Pleasant Bay Citizen Water Quality Monitoring Program

Quality Assurance Project Plan

Prepared By
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4.0 Project/Task Organization

4.1 Organizations

The Pleasant Bay Citizen Water Quality Monitoring Program is coordinated by the Pleasant Bay Resource Management Alliance. The Alliance was formed in 1998 through an inter-governmental agreement involving the towns of Orleans, Chatham and Harwich to implement the recommendations of the Pleasant Bay Resource Management Plan. The Alliance is governed by a Steering Committee with representation from each town. The Steering Committee is assisted by a Technical Resource Committee (TRC) consisting of the towns' appointed resource management professionals, and a coordinator who is responsible for managing implementation activities including the citizen water quality monitoring program.

The Pleasant Bay Citizen Water Quality Monitoring Program is a cooperative effort of the Alliance and existing citizen water quality monitoring organizations within the three towns. The involved water quality organizations are the Orleans Water Quality Task Force, the Harwich Shellfish and Marine Water Quality Committee, and the Chatham Water Watchers/Chatham Water Quality Laboratory. The Alliance works through these organizations to recruit and coordinate volunteers for sampling, transportation of samples, and data management.

In 1999 the Alliance obtained a grant from the Executive Office of Environmental Affairs to design a baywide water quality-monitoring program. To accomplish this task the TRC convened a Water Quality Work Group to design the baywide program. The program design work group consisted of TRC members from the three towns, representatives of the three local volunteer monitoring programs, and water quality experts from the following organizations: National Park Service (NPS), Waquoit Bay National Estuarine Research Reserve (WBNERR), School for Marine and Science Technology (SMAST), and Cape Cod Commission. This work group designed the bay wide program and drafted a Quality Assurance Project Plan.

4.2 Roles/Responsibilities

With the draft QAPP, the Alliance formed the Citizen Water Quality Monitoring Work Group to manage the sampling program. Table 1 describes the assignment of primary functions and responsibilities.

Table 1 Program Functions and Responsibilities

Function	Organization
Program Design and Evaluation	Alliance Citizen Water Quality Monitoring Work Group (see list on front cover)
Volunteer Recruitment Committee	Dr. Robert Wineman Margaret Wineman Martha Stone Carole Ridley, Alliance Coordinator
Training	Dr. Robert Duncanson Dr. Robert Wineman
Sampling Oversight	Dr. Robert Duncanson Dr. Robert Wineman
QA/QC Manager	Dr. Robert Duncanson
Field Volunteer Coordinators	George Olmsted and Martha Stone-Stations 1-5 Heinz Proft – Stations 6-9 Robert & Margaret Wineman – Stations 10-16
Laboratory Analysis & QA/QC	Dr. Brian Howes, - SMAST at UMASS-Dartmouth
Data Management & Evaluation	Dr. Robert Duncanson
Coordination, Grantwriting & Public Information	Carole Ridley

Potential data users, in addition to the Alliance, include the individual towns (e.g. Conservation Commissions, Boards of Health, Natural Resource, etc.), regional agencies (Cape Cod Commission, Barnstable County Department of Health & Environment, Cape Cod National Seashore), state agencies (DEP, CZM, etc), universities, and the local citizenry.

4.3 Program Support

Funding for the program has come from annual appropriations from the Towns of Orleans, Chatham and Harwich, grants awarded by the Executive Office of Environmental Affairs, and contributions from the Friends of Pleasant Bay, Inc. These public and private resources help to leverage the hundreds of hours of time and expertise provided by local volunteers and professional staff. The Cape Cod Commission, Cape Cod National Seashore, and School of Marine Science and Technology-UMASS, Dartmouth provides technical support.

5.0 Problem Identification/Background

5.1 Planning Context

Pleasant Bay (Figure 1) represents one of the most biologically diverse and productive marine habitats on the East Coast of the United States. The extraordinary array of natural resources in and around the Bay, coupled with rapid land development and increasing competition among a variety of commercial and recreational activities, prompted the towns of Orleans, Chatham, Harwich and Brewster to petition the state to designate the 9,000 acre estuary as an Area of Critical Environmental Concern (ACEC). Through a cooperative agreement, the towns developed a resource management plan (RMP) for the ACEC and its watershed. The Towns of Orleans, Chatham and Harwich approved the RMP and funding for its implementation, respectively, at town meetings in 1998.[1] In that same year the three towns formed the Pleasant Bay Resource Management Alliance to implement the approved plan.

The analysis and recommendations of the RMP provide the mandate for establishing a baywide citizen water quality monitoring program. The RMP states *"[t]he extent of current bacteriological testing indicates that water quality in the bay is high, with isolated areas of concern. However, there is insufficient baseline data on the full range of water quality indicators, and no system is in place for monitoring long-term trends in water quality. Moreover, water quality is threatened by intensifying land uses within the watershed, and boating activity in the bay."* [2]

Specifically, a nitrogen loading study completed by the Cape Cod Commission for the RMP identified three sub-embayments "with excessive nitrogen loads coming from existing land uses within their sub-watersheds: Muddy Creek, Arey's Pond, and Round Cove. Two other embayments (Paw Wah Pond and Ryder's Cove) are identified as having the potential to exceed their nitrogen loading limits once all land is developed in their watersheds."[3] The report also indicated that water quality throughout the Bay is at risk should the Chatham inlet return to its pre-1987 configuration. The Commission's study was based on flushing data[4] and nitrogen loading estimates based on land use data. As discussed below, one objective of the baywide monitoring program is to provide data to evaluate/validate the Cape Cod Commission's findings.

The overall goal of the baywide monitoring program is to generate reliable baseline data on general water quality conditions throughout the Bay. Comprehensive data are needed to implement several recommendations of the RMP. These include recommendations for wastewater management, regulation of shoreline structures and boating activity, protection of

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[1] The Town of Brewster Town Meeting did not vote to join the Alliance. Brewster does not have jurisdiction over marine waters in the Bay. However, approximately 13% of the Bay's marine water recharge area is in Brewster.
[2] Pleasant Bay Resource Management Plan, April 1998, p. 74.
[3] Pleasant Bay Resource Management Plan, April 1998, p. 34. See also, Cape Cod Commission, Pleasant Bay Nitrogen Loading Study Final Report, May 1998.
[4] Ramsey, John S., P.E. *Hydrodynamic and Tidal Flushing Study of Pleasant Bay Estuary, MA. Final Report for The Pleasant Bay Steering Committee*. Aubrey Consulting, Inc. Cataumet, Massachusetts. August, 1997.

(Figure 1, Map of Pleasant Bay)

habitats and planning for the safe and reasonable accommodation of Bay uses and facilities such as moorings and aquaculture.

5.2 Water Quality Monitoring in the Bay

Some water quality monitoring activity was underway in the Bay prior to the baywide program described in this QAPP. For example, the Massachusetts Division of Marine Fisheries conducts bacterial testing in all shellfishing areas of the Bay. There were also volunteer efforts underway in some areas. These include:

- The Orleans Water Quality Task Force conducted nutrient monitoring in five upper-bay ponds beginning in 1997. Prior to the Alliance program the task force collected baseline data on air and water temperature, secchi and actual depths, salinity, dissolved oxygen, NO_3, PON, POC, and chlorophyll-a. The Orleans Water Quality Task Force has incorporated all of their Pleasant Bay stations into the Alliance program.

- The Harwich Harbormaster/Natural Resources Officer monitored water quality at two locations within Round Cove in Pleasant Bay beginning in 1998. Sampling occurred June through September to test the following parameters: dissolved oxygen, salinity, temperature, bacteria and phytoplankton (Harwich participates in the Phytoplankton Monitoring Program sponsored by the Massachusetts Division of Marine Fisheries). Nutrients were not tested on a regular basis prior to the Alliance program.

