Water Quality Monitoring Project

In the

Barnegat Bay Watershed, WMA 13

New Jersey Department of Environmental Protection

Water Monitoring and Standards

June, 2011

June 2, 2011

QUALITY ASSURANCE SAMPLING PLAN
Barnegat Bay Watershed, WMA 13

Project Officer 1:

Jill Lipoti 6/8/11

Signature Date

Jill Lipoti, Ph.D Director
Water Monitoring and Standards

NJDEP:

Barbara Hirst 6/8/11

Signature Date

Barbara Hirst, Bureau Chief
Bureau of Environmental Analysis and Restoration
Water Monitoring and Standards

NJDEP:

Leslie J McGeorge 6/8/11

Signature Date

Leslie McGeorge, Administrator
Bureau of Freshwater & Biological Monitoring
Water Monitoring and Standards

NJDEP:

6/8/11

Signature Date

Bruce Friedman, Bureau Chief
Bureau of Marine Water Monitoring
Water Monitoring and Standards

NJDEP: Quality Assurance Officer

Debra Waller for MF 6/8/11

Signature Date

Marc Ferko, Quality Assurance Officer
Office of Quality Assurance

June 2, 2011

1. **Project Name**: Barnegat Bay Sampling Project

2. **Requesting Agency**: NJDEP, Water Monitoring and Standards

3. **Date of Project Requested**: May, 2011

4. **Date of Project Initiation**: June, 2011

5. **Project Officer**: Jill Lipoti

6. Project Description:

Objective and Coverage

Current concerns regarding the use support within the Barnegat Bay Estuary derive in part from observed loss of sea grasses such as eel grass and widgeon grass, collectively referred to as Submerged Aquatic Vegetation (SAV), episodic occurrences of macro algae and brown tides, decline of hard clams, and increasing numbers of invasive species such as sea nettles. The full suite of stressors and biological/chemical/physical processes responsible for habitat alteration, loss of biological diversity and loss of support of designated uses are not entirely known. Alteration of the shoreline, hydrologic modification, resource harvesting, boating, the effects of the Oyster Creek nuclear generating facility and declining water quality are all suspected causes. With regard to water quality, available data indicate that there are areas within the Barnegat Bay where there are excursions from existing surface water quality standards, specifically with respect to dissolved oxygen and pathogen indicators. The Department has recently adopted narrative criteria for nutrients. The current study, as well as completed and other on-going studies, are expected to provide data that will assist in assessing the spatial extent of impairment with respect to these narrative nutrient criteria.

The purpose of this study is to provide water quality data to 1) determine the locations and extent of water quality impairments, 2) identify numeric criteria or loading targets for nutrients, including the need to revise existing SWQS to set the restoration endpoints (revisions may be needed to reflect a better link to supporting designated uses or where natural conditions would preclude support) and 3) calibrate and validate modeling tools that can be used to direct water quality restoration of the bay.

It must be noted that designing an effective data collection program depends on the objective, for example, the type of the impairment(s) to be addressed, the spatial extent and defining characteristics of the study area, the modeling approach (i.e., water quality, hydrologic, hydrodynamic), as well as specific models that must be supported. This sampling program has been prepared to maximize utility to address multiple objectives, while recognizing that there are unknowns at this juncture that may result in a need to revise the plan. In particular, it is not yet known which specific models will be used. This will require an adaptive approach as the project proceeds in order to obtain input from those who will be performing the modeling work.

In addition to characterizing pollutant loads, this study will further identify and characterize specific stressors of the Barnegat Bay ecosystem. Potential stressors may include the patterns of water circulation

within the bay, shallow depth of water in the bay, thermal discharge from Oyster Creek, degree of biological productivity, sediment oxygen demand, turbidity and sediment toxicity.

The Department intends to work with Barnegat Bay partners to accomplish this intensive data collection effort. Critical to the success of this endeavor is the need to develop within this comprehensive Quality Assurance Project Plan measures to ensure that the laboratories conducting the analysis are certified for the work, that field staff (DEP and partners) are trained and approved until June 30, 2012 for Barnegat Bay Project work only to conduct the field analyses and sample collection, and that the laboratories are capable of handling the volume of samples. Therefore, the initial stage (first 6 months) of sampling effort is designed primarily to test out our capabilities, but will also provide data for condition assessment and a model validation data set. This approach is necessitated in part because the monitoring can not be initiated in time to capture an entire growing season, the flow gauging stations will not be installed and operational until at least October, 2011 and monitoring needs may need to be adjusted once modeling tools are selected and the model needs are known. Another need to be met, which requires that this sampling program be initiated immediately, is to enhance baseline data to evaluate and capture the effect of implementing measures to reduce nutrient and other pollutant loads through stormwater infrastructure retrofits and fertilizer use restrictions. Once proof of concept has been achieved and adjustments made as needed, a minimum of a full year of monitoring will be required to develop modeling tools. If abnormal weather patterns prevail, it may be necessary to extend monitoring further in order to collect sufficient hydrodynamic, water chemistry, biological, flow, current, and sediment flux data for development of water quality/quantity models of the Barnegat Bay Estuary.

This field sampling study will address the following objectives:

1. Provide more comprehensive assessment of the relevant water quality conditions throughout the Barnegat Bay both spatially and temporally;
2. Provide water quality and biomass data to better quantify biological productivity and its impact on dissolved oxygen concentrations in the Bay.
3. Estimate the nutrient loadings into the bay and establish boundary conditions for the significant tributaries to the bay;
4. Provide nutrient concentration and loading data needed to evaluate the effects of nutrient load reduction scenarios.
5. Provide an understanding of the physical factors that may be affecting the bay water quality; such as the flushing rate, temperature, salinity and the depth of the bay. These factors play a major role in the physical, chemical and biological processes operating within the bay;
6. Collect sufficient data (minimum 24 months) to develop water quality and hydrodynamics models;
7. Collect data that will capture seasonal variability as well as variability between years;
8. Collect sediment toxicity data to assess if biological changes - loss of SAV, decline in hard clams, and increase in invasive species - are caused by sediment toxicity.

This proposed monitoring program will consist of the following components:

1. Continuous in-situ water quality monitoring,
2. Grab water quality sampling,
3. Two 5-day intensive sampling events;
4. Sediment characterization and toxicity monitoring;
5. Flow monitoring;
6. Bathymetric survey

Phase 1 will provide a proof of concept for the monitoring plan, including the partnership approach. Monitoring partners will be asked to sign an MOU in which they agree to follow the procedures set forth in this QAPP. Sampling will be conducted under various conditions and frequencies. Phase 2 will continue the program for a minimum combined duration of 24 months. However, the sampling period may need to be extended if the conditions experienced are deemed not representative. This Quality Assurance Sampling Plan is developed for Phase 1 this sampling plan. Addendum will be added with any change for the Phase 2 Quality Assurance Sampling Plan.

7. Sampling Network and Design Rationale

7.1- Continuous in-situ water quality monitoring:

Physical and biological parameters such as temperature, dissolved oxygen (DO), DO % saturation, pH, conductivity (salinity), and turbidity in the Barnegat Bay are required for water quality model simulation and, to some extent, for the hydrodynamic model (especially temperature and salinity). Continuous monitoring multi-parameter probes will be deployed at the proposed monitoring sites in Barnegat Bay. Table 1 specifies the list of parameters, frequency of collection and the number of sites for each phase of sampling. Table 2 identifies the bay sampling locations and Figure 1 shows the location of all of the proposed sampling sites.

Table 1: Continuous Monitoring Plan: Monitoring Parameters and Frequency of Collection

Continuous Monitoring Plan*				
Bay				
Sampling Stations	**Sampling Type**	**Sampling Matrix**	**Parameters**	**Frequency**
Phase 1 sampling 4 sites, as identified in Table 2 and Figure 1 below **Phase 2 sampling** 6 buoy locations and 1 fixed station, as identified in Table 2 and Figure 1 below	Continuous monitoring probes at mid depth[1] using 4-6 buoy-located devices and 1 device housed within a fixed station (Mantoloking), depending on phase of sampling program	Aqueous	Dissolved Oxygen concentration (DO), pH, Temperature, Turbidity, Conductivity, Salinity[2], Chlorophyll-a; (possible deployment of NO_3 probe at Mantoloking using a buoy provided by USGS)	Measurements every 15 minutes. Duration of sampling is expected to be continuous for a minimum of 24 months.
Tributary				
Sampling Stations	**Sampling Type**	**Sampling Matrix**	**Parameters**	**Frequency**
Toms River near Thomas River (USGS 01408500)	probes located within the existing gauging station	Aqueous	Dissolved Oxygen concentration (DO), pH, Temperature, Turbidity, Conductivity, Nitrate/Nitrite	Measurements every 15 minutes. Duration of sampling is expected to be continuous for a minimum of 24 months.

