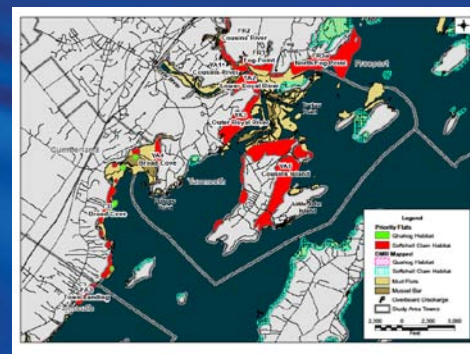
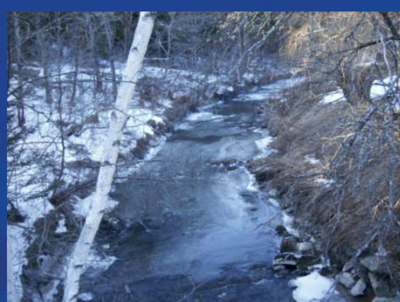
# Expanding and Sustaining the Shellfisheries of Casco Bay 2011





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March 2012

**The Casco Bay Estuary Partnership Clam Team**
dedicates this report to

**Richard "Dickie" Lemont**

who unselfishly devoted much of his life working to open and protect clam flats in Phippsburg and championing the softshell clam industry in all of Maine.
We miss his devotion and passion, his eagerness to share his wealth of knowledge, and we are indebted to him for all that he contributed to expanding and sustaining the softshell clam fishery in Casco Bay.

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# Executive Summary

The Casco Bay Plan, published in 1996 through the Casco Bay Estuary Project (CBEP 1996), includes the goal to open and protect clam flats in Casco Bay, in turn contributing to the health of this fishery and to the economic value of this resource. The purpose of this study was to update and expand upon the work completed through the Phase I and Phase II of Expanding and Sustaining the Shellfisheries of Casco Bay (2003) project and to compile a list of recommendations to continue towards the Plan's goal.

Shellfish harvesting in Maine has been a traditional activity providing a livelihood for many Mainers for generations. The economic value of the softshell clam (*Mya arenaria*) resource to harvesters in the state was nearly $13 million in 2010, with landings of over 10 million pounds (Maine Department of Marine Resources (DMR) (2011a). Another species of importance in some areas of the state is the quahog, or hard shell clam (*Mercenaria mercenaria*); over 4.6 million pounds were harvested in 2010 with an ex-vessel value of nearly $1.8 million. Ex-vessel dollars are those paid directly to the harvesters. An economic activity multiplier of 2.5-3.3 was suggested by Heinig et al. (1995) as a reasonable value to estimate the broader economic worth of the fishery. Applying an average of a 3.0 multiplier would increase the value of these resources to the State of Maine to $39 million for softshell clams and to $5.4 million for quahogs.

In Casco Bay, nearly two million live pounds of softshell clams were harvested in 2010 from the eight communities in this study (Falmouth, Cumberland, Yarmouth, Freeport, Brunswick, Harpswell, West Bath, and Phippsburg). The ex-vessel value was just under $2.8 million. Over 1.5 million live pounds of quahogs were harvested from these communities with a value of almost $1.1 million (Heidi Bray DMR personal communication 2/2/12). Applying a three times (3 x) economic multiplier, as described above, the value of these two species harvested from Casco Bay was $8.4 million and $3.3 million respectively. There were 264 active commercial in diggers Casco Bay in 2010.

The Maine DMR has mapped nearly 11,000 acres of softshell clam habitat in Casco Bay, and close to 1,300 acres of quahog habitat (Webber 2009). This mapping effort collected information from shellfish harvesters, DMR area biologists, and others with knowledge of the resources. The locations of shellfish habitat were recorded onto maps created from NOAA charts with Maine town layers from Maine Office of GIS (MEOGIS). The maps did not differentiate between high or low productivity, only by presence or absence of the resource. Many of the areas mapped as softshell clam or quahog habitat are closed to harvest due to fecal coliform bacteria levels that do not meet the open standard for shellfish growing areas. Shellfish growing areas are classified as prohibited, restricted, conditionally restricted or conditionally approved based on National Shellfish Sanitation Program (NSSP) standards that ensure that harvested shellfish are safe for human consumption. According to the DMR, non-point sources of contamination are the most common and the most elusive to pinpoint and therefore the most difficult to eliminate. Most of the point-source elements contributing to shellfish bed closures have been removed since the completion of Phases I and II of Expanding and Sustaining the Shellfisheries in Casco Bay (CBEP 2003), the exceptions being wastewater treatment plants (WWTP) and some overboard discharges (OBD's). There are three municipal and one community treatment plants in the selected towns in the project area; all four plants are in productive softshell clam areas and account for over 400 acres under the prohibited classification. Through combined efforts of the shellfish committees, town officials, CBEP, and DMR staff, most of the OBD's listed in Phase I and Phase II of this project have been removed. The few remaining OBD's, impacting priority shellfish harvesting areas as expressed by the shellfish committee representatives, contribute to closures in five communities.

Failing septic systems and marinas or anchorages with more than ten vessels are additional causes of closures of shellfish harvesting areas. Areas impacted by marinas and anchorages are generally classified as conditionally approved with harvesting allowed during the winter months. Falmouth Foreside, Royal River, Harraseeket River, and Orr's Cove all have closures related to the presence of marinas or anchorages; two are also associated with WWTP's and all four are in productive softshell clam habitat. Similar to marinas, closures around failing septic systems can also be conditional or can result in prohibited status sometimes determined by the type of residence, i.e. seasonal or year-round. Four of the five priority areas in Phippsburg are affected by poor water quality attributed at least in part to malfunctioning septic systems. Closures due to failing septic systems have been reported in all towns in the project area and seemingly could be remediated through enforcement as directed through the Maine Department of Health and Human Services Chapter 241 Subsurface Wastewater Disposal Rules. These rules require replacement or discontinued use for any failing system. Discharges from vessels within the State's No Discharge Zones are also prohibited; this includes all waters within three miles of the outer most coastal lands. Closures at anchorages are precautionary due to the potential for sewage or gray water discharge from vessels in these areas. Many areas classified as prohibited are the result of non-point source (NPS) pollution, also called stormwater runoff. Non-point source pollution can enter the Bay from residential and street runoff, agricultural lands, and wildlife use areas and is often the most difficult to identify and remediate. NPS continues to be an issue in several areas associated with agricultural land use and wildlife areas. As described in the Stream Flow and Bacterial Sampling Protocol, developed in accordance with guidelines from the Maine Department of Environmental Protection (DEP), DMR, and US Geological Survey (USGS) (Attachment 1), our study has shown that intensive (and expensive) stream flow analyses would be required to provide sufficient information that could allow for reduction in the size of closures. Development of a less intensive sampling protocol that would still provide adequate data could prove to be useful to the Department when determining the sizes and durations of closures on flats impacted by streams after storm events.

As detailed in Expanding and Sustaining the Shellfisheries in Casco Bay Phase I and Phase II (CBEP 2003), shellfish resources in nine towns around Casco Bay were evaluated and causes of pollution affecting the National Shellfish Sanitation Program (NSSP) status (open, restricted, or prohibited) of the clam flats were identified. As a result of that effort, nearly 430 acres of "high priority" clams flats and 32 OBD's affecting the status of those flats were identified. Twenty-seven OBD's were removed, shoreline surveys were updated, and additional water quality data were collected ultimately resulting in the reclassification of 243 acres of clam habitat to "Open". The remaining five systems were being evaluated for removal at the end of the study and have since been removed. Although much effort was expended to achieve those successes, the identified issues were the easiest to resolve. The current priorities are flats with more difficult issues to address. There are five flats from the previous project's highest priority list that are also on the current priority list; non-point sources of pollution and failing septic systems continue to plague these areas. Three areas in Brunswick, one in Freeport, and one area in Yarmouth/Freeport, identified as secondary priority flats in Phase II, have been shifted to the priority list in this current study. Issues affecting the original priority flats have been resolved or interest in those areas has waned due to declining resources or unresolved poor water quality. The most common causes of closure for the flats on the current list are NPS and failing septic systems.

Each town works with the DMR to collect water samples, isolate problems, and conduct resource and shoreline surveys. Improved water quality as a result of OBD removals and remediation of failing septic systems have resulted in upgrades in classifications and reduced size and duration of closures in many areas including Cumberland, Freeport, Brunswick, and Harpswell. All of the eight towns in this study around Casco Bay still have several acres of productive shellfish beds under some type of NSSP closure.

Most closures are related to non-point sources of pollution, failing septic systems, wastewater treatment plants, or marinas and /or anchorages.

Based on the information gathered in this project, recommended “Next Steps” to further the goal to open and protect clam flats in Casco Bay could include: assisting land owners and towns in removing overboard discharges and remediating failing septic systems affecting productive shellfish habitat, and assisting the Department of Marine Resources with further stream flow data collection. Additional work could include: sediment sampling such as pH and grain size analyses to further understand shellfish habitat requirements for survival of bivalve larvae and successful settlement, and circulation studies to determine the source(s) of clam larvae in Casco Bay and the areas that are most likely to have successful larval settlement.

# 1.0 Introduction

Softshell clam (*Mya arenaria*) harvesting in Casco Bay, and throughout the State, has been an important traditional activity and has provided a livelihood for many Mainers for generations. The economic value of this resource to the State was nearly $13 million in 2010, with landings of over 10 million pounds (DMR 2011a). Quahogs, or hard shell clams (*Mercenaria mercenaria*) are another species of importance in some areas; DMR landings data for the state in 2010 reported over 4.6 million lbs were harvested with a value of over $1.8 million. In Casco Bay, nearly 2 million lbs of soft shell clams were harvested in 2010 valued at nearly $2.8 million and over 1.5 million lbs of quahogs were harvested valued at just under $1.1 million (Heidi Bray, DMR, personal communication 2/2/12). An economic activity multiplier of 2.5-3.3 was suggested by Heinig et al. (1995) as a reasonable value to estimate the broader economic worth of the soft shell clam fishery. Applying an average of a 3.0 multiplier to the ex-vessel value would increase the overall worth of these resources to Casco Bay to $8.4 million for soft shell clams and to $3.3 million for quahogs.

The Casco Bay Plan, published in 1996 through the Casco Bay Estuary Project (CBEP 1996), includes the goal to open and protect clam flats in Casco Bay, in turn contributing to the health of this shellfishery and to the economic value of this resource. As part of that mission, Normandeau Associates, in association with MER Assessment Corporation, was contracted to build upon and update portions of Phase I and Phase II Expanding and Sustaining the Shellfisheries of Casco Bay (CBEP 1999, 2003). Also included in this scope of work was the additional task of developing a stream flow sampling protocol to be used by the Maine DMR. Stream flow data collected over multiple flow events and conditions are used to calculate dilution zones which, in combination with fecal coliform concentration data collected under the same flow conditions, are used to determine the areal extent of the shellfish closure areas.

# 2.0 Methods

**Task 1. Update Classification, Resource Value, and Pollution Source Data**

Normandeau developed a spreadsheet approach to compile data for listing and ranking clam flats in Casco Bay for the Phase I and Phase II studies (CBEP 1999, 2003). The same approach was employed for the current evaluation using the most current information available. Shellfish committee members and/or shellfish wardens or other town officials were contacted for the eight selected towns around Casco Bay to obtain information on the shellfish resources within their community. Interviews were conducted to determine which flats held the highest priority for classification upgrades, in terms of resource value, ease of pollution source remediation, and harvester interest. Normandeau also met with DMR to discuss the current status of particular flats and what, if any, actions the Department was pursuing to address classification issues. Water quality data, National Shellfish Sanitation Program

(NSSP) classification data, shellfish habitat and acreage data were obtained from the DMR websites (DMR 2011b, c,) and along with information from the towns, were collated into Tables 1 and 2. Maps were created using aerial photographs and town boundary lines from Maine Office of Geographic information Systems (MEOGIS 2011), softshell clam and quahog habitat, and associated acreages along with substrate type data obtained from DMR (Webber 2009) (Figures 1 and 2). Overboard discharge locations were obtained from the MDEP Google Earth site (MDEP 2011). Acreage values for the flats noted as "priority flats" and flats of interest in Table 1 and Table 2 were obtained from attributes in the shapefiles (DMR 2010d).

Ranking the value for resources was based on values (as reported by the shellfish committee representatives) attributed to commercial standards. Within the commercial industry, a flat with high resource value would be one that yields 100-120 bushels per acre or more; moderate value flats yield between 80 and 100 bushels per acre, and a low value flat would yield less than 60 bushels per acre (C. Heinig, Don Card, and Terry Watson personal communications 2011, 2012). These numbers have remained fairly consistent over the last several (at least 10) years, and likely would have been higher during years when clams were more abundant. The Maine Clam Handbook (Sea Grant 1998) provides a history of the clam industry in Maine and insights into the historical landings of soft shell clams. Resource values for many of the flats discussed in this report were "best professional judgment" estimates from the shellfish committee representatives or harvesters as actual resource survey data were not available.

Harvester interest rankings for each flat were based on resource value and perceived remediation potential. Using the information collected Normandeau assigned each flat a remediation potential according to the following scale:

- High - defined as moderate to high resource value and high remediation potential;
- Moderate- defined as low to moderate resource value and high remediation potential;
- Low - defined as low to moderate resource value and low remediation potential.

Also affecting the remediation potential ranking of a flat was the water quality (WQ) associated with the waters entering the shellfish growing area. Samples are analyzed for counts of fecal coliform colonies per 100 ml of water and results are measured against standards established by NSSP. Two statistical values are calculated from the 30 most recent WQ samples; they are the geometric mean and the 90$^{th}$ percentile or, the P90 value. The classification of a site is dependent on meeting the NSSP Standard for both parameters as shown in the table below:

**Fecal coliform values (membrane filtration method) for shellfish area classification (as of 6/1/2011).**

| Number of Fecal coliform colonies /100mL | Geometric mean | P90 |
|---|---|---|
| Approved | 14 or less | 31 or less |
| Restricted | 88 or less | 163 or less |
| Prohibited | More than 88 | More than 163 |

**Harvesting Activity Allowed Under the Closure Status as described by the DMR**

| Classification | Status | Shellfish Harvesting Activity |
|---|---|---|
| Approved | Open | Harvesting allowed |
| Conditionally Approved | Open<br><br>Closed | Harvesting allowed except during specified conditions (rainfall, Sewage Treatment Plant (STP) bypass or seasonal)<br>Harvesting NOT allowed |
| Restricted | Open | Depuration and/or Relay harvesting only |
| Conditionally Restricted | Open<br><br>Closed | Depuration and /or Relay harvesting allowed except during specified conditions (rainfall, STP bypass or seasonal)<br>Harvesting NOT allowed |
| Prohibited | Closed | No harvesting allowed or water use allowed for processing (administratively imposed precautionary closure) |

http://www.maine.gov/dmr/rm/public_health/howclassified.htm

The remediation potential rank was determined by reviewing the source of pollution causing the NSSP closure status. With the exception of wastewater treatment plants, most point-source causes of pollution such as overboard discharges (OBD's) were given a moderate or high remediation value. Non-point source causes such wildlife habitat were given a low value due to the difficulty in pin-pointing and removing these sources. Flats affected by stormwater runoff from agricultural lands were also given a low rank. These areas could incorporate Best Management Practices (BMP) to reduce bacterial contamination entering a waterway; however, complete elimination and upward reclassification seemed unlikely without significant effort and investment in resources.

The collected information was reviewed and each flat was assigned a overall rank of high, moderate, or low based on the resource value and remediation potential as estimated by the contact person for each town, the size of the flat, harvester interest (as reported to Normandeau by the shellfish committee representatives), and the reason for closure.

- High – defined as areas with high to moderate value resources, high harvester interest, and more than 2.5 acres in size. (Two and one half acres was the smallest mapping unit used during Phase I of this Project and was carried forth to this effort for consistency.)
- Moderate - defined as Flats having moderate value resources, low to moderate harvester interest and were at least 2.5 acres.
- Low – defined as all areas with resource values rated as "Low" regardless of interest or size.

This ranking system is similar to that used for the Phase I portion of this project. Ranks were further adjusted by taking into account the reason for closure and remediation potential.

**Task 2. <u>Soft-shell Clam Resource Screening</u>**

Based on the data collected through Task 1 and the preliminary ranking of high priority flats, the effort for Task 2 was to conduct resource surveys on selected flats where population data were lacking. Through conversations with each town's shellfish committee representative, Normandeau was informed by the committees that all towns had up-to-date shellfish resource surveys, and shoreline surveys had been completed within the past two years. Normandeau later learned that not all towns conduct resources surveys in a meaningful manner, if at all, and with few exceptions, those that are completed do not follow a prescribed protocol. The data received by DMR is in turn difficult to interpret and has proven to be of little value. We recommend the DMR reinstate a formal procedure for resource surveys as prescribed in the Maine Clam Handbook. Results from the resource surveys (estimated bushels per acre) that were available were incorporated into Table 1 and Table 2.

This task also included the preparation of a Quality Assurance Project Plan (QAPP) that would include the resource survey data collection methods as well as the stream sampling protocol. Based on the information given to the project team, the decision was made not to conduct resource surveys therefore did not prepare a QAPP for this task. Normandeau and MER assumed that DMR's existing stream sampling protocol would meet QAPP requirements with only minor revision. However, a consolidated protocol within the Department did not exist and therefore a complete document needed to be created. The draft QAPP, entitled Protocol for Stream Flow Measurement and Fecal Coliform Bacteria Sampling for Purposes of Reclassification of Shellfish Growing Areas Affected by Streams, is provided as Attachment 1. Attachment 2, CBEP Stream Flow and Bacterial Sampling Project Interim Report outlines the challenges encountered during field testing the Protocol and the results of those efforts.

**Task 3. Remediation Potential Ranking**

Using the data collected in Task 1, Task 3 focused on determining the remediation potential for the high priority flats (Table 1). Causes for closures were the primary factors affecting the rankings assigned to remediation potential values. Closures around wastewater treatment plants (WWTP) are mandatory as stipulated by the National Shellfish Sanitation Program and re-classification of Prohibited status is unlikely. Flats adjacent to treatment facilities were ranked as having low remediation potential. Overboard discharge systems (OBD's) also result in mandatory closures; many of the systems identified in the study area are on properties with limited options for alternative disposal systems; however, the potential for removal does exist. Flats impacted by OBD's were ranked as moderate for remediation potential. Flats within areas of non-point source pollution were assigned a low remediation value.

**Task 4. Stream Flow Monitoring**

The goal for Task 4 was to select a number of streams in Brunswick, Freeport, and Yarmouth for stream flow data collection. These data would be incorporated into a database that would allow Department of Marine Resources to calculate dilution zones around the streams and then establish closure areas under specific flow conditions. The Normandeau and MER team met with the Casco Bay Estuary Partnership to discuss the sampling goals and logistics and available time and budget. DMR staff provided an instructional meeting on stream flow data collection for MER and Normandeau followed by an in-field Gurley flowmeter deployment training session in Mill Brook in Falmouth. A second meeting was convened with the CBEP, DMR, MER, and Normandeau to identify the streams for sampling, and to discuss the need to develop a sampling protocol for DMR that would meet EPA QAPP standards. Two streams were selected: Bunganuc Stream in Maquoit Bay and Mare Brook leading from the former Brunswick Naval Air Station into the head of Harpswell Cove. A summary of the methods employed to develop and test the procedures as outlined in the QAPP is provided in Stream Flow and Bacterial Sampling Project Interim Report as Attachment 2.

## 3.0 Results

**Shellfish Resource and Remediation Ranking**

A total of fifty-one flats were evaluated; 14 were rated as high priority after criteria were applied to determine ranking status. The results of our findings are presented by Town.

**Falmouth**. The Town of Falmouth does not have an active shellfish committee and has only three commercial license holders. Normandeau spoke with the harbormaster, who oversees the shellfish program and with a former committee member to obtain information on the fishery within the town. Within the areas listed by these representatives as top priority flats, there are over 90 acres of potentially-suitable habitat for softshell clams. An additional 300 acres, with high resource value, lie within or adjacent to the Presumpscot River Estuary. This area is classified as prohibited and falls within the large closure from Cape Elizabeth to Waites Landing Road in Falmouth (DMR 2011e). This closure is influenced by multiple factors including the wastewater treatment plants in South Portland, Portland, Westbrook, and Falmouth. The Presumpscot River also affects the closure having a large watershed with numerous tributaries, contributing stormwater runoff from commercial, residential, agricultural, and natural wildlife areas into the waters and sediments of the estuary flats.

Mussel Cove was the first area of high priority listed by the town representatives as having a high-value resource. This flat is classified as prohibited due to occasional spikes of high fecal contamination in the water quality samples. The high spikes are likely attributable to residential and street runoff, and from Mill Stream. This stream originates near Route 1 north of the Shaw's Plaza and meanders through a mostly undeveloped tidal freshwater wetland system in close proximity to the commercial development along Route 1. According to DMR, pinpointing and eliminating the non-point source(s) of pollution has proven difficult. There is a pump station on Mill Stream at Rt 88; there was one reported failure at this station in June 2009. Two septic systems located outside, but close to, Mussel Cove were reported as potential pollution sources during the 2010 DMR shoreline survey. Both systems were immediately reported to the plumbing inspector and follow-up work resulted in the discontinuation and replacement of one system and confirmation that the second system was in fact functioning properly. The second priority area is the shoreline around Town Landing Road that offers approximately 20 acres of clam flats and is classified as conditionally approved for all areas except at the landing. The area at the landing is classified as restricted due to the seasonal boat activity and the anchorage. The closure north and south of the Town Landing area is governed by the presence of seasonal anchorages and is open between November 15 and April 30. Mussel Cove and Town Landing are of greatest interest to the Town of Falmouth and together offer high to moderately high resources with approximately 94 acres of harvestable area.

**Cumberland**. Cumberland has one area of municipal interest, Broad Cove. This area has over 85 acres of DMR-mapped softshell clam habitat, and is classified as conditionally approved under a seasonal closure between June 1 and October 31. The Shellfish Committee Chair indicated that the closure could be reduced in size and duration with additional water quality sampling especially at the southern end of the Cove. Two additional sampling stations were added in 2010 (DMR 2011f). Once thirty samples have been collected and attain a P90 of 31 or less, the area may be upgraded to approved status. Land use surrounding Broad Cove is a mix of residential and agricultural lands with farm animals present. These factors along with storm water runoff are likely sources of bacterial pollution contributing to the occasional poor water quality in the Cove. Broad Cove also has a moderate to high resource value with nearly 25 acres of mapped quahog habitat; there is high harvester interest to reduce the size and duration of the closure.

**Yarmouth**. Normandeau contacted the Yarmouth harbormaster to gather information regarding the flats in Yarmouth. Five areas were identified as flats of interest. Each area is of high to moderate interest, and reported to have moderate to high resource values. Each of these areas also has issues that dictate the closure status.

- The Cousins River: affected by one overboard discharge, agricultural land, a failing septic system, stormwater runoff, and the Yarmouth WWTP

- The lower Royal River: affected by the Yarmouth WWTP.
- Royal River to Cousins Island Bridge: part of a closure including, Parker to Sandy to Princess Points is due to poor water quality from a failing septic system, an outfall pipe and pet waste on the beaches (as reported in the 2010 Annual Shellfish Growing area Report).
- Broad Cove: see Cumberland
- Cousins Island. A community WWTP on the east shoreline of Cousins Island and several OBD's on Littlejohn Island result in the prohibited status between the two islands and around much of Littlejohn Island. The north shoreline of Cousins Island is currently conditionally approved; the southern end is classified as restricted due to multiple (non-sewage) discharges from Wyman Station.

**Freeport**. The top priority for Freeport has been the upper Harraseeket River. This area was recently (12/22/11) upgraded to conditionally approved as a result of increased sampling and improved water quality. The area is closed when rainfall exceeds 1" in a 24-hour period and/or when there is malfunction at the Freeport WWTP. The upper portions of the River at Kelsey and Mill Brooks are classified as prohibited as are two coves at Cove Road. These are associated with farm lands and wildlife use, which contribute to non-point sources of bacterial pollution; therefore NSSP status is unlikely to change. The second priority area for the harvesters in Freeport is the portion of the River below the WWTP zone and above the South Freeport Town dock. This area was also upgraded in December 2011 to conditionally approved, dependant on rainfall and operations of the WWTP. Both of these areas have high interest and high resource value. Other areas of interest for the Town of Freeport include: the Cousins River from Route 1 to Fogg Point, the Little River above Burnett Road, and the northeast side of Flying Point. The Cousins River to Fogg Point is classified as conditionally restricted due to OBD's and point- and non-point sources of pollution as described in the Yarmouth section. Little River is classified as prohibited. This river drains through a mostly undeveloped tidal wetland area with adjacent farm land. High fecal counts are likely due to livestock, wildlife, and waterfowl. Resource value and interest were expressed as being moderate in each of these areas. The shoreline northeast of Flying Point is currently open.

**Brunswick**. The Town of Brunswick lists three areas as top priority shellfish flats: Maquoit Bay, Bunganuc Creek, and upper Harpswell Cove. Maquoit Bay is one of the largest (218 acres) and historically most productive areas for the town's harvesters. This Bay has been harvested for both softshell clams and quahogs. The upper bay is adjacent to agricultural lands as well as wildlife and waterfowl habitat, resulting in periodically high spikes of fecal coliform in water quality samples. The town has worked with the DMR to reduce the size of the closure through the accelerated water sampling regime (twice per month collections) and the addition of new water quality stations. As a result of these efforts, the size of the closure has been reduced substantially to include only the portion of the Bay north of Pulsifer Point. This section is currently classified as restricted. The flats associated with Bunganuc Creek offer approximately 14 acres of highly productive habitat. The creek also drains mostly farmlands with few houses along the stream corridor. Occasional high spikes of coliform reported in water samples (DMR 2011c) indicate the presence of bacteria entering the waterway from non-point source(s). As noted in Task 4 of this report, Bunganuc Creek, now classified as prohibited, has been identified as a target for stream flow sampling which, in time, and upon completion of the series of sampling, may lead to upward re- classification and/or a reduction in the size of the closure of the area associated with the creek. The third area of interest is the upper portion of Harpswell Cove. This area was part of the Naval Air Station and access was not available prior to the closure of the base. The closest water quality stations have P90 values (the 90$^{th}$ percentile level) of 13.1 to 24.5 fecal coliform forming units (CFU)/100 ml with scores ranging from 0.24 to 200. Required values for each NSSP classification are shown in Section 2.0. Mare Brook is the major drainage into this portion of Harpswell Cove. A shoreline survey of the area would be required and additional sampling stations may need to be established to ensure representative data for this area were being collected. Sediment and tissue sampling for toxins would also be recommended for this area. The Brunswick marine patrol officer lists this area as having a high resource value; Mare Brook is also part of the stream flow study outlined in Task 4.