- Chatham Water Watchers, a volunteer organization, works in conjunction with the Town of Chatham Water Quality Laboratory (WQL). The organization began monitoring in the Stage Harbor estuary in 1998. This monitoring included dissolved oxygen, salinity, depth (total & secchi), nutrients (NO_2&NO_3, PO_4, NH_4^+, DON, PON, POC), chlorophyll-a, pheophytin-a, and field observations. Although this sampling did not occur in the Pleasant Bay, it helped to develop volunteer expertise that has been applied in the Pleasant Bay program.

The work of these groups generated some baseline data on water quality in selected areas of the Bay. However, several gaps in water quality data were identified and have been addressed in the design of the Alliance's bay-wide program:

- More sampling stations were added to provide a geographically comprehensive view of the Bay's water quality. Sampling locations were selected to provide geographic coverage rather than identify or track pollution sources. Previously, seven sites, located in Round Cove or the smaller salt ponds in the upper bay, were tested within the three towns. In the design of the baywide program a total of sixteen sites were identified to adequately cover the 9,000 acre estuary and represent the variety of physical conditions relevant to water quality. The variety of tidal and flushing dynamics in the Bay, as well as an awareness of limited available resources for sampling and analysis, was taken into consideration in the selection of sampling locations. This is to ensure that sites selected could reasonably be tested on a long-term basis.

- Consistent parameters were selected. In the design of the baywide program it was determined that parameters used to calculate the health index (eutrophication) would be monitored consistently around the Bay. Each town retains the option of sampling for additional parameters relevant to individual areas.

- Procedures for sampling and analysis have been reviewed, refined, and coordinated. Consistent standard operating procedures have been developed for field sampling, sample custody and transport, and laboratory analysis. The baywide program design ensures that standard monitoring procedures are used throughout the Bay.

- The Alliance provides the organizational structure for the collection, integration and analysis of data on a baywide basis.

5.3 Program Objectives

As stated above, the overarching objective of the Pleasant Bay Citizen Water Quality Monitoring Program is to generate baseline data on general water quality conditions in the Bay. A minimum of three years of data will be used to establish current conditions and provide a baseline against which long-term trends in water quality can be evaluated.

A second objective of the program is to monitor nitrogen loading trends. A full suite of nutrient parameters is being tested to track the impact of surrounding land uses on marine resources. The Buzzards Bay Health (eutrophication) Index[5] will be calculated and monitored for all sixteen sampling locations. The index will aid in comparisons of actual water quality conditions with results and predictions from the nitrogen loading analysis conducted by the Cape Cod Commission. Monitoring data will be used to confirm current conditions and identify trends in nitrogen loads. This Information will be used to design and monitor remediation efforts to prevent or reduce excessive nutrient levels.

A third program objective is to analyze data for policy, regulatory and educational applications. Good water quality is fundamental to the health of the Bay's resources, and the enjoyment derived from numerous human uses of the resources. Water quality data will be used as input to the design remediation actions in critical areas. It will also be used in the implementation of a number of actions called for in the RMP, including the design of watershed management programs, managing the Bay's fisheries and waterways, and protecting the viability of critical habitats. Water quality monitoring data and analysis will be made available to local, regional, state and federal resource management professionals involved with the Bay. Information will be presented to the general public through press releases and "user-friendly" reports.

The Alliance recognizes that program objectives may need to be modified in the future based on data trends. Site specific objectives may also be developed, related to topics such as the

[5] The program will utilize the Buzzards Bay Health (Eutrophication) Index formula. Baywatchers II nutrient related water quality of Buzzards Bay embayments: a synthesis of Baywatchers monitoring 1992-1998, December 1999.

condition of eelgrass or other habitat indicator species, the impact of identified point sources (i.e. drainage pipes, etc) or the study of heavy metal concentrations in sediments in selective areas.

6.0 Program/Task Description

6.1 Testing Locations

Sampling locations were selected to further the program objective of providing comprehensive data on general water quality conditions throughout the Bay, and were not tied to specific pollution sources. The following criteria were used in the selection of sites:

- representation of the Bay's sub-embayments, particularly those identified as having or potentially having excessive nutrient levels;
- representation of the geographic diversity of the Bay;
- representation of sites that have previously been tested by the local volunteer groups; and
- accessibility for regular volunteer testing.

Using these criteria, the following sites were selected (see Figure 2 for general locations). Appendix 1 contains more detailed station information (coordinates, depths, etc.) and maps.

Table 2 Pleasant Bay Sampling Locations

PBA-1. Chatham Harbor	PBA-9. Round Cove
PBA-2. Bassing Harbor	PBA-10. Quanset Pond
PBA-3. Inner Ryder's Cove	PBA-11. Paw Wah Pond
PBA-4. Crows Pond	PBA-12. Namequoit Point-South
PBA-5. Muddy Creek	PBA-13. Namequoit Point-North
PBA-6. Big Bay-Southwest	PBA-14. Arey's Pond
PBA-7. Big Bay-Mid	PBA-15. Kescayogansett Pond
PBA-8. Big Bay-Northeast	PBA-16. Meeting House Pond

In addition to the sixteen stations listed in Table 2, the Town of Chatham is monitoring two additional locations, Outer Ryder's Cove (CM-13) and Frost Fish Creek (CM-14), as part of the town's Coastal Nutrient Monitoring Program (see Addendum 1); and the Town of Orleans is planning an additional station near Pochet Creek for its wastewater management program. These locations are being monitored on the same schedule, and under the same protocols/QAPP, as the Alliance stations and will yield additional useful data for the program.

6.2 Sampling Schedule

Sampling for temperature, dissolved oxygen, depth (total & secchi), nutrients, and field observations will occur at each station once a month from May through October, inclusive.

Figure 2, Map of Sampling Station Locations

Although the Health Index only uses data from June through September, the May through October time period was selected to provide a broader view of current water quality conditions during the initial three-year baseline period. Once baseline data has been established throughout the Bay, it may be deemed appropriate to revise the sampling period to concentrate on the June to September period.

6.3 Sampling Parameters

Early on in program design the Alliance determined that the best way to monitor the general health of the Bay's water quality and the impacts of surrounding land uses would be to calculate the Health Index, which has been used by the Buzzards Bay Baywatcher's program since 1992. The Health Index is considered a good tool for assessing the impact of excessive nutrients and conveying information about those impacts to the public. Multiple year baseline data in the Health Index would lead to the identification of problem areas, as well as the design and evaluation of remediation efforts.

The Alliance, therefore, selected as parameters for monitoring those that are necessary for the calculation of the Health Index. In addition to the parameters necessary to calculate the Health Index, the Alliance also decided to monitor total depth, salinity and temperature. The following is a list of the parameters tested in the Pleasant Bay program, and the rationales for each parameter, many of which reflect the work of the Buzzards Bay Citizen Water Quality Monitoring Program[6].

6.3.1 Salinity

Salinity is a measurement of the amount of dissolved salts in a given volume of water and is expressed in parts per thousand (ppt). Pleasant Bay salinities range from approximately 35 ppt near the mouth (Chatham Harbor) to <10 ppt in the upper reaches of tidal creeks with significant freshwater inputs. Salinity varies throughout the tidal cycle and with changes (i.e. precipitation) in freshwater inputs through groundwater and surface discharges. Salinity may also play a role in determining oxygen levels through the process of density stratification, whereby more dense, higher salinity water is overriding by lighter, less dense freshwater. Stratification (water column is not mixed vertically) frequently results in bottom waters experiencing lower dissolved oxygen levels due to a lack of oxygen replenishment from the upper photic zone. The extent to which statification occurs in the relatively shallow waters of Pleasant Bay is unknown. Salinity will be determined via two methods. Surface salinity will be measured by refractometer for the purpose of calibrating the dissolved oxygen meters. Salinity will also be determined at the SMAST laboratory as part of the nutrient analysis.

