figure 10.1 below shows a sample bottle label.
The bottle should be labeled with permanent marker prior to collecting the sample as it is difficult to write on wet sample bottles.

STATION_____

DEPTH_____ **TEMP.**_____ **DATE**_____

INITIALS_____ **SALIN.**_____ **TIME**_____

SAMPLE TYPE_____

REMARKS _____ **LAB. NO.**

_____

BAL

Figure 10.1 BAL Sample Bottle Label.

Figure B.1 in Appendix B shows the chain of custody form for BAL Laboratory. Before the samples are handed over to the laboratory, all fields must be filled in, especially the sample ID and the time of sample collection field. The laboratory gives each sample a BAL Sample Number. This number is written on both the sample bottle and on the chain of custody form by laboratory personnel. The laboratory and RIDEM are given a copy of the completed chain of custody form. Figure B.2 in Appendix B shows the chain of custody form for the Ozark Underground Laboratory.

10.2 Sample Handling

All bacteria samples will be placed in a cooler with ice immediately after the sample is taken. The sample will be delivered to the laboratory within six hours. In some cases, samples may be kept for up to twenty-four hours, providing the are kept at 4°C. A designee of the Project Manger will deliver the samples to the laboratory. Table 8.1 documents the sample container size and preservation techniques.

Table 10.2 Sample Handling System-Fecal Coliform Samples.

	Responsible Party	*Samples*
Sample Collection	RIDEM staff	Source, In-pond, In-stream
Sample Delivery	RIDEM staff	Source, In-pond, In-stream
Sample Analysis	BAL Laboratory	Source, In-pond, In-stream
Sample Archival	None	Not Applicable
Sample Disposal	BAL Laboratory	Source, In-pond, In-stream

All optical brightener sampling pads should be rinsed with in-stream water, placed in zip-lock bags, and squeezed to remove excess water. They will then be placed in a cooler with ice and kept away from light until they are washed (with a garden hose) and analyzed under a black light. After analysis by RIDEM staff, 10% of the cotton pads will be delivered to the Ozark Underground Laboratory for quality assurance purposes. Table 8.2 documents the sampling media characteristics and preservation techniques.

Table 10.2.1 Sample Handling System-Optical Brightener Pads.

	Responsible Party	*Samples*
Sample Collection	RIDEM staff	In-stream, In-spring, Discharge pipes
Sample Delivery	RIDEM staff	In-stream, In-spring, Discharge pipes
Sample Analysis	RIDEM staff & Ozark Underground Laboratory (10% QA check)	In-stream, In-spring, Discharge pipes
Sample Archival	None	Not Applicable
Sample Disposal	RIDEM staff & Ozark Underground Laboratory	In-stream, In-spring, Discharge pipes

11.0 Field Analytical Method Requirements

During sampling, no field analyses will take place.

12.0 Fixed Laboratory Analytical Method Requirements

Samples collected from each survey will be taken to BAL Laboratory in Cranston, Rhode Island. These samples will be analyzed using the mTEC method. Attachment B (L-1) describes the standard operating procedures for BAL Laboratory.

Table 12.1 Fixed Laboratory Analytical Method/SOP Reference Table.

Reference Number	*Fixed Laboratory Performing Analysis*	*Title*	*Definitive or Screening Data*	*Analytical Parameter*	*Instrument*	*Modified for Work Project*
L-1	BAL	BAL Laboratory mTEC Method for Detection of Fecal Coliform and Escherichia Coli	Definitive	Fecal Coliform	NA	N

Ten percent of the optical brightening pads from each dry and wet weather survey will be analyzed by the Ozark Underground Laboratory in Protem, MO. The lab will analyze the pads using the same qualitative methods used by RIDEM staff (fluorescent black light) and in addition, will analyze the samples using a Shimadzu RF-540 Spectrofluorophotometer. Attachment B (L-2) describes the standard operating procedures used by the Ozark Underground Laboratory.

Table 12.2 Fixed Laboratory Analytical Method/SOP Reference Table-optical brighteners.

Reference Number	*Fixed Laboratory Performing Analysis*	*Title*	*Definitive or Screening Data*	*Analytical Parameter*	*Instrument*	*Modified for Work Project*
L-2	Ozark Underground Laboratory	Ozark Laboratory Analysis method for optical brightening study.	Definative	Presence of optical brighteners	Shimadzu RF-540 Spectro-fluorometer	N

13.0 Quality Control Requirements

Table 13.1 Field Sampling QC: Fecal Coliform.

Sampling SOP	S-1					
	Surface Water					
Analytical Parameter	Fecal Coliform					
Concentration Level	<1					
Analytical Method/ SOP Reference	S-1					
QC	***Frequency/ Number***	***Method/SOP QC Acceptance Limits***	***Corrective Action***	***Person Responsible for Corrective Action***	***Data Quality Indicator***	***Measurement Performance Criteria***
Field Duplicates	Minimum 1 per 20 samples	L-1	Discuss any problems in the field with sampler.	Project Manager	Precision	Within 95% Confidence Interval

Table 13.2 Fixed Laboratory Analytical QC: Fecal Coliform, mTEC at BAL Laboratory.

Sampling SOP	S-1					
	Surface Water					
Analytical Parameter	Fecal Coliform					
Concentration Level	<1					
Analytical Method/ SOP Reference	Standard Method 9213D					
QC	***Frequency/ Number***	***Method/SOP QC Acceptance Limits***	***Corrective Action***	***Person Responsible for Corrective Action***	***Data Quality Indicator***	***Measurement Performance Criteria***
Method Blank	1 Per Batch	L-1	Re-prepare Batch	Kathy Feldman	Bias-Contamination	Positive Growth (>2)
Reagent Blank	1 Per Batch	L-1	Re-prepare Batch	Kathy Feldman	Bias-Contamination	No Growth
Laboratory Duplicate	1 per 10 samples	L-1	Reanalyze	Kathy Feldman	Precision-Lab	Within 95% Confidence Interval

Table 13.3 Field Sampling QC: Optical Brightener Study.

Sampling SOP	S-2
	Surface/Storm Water
Analytical Parameter	Presence of fluorescent whitening agents(FWAs)
Concentration Level	na
Analytical Method/ SOP Reference	S-1

QC	*Frequency/ Number*	*Method/SOP QC Acceptance Limits*	*Corrective Action*	*Person Responsible for Corrective Action*	*Data Quality Indicator*	*Measurement Performance Criteria*
Field Duplicates	1 for each pad placement (2 total)	L-2	Discuss any problems in the field with sampler.	Project Manager	Precision	Results agree with each other.