* A separate QAPP has been developed for the Department's continuous monitoring efforts

[1] Sampling sites where depth is greater than 12 feet, two samples will be taken at 1/3 and 2/3 depth.
[2] Salinity to be calculated from conductivity

Table 2: List of monitoring sites within the Barnegat Bay

Project ID	Site Description	Type: Grab/ Buoy/Fixed	Longitude	Latitude	Site Reference ID	Site Partner
BB01	Barnegat Bay at Mantoloking	G,F	-74.054320	40.038320	USGS-01408168	Monmouth University
BB02	Barnegat Bay between Silver Bay and Goose Creek	G,B	-74.098470	39.9776200	BMWM1622	Monmouth University
BB03	Barnegat Bay by Route 37 Bridge	G	-74.101530	39.9481700	BMWM1629B	Monmouth University
BB04	Barnegat Bay near the Mouth of Toms River	G	-74.110140	39.9376200	BMWM1623B	Monmouth University
BB05	Barnegat Bay above Cedar Creek	G,B*	-74.112910	39.8845600	BMWM1645E	EPA
BB06	Barnegat Bay below Cedar Creek and above Forked River	G	-74.102080	39.8526200	BMWM1651D	EPA
BB07	Barnegat Bay below Oyster Creek and above Barnegat Inlet	G,B	-74.153190	39.7926200	BMWM1691A	EPA
BB08	Barnegat Bay by Barnegat Inlet	G	-74.108014	39.7633528	MU-Barnegat Inlet	EPA.
BB09	Barnegat Bay below Barnegat Inlet and close to Long Beach	G,B*	-74.147920	39.7426200	BMWM1674B	DEP-Leeds Pt.
BB10	Barnegat Bay by Route 72 Bridge	G	-74.206530	39.6609500	BMWM1703C	DEP-Leeds Pt.
BB11	Barnegat Bay above Westecunk Creek	G	-74.235700	39.6254000	BMWM1719E	DEP-Leeds Pt.
BB12	Barnegat Bay in Little Egg Harbor	G,B	-74.268750	39.5815100	BMWM1834A	DEP-Leeds Pt.
BB13	Barnegat Bay near Tuckerton Creek	G	-74.324590	39.5690100	BMWM1818D	DEP-Leeds Pt.
BB14	Little Egg Harbor Inlet near Beach Haven Heights	G,B	-74.297370	39.5112300	BMWM1824B	DEP-Leeds Pt.

*** Monmouth University will use buoy to collect real time data at this station.**

In addition to this project, Monmouth University will be collecting data using buoys at 4 locations within Barnegat Bay, addressed in a separate QAPP (Quality Assurance Project Plan for Water Quality Monitoring in Coastal Ocean and Monmouth Counties Using Data Loggers Monmouth University School of Science Urban Coast Institute). The data collected in the Monmouth University study will be used to supplement the study described herein.

7.2- Field Parameters

Field parameters, pH, water temperature, dissolved oxygen and specific conductance, will be measured on site. Collected turbidity samples will be measured at a project field station by Bureau of Freshwater and Biological Monitoring staff certified for turbidity measurements. Sample filtration for dissolved parameters will also be conducted by Bureau of Freshwater and Biological Monitoring staff. At each sampling location, analyze immediately parameters (i.e. pH, specific conductance, salinity (calculated from specific conductance), dissolved oxygen, and turbidity) will be taken using handheld meters or multi parameter sensors.

7.3- Grab Water Quality Sampling:

Grab samples will be collected at the Barnegat Bay locations listed on Table 2 and additionally at tributary sites listed on Table 4. Locations are shown in Figure 1. The proposed frequency varies by phase and season and is listed in Table 3. The sampling period may be extended in response to information obtained during the initial phase of sampling or if conditions experienced are not considered to be representative. Samples will be collected in accordance with approved field sampling procedures and analyzed in certified laboratories. As indicated, the water quality parameters to be sampled will be driven, in part, by the modeling tools selected, but are expected to include those listed in Table 3.

All water quality grab samples will be collected following procedures found in "NJDEP Field Sampling Procedures Manual, August 2005". Sampling locations have been marked and verified with GPS. In addition NJDEP staff and project partners will utilize detailed site sketches to locate the sampling location on the first and subsequent visits. The freshwater tributary locations samples will be collected as center of flow grab samples. At tributary locations greater than 20 ft wide specific conductance measurements were made along a transect and it was determined that at all locations the stream is well mixed and that a center of flow grab sample would be representative of the water quality at that location. Because none of the tributary monitoring locations is greater than 12 ft deep, samples will be collected at a depth of 1 ft. The in bay water quality samples will be taken as surface grab samples at the designated locations. All samples will be taken to a field location for filtration and transportation as reflected in Table 4 and Figures 2-4. All sample containers are being supplied by the DEP and only these sample containers can be used for the project. In addition, for field testing for pH, the DEP will be supplying a single lot of certified primary pH buffers for use in the calibration of the meters. All sample containers must be transported on ice in coolers to preserve the integrity of the samples and maintain sample temperature at greater then freezing and less then 6°C. Necessary acids as preservative will be added at the field station (FREC) or Leeds Point Lab.

.

Table 3: Grab Samples: Monitoring Parameters and Frequency of Collection in Barnegat Bay and its Tributaries

Monitoring Parameters and Frequency of Collection						
Sampling Stations	**Sampling Type**	**Sampling Matrix**	**Parameters**	**Lab**	**Frequency**	
Locations are identified in Tables 2 and 4.	Surface grabs	Aqueous	Total Suspended Solids (TSS)	Leeds Point	Phase one:	Phase two:
			Chlorophyll-a (w/species ID)*	Leeds Point	one sample every two weeks from June 2011 through September 2011 and then once per month from October 2011 through December 2011	one sample every two weeks from January 2012 through March 2012, one sample per week from April 1,2012 through September 30, 2012 and resuming one sample every two weeks in October 2012 through December 2012
			Total Nitrogen (TN)	Leeds Point		
			Dissolved Total N	Leeds Point		
			Dissolved Ammonia	Leeds Point		
			Dissolved Nitrate+Nitrite	Leeds Point		
			Total Phosphorus (TP)	Leeds Point		
			Dissolved Total Phosphorus	Leeds Point		
			Dissolved Ortho-P	Leeds Point		
			Total Organic Carbon	EPA Edison and Maryland/Leeds[1]		
			Dissolved Organic Carbon	EPA Edison and Maryland/Leeds[1]		
			Dissolved Inorganic Carbon[2]	Maryland[2]		
			Alkalinity	EPA Edison		
			Unfiltered Total BOD5	OCUA		
			Unfiltered CBOD5 (nitrification inhibited and no seed or pH adjustment)	OCUA		
			Unfiltered CBOD20 (nitrification inhibited and no seed or pH adjustment)	OCUA		
			Total Si	EPA Edison		
			Dissolved Si	EPA Edison		
			Turbidity	Leeds/BFBM		
			Secchi depth*	Field		
			Transmissometry*	Field		
			pH	Field		
			Dissolved Oxygen (DO)	Field		
			DO Saturation	Field		
			Temperature	Field		
			Conductivity (Salinity)	Field		

***omit in tributaries**

Note: 1. EPA lab will perform the Freshwater sample analysis and Maryland/Leeds will perform the salt water sample analysis. Where Maryland/Leeds is the denoted lab, Maryland will be used until the appropriate equipment is on-line at Leeds. There will be duplicative sampling for three events to allow a determination of the degree of variability between the two labs and two methods of analysis. Once Leeds has the equipment, the method that will be followed is SM 5310C.

2. Only for salt water sample. DIC for the freshwater sample will not be analyzed but will be calculated based on the Alkalinity results for the freshwater samples.