6.3.2 Temperature

Temperature is one of the most important measurements due to its role in controlling, along with salinity, the amount of dissolved oxygen that Bay waters can hold. All other factors being equal warmer waters will generally have a lower potential dissolved oxygen level. Warmer waters also tend to result in increased biological activity that will further depress oxygen levels.

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6 Baywatchers II nutrient related water quality of Buzzards Bay embayments: a synthesis of Baywatchers monitoring 1992-1998, December 1999.

Measurement of surface and bottom temperatures will provide additional indications for the presence, and degree of, stratification that may be occurring. Temperature, measured in degrees Celsius (^{o}C), will be determined by thermistor integrated as part of the dissolved oxygen meter.

6.3.3 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a measure of the amount of oxygen molecules dissolved per given volume of water and is generally expressed as milligrams (oxygen) per liter (water), mg/L (= ppm). DO levels can also be reported as per cent saturation that takes into account temperature and salinity to report the measured DO as a % of what the water could theoretically hold at that temperature and salinity.

Sufficient levels of DO are required for the growth and survival of most aquatic organisms. Lower DO levels can result from the effects of temperature and salinity as discussed above. However, low DO levels more frequently reflect increased biological activity (respiration) and/or the affects of compounds using oxygen during decay (“oxygen demand”). Such demand can originate from the decay of natural organic matter or from the introduction of various pollutants, including nutrients. Replenishment of oxygen generally occurs via two mechanisms, exchange with the atmosphere and photosynthesis. As a result oxygen levels are generally lowest in the early morning and are further impaired on calm, cloudy days.

Most aquatic organisms will function well when DO levels are generally above 5 mg/L. Many organisms, especially those that are non-motile (i.e. shellfish) will begin to experience stress with DO levels between 3-5 mg/L. Levels between 3 and 0.5 mg/L (“hypoxia”) will result in species leaving the area or dying if non-motile. Levels below 0.5 mg/L (“anoxia”) will cause the death of any organism that requires oxygen. In addition to the level of DO, the extent of low DO conditions is also important. Many species can tolerate short periods of hypoxic conditions without ill effect, however, if these periods are prolonged or frequent then effects become more severe. Oxygen concentrations (mg/L and % saturation) will be measured with YSI Model 550 DO meters.

6.3.4 Transparency

Transparency is a measure of the clarity and light penetrating ability of the water and is affected by the amount of suspended material in the water. Suspended material may be biological (phytoplankton and zooplankton) or non-biological (silt/sediment) in origin. Low transparency waters will adversely impact submerged aquatic vegetation (i.e. eelgrass) by reducing the amount of light available for growth and photosynthesis. This can then trigger effects on other organisms by reducing DO levels. Transparency can be affected by natural mechanisms such as storm events that result in the re-suspension of bottom sediments in shallow embayments, runoff from terrestrial systems, etc. Transparency in aquatic systems is frequently affected by the growth of phytoplankton in response to available nutrients. Phytoplankton “blooms”, the result of over-stimulation of the system by excessive nutrient input, can reduce transparency to near zero with significant impacts on aquatic organisms and vegetation. Transparency will be determined by measuring the secchi depth. A black and white disc, known as a Secchi disk, is lowered into the water. The depth at which the disk disappears from view is the Secchi depth, measured in meters. The greater the amount of suspended material in the water the shallower the secchi depth will be. Secchi depth can range from <1 m in highly eutrophic embayments to >4 m in offshore coastal waters.

6.3.5 Nutrients

Biological productivity is driven by the availability of nutrients along with light and temperature. Nitrogen and phosphorus are the two most important plant and phytoplankton nutrients. In marine systems nitrogen is generally considered the limiting nutrient (i.e. is naturally in shortest supply) for growth, while phosphorus is generally limiting in freshwater systems. Although some level of both is essential for continued productivity excessive amounts result in adverse impacts. Excessive nutrient loading ("eutrophication") is being driven primarily by anthropogenic sources (wastewater, runoff, atmospheric deposition, etc.) and results in greater and more frequent growth of aquatic plants (phytoplankton and submerged vegetation). This increased growth reduces water transparency and dissolved oxygen, thereby changing the nature and composition of existing plant and animal communities. As Pleasant Bay and its sub-embayments are primarily marine systems the analysis of nutrients will concentrate on nitrogen species.

Nutrients enter and cycle within an embayment in a variety of forms, some more biologically available than others. For this reason it will be important to measure a number of the forms of nitrogen to obtain an accurate picture of the availability of nitrogen within the systems. Surface and bottom water samples will be collected and analyzed by SMAST for the following:

Dissolved Inorganic Nitrogen (DIN)

The three principal forms of inorganic nitrogen are ammonium, nitrite and nitrate. These are the forms via which most of the nitrogen enters the Bay from wastewater, runoff and atmospheric deposition. These biologically available forms are usually in low levels in most systems as they are rapidly taken up by algae. High measured levels are usually an indication that the system is severely overloaded (eutrophic).

Dissolved Organic Nitrogen (DON)

Organic nitrogen results form the incorporation of inorganic nitrogen into living tissue. DON is a mixture of more complex organic nitrogen compounds (e.g., amino acids, urea) released by living organisms and decaying organic matter. This analysis may also include ultra small algae and bacteria. DON levels are generally higher in eutrophic waters reflecting the higher amounts of living material.

Samples for analysis of dissolved nutrients will be field filtered by volunteers and the filtrate transported to the SMAST laboratory for analysis. Concentrations of inorganic and organic nitrogen will be reported as milligrams of nitrogen per liter (mg N/L).

Particulate Organic Nitrogen (PON)

PON is inorganic nitrogen that has been incorporated into tissue, both living and dead, primarily phytoplankton, zooplankton, algae and larger aquatic organisms. DIN is usually efficiently converted into PON in coastal waters. Eutrophic waters will generally have higher levels of PON than less nutrient enriched waters.

Particulate Organic Carbon (POC)

POC is another measure of the quantity of tissue, living and dead, present in the water column. POC will be reported as milligrams of carbon per liter (mg C/L).

Samples for measurement of particulate constituents will be collected by volunteers and transported to the SMAST laboratory for analysis. A known volume of water will be filtered through a glass fiber filter to collect particles, extracted and assayed.

Orthophosphate (PO_4)
Although phosphate is not generally considered a limiting nutrient in marine systems determining its levels can provide an indication of the influence of freshwater inputs to the systems. Orthophosphate will be determined on the same filtrate fraction as the DIN components and will be reported as mg P/L.

6.3.6 Plant Pigments (Chlorophyll a & Pheophytin)

Measuring plant pigments (chlorophyll a and its breakdown product pheophytin) provides an estimate of the algal biomass, primarily phytoplankton, present in the water sample. Chlorophyll a is the primary photosynthetic pigment found in most phytoplankton and algae. Algal populations will vary throughout the year depending temperature, light levels and nutrient availability. Measuring pigment levels provides an indication of the response of algal populations to the availability of nutrients and provides correlations to water transparency, and oxygen levels. Plant pigments will be measured on samples collected by volunteers at the SMAST laboratory. A known volume of water will be filtered through a 0.45 um membrane filter to collect plant particles, extracted and assayed. Chlorophyll-a and pheophytin concentrations will be reported as micrograms of pigment per liter (ug/L).