Table 13.4 Fixed Laboratory Analytical QC: Optical Brightener Pad analysis-Ozark Underground Laboratory.

Sampling SOP	S-2
	Surface/Storm Water
Analytical Parameter	Presence of Optical Brightening Agents (FWA's)
Detection Level	Approx. 415-422 nm
Analytical Method/ SOP Reference	Use of Shimadzu RF-540 Spectrofluoro-photometer

QC	*Frequency/ Number*	*Method/SOP QC Acceptance Limits*	*Corrective Action*	*Person Responsible for Corrective Action*	*Data Quality Indicator*	*Measurement Performance Criteria*
Method Blank	One per batch	L-2	Data will be flagged	Tom Aley	Bias-Contamination	No fluorescence
Reagent Blank	One per batch	L-2	Data will be flagged	Tom Aley	Bias-Contamination	No fluorescence
Laboratory Duplicate	1 per 10 samples	L-2	Reanalyze	Tom Aley	Precision-Lab	Results agree

14.0 Data Acquisition Requirements

RIDEM's Shellfish Unit has monitored the Green Hill-Ninigret Pond watershed since 1981. In the following years, a volunteer monitoring group called the "Salt Pond Watchers" began to sample in-pond and in-stream stations during the summer months. These two studies, along with field investigations and land use and aerial photo analysis have provided the basis for determining the wet and dry weather fecal coliform sampling sites for RIDEM's 2001 studies. The major limitation to the above-mentioned water quality monitoring programs is that the data do not sample pollution sources or establish the relationship between instream or in-pond water quality and pollution sources. A summary of fecal coliform data from previous water quality studies is presented in Table A.1 in Appendix A.

During wet weather, RIDEM will utilize precipitation information from the National Weather Service Kingston weather station, located in Kingston, Rhode Island. The weather station is located approximately 8 km from the Green Hill-Ninigret Pond watershed. Table 14.1 summarizes non-direct measurements used in setting up the dry and wet weather studies.

Table 14.1 Non-Direct Measurements Criteria and Limitations.

Non-Direct Measurement (Secondary Data)	***Data Source***	***Data Generator***	***How Data Will Be Used***	***Limitations on Data Use***
Rainfall	National Weather Service Cooperative Observer, Kingston, RI station	URI Plant Sciences Dept.	Quantify amount of rainfall received in watershed.	None
Bacteriological Monitoring	Green Hill-Ninigret Ponds RI Shellfish Growing Area 11 Survey and Classification Considerations	RIDEM Shellfish Unit	Evaluate in-pond water quality.	1. No comprehensive monitoring of sources. 2. Samples not representative of wet weather conditions. 3. Different analysis than that used by BAL Lab. Results not comparable. 4. Study did not differentiate between human and non-human sources of bacteria.
Bacteriological Monitoring	SPW Salt Pond water quality monitoring program.	SPW	Evaluate in-pond and instream water quality	1. Summer sampling only. 2. Different analysis than that used by BAL Laboratory (not comparable) 3. Study did not differentiate between human and non-human sources of bacteria.

15.0 Documentation, Records, and Data Management

All information about the field surveys will be documented in the Nalgene notebook. The QAPP includes specific information on what needs to be recorded in the notebook. The Project Manager will review the sheets within three days to identify any possible errors or omissions. The Project Manager will contact any sampler whose sheet shows any discrepancies. In addition, the Project Manager will try to contact all samplers to identify any problems or additional feedback that would make future sampling easier.

The Project Manager and one assistant will collect all fecal coliform samples during the surveys. The Project Manager will be responsible for filling out and checking the chain of custody sheets (Appendix B Figure B.1). The samples and chain of custody sheets are also checked at the laboratory. A copy of the chain of custody form will be given to RIDEM when the samples are dropped off at the laboratory. After analysis is complete, sample results from the laboratory will be mailed to RIDEM.

The Project Manager and one assistant will retrieve all optical brightening devices, clean the pads, prepare them for analysis, and package 10% of the previously analyzed samples to be sent to the Ozark Underground Laboratory. Chain of custody sheets (Appendix B Figure B.2) have been provided by the Ozark Underground Laboratory and will be filled out accordingly and mailed with the samples. A copy of the sample collection data sheets will be kept by the Project Manager. After analysis of the samples is complete, sample results from the Ozark Underground Laboratory will be mailed to RIDEM.

After each sampling report, a brief Status Report will be written to document any changes to the Monitoring Plan. All information collected throughout the project will be summarized in the Final Data Report. Information included in the Final Data Report is described in Section 17.0. Table 15.1 lists records that will be generated throughout this project.

The Project Manager is responsible for the storage of all project files. RIDEM has a central filing system at its Providence Office where all original documents will be kept.

Table 15.1 Project Documentation and Records.

Sample Collection Records	*Field Analysis Records*	*Fixed Laboratory Records*	*Data Assessment Records*
Field Notes/Log Sheets	Field Notes/Log Sheets	Chain of Custody Records	Status Reports
Chain of Custody Records		Tabulated Data Summary Forms: draft and final	Final Data Report
Monitoring Plan			

16.0 Assessments and Response Actions

The Project Manager or designee will be responsible for each of the project tasks and their associated quality assurance and quality control procedures. The Project Manger will provide consistency between sampling events and sampling teams. Continual reports to the QA Officer about the status of sampling, quality assurance, and quality control will highlight any problems that are encountered during sampling. If needed, the QA Officer and Project Manager will halt sampling until problems are remedied.

Table 16.1 Project Assessment Table.

Assessment Type	*Frequency*	*Internal or External*	*Person Responsible for Performing Assessment and Implementing Corrective Actions*	*Person Responsible for Monitoring the Effectiveness of the Corrective Action*
Field Sampling Technical Systems Audit	Start of Sampling	I	Brian Zalewsky RIDEM	Wayne Jenkins RIDEM
Ozark Underground Laboratory Systems Audit	Prior to Sample Receipt	E	Tom Aley Ozark Underground Lab	Brian Zalewsky RIDEM
BAL Laboratory	Prior to Sample Receipt	E	Kathy Feldman BAL Laboratory	Brian Zalewsky RIDEM

17.0 QA Management Reports

Table 17.1 lists the QA Management Reports that will be generated throughout this study.