**Harpswell.** The shellfish committee in Harpswell is very active and continues to work with the DMR collecting water quality samples and conducting shoreline surveys to keep those up to date. The Shellfish Committee Chair for Harpswell listed several areas of interest to the harvesters where they feel that classifications could be upgraded or the size and /or duration of the closures reduced. Five of the 19 flats discussed were rated as high priority flats having the highest resource values, high harvester interest, and good remediation potential. As of November 2011, most of the west shore of Orr's Island was upgraded from prohibited to open as a result of improved water quality and the completion of the Sanitary Survey Report. This reclassification covered one of the areas of interest, Dipper Cove which was rated by the committee chair as having high interest and high resource value, and also Wilsons (or Reed) Cove that has low to moderate resources. The forty-plus acre flat at Ash Point Cove has high resource value and with additional water quality sampling this area may be qualified to be reclassified with the removal of one failing septic system and gray water discharges. Upper and Lower Basin Cove offers 81 acres of high value softshell clam habitat and is also impacted by seasonal poor water quality from old septic systems. This area is classified as conditionally approved with digging allowed December through April in the upper cover and from November to early April in the lower cove. The small cove east of the Gurnet Bridge is also of high interest. This cove had been reclassified to open after Phase II of this project. Currently, one system is thought to be malfunctioning resulting in poor water quality in the cove. This could be investigated to confirm the cause and remediate the issue. Other areas with high interest but moderate to low remediation potential include: Stover's Cove in Harpswell Harbor, a highly productive area with high digger interest, is classified as restricted. High fecal coliform levels are suspected to originate from groundwater and a contaminated well as well as from other non-point sources. According to the committee chair, seasonal digging opportunities are available only in the winter months. Orr's Cove in Quahog Bay was listed as having high resources and high interest by the harvesters. Currently, the Cove has a seasonal closure between May 1 and November 30, classified as conditionally approved due to the presence of a marina with more than 10 boats. The Committee would like to have this area opened for a longer period of time. This marina, Great Island Boatyard, is a Maine Clean Marina already utilizing BMP's for handling waste water and other on site wastes. We suggest discussing further management practices with the owners that may result in shorter or a smaller closure such as:

- Moving boats with heads to the seaward end of the cove
- Scheduling weekly pump-outs for all boats with heads
- Requiring Y-valve lock-outs of holding tank while on the mooring or at the dock

The DMR could increase the water quality sampling frequency to monitor for improvements to WQ if these actions were implemented at the marina.

**West Bath.** West Bath listed three high priority areas for the twenty-one commercial license holders. The Rosedale shoreline has low to moderate resources but is considered of high interest as they continue to works towards isolating and eliminating pollution sources into the new Meadows River. There are three OBD's in the area, numerous seasonal cottages and a marina upstream (in Brunswick) of this section of the West Bath shoreline. The area has prohibited, restricted, and conditionally approved sections from Heron Reach Head to the rail crossing north of Bath Road. The second priority area, Long Cove, is classified as conditionally approved with seasonal closure from June through September. The eastern branch in the very upper portion of the cove is prohibited; one failing septic system at a summer cottage appears to be keeping this area closed, according to the committee chair. Corrective measures could allow for an upgrade in NSSP classification or a reduction in the four-month closure time. The third area listed is Dam Cove. There is also a failing septic system in this drainage, resulting in a Prohibited closure at the upper reaches of the cove, and restricted status on the river side of the Cove. Remediation of this failing system could also result in a classification upgrade with increased harvest opportunity. Both Long Cove and Dam Cove have moderate resources and there is moderate interest regarding efforts to improve conditions at these sites. Access to the flats in Dam Cove is also a concern as there is very limited parking available for the harvesters. Flats considered as high priority during Phase I and Phase II of this study included Sabino, Birch Point, Brigham, and Perry Coves. These areas had several OBD's during the Phase I and Phase II study period that have since been removed, and thus were not listed as areas of concern for this study.

**Phippsburg**. Phippsburg has listed five flats as priority areas. The highest priority area for Phippsburg is east of Harbor Island. According to the Shellfish Committee Chair, this shoreline, classified as prohibited, has moderate to high value for both softshell clams and quahogs. There is one large licensed OBD system at Sebasco Estates within this prohibited closure area. The Committee would like to see the system at Sebasco Estates removed with an expected upgrade in the NSSP classification. Removal of this OBD is underway and is being replaced with an in-ground system. Construction is expected to be completed by the end of 2012 (MEPDES Permit ME0023237, January 23, 2009). Round Cove is located just south of the Harbor Island closure and has been on the priority list for Phippsburg since Phase II of this project. There is one identified potential pollution source that keeps this cove in the restricted category. According to the Annual Shellfish Growing Area Reports, the DMR has been working towards pinpointing and eliminating the source and has conducted a dye study. Round Cove offers roughly 10 acres of softshell clam habitat and is rated as having moderate resources and high interest. The third area, West Point, is rated as high to moderate for quahogs, (as well as oysters, assumed to be European oysters (*Ostrea edulis*) (Heinig and Tarbox 1985), and surf clams (*Spisula solidissima*)). This section of the shoreline has four active OBD's and a faulty septic system. The OBD licenses are scheduled for renewal between 2012 and 2014. Tottman Cove lies east of West Point and is classified as conditionally approved; there is at least one failing septic system draining into the Cove. Tottman Cove offers approximately eighteen acres of habitat and the Committee is expecting an upgrade in classification with the completion of the 2010 DMR Sanitation Survey Report. This is an area with moderate resources and high interest. The fifth area with moderate to high interest is Lobster House Cove. The Cove lies within Cape Small Harbor and is impacted by one failing septic system, affecting 163 acres of resource habitat.

In May of 2003, the Maine State Legislature revised the rules in Chapter 596, *Overboard Discharges: Licensing and Abandonment,* and adopted several amendments to the licensing of OBD's. One new rule requires landowners to retain the services of a licensed site evaluator to determine if it is technologically feasible to replace their existing waste-water treatment system prior to license renewal and install a replacement system within 180 days if grant money is offered by the Department. This policy would likely result in more OBD systems being removed from the shores of Casco Bay as licenses are due for renewal.

**Stream Flow Monitoring**

A draft protocol for stream flow sampling was prepared entitled Protocol for Stream Flow Measurement and Fecal Coliform Bacteria Sampling for Purposes of Reclassification of Shellfish Growing Areas Affected by Streams (Attachment 1). Procedures in the draft QAPP taken from existing protocols used by the DMR, Maine Department of Environmental Protection (MEDEP) and the US Geological Survey are referenced accordingly in the Protocol. The protocol was developed to assist DMR in formalizing procedures for determining the impact of water-borne fecal coliform carried by streams within shellfish growing areas during rain events as a function of rainfall, stream flow, stream discharge, concentration of bacteria relative to flow, and dilution. The goal was to develop a protocol that, once implemented, would improve the understanding of site-specific stream effects on adjacent shellfish growing areas that would lead to improved definition of the impact area and the area's classification under the Food and Drug Administration's (FDA) NSSP. The protocol, developed to conform to the EPA QAPP framework, established the procedures for each of the component measurements and calculations necessary for determining stream impacts:

1. Stream flow measurement
2. Discharge calculation
3. Stream-borne bacteria sampling
4. Receiving water body bacteria sampling
5. Stream water dilution calculation

The draft Protocol was circulated to the Project Team for review and revisions were made to the document. Using the newly developed protocol, MER and DMR visited the two selected streams to test the outlined procedures and determine if there was a need for further modifications. Sampling conditions did warrant further modifications and those were incorporated into the QAPP. Sampling effort details are presented in the Stream Flow and Bacterial Sampling Project Interim Report as Attachment 2.

# 4.0 Conclusions

In Casco Bay, there are close to 10,800 acres of DMR mapped softshell clam habitat and just under 1,300 acres of quahog (hard clam) habitat. Many of these acres are closed to harvest due to fecal coliform levels that do not meet the open standard for shellfish growing areas. Shellfish growing areas are classified as prohibited, restricted, conditionally restricted or, conditionally approved based on NSSP standards that ensure that harvested shellfish are safe for human consumption. Efforts to reduce closure size and duration rely on several activities:

- shoreline surveys, to identify sources of pollution
- water quality sampling, to determine fecal coliform levels in waters over the flats and to identify sources of coliform bacteria
- Paralytic Shellfish Poisoning (PSP) sampling, to better quantify the area affected
- enforcement and remediation of identified pollution sources through Maine Department of Health and Human Services (DHHS) enforcement under Chapter 241, State of Maine Subsurface Wastewater Disposal Rules, Section 2.A.7 guidelines. This rule states that if a malfunctioning system is found it must be corrected, or its use discontinued.

The town's licensed plumbing inspector (LPI) has authority to enforce all provisions in the DHHS Wastewater Disposal Rules and under those rules is required to submit an annual report to their municipality citing all enforcement activities. Following up with the LPIs to determine the status of the numerous suspected malfunctioning systems may result in remediation efforts to eliminate these sources of pollution affecting shellfish habitat.

According to the DMR, non-point sources of contamination are often the most elusive to pinpoint and therefore are the most difficult to eliminate. Most of the point-source elements contributing to shellfish bed closures have been removed since the completion of Phases I and II of this project, with the exception of wastewater treatment plants and some overboard discharges. Prohibited status is mandatory around WWTP's and OBD's; the sizes of the closures around these facilities are determined by the volume of effluent entering the water bodies. There are three treatment plants in the project area, Falmouth, Yarmouth, and Freeport. Treatment plants in Windham and Westbrook also influence water quality in the Presumpscot River and ultimately the estuarine flats in Falmouth and Portland. There is also a community system on Cousins Island; all four are in productive softshell clam areas and account for over 400 acres under the prohibited classification. The Falmouth WWTP is on the Presumpscot River and is within the large Cape Elizabeth to Falmouth closure in DMR Pollution Area 13; an upgrade in classification for the flats at the mouth of the River unlikely.

The Yarmouth WWTP is in the Royal River and impacts the entire River as well as the conditionally restricted status of the Cousins River. There is also one remaining OBD on the Cousins River. In May of 2010, a hydrographic dye study was conducted on the effluent from the Yarmouth Plant. The purpose of the study was to assess the dilution rates, time of travel, and dispersion of effluent into the Royal and Cousins Rivers as well as into offshore waters. Methods are described in the Department of Marine Resources Growing Area WI Triennial Report for 2011 (DMR 2011g). The objectives of the study included: determining potential bacterial conditions under short-term and long-term lapses in treatment and disinfection; assessing the applicability of the CORMIX model for estimating dilution rates; and determining accurate dye amounts to be used and suitable locations for shellfish cages in relation to the outfall for appropriate dilution ranges. Shellfish were collected at the end of the study and analyzed for fecal coliform, mesenchymal stem cell, norovirus, and adenovirus; these data will contribute to the understanding of pathogen accumulation in shellfish and the extent of effluent waste fields under varying discharge dilutions within the Royal River. Although the results are not yet available, they may provide information that could result in a smaller size closure around the WWTP.

On Cousins Island, the Sea Meadows Community System, along with eleven OBD's on Littlejohn Island, are responsible for the prohibited status of the habitat between the two islands and the southeast shore of Littlejohn Island. The presence of the community treatment system will keep this area in prohibited status. However, Yarmouth modified the discharge for this system and added timers to restrict the discharge to just ebbing tides. It should be investigated whether this change or this change and the removal of some of the OBD's would allow more area to be opened.

The Freeport WWTP impacts the NSSP status of the receiving waters of the Harraseeket River resulting in an approximately 300-acre closure around the plant. As recently as December of 2011, the upper and lower portions of the River were upgraded from conditionally restricted to conditionally approved as a result of updated shoreline survey and improved water quality. The flats in the River have been priority areas for the Freeport harvesters since Phase I.

There are few remaining OBD's in Casco Bay that impact shellfish harvesting areas listed by the shellfish committee representatives contacted for this study. Through combined efforts of the shellfish committees, town officials, CBEP, and DMR staff, most of the systems listed in Phase I and Phase II have been removed. The largest and only commercial licensed OBD in the project area is at Sebasco Estates in Phippsburg. This 20,000 gallon system contributes to nearly 1 ½ miles of shoreline being classified as prohibited. The area is of high interest to the Shellfish Committee members, with moderate to high value resources for both softshell clams (17 acres) and quahogs (18 acres). In 2003, the Maine State Legislature adopted several amendments to Chapter 596 rules governing overboard discharges. The new rules require OBD owners whose licenses are up for renewal to enlist the services of a licensed site evaluator to determine whether or not replacement of the existing system is technologically feasible. If replacement is possible, the OBD must be replaced with an alternate system. The Sebasco Estates system was evaluated and the determination was made that the system could be replaced with an in-ground system. The OBD is scheduled to be removed by the end of 2012. Other OBD's affecting resources in Phippsburg include four systems at West Point in a 49-acre area reported to have moderate to high value of quahogs. West Bath still has three OBD's in the Rosedale/Howards Point area; these contribute to the restricted zone south of Rosedale Point while a still unidentified source is responsible for the prohibited zone at Rosedale Point. These systems are in within the top priority area for West Bath harvesters who list the resource value as low.

In Harpswell, there are just two priority areas affected by OBD's. Clarks Cove is listed by the committee chair as an area of high interest and moderate resources. The closure in Clarks Cove impacts roughly 1.2 miles of shoreline and 24 acres of mapped habitat. Lowell Cove (5 acre) has low interest and low resources and is impacted by six OBD's and is included in the closure around all of Bailey Island and much of the east shores of Orr's Island. This is a low priority area.

Failing septic systems and marinas or anchorages with more than ten vessels are additional causes of closures of shellfish harvesting areas. Areas impacted by marinas are generally classified as conditionally approved with harvesting allowed during the winter months. In the priority areas, Falmouth Foreside, Royal River, Harraseeket River, and Orr's Cove all have closures related to the presence of marinas or anchorages; two are also associated with WWTP's and all four are in productive softshell clam habitat. Conditional closures around marinas aren't necessarily a bad thing. In addition to protecting seafood safety, they also relieve digging pressure on the flats for several months, and provide new open areas for harvesters in late fall through early spring.

Similar to marinas, closures around failing septic systems can also be conditional or can result in prohibited status sometimes determined by the type of residence, i.e. seasonal or year-round. A large closure on the Yarmouth shore from Princes Point to Parker Point affecting over 130 acres is, in part, due to a failing septic system. In Harpswell, Upper and Lower Basin Cove, Ash Point Cove, Indian Rest, and Oakhurst Island are all affected by poor water quality from malfunctioning septic systems; these closures impact approximately 160 acres of habitat. Four of the five priority areas in Phippsburg are affected by malfunctioning septic systems. West Point and Lobster Cove are classified as prohibited, Round Cove is restricted, and Tottman Cove is conditionally approved. Combined, these four areas total 240 acres of softshell clam habitat. Closures due to failing septic systems have been reported in all towns in the project area and seemingly could be remediated through enforcement actions requiring repair or replacement. Funding assistance through local or state programs could ease the financial burden on those with limited income.

Many areas classified as prohibited are the result of non-point source (NPS) pollution. Non-point source pollution from residential and street stormwater runoff, agricultural lands and wildlife use areas is often the most difficult to identify and remediate. NPS continues to be an issue in several areas including Broad Cove, Mussel Cove, the (upper) Harraseeket River, Little River, Bunganuc Creek, Maquoit Bay, Wilsons Cove, and Oakhurst Island. These areas are associated with agricultural land use and wildlife areas. Our study has shown that labor-intensive and expensive stream flow analyses would be required to provide sufficient information on nonpoint sources that would allow closure size reductions. As described in the Stream Flow and Bacterial Sampling protocol, numerous data points collected over multiple sampling events would be required to obtain sufficient data to determine the extent of fecal coliform bacteria pollution from a stream under specific flow conditions. For each stream, a complete data set would include up to 65 stream flow measurements and up to 130 fecal coliform samples. One sampling effort could span up 120 hours of data collection for a minimum of three to four people (Table

2a in the protocol). Development of a less intense sampling protocol that would still provide adequate data for determining flow rates, and ultimately size and duration of a NSSP closure could prove to be beneficial to the Department of Marine Resources Shellfish Growing Areas Program.

Expanding and Sustaining the Shellfisheries in Casco Bay Phase I and Phase II (CBEP 2003), focused on the shellfish resources in nine towns around Casco Bay and evaluated and identified the causes of pollution affecting the NSSP status of the clam flats. As a result of this effort, nearly 430 acres of "high priority" clams flats and 32 OBD's were identified. Twenty-seven OBD's were removed, shoreline surveys were updated, and additional water quality data were collected ultimately resulting in the reclassification of 243 acres of clam habitat to "Open". Although much effort was expended to achieve these successes, the identified issues were the easiest to resolve. The current priorities are flats with more difficult issues to address. There are five flats from the previous project's highest priority List that are also on the current priority list. Those include: Ash Point Cove, Lower Basin Cove, and Gurnet Cove in Harpswell; Round Cove in Phippsburg; and Dam Cove in West Bath. Non-point sources and failing septic systems still plague these areas. Three areas in Brunswick- Maquoit Bay, Bunganuc Creek, and upper Harpswell Cove, the Harraseeket River in Freeport, and the Royal and Cousins Rivers in Yarmouth/Freeport, identified as secondary priority flats in Phase II, are considered priority areas in this current study. The most common causes of closure for the flats on the current priority list are non-point sources of bacterial pollution and malfunctioning septic systems.

Each town works with the DMR to collect water samples, isolate problems, and conduct resource and shoreline surveys. Improved water quality as a result of OBD removals, and remediation of failing or malfunctioning septic systems have resulted in upgrades in classifications and reduced size and duration of closures in many areas including Broad Cove, the Harraseeket River, Basin Cove, and Laurel Cove. All eight towns still have several acres of productive shellfish beds under some type of NSSP closure; most closures are related to malfunctioning septic systems, non-point sources of pollution, wastewater treatment plants, or marinas/anchorages.

Stream flow sampling as prescribed by the protocol developed in accordance with guidelines from the DMR, DEP, and USGS, would be very costly. The numbers of samples needed to fulfill the requirements set forth in the QAPP, and the number of sampling events needed to determine dilution rates for most flow conditions dictate a need for over 120 staff hours per site/per event. Also, there is a need for volunteer water quality samplers to be available during the 48 hours prior and 72 hours post-rain event. Other constraints include time frames available for sample delivery to the DMR Water Quality Lab. Samples cannot be delivered between noon on Thursdays and 6:00 AM on Sundays. The ideal rainfall dataset for a stream would contain data from 60 to 80 stream flow measurements (12 to 18 events times 5 intervals/event) and 120 to 160 associated fecal coliform bacteria samples (60 to 80 sampling intervals times 2 bacteria samples/interval; 1 stream and 1 DMR station). This plan is extremely ambitious and given the constraints, would likely take multiple years to obtain a complete data set for a given stream if samples were sent only to the DMR Lab. Consideration could be given to contracting another laboratory to assist with analysis of the water quality samples.

Based on the information gathered in this project, recommended "Next Steps" to further the goal to open and protect clam flats in Casco Bay could include:

Pollution Source Remediation

- As the highest priority, remediating failing septic systems affecting productive shellfish habitat Identifying funding sources to assist with costs associated with replacement

- facilitating meeting(s) with the State Agencies involved (DEP, DMR, DHHS) and the town Code Enforcement Officers to determine a plan and timeline for removing failed septic systems
- assisting land owners and towns in removing overboard discharges
- following up on the replacement of the Sebasco Estates OBD and the opening of the affected flats
- work with the town of Phippsburg and DEP to facilitate removal of the four OBD's whose license renewals are due in 2012-2014. One of these in Lobster House Cove contributes to the closure affecting 163 acres

Stream flow, Resource, and PSP Data Collection as it Affects NSSP Classification

- assisting the Department of Marine Resources with refining stream flow data collection protocols
- assisting DMR with stream flow data collection in one stream judged to have both an impact on an important shellfish resource and a high probability of success
    - contracting with a certified lab to assist with analysis of the large number of samples collected and to accommodate for 24/7 collections
- reviewing the results of the Royal River studies done in 2010. The findings may affect more than just the Royal River, or could be applicable to other watersheds
- requesting an analysis of the Little John/Cousins Island area to ascertain whether changes at the Sea Meadows discharge, either with or without OBD removal, would allow some of the area to be opened
- Investigate whether the CORMIX model can be useful to the stream flow dilution work; can the results from the Royal River Studies be applied to other streams?
- developing (re-instituting) a standard operating procedure for resource survey data collection
    - Provide standardized data forms to survey teams
    - Require data to be collected in the standardized format for acceptance to DMR
- continuing intensive sampling for early PSP detection in mussels to refine red tide closures to the smallest areas possible

Improve Knowledge Base

- circulation studies to determine the source(s) of clam larvae in Casco Bay and which areas are most likely to have successful larval settlement
- sediment sampling for parameters such as pH, grain size, and calcium/aragonite, to further understand shellfish habitat requirements for successful settlement and survival of bivalve larvae

Facilitation/Collaboration

- compile our findings and recommendations (by town) and present to each town for their shellfish committee to review and request a priority list of action items that would assist the town attain upward classification for a priority flat
- offer assistance, through the CBEP Clam Team, to the towns that reply to the above request with a priority item

- facilitate meeting(s) between DMR , harvesters, municipal officials, and other interested parties to explain a perceived “new” focus of testing on streams and after rain events. This testing is considered retribution (by some clammers) for their requested review of the DMR Shellfish program sampling regime (confidential source)
- add a priority for CBEP stormwater funding to remediate stormwater flows causing clam flat closures
- add for stormwater funding, one or two clam flats as priority areas to remediate and open

It should be noted that this report focused on the priority areas as identified by the towns selected to be included in this work. Outside these towns, (Portland, South Portland, Chebeague) there are many acres of clam flats that could be important resources. A further recommendation would be to:

1. review the coastal sediment maps and maps of shellfish habitats in the whole bay, and
2. ground truth the maps with visits to selected flats within the study area and in the towns not included in this study, to confirm the habitat and the presence/absence/abundances of shellfish .

This effort should include flats that have not been open for harvesting and therefore were not mapped as shellfish habitat in the 2009 DMR study. Flats that were included in the study should also be reviewed to confirm the accuracy of the data as reported to the study researcher.

The health and vitality of the shellfish populations in Casco Bay may depend on recruitment from outside the bay but some of the success of these populations likely relies on the habitat and shellfish resources present in the bay. For instance, there are very productive clam flats in South Portland, Portland and Falmouth (Presumpscot River Estuary) that may never be open but **do** these areas contribute to the reproductive success of the system? Are these flats a significant source of larvae? Where do these larvae settle?

We consider the following recommendations to be the items that could produce the best results to open and protect shellfish habitat in Casco Bay:

1. Facilitate the removal of failing septic systems
2. Advocate for towns to conduct resource surveys according to protocol described in the Maine Clam Handbook to provide consistent and accurate data
3. Pursue reduced stream sampling protocol development
4. Investigate the feasibility and facilitate the removal of OBD’s from productive shellfish habitat