6.4 Calculation of the Health Index and Basis of Comparison

Water quality data collected in Pleasant Bay will be used to calculate the Health Index for each station. The comparison of sub-embayment indices each year, and from year to year, will provide a comprehensive and comparable view of the Bay's water quality over time.

The index incorporates measures of oxygen saturation, water transparency (measured by Secchi depth), phytoplankton pigments, dissolved inorganic nitrogen, and total organic nitrogen. The mean of each indicator as measured between June and September will be used to calculate the Health Index. In the case of oxygen saturation, the calculation uses the mean of the lowest twenty percent of the observations. Points are assigned to each of the five parameters contributing to the index (see Table 3). If a mean data value is between the 0 and 100 point values the score is calculated using the following equation:

$$\text{Score}=(\text{In(value)-In(0 point value)/In(100 point value)-In(0 point value))}$$

The Health Index equals the mean of the five parameters, such that all parameters are equally weighted. The end points in the Health Index were chosen based on knowledge of conditions typically found in Buzzards Bay embayments. An assessment of the possible differences in Pleasant Bay waters will be completed following the collection of water quality data for three sampling seasons. Health Index calculations will be compared to the groupings in Table 4.

Table 3 Point Values for Health Index Parameters

Parameter	**0 Point Value**	**100 Point Value**
Oxygen Saturation (lowest 20% of observations)	40% or lower	90% or higher
Transparency (Secchi depth)	0.6m or less	3.0 m or greater
Phytoplankton pigments (Chl-a and pheo a)	10 ppb or more	3ppb or less
Dissolved Inorganic Nitrogen (DIN)	10 micromoles or more (=0.14ppm)	1 micromoles or less (=0.014ppm)
Total Organic Nitrogen (dissolved & particulate)	0.60 ppm or more	0.28 ppm or less

Source: Buzzards Bay Citizen Water Quality Monitoring Program

Sampling data will be collected for a minimum of three consecutive monitoring seasons to provide a baseline for water quality conditions. Annually, parameters will be reviewed against prior year(s) data. Time series data will indicate water quality trends for each testing location, and will allow for comparisons between testing locations throughout the Bay.

Table 4 Water Quality Condition Based on Health Index

Water Quality Condition	Health Index
Good to Excellent	65-100
Fair	35-65
Eutrophic	<35

Source: Buzzards Bay Citizen Water Quality Monitoring Program

Data will be compared to Massachusetts Surface Water Quality Standards for those parameters that are available. In addition, sampling data will be compared with U.S. Environmental Protection Agency (EPA) water quality standards, as they are developed. Sampling data will also be compared with sampling data from other estuaries on Cape Cod and elsewhere where such comparisons could provide insights into water quality trends or the potential effectiveness of management strategies. The Alliance is in frequent contact with the Cape & Islands Watershed Team and the Waquoit Bay National Estuarine Research Reserve. Through these contacts the Alliance will keep abreast of regional water quality monitoring programs, and may cooperate in efforts to standardize protocols for purposes of comparative analysis.

7.0 Data Quality Objectives for Data Parameters

7.1 Precision is the degree of agreement among repeated measurements of the same parameter, and is an indicator of the consistency of sampling methods. To achieve this objective, the Alliance provides thorough volunteer training and uses efficient sampling methods and monitoring equipment. For example, dissolved oxygen meters are used for the collection of DO and temperature data. DO meters are calibrated prior to each use, and volunteers are provided with detailed instructions for the use and maintenance of meters.

7.2 Accuracy is a measure of confidence that describes how close a value is to its "true" value. Taking replicate samples will enhance accuracy. Randomly selected replicate samples will constitute at least ten percent of all samples taken during each sampling season.

7.3 Measurement Range is the range of reliable readings of an instrument or measuring device. Ensuring the proper maintenance of sampling equipment, particularly the calibration of dissolved oxygen meters, as well as proper training in the use of equipment will meet this objective for volunteers.

Specific objectives for precision, accuracy, and measurement range are indicated on the following table.

Table 5 Data Quality Objectives

Parameter	Method	Units	Range	Sensitivity	Accuracy
Temperature	YSI 550 Meter	°C	-5° to 45° C	0.1°C	±0.2°C
Salinity	Refractometer	ppt	0-100 ppt	1ppt	1 division
Dissolved Oxygen	YSI 550	Mg/L and/or % saturation	0-20 mg/L 0-200% air saturation	0.01mg/L 0.1% air saturation	± 0.3 mg/L ± 2% air saturation
Water Clarity	Secchi Disk	Meters	Varies	0.1m	± 0.1 m
Nutrients/ Pigments	See Analytical Methods, section 13.0				

Source: Adapted from *QAPP for the Buzzards Bay Citizen Water Quality Monitoring Program*, April 24, 1996, Table 3.

7.4 Representativeness is the extent to which measurements actually represent true environmental conditions. The sampling design includes the taking of surface and bottom samples at all locations and under random meteorological conditions.

7.5 Comparability is the degree to which sampling can be compared with similar studies. The Alliance will abide by sampling and analytical methods accepted and employed by federal and state agencies, as well as other established water quality monitoring programs in the region, such as the Buzzards Bay Baywatcher's program. This will enhance comparability of data with information from other programs in the region. Data will be reported in standardized, accepted units.

7.6 Completeness is the comparison between the amounts of data that is planned to be collected versus the amount of useable data collected. At present there are no legal or compliance uses anticipated for the data being collected. In addition, there is no fraction of the planned data that must be collected in order to fulfill a statistical criterion. It is anticipated that better than 90% of the planned data collection will be accomplished given the level of volunteer participation.

8.0 Volunteer Recruitment and Training

8.1 Recruitment

The baywide program builds on the base of volunteers already actively involved in the Orleans and Chatham citizen water quality monitoring programs. During the 2000 monitoring season more than 100 volunteers were involved in sample collection, transportation and data management functions. A recruitment team recruits volunteers through outreach activities. Annual retention of volunteers is expected to be high. However recruitment activities will be undertaken each year to ensure a full roster of volunteers for the program. These include:

- Outreach to Support Group Network. There are several established volunteer organizations oriented to water quality issues. Presentations are made to these groups to explain program goals and request interested volunteers.

- Direct Mail. The Alliance mails recruitment letters to its standing mailing list.

- Alliance Web Site and Newsletters. The Alliance maintains a web site (www.pleasantbay.org) with program information and an email link for interested volunteers. The Alliance also issues newsletters from time to time that report on water quality issues and results and request volunteers as needed.

- Media Coverage. Media coverage of the water quality monitoring program, and program results, provide opportunities to recruit volunteers, indirectly by developing public interest in the program, and directly via requests for volunteers. Past experience indicates that press coverage of this topic is dependable and an effective way to reach volunteers.

- Volunteer Communication. The Alliance sends periodic announcements, updates, and appreciation letters to volunteers to keep them up to date and engaged in the program. Volunteers have regular access to one of three volunteer coordinators to address questions about sampling methods and equipment issues. Scheduling matters can be addressed to the station captain for each station.

8.2 Training Program

New recruits and returning volunteers are trained each spring prior to the first monitoring date. All volunteers are requested to attend one indoor session and one in-the-field session.

The training curriculum includes an overview of the baywide programs goals and objectives, the uses of water quality data, program management and communications and the importance of timely and accurate data. The curriculum covers in detail each activity required in the field sampling protocol, the use of instruments and field kits, filtration techniques, sample handling, and routine care and maintenance of equipment. During initial and renewal training volunteers perform simultaneous determinations of temperature, salinity and dissolved oxygen. Volunteer handbooks are distributed to all volunteers. Trainers provide background information on the purpose and importance of each type of measurement, and review helpful hints, as well as common pitfalls to avoid.