As needed during this project, the Project Manager and the QA Officer will meet to discuss any issues related to sampling. These meetings will consist of verbal status reports. Problems encountered in the field will be discussed and any appropriate actions determined and implemented. Any changes and/or problems will be included in the final report.

After each survey event, the Project Manager will generate a Status Report. This Status Report will consist of a written record of any changes to the QA Plan. If a station was not sampled, or if a station was added, it will be documented here. Issues discussed during the Verbal Status Report can also be included. At the completion of all four events, the Project Manager will write a final report summarizing the four sampling events. Information in this final report will include the following information:

- Brief description of each sampling event
- Data tables of all data collected during the sampling event (including rainfall)
- Attachments
  - Status Reports
  - Sampling Logs
  - Chain of Custody forms
  - Laboratory data sheets provided by the labs

Table 17.1 QA Management Reports.

Type of Report	*Frequency*	*Person(s) Responsible for Report Preparation*	*Report Recipient*
Verbal Status Report	As needed	Brian Zalewsky RIDEM	Wayne Jenkins RIDEM
Written Status Report	After each survey	Brian Zalewsky RIDEM	Wayne Jenkins RIDEM
Final Report	Completion of sampling	Brian Zalewsky RIDEM	Wayne Jenkins RIDEM

18.0 Verification and Validation Requirements

Both the Project Manager and the QA Officer will review all data collected during this study to determine if the data meets QAPP Objectives. Decisions to qualify or reject data will be made by the Project Manager and QA Officer. All data collected will be included in the Final Report. To ensure

correct interpretation of the data, all problems encountered in the field will be included in an Appendix to the report and discussed in the general text of the report. Problems will also be documented in each survey's written Status Report.

19.0 Verification and Validation Procedures

All data collected during each study will be included in the appendix of the Final Data Report. Once the data has been collected, it will be entered into Microsoft Excel files. The Project manager will proofread the data entry for errors. Errors will be corrected. Outliers and inconsistencies will be flagged for further review with the QA Officer. The decision to discard data will be made by the Project Manager and QA Officer. Problems will be discussed in the Final Report. Table 19.1 discusses the data verification process.

Table 19.1 Data Verification Process.

Verification Task	*Description*	*I/E*	*Responsible for Verification*
Field Notes	Field notes will be collected at the end of each survey and reviewed. Any required corrective actions will be addressed with the field samplers prior to further sampling. After the field notes will be entered into Excel, the data will be proofread for any data entry errors. Copies of the field notes will be maintained in the project file.	I	Brian Zalewsky/RIDEM
Chain of Custody Forms	Chain of custody forms will be reviewed when samples are collected for delivery to BAL Laboratory. The forms will be maintained in the project file.	I/E	Brian Zalewsky/RIDEM Kathy Feldman/ BAL Laboratory
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness prior to submittal. The data packages will be also reviewed by the sampling organization.	I/E	Brian Zalewsky/RIDEM Kathy Feldman/BAL Laboratory
Field Notes	Field notes will be collected at the end of each survey and reviewed. Any required corrective actions will be addressed with the field samplers prior to further sampling. After the field notes will be entered into Excel, the data will be proofread for any data entry errors. Copies of the field notes will be maintained in the project file.	I	Brian Zalewsky/RIDEM
Chain of Custody Forms	Chain of custody forms will be reviewed when samples are collected for delivery to Ozark Underground Laboratory. The forms will be maintained in the project file.	I/E	Brian Zalewsky/RIDEM Tom Aley/Ozark Lab
Qualitative Analysis	Optical Brightening Pads will be analyzed under a black light by the Project Manager at RIDEM. Ten (10) percent of the samples will be mailed to the Ozark Underground Laboratory for qualitative and quantitative analysis.	I/E	Brian Zalewsky/RIDEM Tom Aley/Ozark Lab
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness prior to submittal. The data packages will be also reviewed by the sampling organization.	I/E	Brian Zalewsky/RIDEM Tom Aley/Ozark Lab

I- Internal E- External

Data validation will utilize the measurement performance criteria documented in Tables 7.1, 13.1, and 13.2 of this report.

20.0 Data Usability/Reconciliation with Project Quality Objectives

As soon as possible after each sampling event, calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. If data quality indicators meet those measurement performance criteria documented throughout this QA Plan, the project will be considered a success. If there are data that do not meet the measurement performance criteria established in this QA Plan, the data may be discarded and sampled again or the data may be used with stipulations written about its accuracy in the Final Report. The cause of the error will be evaluated. Any limitations with the data will be documented in the Status Reports and the Final Report.

References

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Appendix A Sampling Station & Sampling Protocol Information

Table A.1 Summary of fecal coliform data from previous water quality studies-RIDEM Shellfish Monitoring.

Station	*Location*	*No. of years*	*n*	*Geometric Mean (fc/100ml)*	*90th Percentile Value*	*% Greater than 49 fc/100ml*
11	Ninigret Pond- Approximate Center of Tockwotten Cove	10	62	8	75	11
12	Ninigret Pond- Midway along a line from the northern end of Ward Island to the flagpole on the opposite northern shore.	10	62	9	230	13
13	Green Hill Pond- Mid channel under the Charlestown Beach Rd. bridge.	10	62	7	43	10
14	Just off the western edge of Horseshoe Point	10	62	8	43	10
14A	Just inside the entrance to Allen Cove	10	62	7	43	10
14B	Between Gooseberry and Ram Islands, just off the yellow house with dock.	10	62	6	43	8
15	Approximately 100 meters south of the southern tip of High Neck	10	62	4	23	7
16	Midway across the mouth of cove at northeast corner of Green Hill Pond.	10	62	11	93	19
16A	Midway between the two points of land at the entrance to the cove at Limber Point.	10	62	6	43	3
16B	Approximately 50 meters west of the point of land at the middle of Twin Peninsula	10	62	5	23	7
17	At the entrance to Flat Meadow Cove midway between the northern end of Goose Island and the southern tip of Twin Peninsula.	10	62	5	23	3
18	Approximately 100 meters west of the eastern shore of Flat Meadow Cove midway between north and south shores	10	62	7	43	10

Table A.1 cont. Summary of fecal coliform data from previous water quality studies-SPW monitoring.