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# FIGURES

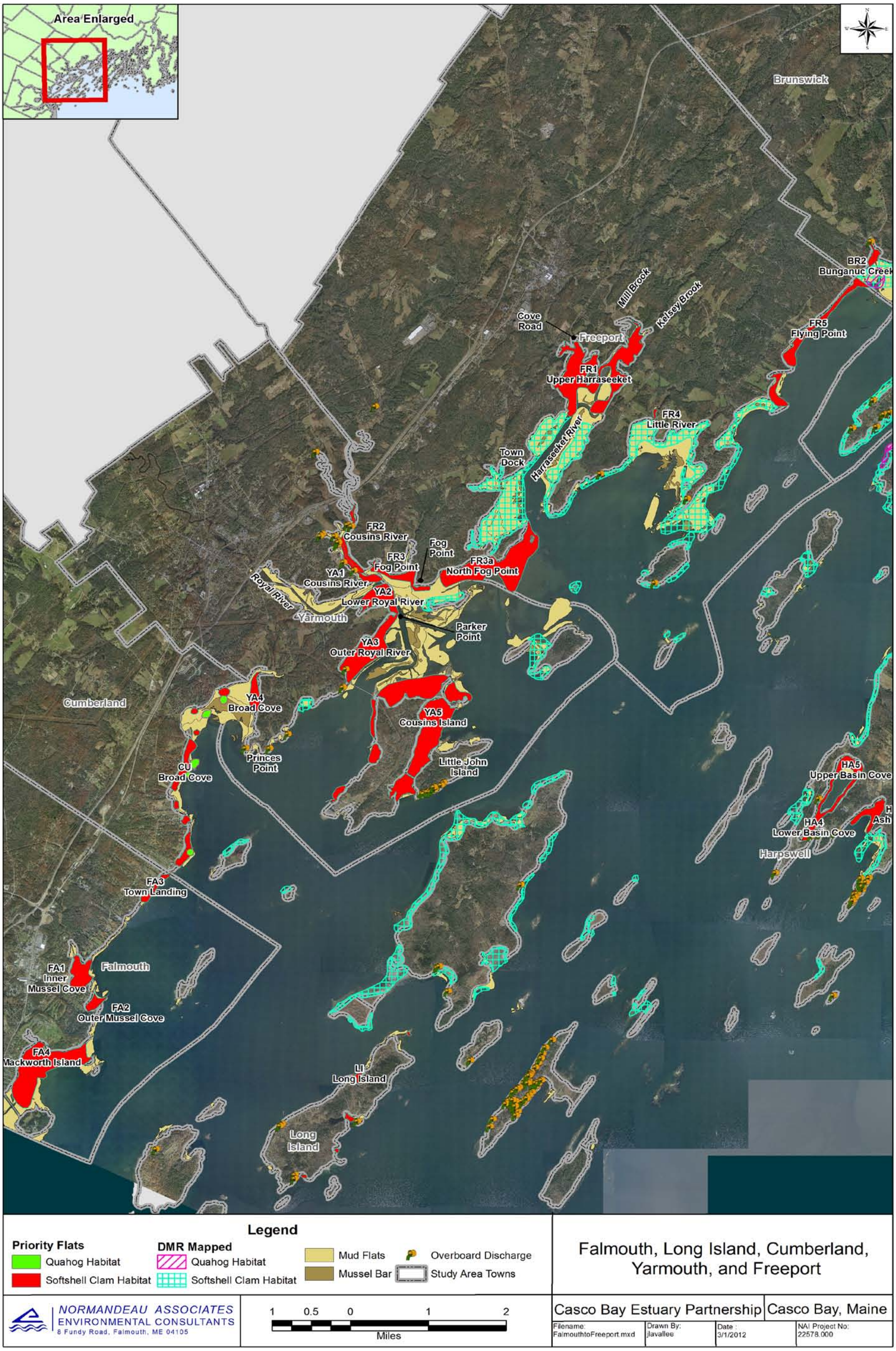


Figure 1. Falmouth to Freeport Priority Shellfish Areas

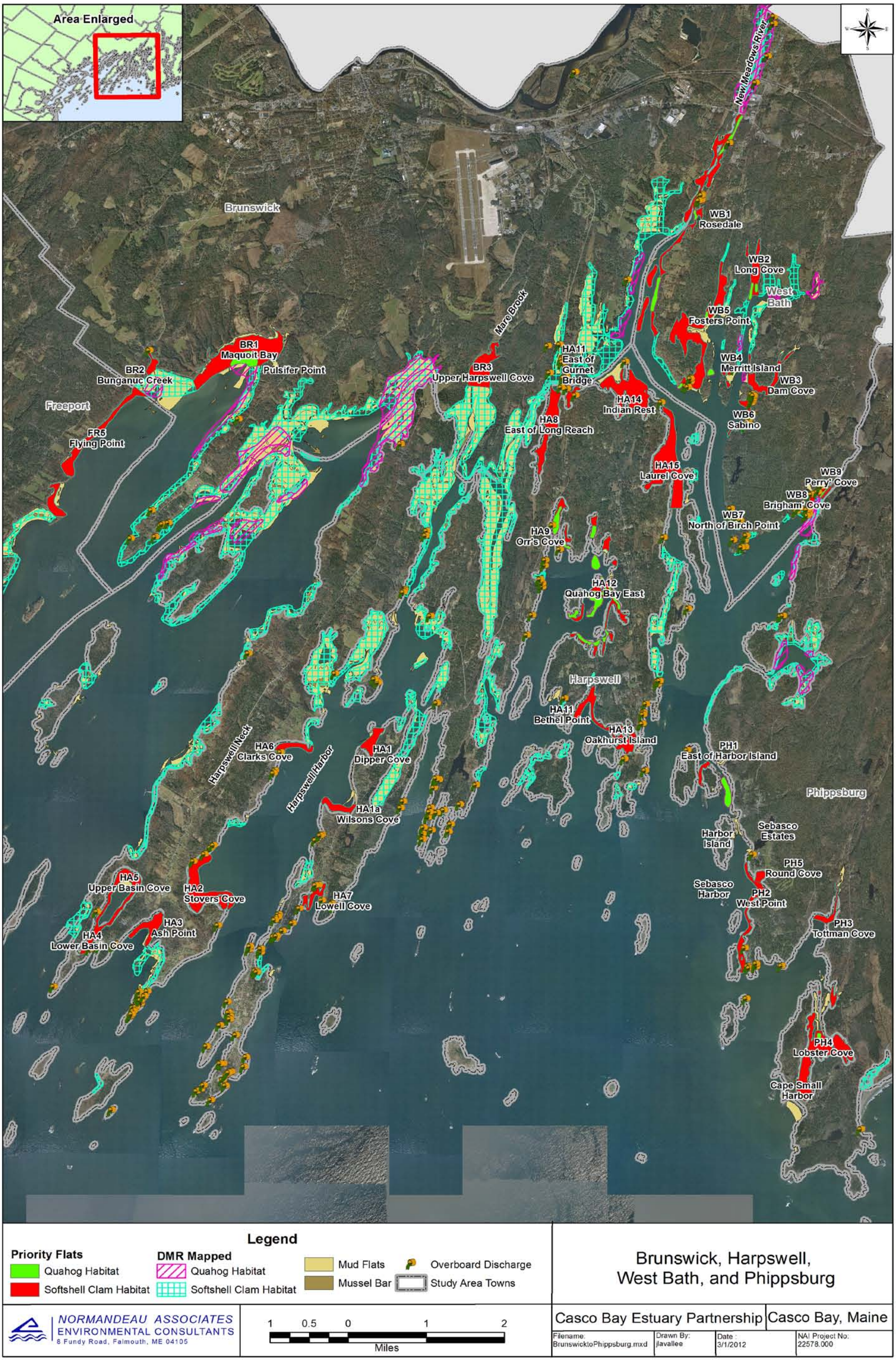


Figure 2. Brunswick to Phippsburg Priority Shellfish Areas

# TABLES

**Table 1. Clam flat Assessment – Highest Priority Flats**

| Town | Flat Name | NAI # | DMR Area/# | Status | Reason | Acreage<br>Soft shell/quahog | Resource Value | Harvester Interest | Upgrade Feasibility | Rank | WQ Station | P90 | Shoreline survey | Remediation Needed | Potential Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cumberland** | Broad Cove | CU | 14/E. | CA | boats, NPS | 86/24 | Mod/High | High | High | High | WI027.00<br>WI028.50<br>WI029.00<br>WI030.00<br>WI033.00<br>WI034.00 | 18.3<br>New<br>New<br>33.1<br>36.8<br>6.4 | C | more WQ testing | closure size reduction |
| **Yarmouth** | Broad Cove | YA4 | 14/E. | CA | boats, NPS | 32 | Mod | Mod/High | High | High | WI033.00<br>WI034.00 | 3.8<br>6.4 | C | more WQ | closure size reduction |
| **Freeport** | Upper Harraseeket River | FR1 | 15/B. | CA | WWTP | 282 | High | High | High | High | WJ09.70<br>WJ011.00<br>WJ014.00<br>WJ014.15<br>WJ014.20<br>WJ014.50 | 10.8<br>20.9<br>14.6<br>New<br>21.9<br>25.2 | C | WWTP upgrade | recent upgrade to CA |
| **Harpswell** | Dipper Cove | HA1 | 17-c/A1 | Open | completed reports | 29 | Mod | High | High | High | WK023.10<br>WK023.20 | 3.7<br>3.9 | C | upgraded in Nov'11 | 29 acres now available |
| | Ash Point Cove | HA3 | 17-B/A5 | R | failing septic | 41 | High | Mod/High | High | High | WJ067.00<br>WJ067.50<br>WJ068.00<br>WJ068.50<br>WJ070.00 | 8<br>2<br>25.2<br>28.1<br>6.9 | C | fix failing system and gray water issues | classification upgrade |
| | Upper Basin | HA4 | 17B/B | CA | septics | 54 | High | High | Mod | High | WJ064.00<br>WJ065.00<br>WJ066.00 | 10.2<br>8.6<br>9.8 | C | remove septics | shorter closure |
| | Lower Basin | HA5 | 17-B/C | CA | septics | 29 | High | Mod | Mod | High | WJ062.00<br>WJ063.00<br>WJ064.00 | 6.6<br>6.9<br>9.8 | C | remove septics | shorter closure |
| | East Gurnet | HA11 | 19A/A6 | P | failing septic | 12 | Mod | High | High | High | WL018.00 | 37.4 | C | fix system | 12 acres more |
| West Bath | Long Cove | WB2 | 19-A/A7 | P/CA | failing septic | 44 | Mod | Mod | High | High | WL044.50<br>WL045.00<br>WL045.50<br>WL046.00<br>WL046.50 | 29.3<br>32<br>New<br>35<br>NO DATA | C | fix system | shorter closure |
| West Bath | Dam Cove | WB3 | 19B/A1<br>19B/B1 | P<br>R | failing Septic<br>failing septic | 47 | Mod | Mod | Mod | Mod | WL049.00<br>WL050.00<br>WL051.00<br>WL052.00 | 13.5<br>NO DATA<br>25.4<br>40.8 | C | fix septic | shorter closure<br>need parking access to this cove |
| Phippsburg | E. Harbor Island | PH1 | 19-C/3 | P | OBD | 17/18 | Mod/high | High | High | High | WL079.00<br>WL081.00<br>WL085.00<br>WL087.00<br>WL087.20 | 5.2<br>31.9<br>55.6<br>21.7<br>NO DATA | C | remove OBD | open for quahogs |
| | Tottman Cove | PH3 | 19-C/B | CA | need report | 18 | Mod | High | High | High | WL096.00 | Not listed | C | Need report | shorter closure |
| | Lobster Cove | PH4 | 19C/6 | P | failing septic | 163 | Mod/High | Mod | High | High | WL099.00<br>WL101.00 | 5.6<br>8.2 | C | fix one system | shorter closure |
| | Round Cove | PH5 | 19-C/4 | R | OBD/Septic | 10 | Mod | High | High | High | WL087.00<br>WL087.20 | 21.7<br>NO DATA | C | fix systems | upgrade classification |

P= Prohibited, R= Restricted, CR= Conditionally Restricted, CA = Conditionally Approved

C= Current shoreline survey

**Table 2. Clam flat Assessment - Secondary Priority Flats**

| Town | Flat Name | NAI # | DMR Area/# | Status | Reason | Acreage Soft shell/quahog | Resource Value | Harvester Interest | Upgrade Feasibility | Rank | WQ Station | P90 | Shoreline survey | Remediation Needed | Potential Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long Island** | | LI | 13/A.1 | P | multiple | 15/0 | low | Low | Low | Low | none | | no | | |
| **Falmouth** | Mussel Cove (inner and outer coves) | FA1 | 13/A2 | P | Pump station. NPS | 74 | High | High | low/mod | Mod | WI017.50 | 15.9 | C | reduce NPS | could provide good area for digging; only depuration as of late |
| | Town Landing | FA2 | 13/B | CA | seasonal boats | 20 | Mod/High | High | Low/Mod | Mod | WI025.00<br>WI026.00 | 12.6<br>39 | C | | |
| | Mackworth | FA4 | 13/A1 | P | multiple | 225 | High | Mod | Low | Low | none | | | | |
| **Yarmouth** | Cousins River | YA1 | 14/C.1 | CR | NPS WWTP | 30 | High | High | Low | Low | WI051.00<br>WI051.50<br>WI053.00<br>WI054.00<br>WI055.00<br>WI055.20<br>WI055.50 | 33.5<br>42.6<br>47.3<br>28<br>21.5<br>50<br>23.3 | C | multiple | classification upgrade |
| | Royal River (Lower) | YA2 | 14/C2 | CR | WWTP | 72 | High | High | Low/Mod | Low | WI048.00 | 70.4 | C | | |
| | Outer Royal R. | YA# | 14/A3 | P | NPS, septic | 132 | Mod | High | Mod | Mod | WI040.00.<br>WI041.00 | 31.2<br>54.2 | C | | |
| **Freeport** | Cousins River | FR2 | 14/C1 | CR | WWTP, OBD | 22 | High/Mod | Mod | Low/Mod | Low | WI051.00<br>WI051.50<br>WI053.00<br>WI054.00<br>WI055.00 | 33.5<br>42.6<br>47.3<br>28<br>21.5 | C | Multiple | classification upgrade |
| | Fogg Point | FR3 | 14/D2 | CR | WWTP NPS | 42 | Mod/Low | Mod | Mod | Mod | WI 55.50<br>WI 56.00 | 23.3<br>NODATA | C | fix septics | shorter closure |
| | North Fogg Point | FR3a | 14/D2 | CA | WWTP, NPS | 243 | Mod | High | Low/Mod | Mod | WI55.00<br>WI56.00<br>WI56.70 | no data in report | C | id NPS ,fix septics | |
| | Little River | FR4 | 15/A2 | P | NPS wildlife | 3 | High | High | Mod | Low | WJ018.00 | 14.5 | C | BMP farmers | upgrade |
| | NE Flying Point | FR5 | 16 | OPEN | | 28 | High | High | Mod | Low | WJ027.30 | 7 | C | area open | |
| **Brunswick** | Maquoit Bay | BR1 | 16/B | R | NPS wildlife | 218 | High | High | Low/Mod | Low | WJ032.00<br>WJ032.50<br>WJ033.00<br>WJ033.70<br>WJ034.00 | 8.4<br>16.2<br>27.9<br>N<br>9 | C | stream flow<br>ID NPS | additional acreage |
| | Bunganuc Creek | BR2 | 16/A1 | P | NPS | 14 | High | High | Mod | Mod | WJ030.00<br>WJ031.50 | 62.2<br>17.5 | C | isolate NPS | upgrade |
| | Harpswell Cove | BR3 | 17A/A1 | R | NPS/ possible Issues from BNAS? | 78 | High | High | Mod | Mod | WJ014.10<br>WJ014.20 | 24.5<br>13.1 | C up to BNAS fence | further WQ | upgrade |

(continued)

**Table 2. (Continued)**

| Town | Flat Name | NAI # | DMR Area/# | Status | Reason | Acreage Soft shell/quahog | Resource Value | Harvester Interest | Upgrade Feasibility | Rank | WQ Station | P90 | Shoreline survey | Remediation Needed | Potential Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Harpswell** | Clarks Cove | HA14 | 17-B/A2 | P | OBD septics | 24 | Moderate | High | Mod | Mod | WK007.00<br>WK007.10 | 3.8<br>29.2 | C | remove OBD<br>more WQ | Clarks to Stovers |
| | Orr's Cove | HA9 | 18/C | CA | marinas | 12 | High | High | Low/Mod | Mod | WK055.00<br>WK056.00<br>WK057.00 | 18.8<br>21.8<br>8 | C | more wq? | Possible to reduce duration of closure<br>pump-out sta. = yes |
| | Quahog Bay east | HA12 | 18/B | CA | boats, NPS | 114/73 | Low | Low | Low/Mod | Low | WK055.00<br>WK056.00<br>WK057.00<br>WK058.00<br>WK059.20<br>WK060.00<br>WK061.00<br>WK063.00<br>WK063.10 | 18.8<br>21.8<br>8<br>6.3<br>8.9<br>5.9<br>67.1<br>48.6<br>33.7 | C | limit boats? | open limited area |
| | Stovers Cove | HA2 | 17-C/A3 | R | ground water | 234 | High | High | Low | Low | WK004.00<br>WK005.00<br>WK005.50<br>WK006.10 | 15.7<br>44.4<br>1.9<br>6.2 | C | Eliminate well or groundwater contamination | large area upgrade |
| | Oakhurst Island | HA13 | 18/A2 | p | septics, wildlife NPS | 24 | Mod/High | Mod | Mod | Low | WK067.00<br>WK068.00 | 19.9<br>147.8 | C | id NPS | upgrade |
| | Bethel Point | HA10 | 18/A2 | P | septics, wildlife NPS | 32 | Mod | Low | Low/Mod | Low | WK065.00<br>WK066.00<br>WK067.00<br>WK068.00<br>WK068.10 | 128.2<br>32<br>19.9<br>147.8<br>8.9 | C | id NPS | upgrade |
| | Lowell Cove | HA7 | 17C/A5 | P | DMR WQ rprt | 5 | Low | Low | Low | Low | no station | | C | Remediate Soil contamination | low value area<br>1 mile of shoreline |
| **West Bath** | Rosedale | WB1 | 19-A/A4<br>A5 | P<br>R | unidentified?<br>OBD's, septics | 148/32 | Low | Mod/High | Low/Mod | Low | WL037.00<br>WL037.50 | 28<br>23.1 | C | fix septics | upgrade |
| **Phippsburg** | West Point | PH2 | 19-C/5 | P | 4 OBD's, septics | 49 | Mod/ High | Mod | Mod | Mod | WL089.00<br>WL095.50 | 10.9<br>NO DATA | C | remove OBD's | areas for quahogs and softshell clams |

P= Prohibited, R= Restricted, CR= Conditionally Restricted, CA = Conditionally Approved

C= Current shoreline survey

# ATTACHMENTS

# Attachment 1

Protocol for Stream Flow Measurement and Fecal Coliform Bacteria Sampling for Purposes of Reclassification of Shellfish Growing Areas Affected by Streams

# Attachment 2

Interim Report Stream Sampling Project Summary

# Protocol for Stream Flow Measurement and Fecal Coliform Bacteria Sampling for Purposes of Reclassification of Shellfish Growing Areas Affected by Streams

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## Introduction

This protocol is being developed to assist the Maine Department of Marine Resources (DMR) in formalizing procedures for determining the impact of water-borne fecal coliform carried by streams on shellfish growing areas during rain events as a function of rainfall, stream flow, stream discharge, concentration of bacteria relative to flow, and dilution within the receiving waters of the shellfish growing areas. The goal is to develop a protocol that, once implemented, will improve the understanding of site-specific stream effects on adjacent shellfish growing areas that will lead to improved definition of the impact area and the area's classification under the Food and Drug Administration (FDA) National Shellfish Sanitation Program (NSSP).

This protocol sets forth the procedures for each of the component measurements and calculations necessary for determining stream impacts:

1. Stream flow measurement;
2. Discharge calculation;
3. Stream-borne bacteria sampling;
4. Receiving water body bacteria sampling; and
5. Stream water dilution calculation.

The procedures set forth here have been taken from existing protocols used by the DMR, other State of Maine agencies, and other federal and states' agencies and are referenced accordingly.

## 1.0 Stream Flow Measurement and Bacteria Sampling Schedule

Stream flow measurements and associated bacteria sample collections need to be made under numerous rain events based on the pre-event soil condition and amount of rainfall to fully understand the response of the stream and bacteria concentrations under varying conditions. Table 1, below, lists the number of measurements required under various soil conditions and precipitation event volumes. (Recommended by DMR Water Quality staff.)

**Table 1. Requisite number of stream flow measurements and bacteria sample collections based on pre-event soil condition and amount of rainfall volume (S=spring; SM = summer; F = fall)**

| Season | Dry baseline | S/SM/F | S/SM/F | S/SM/F | S/SM/F |
|---|---|---|---|---|---|
| Rainfall | <0.5" | 0.5" -1.0" | 0.5" -1.0" | >1.0" | >1.0" |
| Soil condition | dry | dry | wet | dry | wet |
| Min. # samples | 1 | 1 | 3-5 ea season | 1 | 3-5 ea season |

Stream flow measurements and bacteria sample collections will need to be made at intervals during each rain event to fully understand the flux in the concentration of fecal coliform bacteria carried by a specific stream over time as it responds to a specific rain event. Table 2, below, lists the intervals before and after each rain event listed in Table 1, above, at which stream flow measurements and bacteria sample collections need to be made. (Recommended by DMR Water Quality staff).

**Table 2a. Stream flow measurement and bacteria sample collection frequency during rain event for individual stream[1] for MER study.**

| Sampling interval per event | Stream profiles | Stream fecal coliform sample [2] | DMR WQ station fecal coliform sample | Total Samples |
|---|---|---|---|---|
| up to 48 hrs before rain event | 1 | 1 | 1 | 2 |
| within 12hrs of rain event end | 1 | 1 | 1 | 2 |
| 24 hours after rain event end | 1 | 1 | 1 | 2 |
| 48 hours after rain event end | 1 | 1 | 1 | 2 |
| 72 hours after rain event end | 1 | 1 | 1 | 2 |
| | **5** | **Total per rain event** | | **10** |

[1] Samples can only be collected between Sunday 6AM and Thursday 10AM; no sample processing can occur from Thursday noon through Sunday before 6AM.
[2] Stream bacterial samples are to be collected as close to head of tide as possible.

Accordingly, the ideal rainfall dataset for a stream will contain data from 40 to 60 stream flow measurements (8 to 12 events times 5 intervals/event) and 80 to 120 associated fecal coliform bacteria samples (40 to 60 sampling intervals times 2 bacteria samples/interval; 1 stream and 1 DMR station).

**Table 2b. Stream flow measurement and bacteria sample collection frequency during rain event for individual stream[1] for DMR staff**

| Sampling interval per event | Stream profiles | Stream fecal coliform sample [2] | DMR WQ station fecal coliform sample | Total Samples |
|---|---|---|---|---|
| up to 48 hrs before rain event | 1 | 1 | 1 | 2 |
| within 12hrs of rain event end | 1 | 1 | 1 | 2 |
| 24 hours after rain event end | 1 | 1 | 1 | 2 |
| | **3** | **Total per rain event** | | **6** |

[1] Samples can only be collected between Sunday 6AM and Thursday 10AM; no sample processing can occur from Thursday noon through Sunday before 6AM.
[2] Stream bacterial samples are to be collected as close to head of tide as possible.

Accordingly, the ideal rainfall dataset for a stream will contain data from 24 to 36 stream flow measurements (8 to 12 events times 3 intervals/event) and 48 to 72 associated fecal coliform bacteria samples (24 to 36 sampling intervals times 2 bacteria samples/interval; 1 stream and 1 DMR station).

**Steam flow measurements**
**(Based on Maine DEP *Guidelines and Procedures for Measuring Stream Velocity and Discharge (Flow) Using Price AA or Pygmy Flow Meters and then Computing Discharge (Flow))***

## 1.1 Supplies

- Gurley Price Type AA flow meter (Gurley Price Model 622D), (Figure 1) and/or Gurley Pygmy Type flow meter (Gurley Price Model 625A), (Figure 2)
- Flow meter maintenance kit (light oil [not 3-in-1 type oil, which gets gummy when in contact with water]; small screwdriver) (see USGS [1999])
- Standard wading rod with base and attachment for flow meter
- Non-stretch tape measure sufficient to span stream (fiberglass-cloth up to about 35 feet, Kevlar or steel-beaded tape or "tag line" for greater widths)
- Stakes to tack down ends of tape measure
- Flow Measurement Field Data Sheet
- Personal floatation devices (for safety)

**Figure 1. Gurley Price Type AA flow meter** (image/specifications table source: Gurley Precision Instruments http://www.gpi-hydro.com/)

| Specifications - Price Type AA | |
|---|---|
| Accuracy | 2% |
| Minimum Depth Required | |
| Cable suspended | 18 inches |
| Rod suspended | 6 inches |
| Dimensions | |
| Bucket open end diameter | 2.0 inches |
| Bucket wheel diameter | 5 inches |
| Operating Range | |
| Feet per second | 0.2 - 25 |
| Meters per second | 0.06 - 7.6 |

A smaller, more sensitive Gurley Pygmy meter will be necessary under baseline, low flow conditions. Pygmy meters provide reliable measurements of flows down to 0.05 feet per second at depths as shallow as 3 inches.

**Figure 2. Gurley Pygmy flow meter** (image/specifications table source: Gurley Precision Instruments http://www.gpi-hydro.com/)

| Specifications - Pygmy Type | |
|---|---|
| Accuracy | 2% |
| Minimum Depth Required | |
| Cable suspended | Not applicable |
| Rod suspended | 3 inches |
| Dimensions | |
| Bucket open end diameter | 0.78 inches |
| Bucket wheel diameter | 2 inches |
| Operating Range | |
| Feet per second | 0.05 - 3.0*<br>0.02 - 15.00 |
| Meters per second | 0.02 - 0.9*<br>0.02 - 4.57 |

* The range of the pygmy meter can be extended to 11 fps with the 611 hand counter (headphone model) and 15 fps with the Model 1100 flow indicator. However, we recommend using the Price AA for velocities in this range.

## 1.2 Flow measurement procedure

*Note 1: USGS SOP*

This SOP summarizes USGS methods. Prior to one's first time of making water velocity and flow measurements, one should read in detail applicable sections of Rantz *et al*. (1982), especially Chapter 5 of Volume 1 as well as other key chapter sections.

*Note 2: Training Needed*

This SOP outlines the key steps in conducting flow measurements, but does not substitute for proper instruction. Hands-on training with someone (*e.g.*, Maine DEP staff) who has experience in these methods is required. This is especially true when handling the flow meters themselves.

*Note 3: Equipment Notes*

Flow meters are extremely delicate. When in operation, the spin cups rotate on a tiny and precise pin called the pivot. This smooth point of contact is critical to the accuracy of the meter. The pivot must be removed from the meter and stored at all times, except for when you are at the stream bank and ready to take measurements. Leaving the pivot in while walking with the meter will damage the assembly after just a few steps. There is a brass pin that takes the place of the pivot when the meter is being transported or stored. Given the sensitivity of the meter assembly, it is important to receive hands-on training from an experienced person before attempting to use a flow meter. For more details, refer to Chapter 5, pages 93-94, of Rantz et al. (1982). USGS OSW Technical Memo 99.06 (USGS, 1999) describes important protocols for keeping flow meters in good working order including the regular disassembly, inspection, and light oiling of meters. For a more thorough discussion of these types of flow meters, see Rantz et al. (1982), "Vertical-Axis Current Meters", pages 85-88.

### 1.2.1 Flow meter maintenance and check (refer to Appendix I; available at http://www.gpi-hydro.com/Meter_Manual.pdf)

Each flow meter used should have quality control checks specified by the manufacturer to confirm suitable performance. Flow meter calibration is not an option for most meters. All meters should be cleaned with warm water after each use and allowed to air dry before storing in carrying cases. A weekly spin test should be conducted and recorded for meters and the bucket wheel must spin freely for ***2 minutes***. If the meter fails a spin test, the meter should be dissembled, lubricated, and tested again. If it fails a second spin test, the pivot should be replaced, followed by another round of spin tests.

### 1.2.2 Establishing suitable locations for measuring stream flow

Ideally, the section of stream where the flow measurement occurs should have the following qualities:

1. Stream segment is straight, with parallel banks;
2. Velocity is greater than 0.5 feet / second (0.15 m/s).
3. Depth is greater than 0.5 feet (0.15 m). Minimum depth for the Pygmy meter is 0.3 feet (0.09 m).
4. Uniform streambed. Free of heavy algae, vegetation, boulders, etc.
5. Flow is uniform, lacking as much as possible any turbulence, eddies, slack water, etc.
6. Near the stream gauge (*i.e.*, staff gauge or automatic stage [water level] recorder/logger), with no tributary inflows and minimal groundwater effects between measured flow and measured gauge (depth).
7. Ideally, there should be a downstream "control" or restriction point, such as riffles, narrowing, etc. (For details on selecting good "controls", refer to chapter 3 [Gauging Station Controls] of Rantz et al. (1982).)

Field conditions may be less than ideal, in which case the field scientist must exercise judgment in determining where to take flow measurements. At a very minimum, the current must be sufficient to spin the meter, and the depth must permit the meter to be completely submerged and off the stream bed (minimum 15 cm).

### 1.2.3 Step-by-step flow measurement guide using Velocity-Area, Open-Channel Method (aka, Midsection Method, adapted from Rantz et al. [1982; Volume 1; especially pages 134-135 and 139-146])

1. Assemble and inspect the flow meter (refer to Appendix I). This includes replacing the brass pin used for transportation with the pivot pin. The meter should be well balanced on its pin, and turn freely with a very light touch. Perform a spin test, and record the results. If the meter passes the test, continue. Minimum spin test results: ***Price AA = 2 minutes*** (USGS, 1989).

2. Once a suitable location for flow is determined, stretch a tape measure across the stream ***perpendicular to the flow*** and stake the ends. Set the zero end of the tape measure on the left bank (facing downstream). If staking is impossible, one or both ends may be tied to fixed object. The tape may extend well beyond the stream banks. The tape must be perpendicular to stream flow and taut to ensure accuracy.

3. Read the tape measure at the Right Pin (RP) and Left Pin (LP) to which the tape measure or tagline is secured and at the Right Edge of Water (REW) and Left Edge of Water (LEW). The stream width is:

   Stream Water Width = Right Edge of Water (REW) – Left Edge of Water (LEW)

4. Divide the stream width into, whenever possible, ***about 25-30 sections, at least 20, if width allows.*** More sections typically reduce error. Ideally, no rectangular subsection should have more than 10% of the discharge, although this is not always possible. All 25-30 (minimum 20) points should be sampled on at least one occasion representing the baseline and four rainfall conditions, *i.e.* 0.5" -1.0" wet and dry and >1.0" wet and dry. Thereafter, three velocity measurements, taken at the right, middle, and left of the stream are sufficient.

   Read and follow the instructions and illustrations by Rantz et al. (1982, pages 80-81 from Vol. 1) entitled "General Description of a Conventional Current-Meter Measurement of Discharge" included on the following two pages. Note that an italicized "x" (*x*) is frequently used as a subscript for many of the variables listed on those pages. We make note of this in case it is not easily readable.)

   Deeper, faster verticals should be spaced more closely together. Write down a vertical section plan, based on a visual estimate of where the deepest, swiftest points of the stream are. If the stream is of approximately uniform depth and velocity, verticals may be evenly spaced.

5. The depth of the stream will indicate whether the sixth-tenth depth (single-point) or two-point method is used; ***in most cases the sixth-tenths method will be used since the flow meter being used will be a Type AA***. The sixth-tenth depth method means flow is measured at 0.6 depth at each section ("0.6 depth" equals 60% of the water depth, measured down from the top of the stream [the water surface]). For example, when stream depth is 1 foot, measure 0.6 feet from the water surface. In the two-point method, flow is measured at 0.2 and 0.8 depth, and then averaged. (See Table 3.)

**Table 3. Current meter velocity measurement method for various depths (wading measurement)** (adapted from Rantz et al. [1982]). *A Pygmy meter can be used when velocities are less than 2.5 ft/sec (0.76 m/sec).

| Depth | | Meter | Velocity Method |
|---|---|---|---|
| (ft) | (m) | | |
| 2.5 or more | 0.76 or more | Type AA (or Type A) | 0.2 and 0.8 |
| 1.5-2.5 | 0.46 - 0.76 | Type AA (or Type A) | 0.6 |
| 0.3-1.5 | 0.09 - 0.46 | Pygmy* | 0.6 |

   Also, use the 0.6 depth method when stage is rapidly changing and flow must be measured quickly.

6. On data sheet (see Appendix II) record date, type of meter, method (sixth-tenths or two-point), meter ID or serial number, water temperature, GPS coordinates (UTM), who is measuring and recording, depth (if any) at edge of water, other information that may affect the flow or stage conditions. Record the time of first and last flow measurement.