Dr. Robert Duncanson, Director of the Chatham WQL and Dr. Robert Wineman, coordinate volunteer training. Training assistance is provided by volunteer coordinators and other experienced volunteers.

8.3 Certification

The Alliance maintains a record of each type of training that a volunteer has completed. Beginning with the 2001 monitoring season the Alliance will maintain a checklist for training received for each volunteer. Examples of training segments included on the checklist include use of a dissolved oxygen meter, refractometer, Niskin sampler, and Secchi disk. The checklist will record the date of latest training for each training segment.

8.4 Performance Evaluation

Volunteer performance is evaluated by trainers during indoor and field training sessions (simultaneous dip-ins of secchi disk, Niskin Sampler, practice use of refractometer, and dissolved oxygen/temperature measurement). Field volunteer co-ordinators keep in regular contact with volunteers to identify problems with equipment or technique. Field site visits by a trainer or field coordinator occur randomly throughout the sampling season. Dr. Robert Duncanson (QC Manager) or his assistant review field data sheets after being deposited at the Chatham Laboratory and contact volunteers to review any data aberrations or omissions

9.0 Documentation and Records

9.1 Field Data Sheets

Field data sheets (Appendix 2) are completed on-site at the time sampling occurs. Volunteers record site information (date, time, station, collectors, etc.), weather/field observations, and field measurements (secchi/total depth, surface salinity, DO meter calibration value, dissolved oxygen and temperature). The completed field data sheets are returned, along with the nutrient/pigment/particulate samples, to the pre-designated sample drop-off location. Field sheets are photocopied and the copies are sent along with samples to the SMAST laboratory. The original field sheets are archived at the Chatham WQL for a minimum of three years.

9.2 Chain of Custody Forms

The field data sheets incorporate a Chain-of-Custody (COC) record documenting transfer of the samples from the volunteer collectors to the designated drop-off location and subsequent transfer to the Town of Chatham WQL. At the Chatham WQL a composite Chain of Custody form (Appendix 3) is completed for sample transfer to SMAST. The original COC forms are sent along with the samples, signed upon receipt at SMAST and returned to the Chatham WQL. The original COC forms are archived at the Chatham Water Quality Laboratory for a minimum of three years.

9.3 Laboratory Analysis Records

Records of all laboratory analysis conducted at the SMAST laboratory are archived at SMAST for a minimum of three years. The Alliance maintains hard copies of all data result spreadsheets received from SMAST in both hard copy and on computer back-up disks.

10.0 Sampling Process Design

10.1 Sampling Schedule

Monitoring stations are sampled monthly, from May through October, for field observations (weather, temperature, surface salinity, dissolved oxygen, and total/secchi depth) and surface and bottoms samples are collected for nutrient and pigment analysis.

10.2 Station Location

Both bottom and surface samples are taken over the deepest point at each sampling station (see Appendix 1), with 2 exceptions. At stations PBA-2 and PBA-5 the shallow nature of the site precludes surface/bottom sampling, at these locations a single mid-depth sample is obtained. The deepest point is determined by local knowledge and available bathymetric information, and verified by electronic depth finder. Orange buoys, painted with the station ID, are used to mark sampling locations to ensure that samples are always taken from the same location. Movement of buoys is a rare occurrence because most sampling locations are in protected waters. Also volunteers are familiar with the local waterways and are asked to establish landmarks to confirm locations. DGPS coordinates are recorded for all stations when the buoys are placed and again when they are removed at the end of the sampling season.

10.3 Timing of Sampling

Samples are taken during the morning (6AM to 9AM) on the outgoing (ebb) tide. Sampling dates are selected so that sampling occurs at approximately mid-tide. The early morning time period was selected to try and obtain "worst-case" data on dissolved oxygen (DO). Having all samples taken at each station within a three-hour time frame enhances comparability of baywide data and comparability to other monitoring programs.

10.4 Samples

Field measurements for temperature, dissolved oxygen, and samples for nutrients and pigments will be taken from each station at 2 depths, except as noted in section 10.2:

- one sample at 0.5 meters below the surface (the "surface" sample).
- one sample from 0.5 meters above the bottom (the "bottom" sample)

Field measured salinity will only be determined at the surface as it is only being used to calibrate the dissolved oxygen meter.

11.0 Sampling Methods Requirement

The field sampling protocol (Appendix 4) and Volunteer Monitoring Handbook (Appendix 5) contain detailed information on all sampling protocols and equipment. Table 6 below summarizes this information.

Table 6 Sampling Methods

Parameter	Sampling Equipment	Sample Container	Sample Volume	Max. Holding Time	Field Processing	Preservation
Temperature	YSI 550 Meter	None, in-situ measurement	NA	NA	NA	NA
Dissolved Oxygen	YSI 550 Meter	None, in-situ measurement	NA	NA	NA	
Surface Salinity	Refractometer	None, in-situ measurement	NA	NA	NA	NA
Secchi/Total Depth	Secchi Disk/ Tape	None, in-situ measurement	NA	NA	NA	NA
Nitrate & Nitrite	Niskin Sampler	High Density Polyethylene (HDPE), acid-washed	60 ml	48 hrs	0.2um membrane filtration	store on ice, in dark, transport to SMAST
Dissolved Ammonium	Niskin Sampler	HDPE, acid washed	60 ml	12-24 hrs	0.2um membrane filtration	store on ice, in dark, transport to SMAST
DON	Niskin Sampler	HDPE, acid washed	60 ml	12-24 hrs	0.2um membrane filtration	store on ice, in dark, transport to SMAST
Orthophosphate	Niskin Sampler	HDPE, acid washed	60 ml	12-24 hrs	0.2um membrane filtration	store on ice, in dark, transport to SMAST
POC/PON	Niskin Sampler	HDPE, acid washed	1000 ml	24 hrs	none	store on ice, in dark, transport to SMAST
Chlorophyll-a & Pheophytin-a	Niskin Sampler	HDPE, acid washed, brown	1000 ml	24 hrs	none	store on ice, in dark, transport to SMAST

12.0 Sample Handling and Custody Requirements

Samples are labeled in the field using permanent marker. Sample labels include station location, station number, date of sample collection, and sample type (i.e., surface, bottom).

The chain of custody for samples is as follows: in the field the integrity of samples is the responsibility of the designated sampler. Following collection samples are transported to either the Orleans Water Department or the Chatham WQL where the date and time of arrival, and receiving person is recorded on the field sheet. Samples taken to Orleans are subsequently taken by a designated transportation volunteer to the Chatham WQL. The Chatham WQL is a coordination point for the collection of all samples prior to being transported to SMAST, however no analysis occurs at the Chatham Laboratory. Field data sheets contain provisions to record when custody passes from the field sampler to the intermediate Orleans location and to the Chatham WQL. Samples received at the Chatham WQL are held under refrigeration until all samples are received and transported to SMAST.

A composite chain of custody form (Appendix 3) is then completed for all samples being sent to SMAST for analysis. Samples are then transported to SMAST for analysis in coolers with appropriate ice packs to maintain temperatures. All samples are delivered to SMAST within ten hours of collection. At SMAST the sample count is verified against the COC form and date and time of arrival, and receiving individual recorded on the COC. See section 13.0 for information on SMAST COC procedures.

13.0 Analytic Methods Requirements

13.1 Field Procedures

Table 7 Field Methods

Parameter	Matrix	Units	Method	Reference	Field Measurement
Temperature	Water	°C	Thermistor	SM 2550 B.2 [1]	Record to nearest 0.1 °C
Dissolved Oxygen	Water	mg/L or	Steady-State	SM 4500-O G.	Record to nearest 0.1 mg/L
		% sat.	Polarographic		or 0.1%
Surface Salinity	Water	ppt	Refractometer	EPA 842-B-93-004 [2]	Record to nearest 1 ppt
				pgs. 27-29	
Secchi Depth	Water	m	Secchi Disk	EPA 842-B-93-004	Record to nearest 0.1 m
				pgs. 32-35	

[1] Standard Methods for the Examination of Water & Wastewater, 20th Ed., 1998.