Station	*Location*	*n (dry)*	*n (wet)*	*Geomean (dry) fc/100ml*	*Geomean (wet) fc/100ml*	*90th Percentile (dry)*	*90th Percentile (wet)*
16M	Factory Brook mainstem- Upstream side of dirt road in South Shore Management Area.	28	14	10	13	130	300
16S	Factory Brook mainstem- Downstream side of intersection between Matunuck Schoolhouse Road and Green Hill Beach Road.	29	9	127	208	350	1600
16F	Factory Brook mainstem- Upstream of impoundment.	11	13	39	284	130	1381
16G	Factory Brook mainstem- Downstream of impoundment.	46	25	65	251	328	1601
16J	Teal Brook tributary headwaters- Dawley Way.	8	9	27	111	80	512
16E	Teal Brook tributary- Intersection with Mautucket Road.	5	8	61	684	1051	1601
16K	Teal Brook mainstem- Downstream side of Matunuck Schoolhouse Road	41	18	154	126	540	1600
16D	Teal Brook outlet downstream of Teal Pond	20	17	87	181	300	1601

Table A.2 Sampling Design Rationale-Optical Brightener Placement (Dry Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
FB01	Factory Brook at outlet of Factory Pond	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB02	Factory B. mainstem at South Shore Management Area	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB03	Factory B. mainstem at intersection of Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB04	Factory B. mainstem at private drive across from Corey Road.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB05	Factory B. mainstem downstream of impoundment.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB06	Factory B. intersection with Teal Drive.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB07	Factory B. tributary intersection with Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
FB08	Factory B. tributary with Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
TBa	Teal Brook headwaters	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
TB00	Teal B. tributary intersection with Mautucket Rd.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
TB01	Teal B. tributary intersection with Mautucket Rd. South of TB00.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
TB02	Teal B. mainstem intersection with Matunuck Schoolhouse Road.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
TB03	Mouth of Teal Brook and outlet of Teal Pond.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
UN1	Mouth of Unnamed Brook 1.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.
UN2	Mouth of Unnamed Brook 2.	In-stream placement of 2 optical brightener pads for approximately 5-7 days.	Determine if optical brighteners are present in the surface water.

Table A.3 Sampling Design Rationale-Concomitant Fecal Coliform Bacteria Sampling (Dry Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
FB01	Factory Brook at outlet of Factory Pond	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB02	Factory B. mainstem at South Shore Management Area	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB03	Factory B. mainstem at intersection of Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB04	Factory B. mainstem at private drive across from Corey Road.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB05	Factory B. mainstem downstream of impoundment.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB06	Factory B. intersection with Teal Drive.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB07	Factory B. tributary intersection with Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB08	Factory B. tributary with Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TBa	Teal Brook headwaters	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB00	Teal B. tributary intersection with Mautucket Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB01	Teal B. tributary intersection with Mautucket Rd. South of TB00.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB02	Teal B. mainstem intersection with Matunuck Schoolhouse Road.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB03	Mouth of Teal Brook and outlet of Teal Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
UN1	Mouth of Unnamed Brook 1.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
UN2	Mouth of Unnamed Brook 2.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.

Table A.4 Sampling Design Rationale-Optical Brightener Placement (Wet Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
FB01	Factory Brook at outlet of Factory Pond	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB02	Factory B. mainstem at South Shore Management Area	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB03	Factory B. mainstem at intersection of Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB04	Factory B. mainstem at private drive across from Corey Road.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB05	Factory B. mainstem downstream of impoundment.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB06	Factory B. intersection with Teal Drive.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB07	Factory B. tributary intersection with Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
FB08	Factory B. tributary with Matunuck Schoolhouse Rd.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
TBa	Teal Brook headwaters	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
TB00	Teal B. tributary intersection with Mautucket Rd.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
TB01	Teal B. tributary intersection with Mautucket Rd. South of TB00.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
TB02	Teal B. mainstem intersection with Matunuck Schoolhouse Road.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
TB03	Mouth of Teal Brook and outlet of Teal Pond.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
UN1	Mouth of Unnamed Brook 1.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.
UN2	Mouth of Unnamed Brook 2.	In-stream placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the surface water.

Table A.4 cont. Sampling Design Rationale-Optical Brightener Placement (Wet Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
DP01	Drainage Pipe to unnamed cove in Ninigret Pond.	In-pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.
DP02	Drainage Pipe to Green Hill Pond.	In- pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.
DP03	Drainage Pipe to Factory Brook.	In- pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.
DP04	Drainage Pipe to Factory Brook.	In- pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.
DP05	Drainage Pipe to Allen Cove in Green Hill Pond.	In- pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.
OF1	Drainage Pipe to Flat Meadow Cove in Green Hill Pond.	In- pipe placement of 2 optical brightener pads for duration of storm.	Determine if optical brighteners are present in the discharge.

Table A.5 Sampling Design Rationale-Concomitant Fecal Coliform Bacteria Sampling (Wet Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
FB01	Factory Brook at outlet of Factory Pond	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB02	Factory B. mainstem at South Shore Management Area	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB03	Factory B. mainstem at intersection of Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB04	Factory B. mainstem at private drive across from Corey Road.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB05	Factory B. mainstem downstream of impoundment.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB06	Factory B. intersection with Teal Drive.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB07	Factory B. tributary intersection with Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
FB08	Factory B. tributary with Matunuck Schoolhouse Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TBa	Teal Brook headwaters	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB00	Teal B. tributary intersection with Mautucket Rd.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB01	Teal B. tributary intersection with Mautucket Rd. South of TB00.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB02	Teal B. mainstem intersection with Matunuck Schoolhouse Road.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
TB03	Mouth of Teal Brook and outlet of Teal Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
UN1	Mouth of Unnamed Brook 1.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
UN2	Mouth of Unnamed Brook 2.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.

Table A.5 cont. Sampling Design Rationale- Concomitant Fecal Coliform Bacteria Sampling (Wet Weather).

Station	*Description*	*Monitoring Protocol*	*Sampling Rationale*
DP01	Drainage Pipe to unnamed cove in Ninigret Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
DP02	Drainage Pipe to Green Hill Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
DP03	Drainage Pipe to Factory Brook.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
DP04	Drainage Pipe to Factory Brook.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
DP05	Drainage Pipe to Allen Cove in Green Hill Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.
OF1	Drainage Pipe to Flat Meadow Cove in Green Hill Pond.	Sample during placement and retrieval.	Determine if concomitant fecal coliform sampling indicates a human source of bacteria.