7. Using the *Standard* wading rod, screw the base onto the first rod (fine threaded) until snug. Add additional rod sections (coarse threaded) as necessary depending on stream depth. Attach flow meter and vane to the attachment piece and connect the Model 1100 Flow Velocity Indicator electrical lead to the flow meter (see Operation and Maintenance Guide for details).

8. Place the wading rod in the stream at location of first measurement (minimum depth is 15cm) and measure full depth; rod sections are marked at 5cm (single score) and 10cm (double score) intervals. Slide assembly onto the rod to the depth equal to 0.6 total depth and fix flow meter assembly in place using the red thumb screw. Allow the meter to adjust to the current for several seconds before taking measurement (in slow moving current, more time should be allowed).

9. Take measurement using the Gurley Model 1100 Flow Velocity Indicator (refer to Appendix I for details)
   a. Press the "On" button to turn indicator on;
   b. Press the "**622 M/S**" button in the AUTOMATIC section of the Indicator to see velocity in meter/second and record on data sheet;
   c. Press the "**RESET**" button in the MANUAL section of the Indicator – display will read "SEC000";
   d. Press the "**START/STOP**" button in the MANUAL section of the Indicator – display will tick off seconds;
   e. Once 40 seconds have elapsed press the "**START/STOP**" button again – display will stop counting seconds and will show "SEC040";
   f. Press the "**FUNCTION/SELECT**" button in the MANUAL section of the Indicator – display will show number of revolutions as "REV020" - record on data sheet; pressing the "**FUNCTION/SELECT**" button again returns the elapsed number of seconds of the recording.
   g. Repeat for all ***25-30 sections, at least 20, if width allows***, on each visit to the site until sufficient data has been collected covering most conditions; once sufficient data has been collected, measurement at the Standard Measurement Location (SML) (see 11., below) will suffice.

10. Take each measurement standing comfortably downstream of the meter, facing the bank, to reduce possible interference with the meter. Allow the meter to adjust to the current for several seconds before taking measurement. In slow moving current, more time should be allowed.

11. Measure flow rate at an established Standard Measurement Location (SML) (with known GPS coordinates; see Figure 3). Once transect flow profiles of the stream have been made under various flow conditions along with measurements at the SML, a single measurement at the SML will suffice to determine overall stream flow.

12. Measure the distance between an established staff gauge and the water level (see Figure 4).

**Figure 3. Measuring stream flow at Standard Measurement Location**

**Figure 4. Measuring water level at established staff gauge**

## 2.0 Flow calculation

The Maine DMR has developed an Excel® spreadsheet for the calculation of stream flow based on the revolutions measured with a Gurley flow meter and the amount of time during which measurements were taken. An example of the spreadsheet is shown below in Table 4.

**Table 4. Flow calculation spreadsheet based on field collected Gurley meter data and times**

| | |
|---|---|
| **Site name** | Example |
| **River** | Example |
| **Date** | 10/1/2011 |
| **Time** | 1200 |
| **Staff gauge (in)** | 5 |

| Station | Revs | Time (min) | Flow (m/sec) | Flow (ft/sec) |
|---|---|---|---|---|
| **1** | 3 | 40 | 0.0554 | 0.1818 |
| **2** | 4 | 40 | 0.0722 | 0.2369 |
| **3** | 5 | 40 | 0.0890 | 0.2920 |
| **4** | 7 | 40 | 0.1226 | 0.4022 |
| **5** | 9 | 40 | 0.1562 | 0.5125 |
| **6** | 10 | 40 | 0.1730 | 0.5676 |
| **7** | 11 | 40 | 0.1898 | 0.6227 |
| **8** | 12 | 40 | 0.2066 | 0.6778 |
| **9** | 13 | 40 | 0.2234 | 0.7329 |
| **10** | 14 | 40 | 0.2402 | 0.7881 |
| **11** | 13 | 40 | 0.2234 | 0.7329 |
| **12** | 11 | 40 | 0.1898 | 0.6227 |
| **13** | 10 | 40 | 0.1730 | 0.5676 |
| **14** | 8 | 40 | 0.1394 | 0.4573 |
| **15** | 7 | 40 | 0.1226 | 0.4022 |
| **16** | 5 | 40 | 0.0890 | 0.2920 |
| **17** | 4 | 40 | 0.0722 | 0.2369 |
| **18** | 4 | 40 | 0.0722 | 0.2369 |
| **19** | 3 | 40 | 0.0554 | 0.1818 |
| **20** | 2 | 40 | 0.0386 | 0.1266 |
| | | **Average flow** | **0.1352** | **0.4436** |

**Where flow (m/sec) = (0.672 * (Revs/Time))+0.005**
**Where flow (ft/sec) = Flow (m/sec) * 3.28084**

Flow rates developed using the above spreadsheet are then input to a second spread sheet developed by the Maine DMR to calculate overall daily stream flow (see Table 5, below).

**Table 5. Maine DMR Daily stream flow calculation spreadsheet**

| Input data into yellow cells | blue cells are automatic calculations | | | | | | |
|---|---|---|---|---|---|---|---|
| **Example from first 4 stations above** | | | | | | | |
| Width of stream in feet | (Ft) | | | | | | **5.66** |
| | | **1 (bank)** | **2** | **3** | **4** | **5** | **6** |
| Distance between each transect in feet (fill only as many cells as you need, cell one is always 0) | **(ft)** | 0 | 1.9 | 3.8 | 5.7 | | |
| Depth at each transect in inches (starting at the bank) | (inch) | 14.3 | 10 | 5 | 1 | | |
| Depth in feet | (ft) | 1.1916 | 0.8333 | 0.4166 | 0.0833 | 0 | 0 |
| **Transect Sections** | | | **A1** | **A2** | **A3** | **A4** | **A5** |
| Length of Section (only have as many cells filled in as you have measurements for, so if you have no distance measurements (row 7) in a particular column, delete auto filled numbers in cells of that column) | (ft) | | 1.9 | 1.9 | 1.9 | | |
| Average Depth for section (only have as many cells filled in as you have measurements for, so if you have no depth measurements (row 8) in a particular column, delete auto filled numbers in cells for that column) | (ft) | — | 1.0125 | 0.625 | 0.25 | | |
| Area (Average Depth x length of transect section) | ($ft^2$) | | 1.92375 | 1.1875 | 0.475 | 0 | 0 |
| Cross-sectional area for transect | ($ft^2$) | | | | | | 3.58625 |

| **FLOW METER** | | 1 | **2** | **3** | **4** | **5** | |
|---|---|---|---|---|---|---|---|
| Flow Velocity (enter all velocity readings) | (ft/s) | 0.1818 | 0.2369 | 0.2920 | 0.4022 | | |
| Average velocity | (ft/s) | | | | | | 0.278225 |
| Stream flow (Cross Sectional Area x Average Velocity)* | ($ft^3$/s) | | | | | | 0.997784 |
| Stream flow (Cross Sectional Area x Average Velocity)* | ($ft^3$/min) | | | | | | 59.86706 |
| Stream flow (Cross Sectional Area x Average Velocity)* | ($ft^3$/hour) | | | | | | 3592.024 |
| Stream flow (Cross Sectional Area x Average Velocity)* | ($ft^3$/day) | | | | | | 86208.57 |
| Stream flow (Cross Sectional Area x Average Velocity)* | **gal/min** | | | | | | **447.8056** |
| Stream flow (Cross Sectional Area x Average Velocity)* | **gal/day** | | | | | | **644883.2** |

For a detailed description of the USDA method for determining stream discharge refer to Appendix III General Description of a Conventional Current-Meter Measurement of Discharge, pages 80 - 81 in Rantz et al. (1982, Volume 1).

## 3.0 Discharge Calculation

The Maine DMR also uses a spreadsheet, shown in Table 6, below, to calculate discharge of fecal coliform based on stream flow rate (GPM) and fecal coliform concentration (FC/100ml). These two inputs allow calculation of the daily fecal coliform discharge (FC/day).

**Table 6. Spreadsheet used by Maine DMR for calculation of fecal coliform discharge to receiving waters**

| 1 | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 2 | **Sample Date** | **Flow Rate(GPM)** | **FC/100ml** | **FC/day** | | |
| 3 | 1/15/1996 | **110** | 500 | 2,996,070,000 | | |
| 4 | 3/14/2000 | **3530** | 20 | 3,845,864,400 | | |
| 5 | 6/23/2005 | **140** | 2 | 15,252,720 | | |
| 6 | | | | 0 | | |
| 7 | | | | 0 | | |
| 8 | | | | 0 | | |
| 9 | | | | 0 | | |
| 10 | | | | 0 | | |
| 11 | | | | 0 | | |
| 12 | | | | 0 | | |
| **13** | | | **Average FC/day =** | **2,285,729,040** | | |
| | | | | | | |
| | **Equation in Cell E13 needs to be adjusted to include only the actual results in column E. Otherwise all the zeros in the column will be calculated into the average and throw off the results!** | | | | | |
| | | | | | | |
| | **To recalculate, click in the E13 cell then go up to the top and change the formula so that the ending cell matches the cell number of the last number in the column. For example, in the case above, the equation needs to be changed from an average calculation range of E3 through E12 to E3 through E5, otherwise all of the 0 values in E6 through E12 will be erroneously included in the calculation.** | | | | | |
| | | | | | | |
| | **There are 37.829 100ml units in a gallon.** | | | | | |
| | **1 GPM x 60min x 24hrs x 37.829 units is 54,474 100ml units per day.** | | | | | |

The Average daily fecal coliform load (Average FC/day) value is then used to determine whether the fecal coliform load meets or exceeds the Total Maximum Daily Load (TMDL) calculated for the receiving waters based on National Shellfish Sanitation Program allowable fecal coliform concentration thresholds; an example based on the above calculated values is shown in Table 7.

**Table 7. Spreadsheet used to determine compliance with threshold values for fecal coliform for a receiving water body.**

***STREAM RECEIVING WATERS TMDL CALCULATION SPREADSHEET***

This spreadsheet is used to calculate a max daily FC load based on volume of receiving waters.
Use the second page to enter sample data and formulate an average for this calculation.

***RECEIVING WATER INFORMATION***

| | | |
|---|---|---|
| average depth | 5 | ft. |
| square feet of surface water | 20,000 | sq. ft. |
| volume of receiving waters | 100,000 | cu. ft. |
| TMDL | 396,200,000 | fc/day |

***BACTERIA LOADING FROM SAMPLE AVERAGES***

| | | |
|---|---|---|
| Bacteria load (average from samples on previous page) | 2,285,729,040 | Total FC/day |
| or | 2.29E+09 | Total FC/day |

| | | |
|---|---|---|
| **In this case stream bacterial load** | **EXCEEDS the receiving waters TMDL** | |
| **By a difference of** | **1,889,529,040** | **FC/day** |

This color cell requires an input
This color cell is calculated automatically
3927 is the number of sq ft in a 100' semicircle

Copies of all spreadsheets shown above are available from the Maine DMR. An effort will be made to integrate, to the extent possible, the various spreadsheets shown above in order to facilitate calculations and reduce the need to manual data entry.

### 4.0 Stream-borne bacteria sampling

*Note:* The fecal coliform bacteria water sample should be collected while facing upstream to avoid biasing related to stream bed sediment disturbance by the sampler.

1. Apply latex gloves;
2. Label 500ml *Whirl-Pak*®;
3. Remove seal at top of *Whirl-Pak*®;
4. Open *Whirl-Pak*® by pulling on tabs on either side of bag;
5. Dip *Whirl-Pak*® into water just below surface;
6. Remove *Whirl-Pak*® from water and squeeze to displace enough water to allow a pocket of air at top of bag;
7. "Twirl" *Whirl-Pak*® several times (at least three) while holding end tabs to seal;
8. Fold end tabs together to secure closure;
9. Place bag in cooler with ice or ice packs to maintain sample at 4°C. during transport to DMR Water Quality lab within 12 hours of sample collection;
10. Record requisite information on sample collection data sheet.

*Note:* Samples can only be collected between Sunday 6AM and Thursday 10AM; ***no sample processing can occur from Thursday noon through Sunday before 6AM***.

### 5.0 Receiving water body (DMR routine sampling station) bacteria sampling

1. Apply latex gloves;
2. Label 500ml *Whirl-Pak*®;
3. Remove seal at top of *Whirl-Pak*®;
4. Using DMR stainless-steel wire-alligator clip sampling wand, attach *Whirl-Pak*® to sampling wand by clipping white tabs to alligator clips;
5. Dip *Whirl-Pak*® into water to the full depth of the stainless-steel sampling wand;
6. Allow wand to spring *Whirl-Pak*® open and drag wand through water until bag is filled;
7. Remove *Whirl-Pak*® from water and squeeze to displace enough water to allow a pocket of air at top of bag;
8. "Twirl" *Whirl-Pak*® several times (at least three) while holding end tabs to seal;
9. Fold end tabs together to secure closure;
10. Place bag in cooler with ice or ice packs to maintain sample at 4°C. during transport to DMR Water Quality lab within 12 hours of sample collection.
11. Record requisite information on sample collection data sheet.

*Note:* Samples can only be collected between Sunday 6AM and Thursday 10AM; ***no sample processing can occur from Thursday noon through Sunday before 6AM***.

The Maine DMR SOP for Water Sample Collection is included as Appendix IV. An example of a DMR decision on reclassification of a shellfish growing area based on stream flow sampling, discharge and dilution calculations and bacteria sampling is included as Appendix V.

## 6.0 Data updates and maintenance

Once a clear profile along a transect established at a known point along the stream for various flows and discharges, measurement of flow and depth at the Standard Measurement Location (SML) should be sufficient for discharge estimation. In such case, the depth needs to be determined using a measuring rod or stick or the recorded data from a depth logger, *e.g.* Onset HOBO U20 Water Level Data Logger http://www.onsetcomp.com/products/data-loggers/u20-001-01 to estimate flow and discharge. Data set maintenance would therefore require only a single flow and depth measurement and the collection of a single stream water sample for fecal coliform determination; a similar water sample would also need to be collected at the associated DMR Water Quality sampling station.

## 7.0 References

Maine DEP SOP for VRMP and FISQ, June 1, 2010. Appendix E: Guidelines and Procedures for Measuring Stream Velocity and Discharge (Flow) Using Price AA or Pygmy Flow Meters and then Computing Discharge (Flow), p 1-10.

Maine DMR SOP for Water Sample Collection, February 10, 2010, pages 43-54.

Rantz, S. E., and others. 1982. Measurement and Computation of Stream flow: Measurement of Stage and Discharge (Volume 1) and Computation of Discharge (Volume 2). US Geological Survey Water-Supply Paper 2175. http://pubs.usgs.gov/wsp/wsp2175/

US Geological Survey (USGS). 1989. Office of Surface Water Technical Memorandum No. 89.07. June 2, 1989. Policy to Ensure the Accurate Performance of Current Meters. Prepared by E. F. Hubbard. Accessed February 15, 2010 at http://water.usgs.gov/admin/memo/SW/sw89.07.html.

US Geological Survey (USGS). 1999. Office of Surface Water Technical Memorandum No. 99.06. June 2, 1999. Care and Maintenance of Vertical-Axis Current Meters. Prepared by T. H. Yorke. Accessed February 15, 2010 at http://water.usgs.gov/admin/memo/SW/sw99.06.html

# Appendix I

# Gurley Flow Meter
# Operation and Maintenance Guide

GPI

Gurley Precision Instruments

# Gurley Precision Instruments
# Hydrological Equipment

## Operation and Maintenance Guide

**The Company**

Gurley Precision Instruments was founded in 1845, and has sustained continuous operation to date at its original production facilities.  Since its inception as a manufacturer of compasses, surveying instruments and brass castings, the company has become a leader in the field of precision measuring instruments.  In April of 1968, the company became a division of Teledyne Incorporated, resulting in its ability to offer extensive experience and unusual depth of resources. Today, Gurley continues to uphold its long stood reputation for quality and progress in precision instruments.

**Company History**

| | |
|---|---|
| 1845 – 1968 | W & L.E. Gurley |
| 1968 – 1993 | Teledyne Gurley |
| 1993 – present | Gurley Precision Instruments |

**Genuine Gurley™**
*Precision Instruments since 1845*

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## Contents

## Overview of Guide

This manual contains complete instructions and illustrations for the assembly and maintenance of Gurley hydrological measuring equipment. Gurley Hydrological measuring outfits consist of three basic components: the meter (Price or pygmy), the suspension system (cable or rod), and the detector (headphone, Model 1100 digital flow indicator). These components must be properly assembled, maintained, and operated in order for the outfit to function as designed. Using the Hydrological Equipment Operation and Maintenance Guide, you can easily assemble, maintain and operate any measuring outfit configuration.

*How to use this guide*
The components of Gurley hydrological systems are modular in nature, so that you can assemble the outfit that best suits a particular site. To locate the instructions that pertain to the components of your outfit, see the detailed table of contents.

The guide is divided into five parts:

- Part 1 – Assembling the complete measuring system
- Part 2 – Maintaining Price and Pygmy Meters and Headphones
- Part 3 – Using the Model 1100 Digital Flow Velocity Indicator
- Part 4 – Converting Headphone Style Meters to Digital
- Part 5 – Repair Parts

Within the first four parts are sections that describe individual tasks or components. Part 5 contains parts listed for the equipment described. Rating tables are located immediately inside the back cover.

The step-by-step instructions for completing each task are accompanied by photographs of the equipment with parts clearly labeled. Instructions appear in the right-hand page, and illustrations on the facing left-hand page.



Because the assembly and maintenance operations are relatively simple, you may need to use these detailed instructions only once or twice. From then on, refer to the guide for seldom-performed procedures, to refresh your memory, or for part numbers. Its compact size means you can carry it with you in the field.

***Measurement procedures***
Price and pygmy meters satisfy U.S. Geological Survey requirements for Type AA current meters when used according to standard procedures. This guide does not include measurement procedures.

***Model Comparison Chart***

| **Model** | **Type** | **Status** |
|---|---|---|
| 622A | Price – headphone (analog) | Available |
| 622D | Price – digital | Available |
| 625A | Pygmy–headphone (analog) | Available |
| 625D | Pygmy – digital | Available |
| 645* | Pygmy - old digital | Replaced by 625D |
| 665* | Price – analog | Replaced by 622A and 622D |
| 667* | Price – analog | Replaced by 622A and 622D |
| 675* | Price – old digital | Replaced by 622D |
| 700 | Old style digital indicator | Replaced by 1100 indicator |

*Can be converted for use with the new model 1100 digital indicator.

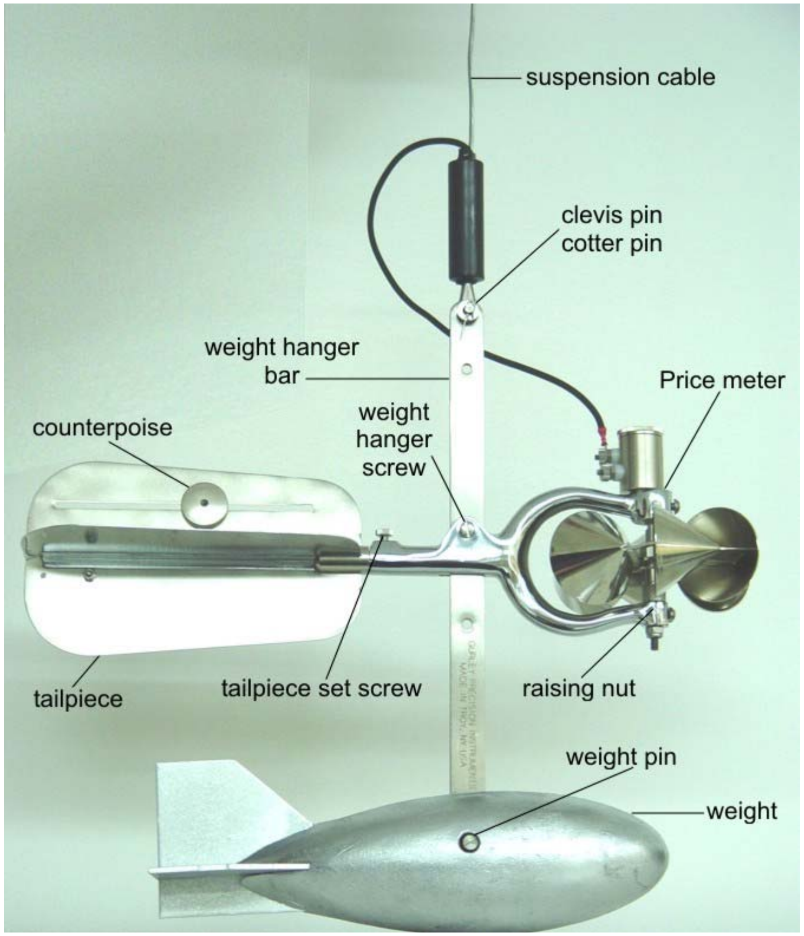
Replacement parts and service for most discontinued products is available.

**Part 1**
**Assembling the Complete Measuring System**

To assemble a complete measuring system, you must first assemble the suspension system (cable or wading rod), and then connect the electrical leads to the detector (headphones, Model 1100).

This part of the guide has two sections – one for a cable suspension system and one for a rod suspension system. Within each of these sections are instructions for assembling the system and for connecting the electrical leads to detectors.

***Model 622AE Shown***






## CABLE SYSTEM

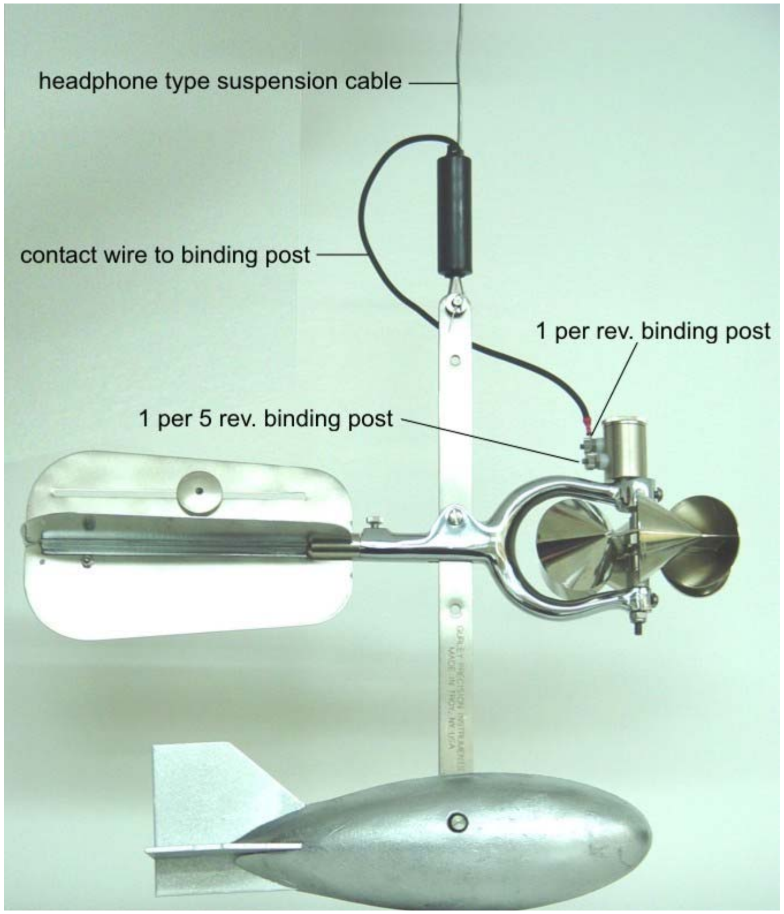
### Assembling the cable system (Model 622A or 622D Price Meter)

Use the following instructions to assemble both digital and headphone style cable systems and to attach a Price meter.

1. Remove cotter and clevis pins from the forked end of the 50-foot suspension cable.
2. The weight hanger bar has holes in both ends, one threaded, one not threaded. Align the unthreaded hole with the hole in the fork, insert the clevis pin and lock it in place with the cotter pin.
3. Remove Price current meter from case. Loosen the weight hanger screw, then slide the weight hanger bar down through the slot in the frame. Lock it in place at either of the two center holes using the weight hanger screw. NOTE: New outfits come with the cable already attached to the weight hanger bar.
4. Slide the free end of the weight hanger bar into the top of the lead weight. Lock it in place with the vane catch. Insert the tailpiece assembly into the end of the meter frame and lock it in place using the tailpiece set screw.
5. Assemble tailpiece sections by sliding the vanes together and locking them in place with the vane catch. Insert the tailpiece assembly into the end of the meter frame and lock it in place using the tailpiece set screw.
6. Elevate the knurled raising nut (directly beneath bucket wheel) to allow the bearing to ride on the pivot.

Turn to the next section for instructions on connecting your Price meter to a detection device.

***Model 622AE Shown***






**Connecting Electrical Leads to Headphones**

Use the following instructions to connect headphones to your cable-suspended Price meter.

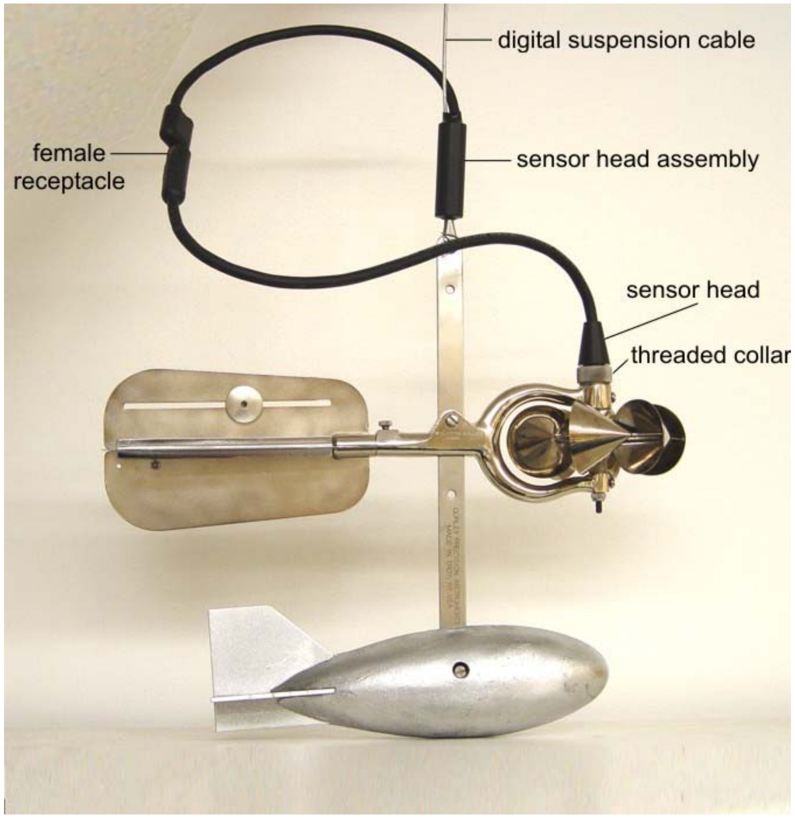
1. After the meter has been attached to the weight hanger bar, connect the spade terminal, located on the wire at the base of the suspension cable, to the desired binding post on the current meter. The upper binding post registers every fifth revolution.
2. Connect the headphone lead to the other end of the suspension cable using the male and female molded connectors.

Spinning the bucket wheel should now produce audible clicks in the headphones. If you do not hear clicks, do the following:

1. Check all electrical connections.
2. Replace the headphone battery. (See page 49)
3. Check the adjustment contact wire. (See page 31)

When using headphones with the Price meter, count the number of audible clicks over a known time period. This information can be converted to flow rate using the rating chart provided with the meter.

***Model 622DE Shown***






**Connecting electrical leads to the Model 1100 Digital Flow Velocity Indicator**

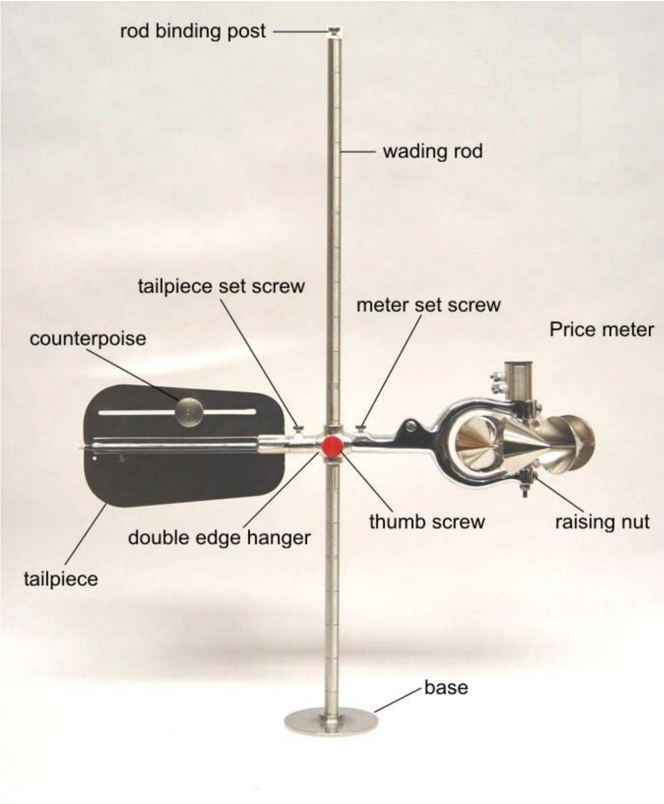
Use the following instructions to connect the Model 1100 Digital Flow Velocity Indicatory to your cable-suspended Price meter.

1. After attaching the meter to the weight hanger bar, remove the current meter cap and sensor head plug. Connect the sensor head to the rotor housing on the meter. Use the threaded collar to lock it in place.
2. Insert the male end of the sensor head cable assembly into the female receptacle at the base of the digital suspension cable.
3. Insert the four-pin connector at the top of the suspension cable into the female receptacle on the side of the Model 1100; align the grooves in the female connector with the ridges on the male connector. Lock it in place using the threaded collar. (page 18)
4. Turn on the Model 1100, and then press either of the 622 buttons once.

| To measure in these units: | Press this button: |
|---|---|
| feet per second | 622 FS |
| meters per second | 622 MS |

Spinning the bucket wheel should now produce a velocity reading in a few seconds. For detailed operating instructions, see Part 3, “Using the Model 1100 Digital Flow Velocity Indicator”, page 51.

*Model 622AF Shown*






## WADING ROD SYSTEM

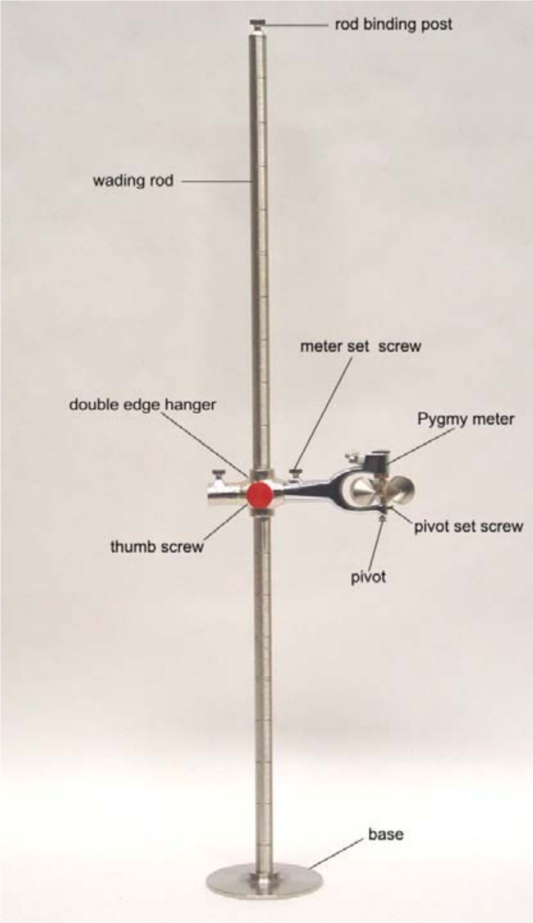
### Assembling the wading rod system (Model 622A or 622D Price meter)

Use the following instructions to assemble either a standard wading rod system or a top-setting rod and to attach a Model 622A or 622D Price meter.

1. For *standard rod systems*, screw the rod base onto the bottom rod section, which has a fine male thread at one end. For *top-setting rods*, simply screw the base onto the bottom of the rod.
2. Slide the double end hanger over the rod to the desired depth and lock it in place with slide thumb screw. On the *top-setting rod* the hanger is built into the rod. See
   instructions provided with the top-setting rod for assembly and use.
3. Remove current meter from case and mount it on the hanger post. Lock it in place using meter set screw.
4. Assemble the tailpiece by sliding the vanes together and locking them in place with the vane catch. Mount the tailpiece assembly on the hanger and lock it in place by tightening the set screw. Elevate the raising nut to allow the bearing to ride on pivot.
5. *Standard rod*. Add rod sections as required, then screw the rod binding post into top of the uppermost section.

Turn to the next section for instructions on connecting your meter to a detection device.

***Model 625AF Shown***



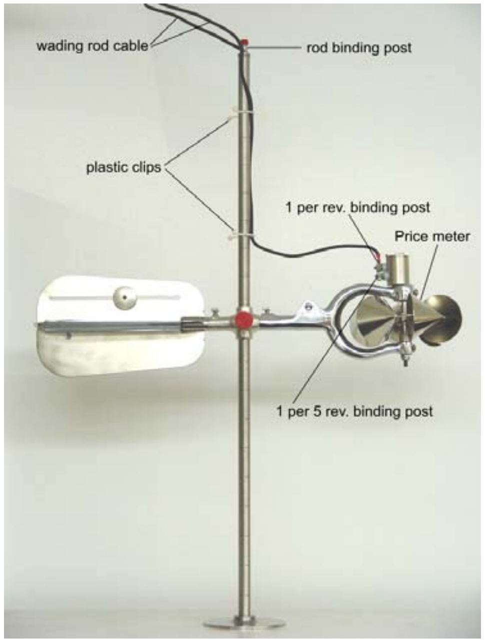


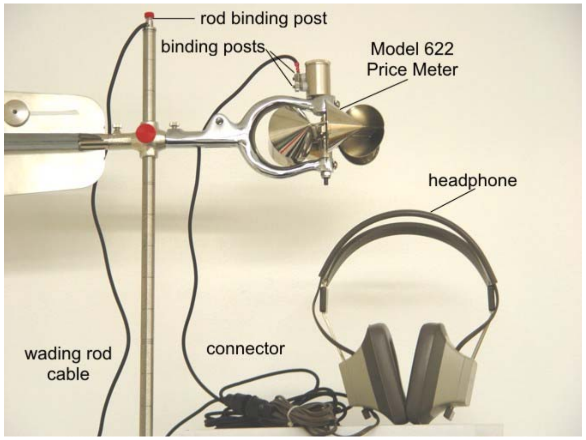

**Assembling the wading rod system**
**(Model 625A and 625D pygmy meter)**

Use the following instructions to assemble either a standard wading rod system or a top-setting rod and to attach a Model 625A and 625D pygmy meter.

1. For *standard rod systems*, screw the rod base onto the bottom rod section, which has a fine male thread at one end. For *top-setting rods*, simply screw the base onto the bottom of the rod.
2. Slide the double end hanger over the rod to the desired depth and lock it in place with the slide thumb screw. On the *top-setting rod* the hanger is built into the rod. Refer to instructions provided with the top-setting rod for assembly and use.
3. Remove the Model 625A pygmy meter from case.
4. Remove the shipping pivot and install the working pivot. Face the contact chamber cap down, loosen the pivot set screw, and remove the shipping pivot. Insert the working pivot with the flat side of the shaft facing the set screw. Tighten the set screw. The bucket wheels should spin freely. (Detailed instructions for adjusting the pivot are found on page 39). New units are shipped with two factory adjusted working pivots.
5. Mount the meter on the double-end hanger post and lock it in place using the meter set screw.
6. *Standard rod*. Add rod sections as required, then screw the rod binding post into the top of the uppermost section.

Turn to the next section for instructions on connecting your meter to a detection device.






**Connecting electrical leads to headphones**

Use the following instructions to connect headphones to your rod-suspended Price or pygmy meter.

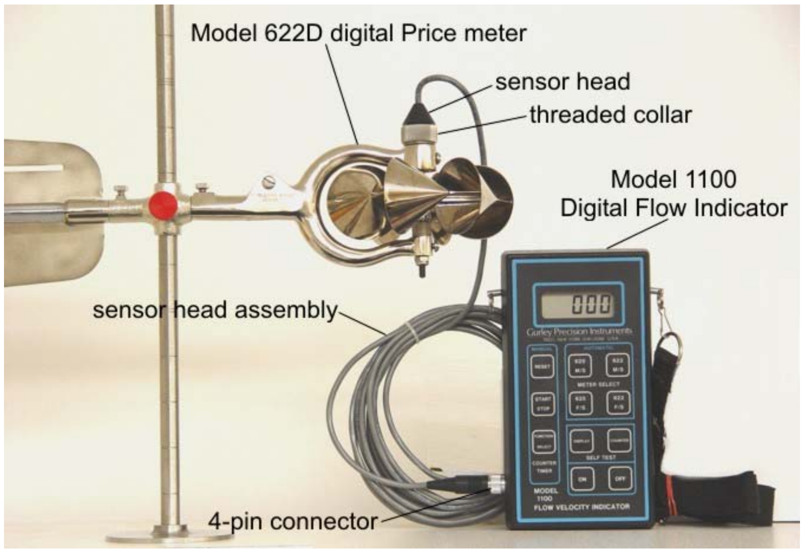
1. Connect the long lead of the wading rod cable to the appropriate meter binding post. The *Price meter* has two binding posts. The upper binding post registers every revolution, the lower post every fifth revolution. The single binding post of the *pygmy meter* registers every revolution.
2. Loosen the set screw on the rod binding post. Insert the short lead of the cable into the hole in the binding post, and lock it in place by tightening the set screw.
3. Connect the headphone lead to the other end of the cable using the male and female molded connectors.Fasten the cable to the rod using plastic clips.

Spinning the bucket wheel should now produce audible clicks in the headphones. If you do not hear clicks, do the following:

1. Check all electrical connections.
2. Replace the headphone battery. (See page 49)
3. Check the adjustment of the contact wire. (See page 31 or 43)

When using the headphones with the Price or pygmy meters, count the number of clicks from the meter over a known time period. This information can be converted to flow rate using the rating chart provided with the meter.

***Model 622DF Shown***






**Connecting electrical leads to the Model 1100 Digital Flow Velocity Indicator**

Use the following instructions to connect the Model 1100 Digital Flow Velocity Indicator to your rod-suspended digital Price or pygmy meter.

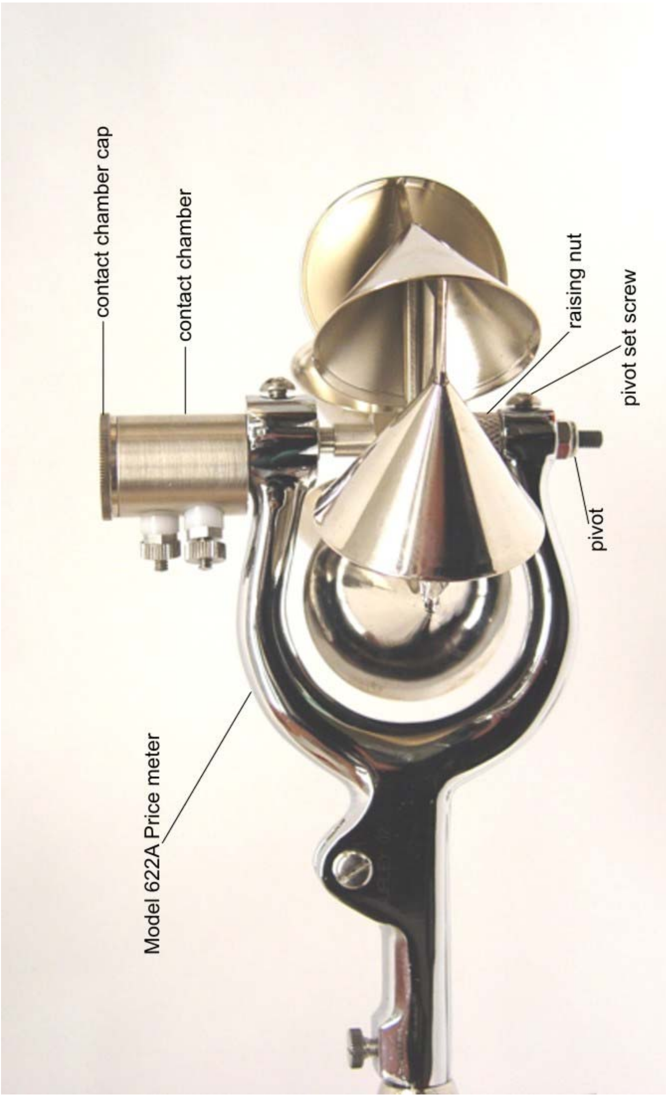
1. Remove the protective caps from the rotor housing on the meter and the sensor head on the cable.
2. Connect the sensor head on the digital wading rod cable to the rotor housing on the digital Price or pygmy meter. Use the threaded collar to lock it in place.
3. Insert the four-pin connector at the other end of the cable into the female receptacle on the side of the Model 1100; align the grooves in the female receptacle with the ridges on the male connector. Lock it in place using the threaded collar.
4. Turn on the Model 1100, and then press the appropriate meter/units button once.

| To use this type of meter: | And measure in these units: | Press this button: |
|---|---|---|
| Price 622 | feet per second | 622 FS |
| Price 622 | meters per second | 622 MS |
| pygmy 625A | feet per second | 625 FS |
| pygmy 625A | meters per second | 625 MS |

Spinning the bucket wheel should produce a velocity reading on the display within four seconds. For detailed operating instructions see Part 3, “Using the 1100 Digital Flow Velocity Indicator”, page 51.

## Part 2
## Maintaining Price and Pygmy Meters and Headphones

Your price meters will give you years of accurate readings if you maintain them properly.  This part of the guide contains one section for Price meter maintenance and one for pygmy meter maintenance.  An additional section describes how to replace the battery in the headphones.






**PRICE METER**

**Cleaning and lubricating the meter**

To ensure proper operation, the current meter must be cleaned and lubricated at the end of each day's use.  Complete the following instructions to clean and lubricate your Price meter.

1. Remove the contact chamber map.
2. Loosen the pivot set screw and remove the pivot,.
3. Clean and dry the pivot with a soft cloth.  Set it aside.
4. Clean the lower bearing with a small pointed stick or a cotton swab.
5. Hold the current meter with the contact chamber up.  Place a small drop of oil in the bearing, insert the pivot with the flat side of the shaft toward the set screw, and lock it in place using the pivot set screw.
6. Hold the current meter with the contact chamber up.  Oil the top of the shaft, steady bearing, worm and gear, as well as the gear bearing.
7. Replace the chamber up.

Follow this procedure after each use to help prevent rust.  If the meter is to be stored for extended periods of time, cover the pivot and bearing with grease.

NOTE: After cleaning and lubricating the meter at the end of each day's use, lower the raising nut under the bucket wheel assembly to take pressure off the pivot.

**Adjusting the pivot**
**(Model 622A Price Meter, headphone style)**

Use the following instructions to adjust the pivot on your headphone style Price meter.

1. With the contact chamber tightly in place, invert the current meter so that the top of the shaft rests against the inside of the cap.
2. Loosen both the nut on the bottom of the pivot and the set screw. With the flat side of the shaft facing the pivot set screw, insert pivot until there is no vertical play in the shaft. Lock it in place using the vertical set screw.
3. Advance the pivot-adjusting nut until it rests against the frame.
4. Loosen the set screw slightly and advance the pivot-adjusting nut one quarter of a turn, making sure the pivot us not turning. Tighten the set screw.

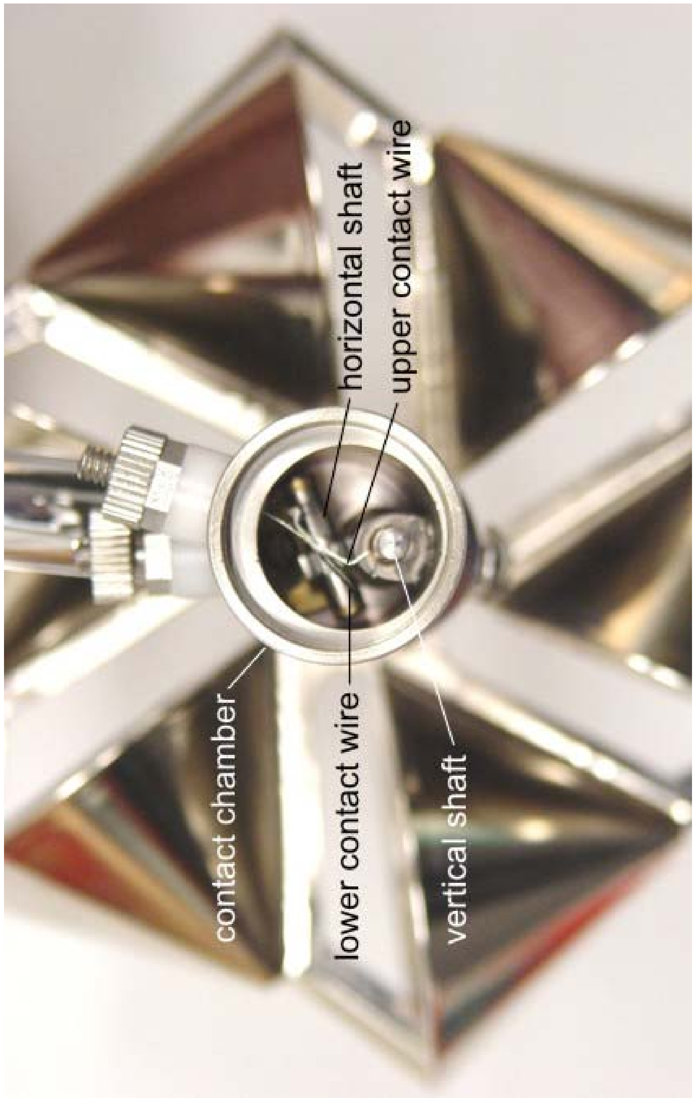
This adjustment provides an endplay of about 0.008-inch. *It is essential that this adjustment be made when replacing a pivot.*

**Adjusting the pivot**
**(Model 622D Price Meter, digital style)**

Use the following instructions to adjust the pivot on your digital style Price meter.

1. Invert the current meter so that the shoulder of the hub extension rests against the bottom of the rotor housing.
2. Loosen both the nut on the bottom of the pivot and the set screw. Insert the pivot into the lower bearing with the flat side facing the pivot set screw, until there is no vertical play in the hub extension. Lock it in place using the set screw.
3. Advance the pivot adjusting nut until is rests against the frame.
4. Loosen the set screw slightly and advance the adjusting nut one quarter of a turn, making sure the pivot does not turn. Tighten the set screw.

This adjustment provides an endplay of about 0.008 inch. *It is essential that this adjustment be made when replacing a pivot*



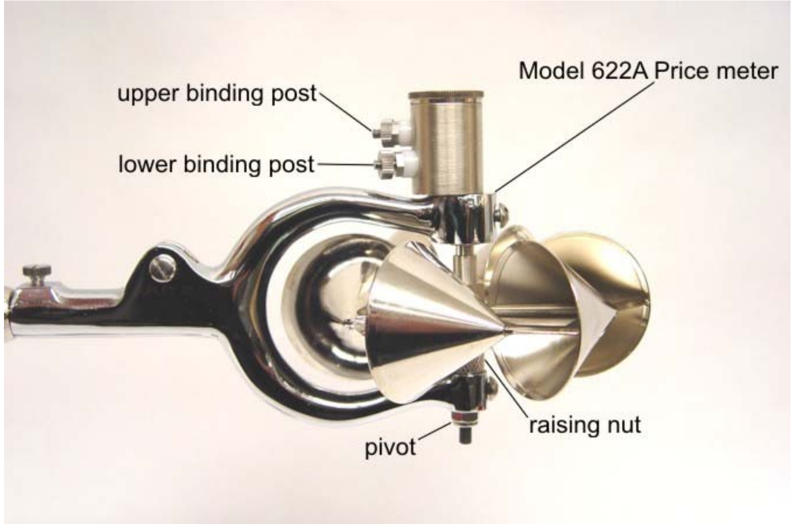


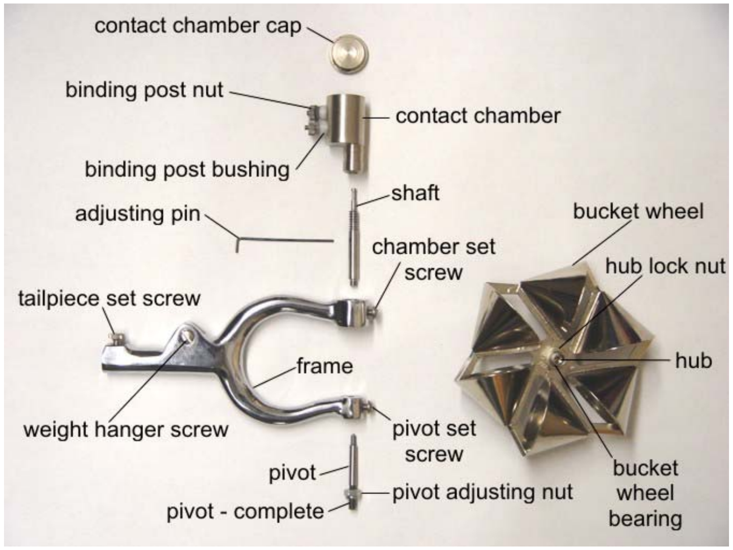

**Adjusting the contact wire**
**(Model 622 Price meter, headphone style)**

The contact wire should make light contact with the shaft. If pressure is too heavy, drag and wear of the shaft and wire will result. Use the following instructions to adjust the contact wire on your headphone style Price meter.

1. Assemble the meter and headphones, as described in Part 1 of this guide. (See page 7).
2. Spin the bucket wheel. Clicks should be sharp, with no dragging sound.
3. Remove the contact chamber cap. There are two contact wires in the Price meter. The wire on the vertical shaft produces one pulse per revolution of the bucket wheel. The contact wire on the horizontal shaft produces one pulse for every five revolutions of the bucket wheel. The wires must be gently adjusted to give proper signal.
4. The contact wire on the horizontal shaft is the lower contact wire. On the shaft you will see a contact lug. Use tweezers to adjust the wire so that it touches the raised lug lightly but does not touch the shaft when the raised lug is rotated.
5. The vertical shaft also has a raised lug. Adjust this contact wire to touch the lug lightly.
6. Replace contact chamber cap when finished.

With proper adjustment of pivot and contact wire, the bucket wheel should spin freely.





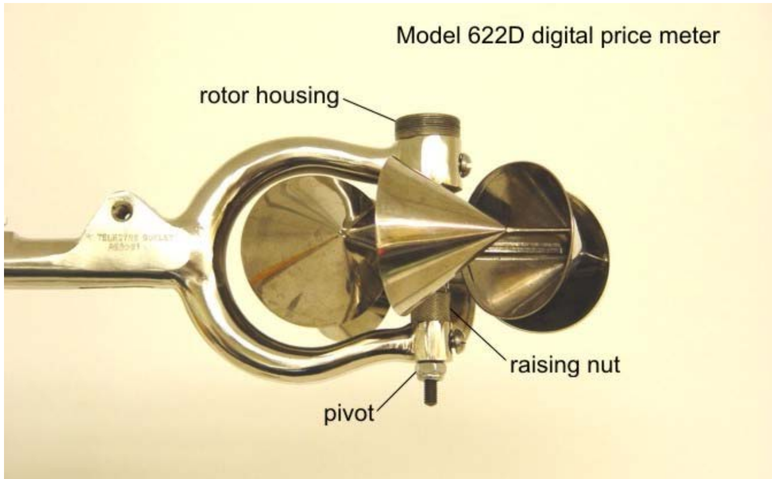

**Disassembling the meter**
**(Model 622A Price meter, headphone style)**

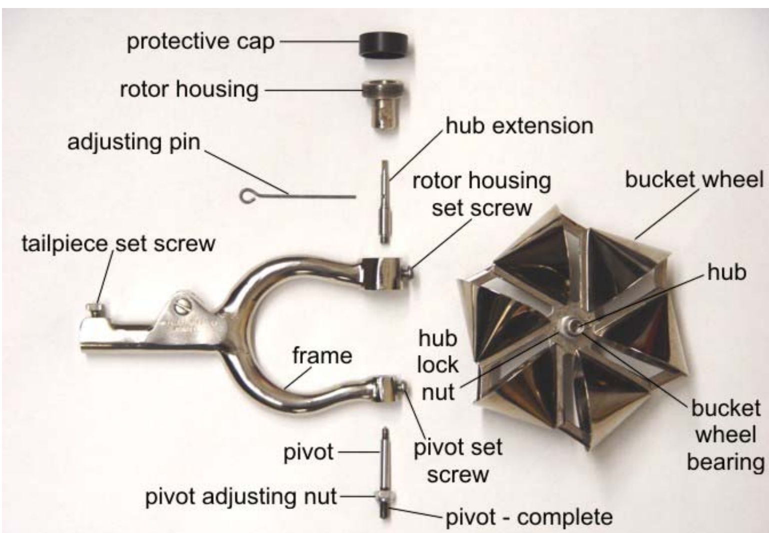
Although we recommend that damaged instruments be serviced at the factory, most parts can be replaced in the field.

Use the following instructions to disassemble your headphone style Price meter.

1. Remove the contact chamber map.
2. Loosen the set screws on the pivot and the contact chamber.
3. Remove the pivot.
4. Gently pull and twist to remove the contact chamber.
5. Raise the bucket wheel until the hole in the shaft is visible. Insert the adjusting pin or a nail and turn it counter-clockwise to loosen. Remove the shaft.
6. Remove the bucket wheel from the frame.
7. Remove the hub assembly from the bucket wheel by removing the hub lock nut. NOTE: Do this only if replacing the hub bearing or the bucket wheel. We recommend you return the hub assembly to the factory if bearing replacement is necessary.

Reassemble the meter by reversing the above steps.





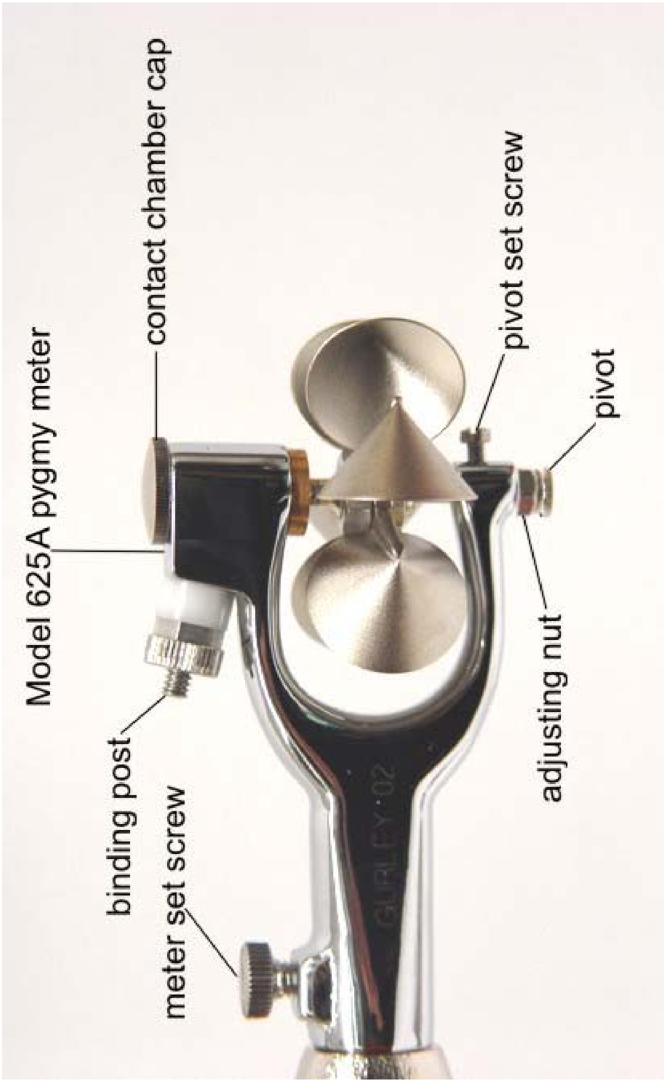

**Disassembling the meter**
**(Model 622D Price meter, digital style)**

Although we recommend that damaged instruments be serviced at the factory, most parts can be replaced in the field.

Use the following instructions to disassemble your digital Price meter.

1. Loosen the pivot set screw.
2. Remove the pivot assembly.
3. Loosen the rotor housing set screw.
4. Remove the rotor housing.
5. Raise the bucket wheel until the hole in the hub extension is visible. Place the adjusting pin or a nail through the hole and turn the hub extension counter-clockwise to loosen it. Remove the hub extension.
6. Remove the bucket wheel from the frame.
7. Remove the hub assembly from the bucket wheel by removing the hub lock nut. NOTE: Do this only if replacing the hub bearing or the bucket wheel. We recommend that you return the hub assembly to the factory if bearing
   replacement if necessary.

Reassemble the meter be reversing the above steps.






**PYGMY METER**

**Cleaning and lubricating the meter**

To ensure proper operation, the current meter must be cleaned and lubricated at the end of each day's use. Complete the following instructions to clean and lubricate your pygmy meter.

1. Remove the contact chamber cap.
2. Loosen the pivot set screw and remove the pivot assembly.
3. Clean and dry the pivot with a soft cloth. Set is aside.
4. Clean the lower bearing with a small pointed stick or a cotton swab.
5. Hold the meter with the contact chamber down. Place a small drop of oil in the bearing, insert the pivot and lock it in place using the set screw.
6. Replace the contact chamber cap.

Follow this procedure after each use to help prevent rust. If the meter is to be stored for extended periods of time, cover the pivot and bearing with grease. Clean and lubricate as above prior to use.

NOTE: After cleaning the meter at the end of each day's use, we recommend removing the working pivot and installing the shipping pivot to prevent pivot damage.

**Adjusting the pivot**
**(Model 625A pygmy meter, headphone style)**

Use the following instructions to adjust the pivot on your headphone style pygmy meter.

1. With the contact chamber cap tightly in place, invert the current meter.
2. Loosen the pivot-adjusting nut and the pivot set screw. Insert the pivot into the lower bearing with the flat side facing the pivot set screw, until there is no vertical play in the shaft. Lock it in place using the set screw.
3. Advance the pivot adjusting nut until it rests against the frame.
4. Loosen the set screw slightly and advance the pivot adjusting not one quarter of a turn, making sure the pivot is not turning. Tighten the set screw.

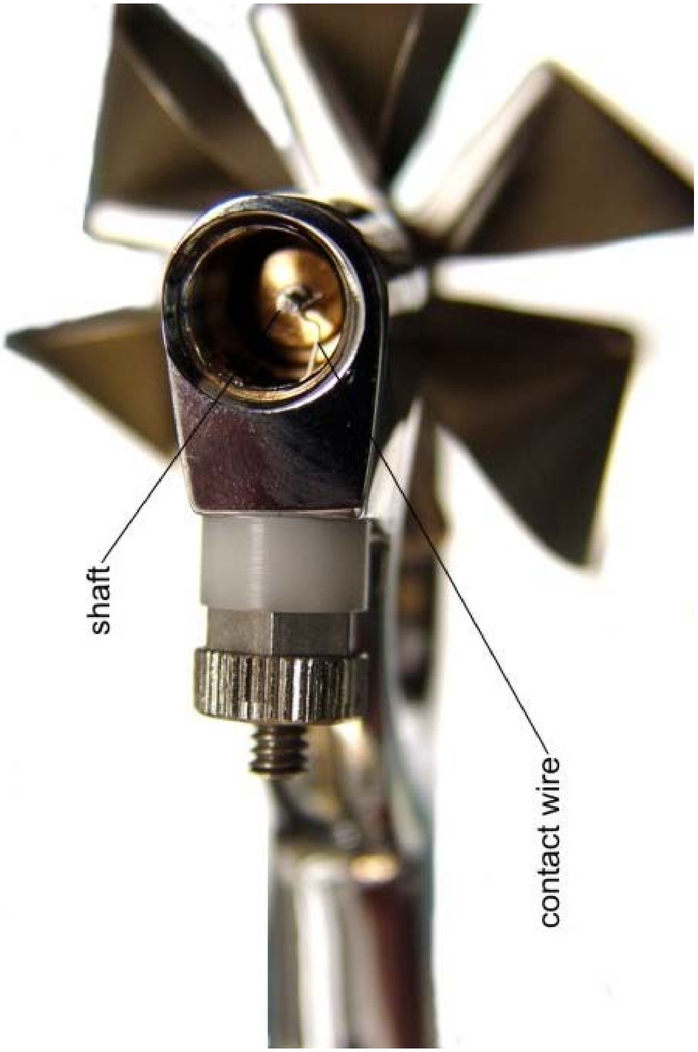
This adjustment provides an endplay of about 0.008 inch. *It is essential that this adjustment be made when replacing a pivot.*

**Adjusting the pivot**
**(Model 625D pygmy meter, digital style)**

Use the following instructions to adjust the pivot on your digital style pygmy meter.

1. Invert the current meter so that the shoulder of the hub extension rests against the bottom of the rotor housing.
2. Loosen the pivot-adjusting nut and the pivot set screw. Insert the pivot into the lower bearing with the flat side facing the pivot set screw, until there is no vertical play in the hub extension. Lock it in place using the set screw.
3. Advance the pivot-adjusting nut until it rests against the frame.
4. Loosen the set screw slightly and advance the adjusting nut one quarter of a turn, making sure the pivot does not turn. Tighten the set screw.

This adjustment provides and endplay of about 0.008 inch. *It is essential that this adjustment be made when replacing a pivot.*



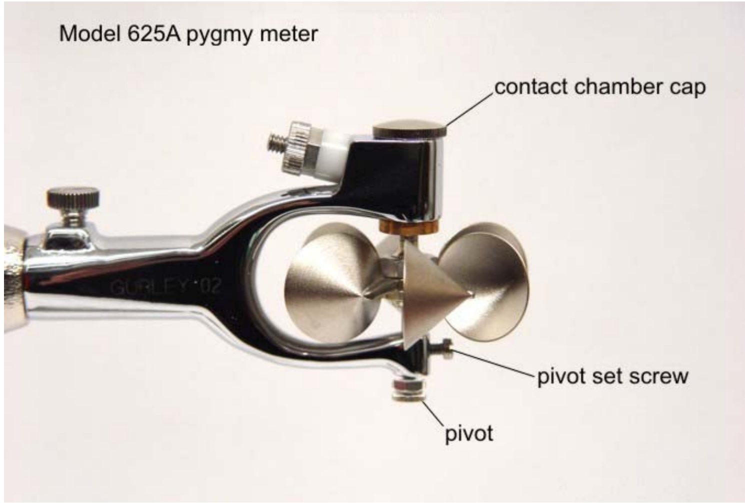


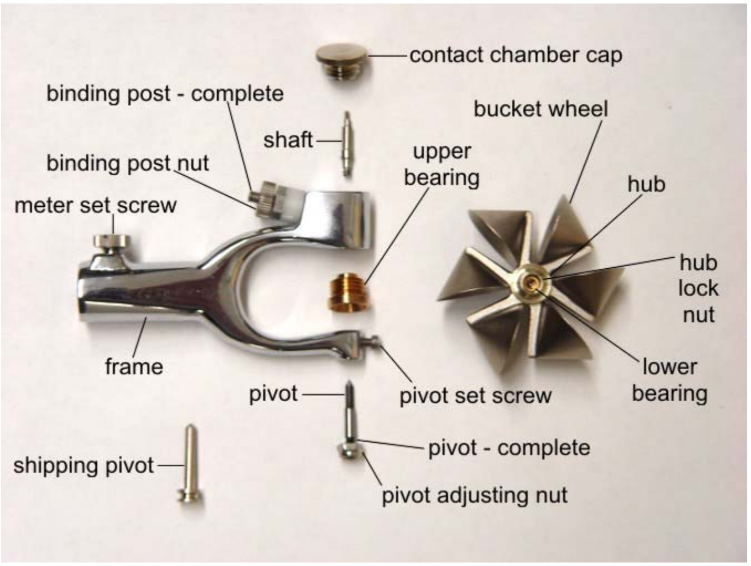

**Adjusting the contact wire**
**(Model 625A pygmy meter, headphone style)**

The contact wire should make light contact with the shaft. If pressure is too heavy, drag and wear of the shaft and wire will result. Use the following instructions to adjust the contact wire on you headphone style pygmy meter.

1. Assemble the meter and headphones as described in Part 1 of this guide.
2. Spin the bucket wheel. Clicks should be sharp, with no dragging sound.
3. Remove the contact chamber cap.
4. Inside the contact chamber there is a vertical shaft with a raised contact lug. With tweezers, gently adjust the contact wire so that it lightly touches the lug but does not touch the shaft when the lug is rotated.
5. Replace the contact chamber cap when finished.

When the pivot and contact wire are properly adjusted, the bucket wheel should spin freely.





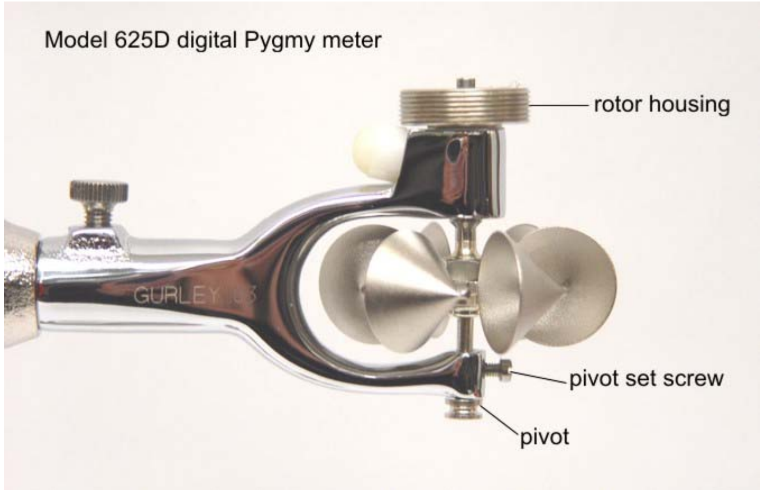

**Disassembling the meter**
**(Model 625A pygmy meter, headphone style)**

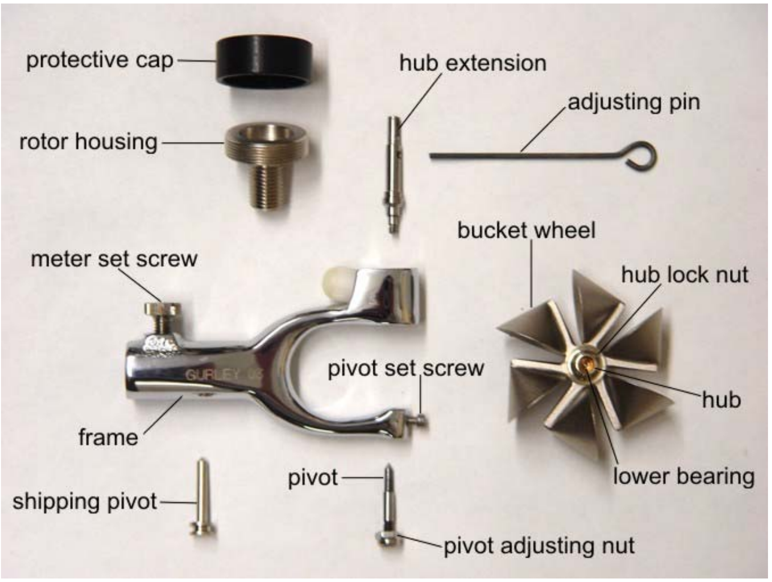
Although we recommend that damaged instruments be serviced at the factory, most parts can be replaced in the field.

Use the following instructions to disassemble your headphone style pygmy meter.

1. Remove the contact chamber cap.
2. Loosen the pivot set screw and remove the pivot assembly.
3. The shaft has opposing flat sides directly above the bucket wheel hub. Carefully turn the shaft counter clockwise using needle-nose pliers on these flats. Remove the shaft.
4. Remove the bucket wheel from the frame.
5. Remove the upper bearing from the frame by unscrewing it.
6. Remove the hub assembly from the bucket wheel by removing the hub lock nut. Do this only if replacing the hub, bearing or bucket wheel. We recommend you return the hub assembly to the factory if bearing replacement is necessary.

Reassemble the meter by reversing the above steps.






**Disassembling the meter**
**(Model 625D pygmy meter, digital style)**

Although we recommend that damaged instruments be serviced at the factory, most parts can be replaced in the field.

Use the following instructions to disassemble your digital style pygmy meter.

1. Remove the rotor housing.
2. Loosen the pivot set screw and remove the pivot.
3. Use the adjusting pin to remove the hub extension from the bucket wheel.
4. Remove the bucket wheel.
5. Remove the hub assembly from the bucket wheel by removing the hub lock nut. Note: Do this only if replacing the hub bearing or bucket wheel. We recommend that you return the hub assembly to the factory if bearing replacement is necessary.

Reassemble the meter by reversing the above steps.




## HEADPHONES

### Replacing the battery

Use the following instructions to replace the battery in your headphones.

1. Disconnect the earphone cable from the suspension cable or the rod cable.
2. Remove the plastic earpiece cushion from the earpiece that does not have the cable entering it.
3. Insert a small flathead screw driver in the groove on the right side of the earpiece and gently pop the cover off the earpiece. Do not pull on the cover, or you may break the soldered connections.
4. Using the screw driver, gently pry the battery out of the battery holder.
5. Insert a new, type N battery in the battery holder. You may insert the battery in either direction.
6. Replace the earpiece cover by inserting the left side of the cover into its grooves and then pressing the right side into place.
7. Replace the plastic earpiece cushion.
8. Connect the earphone cable to the suspension cable or the rod cable.

Spinning the bucket wheel should now produce audible clicks in the headphones.

**Part 3**
**Using the Model 1100 Digital Flow Velocity Indicator**

The Model 1100 Digital Flow Velocity Indicator attaches to either your Price or pygmy meter to quickly give you accurate current measurements.

This part of the guide contains three sections on how to use the Model 1100. The first section describes the panel of the Model 1100 and defines the function of each button. The second section describes the Model 1100's self-test functions. The last section describes how to operate the Model 1100 in each of its three modes – automatic, averaging, and manual.




### Understanding the Panel Functions

The following table describes the panel functions of the Model 1100 Digital Flow Velocity Indicator.

| Item | Description |
|---|---|
| 1 | Power on button. Push to turn it on. |
| 2 | Power off button. Push to turn it off. |
| 3 | Display self-test button. Push to start self-diagnostics of display and internal electronics. |
| 4 | Counter self-test button. (Can be used only after display self-test). Push to start counter test. |
| 5 | 625A MS Button. Push to start automatic velocity readout using pygmy 625A type meter with units in meters per second. |
| 6 | 622 MS Button. Push to start automatic velocity readout using Price 622 type meter with units in meters per second. |
| 7 | 625A FS Button. Push to start automatic velocity readout using pygmy meter with units in feet per second. |
| 8 | 622 FS Button. Push to start automatic velocity readout using Price 622 type meter with units in feet per second. |
| 9 | Reset Button. Push to initiate manual mode and reset internal counter and timer. |
| 10 | Start/Stop Button. After reset, push to start event counter and timer. Push a second time to stop event counter and timer. |
| 11 | Function Select Button. Push to select the display of event counter (revolutions) or event timer (elapsed time in seconds). Can be pushed at any time without affecting event timer or counter. Continued pushing of the button toggles between revolutions and seconds. |
| 12 | Three digit display. (For seconds, revolutions, or velocity.) |
| 13 | 622 Display. Visible whenever the unit is in the 622 automatic or averaging mode. |
| 14 | 625 Display. Visible whenever the unit is counting in meters per second. |
| 15 | F/S Display. Visible whenever the unit is counting in feet per second. |
| 16 | M/S Display. Visible whenever the unit is counting in meters per second. |
| 17 | AVE Display. Visible whenever the unit is in averaging mode. |
| 18 | BAT Display. Flashes on and off when battery voltage is low and battery should be replaced. Unit has a few hours of operation remaining when this warning commences. |
| 19 | SEC Display. Visible whenever the unit is in the manual mode and the Function Select button is set to display elapsed time (seconds). |
| 20 | REV Display. Visible whenever the unit is in the manual mode and the Function Select button is set to display revolutions. |
| 21 | Connector for Price model 622 or pygmy model 625 meter with opto-electronic sensor pickup. |

**Performing a self-test**

The Model 1100 Digital Flow Velocity Indicator has built-in diagnostics to ensure proper operation of the unit. The diagnostics are performed in two stages: (1) operation of micro-controller/display and (2) operation of signal conditioning/counter. Complete the following instructions to perform a self-test on your Model 1100.

1. Disconnect any metering unit (622D or 625D) from the Model 1100 Indicator.
2. Press the ON button. Display will read 000.
3. Press the DISPLAY button to begin the first stage of the self-test. NOTE: COUNTER button has no action until display button has been pressed and the unit has completed its sequence of test. After pressing DISPLAY button, each digit of the display will count from 0 to 9, beginning with the right digit, ending with the display at 999. Next, all of the display messages, except BAT, will be visible for approximately 3 seconds, then the display returns to 999.
4. If desired, self-test mode can be cancelled at this time to enter another mode. To do so, press the OFF button. To begin the second stage of the self-test, press the COUNTER button. The counter will now begin incrementing the display at a rate of one count per second.
5. Compare the display count rate against an accurate watch for the appropriate count rate. If they are in agreement, the Model 1100 has passed its diagnostics.
6. To leave this counting mode, press the OFF button.
7. If problems persist, try substituting a different meter unit, or replace the battery.

If the voltage of the battery is low, the BAT display message will flash on and off. At this point, the unit will still have a few hours of service left. However, failure to replace the battery will result in erratic or no operation of the unit.

To replace the battery, remove the battery cover located on the rear of the Model 1100 case. Insert a new 9VDC battery and replace cover.

## Operating the Model 1100

### Automatic mode

For quick and convenient readings of flow velocity, the Model 1100 provides automatic velocity computation for the 622D and 625D meters in both feet per second and meters per second. To operate your Model 1100 in the automatic mode, use the following instructions.

1. Connect the Price 622D Meter (or pygmy 625D) to the Model 1100 Indicator using the connector on the side of the Model 1100.
2. Press the ON button.
3. Press a meter select button once to indicate the type of meter being used and the desired units (e.g. 622 MS or 625 FS). NOTE: After pressing the button, the display will go to 000 and the type of meter and units selected will be shown on the display.
4. Every four seconds the display will be updated showing the flow velocity.

### Averaging Mode

An averaging feature is incorporated into the Model 1100 to smooth out flow velocity variations. To operate your Model 1100 in the averaging mode, use the following instructions.

1. Connect the price 622D Meter (or pygmy 625D) to the Model 1100 Indicator using the connector on the side of the Model 1100.
2. Press the ON button. Display will read 000.
3. Press a meter select button twice to indicate the type of meter being used and the desired units (e.g., 622 FS or 625A MS). NOTE: After pressing the button twice, the display will go to 000 and the type of meter, units selected, and AVE will be shown on the display.
4. Every sixteen seconds the display will be updated showing the flow velocity averaged over four of the standard automatic samples. NOTE: Press the meter select button again to toggle the meter between standard and average modes.



### Manual mode

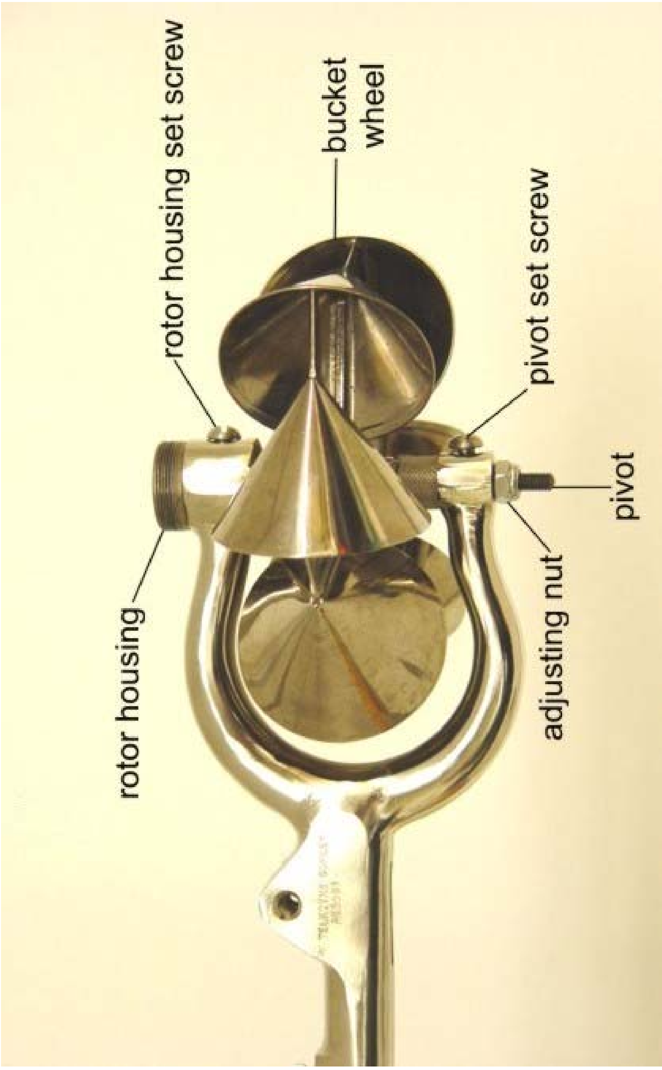
Where longer sampling periods are needed due to very low velocity, or if a higher degree of accuracy is required, we recommend that you use the manual operating mode and the rating tables to determine the flow rate. To operate your Model 1100 in the manual mode, use the following instructions.

1. Connect the Price 622D meter (or pygmy 625D) to the Model 1100 Indicator using the connector on the side of the Model 1100.
2. Press ON button.
3. Press RESET button to enter manual mode of operation.
4. When ready to begin counting revolutions and elapsed time, press the START/STOP button once.* NOTE: At this time the indicator will begin counting revolutions and elapsed time. The display will show the elapsed time in seconds. To display the number of revolutions, press the FUNCTION SELECT button once. The display will show REV and the number of complete revolutions counted. Pressing the FUNCTION SELECT button causes the display to toggle between elapsed time and revolutions.
5. To stop counting and freeze elapsed time, press the START/STOP button a second time. The elapsed time and number of revolutions will be stored and can be read by using the FUNCTION SELECT button to toggle between elapsed time and revolutions. Determine the flow rate using this information and the rating table included with the meter.
6. To take another measurement, press the RESET button and repeat steps 4 and 5.

* The Model 1100 will begin actual counting of rotations and seconds when the metering unit has rotated past the first input pulse.

## Part 4
## Converting Headphone Style Meters to Digital

Headphone style Price and pygmy meters can be converted to digital meters using conversion kits available from Gurley.





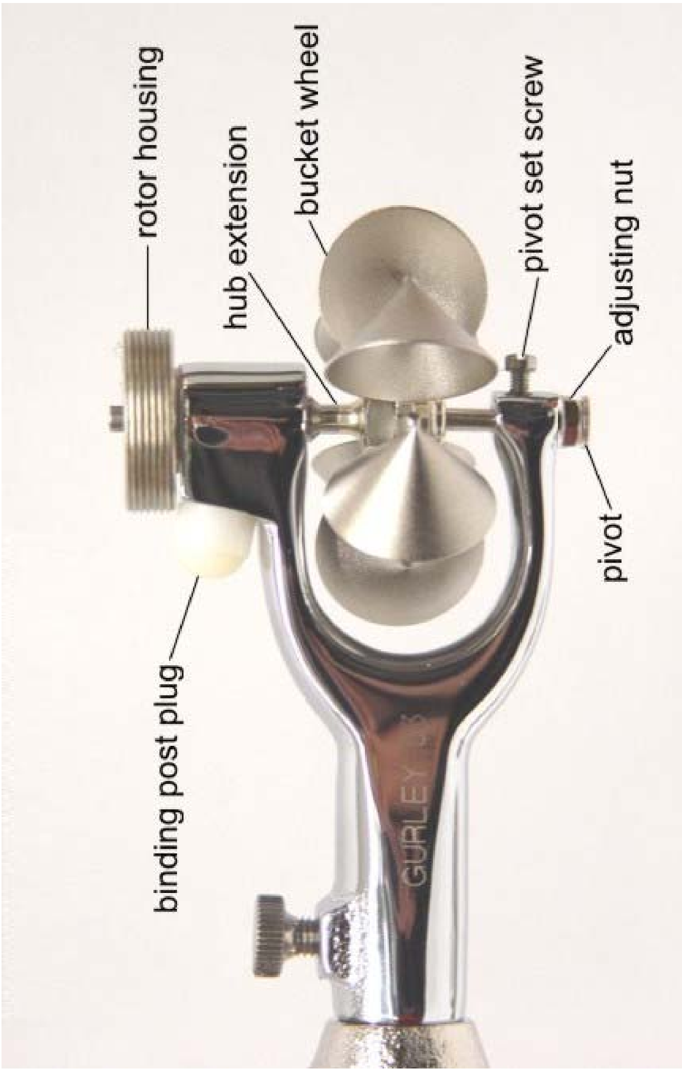

**Converting the Price 622-AA meter**

Use the following instructions to convert a Price headphone style meter to a digital meter.

1. Loosen the screw holding the contact body chamber and remove the chamber by gently pulling and twisting.
2. Unscrew the shaft, remove from the bucket wheel.
3. Screw the hub extension from the conversion kit into the bucket wheel. Lift the bucket wheel to expose the through hole on the shaft; place adjusting pin or nail through this hole to tighten.
4. Place the rotor housing supplied with the conversion kit into the top of the frame with the hub extension through the center of the housing. The flat side of the rotor housing should face the set screw. Tighten the set screw.
5. Adjust the pivot (see page 29).

Conversion complete.

To use the digital Price meter, attach the sensor head assembly to the rotor housing. See page 9 for suspension type applications or page 19 for wading rod applications. NOTE: Screw the protective cover on the rotor housing and sensor head when the meter is not in use.






**Converting the pygmy 625A meter**

Use the following instructions to convert a pygmy headphone style meter to a digital meter.