[2] EPA Volunteer Estuary Monitoring: A Methods Manual, December 1993.

13.2 LABORATORY PROCEDURES AND QA/QC *(the information below was provided by the Coastal Systems Laboratory at SMAST)*

Analyses are performed for most parameters by the Coastal Systems Laboratory at the School of Marine Science and Technology (SMAST) at the University of Massachusetts in New Bedford, MA. The laboratory follows Standard Operating Procedures (SOPs) strictly as described in more detail below.

13.2.1 Overview

The methods employed in the nutrient assays are the standard methods of research level environmental laboratories. The SMAST Coastal Systems focuses on analysis of nutrients and other biogeochemical parameters in ecosystems and natural waters (freshwater, estuarine and marine). The SMAST Lab has provided analytical support (and filed detailed QAPP's) for work with the Buzzards Bay Project's Buzzards Bay Monitoring Program (since 1992), the MWRA HOM Program (1995-1998, including lab intercalibrations), USGS's Namskaket Marsh Project (included laboratory intercalibration with the USGS Central Lab), National Science Foundation and NOAA funded research programs, and many monitoring and research programs involving ecosystem functioning and assessment. The methods used by the laboratory have been through many EPA and other agency reviews as part of QAPP procedures over the past almost 2 decades (3 years at SMAST, 15 years WHOI). Dr. Brian Howes, the manager of the Coastal Systems Program at SMAST has more than 25 experience in biogeochemical sampling of natural waters. He has served as the QA Officer on numerous research programs both within the U.S. and internationally. The laboratory has produced the nutrient analysis for more than 100 publications and technical reports, several on analytical techniques, methods and sampling approaches.

The SMAST laboratory will use accepted approaches for the present effort. Samples will be logged-in upon delivery to the SMAST Coastal Systems Laboratory based upon field logs and Chain of Custody forms prior to signature by the authorized laboratory staff member. During log-in, sample integrity and clarity of label are checked and any unusual sample characteristics (identified by visual inspection or information from sample courier) are noted on the COC and in the appropriate laboratory notebook. All frozen and/or archived samples are stored in a locked freezer (-20^{o}C) accessible only to authorized laboratory personnel. The laboratory analysts are responsible for the samples from arrival to analysis and data entry.

13.2.2 Data Quality Requirements and Assessments

Monitoring parameters, sample volumes, containers, sample processing and storage for this project are listed in Table 6. Analytical methods and associated references are listed in Table 8. Complete standard curves are generated for each analytical run. If more than a 10 fold range of concentrations is encountered in the samples, then both a high and low standard curve is created. In all cases the standards are prepared new each day and are chosen to give at least 5 points over the sample concentration range. Standards well above the sample range are not used. Nitrate+Nitrite (run in duplicate) and Particulate C & N by autoanalysis have additional standards run before and after every five (5) samples. Failure of these additional standards (run as samples) to agree within 10% of their known value halts the assay line for complete recalibration and the re-running of the last sample set. Calibration checks of the fluorometer by purchased analytical standards are routinely conducted to insure accuracy of the Chlorophyll-a and phaeopigment results.

For nitrate+nitrite, dissolved ammonium, total dissolved nitrogen, ortho-phosphate, and total phosphorus, non-automated assays are all run in duplicate (at a frequency of at least 10% of the samples) with a <5% tolerance between duplicates required for acceptance. After completion of analyses, remaining sample is frozen, for possible reanalysis if required. For the particulate analyses (PON, POC), only field duplicates and laboratory standard duplicates are run as the analysis consumes the entire sample.

Reagent blanks and standards are prepared and analyzed with each new batch of reagent. These blanks are compared to previous data on blanks to evaluate the potential of contamination and the standard curve compared to previous records. If this initial blank and standard curve is deemed satisfactory, samples are then analyzed. Calibration blanks are prepared and analyzed simultaneously with the creation of each standard curve that is created for each sample series.

Spiked samples are periodically analyzed as analytical checks in dissolved ammonium, nitrate+nitrite and ortho-phosphate assays. Spiked samples are not widely run, as the standards are made up in the same matrix as the samples. Greater numbers of spiked samples are sometimes run as "unknowns" similar to field duplicates. Recovery of spikes must be within 20% of expected. Nutrient samples are analyzed against reference standards having nutrient concentrations bracketing those of the samples. Standards are analyzed daily, and checked for linearity (r^2>0.98) and acceptability of blanks. Spikes for PON/POC samples are not available. Therefore, POC/PON at known concentrations is added directly to filters, which is done during machine calibration as an internal check after every fifth field sample run.

As available (e.g., POC/PON not available, TOC is not appropriate for POC evaluation), Performance and Evaluation Samples for the nutrient assays are purchased and run. These data are used to evaluate the accuracy of the CMAST laboratory.

13.2.3 Sample Holding Times

Assays will be within the recommended holding times specified in Table 6. All chemical assays for dissolved constituents are filtered upon collection in the field. Initial sample processing is generally undertaken immediately upon receipt by the laboratory. Particulates and chlorophyll a samples are filtered in the laboratory after vigorous shaking of the sample bottles. Analytical detection limits, accuracy and precision for laboratory analyses are listed in Table 9.

13.2.4 Inspection and Maintenance of Analytical Instrumentation

Analytical equipment (Bausch and Lomb, Genesis Spectrophotometers, Lachat Autoanalyzer, Perkin-Elmer Elemental Analyzer, Turner Fluorometer, conductivity meters, etc.)

are calibrated through the processing of standards in the normal analytical procedure. Meters and electrodes are multi-point calibrated with certified standards. Laboratory analytical balances are under annual manufacturer service and calibration. CMAST also maintains and routinely uses certified calibration weights and thermometers. The freezer has a chart record of temperature and a temperature alarm to ensure the maintenance of frozen samples below -201C.

13.2.5 Documentation, Data Reduction and Reporting

Raw data is maintained in duplicate notebooks. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards. The results will be reported in terms of concentration, as means and standard errors. All data are subject to 100% check at all stages by everyone. All data reported are reviewed to check for errors in transcription, calculation, or computer input. If data points are judged to be aberrant, the reserved sample will be reanalyzed. Data are also reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, are used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

13.2.6 Data Review and Validation

Laboratory data will be reviewed relative to the sample spikes, reagent and calibration blanks and standard curves. Results will be checked against the expectations of precision and accuracy as detailed in the analytical sections above. Data entry will be independently compared to the raw data sheets by a second analyst.

Samples which do not meet the validation (either recalculation or based on performance criteria) will require a re-check of all data from that sampling event. Assays, which fail to show recoveries within 20% for spiked samples or blind duplicates may necessitate a complete, re-run using archived samples.