Table 4. THE ANALYTICAL METHOD TABLE

Org	Parameter		Prep	Code	Method	Container	Preservative	Holding Time	Bottle
NJDEP BFBM	Turbidity	Fw Sw	U	Turb	SM 2130 B	50 mL centrifuge tube	Ice, 4ºC	48 hours	T1
NJDEP Leeds Point Lab	Total Suspended Solids	Fw Sw	U	TSS	USGS I-3765-85	Amber 500 mL HDPE	Ice, 4ºC	24 hours	L1
	Chlorophyll a (bay only)	Sw	"	Chla	SM 10200-H	Amber 500 mL HDPE	Ice, 4ºC	24 hours	L1
	Total Nitrogen	Fw Sw	U	TN	USGS I-4650-03	50 mL centrifuge tubes	Ice, 4ºC	28 days	L2
	Total Phosphorous	Fw Sw	"	TP	USGS I-4650-03	50 mL centrifuge tubes	Ice, 4ºC	28 days	L2
	Dissolved Ammonia	Fw Sw	F	DNH3	350.1 MOD	50 mL centrifuge tubes	2 ml 3.5% Phenol	14 days	L3
	Dissolved Nitrite + Nitrate	Fw Sw	"	DNO2 + NO3	EPA 353.4	50 mL centrifuge tubes	Ice, 4ºC	28 days	L4
	Dissolved Orthophospha te	Fw Sw	"	DOPO4	EPA 365.5	50 mL centrifuge tubes	Ice, 4ºC	28 days	L4
	Dissolved Nitrogen	Fw Sw	"	DN	USGS I-4650-03	50 mL centrifuge tubes	Ice, 4ºC	28 days	L4
	Dissolved Phosphorous	Fw Sw	"	DP	USGS I-4650-03	50 mL centrifuge tubes	Ice, 4ºC	28 days	L4
	Total Organic Nitrogen	Fw Sw		TON	Calculated	NA	NA	NA	NA
	Dissolved Organic Nitrogen	Fw Sw		DON	Calculated	NA	NA	NA	NA
	Dissolved Organic Phosphorus	Fw Sw		DOP	Calculated	NA	NA	NA	NA
	Particulate Organic Nitrogen	Fw Sw		PON	Calculated	NA	NA	NA	NA
	Particulate Phosphorus	Fw Sw		PP	Calculated	NA	NA	NA	NA
OCUA	Biochemical Oxygen Demand (5 day)	Fw Sw	U	BOD5	SM 5210B	2 L HDPE	Ice, 4ºC	48 hours	O1
	Carbonaceous Oxygen Demand (20 day)	Fw Sw	"	CBOD20	SM 5210B	2 L HDPE	Ice, 4ºC	48 hours	"
	Carbonaceous Oxygen Demand (5 day)	Fw Sw	"	CBOD5	SM 5210B	2 L HDPE	Ice, 4ºC	48 hours	"
USEPA Region 2 Edison Lab	Alkalinity	Fw Sw	U	Alk	SM 2320 B	250 mL HDPE	Ice, 4ºC	14 days	E1
	Total Silica	Fw Sw	U	Si	EPA 200.7 rev 4	125 mL HDPE	Conc. HNO3, pH<2	6 months	E2

Org	Parameter		Prep	Code	Method	Container	Preservative	Holding Time	Bottle
	Dissolved Silica	Fw Sw	F	DSi	EPA 200.7 rev 4	250 mL HDPE	"	"	E3
	Total Organic Carbon	Fw	U	TOC	SM 5310 B	250 mL HDPE	Conc. H2SO4, pH<2	28 days	E4
	Dissolved Organic Carbon	Fw	F	DOC	SM 5310 B	250 mL HDPE	"	"	E5
University of Maryland CES Lab	Dissolved Organic Carbon	Sw	F	DOC	EPA 415.1[a]	30 mL Teflon bottle	Freeze	28 days	M1
	Dissolved Inorganic Carbon	Sw	"	DIC	EPA 415.1[a]	30 mL Teflon bottle	Freeze	28 days	M1
	Particulate Organic Carbon	Sw	F	POC	EPA 440.0[a]	25 mm GF/F pad	Freeze	28 days	M2
	Total Organic Carbon	Sw		TOC	Calculated	NA	NA	NA	NA
NJDEP BEAR	Biogenic Silica	Fw Sw		bSi	Calculated	NA	NA	NA	NA
	Particulate Organic Carbon	Fw		POC	Calculated	NA	NA	NA	NA
	Dissolved Inorganic Carbon	Fw		DIC	Calculated	NA	NA	NA	NA

a: Leeds Point lab will use Method 5310 C for the analysis after they purchase the equipment.

Table 5: Tributary Sampling Locations

Station ID	Site #	Description	LATITUDE	LONGITUDE	Flow-Measurement Type	Flow Site Partner	Water Quality Site Partner
USGS-01408123	BT01	North Branch Metedeconk R near Laurelton	40.081648	-74.151811	Extrapolate from existing gage	NA	Brick MUA
USGS-01408152	BT02	SB Metedeconk River near Laurelton (Chambers Bridge Rd)	40.078763	-74.156729	Gage (new) Measure phase 1 (if wadeable and until relationship established with gage site)	USGS	Brick MUA
USGS-01408505	BT03	Toms River near Toms River	39.976389	-74.218333	Gage (existing)	NA	DEP
USGS-01408600	BT04	Wrangle Brook near South Toms River	39.952854	-74.218515	Measure	NJDEP	BBP
USGS-01408710	BT05	Jakes Branch at South Toms River (route 619)	39.935418	-74.211554	Measure	NJDEP	OCHD
USGS-01409000	BT06	Cedar Creek at Lanoka Harbor	39.868887	-74.17043	Gage (existing)	NA	OCHD
USGS-01409055	BT07	NB Forked R at Forked River	39.836035	-74.196013	Measure	NJDEP	MATES
BFBM000165	BT08	Middle Br Forked River (upstream Rt 9)	39.828238	-74.201971	Measure	NJDEP	MATES
BFBM000166	BT09	South Br Forked River (upstream Rt 9 @ JCPL)	39.82038	-74.203128	Measure	NJDEP	DEP
BFBM000167	BT10	Oyster Creek (upstream Rt 9 @ JCPL)	39.810584	-74.204626	Gage (new) Measure Phase 1	NJDEP	DEP
USGS-01409210	BT11	Mill Ck at Manahawkin (Bay Avenue)	39.695405	-74.259527	Gage (new) Measure Phase 1	USGS	Pinelands
USGS-01409281	BT12	Westecunk Ck at Railroad Ave at West Ck	39.640297	-74.30797	Measure	USGS	Pinelands
USGS-01409310	BT13	Tuckerton Creek at Tuckerton*	39.60274	-74.34163	Measure	USGS	DEP-Leeds Pt.

* From June through August 2011, then suspend due to reconstruction of dam

In addition, NJDEP will deploy a temperature data logger in the cooling water channel at the Oyster Creek Generating Station. Measurements will be made every 0.5 hrs to document general daily fluctuations and brief, but potentially significant, abrupt changes in water temperature. The data logger will be deployed during the summer of 2011. A separate QAPP developed for ambient water temperature monitoring will apply to this activity.

Table 6: Dates and time frame of sampling collection for Phase 1—

Proposed Phase 1 2011 Sampling Schedule			
Sample Event	**Dates ***	**Sample Collection Times ****	**Sample Drop Off Deadline at Leeds Point or FREC ****
1	6/6/2011	8:00-11:00 AM	1:00 PM
2	6/23/2011	8:00-11:00 AM	1:00 PM
3	7/5/2011	8:00-11:00 AM	1:00 PM
4	7/21/2011	8:00-11:00 AM	1:00 PM
5	8/8/2011	8:00-11:00 AM	1:00 PM
6	8/25/2011	8:00-11:00 AM	1:00 PM
7	9/15/2011	8:00-11:00 AM	1:00 PM
8	9/26/2011	8:00-11:00 AM	1:00 PM
9	10/13/2011	8:00-11:00 AM	1:00 PM
10	10/24/2011	8:00-11:00 AM	1:00 PM
11	11/10/2011	8:00-11:00 AM	1:00 PM
12	12/8/2011	8:00-11:00 AM	1:00 PM
* Dates may change due to severe inclement weather, sampling groups will be contacted the day before a canceled event			
** Deadline times may change based on the results of the June 6th sampling event			

7.4- Two 5-Day intensive sampling events:

In addition to the periodic grab sample program identified in Task 2, two 5-day intensive surveys are also planned during the phase 2 sampling program. Grab samples will be collected during each of the two 5-day events, at a frequency of eight (8) per day. These intensive sampling events are needed to properly calibrate the water quality model. The sampling parameters and sites will be the same as described under Task 2. The first sampling event should be accomplished within a window from June/July of 2012 and the second event within a window from August/September 2012. The intensive sampling task may be adjusted after review of the Phase 1 data.

7.5- Sediment Monitoring: (Placeholder)

Sediment can also impact the dissolved oxygen demand in the Bay through biological and chemical activities. Sediment toxicity may be a cause of changes observed in SAV, hard clam populations and invasive species. To characterize the effects of sediment relevant to water quality model development and simulations, physical and chemical makeup of the sediment must be determined. The monitoring plan details are presented in Table 6. To supplement this information, additional sediment toxicity monitoring is planned, as presented in Table 7.

Table 7 - Sediment physical and chemical characterization monitoring:

Monitoring Parameters and Frequency of Collection			
Sampling Sites	**Sampling Type**	**Parameters**	**Frequency**
At a minimum, 3 sites within the Bay and at mouth of Toms River	Core and Grab—	✓ SOD ✓ Dissolved Inorganic P, N, C ✓ Particulate Inorganic P, N, C ✓ Particulate Organic P, N, C ✓ Dissolved Organic C ✓ Grain size and type ✓ Flux - Sulfide, NO3, NH3 and DIP ✓ Pore water NH3, NO3, DIP, H_2S, Si, ✓ TN ✓ TP ✓ Sulfide	Monthly samples - July through September

Table 7 - Sediment toxicity monitoring

Monitoring Parameters and Frequency of Collection: Sediment Toxicity			
Sampling Sites	**Sampling Type**	**Parameters**	**Frequency**
Identify locations	Core and Grab	Identify parameter list	Identify # of samples and timing

Placeholder: Wave & Re-suspension Monitoring: (Phase 2, depends on model needs)
Measure shallow water wave energy and sediment re-suspension at key points. Move an instrumentation package weekly to different shoals/beaches to obtain distribution of data. Consider adding UGEMS sediment erodibility measurements on cores. Allow for calibration of a sediment re-suspension of modeling component. Model selection will determine need for this component.

7.6- Flow monitoring:

In addition to existing gages, 9 additional gages will be installed to measure flow. These data are necessary inputs for the hydrodynamic and water quality models. The locations of existing and new gages are presented in Table 8 and shown in Figure 1. At tributary locations where gages are absent, flow will be measured using hand held equipment such as SONTEK Flow Tracker (or equivalent). Flow measurement SOP is available in Flow Tracker Handheld ADV Users Manual (SonTek/YSI 2009 FlowTracker Handheld ADV User's Manual Firmware Version 3.7). Discharge measurements at higher stages that can not be waded at the SB Metedeconk River at Chambers Bridge Road near Laurelton will be made from the bridge or a pulley system. A Teledyne RDI StreamPro Acoustic Doppler Current Profiler (ADCP) mounted to a tethered boat will be pulled across the stream from the downstream side of a bridge or on a pulley system from bank to bank (Gotvald and Oberg, 2009). A minimum of four transects are made across the

channel. The ADCP transmits acoustic pings that record the velocity and depth of water. A Bluetooth wireless link from the ADCP transmits depth, distance and velocity data every second to a field computer. The field computer calculates the discharge for each transect. The discharge from the 4 transects are averaged. The USGS quality assurance plan for discharge measurements using ADCPs is published in Oberg and others, 2005. References are available online at http://pubs.er.usgs.gov/usgspubs/sir/sir20055183. and **http://pubs.er.usgs.gov/usgspubs/fs/fs20083096**

Table 8: Existing and New Gauging Stations

Station Description	Latitude	Longitude	Type
Westecunk Creek at Stafford Forge NJ	39.666667	-74.320278	Existing-Trib
Cedar Creek at Lanoka Harbor NJ	39.8675	-74.169167	Existing-Trib
North Branch Metedeconk River near Lakewood NJ	40.091667	-74.1525	Existing-Trib
Point Pleasant Canal at Point Pleasant, NJ	40.070278	-74.059722	New-outlet/inlet
Barnegat Bay at Mantoloking Bridge at Mantoloking	40.04	-74.057222	New - in bay
Barnegat Bay at Route 37 Bridge near Bay Shore,	39.946111	-74.103056	New - in bay
Barnegat Inlet at Barnegat Light, NJ	39.766389	-74.099167	New-outlet/inlet
Barnegat Bay at Route 72 Bridge near Ship Bottom	39.663333	-74.206944	New - in bay
Little Egg Harbor Inlet near Beach Haven Heights	39.5075	-74.3075	New-outlet/inlet
Oyster Creek near Brookville, NJ	39.798333	-74.250556	New-Trib
S.B. Metedeconk River near Lakewood, NJ	40.085833	-74.185556	New-Trib
Mill Creek at Manahawkin, NJ	39.695278	-74.26	New-Trib

7.7- Bathymetric Survey (Placeholder)

The existing bathymetry was prepared in 1934-36 and predates significant events, such as modifications to the Barnegat Bay inlet. Limited recent bathymetric data is available in the vicinity of Barnegat Inlet. These data show that while some locations have experienced minor change, others have undergone significant change. Verification of the bathymetric configuration is needed to ensure reliable modeling results. It is also necessary to characterize sediment for sediment transport modeling. High resolution bathymetry will enhance the accuracy of the circulation model, which in turn, will enhance the ability to simulate sediment transport and other important parameters, e.g., salinity and temperature. A sampling project for measurement of Barnegat Bay bathymetry, bottom-sediment type and shallow structures is proposed using side-scan sonar swath bathymetry, sub bottom profiler, and sediment sampling. This method will be applied in deeper waters. Spot verification using equipment yet to be specified will be applied in shallow waters where the sonar equipment cannot be used.

Data Usage:

Water quality data sampled under this project will be used to identify assess water quality impairment and populate, calibrate and validate modeling tools along all other quality assured historic data. All sampling procedures must be in conformance with NJDEP or USGS (URL http://water.usgs.gov/owq/FieldManual/index.html) field sampling procedures as well as other applicable guidance. If a method or procedure requires change and is not contained in Table 3 and Table 4, this information should be brought to the attention of the signatories of this QAPP through writing and needs approval prior to being used.

8. Reports:

All water quality data collected, locations of final sampling sites, and related field notes should be entered in the New Jersey Water Quality Data Exchange (WQDE). Data quality assurance will occur at NJDEP Bureau of Freshwater and Biological Monitoring and Bureau of Environmental Analysis and Restoration using protocols found in USGS open file Report 02-383 "Methods for Quality Assurance Review of Water Quality Data in New Jersey".

9. Project area:

Watershed project area covered under this project is the Barnegat Bay Watershed in WMA 13 (see Figure 1 for the spatial extent of the study). The GIS map provided identifies proposed monitoring locations, dischargers, and approximate head of tide.

10. Data Representativeness

The same methods and techniques will be used by all field collection staff. Office of Quality Assurance will be on-site for the 1st sampling event to review and ensure that all samples are collected per the QAPP. Any deviations from the QAPP will be documented and will be resolved prior to the next sampling event

11. Data Validation:

Method blank (lab), equipment blank, duplicate, and replicate samples will add approximately 10 percent more to the total number of samples collected. A midpoint project review is scheduled for Sept 2011. At that time all aspects of the sample collector procedures will be evaluated and revisions incorporated, as needed. An addendum to this plan will be issued at that time detailing any changes. The data is verified using the replicate data percent difference discussed above. The data is validated using the QC data. The QC sample should fall between two standard deviations at the 95^{th} percentile confidence level to be valid. All laboratory and field spikes should be with between 80-120 %. Water quality results will be assessed against available, historical water quality data from the locations monitored. Data will also be assessed using USGS Open-File Report 02-383 "Methods for Quality Assurance Review of Water-Quality Data in New Jersey ". That report provides information on standard ranges of specific parameters in New Jersey streams and standard relationships between specific parameters. . All data collected will be provided to NJDEP and WM&S staff will perform the data validation process. Data that can not be confirmed by these reviews or explained by circumstances (i.e. heavy rain, drought) or project QA data will be classified as questionable by NJDEP. In addition, quality assurance protocols will be used by EPA Edison, OCUA, Leeds Point, the Maryland Lab and BFBM for the data validations under the supervision of a quality assurance officer.

12. Data Quality Requirements

Continuous Data Quality

Data recorders are calibrated and programmed within 24 hrs of each deployment following the manufacturer's manual. Duplicate DO measurements are made at the time of meter deployment and meter retrieval with a second meter, calibrated on site. Comparative DO readings not within the stated accuracy of the meters used will be reviewed against historical water quality data from that site as an additional quality review step. Data outside the stated accuracy of the meters used in the comparative readings and outside the historical range for DO at that location will not be used. At each sampling event water quality grab samples will be taken at the location of the continuous meters and analyzed for the parameters listed in Table 4. This data will be utilized to validate the data collected by the continuous meters.

Field Quality Assurance and Quality Control

NJDEP and Partner groups field staff will be approved by DEP's Office of Quality Assurance for field measurements, which include: specific conductance (Wheatstone Bridge, SM 2510 B), dissolved oxygen (electronic SM 4500-OG), pH Electronic SM 4500-HB) and temperature (Thermometric). Project staff will follow manufacture's manuals regarding calibration and operating procedures for specific meters. Results of daily pH calibrations, D.O. air calibrations and specific conductance calibrations will be recorded on field calibration forms. Weekly temperature ASTM- QC checks and Winkler D.O. checks are also recorded. Turbidity samples will be analyzed at one of the laboratories by NJDEP field staff who are certified for the measurement of turbidity (Nephelometric, SM 2530 B), The marine sample field quality control will consist of analyzing in the laboratory, the remaining sample not used for filtration for salinity; in addition, a dissolved oxygen Winkler titration sample will be collected. This data will be used to validate the data collected by sensors in the field. The Winkler titration sample must be protected from the intrusion of atmospheric oxygen and needs to be analyzed prior to the validation for the salinity.

The Laboratories participating in this project are state or National Environmental Laboratory Accreditation Program (NELAP) certified to perform the parameters conducted for ambient water quality monitoring and will follow the Laboratory methods as outlined in Appendix A. Any changes to the methods used must be pre-approved by the DEP before sample testing continues.

The field meters or multi parameter sensors will be calibrated using manufacturer specifications. Calibration and verification will be performed with the following:

Temperature

Temperature thermistors are factory calibrated. Thermistors must be checked against a National Institute of Standards and Technology (NIST)-certified thermometer on a quarterly basis. If not found to be accurate within + 0.5 °C of the certified thermometer an offset value will be applied to correct the reading or if drift is continuing to take place sensor will be replaced. Any change will be noted in the calibration log. Temperature units will be degrees Celsius (°C). On August 17, 2011, the temperature monitoring devices were calibrated by DEP personnel against a NIST certified thermometer. This calibration must be repeated on August 17, 2011 and quarterly thereafter through the duration of the project.

Duplicate testing is required once every 20 samples tested.

Salinity/Specific Conductance

Specific conductance is calibrated using a factory prepared conductivity standard with a value of 50 mS/cm or a 35 ppt salinity standard for the marine samples and 1.412 mS/cm for the fresh water locations. Specific conductance units will be mS/cm, Salinity will be expressed in parts per thousand (ppt). For sensor verification, another standard from a different source will be analyzed. The calibration must be checked in the measure mode with a standard. The required accuracy is that the calibration check data must be within 1% of the true value of the standard used to be acceptable for analysis.

Duplicate testing is required once every 20 samples tested.

Dissolved Oxygen

Calibration of a DO meter at 100 percent oxygen saturation is made by adjusting the meter reading for air saturated with water vapor, as per the manufacturer's instructions. Sensors will record both Dissolved Oxygen (DO) milligrams/liter (mg/l) and DO percent saturation (%). Samples for the Winkler titration will be collected at the marine water sites for sensor verification. Each week of use the DO meter must be verified against a Winkler titration procedure. The accuracy required between the reading from the DO meter and the results of the Winkler test must be within +/- 0.3 mg/L of each other to be acceptable.

Duplicate testing is required once every 20 samples tested.

pH

Most multi-meters require the use of a three point calibration with 4, 7 and 10 pH buffers. A three point calibration is the preferred approach to a quality calibration. All calibrations must be performed with the buffer solutions supplied by the DEP for consistency and must meet the accuracy requirement of being within 0.05 s.u. of the true value of the buffer used to be considered acceptable. A two point calibration can be performed using 7 and 10 buffers for the marine locations and 4 and 7 buffers for the fresh water locations as long as a calibration check (with the instrument in the measure mode) is conducted with the second of the two buffers used for calibration (i.e. 10 buffer for the marine and 7 buffer for the freshwater). The required calibration check result must be within 0.10 s.u. of the true value of the buffer used. Every three hours of use the meter must be checked with the calibration check buffer and must be accurate to 0.2 s.u. of the true value to be considered acceptable for continued use. The field staff may also recalibrate the meter at each site as an alternative to the three hour calibration check requirement.

Duplicate testing is required once every 20 samples tested.

Millivolt readings are also taken as a check of probe performance. For sensor verification, another certified pH buffer from a different source will be analyzed.

Turbidity

Turbidity samples will be analyzed at one of the field laboratories (FREC or Leeds Point). Calibration of a turbidity meter will be accomplished by a 2 point method using an YSI produced microbead synthetic turbidity standard (123NTU) and deionized water (0NTU) each day of use. Turbidity units will be (NTU).

Duplicate testing is required once every 20 samples tested.

A formazin standard or a standard from a different source will be analyzed for sensor verification.

Filtration Quality Control

Filtration quality control will consist of analyzing a filtration blank, that will be deionized water run through the pump tubes and the filter, preserved and analyzed as the other nutrient samples, prior to the filtration of a sample. Between each sample, the pump tubes will be flushed with a cycle of deionized water/ 10% HCl/ deionized water. The filtration blank will be repeated after roughly half (13 samples) and at the end of the processing of 27 samples. This will ensure the validity of the data and the pump cleansing process. In addition, 2 filtration spikes and replicates will be performed for each sample run. The spike will consist of adding a known amount of analyte to a volume of sample, and the sample will be filtered and processed as the other samples, the spike will ensure that there are no interferences, loss of analyte or contamination of the sample. Filtrations must be performed within 8 hours of sample collection or sooner and the time of filtration will be documented in the laboratory records or on the chain of custody form for the project.

Table 9

Lab	Parameter		Prep	Code	Lab Reporting Limit	Method	Holding Time
FREC/Leeds Point	Turbidity	FwSw	U	Turb	0.1 NTU	SM 2130 B	48 hours
Leeds Point	Total Suspended Solids	FwSw	U	TSS	1.0 mg/l	USGS I-3750-85	24 hours
Leeds Point	Chlorophyll a (bay only)	Sw	U	Chla	0.42 ug/l	SM 10200-H	24 hours
Leeds Point	Total Nitrogen	FwSw	U	TN	0.08815 mg/l	USGS I-4650-03	28 days
Leeds Point	Total Phosphorus	FwSw	U	TP	0.02501 mg/l	USGS I-4650-03	28 days
Leeds Point	Dissolved Ammonia	FwSw	F	DNH3	0.02672 mg/l	350.1 MOD	14 days
Leeds Point	Dissolved Nitrite + Nitrate	FwSw	F	DNO3	0.02617 mg/l	EPA 353.4	28 days
Leeds Point	Dissolved Orthophosphate	FwSw	F	DPO4	0.01301mg/l	EPA 365.5	28 days
Leeds Point	Dissolved Nitrogen	FwSw	F	DN	0.08815 mg/l	USGS I-4650-03	28 days
Leeds Point	Dissolved Phosphorus	FwSw	F	DP	0.02501 mg/l	USGS I-4650-03	28 days
Leeds Point	Total Organic Nitrogen	FwSw		TON	NA	Calculated	NA
Leeds Point	Dissolved Organic Nitrogen	FwSw		DON	NA	Calculated	NA
Leeds Point	Dissolved Organic Phosphorus	FwSw		DOP	NA	Calculated	NA
Leeds Point	Particulate Organic Nitrogen	FwSw		PON	NA	Calculated	NA
Leeds Point	Particulate Phosphorus	FwSw		PP	NA	Calculated	NA
OCUA	Biochemical Oxygen Demand (5 day)	FwSw	U	BOD5	1.0 mg/l	SM 5210B	48 hours
OCUA	Carbonaceous Oxygen Demand (5 day)	FwSw	U	CBOD5	1.0 mg/l	SM 5210B	48 hours
OCUA	Carbonaceous Oxygen Demand (20 day)	FwSw	U	CBOD20	1.0 mg/l	SM 5210B	48 hours
EPA Region 2	Alkalinity	FwSw	U	Alk	1.0 mg/l	SM 2320 B	14 days
EPA Region 2	Total Silica	FwSw	U	Si	1.0 mg/l	EPA 200.7 rev 4	6 months
EPA Region 2	Dissolved Silica	FwSw	F	DSi	1.0 mg/l	EPA 200.7 rev 4	6 months

Lab	Parameter		Prep	Code	Lab Reporting Limit	Method	Holding Time
EPA Region 2	Total Organic Carbon	Fw	U	TOC	1.0 mg/l	SM 5310 B	28 days
EPA Region 2	Dissolved Organic Carbon	Fw	F	DOC	1.0 mg/l	SM 5310 B	28 days
University of Maryland	Dissolved Organic Carbon	Sw	F	DOC	0.12 mg/l	EPA 415.1	28 days
University of Maryland	Dissolved Inorganic Carbon	Sw	F	DIC	0.12 mg/l	EPA 415.1	29 days
University of Maryland	Particulate Organic Carbon	Sw	F	POC	0.0633 mg/l	EPA 440.0	30 days
University of Maryland	Total Organic Carbon	Sw		TOC	NA	Calculated	NA

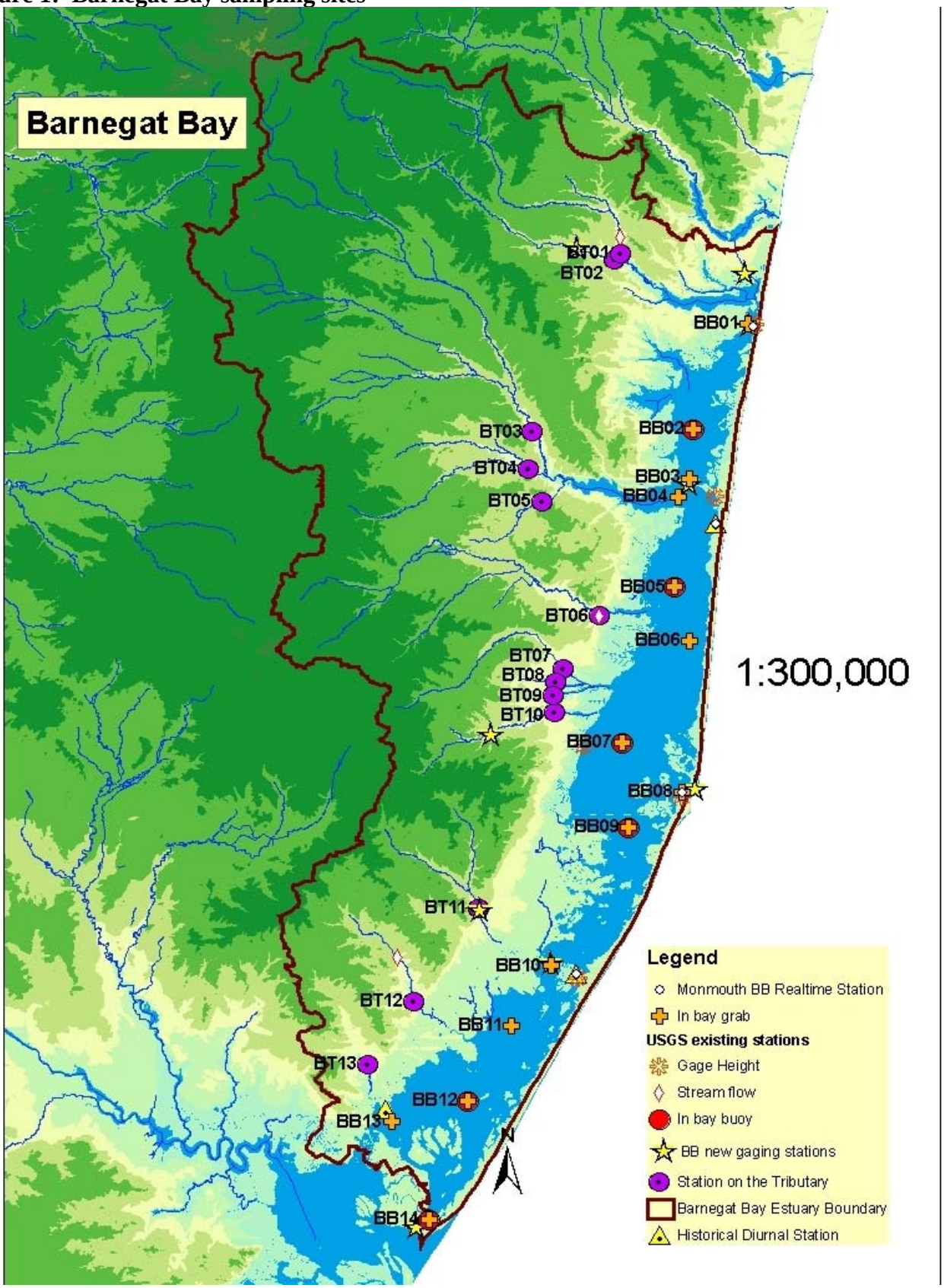
13. Chain Of Custody

Chain of custody procedures will be instituted for this project. Chain of custody procedures will be employed until samples reach the appropriate laboratory. Once samples reach the laboratory the laboratories internal sample tracking procedures will be utilized. (See Appendix B)

14. Corrective Action:

All laboratories involved in this project are required to maintain standard operating procedures which outline specific action to pursue should corrective action be necessary. If acceptable results cannot be obtained due to: either field or laboratory errors (calibration standards, proficiency testing samples, blanks, spikes, or duplicates falling out of range) the affected samples will be re-analyzed and steps will be taken to ensure that the data produced is accurate. Standards and reagents will be replaced, equipment will be checked, or other action, will be taken to remedy the situation. NJDEP designated project officers will be notified in writing anytime a deviation from the approved work plan has occurred.

Figure 1: Barnegat Bay sampling sites



Appendix A Sample Chain of Custody Form

Barnegat Bay Monitoring Program Analysis Request and External Chain of Custody Form

General Information					
Site #		Site Description		Sample # (Site # + Date)	
Sample Collection Date (mm/dd/yyyy)		Sample Collector		Sample Type (circle one)	Sample Blank Replicate
Sample Collection Time (hh:mm)		Collector Organization			
Filtration Time (hh:mm)		Turbidity Measurement Time (hh:mm)		Turbidity (NTU)	

Field Measurements/Observations					
Field Measurement Time (hh:mm)		pH		Secchi Depth (ft)	
Uncorrected Water Temperature (deg C)		Specific Conductance (circle units) uS/cm mS/cm		Comments	
Corrected Water Temperature (deg C)		Ambient Transmissionmetry			
Dissolved Oxygen (mg/l)		Underwater Transmissionmetry			
Dissolved Oxygen Saturation (%)		Salinity (ppth)			

Raw Sample					
Container ID	Container	Matrix	Parameter	Fraction	Preservative
L1 - U	Amber HDPE, 500 mL	Freshwater / Saltwater	TSS, Chlorophyll a (bay only)	Total	Ice, 4 deg C
O1 - U	HDPE, 2L	Freshwater / Saltwater	BOD5, CBOD5, CBOD20	Total	Ice, 4 deg C
R1 - U	HDPE, 2L	Freshwater / Saltwater	NH3, NO2+NO3, PO4, TN, TP, Turbidity	Total	Ice, 4 deg C

NJDEP Leeds Point Laboratory (NJ Lab Certification #: 01179)					
Container ID	Container	Matrix	Parameter	Fraction	Preservative
L1 - U	Amber HDPE, 500 mL	Freshwater / Saltwater	TSS, Chlorophyll a (bay only)	Total	Ice, 4 deg C
L2 - U	50 mL HDPE centrifuge tube	Freshwater / Saltwater	TN, TP	Total	Ice, 4 deg C
L3 - F	50 mL HDPE centrifuge tube	Freshwater / Saltwater	DNH3	Dissolved	2 ml 3.5% Phenol
L4 - F	50 mL HDPE centrifuge tube	Freshwater / Saltwater	DNO3, DPO4, DN, DP	Dissolved	Ice, 4 deg C

Ocean County Utilities Authority Laboratory (NJ Lab Certification #: 15537)					
Container ID	Container	Matrix	Parameter	Fraction	Preservative
O1 - U	HDPE 2 L	Freshwater / Saltwater	BOD5, CBOD5, CBOD20	Total	Ice, 4 deg C

USEPA Region 2 Laboratory at Edison Environmental Center					
Container ID	Container	Matrix	Parameter	Fraction	Preservative
E1 - U	HDPE, 250 mL	Freshwater / Saltwater	Total Alkalinity	Total	Ice, 4 deg C
E2 - U	HDPE, 125 mL	Freshwater / Saltwater	Silica	Total	conc HNO_3 pH<2
E3 - F	HDPE, 125 mL	Freshwater / Saltwater	Silica	Dissolved	conc HNO_3 pH<2
E4 - U	Glass, 250 mL	Freshwater	TOC	Total	conc H_2SO_4 pH<2
E5 - F	Glass, 250 mL	Freshwater	DOC	Dissolved	conc H_2SO_4 pH<2

University of Maryland Center for Environmental Science Laboratory					
Container ID	Container	Matrix	Parameter	Fraction	Preservative
M1	Teflon, 30 mL	Saltwater	DOC, DIC	Total	Ice, Freeze
M2 - PC	Foil, (2) 25 mm GF/F media	Saltwater	Particulate Carbon	Particulate	Ice, Freeze

Chain of Cusody				
Container ID	Relinquished	Received	Date/Time	Reason
L1-U, R1-U, O1-U			/ /2011 _____	Sample drop off at FREC or LEEDS
R1-U			/ /2011 _____	Sample filtration & preservation
R1-U			/ /2011 _____	Sample filtration & preservation (BB sites ONLY)
L1-4, E1-___, (M1-2)			/ /2011 _____	Placement in coolers for lab transfer (LEEDS runner sign received)
L1-4, E1-___, (M1-2)			/ /2011 _____	Transfer to lab for analysis

Send to: ___ Leeds Point ___ OCUA ___ EPA ___ UM/CES

Appendix B
Sample Routing and Field Preparation Figures 2-4

Figure 2

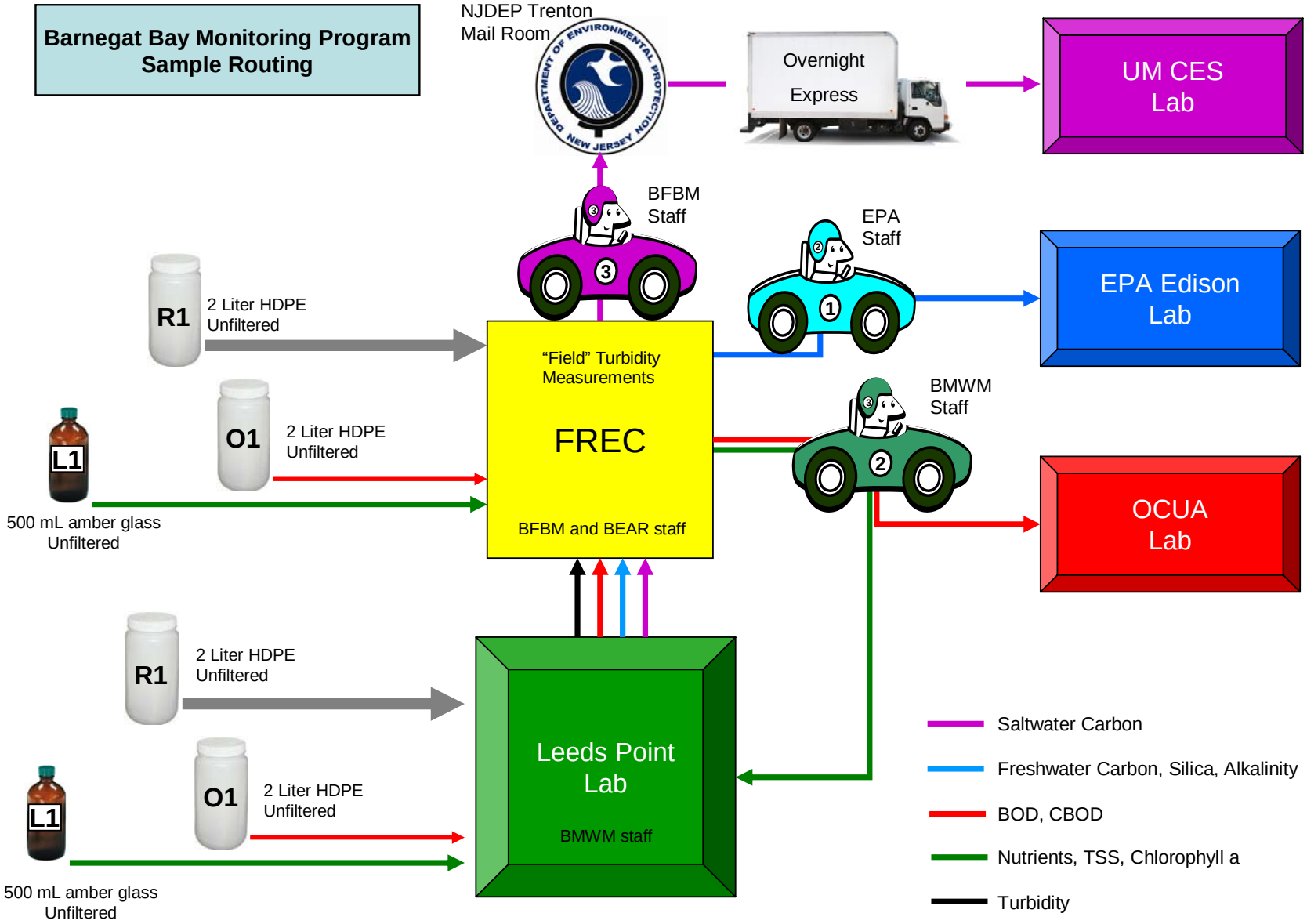

Barnegat Bay Monitoring Program
Sample Routing
NJDEP Trenton
Mail Room
Overnight
Express
UM CES
Lab
BFBM
Staff
EPA
Staff
EPA Edison
Lab
R1
2 Liter HDPE
Unfiltered
"Field" Turbidity
Measurements
FREC
BFBM and BEAR staff
BMWM
Staff
O1
2 Liter HDPE
Unfiltered
L1
500 mL amber glass
Unfiltered
OCUA
Lab
R1
2 Liter HDPE
Unfiltered
Leeds Point
Lab
BMWM staff
O1
2 Liter HDPE
Unfiltered
L1
500 mL amber glass
Unfiltered
Saltwater Carbon
Freshwater Carbon, Silica, Alkalinity
BOD, CBOD
Nutrients, TSS, Chlorophyll a
Turbidity

Figure 3

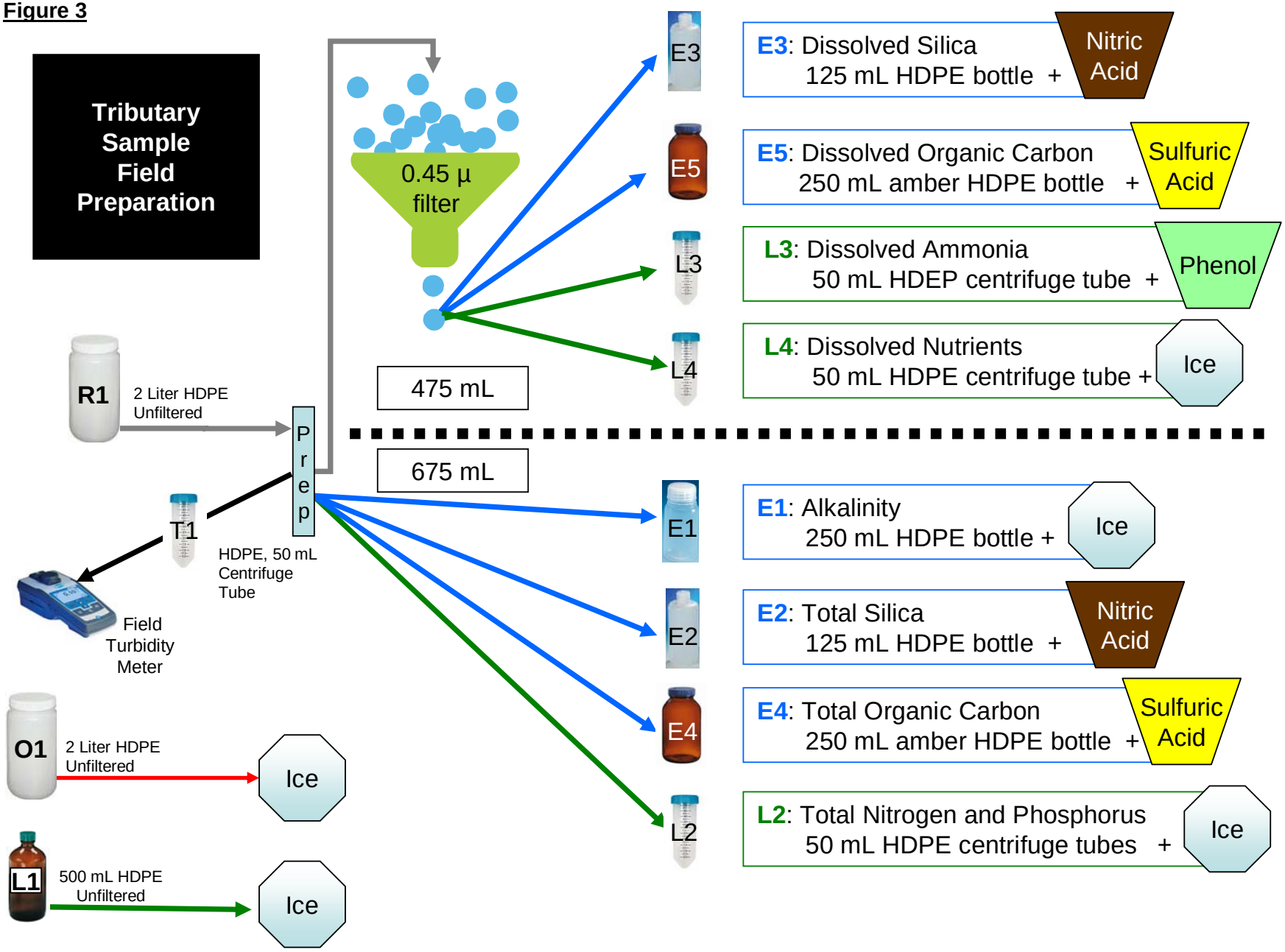
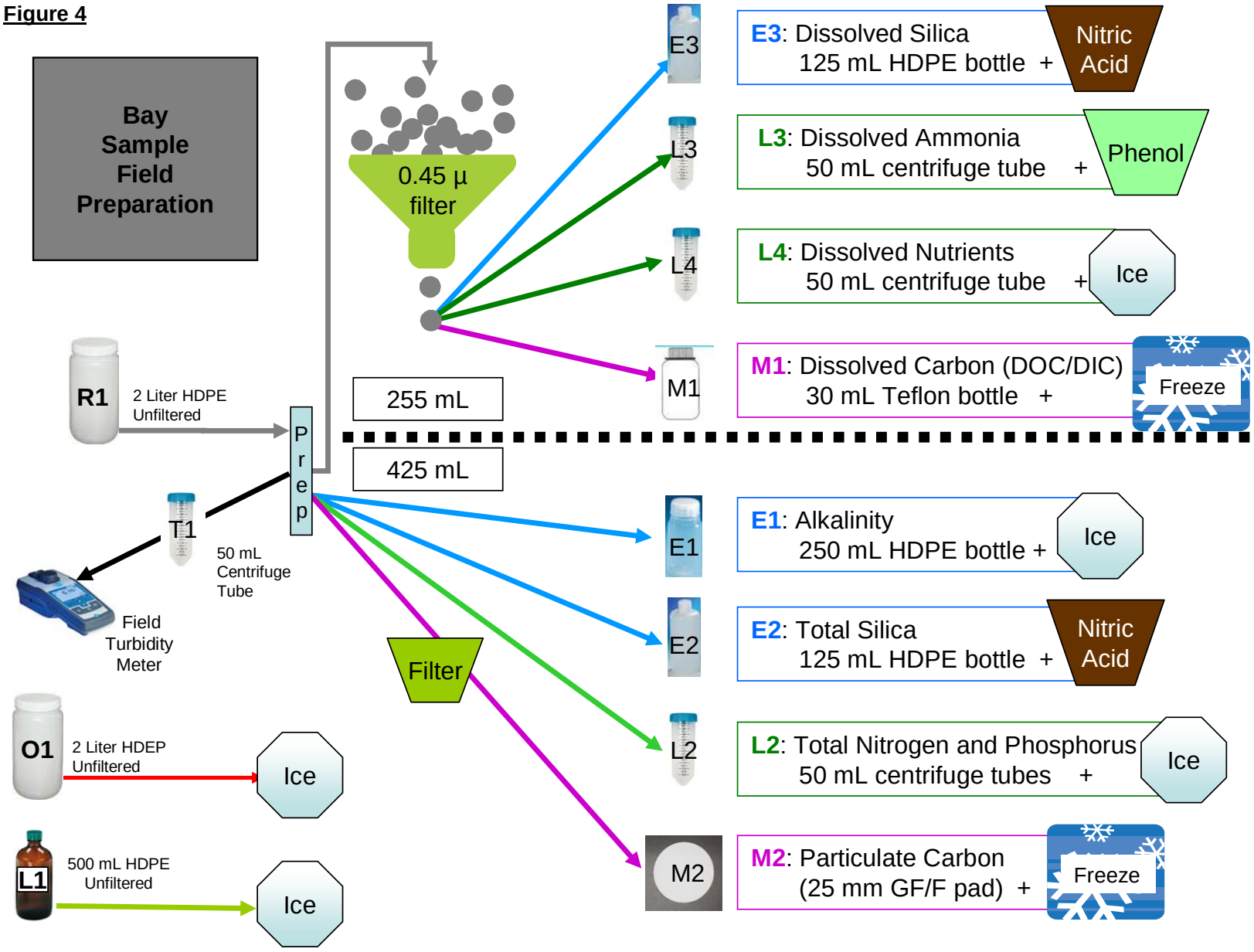

Tributary Sample Field Preparation
0.45 µ filter
E3
E5
L3
L4
E3: Dissolved Silica
125 mL HDPE bottle +
Nitric Acid
E5: Dissolved Organic Carbon
250 mL amber HDPE bottle +
Sulfuric Acid
L3: Dissolved Ammonia
50 mL HDEP centrifuge tube +
Phenol
L4: Dissolved Nutrients
50 mL HDPE centrifuge tube +
Ice
475 mL
675 mL
R1
2 Liter HDPE Unfiltered
Prep
T1
HDPE, 50 mL Centrifuge Tube
Field Turbidity Meter
E1
E2
E4
L2
E1: Alkalinity
250 mL HDPE bottle +
Ice
E2: Total Silica
125 mL HDPE bottle +
Nitric Acid
E4: Total Organic Carbon
250 mL amber HDPE bottle +
Sulfuric Acid
L2: Total Nitrogen and Phosphorus
50 mL HDPE centrifuge tubes +
Ice
O1
2 Liter HDPE Unfiltered
Ice
L1
500 mL HDPE Unfiltered
Ice

Figure 4


Bay Sample Field Preparation
0.45 µ filter
E3
E3: Dissolved Silica
125 mL HDPE bottle +
Nitric Acid
L3
L3: Dissolved Ammonia
50 mL centrifuge tube +
Phenol
L4
L4: Dissolved Nutrients
50 mL centrifuge tube +
Ice
M1
M1: Dissolved Carbon (DOC/DIC)
30 mL Teflon bottle +
Freeze
R1
2 Liter HDPE Unfiltered
255 mL
425 mL
Prep
T1
50 mL Centrifuge Tube
Field Turbidity Meter
E1
E1: Alkalinity
250 mL HDPE bottle +
Ice
E2
E2: Total Silica
125 mL HDPE bottle +
Nitric Acid
Filter
L2
L2: Total Nitrogen and Phosphorus
50 mL centrifuge tubes +
Ice
O1
2 Liter HDEP Unfiltered
Ice
L1
500 mL HDPE Unfiltered
Ice
M2
M2: Particulate Carbon
(25 mm GF/F pad) +
Freeze