Table A.6 Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Dry Weather-Optical Brightening Study.

Sampling Location	***Medium/ Matirx***	***Placement***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Analysis Requirements***	***Maximum Holding Time***
FB01[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB02[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB03[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB04[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB05[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB06[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB07[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB08[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TBa[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB00[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB01[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB02[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB03[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
UN1[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
UN2[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days

Table A.7 Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Dry Weather Fecal Coliform Analysis.

Sampling Location	***Medium/ Matirx***	***Depth (Units)***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Preservation Requirements***	***Maximum Holding Time***
FB01[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB02[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB03[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB04[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB05[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB06[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB07[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB08[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TBa[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB00[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB01[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB02[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB03[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
UN1[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
UN2[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs

Table A.8 Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Wet Weather-Optical Brightening Study.

Sampling Location	***Medium/ Matirx***	***Placement***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Analysis Requirements***	***Maximum Holding Time***
FB01[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB02[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB03[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB04[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB05[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB06[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB07[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
FB08[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TBa[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB00[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB01[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB02[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
TB03[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
UN1[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
UN2[1]	Surface Water	Perpendicular To flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days

Table A.8 cont. Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Wet Weather-Optical Brightening Study.

Sampling Location	***Medium/ Matirx***	***Placement***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Analysis Requirements***	***Maximum Holding Time***
DP01	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
DP02	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
DP03	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
DP04	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
DP05	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days
OF1	Storm Water	Within flow	Presence of Optical brighteners	2 (placement & retrieval)	S-2	L-2	N/A	Rigid sampling device	Rinse pads; cold, no light	< 3 Days

Table A.9 Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Wet Weather Fecal Coliform Analysis.

Sampling Location	***Medium/ Matirx***	***Depth (Units)***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Preservation Requirements***	***Maximum Holding Time***
FB01[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB02[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB03[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB04[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB05[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB06[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB07[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
FB08[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TBa[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB00[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB01[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB02[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
TB03[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
UN1[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
UN2[1]	Surface Water	6”	Fecal coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs

Table A.9 cont. Sampling Locations, Sampling and Analysis Methods/SOP Requirements-Wet Weather-Optical Brightening Study.

Sampling Location	***Medium/ Matirx***	***Placement***	***Analytical Parameter***	***No. of Samples***	***Sampling*** SOP	***Analytical*** SOP	***Sample*** Volume	***Containers***	***Analysis Requirements***	***Maximum Holding Time***
DP01	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
DP02	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
DP03	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
DP04	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
DP05	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs
OF1	Storm Water	Within flow	Fecal Coliform	2 (placement & retrieval)	S-1	L-1	N/A	250 ml	Ice; light protected	6 hrs

Figure A.1. Optical Brightening Sample Locations (wet and dry weather).

Attachment A Field Sampling Standard Operating Procedures (SOP)

Field Sampling SOP 1 (S-1): Fecal Coliform Sampling

1. The laboratory-provided autoclaved sample bottles will be distributed to pertinent RIDEM staff.

2. The following information is on the sample bottle label. The fields that should be filled in prior to sampling are in bold below. Label the bottle before taking the sample. It is difficult to write on wet sample bottles.

3. Sample Bottle Label

Station:		
Depth:	Temp:	**Date:**
Initials	Salin.	**Time:**
Sample Type:		

The fields in **bold**, the station, date, time, and initial fields should be labeled on the sample bottle.

4. If you are using a sample stick, place the bottle in the stick.

5. When you are ready to take the sample, take the cap off the sample bottle. Hold the lid in your other hand. Do not touch the inside of the bottle or cap. Do not put the cap on the ground.

6. Avoid contaminating the samples by not allowing the sample water to come in contact with anything before it is placed in the bottle. Be careful not to bring the rim or cap of the sample bottle into contact with anything. If possible, samples will be taken with a sample stick to avoid causing upstream disturbance prior to and during sampling.

7. Holding the bottle upside down, push the bottle through the water to mid-depth or as far as you can reach. Turn the bottle forward and scoop it forward and up and out of the water. Do this in one sweeping motion. Make sure you sample forward and away from you so that there is no chance that you will contaminate the sample with bacteria from your arm.

8. Pour off water to the neck of the bottle. Water should reach to within an inch to an inch and half of the top of the sample bottle. This provides space for mixing.

9. Cap the bottle tightly. Place the bottle upright in a cooler with ice to maintain a temperature of 4°C.

10. Be sure to record the time that the sample was taken in the sample log.

Field Sampling SOP (S-2): Optical Brightening Pad Placement

1. Avoid all direct contact with laundry soaps and detergents for at least 24 hours prior to handling any samplers.

2. Use disposable gloves when handling cotton pads and during placement of sampling devices.

3. Store all cotton pads in new plastic bags (such as zip-lock bags) which are free of optical brighteners. Optical brighteners are found in laundry soaps and detergents and are routinely found adsorbed on clothing and paper.

4. Samplers placed in springs or streams should not be placed where they are likely to be readily seen; samplers can often be hidden by careful placement of a few rocks.

5. When sampling springs or streams, the sampling devices are routinely anchored at a point where the sampler is as well exposed to the current as possible.

6. The sampler should be attached to a sturdy copper or galvanized wire, which in turn, is attached to a large stake (a tent stake works well) pushed into the ground.

7. Alternatively, the sampler may be fixed in place by attaching the copper or galvanized wire to a brick or other stable structure.

8. When sampling discharge pipes, the sampling devices should be anchored so that it will be well exposed to the flow exiting the pipe.

9. Anchorage is provided by using a large brick, or any other device to keep the sampler from becoming detached.

10. Two sampling devices are placed at each station. They should be placed so that they do not become entangled.

11. Sampling sites should be marked with flagging but should not be obvious to the casual observer.

12. Record placement date, time, location, and any other relative information in a Nalgene Notebook.

13. A bacteria sample should be collected after the sampling devices have been securely placed.

Field Sampling SOP (S-2): Optical Brightening Pad Retrieval

1. **Avoid all direct contact with laundry soaps and detergents for at least 24 hours prior to handling any samplers. Gloves need to be worn when retrieving optical brightening devices**.