1. Unscrew the binding post assembly from the frame.
2. Loosen the pivot set screw and remove the pivot assembly.
3. Remove the contact chamber map.
4. Remove the shaft from the bucket wheel.
5. Remove the bucket wheel from the frame. (If the bucket wheel will not slide out, try rotating it to another position.)
6. Remove the upper bearing from the frame.
7. Place the bucket wheel in position in the frame.
8. Screw the hub extension from the conversion kit into the bucket wheel. Insert the adjusting pin through the hole to tighten.
9. Screw the rotator housing from the conversion kit into the top of the frame.
10. Reinstall the pivot assembly with the flat side of the shaft toward the set screw. Tighten the set screw.
11. Screw in the binding past plug.
12. Adjust the pivot. (See page 41)

Conversion complete.

To use the digital pygmy meter, attach the sensor head assembly to the rotor housing. See page 19. NOTE: Screw the protective cover onto the meter housing and the sensor head when the meter is not in use.

**Caring for the opto-sensor assembly**

When finished using the meter, remove the detector assembly and dry the chamber and detector assembly with a soft cloth. Cover the chamber and detector assembly with the cap and plug provided.

**Part 5**
**Repair Parts**

Specifications and part numbers subject to change without notice.

## WADING ROD SETS

| Number | Description |
| --- | --- |
| 627E | English rod set, Price and pygmy meter – 8 feet |
| 627M | Metric rod set, Price and pygmy meter – 2 feet |
| 627F | English rod set, Price meter – 6 feet |
| 299-309 | English top setting rod – 4 feet |
| 299-309-2 | English top setting rod – 6 feet |
| 299-309-3 | English top setting rod – 8 feet |
| 299-309-5 | Metric top setting rod – 1 meter |
| 299-309-6 | Metric top setting rod – 2 meters |

All 627 rod sets include: 233-17 case, 24674 double end hanger and appropriate wading rod base.

## WADING ROD PARTS AND ACCESSORIES

| Number | Description | Page |
| --- | --- | --- |
| AXO4239 | Plastic cable clips (set of 8) | 19 |
| 427 | Binding post | 15 |
| 233-71 | Canvas case | |
| 24674 | Double-end hanger | 15 |
| 28962 | Rod base – Price or pygmy | 15 |
| 32963 | 24” intermediate section | |
| 32956 | ½ meter intermediate section | |
| 32957 | ½ meter bottom section – Price or pygmy | |
| 32958 | 24” Bottom section – Price or pygmy | |

## BATTERIES

| Number | Description | Page |
|---|---|---|
| 279-204 | Dry cell no. 711, 1.5 volts (earphones prior to 1990) | |
| AX03876 | 9 volts for 1100 indicator | |
| AX04083 | Type N, 1.5 volts (headphones from 1990) | 49 |

## CABLE SUSPENSION EQUIPMENT
### Cables

| Number | Description | Page |
|---|---|---|
| DX00762N | 50' rubber and steel cable –digital model replaces DX00676 and combinations of 34623 and DX00621 cables) | 11 |
| DX00763N | 50' rubber and steel cable – headphone model (replaces DX00677 and combinations of 440 | 9 |

Both cables above come with a 395 weight hanger bar.
Additional lengths and special cables available upon request.

### Parts

| Number | Description | Page |
|---|---|---|
| 392 | Lead weight, 15 lbs | 9 |
| 393 | Lead weight, 30 lbs | |
| 394 | Lead weight, 50 lbs | |
| 395 | Weight hanger, 15 lb, 30 lb | 9 |
| 486 | Weight hanger, 50 lb | |
| 396 | Weight pin, 15 lb, 30 lb | 9 |
| 472 | Weight pin, 50 lb | |
| AXO4089 | Weight hanger screw | 9 |
| 444 | Lead weight, 75 lbs | |
| 443 | Lead weight, 100 lbs | |



## Current meter parts, headphone style

### Price Model 622

| Number | Description | Page |
|---|---|---|
| 12 | Raising Nut | 25 |
| 232-125 | Meter case | |
| AX04878 | Gear | 31 |
| 24148 | Gear assembly | 31 |
| 31493 | Hub | 33 |
| 31494 | Pivot | 33 |
| 31495 | Shaft | 33 |
| 31497 | Hub including bearing & raising nut | 33 |
| 31499 | Pivot – complete | 33 |
| 31987 | Bucket wheel | 33 |
| 32574 | Upper binding post | 33 |
| 32575 | Lower binding post | 33 |
| 33055 | Counterpoise | 9 |
| 33502 | Tailpiece assembly | 9 |
| 401 | Cap | 32 |
| 404 | Gear holder | 30 |
| 405 | Frame | 33 |
| 411 | Contact chamber | 33 |
| 455 | Binding post bushing | 33 |
| X-151 | Binding post nut | 33 |
| X-152 | Hub lock nut | 33 |
| AX03931 | Pivot adjusting nut | 33 |
| 211-245-041 | Gear holder screw | 31 |
| AX05237 | Bucket wheel bearing | 33 |
| X-150 | Tailpiece set screw | 9 |
| AX03594 | Chamber/pivot set screw | 33 |
| 294-112-57 | Adjusting pin | 35 |

**Pygmy Model 625A**

| Number | Description | Page |
|---|---|---|
| 232-127 | Meter case | |
| 28227 | Frame | 37 |
| 28228 | Cap | 37 |
| 28231 | Upper bearing | 37 |
| 28232 | Bucket wheel | 37 |
| 28236 | Hub | 37 |
| 28238 | Hub lock nut | 37 |
| 28239 | Pivot – complete | 37 |
| 28240 | Pivot | 37 |
| 28242 | Shipping pivot | |
| AX04875 | Lower bearing | 37 |
| 32574 | Binding post – complete | 37 |
| 33982 | Shaft | 37 |
| AX3930 | Pivot adjusting nut | 37 |
| AX05641 | Pivot set screw | 37 |
| X-150 | Meter set screw | 37 |
| X-151 | Binding post nut | 37 |
| 445 | Binding post bushing | 37 |

**Headphone set**

| Number | Description | Page |
|---|---|---|
| 488 | Headphones (includes type N battery) | 19 |
| 433 | Cable from earphones (or 611 counter) to Meter (622 and 625A) – 15' length | 19 |
| AX03852M AX08352F | Connector, 2 prong | |
| BX02358 | Top set rod adapter case | |

**Accessories**

| Number | Desription |
|---|---|
| 233-1 | Canvas equipment bag |
| 619 | Stop watch |



**Current meter parts, digital style**

| Name | Description | Page |
|---|---|---|
| CX00632N | 18" Sensor head assembly | 11 |
| CX00621N | 15' Sensor head assembly | 21 |
| CX00591 | Rotor housing – model 625A | 47 |
| CX00596 | Rotor housing – model 625A | 35 |
| BX00507 | Hub extension – model 625A | 47 |
| BX00510 | Hub extension – model 625A | 35 |
| AX05394 | Rotor housing set screw – model 622 | 35 |
| 294-112-57 | Adjusting pin | 35 |
| BX00535 | Sensor head plug | 35 |
| BX00536 | Current meter cap | 35 |
| 1100 | Model 1100 indicator | 21 |

Call or send an email to Travis Coon (t.coon@gurley.com) for parts to convert an older headphone or digital current meter to use a new Model 1100 digital indicator.

# Appendix II

## Field data sheet
## (Example)

Rainbow Smelt Spawning Habitat Assessment: **Field Water Chemistry and Flow Data** Form 3.1

**Date:** **Samplers:**

WATER CHEMISTRY

| **Station** | **Sample Time** | **Water Temp.** *(°C)* Middle | **Water Temp.** *(°C)* Left | **Water Temp.** *(°C)* Right | **Spec. Cond.** *(mS/cm)* Middle | **Spec. Cond.** *(mS/cm)* Left | **Spec. Cond.** *(mS/cm)* Right | **pH** Middle | **pH** Left | **pH** Right | **D.O.** *(mg/l)* Middle | **D.O.** *(mg/l)* Left | **D.O.** *(mg/l)* Right | **D.O.** *(% sat.)* Middle | **D.O.** *(% sat.)* Left | **D.O.** *(% sat.)* Right | **Turb.** *(NTU)* Middle | **Turb.** *(NTU)* Left | **Turb.** *(NTU)* Right |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | |
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WATER VELOCITY AND DEPTH

| **Station** | **Sample Time** | **Middle** (rev.) | **Middle** (m/sec) | **Middle** (cm) | **Left** (rev.) | **Left** (m/sec) | **Left** (cm) | **Right** (rev.) | **Right** (m/sec) | **Right** (cm) | | **Precipitation** | **Staff Gage** | **Notes** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
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**Flow Meter Spin Test:**

# Appendix III

## General Description of a Conventional Current-Meter Measurement of Discharge (from Rantz et al. (1982, Volume 1, pages 80-81)

method, observations of width, depth, and velocity are taken at intervals in a cross section of the stream, while the hydrographer is wading or supported by a cableway, bridge, ice cover, or boat. A current meter is used to measure velocity. This chapter describes the conventional current-meter method.

## GENERAL DESCRIPTION OF A CONVENTIONAL CURRENT-METER MEASUREMENT OF DISCHARGE

A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities. The formula

$$Q = \Sigma(a\ v) \tag{9}$$

represents the computation, where $Q$ is total discharge, $a$ is an individual subsection area, and $v$ is the corresponding mean velocity of the flow normal to the subsection.

In the midsection method of computing a current-meter measurement, it is assumed that the velocity sample at each vertical represents the mean velocity in a rectangular subsection. The subsection area extends laterally from half the distance from the preceding observation vertical to half the distance to the next, and vertically from the water surface to the sounded depth. (See fig. 41.)

The cross section is defined by depths at verticals 1, 2, 3, 4, . . . $n$. At each vertical the velocities are sampled by current meter to obtain the mean velocity for each subsection. The subsection discharge is then computed for any subsection at vertical $x$ by use of the equation,

$$q_x = v_x \left[\frac{(b_x - b_{(x-1)})}{2} + \frac{(b_{(x+1)} - b_x)}{2}\right] d_x$$

$$= v_x \left[\frac{b_{(x+1)} - b_{(x-1)}}{2}\right] d_x \tag{10}$$

where

$q_x$ = discharge through subsection $x$,
$v_x$ = mean velocity at vertical $x$,
$b_x$ = distance from initial point to vertical $x$,
$b_{(x-1)}$ = distance from initial point to preceding vertical,
$b_{(x+1)}$ = distance from initial point to next vertical, and
$d_x$ = depth of water at vertical $x$.

Thus, for example, the discharge through subsection 4 (heavily outlined in fig. 41) is

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2}\right] d_4.$$

The procedure is similar when $x$ is at an end section. The "preceding vertical" at the beginning of the cross section is considered coincident with vertical 1; the "next vertical" at the end of the cross section is considered coincident with vertical $n$. Thus,

$$q_1 = v_1 \left[\frac{b_2 - b_1}{2}\right] d_1$$

and

$$q_n = v_n \left[\frac{b_n - b_{(n-1)}}{2}\right] d_n.$$

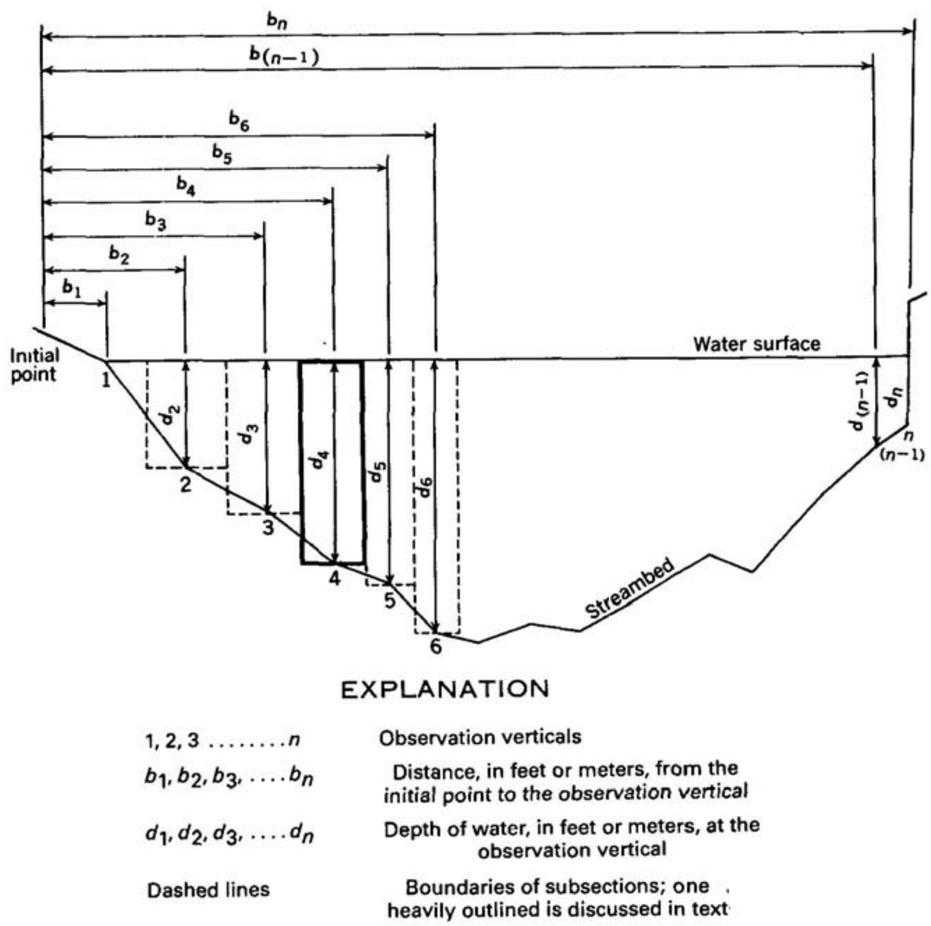


FIGURE 41.—Definition sketch of midsection method of computing cross-section area for discharge measurements.

# Appendix IV

## Maine DMR SOP for Water Sample Collection

## 4.0 SOP for Water Sample Collection

This Standard Operating Procedure covers the following content:



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### 4.0.1. Introduction

The following standard operating procedure is to be used by all DMR staff and volunteers when collecting water samples for fecal coliform analysis. As this is a bacterial analysis, cleanliness and careful attention are critical to ensure a reliable sample. Since the seawater samples are analyzed microbiologically, it is extremely important that sample collection is conducted using **sterile technique and that extreme care is taken to prevent contamination of the sample**. Laboratory findings are dependent upon your following proper, aseptic technique.

In the microbiology laboratory, seawater samples collected for the purpose of classifying shellfish growing areas are analyzed for fecal coliform bacteria which are a potential indicator of human sewage in the water. Human sewage contains potentially pathogenic bacteria, viruses, and parasites which can accumulate in the gut of filter-feeding shellfish and cause illness in people who eat them. Fecal coliform are a sub-set of bacterial species which are part of the larger coliform group of bacteria which, in the marine environment, have a high probability of being associated with fecal matter from warm-blooded animals. Fecal coliform are readily and inexpensively analyzed in the lab, and have been selected by the U.S. Food and Drug Administration (FDA) as an indicator organism suitable for the evaluation of the sanitary condition of seawater.

The DMR Volunteer Coordinator is the immediate supervisor and contact for volunteers, although the data collected from a particular area by volunteers will be used by the Water Quality staff member responsible for that area.  (See Program Overview for addresses and phone numbers for DMR water quality staff).

Before volunteer sampling work begins, and annually thereafter, the DMR Volunteer Coordinator and the corresponding area Water Quality Staff will meet with volunteers for a comprehensive training on the Water Quality Sampling Program and visit the stations that volunteers will be sampling. Equipment and coaching on the sampling technique is provided to all to ensure the successful collection of high quality samples. Because the sampling technique can be awkward initially, the DMR encourages all samplers to practice the procedure as often as necessary to ensure sample integrity.

### 4.0.2. Equipment & Safety

- Maps, GPS Coordinates and directions for sampling stations;
- DMR Water Quality Report datasheet forms;
- Sampling tongs;
- "Whirl-Pak" 120 ml sampling bags [*Plan to have at least one extra bag per sample site in case you get a sample bag with a leak.  If a bag leaks or tears, discard the sample and collect another sample using a new bag.*];
- Metal dial field thermometer;
- Ice packs to keep samples chilled;
- Freezer boxes or wire sample racks for your cooler to keep bags upright in cooler;
- Glass, liquid-filled cooler thermometer;
- Sample cooler;
- Waterproof marker ("Sharpie") to label bags;
- Pen to record data on WQ Report datasheet forms.
- Waterproof hip-boots or waders;
- Your own transportation (vehicle or boat);
- First aid kit;
- Watch or automobile clock;
- Cell phone (recommended).

**Note:** Volunteers should work with the Volunteer Coordinator on equipment needs.

Collecting water samples by foot involves walking over uneven surfaces, wading into growing area waters to a minimum depth of 18", and working in sometimes cold, rainy, and slippery conditions.  Some mudflats are unsafe to traverse due to the extremely fine sediments, which can create "honey pots". These are patches of soupy, unstable mud where it is possible to quickly sink into the mud to above your knees, waist, or higher. In these circumstances, it may be difficult or impossible to free yourself without assistance.  **If you have any doubts about your**

**safety DO NOT collect the sample.** Note safety concerns on the field sheet with the station number.

When collecting water samples by boat make sure the boat is inspected, registered and carries all appropriate safety equipment. DMR staff members are required to follow the Department Boating Safety Policy.

Each vehicle or staff member will have a first aid kit and cellular phone. When working alone, it is recommended that the sampler make sure someone knows they are sampling, their planned route for the day and an estimate of the time of return.

Samplers are expected to dress for the weather. If it is a hot, sunny day, make sure to wear a hat and sunscreen and bring plenty of water to avoid dehydration.

When collecting your sample by land, you must walk into the water to a minimum depth of 18", so hip boots or waders are very important - especially when walking through mud flats. Samples may be collected from shore from a dock or bank when the water is at least 18" deep.

Sampling runs will be cancelled when state offices are closed due to inclement weather, and on a case by case basis as determined by the DMR, In the event of a missed run due to hazardous conditions, the missed run will be handled as described under the missed run section 2.0.1.4..

### 4.0.3. Sample Collection

It is very important to adhere to the sampling schedule generated by the DMR. The schedule is extremely important to the validity and acceptability of Maine's Water Quality Program. The schedule is "random" meaning that it is meant to get data from different tidal stages, different seasons, and different weather conditions. By creating the sampling schedules at the start of each sampling year, the DMR staff is randomly selecting dates with no prior knowledge of the exact conditions that will exist on any particular date thus ensuring that samples over time at any given site will represent all the various conditions that may affect water quality. Once an area has been classified, it requires a maintenance sampling schedule of at least six samples a year. Over time, this results in a high probability for a wide variety of weather, season, tide, and other environmental conditions. **No sample collection date can be changed without the permission of the MDMR. No samples can be added or dropped from the sample run without the permission of the MDMR.** Samples cannot be collected prior to 0600 (6:00am) unless it is an emergency OR prior permission has been obtained.

The sample runs are assigned to DMR staff and volunteers at the beginning of the month and year, respectively. The SRS schedule is online in MS Outlook under Public Folders/DMR/Division Calendars/Public Health. Volunteers will be notified and the schedule confirmed with the volunteer coordinator in accordance with the Volunteer SOP. All sample collectors should confirm the date of the sampling run, which sampling run is assigned, confirm that they have a current sample station map and directions and have all equipment needed.

When you arrive at the first sample station you will begin by filling in the Water Quality Report Form. It is extremely important to correctly fill in the form. The information on the form helps the lab personnel to quickly and correctly analyze your samples. Missing or non-legible information will compromise the data. Please **use a pen**, NOT a waterproof marker, which can be hard to interpret. If you make an error on your field sheet, put a single line through the error, write the correction above/near it and initial the change. Before you begin to sample for the day, you may fill out general information that is not specific to a single site. This would include the header information on the form. A sample Water Quality Report form follows:

| **Field** | **Content** |
|---|---|
| Collected by: | The acronym for your group/ your name(s) (e.g. YSC/John Smith) |
| Date Collected: | The sampling date |
| Area Letter & Name or Run #: | The DMR shellfish growing area letter (A - Z); and the geographic name of the area* |
| Run: Scheduled/Makeup/Reopen/Flood | |

* Volunteers should check with the DMR Volunteer Coordinator or the appropriate WQ staff member for the area name and the shellfish growing area letter.

The **"Examined by**:" and "**Date Examined**:" fields will be filled in by DMR lab staff - leave these blank.

In the "**Comments**" column at the right of the datasheet and in the "**Remarks**" section below the data entry columns, put any additional information that may be helpful to staff when interpreting the analysis results. For example:

- Did you see something that you do not usually see in very close proximity to the station that might be a source of fecal pollution (ducks, cormorants, seagulls, etc.)?
- Was there land runoff due to a recent storm event?
- Were there signs of waterfowl or wildlife populations in the general area?
- Did you miss a station normally sampled? If so, explain why (e.g. tide too low, access blocked, etc.).

The purpose of the remarks is to give supporting information to the staff. When you are collecting samples, you are the eyes in the field. You see the conditions in which the samples were collected, and sometimes these remarks will help the staff to understand the reasons for a certain water score or point to a persistent pollution problem.

**Missed Station** — If the station cannot be collected for the following reasons, use the following codes: **T** = tide (too low to sample, less than a mimimum of 18” at station), **A** = access (the station was not accessible due to trespass or natural obstructions, **S** = safety, **I** = ice (the station was iced over and water not available), **O** = other (you must note what the “other” is in the comment box)

**Area Letter** Record the Growing Area Letter of your sample site (e.g. WA, EB).

**Station #** Record the station number (e.g. 17).

**Military Time** Record the time of sample collection. Use the 24 hour clock -- military time – no colon (e.g. 1400 vs 2:00 PM)

**Boat/Land/Shellfish** "L" = if the sample was taken from land or
"B" = if the station was sampled from a boat
For shellstock samples use the following codes: C = soft shelled clams, M = mussels, Q = quahogs or hard shelled clams, O = oysters.

**Temp** Water temperature to the nearest degree Celsius °C measured at sampling station using your metal dial field thermometer

**Random or Adverse** "R" for random (unless you are otherwise instructed)

**Condition or Adversity(ies)** Use the letter code(s) taken from the Adversities List on the reverse side of the Report Form (eg. boats, wildlife, precipitation etc) that best describes the potential pollution sources that you observed in the field separate from the station justification

**Wind Direction** Record the direction from which the wind is blowing at each station using one of the following codes: N, NE, NW, S, SE, SW, E, or W. If it is calm, use CL as a code.

**Status** See your sample schedule for the current status (e.g. Open or Closed)

**Salinity (staff field)** DMR laboratory staff will record the salinity when they analyze the sample.

**MF** DMR staff will record the coliform score after analysis. CFU /100ml or FC/100gr(staff field)

The annual sampling schedule provides information regarding the current status (Open or Closed) and classification of the all sampling stations. Please consult your schedule when filling out the “Open or Closed” column of your Water Quality Report Form.

Samples that are collected for additional information outside of the SRS or Adverse condition sampling regimes will be coded "E" under the STRATEGY heading on the field sheet.

Make sure that you are using only "Whirl-Pak" brand bags provided by the MDMR "Whirl-Pak" bags have a yellow wire tab printed with the "Nasco Whirl-Pak" brand name across the top and a broad white label across the middle of the bag front. Please, do not use the old style bags with the white wire tab across the top of a clear bag and no label.

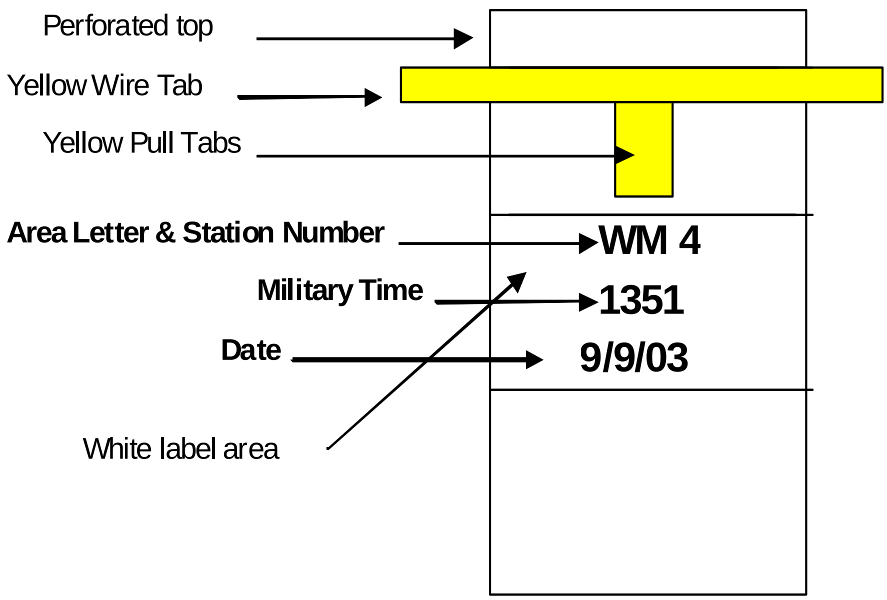
The sterile sample bags are made of transparent polyethylene and sealed with a perforated top which is torn off just before the water sample is collected. Each sample bag must be labeled with the identifying information explained below using a waterproof marker before the sample is collected. Remember to label BEFORE you sample with the supplied 'Sharpie' permanent marker because it is impossible to write on wet bags. Please try to keep the information within the white label area on the front of the bag. If you must stray outside of this area, use the area just below (rather than above) the label so that the information is visible after the bag is whirled closed. It is easiest to label the bag before leaving your vehicle as you double-check your sampling schedule to confirm that you are at the correct sampling site and check the time which must be recorded on both the sample bag and the Water Quality Report Form.

Be sure to include both the area letter and the station number on the bag. Record the time (in military format) that you collect your sample.

Write the following data in the white label area on the front of the sample bag:

Area letter and station number;
Time (military format);
Date (month/day/year).

**EXAMPLE WQ SAMPLE BAG WITH SAMPLE LABEL**




Every attempt should be made to collect the water sample as close as possible to the GPS mapped sample site position. Many sample stations cannot be collected during the lower tides simply because there is not a minimum water depth of 18" at that time. Some samples can be collected if the sampler samples by boat (or walks) a short distance from the GPS mapped location, however, the sampler has to use his/her best judgment to determine if the water collected is still a representation of the typical overlying water at the mapped location. Other important requirements include:

i) **DO NOT** collect the sample from a channel or stream which may be flowing across the flat from the upland area. These streams are predominately fresh water and not representative of the water that the shellfish was exposed to at the higher tide stages;

ii) **DO NOT** collect your sample from puddles or pools that may have been stranded in depressions on the flat as the tide receded. Samples taken from pools or puddles at low tide are essentially a pollution source sample and are not representative of the water that the shellfish are exposed to at higher tide stages;

iii) **DO NOT** collect your sample after moving seaweeds around;

iv.) **DO NOT** scrape the bottom or disturb and suspend sediments while collecting your sample;

v. **DO NOT** sample the surface layer, sample only if you can plunge the bag to a depth of 8-10" below the surface.

vi. **DO NOT** travel more than a 300 foot radius seaward from the normal high tide sampling station site. DMR will identify a list of specific beach stations which can be collected >300 feet from the established station site.

There must be a mimimum of 18" of water depth in order to collect your sample following the proper procedure with the sampling tongs.

Sampling tongs are used to hold the bag during sample collection to minimize the handling and contamination of the bag. The tongs also make it possible to collect the water sample from 8-10" below the surface to avoid debris that may be floating on the water surface. The sampling bag is secured to the sampling tongs by clamping the alligator clips onto the white pull tabs on either side of the yellow wire tab. Hooking the bag to the clips is an awkward procedure but with practice you will develop a technique that works best for you. The following are the required steps for proper sample collection:

1. Start by holding the tongs under your arm with the clips parallel to the ground with the opening of the clips facing toward the middle of your body. Place the bag between the alligator clips with the yellow wire tab parallel to the ground and with the bag mouth facing in the same direction as the opening of the clips, toward the middle of your body. Take the white pull tab on one side of the yellow wire tab and securely clamp it into the teeth of the clip on that side; repeat on the opposite side.