Table 8 Laboratory Analyses [h]

Parameter	Matrix	Units	Method	Reference
Nitrate + Nitrite	water	ug/L	Autoanalyzer	a
Dissolved Ammonium ($NH_3 + NH_4^+$)	water	ug/L	Indophenol	b
Total Dissolved Nitrogen	water	ug/L	Persulfate Digest	c
Particulate Carbon/Nitrogen	water	ug/L	Elemental analysis	d
Ortho-Phosphate	water	ug/L	Molybdenum Blue	e
Total Phosphorus	water	ug/L	Persulfate Digest Molybdenum Blue	f
Chlorophyll-a and Pheopigments	water	ug/l	90% Acetone Extraction	g

a Lachat Autoanalysis procedures based upon the following techniques
- Wood, E., F. Armstrong and F. Richards. 1967. Determination of nitrate in sea water by cadmium copper reduction to nitrite. J. Mar. Biol. Ass. U.K. 47:23-31.
- Bendschneider, K. and R. Robinson. 1952. A new spectrophotometric method for the determination of nitrite in sea water. J. Mar. Res. 11: 87-96.

b Scheiner, D. 1976. Determination of ammonia and Kjeldahl nitrogen by indophenol method. Water Resources 10: 31-36.

c D'Elia, C.F., P.A. Stuedler and N. Corwin. 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. Limnol. Oceanogr. 22: 760-764.

d Perkin-Elmer Model 2400 CHN Elemental Analyzer Technical Manual.

e Murphy, J. and J. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27: 31-36.

f Persulfate Digestion Method for Total Phosphorus; Standard Methods 4500-P B.5 (18th ed.)

g Parsons, T.R., Y. Maita and C. Lalli. 1989. Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press, 173 pp.

h The techniques used by the SMAST laboratory are methods generally used by state-of-the-art research laboratories. All of the methods and QA/QC are routinely performed by the SMAST laboratory have been accepted by EPA, USGS, MCZM, DEP, NSF and NOAA as part of previous studies conducted by the SMAST lab under their review.

Table 9 Detection Limits and Accuracy for Laboratory Measurements

Variable (Lab)	Matrix	Units	Lower Detection Limits	Accuracy and Precision* *(Better than)*
Nitrate +Nitrite	water	ug/l	0.1	5%
Dissolved Ammonia	water	ug/l	0.1	5%
Total Diss. Nitrogen	water	ug/l	0.3	5%
Partic. Org. Carbon/Nitrogen	water	ug/l	0.6	5%
Ortho-Phosphate	water	ug/l	0.3	5%
Total Phosphorus	water	ug/l	0.6	5%
Chlorophyll-a and Pheopigments	water	ug/l	0.1	5%

* Accuracy based on results of laboratory control standards and spiked samples; however, no spikes are available for POC/PON analysis; precision based on relative %difference of duplicate samples.

14.0 Quality Control Requirements

Replicate samples are needed to evaluate the statistical variability of data. Replicate samples are separate samples (as opposed to split samples) taken at testing locations. Replicates allow for the assessment of the spatial variability of the parameter being measured. This provides for an evaluation of how well measurements represent environmental conditions. Each month, one station is randomly selected for surface and bottom replicate samples for nutrient and pigment parameters. Initial results from replicate sampling are reviewed to assess whether replicate sampling should be increased.

15.0 Instrument/Equipment Testing, Inspection and Maintenance Requirements

At the beginning of each sampling season, all field monitoring equipment is compiled into field kits. Field kits are compiled using a checklist (Appendix 6) to ensure that each kit has the proper components. At the beginning of each season each Dissolved oxygen meter is inspected, has the batteries replaced, and has the electrolyte and membrane replaced. Each instrument is then calibrated to ensure proper working order. Niskin samplers are inspected for working order and the depth markings on the rope checked. Salinity refractometers are inspected and calibrated. Secchi disks and tape measures are inspected and checked for proper operation. All expendable supplies (deionized water, disposable droppers, Kinwipes, membrane filters, etc.) in the field kits are replaced as needed. Replacement equipment and expendable supplies are available through the Chatham WQL as needed. A maintenance log is maintained at the Chatham WQL for all equipment. Following completion of the sampling season all field kits are returned to the Chatham WQL were the contents are inventoried, repairs made as necessary, and stored till the next sampling season.

Volunteers are trained on routine maintenance (e.g., cleaning and storage between use) of equipment. Volunteers are instructed to return equipment to the Chatham Water Quality Lab for inspection/repair if they perceive any abnormalities in functioning.

16.0 Instrument Calibration and Frequency

Dissolved oxygen meters will be calibrated each year following the installation of new batteries, electrolyte and membrane, and prior to each use, according to the manufacturers instructions (specific procedures are found in the Field Protocol (Appendix 4) and Volunteer Monitoring Handbook (Appendix 5). The temperature thermistor for each instrument is set at the factory. Therefore, local temperature calibration will consist of comparing the DO meter temperature reading to that of a factory-certified, NIST traceable thermometer following equilibration prior to each sampling season. Acceptable limits will be $\pm$ 0.3 ^{o}C, based on the manufacturers specifications.

As noted above, DO calibration will occur following maintenance and prior to each sampling event. DO calibration will be the conducted using the water-saturated air (% saturation) method. During calibrations prior to each sampling season the meters will be calibrated against each other as well as a HydroLab Datasonde 3 unit. Volunteers are trained to take a corrected salinity measurement for use in the calibration procedure. Acceptable limits for DO % saturation calibration is 95 to 105%. If the meter calibrates outside of this range the volunteers are instructed to repeat the calibration procedure, including the salinity determination if necessary. The field data sheet contains a space for recording the calibration value for later review if needed.

Salinity refractometers are calibrated prior to each sampling season using deionized water and a seawater sample of known salinity. The salinity of the seawater sample is determined by independent measurement. In addition, each refractometer will be checked for a zero reading, using deionized water, by the volunteers prior to each sampling and the result recorded on the field data sheet. This allows the volunteers to determine a “corrected” salinity if the refractometer is not zeroed and will flag the unit for inspection/repair when the data sheets are returned.

Secchi disks are deployed using fiberglas tape measures with metric units. Therefore, these do not require calibration beyond ensuring that the disks and tapes are in proper working order. Water samples are collected using Niskin Water Samplers (1.7L volume, General Oceanics, Inc.) with polypropolyne lines. The lines are marked at 0.5 m intervals up to 7m, with different color markings for the whole and half meters. Calibration of the Niskin samplers consists of a pre-deployment check of the line markings against a metric measuring tape.

The QC manager maintains yearly pre-deployment calibration results for field equipment in log book. Results will be traceable via instrument serial number and/or station ID.

A discussion of laboratory analytical instrumentation calibration and frequency is contained in section 13.

17.0 Inspection/Acceptance Requirements for Supplies

A program supplies checklist is developed at the Chatham WQL prior to each monitoring season, and is checked with field volunteer coordinators. The program checklist provides the basis for purchasing expendable supplies and equipment for the sampling season. All supplies are purchased through the Chatham WQL from customary scientific supply sources. All items received are inspected and checked against the original purchase order by the laboratory director. Faulty or incomplete orders are brought to the immediate attention of the suppliers for correction.

Pre-cleaned (10% HCL leached) sample collection bottles (60 and 1000ml) are obtained directly from the Coastal Systems Laboratory at SMAST prior to the beginning of each sampling season and stock replenished at each sampling event.

18.0 Data Acquisition Requirements

The Alliance may rely on data provided from the Cape Cod Commission, Division of Marine Fisheries, Department of Environmental Protection, U.S Environmental Protection Agency, or other reliable source for use in the program. These data sources may be used for comparison purposes, or to provide data not addressed through the program.

19.0 Data Management

19.1 Data Coding

Field data sheets are completed by the sampling team prior to leaving the station. Completed sheets are reviewed for errors/omissions upon receipt at the Chatham WQL by the QC Manager. Station volunteers will be contacted to discuss and resolve any data sheet errors/omissions. The QC Manager will also review all sample bottles to ensure that they are labeled with appropriate field information.

- Field Data: Hand-recorded field data is entered into a computer at the Chatham WQL by a trained volunteer or laboratory assistant. An Excel spreadsheet is used for standard presentation of data. Field data entry is completed as soon after the monitoring data as possible.