2. Samples are unwired and removed from the stream, spring, or discharge pipe.

3. Gently remove cotton pad from the rigid sampling device.

4. Holding the pad in the water, gently rinse any organic matter or debris from the cotton pad

5. The samplers should be placed in a whirl-pak type bag. Plastic zip-lock bags can also be used. Prior to collection, each bag should be labeled with a permanent black ink felt pen to indicate the following:

    A) Sampling station (number or name).
    B) Date and time sampler was placed.
    C) Date and time sampler was recovered.

6. After placement of the sampler in the plastic bag, squeeze out excess water from the sampler by holding the bag and packet between the palms of your hands and pushing firmly; the excess water is allowed to drip out of the open end of the bag. Do not wring out the samplers; it makes it more difficult to clean the pad before analysis.

7. **Do not put a label of any type inside the plastic bag. Do not put any used anchoring wire in the plastic bag. Close the bag effectively.**

8. All collected samplers should be kept in a cooler or refrigerated until they are prepared for analysis.

9. A bacteria sample should be collected after the sampling devices have been retrieved.

Field Sampling SOP (S-2): Optical Brightening-Analysis Preparation

1. Before analysis, the cotton pads need to be rinsed with water to remove dirt and organic material that may interfere with analysis.

2. The samplers can be rinsed of debris with a garden hose, taking care not to damage the pad. Again, use gloves when handling all cotton pads.

3. Each pad should be rinsed individually, placed in the zip-lock bag, and squeezed to remove excess water.

4. Return pads to the cooler, making sure the bags are sealed properly.

Attachment B. Fixed Laboratory Analytical Methods and Standard Operating Procedure

Fixed Laboratory Method 1 (L-1): BAL Laboratory mTEC Method for Detection of Fecal Coliform and *Escherichia Coli*

Prepared

BAL LABORATORY
185 Frances Avenue
Cranston, RI 02910

Sample Collection

Representative samples from water systems are collected using aseptic technique with sterile glass or plastic containers. Suggested sample volumes are between 250 and 500 mls. Samples are kept on ice (4 ^{o}C) and transferred to the laboratory for analysis preferably within 6 hours, however, samples may be analyzed up to 24 hours following collection.

A chain-of-custody form is to be completed for each set of samples. One copy remains with the samples and a second copy is given to the client. Upon receipt at the laboratory, lab personnel log samples into the logbook and assign them a unique sample number. Also noted is the time/date of receipt, the condition of sample, and the person accepting/dropping off the sample(s).

Sample Analysis

Samples are usually analyzed immediately upon receipt or before the 6 h recommended holding period, however, under special circumstances they may be analyzed anytime within 24 h as long as samples are maintained at 4 ^{o}C.

The procedure outlined in Standard Methods 9213D is used to analyze the samples. mTEC media is purchased from Difco and is prepared according to package directions. Media is poured into sterile petri plates (Fisher Scientific) at 50 ^{o}C.

Membrane filter holders are sterilized with UV light prior to usage. Membrane filters are purchased sterile from Gelman Sciences. Sample volumes are filtered through the membrane filter and rinsed several times with sterile phosphate buffer. The membrane is removed aseptically from the filter holder and placed onto mTEC agar. Plates are incubated at 35 $\pm$ 0.5 ^{o}C for 2 h to rejuvenate injured or stressed bacteria, and then incubated at 44.5 $\pm$ 0.2 ^{o}C for 22 h.

After 24 hours yellow colonies are counted as fecal coliforms. The membrane filters are then transferred to a filter pad saturated with urea substrate. After 15 min, the yellow or yellow-brown colonies are considered to be *E. coli*. Note, any blue colonies are usually *Klebsiella sp*.

Report

Following completion of analysis a final report is prepared and submitted to the client. In addition to the results, information in the report includes time/date of collection, time/date of receipt at lab, time/date of analysis and any unusual observations noted during sample handling. Results are reported as colony forming units per 100 ml of sample (CFU/100ml).

Quality Control

Temperatures for incubators and refrigerators are noted twice per day at two different locations.

Prior to use, each batch of mTEC media undergoes a QC check in which 5 plates of the new batch are compared with 5 plates of the previous batch by inoculation with a stock culture of *E. coli* which has been incubated according to Standard Methods (see above).

Prior to use, each batch of membrane filters undergoes a QC check in which 5 membranes of the new lot are compared with 5 membranes of the previous lot by inoculation with a stock culture of *E. coli* which is plated on mTEC or mENDO-LES media and incubated according to Standard Methods.

A positive and negative control is run with each set of analysis. The positive control is *E. coli* A (isolated from a river sample in 1995). The negative control is sterile phosphate buffer.

Ten percent of all samples received are analyzed in duplicate. All other samples are analyzed once only.

Ten percent of all positive mTEC plates are confirmed by transferring 10 well isolated colonies to EC medium (Difco) and incubated at 44.5 ^{o}C for 24 hours. Tubes producing gas are considered positive for fecal coliform. If confirmation of *E. coli* is required, colonies are transferred to EC MUG medium (Difco) and incubated at 44.5 ^{o}C for 24 h. Tubes producing fluorescence are positive for *E. coli*.

Analysis Method for Optical Brightening Study (L-2)-Qualitative Analysis

Prepared by:
RIDEM

Analyzed at:
University of Rhode Island
NRS Dept.
1 Greenhouse Road
Kingston, RI 02881

Sample Analysis
All samples will be analyzed in a darkroom in the NRS Dept. at the University of Rhode Island.

The pads are placed on a table and viewed in a darkroom using a solid state battery operated BLAK-RAY ML-49 long wave ultraviolet fluorescent light. Operating instructions for this light are provided in Appendix C.

All lights are turned out, doors closed, and all measures possible should be taken to prevent ambient light from entering the analysis room.

A non-exposed and exposed sampling pad are used as controls and compared to each pad as it is exposed to the U.V. light.

There are three qualitative results: **Positive**, **Negative**, and **Retest**. A pad will very definitely glow (fluoresce) if it is positive. If it is negative it will be noticeably drab and similar to the control pad. All other tests are undetermined or retests. As each pad is read, the results (including the sampling location) are recorded in a Nalgene Notebook.

In some instances, only a portion of the pad or simply the outer edge will fluoresce after being exposed to optical brightener. This can be caused by many factors but is usually the result of an uneven exposure to the dye in the watercourse due to sedimentation or the way the pad was placed in water.

In these cases, one can always account for the unevenness by associating the pattern with the sedimentation distribution, folds in the pad, etc. Regardless, as long as a portion of the pad fluoresces and one can explain why the remainder was not, it should be considered positive.

There is never a borderline positive or negative call.

Since paper and cotton dust is so pervasive, it is common to see specks or spots of fluorescence on the sample or control pads. These should be ignored and not used to indicate a positive result.

Ten (10) percent of the cotton pads will be mailed to the Ozark Underground Laboratory for quality control purposes. The cotton pads should be shipped one to two-day air mail. They do not need to be kept cool. The Lab will qualitatively analyze the pads (as described above) as well as quantitatively using the Shimdzu RF-540 Spectrofluorophotometer.

Analysis Method for Optical Brightening Study (L-2)-Quantitative Analysis

Prepared by:
RIDEM

Analyzed at:
Ozark Underground Laboratory
1572 Aley Lane
Protem, MO 65733

Sample Analysis
The cotton samplers are placed in a solid sample holder for analysis in a Shimadzu RF-540 Spectrofluorophotometer. The instrument is operated and maintained in accordance with the manufacturer's recommendations. On-site installation of the instruments and a training session on the use of the spectrofluorophotometers was provided by Delta Instrument Company. Operating instructions for the Spectrofluorophotometer are available at Ozark Underground Laboratory (417-785-4289)

Any areas identified as likely to contain optical brighteners are oriented so as to be included in the analysis.

The instrument is programmed to conduct a synchronous fluorescence scan with an excitation slit of 5 nm. The separation between the excitation and emission scans is 17 nm. The data are plotted on an output chart by the RF-540. If optical brighteners are present there will be a distinct broad peak with a maximum ranging from about 415 to 422 nm. The difference is due in part to the existence of different optical brighteners with slightly different fluorescent properties.

A plot of the synchronous scan for each sample is produced by the instrument; the plot shows emission fluorescence only. It is copied as a part of the final record. The synchronous scans are subjected to computer peak picks; peaks are picked to the nearest 0.1 nm. All samples run on the RF-540 are stored on disk and printed on normal typing paper with a laser printer; sample information is printed on the chart.

Quality Control
Laboratory blanks are run for every sample where the last two digits of the laboratory numbers are 00, 20, 40, 60, 80.

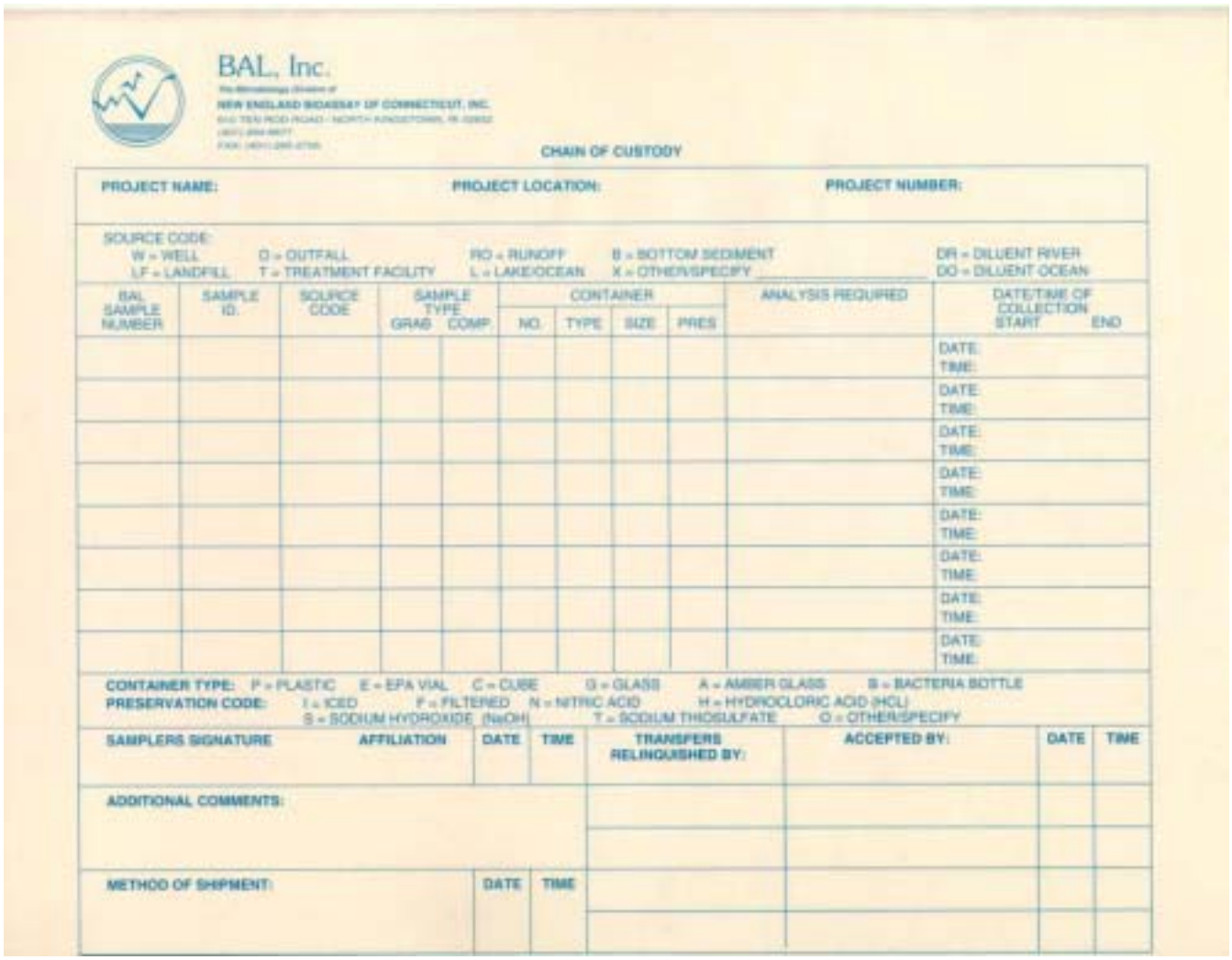
System functioning tests of the analytical instruments are conducted in accordance with the manufacturer's recommendations.

All materials used n sampling and analysis work are routinely analyzed for the presence of any compounds which might create fluorescence peaks in or near the acceptable wavelength ranges for any of the tracer dyes. This testing typically includes approximately 1% of materials used.

Reports
Reports are provided in accordance with the needs of the client. At a minimum the Lab provides copies of the analysis graphs and a listing of stations and samples where optical brighteners were detected.

Appendix B. Chain of Custody Forms

Figure B.1. BAL Laboratory Chain of Custody Form.



BAL, Inc.

NEW ENGLAND BIOASSAY OF CONNECTICUT, INC.

CHAIN OF CUSTODY

PROJECT NAME:	PROJECT LOCATION:	PROJECT NUMBER:

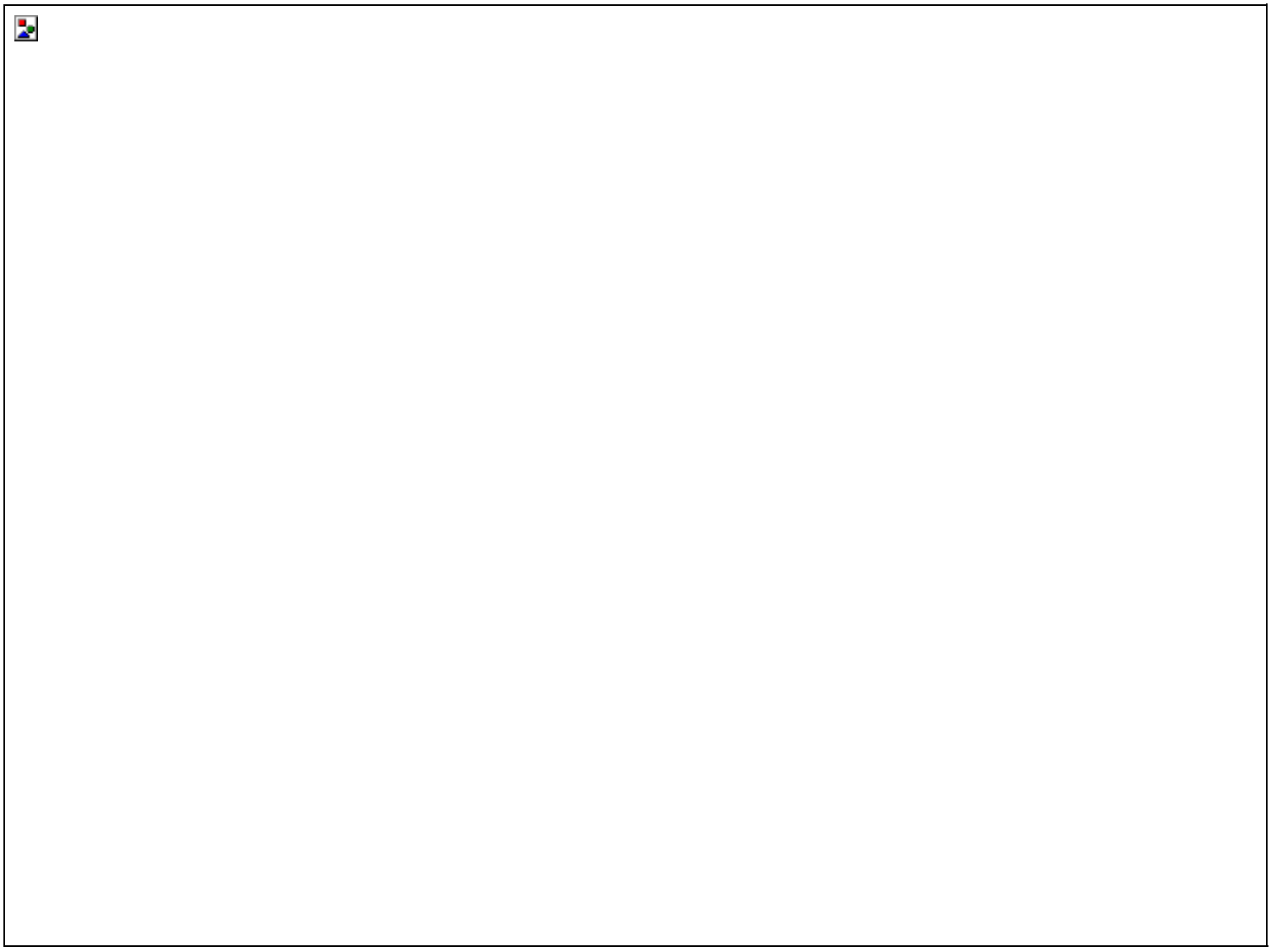
SOURCE CODE:
W = WELL O = OUTFALL RO = RUNOFF B = BOTTOM SEDIMENT DR = DILUENT RIVER
LF = LANDFILL T = TREATMENT FACILITY L = LAKE/OCEAN X = OTHER/SPECIFY _____ DO = DILUENT OCEAN

BAL SAMPLE NUMBER	SAMPLE ID.	SOURCE CODE	SAMPLE TYPE GRAB	SAMPLE TYPE COMP.	CONTAINER NO.	CONTAINER TYPE	CONTAINER SIZE	CONTAINER PRES	ANALYSIS REQUIRED	DATE/TIME OF COLLECTION START	DATE/TIME OF COLLECTION END
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	
										DATE: TIME:	

CONTAINER TYPE: P = PLASTIC E = EPA VIAL C = CUBE G = GLASS A = AMBER GLASS B = BACTERIA BOTTLE
PRESERVATION CODE: I = ICED F = FILTERED N = NITRIC ACID H = HYDROCLORIC ACID (HCL)
S = SODIUM HYDROXIDE (NaOH) T = SODIUM THIOSULFATE O = OTHER/SPECIFY

SAMPLERS SIGNATURE	AFFILIATION	DATE	TIME	TRANSFERS RELINQUISHED BY:	ACCEPTED BY:	DATE	TIME
ADDITIONAL COMMENTS:							
METHOD OF SHIPMENT:		DATE	TIME				

Figure B.2. Ozark Underground Laboratory Chain of Custody Form.



Appendix C. Operating Instructions for BLAK-RAY ML-49 Portable Ultraviolet Lamp.