2. When sampling by boat, make sure that the keel and the engine of the boat do not touch the bottom and disturb sediments in any way. There must be a minimum of 18" of water on site for the sample to be collected. If sediments have been suspended, wait until they are taken away by the current before you collect your sample. You must always collect the sample on the upstream side to avoid sampling water that may contain sediments that were suspended. Sampling must occur within a 300' radius of the established station.

3. When sampling by land, wade into the water to a depth of at least eighteen inches. Take extreme care to not stir up the bottom. If sediments have been suspended, wait until they are taken away by the current before you collect your sample. You must always collect the sample on the upstream side to avoid sampling water that may contain sediments that were suspended when you walked out to the station.

4. Pull the top perforated flap from the bag and put the top in your pocket. **Do not touch the top of the bag with your fingers**.

5. **KEEPING THE BAG CLOSED UNTIL IT IS SUBMERGED TO SAMPLING DEPTH,** plunge the bag 8 to 10 inches below the surface. Allow the tongs to open after the bag is submerged. Quickly draw the bag through the water in an upstream direction, away from your body, to fill the bag completely. If there is no current, push the bag through the water horizontally away from your body. **Before pulling it back up to the surface and out of the water, close the bag by bringing the clips back together while the bag is still submerged.**

6. Withdraw the sample bag from the water and remove the bag from the tongs, holding it by its yellow wire ends. The bag must be filled to between the two bold black lines in the upper area of the white label; the 100 ml Fill Line and the 4 oz Fill Line. **Do not fill above the 4 oz Fill Line.** If you have too much water, squeeze the bag by pinching it a third of the way down, to expel the extra water. Allow some air to enter the bag before closing it. ***Critical – the bags must be shaken by the lab staff prior to analysis to ensure that the sample is well mixed. The air pocket provides the extra space in the bag to allow for this mixing.***

7. Twirl the bag closed by holding it by its yellow wire ends on either side of the bag opening and spinning the bag three or four turns. This will create a firm pillow-like bag with an air pocket. There should be an air-pocket of an inch or so and the bag should feel firm. Secure the bag by crossing the two yellow wire tabs above the closed bag to form an "X". Fold one tab towards the front of the bag and one tab towards the rear of the bag. Do not twist the tabs as you would on a bread bag tie. Gently squeeze the bag to check for leaks and to make sure that it is securely fastened. The folded tab "X" closure creates a secure closure that is easy for the lab staff to open and keeps the wire tabs away from the bag (and adjacent bags) to avoid accidental puncturing during sample transport.

   If you notice a leak, label a new bag and take another sample. If you have left the sampling site and notice that you have a leaking bag, label a new bag and using aseptic technique; carefully transfer the sample from the leaking bag to the new labeled bag. DO NOT place the leaking bag into a new bag because the water which leaks out of the sample bag into the new bag must be considered contaminated and can not be used for analysis.

8. Stand the bags upright in the wire rack in a cooler with ice packs and a cooler thermometer. Sample bags must not be submerged in melt water from ice. Place the samples in the rack in the order that they are listed on the datasheet (for example):

   a. Sample one goes in the lower left front space in the rack;
   b. Sample two goes immediately behind it, and so on;
   c. Once the first row is full, front to back, place your seventh sample in the front of the rack in the next row to the right;
   d. Fill the rack again front to back and left to right.

### 4.0.3.3. 1. Boat Sampling

DMR will utilize volunteer industry or shellfish warden boats where possible and when provided [under a MOA with the DMR] for growing area classification sampling. Boats must also ensure that an adequate depth (a minimum of 18" of water) is present at the station when the sample is collected.  As noted in the Maine Peer Team Review Summary (October 29, 2007-November 2, 2007) Maine has a very extreme environment, as compared to other states, making the full year-round utilization of boats impossible.  When sampling by boat, the standard operating procedures for sample collection in Section 4.0.3. is followed.  The boat should be operated in such a way as to allow the boat to get within a 300' radius of the established water sample site.  If the sample collection criteria above cannot be met, document the missed station and DMR staff will re-schedule the sample collection as outline in section 2.0.1.4.  When working from a boat, make sure the boat is inspected, registered and that it carries all appropriate safety equipment. DMR staff must follow the Boating Safety SOP, which includes, but is not limited to, 2 people per boat, wearing of floatation device and boating safety/CPR training.

If a boat run is cancelled due to a boat breakdown, weather, etc. and the run can be collected by land, the run will be collected by land to maintain compliance with the systematic random sample schedule.  Otherwise, the sample run must be re-scheduled as outlined in section 2.0.1.4.
.

**4.0.3.3.2.  Cold Weather/Winter Sampling**

When sampling in the winter, all attempts should be made to use safe practices. It is recommended that cleats be used if it is icy, snowshoes if it is necessary to walk long distances in deep snow, carry cell phones for emergency calling and use 4-wheel drive vehicles if sampling runs are in remote areas or on back roads. For safety purposes, do not walk out onto accumulated ice packs over coves and wear your DMR provided suspender type auto-inflating personal floatation device.

Do not drill holes in ice to collect a sample.

Aside from safety issues, there are water sample integrity issues with cold weather sampling. Samples with ice or ice slurry cannot be analyzed for fecal coliforms.  Bacterial cells tend to burst when subjected to freezing; any freezing that occurs once the sample has been collected will alter the original concentration of fecal coliforms in that sample.  If the sample is collected where ice is present, every effort should be made to exclude ice from the sample collection.  If ice slurry is present, the slurry must be expelled before closing the bag.  The sample must be protected from freezing and ice formation from sample collection site to eventual delivery to the laboratory.  This may mean carrying the sample in a pocket from sample site to the cooler in the vehicle.  It may mean keeping the cooler inside the vehicle during the sample collection trip and transport to the laboratory; the coolers are not designed to protect from freezing if they are subjected to freezing temperatures and wind chill conditions.  Freezing wind chill conditions can develop on a cold day in the bed of an open pick up truck during transport.

**4.0.3.4.  Water Temperature**

Water temperature is a standard environmental parameter and is routinely measured any time water samples are taken for any type of analysis. Temperature may be correlated to the growth or presence of various marine organisms and microorganisms and may be helpful in explaining the analysis results and understanding the impact of conditions observed in the field.

The dial bimetallic field thermometer that is used by DMR has a round, dial face and a metal stem, which is the sensing unit to be immersed in the water. These thermometers are mechanical; meaning that the temperature recorded on the dial is the result of the expansion of the metal wire housed in the stem and connected to the thermometer dial. The thermometer's scale, -10°C to 110 °C, is in degrees Celsius. The temperature should be read to the nearest 1°C.

All thermometers are relatively fragile instruments requiring special treatment for accurate measurements. Rough handling of these dial thermometers can affect the connection between the dial and the stem. When not in use, store thermometers in a protected location such as your sample cooler to reduce handling and abuse.

For ease of use in the field, you may want to equip your thermometer with the following: a small float (simply push the pointed metal stem gently through a small block of styrofoam or a cork) which will keep the dial face above the water for easier reading, and a string (tied around the metal stem under the dial face) which will provide a tether to keep the thermometer from being swept away from you by the wind or waves.

*NOTE: Check your thermometer's operation frequently*
Although each thermometer is annually calibrated against a NIST-certified thermometer by the lab staff, you should also check your thermometer at the start of each field day to make sure that it is responding appropriately. Place your metal field thermometer in your sample cooler along with your cooler thermometer before you start on your sampling trip. When you get to your first sampling site, compare the temperature readings on both thermometers. They should be within a degree of one another. If you find a larger discrepancy, make a note of the difference in readings on your Water Quality Report form and request a replacement thermometer from the volunteer coordinator or another member of the DMR staff.

To take the water temperature measurement, follow these steps:

1. Drop your field thermometer into the water, at each sample station, before you collect your water sample. The metal stem should be completely immersed. The metal equilibrates to the ambient water temperature quickly; typically in less than one minute;

2. After collecting your water sample, check the thermometer dial to be sure that the reading has stabilized and read the temperature on the dial face to the nearest °C. Keep the thermometer's stem immersed while you read the temperature. The thermometer responds too quickly to temperature change to allow an accurate reading if the thermometer is pulled from the water to be read;

3. When you return to your vehicle, record the temperature in the “Water Temp” column of the Water Quality Report form.

### 4.0.3.5. Observations

If you have not already done so, complete the data required in the Water Quality Report heading. As you collect each sample you will need to enter your station number, sampling time, water temperature, and your field observations for each station.

Look around your sampling location to check for **adverse conditions** which may be potential sources of fecal pollution. Examples include birds, streams or stormwater pipes which flow only during wet weather, etc.. Look on the reverse of your Water Quality Report form for a list of **Adversities** and the codes to be used on the field sheet. Also, in the remarks section, please note if there has been **precipitation** in the past 24 - 36 hours. You may have had a local rainstorm that was not recorded by any of the rain gauges that are monitored along the coast.

Please observe whether the wind is blowing at each station. If it is blowing, record the direction from which it is blowing: N, NE, NW, S, SE, SW, E, or W. If it is calm, use CL as the code. You do not need to estimate the wind speed, just the direction.

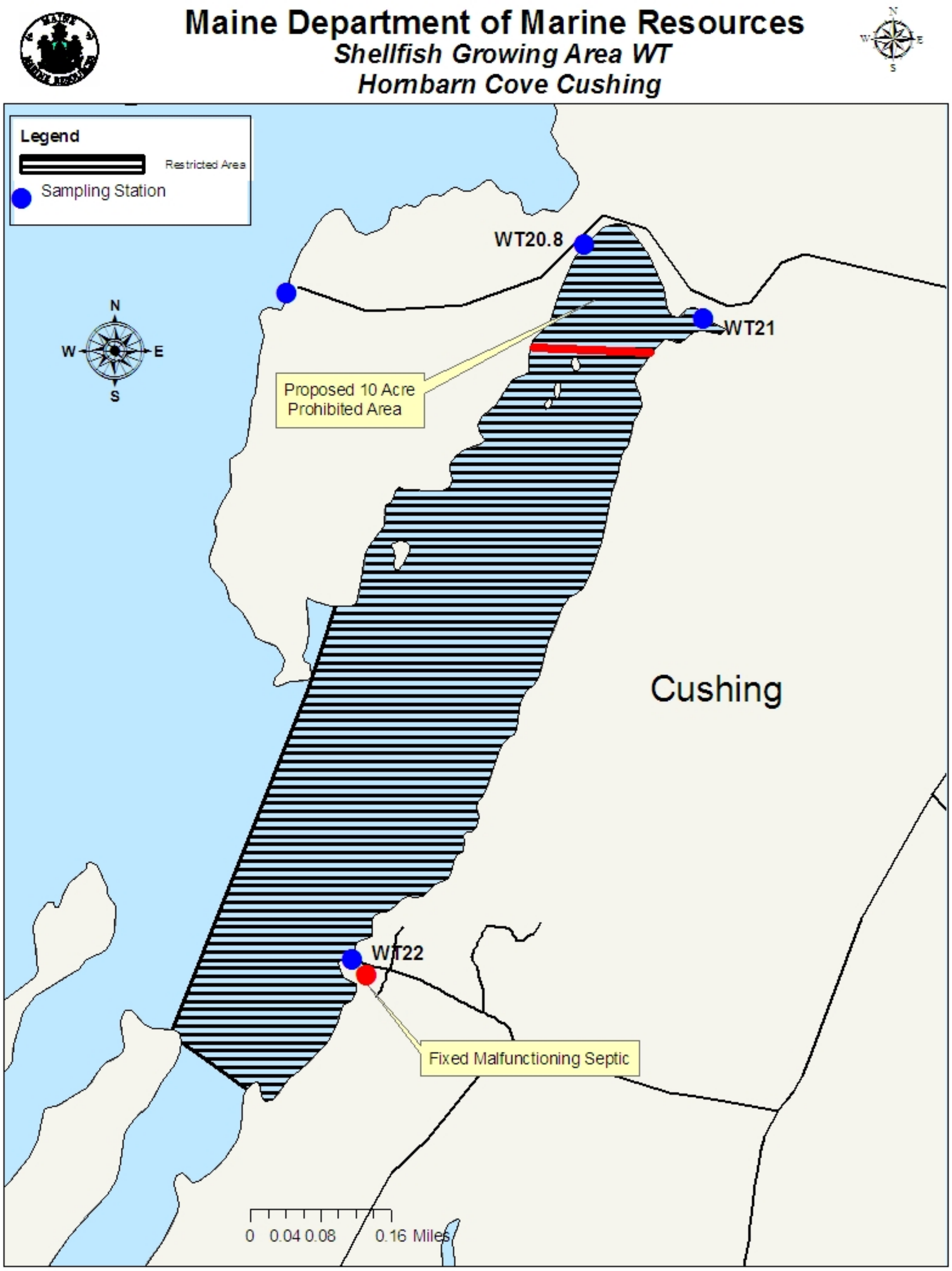
If you see something which can not be adequately described with a code, enter a description in the “**Comments**” column at the right side of the datasheet in the datasheet row of the station at which you made the observation. You may also record general observations that pertain to all stations in the “**Remarks**” area at the bottom of the datasheet.

Note: For complete sampling handling instructions, see SOP 6.0 for Sample Handling & Lab Receipt

# Appendix V

## Example of reclassification of a shellfish growing area based on stream flow sampling, discharge and dilution calculations and bacteria sampling

**Figure 1. Hornbarn Cove, Cushing**



## Shellfish Growing Area WT

### *Hornbarn Cove, Cushing*

Hornbarn Cove, Cushing has three water sampling stations along the shore of the cove. Sampling station WT21 monitors water quality in the northeast corner of the cove nearby the mouth of a stream, sampling station WT22 monitors the southern portion of the cove and a new sampling station (WT20.8) was created in 2010 to monitor the water quality on the northwest side of the head of the cove. The water quality at station WT21 deteriorated in 2010 and Hornbarn Cove was reclassified from approved to restricted for shellfish harvest on January 12, 2010. The area was surveyed in 2009 and no pollution sources were identified. There is one dwelling at the head of the cove at the site of sample station WT21. The septic system for this dwelling is located away from the shore. One pollution source was identified at the southern end of the cove (nearby station WT 22) which was fixed in the late fall of 2009.

Station WT 21 is located at the mouth of a stream. Following the shoreline survey of the area, when no pollution sources were found in the immediate area, it seemed likely that the stream may be the source of pollution. A new sampling station was established (WT20.8) away from the stream and the new station and stream were sampled with greater frequency. The new station (WT 20.8) was sampled on an accelerated schedule which allows for up to two samples being collected each month. Station WT 20.8 was sampled a total of 14 times in 2010. The stream (S1WT21) was sampled a total of 9 times. A flow rate for the stream was done using a Gurley Precision Instrument flow meter. The flow rate was determined to be 545,156 gallons per day during moderate-high flow conditions. The fecal load of the stream was determined based on the average of the wet weather scores from the stream samples. The fecal concentration was determined to be 341 fecal coliform colonies/100 ML. A dilution calculation was then completed using the flow rate, the fecal concentration and an average mid-tide water depth at the head of the cove of four feet. Based on these parameters, the dilution calculation determined that the required closure size needed to dilute the water quality to approved standards is ten acres. Water quality at the southern end of the cove at station WT22 has continued to meet approved standards and currently has a P90 score of 9. An additional assessment was completed for station WT22 to determine the effect of precipitation (cumulative rainfall of >0.5 inches within 3 days of collection and on collection day) on the geometric mean and P90 scores. For this assessment, all SRS, extra, and adverse data from samples specifically scheduled to target precipitation events were considered; data collected during flood closures were not considered. When the data was run, the P90 score for the data collected following rainfall was 41.5. While this shows an impact from rainfall events of >.50 inches, there were only two elevated scores in the data set (Table 4). Both of these scores are associated with more elevated levels of rainfall (>1.49 inches in 24 hours). Based on these findings, a ten acre closure will remain at the head of Hornbarn Cove and the remainder of the cove will be reclassified as approved for shellfish harvest.

**Table 1. Stream Data Hornbarn Cove, Cushing**

| Stream ID | Collect Date | Stream Fecal Score | Stream Salinity | Station Fecal Score | Station Salinity | rain 3 days | Flood Closure | Rainfall 3 |
|---|---|---|---|---|---|---|---|---|
| S1WT0021.0 | 4/12/2010 | 6 | 0 | <2 | 22 | 0.03 | | |
| | 5/11/2010 | 5.7 | 0 | <2 | 28 | 0.1 | | |
| | 6/2/2010 | 82 | 0 | no sample | | 0.21 | | |
| | 6/7/2010 | 122 | 0 | no sample | | 2.25 | | 1.3 on 6/6 |
| | 6/9/2010 | 24 | 5 | no sample | | 0.23 | | |
| | 6/16/2010 | 1.9 | 26 | 4 | 30 | 0.01 | | |
| | 6/30/2010 | 48 | 0 | 2 | 28 | 0 | | 1.51 on 6/27 |
| | 7/14/2010 | 560 | 0 | 208 | 28 | 2.13 | | 2.11 on 7/14 |
| | 8/3/2010 | 18 | 0 | 3.6 | 28 | 0.08 | | |
| | 9/8/2008 | 720 | 0 | no sample | | 5.75 | Yes | |

**Table 2. Hornbarn Cove, Cushing P90 scores**

| Hornbarn Cove, Cushing P90 Scores | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Class** | **Count** | **MFCount** | **GM** | **SDV** | **MAX** | **P90** | **Appd_Std** | **Restr_Std** | **Min_Date** |
| WT020.80 | R | 14 | 14 | 3.6 | 0.45 | 56 | 13.9 | 31 | 163 | 3/17/2010 |
| WT021.00 | R | 30 | 30 | 9.4 | 0.83 | 960 | 109.9 | 31 | 163 | 6/11/2007 |
| WT022.00 | R | 30 | 26 | 2.8 | 0.38 | 132 | 9 | 32 | 176 | 4/4/2006 |

**Table 3. Rainfall assessment Sampling Station WT22**

| Rain_P90 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Class** | **Count** | **MFCount** | **GM** | **SDV** | **MAX** | **P90** | **Appd_Std** | **Restr_Std** | **Min_Date** |
| WT022.00 | R | 14 | 8 | 5.2 | 0.69 | 240 | 41.5 | 37 | 211 | 4/3/2003 |

**Table 4. Raw data used in Rainfall Assessment for Station WT22**

| Station | Date | Tide | Sal | Score | Rain0Hrs | Rain24Hrs | Rain48Hrs | Rain72Hrs | Sum Rain |
|---|---|---|---|---|---|---|---|---|---|
| WT022.00 | 03-Apr-03 | HE | 31 | 2.9 | 0.03 | 0.05 | 0 | 0.43 | 0.51 |
| WT022.00 | 20-Jul-09 | E | 29 | 1.9 | 0 | 0 | 0.6 | 0 | 0.6 |
| WT022.00 | 06-Dec-07 | E | 30 | 1.9 | 0 | 0.05 | 0.2 | 0.54 | 0.79 |
| WT022.00 | 24-Jul-03 | E | 31 | 3.6 | 0.03 | 0.78 | 0.02 | 0 | 0.83 |
| WT022.00 | 06-Sep-06 | H | 31 | 4 | 0.03 | 0 | 0.91 | 0.03 | 0.97 |
| WT022.00 | 04-Apr-06 | LF | 30 | 2.9 | 1.17 | 0 | 0.05 | 0 | 1.22 |
| WT022.00 | 20-Sep-10 | E | 32 | 1.9 | 0 | 0 | 0 | 1.3 | 1.3 |
| WT022.00 | 12-Jul-06 | E | 30 | 2.9 | 0.01 | 1.3 | 0 | 0 | 1.31 |
| WT022.00 | 27-Jul-04 | E | 31 | 2.9 | 0 | 0 | 0 | 1.32 | 1.32 |
| WT022.00 | 07-Oct-09 | H | 30 | 15 | 0.89 | 0 | 0.04 | 0.43 | 1.36 |
| WT022.00 | 17-Mar-10 | E | 30 | 1.9 | 0 | 0 | 1.17 | 0.2 | 1.37 |
| WT022.00 | 22-Nov-10 | E | 30 | 132 | 0.22 | 0 | 1.27 | 0 | 1.49 |
| WT022.00 | 11-Mar-08 | H | 29 | 1.9 | 0 | 0 | 1.03 | 0.65 | 1.68 |
| WT022.00 | 29-Aug-05 | E | 30 | 240 | 2.03 | 0 | 0 | 0 | 2.03 |

**Attachment 2.**

**CBEP Stream Flow and Bacterial Sampling Project**
**Interim Summary Report**
***17* January 2012**

The project began with a "kick-off" meeting at CBEP offices on 28 June 2011. An instructional session with Claire Enterline of DMR, attended by Chris Heinig and Steve Karpiak of MER and Kim Payne of NAI, was held at NAI's Falmouth Maine office on 13 July 2011 followed by in-field Gurley flow meter deployment training in xx Creek that flows into Mussel Cove, Falmouth. A final Project Planning meeting was held at CBEP between Curtis Bohlen, Matt Craig, Kim Payne, Chris Heinig, and Alison Sirois (on phone) to discuss DMR objectives and goals and sampling logistics given the discrepancies between desired level of sampling and available time and budget for the project. This meeting set the primary objective of developing a sampling protocol for DMR (QAPP) and reduced the number of sampling sites to two: Bunganuc Stream at Maquoit Bay and the stream leading from the former BNAS, now Brunswick Landing, into the head of Harpswell Cove.

**Bunganuc Stream**

**BNAS / Harpswell Cove site**


A draft *Protocol for Stream Flow Measurement and Fecal Coliform Bacteria Sampling for Purposes of Reclassification of Shellfish Growing Areas Affected by Streams* was prepared between 2 and 22 August 2011 and circulated to the project team. C. Heinig also met with Alison Sirois on 22 August 2011 to discuss the draft and arrange for a field sampling date. Additional revisions were made to the protocol on 5-6 September 2011 in response to recommendations by Curtis Bohlen, Matt Craig, and Alison Sirois. An initial field sampling date was set for 12 September 2011 for C. Heinig and S. Karpiak of MER to sample Bunganuc Stream and the Harpswell Cove stream together with Claire Enterline and Alison Sirois of DMR; the purpose of the joint sampling event was to follow the protocol developed by MER line-by-line to determine any final modifications of procedures that might be necessary.

The sampling visit to Bunganuc Stream served as a practical "reality check" of a culvert sampling situation. The culvert at Bunganuc Stream is a straight vertical concrete wall structure with a semicircular, corrugated steel ceiling. The vertically-straight concrete side walls of the culvert offer easy measurement of the width of flow that will remain consistent with increased water height as flow increases. The bottom of the culvert, however, is highly irregular with depths at near zero flow ranging from a few inches to two feet or more depending on where along the culvert a horizontal transect (cross-sectional line) is established; the bottom is also covered with algae that is extremely slippery. The irregularity of the bottom within the culvert led to investigation of possible alternative cross-sectional sites to the west of Bunganuc (Little Flying Point) Road. Although locations were found where the bottom appeared to have a more consistent depth, *i.e.* flatter bottom, the grade of the banks on either side of the stream were much shallower, that is, as flow volume increases, the width of the stream increases substantially. Further complicating flow measurements, the banks on either side are vegetated with grass which would entangle the flow meter when measurements were taken along the banks, confounding or completely preventing measurements. Clearer banks might have been found further up the stream; however, the location of stream sampling for bacterial purposes is best located as close to head of tide as possible to ensure all potential sources of bacterial contamination are covered. A decision was made to locate the cross-sectional sampling transect within the culvert along as regular a bottom as can be found.

Bungancu Stream presents additional sampling challenges. While parking upon arrival at Bunganuc Road and Highland Road, Claire Enterline was verbally assaulted by a riparian owner who was joined shortly after by another property owner who arrived by truck. One property owner expressed her frustration with State workers and DMR staff in particular while the second threatened tire slashing. The Bunganuc Stream and Highland Road residents have historically proven extremely independent and vociferously express their anti-regulation and objection to government involvement in their affairs (C. Heinig, pers. exp.).

Logistically, Bunganuc Stream trifurcates immediately east of the culvert opening; sampling is therefore limited to the culvert itself. Fortunately, a metal measuring plate is permanently attached to the southern wall of the culvert at its eastern end that can be used as a "staff' gage for measuring water level and flow (see photos below).

Bunganuc Stream drains a rather large watershed that includes much, if not most, of west Brunswick and consequently flow volume through the stream can quickly become dangerous. We will need to watch this carefully; I have seen Bunganuc Stream as a torrent of water shooting out onto the rocks... not conducive to sampling!

The stream leading into the head of Harpswell Cove off of former Brunswick Naval Air Station was also visited. We first introduced ourselves to the staff of the Brunswick Landing office who then put us in contact with the Navy's liaison to the Midcoast Regional Redevelopment Authority (MRRA) and Brunswick Landing. He took us to the dam and pond behind the dam that is the origin of the stream; this location is well above head-of-tide. According to our liason, the groundwater flow to the pond may be contaminated and is currently the focus of a DEP study. We then went to the next location where the stream flows under a road through a culvert. However, both sides of the road have 7 to 8-foot chain-link fencing that prevents access to the stream; this location still appears to be well above head-of-tide. We then proceeded to the golf course area where access to the tidal marsh is easier. We walked along the edge of the fairways toward the water but subsequently found that there is a dirt maintenance road that leads almost to the shoreline. Brunswick Landing has requested a copy of the final Sampling Protocol for review before granting full, unlimited access via the golf course.

This sampling site also poses some challenges. The sampling location is within the tidal portion of the marsh, therefore it would need to be sampled only at low tide in order to ensure the water being sampled is truly "stream" flow and not just tidal, seawater flow. In addition, the sampling location is upstream of several other smaller freshwater inputs to the marsh and therefore the location of the sampling station may miss certain potential sources of contamination; these additional sources appear to exist on both the west and east sides of the marsh.

**Other challenges:**

1. Constraints on allowable sampling times to meet DMR Water Quality Lab schedule, i.e. no sampling between 12:00 noon Thursday and 6:00AM Sunday. Three rain events in September 2011 could not be sampled because the events either began or would continue through Thursday, Friday and Saturday, thus sampling could not be done... for bacteria. Stream flow measurements could be done, but would not have any associated fecal coliform measurements.

2. Number of sampling intervals is large and requires commitment to being available for sampling, but sampling would only require a few hours, but several consecutive days would need to be dedicated, i.e. no other field work can be scheduled during the Stream Flow study sampling event... lab and office work could be done, however.

3. Coordination with volunteers to simultaneously sample the DMR routine growing area stations might be difficult.

4. Availability during April and May due to commitment to other pre-scheduled field work; NAI available?

5. Cost, in view of the anticipated level of effort to meet sampling schedule and data requested, would be very expensive. The minimum sampling plan assuming 8 rain events and 5 samplings per event between 48 hrs prior-to-event to 72 hrs post-event, 1 hour at each site, full 20 section flow measurements on each sampling event, would equal 40 hrs of sampling at each site; 80 hrs for 2 sites. Cost would exceed

$18,000.00. Assuming 12 rain events and 5 samplings per event between 48 hrs prior-to-event to 72 hrs post-event and approximately 1 hr. from arrival at site to departure from site - full 20 section flow measurements on each sampling event, thus 60 hrs of sampling at each site; 120 hrs for 2 sites, costs would exceed $30,000.00.