- Laboratory Data: Results of sample analysis is computer coded by SMAST and is sent to the Alliance to be incorporated with the field data on the Excel spreadsheet (additional discussion is presented in section 13).

19.2 Review and Analysis

The Water Quality Work Group will have responsibility for analyzing, or alternatively managing the analysis of, data. Available data will be reviewed after each month's sampling, and upon receipt of laboratory data. Data will also be reviewed annually. Data will be compared to acceptable accuracy ranges. If unusual or inconsistent data is noted during the review, Work Group members will discuss possible interpretations or procedure corrections. Data computer files, field data sheets, and laboratory reports will be stored at the Chatham WQL. Interim data, including field data sheets, laboratory reports, and computer files, will be available to the public in their existing form for the cost of duplication.

Upon the completion of data verification procedures, calculations will be completed for the determination of the Health Index for each sampling location. Statistical methods will be used to determine significant trends and to compare available nitrogen loading analyses.

20.0 Assessment and Response Actions

At the end of each monitoring season the work group will review field equipment and operations procedures, laboratory procedures, volunteer recruitment and training, and transportation and custody procedures to identify problem areas and developed alternative responses. Significant changes in procedures will be codified and added to the QAPP, and sent to the distribution list. Volunteers attend yearly training renewal sessions and receive sampling technique notes/updates by mail as needed. If errors in sampling techniques are consistently identified, retraining may be scheduled more frequently. If volunteers identify procedures with which they do not feel confident following scheduled training sessions additional one-on-one training will be provided.

21.0 Reports and Data Applications

An annual summary report on water quality conditions in the Bay will be produced and distributed following the receipt of all laboratory data. This document will be available during the winter/early spring following each sampling season. The Alliance water Quality Workgroup will be responsible for production and distribution. The report will be prepared for distribution to project volunteers, members of the general public, local and county policy makers, state and Federal agencies, and the media. Copies will be sent to all individuals on the distribution list. These reports will consist of data results, interpretation of data (if possible), information on project status, volunteer highlights, results of QC audits and internal assessments.

The report and data analysis will be used in the following applications:

- identification of water quality trends (via calculation of the Health Index for each sub-embayment);
- identification and prioritization of critical areas;
- design and monitoring of remediation actions for critical areas;
- integration with related local, regional or state permitting and regulatory decisions; and
- integration with implementation of the Pleasant Bay resource management plan.

Access to information about the Bay's water quality will be facilitated through the following ways:

- water quality information will be presented to local boards and commissions;
- highlights concerning water quality will be published in regular Alliance's newsletters and on the Alliance's web site; and
- distribution of the annual water quality report.

22.0 Data Review, Validation and Verification Requirements

All data reported for the program will be subject to checks by the QC manager for errors in transcription, calculation, or computer input. All field data forms will be reviewed to ensure they are complete and signed by the volunteers. Any changes made to the field data sheets must be initialed. Field sheet data will be entered by a trained volunteer or laboratory assistant at the Chatham WQL and reviewed by the QC Manager. All data entries are doubled checked by someone other than the person who entered the data. If unusual or inconsistent data is noted or an entry is missing it will be flagged and the sampling volunteer called to discuss. Laboratory data generated at SMAST will be reviewed and verified as discussed in section 13. Laboratory data will be further reviewed by the QC Manager upon receipt from SMAST. Decisions to reject or qualify data will be made by the QC Manager and Water Quality Workgroup with input from SMAST staff.

23.0 Validation and Verification Methods

Once field data for a given sampling event has been entered into the Excel spreadsheet it will be printed out and proofread against the original data sheets. Errors in data entry will be corrected. Outliers and inconsistencies will be flagged for further review, or discarded. SMAST will conduct data validation/verification as discussed in section 13. Problems with data quality will be discussed in the yearly reports provided to data users.

24.0 Reconciliation with Data Quality Objectives

As soon as possible after each sampling date, review will be made of data against data quality objectives. If data do not meet specified standards, data may be discarded, or re-sampling may occur. Efforts will be made to identify why data do not meet standards. Problems with equipment failure calibration and/or maintenance techniques will be reassessed and improved. If the problem is found to be related to the sampling team or protocols retraining will be provided and protocols revised if needed. Any limitations on data use will be detailed in reports issued.

If failure to meet project specifications is found to be unrelated to equipment, methods, or sample error, specifications may be revised prior to the next sampling season. The project QAPP would be revised to reflect any proposed changes and submitted to appropriate agencies for approval.

Pleasant Bay Alliance Citizens Water Quality Monitoring Program

FIELD KIT CONTENTS

Kit #:____________

Packed ... Received

______ 1. Tool Box (1) containing: ______

______ 2. Secchi Disk with tape measure (1), holder (1), clothes pins (3). ______

______ 3. Syringe (2). ______

______ 4. Filter Holder (2). ______

______ 5. 47 mm Filters (1 pack of 25). ______

______ 6. Filter Forceps (1). ______

______ 7. Salinity Refractometer (1). ______

______ 8. Squeeze Bottle with deionized water (1). ______

______ 9. Kim Wipes (1 box). ______

______ 10. Dissolved Oxygen Meter w/ membrane kit (1). Serial # ___________

______ 11. Pencils (2). ______

______ 12. Sharpie Marker (1). ______

______ 13. Laminated Field Procedures Sheet (1). ______

______ 14. Laminated Beaufort Scale (1). ______

______15. Roll Tape (1). ______

______16. Field Data Sheets (10). ______

______ 16. Niskin Sampler (1) with line and weights. ______

______ 17. Cooler (1) containing: ______

______ 18. Ice packs (2). ______

______ 19. 60ml plastic bottles (2). ______

______ 20. 1L white plastic bottles (2). ______

______ 21. 1L dark plastic bottles (2). ______

Received by:______________________________ Date:_____________________

Phone Number:____________________________

Returned: Rcvd. By:________________________ Date:_____________________

PLEASANT BAY CITIZEN WATER QUALITY MONITORING PROGRAM

FIELD DATA SHEET

1. Circle Station Number and Name			
1. Chatham Harbor	5. Muddy Creek	9. Round Cove	13. Namequoit Point-N
2. Bassing Harbor	6. Big Bay–SW	10. Quanset Pond	14. Arey's Pond
3. Ryders Cove-Inner	7. Big Bay-Mid	11. Paw Wah Pond	15.Kescayogansett Pond
4. Crows Pond	8. Big Bay-NE	12. Namequoit Point-S	16. Meeting House Pond

2. Volunteer Collectors: **3. Sampling Date:**

Physical Conditions

4. Weather (circle): clear partly cloudy overcast foggy drizzle rain snow

5. Wind Force (Beaufort Scale**):** _____ **6. Direction** (circle): N S E W NW SW SE NE

7. Water Condition (circle): clear muddy cloudy algae/plants foam oily sheen dead fish debris/trash

8. Other:

Depth Measurements

9. Secchi Disk Transparency:

Disappearance/descending: _______________(m)

Reappearance/ascending:________________(m)

Average:__________________(m)

Hit bottom before disappeared (circle): yes no

10. Total Depth of Station:__________________(m)

Salinty

11. (a) De-ionized water _______ppt (b) Surface water ______ppt

(a) – (b) = (c) "c" is the corrected value used in the DO meter

(c) Corrected salinity value _______ppt

Water Samples, DO and Temperature

	Sample Time (24 hr clock)	Sample Depth	Temperature (^{O}C)	DO Calibration Value	DO (% saturation)	DO MG/L

Other Comments:

Relinquished By:	Received By:	Received CWQ Lab:
Date/Time:	Date/Time:	Date/Time: