

# **VOLUNTEER TRAINING MANUAL**

## **CITIZENS ENVIRONMENTAL MONITORING PROGRAM**

**First Edition  
August, 1998**

# VOLUNTEER TRAINING MANUAL

*for*

## COOK INLETKEEPER CITIZENS ENVIRONMENTAL MONITORING PROGRAM

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REGION 10**

*and*

**STATE OF ALASKA  
DEPARTMENT OF ENVIRONMENTAL CONSERVATION  
Division of Air and Water Quality**

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The Keeper adapted much of the information in this manual from the Citizen Water Quality Monitoring Manual of Friends of Casco Bay (Maine), and the Volunteer Environmental Monitoring Manual of Texas Watch. Keeper offers special thanks to the staff of Texas Watch and to Casco Baykeeper Joe Payne and his able staff. Information from this manual can be used freely if properly credited. Copies of this manual are available at \$10.00 each, including shipping and handling, by contacting:

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## I. INTRODUCTION

The purpose of this Manual is to provide Cook Inlet Keeper volunteers with the information needed to monitor water quality in the Cook Inlet watershed. As human activities in the region continue to expand, it is increasingly important for us to understand the effects of such activities on Cook Inlet's spectacular resources. This Manual will help achieve that goal by giving citizens the tools they need to sample and test water quality.

This Manual provides specific step by step instructions for all monitoring procedures currently included in Keeper's Citizens' Environmental Monitoring Program (CEMP). It outlines the Keeper monitoring program, and describes the importance of water quality monitoring in general. Safety and access issues are addressed as well as basic water quality monitoring strategies. The Appendices include a statement of our monitoring policy, a glossary of terms, a list of references for those who may want to learn more and Material Safety Data Sheets (MSDS) for some of the reagents used, plus a variety of charts and tables to assist you in collecting data. Appendix N includes information on how to report pollution and habitat degradation.

The material in this manual was developed specifically for use by the Cook Inlet Keeper Citizens Environmental Monitoring Program. The Monitoring Coordinator for this program is Steve Hackett. He can be reached at:

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We welcome your comments, suggestions and participation, and we thank everyone who has volunteered their time, expertise and support. In these times of shrinking federal and state budgets, volunteer monitoring plays an increasingly important role in collecting the data needed to make intelligent decisions about the future of Cook Inlet. The data we collect can be used by federal and state agencies, local governments, schools and businesses. Everyone involved in the Keeper's Citizens Environmental Monitoring Program is making a real contribution toward protecting the Cook Inlet watershed and its spectacular resources.

## II. ABOUT COOK INLET KEEPER

Cook Inlet Keeper is a 501(3)(c) non-profit, member-based organization dedicated to protecting the Cook Inlet watershed and the life it sustains. Keeper received start-up funding in fall 1995 from the settlement of a Clean Water Act lawsuit, and proceeded to implement the first comprehensive, volunteer monitoring program in Alaska.

To assist with developing and refining its Citizens Environmental Monitoring Program, Keeper convened a Technical Advisory Committee (TAC), comprised of water quality experts from across Alaska and beyond. To translate the recommendations of the TAC into workable implementation strategies, the Keeper convened a Citizens Advisory Panel (CAP), comprised of residents of the Lower Kenai Peninsula concerned about water quality. See Appendix D for lists of TAC and CAP members. Together, the TAC and the CAP have provided Keeper with invaluable input on shaping and implementing its monitoring program.

Keeper's initial efforts to implement volunteer monitoring in Cook Inlet have focused on surface water monitoring in Kachemak Bay. After refining this pilot program, Keeper will expand its efforts to include water column, sediment and bioassessment testing throughout the entire 39,000 square mile Cook Inlet watershed, to gain a more complete picture of the "health" of this remarkable ecosystem.

In addition to water quality monitoring, Keeper engages in a variety of education, computer mapping, and advocacy activities designed to protect Cook Inlet. For more information, visit Keeper's homepage at: [www.xyz.net/~keeper](http://www.xyz.net/~keeper), stop by the Keeper office in Homer's Lakeside Mall or contact us at: ph: (907) 235-4068; fx: (907) 235-4069; e-mail: [keeper@xyz.net](mailto:keeper@xyz.net).

### **III. WHY DO WE MONITOR WATER QUALITY?**

#### **A. THE NEED FOR MONITORING**

The federal Clean Water Act of 1972 states that "it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985." Despite substantial progress in the past three decades, we clearly have yet to meet this important goal. In Cook Inlet, industries, municipalities and individuals continue to discharge great quantities of pollution each year. Some of these pollutants can be highly toxic to people and marine life, while other pollutants are less immediately harmful but nonetheless can cause long term damage to the sensitive resources of Cook Inlet.

The single largest factor limiting our ability to make intelligent policy decisions on issues affecting Cook Inlet water quality is that we do not have sufficient information (i.e. hard data). Although numerous organizations – including state and federal agencies, citizens groups, universities and private industry – have conducted a variety of tests and studies in Cook Inlet, there remains a significant gap in our understanding of water quality in this watershed. The reason for this gap is that no one to date has implemented a comprehensive, continuous water quality monitoring program.

Alaska's 1996 Water Quality Assessment (305(b) Report), which is submitted every two years to Congress, states:

***"The vast majority of Alaska's watersheds, while not being monitored, are presumed to be in relatively pristine condition..." (emphasis added).***

This sweeping presumption is based partly on the fact that Alaska traditionally has witnessed small populations of people and industry relative to its expansive size. For much of Alaska's history, this

presumption may not have been far off base. But in recent years, Alaska in general, and Cook Inlet in particular, has experienced a dramatic growth in population and its associated pressures on water quality and natural resources. The Cook Inlet watershed is currently home to nearly 2/3 of Alaska's human population, and population in the area increased from just over 14,000 in 1950 to over 400,000 at present. We need only look at any other water body in the Lower 48 to know that increasing populations can correlate closely with water quality degradation. Yet despite the remarkable population increases in the Cook Inlet watershed, there has been no comprehensive ongoing program to gather the information needed to understand the human impacts on the region's spectacular resources.

Due, in part, to continuing budget cuts, the federal and state agencies charged with monitoring and protecting water quality have found it increasingly difficult to fulfill their mandates. More and more agencies have come to value the contributions of citizen based programs. That is why your efforts as volunteer monitors are so important. We are beginning to collect the information needed to chart an intelligent and sustainable course for the future of Cook Inlet. Gathering this data will not occur overnight; rather, it will take several years to accumulate enough information to be able to identify the trends that will help us shape management decisions. But the effort will be worthwhile, because we have the opportunity to maintain the quality of life which is so important to those who live and visit here.

## **B. THE WATERSHED CONCEPT**

### **What is a Watershed?**

A watershed is the land area which drains into a common body of water. As a result, specific watersheds are defined by their receiving waters. The Cook Inlet watershed (i.e. the land area which drains into Cook Inlet) covers over 39,000 square miles. It stretches from the tip of the Kenai Peninsula, across the Kennedy entrance and up through the Susitna River Valley, and includes nearly 2/3 of Alaska's population. There are numerous smaller watersheds "nested" within the Cook Inlet watershed, such as the Kachemak Bay watershed, the Kenai River watershed and the Ship Creek watershed. Keeper strives to address environmental issues on a watershed-basis because nature's complex physical, chemical and biological processes are more-readily understood using such integrated methods.

Watershed-based water quality management is just taking hold in Alaska. Cook Inlet resource managers and citizen groups are quickly moving toward innovative ways to look at water quality policy. In short, watershed-based directives take a step back from looking at pollution sources and impacts in immediately local areas, and strive instead to look at the complex ecological, chemical and physical interactions of water quality dynamics from a broader, more holistic perspective. This means we must consider the larger geographic area which drains potentially polluting waters into Cook Inlet. For example, a watershed perspective will consider not only the industrial discharge which goes directly into Cook Inlet, but also the septic tanks and other potential pollution sources in the uplands of the Susitna Valley.

## IV. SAFETY & ACCESS ISSUES

**O**f paramount importance to the Keeper monitoring program is to ensure the safety of its volunteers. Assuring reasonable and legal access to sampling stations is another important concern. Please read this section carefully and make sure you understand all the safeguards and practices for protecting yourself and others during monitoring activities. See Appendix E for the Keeper's mandatory liability release form.

### A. PREPARE FOR THE ELEMENTS

Although there are hundreds of volunteer monitoring programs across the country, few if any, must contend with the severe weather and rough water that make Cook Inlet unique. As a result, CEMP volunteers must be prepared for cold, dark and wet conditions during the winter months, and wind, rain and extended sun during the summer months. Regardless of the season, water temperatures around Cook Inlet rarely exceed 50° F, making it necessary to always take care around the sampling station. Here are a few rules which all volunteers must follow:

- ✓ *ALWAYS LEAVE WORD with a reliable source as to where and when you will be sampling.*
- ✓ *ENSURE SUFFICIENT SUPPLIES (e.g. food, water, clothes, fuel, flashlight/batteries, cellular phone) to sustain you and other team members in the event of an emergency.*
- ✓ *DRESS APPROPRIATELY FOR ALL POSSIBLE WEATHER CONDITIONS. Cook Inlet is notorious for its rugged, fast-changing weather, and volunteers should be prepared with the necessary footwear (e.g. waterproof boots), raingear, gloves, hats, coats, long underwear, sunblock, etc... Remember that you will be outside, remaining fairly still, for 40 to 60 minutes. You may slosh water on yourself. Layered clothing, gloves, and boots are important in colder weather. Wool and polypropylene are the best fabrics to wear to retain body heat when wet.*
- ✓ *ALWAYS SAMPLE WITH A QUALIFIED PARTNER. Volunteers are assigned to monitoring teams and should strive to sample in groups of two or more. You will be given the names and phone numbers of each member of your team as well a list of alternate monitors. If your teammates are not available for a particular sampling event they are responsible for helping you locate a qualified alternate. If no trained alternate is available, please contact the Monitoring Coordinator for assistance.*

### B. PROTECT YOURSELF AND YOUR EQUIPMENT

The Keeper's water quality monitoring kits include a number of chemical reagents which can be harmful if improperly handled or disposed. Please follow these important rules when sampling and testing:

- ✓ *Read all instructions to re-familiarize yourself with the test procedures before you begin, and note all precautions.*
- ✓ *Read the label on each reagent before use. Some containers include precautionary notices or material safety data sheets (MSDS) which provide important safety information. See Appendix F for available MSDS information.*
- ✓ *Avoid contact between chemicals and skin, eyes, nose and mouth.*
- ✓ *Wear safety goggles or glasses and rubber gloves when handling chemicals.*
- ✓ *Use test tube caps or stoppers, not your fingers, when shaking or mixing reagents.*
- ✓ *When dispensing a chemical from a squeeze bottle, hold the bottle vertically upside-down (not at an angle) and squeeze gently.*
- ✓ *Rinse test tubes and other containers after use, cap all reagents tightly and wash and dry your hands after each test session.*
- ✓ *Wipe up any chemical spills immediately and dispose of chemical wastes in appropriate waste containers at the Keeper office.*
- ✓ *Keep all equipment and chemicals out of the reach of young children.*
- ✓ *Avoid prolonged exposure of equipment and reagents to direct sunlight, and protect them from extreme high and low temperatures. Check your reagent solutions for cloudiness or the formation of precipitates. If any of your reagents appear abnormal, call (907) 235-4068 or email keeper2@xyz.net and the Monitoring Coordinator will supply a replacement. Postpone your sampling session until you get the new reagents.*
- ✓ *Check your thermometers to make sure that the fluid inside has not separated, as separation will cause inaccurate readings. If your thermometer fluid has separated, contact the Monitoring Coordinator for a new one.*
- ✓ *In the event of a chemical accident or suspected poisoning, immediately contact the Poison Information Center (1-800-478-3193) and be prepared to provide the name and identification number of the relevant chemical. This information is located on the reagent container.*

## C. ACCESSING THE SAMPLING STATION

### 1. Entering Private Property

Although the State retains ownership of marine tidelands up to the mean high tide line in most places, accessing those areas - and accessing freshwater streams and creeks in the uplands - may involve crossing private property. While access to government land (e.g. state, federal, borough, city) typically is presumed, volunteer monitors must obtain express authorization from private property owners if the volunteer enters or crosses the property owner's land at any point during sampling activities.

The first rule of monitoring on or around private property is NEVER TRESPASS. To avoid unintended trespass, please check the land ownership maps in the Keeper office prior to occupying your monitoring station, and obtain written authorization from property owners as needed. See Appendix G for private property access authorization forms.

### 2. Safe & Sound Site Access

Weather, daylight, rugged terrain, wild and domestic animals and other access issues can impact your sampling efforts. Although sampling stations should be selected in ways that promote accessibility, sometimes the only way to get to a particular waterbody is through or over rugged terrain. In such cases, the monitor should ensure that she/he is fully prepared - physically and otherwise - to get in and out of the site. Furthermore, because a primary purpose of the Keeper's monitoring efforts is to promote sound stewardship practices, volunteers should always avoid streambank trampling or accelerating waterside erosion. Here are a few other rules for ensuring a safe and sound sampling experience:

- ✓ *If driving, park your vehicle off roads and out of the way of traffic. Always watch for traffic.*
- ✓ *Always plan for incoming tides at marine or estuarine sampling stations.*
- ✓ *Use common sense in approaching your site and approach your site carefully. Mud, exposed roots, steep slopes and ice can pose dangerous access problems. Walking sticks, ice axes, toe cleats and other equipment can help make access safer. Getting samples is important, but not at the risk of injury.*
- ✓ *Bring a flashlight to guide you during dark or overcast conditions.*
- ✓ *Take appropriate precautions around domestic and wild animals.*

## **D. AT THE MONITORING STATION**

Prior to sampling, monitors should check their kits and reagents to ensure they have all the chemicals and equipment needed to monitor the full spectrum of parameters. When you arrive at the sampling station, try to find a place to set out your equipment and chemicals where they will not be sitting in strong, direct sunlight. On windy days, beware of small containers being blown into the water. And of course, follow all the safety and access rules outlined in this section.

## **V. MONITORING OVERVIEW**

**T**his section provides a general overview of the tests and procedures you will use to obtain accurate and useful data, and discusses how these tests will help us better understand the health of the Cook Inlet watershed.

### **A. SOME TYPES OF WATER QUALITY MONITORING**

#### **1. Baseline Monitoring**

Baseline monitoring involves the collection of various types of data to gain an understanding of "normal" conditions in a particular waterbody. Without such information, we are unable to know what changes human and other impacts are having on our aquatic systems. For example, during the *Exxon Valdez* disaster, biologists were poorly equipped when asked about the ecological impact of the spill. Although they knew that birds and marine mammals were dying, they did not have enough information to make knowledgeable comparisons between the pre- and post-spill environments. This body of knowledge is critical if we hope to understand the complex effects of human activities on ecological health.

#### **2. Compliance and Enforcement Monitoring**

Compliance and enforcement monitoring, as the name suggests, tests whether a certain discharge or effluent is meeting limits imposed by law. For example, under the Clean Water Act's National Pollution Discharge Elimination System (NPDES), anyone who discharges a pollutant into the waters of the United States must obtain an NPDES permit and monitor the discharge to ensure compliance with that permit. In an enforcement scenario, an agency or other organization may take samples to demonstrate that a violation of a permit or standard has occurred.

### **B. WATER QUALITY TEST METHODS**

Below are descriptions of general water quality testing methods, to help clarify how each one works in Keeper's monitoring program. Always follow the specific instructions provided in Section VI of this manual.

#### **1. Titrimetric**

Titrimetric analyses are based on adding a solution of a known strength (i.e. the titrant) to a specific volume of a treated sample in the presence of an indicator. The indicator produces a color change indicating the reaction is complete. Titrants are generally added using a titrator (graduated dropper) or a precise glass pipet. The Winkler method for measuring dissolved oxygen is an example of a titrimetric analysis.

## **2. Colorimetric**

Colorimetric tests measure the concentrations of various substances by gauging the reaction of an indicator with a known sample amount, and comparing the resulting color with a known range of values. For example, pH is a measure of the concentration of hydrogen ions (i.e. the acidity of the solution) determined by the reaction of an indicator that varies in color depending on the hydrogen ion levels in the sample water. The sample's color is then visually compared to a known range of pH values using an Octet Comparator.

## **3. Electronic Meters**

Specific electronic meters are manufactured for field and laboratory tests of various water quality factors. At fresh water sites, Keeper uses a Hanna Meter which tests for pH, conductivity, oxidation-reduction potential and temperature. Electronic meters must be calibrated periodically to ensure accurate test results.

# **C. SAMPLING SCHEDULE**

Samples are to be taken on the second and last Sundays of each month during the months of May, June, July and August and on the last Sunday of each month during the remainder of the year (i.e. September through April) for a total of 16 times per year. If monitoring cannot be done on a designated Sunday because of weather, illness, vacations or for other reasons, it should be scheduled during the two days just before or just after the designated date (i.e. Friday through Tuesday). Please do not complete part of a session one day and finish it up the next. If you need to break off a session (due to weather, injury, etc.), all procedures should be repeated on the next attempt. We are trying to get a data "snapshot" of the conditions at your site at a particular date and time.

To the extent possible, sampling is to be conducted at 2:00 PM. When this is not possible sampling should be done between the hours of 11:00 AM and 5:00 PM. Some of the parameters to be measured depend on the amount of sunlight available and therefore vary throughout the day - for example, temperature in shallow areas or dissolved oxygen. The shorter days of the winter months pose particular challenges here. Essentially, we have specified a "sampling window" in order to collect comparable data.

The quality of the data collected by our program depends on regular and consistent monitoring. If you anticipate missing an event (for example, if you are going on vacation), it is your responsibility to make arrangements with a trained alternate. If the alternate is not on your monitoring team, make sure they know the exact location of the site. If no trained alternate is available, or in an emergency, please

contact the Monitoring Coordinator at (907) 235-4068. It is mandatory that all monitoring be conducted by fully trained personnel. Please do not try to give a novice a quickie training session and then send them out on their own. (But feel free to bring them to our next "official" training session - we are always looking for new recruits!)

## **D. KEEPER TEST PARAMETERS AND WHY**

This section reviews the types of water quality data and other information to be collected and discusses why each is important to understanding the "health" of the Cook Inlet Watershed.

### **FIELD OBSERVATIONS**

In addition to the water quality parameters you will monitor, there is other important information which will help draw a more complete picture of the environmental health of your sampling site and the Cook Inlet Watershed as a whole. Gathering this information involves using your senses to observe conditions at your site.

Recording basic observations about your site will put the data you collect into context. You will be producing a record of conditions over time, through changes in tide, weather and season as well as varying human and wildlife activity.

#### **Air Temperature**

Air temperature is a standard measurement taken by most environmental monitoring programs. Recording air temperatures helps to create a complete picture of conditions at the sampling site at the time of monitoring and to document climatic conditions over an extended period.

#### **Wind & Weather**

Weather conditions (whether raining or sunny, windy or calm) can have an impact on physical, chemical and biological activity in the water. Wind speed and direction can be an indication of the source of certain air borne pollutants. It can also affect turbidity, dissolved oxygen and surface water temperature. In the Keeper program you will reference the Beaufort Scale to estimate wind speed (see Appendix H).

Rainfall can affect the rate of run-off pollution from land as well as the temperature, pH and turbidity of surface water. Volunteers record current weather conditions and the number of consecutive days prior to sampling that have had similar weather. Monitors also record the type and amount of precipitation at each site for the past 24 hours. You can obtain a rain gauge from the Monitoring Coordinator or, if you live in the same watershed as your site, you may want to find out if a neighbor is already tracking rainfall and is willing to share the information.

#### **Water Surface & Tidal Conditions**

Whether calm, rippled, or with waves and white caps, surface water conditions indicate how much mixing is occurring in the top layer of the water body. When the surface is placid, very little wind-

induced mixing occurs. Waves whipped up by wind, however, indicate substantial mixing and the introduction of oxygen to the water. If you are sampling in a stream segment where wind does not have a major impact on surface water conditions, it is still important to note whether your site is located in or near rapids, riffle, smooth flowing water, or a calm eddy. This information may assist in interpreting dissolved oxygen data.

The tidal stage can also have a significant impact on some of the parameters you will be testing. Cook Inlet experiences the second largest tidal shifts in the world (the Bay of Fundy in Nova Scotia is first). As the tide comes in, salinity will commonly increase at estuarine sampling sites and water temperature is likely to change, which will in turn affect dissolved oxygen levels. Recording the stage of the tidal cycle at the time of sampling helps account for some of these changes. The Monitor Data Sheet (Appendix I) includes a worksheet space for determining tidal stage based on the tide book provided in your kit and the tidal stage guide in Appendix K.

### **Comments & Observations**

Despite being the least quantitative of the parameters, visual assessment of the monitoring site can provide valuable information and assist in interpretation of other physical, chemical and biological data. Visual assessment is simply observing the environmental conditions at the site and recording those that are noteworthy.

Visual information can also provide an account of events or conditions that may help explain the monitoring data collected. For example, if dead fish are floating on the water surface, they may signal a sudden drop in dissolved oxygen levels, the influx of some toxic substance, or a disease or infestation of the fish.

In addition to visual assessment you will also use your ears and your nose to monitor your site. Listen for birds and other wildlife as well as sounds of human activity such as engines. Check for unusual odors. Though quite subjective, water odor can reveal water quality problems that may not be visually apparent. Industrial and municipal effluents, rotting organic matter, and bacteria can all produce distinctive odors. Raw sewage, for example, has an unmistakable aroma.

### **Photos or Sketches**

A picture should be taken prior to the first round of sampling at each site. Additionally, it is a good practice to take routine pictures of your site at least four times a year, in order to get a sense of its seasonal and other variations over time. If your site is subjected to either long term or sudden environmental impact your photos will help document the effects of these changes.

Regardless of your level of artistic ability, a rough sketch of your site can be a valuable tool for physically locating your observations during each sampling event.

Please do not underestimate the importance of this observational data; although it is less “hard” than the numbers and figures you will measure in your water testing, it nonetheless provides an important window into the ecology of your sampling area.

## **WATER QUALITY PARAMETERS**

Keeper's Citizens' Environmental Monitoring Program includes testing for a wide range of water quality indicators. Selection of the parameters to be tested was based on a number of factors including how the collected data would contribute to understanding of water quality and overall watershed "health", the ease with which tests could be performed and the long term affordability of monitoring equipment and supplies.

### **Apparent Color**

Apparent color of water results from dissolved substances and suspended matter, and provides general but useful information about the water's source and content. Metal ions, plankton, algae, pollution and other natural and human-induced materials may all produce color in water. Depending on the materials in it, water absorbs certain wavelengths of light, and reflects others. The reflected wavelengths are the ones we observe when determining apparent color.

Transparent water with a low accumulation of dissolved materials appears blue and indicates low productivity. Dissolved organic matter, such as humus, peat or decaying plant matter, can produce a yellow or brown color. Some algae or dinoflagellates produce reddish or deep yellow waters. Water rich in phytoplankton and other algae usually appears green. Soil runoff produces a variety of yellow, red, brown and gray.

Uniform color scales are used in determining apparent color to ensure that standardized color information can be shared and compared between researchers. Keeper has selected the Borger Color System, (BCS) which was originally devised to measure the color of flies for fishermen, but which is well-suited for water testing too.

### **Turbidity (Clarity)**

Turbidity, or water clarity, is a measurement that pulls together many important features of an aquatic system. Turbidity is caused by suspended solid matter which scatters light passing through the water. Any material mixed and suspended in water will reduce its clarity and make the water turbid (i.e. muddy and cloudy). Such materials can come from many sources. In early spring, the water may become more turbid as silt is carried into the estuary with the spring thaw and run-off. At any time of year, silt-laden surface water can flow into the estuary from tributaries and storm drains during periods of heavy rain and associated runoff. In Cook Inlet, glacial silts are also a major cause of turbidity. In late spring through early fall, turbidity may be caused by plankton as they grow and multiply rapidly in warm, sunlit, nutrient-rich water.

In shallow areas, wind-generated waves and boat wakes can stir up sediments from the bottom. As waves generated by wind and passing boats break on the shore, they can also increase the turbidity. Upstream construction activities, land clearing, or any other activity which erodes the soil, may release sediment to tributaries of Cook Inlet and increase turbidity.

Turbidity affects fish and aquatic life in many ways:

- High turbidity levels interfere with the penetration of sunlight. Submerged aquatic vegetation (SAV) needs light for photosynthesis. If suspended particles block out light, lower rates of photosynthesis produce less oxygen. SAV, like the eelgrasses and kelp in many areas of Cook Inlet, provide important habitat for a diverse community of marine life. These are critical areas where many species including shellfish, waterfowl, and fish can find essential food and shelter. If light levels get too low, photosynthesis can stop all together and the vegetation will begin to die off.
- Large amounts of suspended matter can clog the gills of some species of fish, reducing oxygen transfer.
- Excessive amounts of suspended matter clog the feeding apparatus of bottom-dwelling animals (e.g. crabs, anemones or clams) and may even smother them completely.
- Suspended particles may provide a place for harmful bacteria and microorganisms to settle and grow. The particles can also carry pesticides, toxic metals and excess nutrients down tributaries or throughout the dynamic Cook Inlet estuary. Suspended particles near the water surface absorb additional heat from sunlight and can raise the surface water temperature.

There are several ways to test turbidity. One turbidity test involves an electronic instrument called a nephelometer, which uses scattered light to measure turbidity in Nephelometric Turbidity Units (NTUs). Another involves the use of a Secchi Disk - a small (20 centimeters in diameter) disk divided into black and white quadrants which is lowered into a waterbody. The level where the disk disappears is recorded, and the measurement correlates to turbidity.

Keeper has elected to use the Secchi Disk method at sites where water depth is three meters (approximately 10 feet) or greater. In shallower areas Keeper monitors perform a comparative turbidity test, which uses a chemical reagent in a tube to measure turbidity in Jackson Turbidity Units (JTUs). (Note: JTUs correlate with NTUs).

## **Water Temperature**

While temperature may be one of the easiest measurements to perform, it is also one of the most important parameters we test because it dramatically affects the rates of chemical and biological reactions within the water. Some of the most common biological, physical and chemical processes that are temperature dependent are listed below.

- The rates of photosynthesis and plant growth both increase in warmer water. Therefore, it is important to understand the connection between the processes of photosynthesis and respiration. In photosynthesis, plants use sunlight, carbon dioxide, and water to create the organic molecules they need to grow. In the process, the plants release oxygen. Respiration is the reverse of photosynthesis; when no light is available, plants respire (i.e. they take in oxygen and break down

the stored organic molecules to get energy), releasing carbon dioxide. Thus, temperature changes can dramatically affect plant growth and the amount of oxygen in the water.

- An increase in plant growth and photosynthesis means that more oxygen is produced, but it also means that more oxygen is consumed through plant respiration. The balance between photosynthesis and respiration depends on the availability of sunlight. Especially in summer, when the days are longer, there is a net production of oxygen. Another factor is that when the plants die, oxygen is consumed in the process of bacterial decay.
- Individual organisms living in the water are healthiest when temperatures stay within their range of tolerance. The metabolic rates of organisms increase in warmer water and in many organisms, increased metabolism means increased oxygen demand. Even if there is enough dissolved oxygen to supply the greater demand, under extreme high or low temperature conditions marine organisms become stressed and are more vulnerable to toxic chemicals, diseases, and parasites. The requirements of any one organism change as it goes through different stages of life. For example, fish larvae and eggs usually have a narrower tolerance range than adult fish; conditions that would have been tolerable for the adults may kill off the larvae before they have a chance to reach adulthood
- Temperature affects the distribution of various types of organisms because different organisms have different temperature requirements and different ways of responding to changes in temperature. Motile organisms - those capable of moving on their own, such as fish - may be able to escape unfavorable temperature conditions by migrating elsewhere. Sessile (i.e. immobile) organisms such as algae and slow-moving organisms such as anemones remain to be weakened or even to die.
- Gases such as oxygen are more soluble in cool water than in warm water. In other words, cool water can hold more dissolved oxygen. Solids, on the other hand, are usually more soluble in warm water. For example, heavy metal compounds deposited in sediments at cooler temperatures can be released at warmer temperatures. First, the compounds already existing in the sediments become more soluble; second, as the concentration of oxygen decreases, the metals react chemically to form new and even more soluble compounds. Once the metals are released from the sediments into the water, they can be taken up by marine life.
- The rates of chemical reactions in fresh and brackish water generally increase with increasing temperature.
- The density of seawater decreases with increasing temperature. This variation of density with temperature affects inversions, mixing, and current movements.
- Because significant portions of Cook Inlet are naturally shallow, the capacity of these parts of the estuary to store heat for long time periods is relatively small. As a result, water temperatures fluctuate considerably over time and by location. In shallow areas, tides, currents, and wind tend to minimize temperature differences between surface and subsurface water.
- In deeper areas, the temperatures of surface and subsurface water often differ. Generally, deeper water is colder and therefore denser. The vertical temperature profile of the water column follows a

fairly predictable annual cycle. In spring and summer months, the surface waters are warmed by the sun; the bottom waters remain much cooler. In the fall, the sun gets lower in the sky, the days get shorter, and the air gets cooler. The surface waters also cool, increasing in density. When the surface water is colder and denser than the bottom water, it begins to sink, and vertical mixing occurs. Wind speeds up the process. This annual turnover creates an upwelling of nutrients and minerals from the bottom that are newly available to the phytoplankton and other inhabitants of the surface waters. During the remaining winter, the water temperature becomes nearly constant from surface to bottom. Then, in early spring, the radiation of the sun again warms the surface waters. The top layer warms and the bottom remains cool, until the next fall when turnover and upwelling occur again.

Temperature is measured using a familiar instrument: a thermometer. Most liquids expand with increasing temperature. A thermometer consists of a reservoir of a known liquid in the bulb (in our case, alcohol mixed with dye) and a narrow-bore tube into which the liquid expands. Measuring the height to which the liquid has expanded in the tube gives the temperature.

Water temperatures will be reported in degrees Celsius, the standard temperature unit for scientific data. On the Celsius scale, fresh water boils at 100°C and freezes at 0°C. Seawater, on the other hand, freezes at a somewhat lower temperature depending on its salinity. Because Americans still frequently rely on the Fahrenheit scale (where freshwater boils at 212°F and freezes at 32°F), it may help you to use the following formula to convert between the two scales:

**To convert from °F to °C:**

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times (5/9) \quad \text{or} \quad ^{\circ}\text{C} = (^{\circ}\text{F} - 32) \div 1.8$$

**To convert from °C to °F:**

$$^{\circ}\text{F} = [(9/5) \times ^{\circ}\text{C}] + 32 \quad \text{or} \quad ^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

## **pH**

pH is the measure of how acidic or basic a solution is. Because a variety of chemical and biological processes depend on certain pH values, pH measurements provide important information about the state of water quality. As water travels through the watershed, a number of factors may affect its pH:

- Leaching of soil and rock outcrops, especially during periods of heavy rain or snowmelt.
- Human-generated wastes (e.g. industrial discharges, sewer overflows, lawn runoff).
- Aerosols, dusts and gases picked up from the air.
- Photosynthesis by aquatic plants, which consumes carbon dioxide and can raise the pH of surrounding water.

The pH of the fresh water flowing into Cook Inlet depends on where the water has been and what it is carrying. Once water reaches Cook Inlet, local variations tend to be homogenized, partly by the motion

of currents and tides, but also due to the strong buffering of seawater. Local pH values can increase during intense phytoplankton blooms, as the phytoplankton consume carbon dioxide in photosynthesis.

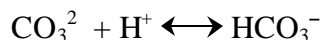
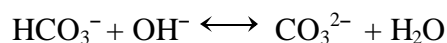
The resistance of water to changes in pH is critical to aquatic life because it determines the range of pH that organisms have to adapt to in order to survive. Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes more than 9.0 or less than 5.0. However, the ideal range for aquatic life in general - including both fresh water and salt water species - falls between 6.5 and 8.2. Marine organisms in the open ocean are usually exposed to an even narrower pH range of 8.1 to 8.3. When water with a low pH value comes in contact with certain chemicals and metals, the acidity of the water may cause these substances to become more soluble or more toxic than normal, increasing the effects of the pollutant load on Cook Inlet. Fish that can stand a slightly acidic pH may die at a more neutral pH if low concentrations of iron, aluminum, lead, or mercury are present. Phytoplankton blooms can play an interesting role here; as a bloom dies off, chunks of it sink to the bottom and decompose. The decomposition process produces organic acids which can lower the pH and react with the sediments to release metals and other toxins into the water.

Pure distilled water has a pH of 7.0 and is said to be neutral. The pH values of natural waters are controlled by the salts and gases dissolved in them. Seawater typically has a pH of 8.1 to 8.3. Because its pH is greater than 7.0, it is said to be basic or alkaline (the two terms are synonymous). The pH of seawater is fairly stable because it is highly buffered - that is, the water contains pairs of ions which react to damp down changes in pH.

The strong buffering and constant motion of seawater tend to minimize variations in pH. Short-lived, local variations may be caused by intense phytoplankton blooms, or at locations where industrial discharges and sewer outflows enter the ocean, or where there are large influxes of fresh water. Natural fresh water typically has a lower pH than seawater. Rain water and snow melt usually has a pH of 5.6 to 6.0. Because its pH is less than 7.0, even unpolluted rain water is said to be acidic. So-called "acid rain" has an even lower pH due to atmospheric pollutants.

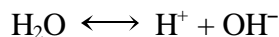
### Buffers

Seawater contains both bicarbonate ions ( $\text{HCO}_3^-$ ), which can consume excess hydroxyl ions ( $\text{OH}^-$ ), and carbonate ions ( $\text{CO}_3^{2-}$ ), which can consume excess hydrogen ions ( $\text{H}^+$ ):



The ratio of carbonate to bicarbonate ions present in seawater buffers its pH to a fairly stable value of 8.1 to 8.3. The ratio of borate ions ( $\text{H}_2\text{BO}_3^-$ ) to boric acid ( $\text{H}_3\text{BO}_3$ ) also plays a lesser but significant role in the buffering of seawater.

pH is defined as the negative logarithm of the concentration of hydrogen ions; the higher the concentration, the lower the pH. In any given aqueous solution, a certain proportion of water molecules dissociate to form hydrogen ( $H^+$ ) and hydroxyl ( $OH^-$ ) ions:



In neutral solutions (pH = 7.0), the concentrations of hydrogen and hydroxyl ions are equal. Acidic solutions (pH < 7.0) contain more hydrogen than hydroxyl ions. Basic or alkaline solutions (pH > 7.0) contain more hydroxyl than hydrogen ions.

Because the pH scale is logarithmic, pH does not increase or decrease in a simple linear fashion. Instead, the increases are in powers of 10. For example, at a pH of 5 there are ten times more  $H^+$  than a pH of 6:

$$\text{pH } 6: [H^+] = 1 \times 10^{-6} = 0.000001$$

$$\text{pH } 5: [H^+] = 1 \times 10^{-5} = 0.00001$$

Thus, a solution of pH 3 is not simply twice as acidic as one with a pH 6, but 1000 times as acidic.

One of the easiest ways to measure pH is to use an indicator solution. Most indicators are organic molecules which have a hydrogen ion they can easily gain or lose and which happen to change color when this occurs (making the reaction easy to observe). Keeper has selected a "wide range" indicator, which can measure pH throughout most of the pH range.

## Salinity

Salinity is an important factor affecting the physical and chemical make-up of Cook Inlet waters. It is defined as the concentration of dissolved salts in the water, usually expressed in parts of salt per thousand parts of water (ppt). Seawater averages 35ppt (3.5% by weight) in the open ocean and 27 to 33 ppt (2.7% to 3.3% by weight) in most coastal waters. Fresh water usually contains few salts (drinking water usually has a salinity of less than 0.5ppt). A liter of Cook Inlet water typically contains 28 to 34 grams of dissolved salts. In other words, a quart would contain about an ounce of salts.

The surface salinity levels within Cook Inlet, especially near the coast, vary with many factors, including the tides and the volume of fresh water flowing into the Inlet. Salinity tends to decrease in the spring when heavy rainfall, the release of groundwater, and melting snow combine to greatly increase the amount of fresh water flowing in. Some decreases in salinity may be attributed to human activities which reduce the water-holding capacity of the land (such as paving or removal of vegetation) or directly accelerate fresh water discharge (such as storm drains and sewers). On the other hand, excessive

withdrawals of water from the fresh water portion of a tributary (for agricultural use, drinking water, etc.) can elevate salinity near the mouth of this tributary.

Salinity levels also vary vertically from top to bottom. In general, salinity increases with depth. The fresh water coming down river is less dense than the heavier seawater, so the entering fresh water tends to float on top of the seawater and may not mix immediately. The volume of entering fresh water is also the greatest closest to land. The net result is a wedge of lighter fresh water lying over the heavier seawater, with poorly defined edges that are continually mixed by wind, waves, and tides. In shallow waters, the mixing of top and bottom layers can obscure this "wedge" or "lens" completely.

Perhaps the most important aspect of the estuary's salinity gradient is its effect on the distribution and well-being of the biological population that inhabits the Inlet. Some species of fish, such as salmon, require the fresh water portion of the estuary to spawn, but live the rest of their lives in the marine portion. Some organisms are extremely tolerant of the changes in salinity and are found everywhere from the open sea to waters with only the slightest tinge of salt. Sessile (immobile) bottom-dwellers such as butter clams are tolerant of salinity variations, but salinity does affect their growth and spawning.

The solubility of heavy metals also increases with increasing salinity. In summer, higher temperatures can combine with higher salinity and lower dissolved oxygen levels to create conditions where heavy metals previously deposited in the sediments can be more readily released into the water. This is also the season when bottom-dwelling and burrowing organisms are at their most active in turning over sediments and exposing them to react with the water.

There are many ways to measure salinity. Most depend on measuring some other property which is directly related to salinity. In the Keeper program, we measure the specific gravity of water using a hydrometer and convert the specific gravity readings to salinity. The specific gravity of a substance is its density divided by the density of pure water at 4°C - easy enough to do, since the density of pure water at 4°C is 1 gram per milliliter. A hydrometer placed in a liquid will always displace its own weight of liquid, so the denser the liquid is, the less volume of liquid will be displaced and the higher the hydrometer will float. Measuring the point at which the hydrometer stem breaks the surface of the liquid gives the liquid's specific gravity.

The density of water changes with temperature. Pure water reaches its maximum density at 4°C. At temperatures above 4°C, the density of pure water decreases with increasing temperature. As salts are dissolved in water, the temperature at which it reaches its maximum density decreases from 4°C and approaches the freezing point. At 25ppt salinity water reaches its maximum density at its freezing point. For solutions with salinity above 25ppt, such as seawater (typically 35ppt), density always decreases with increasing temperature even when temperatures are below the freezing point.

Because of the dependence of specific gravity on temperature, a sample's temperature has to be measured at the same time as its specific gravity. A table can then be used to a) convert these measurements to the specific gravity the sample would have at a standard temperature of 15°C and b) convert these standardized specific gravities to salinities; the higher the specific gravity, the higher the salinity (see Appendix J for conversion table).

## Hanna Meter

The Hanna meter is an electronic meter which measures the parameters temperature, pH, conductivity and oxidation-reduction potential. Although temperature and pH measurements duplicate those of previous tests, the meter provides an important check on data accuracy. By also recording conductivity and oxidation-reduction potential readings, the Hanna meter provides additional insight into water quality.

### a) Temperature

As discussed above, temperature is an important factor for many physical, chemical and biological processes in Cook Inlet. Using the Hanna meter for temperature readings at the start and finish of Hanna Meter testing allows for more accurate temperature measurements, and provides a check on thermometer readings.

### b) pH

pH is also important for many physical, chemical and biological systems. Taking three (3) sequential readings with the Hanna meter provides for more accurate pH measurement, and a check on the pH value obtained from the Octet Comparator.

### c) Conductivity

Conductivity measures the electrical conductance of water, which is proportional to the nature and quantity of total dissolved solids (TDS) in the sample water. TDS is defined as the material left behind after a water sample is filtered and evaporated. The quantity of dissolved matter depends mainly on the solubility of the rocks and soils the water contacts, and each water body contains a unique mixture of dissolved materials.

Because the amount of dissolved material determines the water's ability to conduct electricity, TDS can be measured by recording conductivity. The Hanna meter contains electrodes, which measure the electrical current which is conducted between them in the sample water. Conductivity is measured in micromhos (or micro-Siemens) per centimeter (mhos/cm or  $\mu\text{S}/\text{cm}$ ).

### d) Oxidation-Reduction Potential (ORP)

In a manner similar to that in which acidic or alkaline solutions are quantified by pH measurements, solutions can also be graded as oxidizing or reducing based on measurements of ORP (sometimes called 'redox') values.

The Oxidation Reduction Potential defines the capability of a substance to either release or gain free electrons. Oxidation is always coupled together with reduction so that as one element gets oxidized another automatically is reduced.

Oxidation and reduction reactions mediate the behavior of many chemical constituents in water. The reactivities and mobilities of important elements in biological and chemical systems depend strongly on redox conditions. Measurement of redox potential is useful in developing a more complete understanding of water chemistry.

ORP is also a reliable indicator of bacteriological water quality because the life expectation of bacteria in water is related to this parameter. For example, studies have shown that the life span of bacteria in water decreases more directly due to the ORP value than to the concentration of chlorine in the water. The graph on the right represents the disinfection time for the bacteria

E. coli with respect to ORP value.

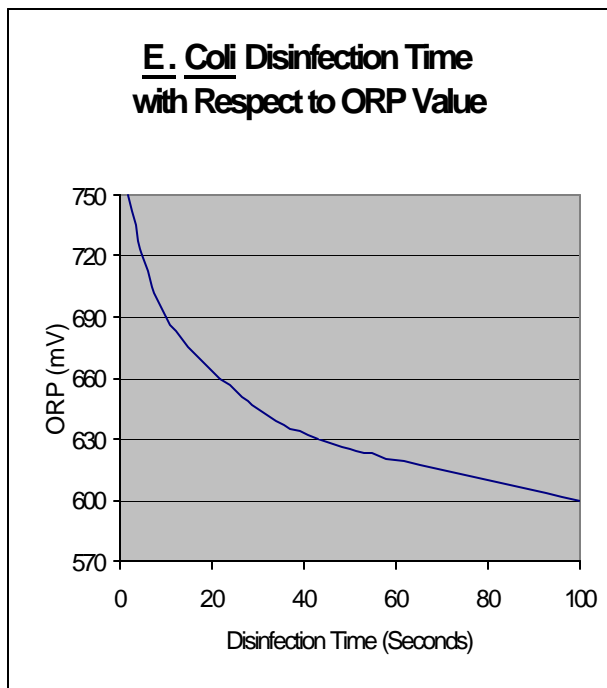
ORP measurements are based on the potential difference between an electrode made of an inert metal (normally platinum or gold) and a reference electrode. The identical reference system utilized for the pH electrode (Ag/AgCl) is also used for redox measurements.

When the redox electrode is immersed in a solution containing a reversible chemical reaction system, a migration of electrons is established between the electrode and the system. This electron flow can be construed as an exchange current density and is of paramount importance for accurate, fast and reproducible redox potential measurement.

The Hanna meter relies on its sensitive electrodes housed in the meter's black base compartment. These electrodes are fragile and should not be handled. Always remember to rinse the electrodes with distilled/dionized water prior to and after testing.

## Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicators of water quality for aquatic life. It is essential for the basic metabolic processes of animals and plants inhabiting our coastal waters. Dissolved oxygen is measured in milligrams per liter (mg/l) which equates to parts per million (ppm). When oxygen levels fall below about 3 to 5mg/l, fish and many other marine organisms are stressed and some cannot survive. Dissolved oxygen is a particularly sensitive constituent because other chemicals present in the water, certain biological processes, and physical factors such as temperature and water clarity exert a major influence on its availability throughout the year.



The maximum amount of oxygen water can hold depends a great deal on its temperature and salinity. A DO test (using a meter or chemical kit) tells you how much oxygen is dissolved in the water, but it does not tell you how much oxygen the water is capable of holding at the temperature and salinity at which it was tested. Warmer water holds less dissolved oxygen; as water approaches its boiling point, it can hold almost no oxygen. Dissolved oxygen also decreases with increasing salinity. When water holds all the dissolved oxygen that it can at a given temperature and salinity, it is said to be 100 percent saturated with oxygen. If water holds only half that amount of DO at the same temperature and salinity, it is said to be 50 percent saturated. The table below shows this relationship for various temperatures and salinities.

TEMPERATURE °C	SALINITY		
	Freshwater 0 ppt	Brackish water 5 ppt	Open Ocean 35 ppt
0	14.6	14.1	11.3
5	12.8	12.4	10.1
10	11.3	11.0	9.0
15	10.2	9.9	8.3
20	9.2	9.0	7.5
25	8.4	8.2	6.9
30	7.6	7.4	6.1

**Potential dissolved oxygen levels in milligrams per liter (mg/l) at sea level**

Consider some of the more shallow areas in Kachemak Bay on a hot August day. Except for in glacial streams, stream levels are relatively low at that time of year, so less fresh water is flowing into the Bay and the salinity is relatively high. The average water temperature in the Bay is also relatively high (by Alaska standards) and it gets higher locally as the tide comes in over a clam flat or beach that has been baking in the sun. Both the higher salinity and the higher temperature lower the water's ability to hold oxygen. Any events that increase the oxygen demand - e.g. a salmon run, or an influx of nutrients that causes a plankton bloom followed by a die-off - can push the local ecosystem over the edge and cause serious problems.

One of the largest sources of dissolved oxygen is oxygen transferred from the atmosphere into surface waters by the re-aerating action of wind and waves. A second major source is oxygen produced by aquatic plants (including phytoplankton) during photosynthesis. Photosynthesis requires sunlight, so it is limited by depth. In the open ocean, most photosynthetic activity occurs in the upper 80 meters (260 feet), with some activity continuing down to 600 meters (1,970 feet). In coastal areas, the depths at which photosynthesis can occur are more variable and more influenced by activities on land.

Once in the water, oxygen is consumed by marine organisms. Like land animals, fish and other marine species need oxygen for respiration. When no light is available, plants also need oxygen. Bacteria consume oxygen as they decompose dead plants and animals. Oxygen shortages occur when consumption outstrips the available oxygen resources. Oxygen levels may be reduced because the water is over-heated, as it might be near an industrial discharge or marine log storage area; warmer water simply cannot hold as much oxygen as cooler water. If water clarity decreases - that is, the water

becomes turbid - due to an influx of glacial silt, organic matter, etc., less sunlight will reach the photosynthesizing plants, and they will be less able to produce oxygen.

Large amounts of organic matter in the water can not only decrease oxygen production, but also increase consumption as bacteria work on breaking down and decaying the matter. When run-off from the land or the addition of sewage effluents provides excessive amounts of nutrients such as nitrogen (in salt water near the coast) or phosphorus, a phytoplankton bloom can occur. The availability of extra nutrients allows the reproductive rate of these microalgae to zoom; the population of some species can double every twenty minutes. The phytoplankton bloom can block sunlight from reaching other types of plants. When the extra nutrients are gone, the bloom suddenly dies off, and huge amounts of oxygen are used up in its decay. A massive phytoplankton bloom can result in anoxic conditions (i.e. absence of oxygen) and can cause substantial die-offs of fish and shellfish in coastal waters.

For surface sampling, dissolved oxygen will be measured using a method called Winkler titration (named after Hungarian chemist Lajos Wilhelm Winkler). One of the immediate problems involved in measuring the concentration of oxygen dissolved in a water sample is to prevent any of the oxygen from escaping. To achieve this, two solutions are added to the sample. One contains manganous ions ( $\text{Mn}^{2+}$ ) and the other hydroxyl ions ( $\text{OH}^-$ ). Because of its high concentration of hydroxyl ions, the second solution is described as "alkaline." Together, these ions react to form manganous hydroxide, which is fairly insoluble in water and forms a white, fluffy flocculate (or floc). Immediately, the oxygen molecules in the water react with the floc to convert it from manganous hydroxide to hydroxides of various manganese ions with charges higher than  $+2$  (e.g.,  $+3$ ,  $+4$ , and  $+7$ ). These new hydroxides give a brownish color to the floc.

The next step is to add a strong acid to the sample to dissolve the hydroxides. As the manganese ions are freed from the floc, they react with the iodide ions ( $\text{I}^-$ ) contained in the alkaline solution added earlier and form manganous ions (the same kind you started with) and iodine molecules ( $\text{I}_2$ ). Because of the iodine, the sample turns a yellow-brown color.

At this point, the oxygen molecules are no longer floating around in the water. Instead, they have been entirely used up in the conversion of the manganese ions. If you are sampling in messy weather or from an unstable surface, you can take the treated sample to some more convenient place to finish the procedure. Protect the sample from light and heat (sample temperature should remain between  $+4^\circ\text{C}$  and  $+10^\circ\text{C}$ ), and finish the procedure within six hours.

A carefully measured portion of the treated sample is "titrated" with thiosulfate ions ( $\text{S}_2\text{O}_3^{2-}$ ) - that is, sodium thiosulfate solution is added drop by drop to determine the exact amount necessary to consume all of the iodine in a reaction that produces iodide and tetrathionate ions ( $\text{S}_4\text{O}_6^{2-}$ ). In order to make it easier to see the exact point at which all the iodine is consumed, a starch indicator is added to the titration sample. Starch turns dark blue in the presence of iodine. As the last of the iodine vanishes, so does the dark blue color.

The whole point of this procedure is that all of the oxygen molecules are consumed in the conversion of the manganese ions, but all of the manganese ions are converted back to manganous ions by the iodide ions. The net result is that two iodine molecules are produced for each of the oxygen molecules you started with. Each iodine molecule then converts two thiosulfate ions into one tetrathionate ion.

The titration procedure measures the molar volume of a sodium thiosulfate solution of known concentration needed to consume all of the iodine in a titration sample of known volume. Multiplying the molar volume of thiosulfate solution used by its concentration gives the number of thiosulfate ions that were consumed. The number of iodine molecules involved is one half of this, and the number of oxygen molecules originally dissolved in the titration sample is one half of this again. Dividing the number of oxygen molecules by the volume of the sample gives the dissolved oxygen concentration. In the procedure we're following, a syringe holding 1 milliliter of sodium thiosulfate solution and divided along its length into ten units is used to titrate a 20 milliliter water sample. The concentration of the thiosulfate solution is chosen so that every 1 milliliter used in the titration indicates a DO concentration of 10 mg/l. In other words, each unit marked on the syringe corresponds to 1 mg/l dissolved oxygen in the sample.

## **Nutrients**

Phosphorus and nitrogen are both nutrients that occur naturally in water. They appear to be the most important nutrients in the eutrophication process and can often become detrimental by accelerating eutrophication, which is the natural aging process of a body of water such as a bay or lake.

Nutrients are also contained in stream sediments. If these are suspended they can maintain eutrophic (increased plant growth) conditions for many years. Many factors influence how much nutrient in a waterway is dissolved (soluble) and how much is attached to particles (particulate). These factors include:

➤ **Environmental factors**

High rainfall causes high-flow events and under these conditions soluble and particulate nutrient concentrations in waterways increase.

➤ **Catchment characteristics**

Factors such as slope, plant cover, soil type and soil moisture content will influence nutrient concentrations and the amount in soluble or particulate forms. Some soil types are more prone to water erosion than others. Sandy soils are most likely to produce the highest soluble phosphate concentrations, but this will depend on the likelihood of run-off or infiltration.

➤ **Management practices**

Water samples collected soon after fertilizer is applied may have high concentrations of soluble phosphate. If particles can settle out from flowing water (say, in a wetland or detention basin), then soluble phosphate concentrations in this basin may represent a very high proportion of the total nutrient load.

## **Phosphorus**

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is a nutrient in short supply in the typically clay rich soils of southcentral Alaska and in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a waterbody. These may

include accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and croplands, outhouses and failing septic systems, animal manure, runoff from disturbed land areas, drained wetlands, water treatment and commercial cleaning chemicals.

Phosphorus has a complicated story. Pure, “elemental” phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (PO<sub>4</sub>). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate.

Phosphorus cycles through the environment, changing form as it does so. Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Aquatic animals get the organic phosphorus they need by eating either aquatic plants, other animals or decomposing plant and animal material.

As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom. Bacterial decomposition converts it back to inorganic phosphorus. Inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions or water currents. Then it is taken up by plants and the cycle begins again.

In a river system, the phosphorus cycle tends to move phosphorus downstream as the current carries soil, decomposing plant and animal tissue and dissolved phosphorus. It becomes stationary when it is taken up by plants or is bound to particles that settle to the bottom of pools.

In the field of water quality chemistry, phosphorus is described using several terms. Some of these terms are chemistry-based (referring to chemically based compounds), and others are methods-based (they describe what is measured by a particular method).

The term “orthophosphate” is a chemistry-based term that refers to the phosphate molecule all by itself. “Reactive phosphorus” is a corresponding method-based term that describes what you are actually measuring when you perform the test for orthophosphate.

More complex inorganic phosphate compounds are referred to as “condensed phosphates” or “polyphosphates.” The method-based term for these forms is “acid hydrolyzable.”

Monitoring phosphorus is challenging because it can involve measuring very low concentration – down to 0.01 milligram per liter (mg/L) or even lower. Very low concentrations of phosphorus can have a dramatic impact on some waterbodies. Less sensitive methods are used to identify serious problem areas.

There are many tests for phosphorus. The one performed by Keeper volunteer monitors is a total orthophosphate test, which is largely a measure of orthophosphate. Because the sample is not filtered, the procedure measures both dissolved and suspended orthophosphate. The method for measuring total orthophosphate is known as the ascorbic acid method. Briefly, a reagent containing ascorbic acid reacts with orthophosphate in the sample to form a blue compound. The intensity of the blue color is directly proportional to the amount of orthophosphate in the water. An Axial Reader type color comparator is then used to determine phosphate levels in parts per million.

## **Nitrogen**

Nitrogen makes up about 80 percent of the air that we breathe. It is an essential component of proteins and is found in the cells of all living things. Nitrogen is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia ( $\text{NH}_3$ ), nitrates ( $\text{NO}_3$ ), and nitrites ( $\text{NO}_2$ ). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems.

Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in a waterbody. This, in turn, affects dissolved oxygen, temperature and other water quality indicators. Excess nitrites can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (1 mg/L or higher) under certain conditions. Hemoglobinemia (blue baby syndrome) is caused by excess nitrites. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L). Nitrites are commonly less than 10 percent of the nitrate/nitrite total. In the effluent of wastewater treatment plants, nitrate/nitrogen can range up to 30 mg/L. The standard for nitrates in drinking water is 10 mg/L. Unpolluted water generally has a nitrate reading of less than 1.00 ppm.

Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and croplands, outhouses and failing on-site septic systems, animal wastes, acid rain deposition and industrial discharges that contain corrosion inhibitors.

Nitrates from land sources can end up in rivers more quickly than other nutrients like phosphorus. This is because they dissolve in water more readily than phosphates, which have an attraction for soil particles. As a result, nitrates serve as a better indicator of the possibility of a source of sewage or other pollution during dry weather.

Water that is polluted with nitrogen-rich organic matter might show low nitrates. Decomposition of the organic matter lowers the dissolved oxygen level, which in turn slows the rate at which ammonia is oxidized to nitrite ( $\text{NO}_2$ ) and then to nitrate ( $\text{NO}_3$ ). Under such circumstances, it might be necessary to also monitor for nitrites or ammonia, which are considerably more toxic to aquatic life than nitrate.

Volunteer monitoring programs typically use one of three methods for nitrate testing: the cadmium reduction method, the nitrate electrode or the new zinc diazotization/coupling reaction.

Both the cadmium reduction method and the zinc diazotization/coupling reaction method produce a color reaction that is then measured either by comparison to a color wheel or color comparator, or by use of a spectrophotometer. The cadmium reduction method, however, produces hazardous waste. For that reason, the Keeper program has chosen to use the new zinc method for nitrate testing. Monitors add a series of tablets to their water sample causing it to turn a shade of pink whose intensity is proportional to the amount of nitrate in the sample. An Octa-Slide color comparator is then used to determine nitrate levels in parts per million.

## **Coliform Bacteria**

The coliform group of bacteria live by fermenting lactose (milk sugar) and are native to the intestinal tracts of mammals and birds. Although most coliform species can also exist as free-living organisms, species of the genus *Escherichia* cannot. The term "fecal coliform" refers primarily to the species *Escherichia coli* or *E. coli* (and occasionally to *Klebsiella* species as well).

Coliform bacteria are generally pretty harmless alone. In fact, water may contain coliforms from a variety of sources besides sewage. However, the presence of high levels of coliform bacteria and, in particular, of fecal coliforms (which can't live free) suggests that sewage is being discharged into the water. Sewage discharges raise the level of nutrients in the water and can cause phytoplankton blooms. Worse, sewage contains organisms that cause disease: pathogenic bacteria, viruses, protozoans, and parasites. For example, certain species of pathogenic bacteria can cause typhoid fever, dysentery, and cholera.

You might be wondering why we are looking at the relatively "harmless" fecal coliforms. It is because pathogenic bacteria are difficult to culture in the lab, and intestinal parasites and viruses can be even harder to analyze. Furthermore, if you were going to try to detect the disease-causing species directly, you would need to use a different test for each one. By contrast, fecal coliforms are relatively easy to detect and analyze. For these reasons, the fecal coliform group of bacteria is used by the Food and Drug Administration as a microbiological indicator of sewage pollution. In other words, when the FDA closes a shellfish flat, they are doing so on the basis of the fecal coliform count. The species *E. coli* is also used by the EPA to test the quality of fresh water for swimming. (In salt water a non-coliform type of bacteria called *enterococci* is used).

Traditional tests for coliforms and fecal coliforms require the inoculation of media containing lactose, incubation under carefully controlled temperatures, and examination for the presence of gas from lactose fermentation. Additional special media must then be inoculated and incubated at elevated, carefully controlled temperatures to confirm the presence of fecal coliforms (*E. coli*). All these require extra equipment and careful regulation of time and temperature. This approach is not only expensive and time consuming, but can be less than precise in indicating the numbers of specific organisms present.

As a result of the difficulties and lack of precision inherent in the older technology, new approaches have been developed and are being used very successfully. One of the best approaches is based on the fact that in order for coliforms to ferment lactose, they must produce certain enzymes which can be identified and used to verify the presence of the coliforms. General coliforms produce the enzyme galactosidase in lactose fermentation and fecal coliforms produce the enzyme glucuronidase in addition to galactosidase.

The “Coliscan” method used in the Keeper program takes advantage of these facts. It provides a simple, accurate and quantitative way to identify and differentiate coliforms and fecal coliforms from other bacteria. This method incorporates two special chromogenic substrates which are acted upon by the presence of the enzymes galactosidase and glucuronidase to produce pigments of contrasting colors. All that is needed to identify the presence and numbers of coliforms and fecal coliforms is to add a test sample to the medium, pour it into a petri dish and incubate it at room temperature or at a higher controlled temperature. General coliforms will produce the enzyme galactosidase and the colonies that grow in the medium will be a pink color. Fecal coliforms (*E. coli*) will produce both galactosidase and glucuronidase and will therefore grow as purple colonies in the medium. It is simple to count the purple colonies (*E. coli*) which indicate the number of fecal coliforms per sample. The pink colonies indicate the number of general coliforms per sample. The combined general coliform and fecal coliform number equals the total coliform number. Any non-colored colonies which grow in the medium are not coliforms, but may be members of the family Enterobacteriaceae. Since the Coliscan contains inhibitors, most other bacterial types will not grow.

## **E. SURFACE WATER QUALITY MONITORING KITS**

Keeper has adopted the LaMotte tidal water monitoring kit, (with several adaptations) to monitor the marine, estuarine and freshwater sources in the Cook Inlet watershed. Each kit should contain the following materials:

Supply of Monitor Data Sheets  
 Pre-addressed stamped envelopes  
 Fine-point Sharpie & #2 pencil  
 Rubber Gloves  
 2.5gal. Plastic Bucket w/line  
 Distilled Water/Wash Btl  
 Waste Containers (2)  
 1 ml Pipets (2)  
 Glass Stir Rod  
 Tide Tables Book  
 MSD Sheets  
 Borger Color System Booklet  
 Air Thermometer (red)  
 Water Thermometer (green)  
 Secchi Disk & Line  
 2 Turbidity Columns  
 Standard Turbidity Reagent (60 ml)  
 Turbidity Chart  
 5ml Test Tubes w/Caps (2)  
 Octet pH Comparators (2)  
 pH Indicator Solution  
 650ml Salinity Cylinder  
 Hydrometer in Container  
 Hydrometer Instructions

60 ml Water Sample Btls (3)  
 250 ml Water Sample Btls (2)  
 Manganous Sulfate Solution (30ml)  
 Alkaline Potassium  
 Iodide Azide (30ml)  
 Sulfuric Acid (30ml)  
 Titration Vial w/Cap (20ml)  
 Titration w/Plunger & Extension Tip  
 Sodium Thiosulfate (60ml)  
 Starch Indicator Solution (30ml)  
 4 in 1 Hanna Meter  
 Hanna Instruction Book

### **Nitrate Nitrogen Kit**

5ml Test Tubes w/Caps (2)  
 Octa- Viewer and Slide  
 1 Box Nitrate #1 Tablets  
 1 Box Nitrate #2 Tablets  
 LaMotte Instructions & Safety Card  
 Safety Card  
 MSD Sheets

### **Phosphate Test Kit**

10ml Test Tubes w/Caps (4)

Octet Comparator and Axial Reader  
Ampule of Distilled Water  
Phosphate Acid Reagent (60ml)  
Phosphate Reducing Reagent (5g)  
1ml Pipet  
0.1 gram Measuring Spoon  
LaMotte Instructions  
Safety Card  
MSD Sheets

#### **Coliscan Bacteria Kit**

Plastic Petri Dishes (3)  
Coliscan Easygel® (3 btls)  
1ml Pipet  
10ml Pipet (2)  
Coliscan Data Sheet  
Micrology Labs Instruction Sheet

## **F. MONITOR DATA SHEETS**

All data should be recorded on the standardized data sheets provided by the Monitoring Coordinator (Appendix I). Please keep an ample supply of these sheets on hand and use a fresh one for each sampling event at each site. If you are running low, call (907) 235-4068.

Data should be entered using a fine-point "Sharpie" or other indelible marker. If the data sheet is wet and the Sharpie won't write, use a #2 pencil and go over it with a Sharpie when the sheet dries. If you make a mistake, draw one line through the characters in question, enter the new characters to the immediate right of the lined-out entries, and initial the change immediately after the new characters.

It may not always be easy under field conditions, but try to write as legibly as possible, especially when entering numbers. All numeric data should be entered in the appropriate spaces, using the decimal places provided on the form. When entering temperatures, please remember to specify if they are negative. All letters and words should be printed. Record all of your observations and test results as you go along; don't rely on memory!

The first data you record on your data sheet should be the printed names of the monitors, the name and number of the station, the date, and the time. When entering the time be sure to circle either AM or PM. Next, record the latitude, longitude and elevation of your site and indicate whether you used a GPS or a topographical map to determine this information. (If you are returning to your regular monitoring site you may copy this information from previous data sheets).

Finally, do not forget to have all monitors sign the data sheet when testing is complete!

## **VI. MONITORING PROCEDURES**

**T**his section provides a step-by-step guide to the proper field and laboratory techniques needed to successfully obtain credible water quality data.

## A. FIELD PROCEDURE CHECKLIST

Below is the recommended order in which to conduct your tests. This order tends to maximize your efficiency, and should keep your sampling activities to under one hour.

- Put on safety gear (rubber gloves & eye protection).
- Collect the water sample according to the procedure described later in this section.
- Fill the black compartment of the Hanna Meter with distilled/de-ionized water. (This will need to stand for at least five minutes in order to dissolve any salts that may have accumulated on the base of the meter and presoak the electrodes).
- Place air thermometer in shaded area near sample bucket to allow it to stabilize.
- Hang water thermometer inside sample bucket.
- Perform steps 1 through 8 of the dissolved oxygen testing procedure as described later in this section. Set sample bottles aside to allow the floc to settle out.
- Fill out page one of the data sheet: monitor names, site name, site number, date, time, site location, air temperature, wind and weather conditions, water surface condition, tidal stage, observations, sketches or photos.
- Compare and record the apparent color of the sample water.
- Measure and record clarity of the sample water.
- Read the water temperature and record it on the data sheet.
- Measure and record the pH of the sample water.
- Measure the specific gravity and record the salinity of the sample water.
- Conduct Hanna Meter tests and record results.
- Complete steps 9 through 17 of the dissolved oxygen test procedures and record the results. (Steps 10 through 17 can be performed up to six hours after fixing as long as sample temperature is maintained between +4°C to +10°C).
- Measure and record Phosphate & Nitrate (freshwater only) content of water in sample bucket. (Phosphate & Nitrate tests may be performed up to six hours after sample collection as long as sample temperature is maintained between +4°C to +10°C).

- Measure 1ml, 3ml and 5ml quantities of sample water into pre-labeled coliscan sample bottles for plating when you get home. (Plating should be performed within six hours and sample temperature must be maintained between +4°C to +10°C until plating occurs).
- Check for completeness and legibility and have all team members sign the data sheet!

## **B. WHEN YOU GET HOME**

- Plate coliscan samples and incubate them. Results should be taken and recorded on 24 to 48 hours after plating.
- Measure and record Phosphate & Nitrate content of sample water if this was not completed in the field.
- Titrate the dissolved oxygen samples and record the results if this was not completed in the field.
- Follow the instructions under “When You’re Done Testing” in the next section of this manual to clean and stow your equipment and take care of wastes.
- Make sure children and pets cannot get at the equipment and reagents.
- If you're running low on any reagents, or if any of them are changing in color or consistency, contact the Monitoring Coordinator at (907) 235-4068 for a fresh supply. Also contact the Monitoring Coordinator if any of your equipment has been acting oddly.

## **C. FIELD OBSERVATIONS**

When you arrive at your sampling site, first put on your safety gear, then collect your water sample following the procedures described below. Fill the black compartment of your Hanna Meter with distilled water and set it aside. Remove the plastic sheathe from your water thermometer, (green filled Celsius thermometer) hang it inside your sample bucket and hang your air thermometer (red filled Fahrenheit thermometer) nearby. Perform the first 7 steps of the dissolved oxygen test, then begin collecting and recording data.

### **Air Temperature**

The air thermometer should be hung somewhere where it's not leaning against any solid object and where it's protected as much as possible from direct wind and sunlight.

The thermometer will take at least five minutes to equilibrate. It might take longer if it has to adjust for large changes in temperature - for example, if you've been carrying it in a warm car on a cold day. If you've waited the five minutes but the reading looks warmer or cooler than you expected, wait another minute and see if the reading changes. Keep checking at one-minute intervals until the reading comes up the same twice in a row - it shouldn't take longer than ten minutes for this to happen. Once the

thermometer has equilibrated, read the air temperature to the nearest 1°F and record it on your data sheet.

While you're waiting for the thermometer to equilibrate, you can fill in the first page of your data sheet, beginning with monitor names, site name, number and location, date and time.

### **Wind and Weather**

In light, unsteady winds, you may have trouble judging wind direction - try tying a piece of ribbon or yarn to a pole or other upright object at your site. Record the wind direction as N, NE, E, SE, S, SW, W, or NW. Determine the wind speed using the Beaufort Wind Scale (Appendix H) and record the range you observe at your site in mph. Also note whether the wind is gusty, steady or variable.

Use the list of adjectives in the “Weather” box to describe overall weather conditions and estimate the inches of precipitation during the past 24 hours to the best of your ability. As previously mentioned, you can obtain a rain gauge from the Monitoring Coordinator to track rainfall or find a neighbor who is already tracking rainfall and will share the information with you. Report the type of precipitation that has fallen and record the number of consecutive days these weather conditions have persisted, including the day of sampling.

### **Water Surface & Tidal Conditions**

Use the list of adjectives provided to describe the surface of the water at your site. A tide table for the current-year is included in your kit. Use it and the worksheet in this section to determine and plot the stage of the tide at the time of sampling. Begin by recording the district from which you are reading your tides – this is located at the top of each page of tide charts. You should choose the district closest to your site (in the case of Kachemak Bay, this will be the Seldovia District). Next, go to the back of your tide book to find and record your location within the district. Then look to the right of your location and find and record the tidal corrections as they are shown (time corrections in minutes, first for high tide, then for low followed by height corrections in feet, first high, then low). Using these corrections record the time and height of the four most recent tide cycles. From this information you can determine where you are at in the present tide cycle. Use the Guide to Tidal Stages (Appendix K) in reporting the tide stage. Once you have recorded the tidal stage, plot it on the Tidal Chart.

The data sheet also includes space to record a recent tide or bank mark description. The first time you sample at your site you should locate a stationary object (large rock, bridge piling, partially submerged tree, etc.) and use it to reference the water level. Each time you return you should make a comparative measure of the tidal stage or stream level based on this reference.

### **Comments & Observations**

Now take a moment to exercise your senses. Look around your sampling site. Note how humans, livestock and wildlife are using the water. Look for tracks and other signs of visitors. Listen for birds and other wildlife as well as for the sounds of human activity that might affect water quality.

Be aware of any odors in the area and smell the water itself. The human nose can accurately detect a wide variety of smells, making it an effective odor-testing device. Use your hand to wave the air above your water sample toward you. If you detect an odor, use the list in Appendix L to describe it.

Record all your observations, including: abnormal color, oil slicks, foam on the water, algae blooms, unusual odors, fish kills or other dead plants or animals, sightings of live fish or other animals including humans, signs of erosion, trash or debris.

The comments and observations section should also be used to report any problems you have with sampling procedures or equipment (including the data sheet itself). Suggestions for improvement are always welcome.

### **Photos or Sketch Illustrating Site/Observations**

Space has been provided to attach photos or make a sketch showing the layout of your site and the locations of what you have described in your comments and observations. Do your best to make a scale drawing of the area surrounding your site during each sampling event and mark the location of each observation you have recorded.

As previously mentioned, you should photograph your site during your first sampling. Taking photos of your site periodically there after will help to get a sense of its seasonal and other variations. Take the time to photograph your site at least four times a year so that we can create a photo journal documenting changes over time.

## **D. COLLECTING THE WATER SAMPLE**

A few yards away (preferably downstream or down current) from your exact sampling site, rinse the plastic bucket three times with the water to be sampled. Now go over to your site, lower the bucket gently into the water, and fill it to a level about 2 inches from the lip of the bucket. If the water at your site is more than an arm's length away, your bucket should have a rope tied to the handle. After securing the other end of the rope to something solid, fill the bucket by turning it upside down and dropping it straight down into the water. This will help avoid the futility of having the empty bucket floating all over the surface and refusing to fill. If you are working in very shallow water, do not disturb the bottom while collecting the sample.

Be careful not to artificially increase the dissolved oxygen content of the water you're sampling. This can happen if you splash the water around too much before you sample it - that's why you should rinse your bucket a few yards away from your sampling site. Once you've got the sample, handle it gently. Avoid jostling the bucket or sloshing the water around.

## **E. TESTING PROCEDURES**

### **Apparent Color**

1. Compare the color of the water in your sampling bucket with the BCS numbers in the Borger Color System booklet (if deciding on one BCS number is too difficult, you may use up to 2 BCS numbers to describe apparent color).
2. Record a one or two word description of the apparent color of your sample as well as the corresponding BCS number on your data sheet.
3. Rinse a Turbidity Column three times with sample water then fill it to the 50ml line and again compare and record its apparent color and corresponding BCS number.

### **Turbidity (Clarity)**

In water deeper than 3 meters you will test for turbidity using two methods. First use a Secchi disk to test both overall water depth and water clarity or turbidity.

1. Attach the end of the Secchi disk line to a stationary object and slowly lower the disk into the water until you feel it touch bottom.
2. Note where the line breaks the surface of the water. Slowly pull the line in, and as you do so keep one hand on the spot where it broke the water's surface.
3. The Secchi disk line is marked in red at every meter and in black at the half meter, yellow tape marks every five meters. Count the marks from the waterline to the Secchi disk and record this to the nearest ½ meter as the bottom depth on your data sheet.
4. Slowly lower the disk into the water again until it disappears from sight.
5. Carefully raise the disk until you can just make it out in the water.
6. Note where the line breaks the water's surface. Again, pull it in and count the marks to determine and record the Secchi depth of the water to the nearest ½ meter. (If you can see the disk when it is on the bottom your bottom depth and Secchi depth are the same).

In the case of shallow water sampling stations (less than 3 meters in depth) you will use only the second method for determining turbidity.

1. Use the Turbidity Column you have previously filled to the 50 ml line with sample water for the apparent color test. Stir the sample with the glass stirring rod in order to distribute turbidity particles. Look vertically through the tube. If the black dot on the bottom of the tube is not visible when looking through the column of liquid, pour out a sufficient amount of the test sample so that the tube is filled to the 25 ml line. If you still cannot see the dot, record the turbidity as "greater than (>) 200 JTU," otherwise, go to step 2.
2. Fill the second Turbidity Column with an amount of distilled water equal to the amount of sample being measured (e.g. 50 ml or 25 ml). This is the "clear water" tube.

3. Place the tubes side-by-side, and note the difference in clarity between the two. If the black dot is equally clear in both tubes, then the turbidity of the sample water is zero. If the water in the sample tube is less clear, go to step 4.
4. Shake the Standard Turbidity Reagent bottle vigorously. Add 0.5 ml to the clear water tube. Stir contents in both tubes to again distribute turbid particles. Check the amount of turbidity by looking down through the solution at the black dot. If the turbidity of the sample remains greater than the clear water tube, continue to add Standard Turbidity Reagent in 0.5 ml increments, stirring after each addition until the turbidity in each tube appears equal. Record the total amount of Standard Turbidity Reagent added.
5. Each 0.5 ml addition to the 50 ml size is equal to 5 Jackson Turbidity Units (JTUs). If a 25 ml sample is used, each 0.5 ml addition of Standard Turbidity Reagent is equal to 10 JTUs. Use the table below to record the turbidity reading in JTU's on your data sheet. Rinse each tube carefully after each measurement.
6. It is also important to record the temperature of the water at the time of the turbidity reading following the instructions below.

#### **TURBIDITY TEST RESULTS**

<b>Number of Measured Additions</b>	<b>Amount (ml)</b>	<b>50 ml Graduation</b>	<b>25 ml Graduation</b>
1	0.5	5 JTU	10 JTU
2	1.0	10 JTU	20 JTU
3	1.5	15 JTU	30 JTU
4	2.0	20 JTU	40 JTU
5	2.5	25 JTU	50 JTU
6	3.0	30 JTU	60 JTU
7	3.5	35 JTU	70 JTU
8	4.0	40 JTU	80 JTU
9	4.5	45 JTU	90 JTU
10	5.0	50 JTU	100 JTU
15	7.5	75 JTU	150 JTU
20	10.0	100 JTU	200 JTU

#### **Water Temperature**

1. The water thermometer should be submerged in your 2 ½ gallon sample bucket for at least 1 ½ minutes prior to measurement.
2. Locate the bucket away from direct sunlight or wind (on particularly cold days, try to minimize the time the bucket is exposed to ambient air, because the cold air temperature may skew your water temperature reading).

3. Remember to hold the thermometer on the end that is opposite the bulb! Keep the tip of the thermometer submerged (do not lift thermometer from water to read!). Read the temperature while looking at the thermometer perpendicular to the stem.
4. Record the temperature to the nearest 0.5°C.

## pH

1. Rinse two (2) small test tubes with sample water three times. Fill each tube to the 5ml line with sample water.
2. While holding the dropper vertically, add ten (10) drops of indicator solution (green, Wide Range Indicator Solution) to each test tube.
3. Cap, invert and shake each tube several times to mix.
4. Remove the caps and insert each tube into the Octet Comparator (Black Box) and match sample color to appropriate color standard. HINT: Hold the comparator up so that light enters through the special light-diffusing screen in the back, but avoid viewing the comparator against direct sunlight or an irregularly lighted background.
5. Read pH measurement to the nearest 0.5 value, compare both tubes for consistency, and take the average of the two measurements and record it as the final pH measurement. If there is a significant difference between the two measurements (i.e. 1.0 pH unit difference), then make a note and repeat the test.

## Salinity

1. Rinse the 650 ml clear plastic hydrometer cylinder three times by pouring small amounts of water from the sample bucket. Then, fill the hydrometer cylinder to within 2 inches of the top with water poured from the bucket.
2. Hang the water thermometer in the cylinder so that it is totally immersed, and readable through the side of the cylinder.
3. Carefully remove the hydrometer from its padded case and insert it into the cylinder, until it begins to float then give it a slight twist to remove bubbles. Take care that the hydrometer does not hit the bottom hard (it might break), and that drops of water do not splash on to the hydrometer stem above water level. Allow the hydrometer to float freely. (If the hydrometer is resting on the bottom of the cylinder you need more water.)

The accuracy of the hydrometer depends on its having exactly the same weight as when it was calibrated in the factory. Anything that changes that weight - dried salt from previous use, grease from fingerprints, water droplets on the portion of the stem that's not submerged - will throw the results off.

To avoid the fingerprint problem, handle the hydrometer as little and as lightly as possible. This almost sounds like a contradiction - it's fragile, so you don't want to drop it, but neither do you want to get a chokehold on it. Think of the way you would handle a photograph - carefully and

4. Wait until 3 minutes have gone by since Step 2. Read the temperature of the water in the cylinder to the nearest 0.5°C and record it on your data sheet in the space below the specific gravity reading.
5. Read the specific gravity from the scale on the hydrometer stem to the nearest 0.0005 and record it on your data sheet. Be sure to take the reading:
  - Without touching the hydrometer.
  - With your eyes at the same level as the water surface in the hydrometer cylinder (viewing the scale up or down at an angle can give an incorrect reading).
  - At the point where the flat water surface would cross the hydrometer stem. You will notice that the water curves up slightly next to the wall of the stem (the curve is a meniscus, and it is the same effect witnessed during the dissolved oxygen test). **Make sure you measure your result from the bottom of the curve, not the top.**

Don't worry if the water temperature you read in the hydrometer cylinder is different than the one you measured previously in the sample bucket. The whole point of measuring the temperature in the cylinder is that the bucket's been sitting out for a while by now, and the temperature has probably changed. Furthermore, the temperature of the water in the cylinder could change as you work!

The relationship between specific gravity (what the hydrometer measures) and salinity (what we're trying to determine) is very temperature dependent, so it's important to know the exact temperature at which you're reading the hydrometer.

6. Re-check the water temperature reading you recorded earlier.
7. Use the hydrometer conversion chart (Appendix J) to convert your specific gravity reading to salinity in parts per thousand. Run horizontally across the table until you find the column for the temperature at which you took the reading. Then run down the column until you get to the row for the specific gravity you recorded. If the temperature at which you read the specific gravity

falls between two of those listed in the table, split the difference, always rounding to the even number.

### **Hanna Meter**

1. Record the number written on your meter.
2. Fill the black compartment at the base of the Hanna meter with distilled water and let it stand for five (5) minutes to allow any dissolved salts on the electrodes to dissipate and to pre-soak the electrodes. (You may have completed this step earlier – if so you do not need to repeat it).
3. Carefully flush out the black base compartment three (3) times with sample water. **Do not immerse the meter above the maximum level indicated by a line on the base of the meter.**
4. Fill the black base compartment with sample water, let it stabilize for 15 seconds, then record the initial Temperature.
5. Press the meter's Range Switch, wait 15 seconds, then record three (3) sequential readings for Conductivity at 15 second intervals.
6. Press the Range Switch again and wait 15 seconds. Record three (3) sequential pH readings at 15 second intervals.
7. Press Range Switch once more and wait 15 seconds. Record three (3) sequential Oxidation Reduction Potential (ORP) readings at 15 second intervals
8. Press the Range Switch and wait 15 seconds. Record the final Temperature reading.
9. Calculate an average for each parameter (i.e. add all readings for each parameter and divide by the total number of readings for that parameter) and record each parameter's average on your data sheet.

### **Dissolved Oxygen (DO)**

When you begin the fixing process for DO (steps 1-9) start by recording the time and the current temperature of the water in your sample bucket in case it has changed since you first recorded it. As you work through the DO testing procedure, you'll notice the emphasis to avoid trapping any air bubbles in the sample or splashing it around too much. The point is to avoid changing the amount of oxygen dissolved in the water by contact with the oxygen in the air.

To assure more precise dissolved oxygen measurement, three 60 ml samples will be prepared for titration. You will begin by titrating a 20 ml portion of each of these samples. If the results from all three titrations fall within a range of less than 0.6 mg/l you will average these results and report this as your DO average. If the difference between any two titrations is 0.6 mg/l or greater, titrate another 20 ml portion of the 60 ml sample which reads outside of the range. If the result is still different from one or

both of your other samples by 6 mg/l or more then average only the two closer readings and record this number as your DO average. If no two of your three original readings fall within a 0.6 mg/l range you will have to repeat the titration process on three new 20 ml portions of each 60 ml sample. Record the results of all titrations (even those you suspect are in error) and average only those which fall within the 0.6 mg/l range.

1. Mark the labels of three 60ml sample bottles with your site number and the letters "A", "B" and "C".
2. Rinse each bottle with small amounts of water from the bucket three times. Rinse the outsides of the bottles and the caps as well.
3. Tightly cap the mouth of the bottle marked "A". Holding the bottle sideways, submerge it to mid-depth in the sample bucket, and remove the cap to allow the bottle to fill.
4. Turn the submerged bottle slowly to a vertical position (mouth up) and tap the sides with the cap to dislodge any air bubbles clinging to the inside. Replace the cap while the bottle is still submerged.
5. Retrieve the bottle and examine it carefully to make sure that no air bubbles are trapped inside. Once a satisfactory (i.e. bubbleless) sample has been collected, repeat Steps 2 through 4 with bottles "B" and "C".
6. Uncap all three samples. Add 8 drops of manganous sulfate solution (pink reagent) to each sample.
7. Add 8 drops of alkaline potassium iodide azide (clear reagent) to each sample. Be sure to add the manganous sulfate first. Drop the solutions in gently to avoid splashing and mixing in air. Hold the reagent bottles vertically, and do not allow the dropper tips to touch the sample.
8. Cap each sample bottle carefully and mix by repeatedly tipping capped bottle back and forth in a gentle rocking motion for fifteen seconds. A fluffy, white to brownish precipitate will form. Set the bottles in their holes in the LaMotte monitoring kit; the styrofoam will help keep the samples at a constant temperature. Allow the precipitate to settle a third of the way down the bottles (past the neck and down to the shoulder of the bottle), so that it fills only the bottom two-thirds. Settling may take as long as an hour at cooler temperatures, but it will usually be faster.

Because settling takes some time, it is recommended that steps one through seven be performed soon after you arrive at the sampling site. While the precipitate is settling you can record field observations and conduct your color, turbidity, water temperature, pH, salinity and Hanna Meter tests and record your results.

The settling can take a while, especially in cold weather, and it's better to allow plenty of time for the DO fixing process. Once the precipitate is settled, continue with Step 9 of the DO procedure.

**After the samples have been gently mixed and allowed to settle, return to the DO procedure at this point:**

9. Add 8 drops of sulfuric acid (clear solution) to the first sample bottle marked "A." Cap the bottle and mix by tipping gently as before until the precipitate has dissolved. Depending on the oxygen content of the sample, a clear yellow to brown-orange color will develop as the precipitate dissolves.

Add the acid to all three sample bottles at this time. The dissolved oxygen in your samples is now bound up in the floc (i.e. "fixed"). As long as you keep the samples cool and in the dark, you can complete the analysis any time in the next six hours. In inclement weather, you might want to take your treated samples home and finish the DO titration there.

10. Rinse the titration vial (it is labeled "Code 0299" and has a flat lid with hole in the center) with a small amount of the solution from the sample bottle, then fill it to the 20-ml line. (You'll notice that the upper surface of the solution in the cylinder may curve up or down slightly; this curving upper surface is known as the meniscus. It's the bottom of the curve that should be level with the 20-ml mark, not the portion near the walls of the cylinder).
11. Depress the plunger of the direct-reading titrator (the small syringe) to expel air. Holding the plunger tightly down, insert the titrator into the plastic fitting of the bottle of sodium thiosulfate (titrator) solution. (This bottle is slightly larger than the others and does not have a dropper tip. The sodium thiosulfate solution is colorless.) Invert the bottle and withdraw the plunger slowly until the bottom of the plunger is about half an inch past the zero mark on the titrator scale.

As you start to withdraw the plunger, inspect the solution filling the syringe for air bubbles, especially at the tip of the plunger or in a silvery rim around the tip. If bubbles appear while you've only got a small amount of solution in the titrator, pump the solution back into the thiosulfate bottle, pressing the plunger down quickly and firmly. Bubbles tend to be a particular problem when the dry titrator is filled for the first titration of the day. It may be necessary to pump the solution back and forth several times to get the plunger surface wetted.

Once you've gotten a small amount of sodium thiosulfate solution into the titrator without bubbles, continue to inspect for bubbles as you slowly withdraw the plunger. If you spot a bubble when the titrator is nearly full, remove the titrator from the thiosulfate bottle, hold it over your wastewater bottle, and press the plunger down until the bubbles are expelled. Reattach the titrator to the thiosulfate bottle and continue filling to beyond the zero mark.

In a perfect world, you would never squirt solution back from the titrator into the bottle of thiosulfate. If there were contaminants on the inside of the titrator, you would risk contaminating your entire supply of reagent. In reality, however, it is almost impossible to get rid of the bubbles without pumping small amounts of solution back and forth. You should minimize the risk of contaminating your reagent supply by avoiding returning larger amounts of

Turn the thiosulfate bottle upright and carefully remove the titrator. Hold the titrator over your wastewater bottle and press the plunger slowly downward until the lowermost tip of the black rubber plunger is opposite the zero mark. Inspect the titrator carefully for air bubbles.

12. Insert the titrator into the central hole of the titration vial cap until it snaps into place. Add 1 drop of sodium thiosulfate and swirl the tube (with the titrator still attached) to mix it. Continue this titration process one drop at a time until the yellow-brown solution in the tube just begins to fade or get lighter. The solution should be a pale yellow color - about the shade of pale straw.
13. Gently remove the titration vial cap with the titrator still attached. Be very careful not to change the position of the plunger or to shake any fluid loose from its tip. Add 8 drops of starch indicator solution to the titration tube. The sample solution should begin to turn from pale yellow to dark blue.

If you're unsure of the exact point at which to add the starch solution, it's better to do it a little early than too late.

14. Replace the cap with the titrator carefully on the titration vial and swirl until the solution turns a uniform blue. Continue the titration process described in Step 10. Be sure to gently swirl after each drop. Continue the titration until the solution just turns from blue to clear - the first complete disappearance of the blue color is the endpoint of the titration. (If the solution turns blue again a moment later, ignore it.) Hold the solution against a sheet of white paper (for example, your data sheet) to check the color.

If your sample has a really high oxygen content, you may have to refill the titrator in order to reach the endpoint. Do not completely empty the titrator into the titration sample. The plunger should be lowered only far enough so that the lowermost tip of the black rubber plunger is level with the 10-unit mark on the scale. If you reach this point without hitting the endpoint of the titration, remove the titrator from the titration vial. Refill the titrator to the zero mark again as described in Step 10 and continue the titration.

15. Read the total number of units of sodium thiosulfate used in the titration from the scale opposite the lowermost tip of the black rubber plunger. The divisions are in 0.2 units, but you should be able to read the results to the nearest 0.1 units.

If you had to refill the titrator, remember to add in the ten units from the first filling. The number of units used equals the milligrams per liter (mg/l) of oxygen dissolved in the water. Record this figure on your data sheet to the nearest 0.1 mg/l.

- 16 Carry out Steps 10 to 15 on the sample bottles marked "B" and "C". If all three titration values are within 0.6 mg/l of each other, average them together and record the result to the nearest 0.1 mg/l as the DO average. If any two titration readings differ by 0.6 mg/l or more, titrate another 20 ml sample from the bottle whose reading fell outside the 0.6 mg/l range. If the second titration still shows a value different from the others by 0.6 mg/l or more then average only the two which fall into the 0.6 mg/l range and record the result as the DO average. If no two of your three original readings fall within a 0.6 mg/l range, repeat steps 10 through 16 using three new 20 ml portions of each sample. Record the results of all titrations (even those you suspect are in error) and average only the two or three values which fall within the 0.6 mg/l range. Discard the contents of the sample bottles in your wastewater bottle.
- 17 Calculate the percent of saturation by finding the water temperature you recorded at the time of "fixing" on the chart below and comparing the DO average you recorded to the maximum dissolved oxygen concentration for water at that temperature. Divide your average DO measurement by the maximum measurement on the chart and multiply your results by 100. Record this as the percent of saturation for your sample.

For example, if your sample water temperature at the time of fixing was 5°C the maximum dissolved oxygen concentration would be 12.75. You would then divide your DO average by 12.75. If your DO average was 10 then your percent saturation would be  $(10 \div 12.75) \times 100$  or 79%.

#### Maximum Dissolved Oxygen Concentration

Temperature °C	Dissolved Oxygen mg/L	Temperature °C	Dissolved Oxygen mg/L
0	14.60	16	9.85
1	14.19	17	9.65
2	13.81	18	9.45
3	13.44	19	9.26
4	13.09	20	9.07
5	12.75	21	8.90
6	12.43	22	8.72
7	12.12	23	8.56
8	11.83	24	8.40
9	11.55	25	8.24
10	11.27	26	8.09
11	11.01	27	7.95
12	10.76	28	7.81
13	10.52	29	7.67
14	10.29	30	7.54
15	10.07	31	7.41

## DISSOLVED OXYGEN TITRATION TIPS

The DO titration is easily the most complicated field procedure you'll be doing. Here are a few tips to help you get through it more efficiently and accurately:

- ✓ Be sure your sample bottles are clean and rinsed 3 times with water from your sample bucket.
- ✓ After filling a sample bottle, check it carefully for bubbles - the oxygen trapped in the air bubbles will throw off your results.
- ✓ Hold the dropper bottles vertically when adding the manganous sulfate (reagent #1) and alkaline potassium iodide azide (reagent #2) solutions. Try to avoid splashing that may introduce air into the sample. Be sure to add the manganous sulfate first.
- ✓ Since the sample bottle is supposed to be completely filled, without any air space, some of the sample may overflow as you add the reagents. Don't worry about this.
- ✓ The manganous sulfate and alkaline potassium iodide azide solutions are added in excess. The precise number of drops is not critical as long you add enough manganese to bind up all the dissolved oxygen and enough iodide to mop up all the manganese. Try for 8 drops, but if you accidentally add 9 drops instead, that's okay. If you lose count and are not sure whether you've added 7 drops or 8, add an extra one.
- ✓ The manganous sulfate and alkaline potassium iodide azide solutions should be added to the samples as soon as possible after collection. Once these reagents and the sulfuric acid have been added and mixed, the samples can be held for up to 8 hours before finishing the analysis (we recommend completing titration within 6 hours if possible). They should be protected from light and kept at or near the temperature of the water they were collected from.
- ✓ Allow enough time for the fluffy, white to brownish precipitate (the floc) to settle a third of the way down the bottle (at least to the bottle's shoulder) after mixings. Impatience may result in an incomplete reaction and false low results.
- ✓ The sulfuric acid (reagent #3) is also added in excess - try for 8 drops, but 9 are okay. Adding the acid should dissolve all of the fluffy or "gloppy" precipitate. If 8 drops don't do the trick, continue to add acid one drop at a time until the gloppy precipitate dissolves. You may find that your sample contains dark, solid-looking grains of organic material or sediment that do not dissolve. Ignore these; they will not affect the test results.
- ✓ It is critical that the amount of sample to be titrated is measured out carefully. The bottom of the meniscus (the curved surface of the liquid) should be level with the 20-ml mark on the titration bottle

- ✓ It is critical that the titration be performed carefully. Before starting, check that the syringe plunger moves smoothly. If it seems to be sticky, lubricate it with a bit of sodium thiosulfate solution. (Remember to rinse it with fresh water when you get home.) If the problem persists, report it to the Monitoring Coordinator.
- ✓ Check the titrator carefully for air bubbles after filling. The volume taken up by the bubbles will produce inaccurate readings of the volume of thiosulfate solution used in the titration. Do not proceed with the titration until your titrator is full and bubble free.
- ✓ Measurement of the amount of thiosulfate solution used in the titration is critical. At the start of the titration, the lowermost tip of the black rubber plunger should be level with the 0-unit mark on the top of the titrator scale. Handle the titrator carefully after filling it, taking special care not to move the plunger inadvertently. Moving the plunger accidentally downwards will expel solution; moving it upwards will draw air into the syringe.
- ✓ If your sample contains more than 10 mg/l dissolved oxygen, you will have to refill the titrator during the titration. This is especially likely to happen if you're sampling water that can hold more oxygen - i.e., cool water (less than 10°C or 50°F) or water with an unusually low salinity. One tip-off that you've got high oxygen levels is that when you add the sulfuric acid, the solution turns a brown-orange color as lots of iodine is created.
- ✓ As the plunger approaches the bottom of the titrator, be sure not to depress the lowermost tip of the black rubber plunger below the 10-unit mark on the titrator scale. If you depress the plunger further, you are adding an unknown volume of thiosulfate to your titration sample. When the lowermost tip reaches the 10-unit mark, remove the titrator from the titration tube and refill the titrator.
- ✓ Exactly when and how much of the starch indicator solution is added is not critical. The important thing is that the sample turns blue. If you have a sample with low oxygen levels, adding the sulfuric acid may cause it to turn a pale yellow or pale straw color before you've added any thiosulfate at all. In this case, you'll want to add the starch indicator before you start the titration. It's always better to add the starch solution a bit too early than too late.
- ✓ Once you've reached the pale-yellow color and added the starch indicator, proceed with the titration slowly and carefully so that you don't overshoot the endpoint.
- ✓ If the sample fails to turn blue when you add the starch, this means that you've already added too much thiosulfate and overshot the endpoint. If this happens, or if you overshoot after adding the starch, discard the results of this titration. Measure out a second titration sample from the same sample bottle and repeat the procedure.
- ✓ The first complete disappearance of the blue color is the endpoint. If you see the solution turn blue again a moment later, ignore it! The "re-bluing" effect is caused by the interference of other chemical compounds in the sample.

## **Nutrients**

When feasible, nutrient testing should be performed on site; however, in inclement weather it is permissible to label the 250 ml sample bottles provided in your kit with the date and your site name and fill them with water from your sample bucket to be taken home for testing. If you do this, you must keep your samples cool (between 4°C and 10°C) and complete all testing within six hours of sampling.

### **Ortho-Phosphate**

1. Rinse 3 test tube from your LaMotte Phosphate Test Kit three times with sample water and fill them to the 10ml line with water from your sample bucket.
2. Use the 1ml pipet to add 1ml of Phosphate Acid Reagent to one of the three sample tubes. Cap this test tube and mix by repeatedly inverting it for five seconds.
3. Use the 0.1g spoon to add one level measure of Phosphate Reducing Reagent. Cap the tube again and mix for another five seconds or until all powder is dissolved. Wait five minutes.
4. Place the Axial Reader on a flat surface with the label facing away from you.
5. Insert the Low Range color comparator into the Axial Reader with the labels and blue vials facing toward you.
6. Insert the ampule of distilled water into the square hole on the left side of the comparator.
7. When it has been five minutes, remove the cap from the sample test tube to which you have added the reagents and insert it into the slot in the Axial reader which is directly behind the distilled water ampule.
8. Insert the two test tubes of untreated sample water into the slots in the Axial Reader on either side of the sample tube.
9. Slide Axial Reader up until the top of the Reader is even with the top of the color comparator.
10. Place the comparator so that natural light (or strong fluorescent light) shines down through the test tubes.
11. Compare the color in the center (sample) test tube to the colors in the top left corner of the comparator. If the color of your sample is darker than these color standards move the Axial Reader down so the bottom is even with the bottom of the comparator and compare the center tube to the colors in the lower left hand corner of the comparator. If your sample is still darker than the color standards, move the ampule and all three test tubes to the right side of the comparator and Axial Reader and repeat the comparison process.
12. Once you have matched the color in the sample tube to a color standard, note the shade of blue (clear, faint, light, medium, dark) of the sample on the Monitor Data Sheet.

13. Record the number of the matching color standard as Ortho-Phosphate in ppm on your data sheet.

### **Nitrate/Nitrogen**

1. Rinse one square test tube from your LaMotte Nitrate Nitrogen Tablet Kit three times with sample water and fill it to the 5ml line with water from your sample bucket.
2. Add one Nitrate #1 Tablet to the tube. Cap the test tube and mix by inverting repeatedly until the tablet dissolves completely.
3. Add one Nitrate #2 CTA Tablet to the test tube. Cap the tube again and mix until the tablet dissolves completely. Wait for 5 minutes.
4. Repeat steps 1 through 3 using the second test tube from your Nitrate Nitrogen Tablet Kit.
5. Insert the Nitrate-N color slide into the Octa-Slide viewer.
6. Insert the first test tube into the top of the slide viewer.
7. Note the shade of pink (clear, faint, light, medium, dark) of the sample on the data sheet.
8. Match the sample color to a cell of the color slide and record the number of that slide as Nitrate-Nitrogen in ppm on your data sheet.
9. Repeat steps 6 through 8 with the second test tube in order to verify your results.
10. Multiply the color slide number by 4.4 and record the result as Nitrate in ppm.

### **Coliform Bacteria**

1. Use your sharpie to mark the lids of 3 bottles of Coliscan Easygel™ with the numbers 1, 3 and 5. Use the sterile pipet included in your kit to carefully draw a 1ml water sample from your sample bucket and deposit it into the Easygel™ bottle you have marked as 1. Next, carefully draw and deposit a 3mL water sample from your bucket into the bottle of Easygel™ marked with a 3. Repeat the process once more, this time drawing and depositing a 5mL sample into the bottle marked 5.

Step 1 should be performed in the field. Step 2 will need to be performed once you get home. In the meantime, your sample bottles must be kept cool (between 4°C and 10°C).

2. Mark the lids (the larger half) of three pretreated petri dishes with the date, the time, the name and number of your sampling site, and the amounts 1ml, 3ml and 5ml. (Keep your writing close to the edge of the lids). Match the bottles of Coliscan-water mixture to the petri dishes marked with the

same number. One at a time, pour each bottle of Coliscan-water mixture into the bottom half (the smaller half) of its respective petri dish. Cover the dishes with the designated lids and gently swirl the liquid so that it covers the entire bottom of the dish.

3. Place the petri dishes containing the Coliscan-water mix in a warm place and incubate for 24 to 48 hours.

Optimally, sample temperatures should be maintained between 30°C and 37°C (85°F-99°F) during incubation. You may be able to accomplish this at home by placing your petri dishes under a reading lamp and monitoring the temperature with the air thermometer from your kit. Coliscan samples can also be incubated at room temperature, but an additional 24 hours should be added to the incubation time.

4. After about 30 to 40 minutes the Easygel™ will set into a gel form. Once this occurs turn each entire petri dish over and continue incubating.
5. After 24 hours have past, count the number of purple colonies that have formed in the petri dish. (Using the quadrant grid on your Coliscan Data Sheet will facilitate counting). This is the fecal coliform (*E. coli*) count for this sample. Next, count the number of pink or red colonies and add this to the fecal coliform count. This is the total coliform count for the sample. Record the fecal and total coliform counts for each sample (1ml, 3ml and 5ml) in the 24 hour incubation spaces on your Coliscan Data Sheet. Repeat this counting procedure after a total of 48 hours have past since plating and record the results on your Coliscan Data Sheet in the 48 hour incubation spaces and on your Monitor Data Sheet.

## **F. SAMPLE CUSTODY**

Keeper monitoring and testing procedures are generally conducted in the field. If a sample is deemed to require laboratory testing, it should be handled using the following chain of custody procedure:

- Samples are to be labeled (see example below) and logged in a monitor notebook upon collection.
- In the field, samples are the responsibility of the monitor team leader and should remain in that person's custody.
- Once samples have been collected they are to be brought to the Keeper office in a timely manner, where they are logged in for temporary storage.
- Samples are refrigerated to maintain a temperature between 4 C and 10 C.
- The Monitoring Coordinator is then responsible for transporting samples to an ADEC or EPA certified laboratory for analysis.
- Laboratory personnel will record the date and time the sample arrives at the lab.
- After samples are analyzed, laboratory information is added to the label.
- A Sample Custody Form (see Appendix M) will be used to record all transport and storage information.

- When samples are to be delivered to the Alaska Department of Environmental Conservation (ADEC), an official State of Alaska ADEC sample collection form will be used as the 'chain of custody' document.

The CEMP commitment includes the investigation of additional testing. If other tests are identified which require different sample custody procedures, they will be specifically developed and added to this manual.

### Sample Container Label

<b>COOK INLET KEEPER</b> <b>(907)235-4068</b>	
<b>Field Information:</b>	Type of Sample: _____
Site #: _____ Location: _____	Sample Number ___ of ___
Preservation Method: _____ Gear: _____	Date: __/__/__
Time: _____ AM PM	Monitor Name: _____
Phone: _____	Monitor Signature: _____
<b>Lab Information:</b>	
Date: __/__/__	Time: _____ AM PM Phone: _____
Analyst: _____	Signature: _____

## G. COMPLETING & SUBMITTING DATA SHEETS

Please make sure that all monitors sign the Monitor Data Sheet next to their printed name. Send in data sheet(s) as soon as possible after sampling and testing is complete, or drop them off at the Keeper office in Homer's Lakeside Mall. This will help us keep our database up to date and alert the Monitoring Coordinator to the development of potential problems. Before mailing, please make a copy of the sheet for your own files. On a quarterly basis, Keeper will send you printouts of your data to check for errors, so you'll need copies of the original data sheets. The copies will also be lifesavers if the original sheets get lost in the mail. If you are bringing the sheet in yourself, you can make a copy on our office copier. Data sheets can be mailed in the stamped, pre-addressed envelopes provided or in any envelope addressed to:

**Cook Inlet Keeper**  
Citizens Environmental Monitoring Program  
P.O. Box 3269  
Homer, Alaska 99603

Please write your return address on the envelope.

## VII. EQUIPMENT CARE & WASTE DISPOSAL

## **A. BEFORE SAMPLING BEGINS**

All equipment, meters, and monitoring kits are checked by the Monitoring Coordinator to ensure that they are operating within specifications before they are issued to Volunteer Monitors. Each reagent bottle is dated with the expiration date prior to being issued. A Kit Inspection Form including reagent expiration dates is kept on file at the Keeper office. This form is updated each time a kit receives new or replacement equipment or reagents.

Hanna “4-in-1” Water Test Meters should be brought to the Monitoring Coordinator four times a year for inspection and calibration check. Maintenance logs are kept on each meter.

Before each sampling event you will need to inspect all your sampling equipment. Thermometers (air and water), bottles and test tubes, color comparators, hydrometer, droppers, and other related testing equipment should be examined for cracks or breaks. Thermometers should also be checked to see that the column of indicator fluid is continuous and has not separated. Chemicals should be checked for expiration dates, sufficient quantities and any discoloration. All testing equipment should be clean and in good working order before it is used for monitoring.

The Monitoring Coordinator maintains a supply of replacement equipment and reagents at the Keeper office. If any equipment or chemical reagent is found to be defective in any way please contact the Monitoring Coordinator for immediate replacement.

The quantity of reagent and other chemicals needed for most tests is anticipated to assure that you receive replacements before your supplies become exhausted, usually every 3 to 4 months. The Monitoring Coordinator will rotate out chemical stocks every four to six months or according to manufacturer’s recommendation.

## **B. WHEN YOU’RE DONE TESTING**

### **Liquid Wastes**

In selecting the testing methods employed by the Keeper monitoring program efforts have been made to minimize the production of hazardous wastes. Still, it is important that you handle all your liquid wastes with care and see that they are disposed of properly. Your kit is supplied with two brown wastewater bottles. These are to be used to collect all wastes produced while monitoring. These wastes will not react together in a detrimental way when mixed. Thus, there should be no concern with respect to the formation of toxic gases or explosions. When you get home you can transfer your liquid waste to a plastic milk jug or other plastic container. When this becomes full bring it to the Keeper office for disposal.

### **Equipment and Supplies**

It is important to clean and properly stow all of your equipment and reagents after each monitoring event. Most of your equipment is re-usable and, if properly cared for, will serve you and other volunteer monitors for years to come. A few items, however, are designed to be disposed after one use. They include: any pipet which comes in a sealed plastic wrapper, the pre-treated petri dishes used in the Coliscan test and empty Coliscan Easygel® bottles.

The following pieces of equipment should be thoroughly rinsed with tap water before being stowed in your monitoring kit:

rubber gloves	salinity cylinder and hydrometer
sample bucket	three 60 ml DO sample bottles
stir rod	titrator, plunger and plastic tip
air and water thermometers	titration vial and cap
Secchi disk and line	Hanna Meter (below submersion line only)
turbidity columns	the pipet from the Phosphate Test Kit
all test tubes	

Your tide book, color chart and other paper materials should be kept as dry as possible and stored in the zip-lock bags provided for them. All equipment should also be dried and properly stowed in the black plastic "suitcase" to protect them it excess exposure to light. Keep the suitcase in a dry place protected from extremes of heat and cold. Don't leave it in your car, which can get pretty hot in the summer and pretty cold in the winter. Chemicals may also freeze if kept in a garage or arctic entry.

Always keep all chemicals and equipment out reach of children and pets at all times.

## **VIII. DATA MANAGEMENT & REPORTING**

### **A. VERIFYING ACCURACY**

Check your data sheets prior to sending them in to the Keeper office. Look to see that they are complete and that all figures are legible. Be sure that all monitors have signed next to their names. Take a final look at all the numbers to see if any seem anomalous. If you find illegible or incorrectly entered data do not attempt to erase them. Draw one line through the entry and write the correct information just to the right of it.

The Monitoring Coordinator and the Program Director will check each data sheet for missing or illegible information, errors in calculation and values outside of the expected range. If questions arise, you may be contacted for clarification, so it's important to keep a copy of each data sheet for your records.

Data is then entered into the Keeper data system, which is designed to flag any values that fall outside of the expected range for each parameter. On a quarterly basis the Monitoring Coordinator will send you printouts of your data to check for errors against your original data sheets. Errors in data entry can then be corrected and inconsistencies can be flagged for further review.

## **B. DATA ANALYSIS & REPORTING**

Data will be presented annually using graph and report formats to document baseline water quality, identify trends and detect deficiencies in data collection or program design.

Annual reports will include discussion of any data quality problems. These reports will be provided to the Alaska Department of Environmental Conservation and the US Environmental Protection Agency. Reports will also be available to other government agencies, to volunteer monitors, and to citizen groups. Members of the Citizens Advisory Panel and the Technical Advisory Committee will be asked to review annual reports and offer suggestions for improving the Citizens' Environmental Monitoring Program. Suggestions from water quality monitors are welcome and encouraged at any time.

## **C. WHAT IT ALL MEANS**

Although it is still relatively pristine, the Cook Inlet watershed is beginning to show the signs of environmental stress associated with increased population, development and urbanization. Currently the watershed is home to roughly two thirds of Alaska's human population. Long-time residents have seen local declines in inter-tidal biological communities and species abundance in Cook Inlet waters, but no one can say for sure whether pollution and human impacts are directly harming the resources of Cook Inlet. While a number of studies have been done by government, universities, and industry, the fact remains that there is not enough baseline data available to determine the effects of point and non-point source pollution on the water quality of the Cook Inlet Watershed.

Cook Inlet waters support multi-million dollar sport and commercial fisheries, and provide important subsistence resources for native and other groups. Citizens, industry and resource managers need a comprehensive ongoing water quality monitoring program to understand the potential effects of water pollution on Cook Inlet in order to make economically and environmentally sound decisions.

Many state and federal agencies lack the resources to conduct continuous water quality monitoring projects at a representative number of sites throughout the basin. Cook Inlet Keeper's Citizen's Environmental Monitoring Program can collect accurate baseline data using trained volunteers in a cost effective manner. With your help we can build a greater understanding of what makes our watershed so abundant, and what might threaten its abundance.

## **IX. QUALITY CONTROL**

**T**he Keeper has submitted a Quality Assurance Project Plan with the US EPA and the ADEC. In accordance with this plan the Monitoring Coordinator will make an effort to join 2 to 4 volunteer teams each month to assist with monitoring and ensure that all equipment is functioning properly and all protocols are being followed.

Two Quality Control / Re-training sessions are scheduled each year (one in the spring and one in the fall). All volunteers are asked to attend at least one of these day-long sessions each year to ensure the consistency and accuracy of our water quality monitoring efforts. These quality control sessions will include a laboratory and field practicum along with discussions of monitoring techniques and suggestions for improving the water quality monitoring program.

# **APPENDIX A**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

## **Glossary of Terms**

## Glossary of Terms

**Acid** - a substance with more hydrogen (H<sup>+</sup>) ions than hydroxide (OH<sup>-</sup>) ions (pH less than 7)

**Algae(pl), alga** - a collective term referring to several groups of simple photosynthetic plants, mostly microscopic, lacking roots, stems and leaves; they can be found in a variety of habitats; many species of algae exist as single cells, others form simple filaments or colonies and others exist as more complex structures like the larger seaweeds

**Algal bloom** - a particularly extensive growth of algae in a body of water; this is usually a result of increased nutrient content

**Alkaline** - a substance with more hydroxide (OH<sup>-</sup>) ions than hydrogen (H<sup>+</sup>) ions (pH greater than 7)

**Ammonia (NH<sup>4</sup>)** - a colorless gas consisting of nitrogen and hydrogen atoms; it is the main substance used by organisms as a source of nitrogen

**Ampule** – sealed container of liquid

**Anoxia** – conditions where oxygen is absent

**Apparent Color** – the color observed in water based on the amount and nature of dissolved and suspended materials and how they refract light

**Axial Reader** – a type of color comparator capable of reading even faint color indicators

**Bacteria** - a group of essentially single-celled microscopic organisms lacking chlorophyll which break down material

**Baseline Water Quality** – a measure of naturally occurring water quality used for comparing water quality over time and identifying water quality trends

**Basin** - an area drained by a given river and its tributaries (see catchment)

**Beaufort Wind Scale** – an internationally agreed upon scale of wind force that has thirteen standardized categories and associated descriptions

**Bioassessment** - the use of living organisms to assess environment health; the examination of biological communities, particularly stream insects (technically called benthic macroinvertebrates), provides an indication of water quality

**Borger Color System** – a standardized system of numbered color chips originally devised to measure the color of flies for fisherman now widely used for determining the apparent color of water

**Catchment** - the area of land that is drained by a river and its tributaries; the dividing line between catchments is physically defined by mountains, crests of hills or the ridge of high ground

**Coliform bacteria** - bacteria, found in the intestines of warm-blooded animals, that aid in the

digestion process; used as indicators of fecal contamination in water-quality analyses

**Color Comparator** – device used in colorimetric testing

**Colorimetric** – type of test measuring the concentrations of various substances by gauging the reaction of an indicator with a known sample amount and comparing the resulting color with a known range of values

**Conductivity** - a measure of electronic resistance caused by organic and inorganic materials in water; conductivity can also be used to measure salinity

**Dissolved oxygen** - the amount of oxygen dissolved in water and available for living organisms to use for respiration

**Distilled Water** – water that has had most of its impurities removed

**Ecosystem** – biotic community (living organisms) and its abiotic (non-living) environment function as one system

**Effluent** - waste material (e.g., smoke, sewage etc.) discharged into the environment

**Equilibrate** – bring into equilibrium or balance

**Erosion** - the wearing away of the land by running water, rainfall, wind, ice or other geological agent or process including weathering, dissolution, abrasion and corrosion

**E. coli (Escherichia coli)** - one of the species of bacteria in the fecal coliform group; it is found in large numbers in the gastro-intestinal tract and feces of warm-blooded animals and humans; its presence in water is considered indicative of fecal contamination

**Estuary** - an open drainage depression adjacent to the sea, typically at the mouth of a river, into which the tide ebbs and flows; tide movements accentuate erosion and continually modify the drainage channels within the estuary

**Eutrophic** - waters enriched with plant nutrients, which may become deoxygenated

**Eutrophication** - the natural and artificial addition of nutrients to a waterbody, which may lead to depleted oxygen concentrations – eutrophication is a natural process that is frequently accelerated and intensified by human activities

**Fecal** - relating to animal, including human, excrement

**Fecal Coliform** – coliform bacteria of the species *Escherichia coli* (occasionally the *Klebsiella* species is included in this category as well)

**Fertilizer** - any substance, natural or manufactured, added to the soil to supply essential plant nutrients for plant growth

**Field Observations** – observational data collected on site

**Fixing** – portion of the dissolved oxygen test procedure by which oxygen molecules are bound or

“fixed” in solution

**Flocculent (floc)** – a mass of particles that form into a clump as a result of a chemical reaction

**Galactosidase** – enzyme produced by coliforms during lactose fermentation

**Glucuronidase** - enzyme produced by fecal coliforms during lactose fermentation

**GPS (Global Positioning System)** – satellite based system used to pinpoint geographic position

**Graduated cylinder** – a cylinder used to measure liquids that is marked in units

**Heavy metals** - any element with an 'atomic number' larger than 20 that can be precipitated by hydrogen sulfide in acid solution; e.g., copper, cadmium, chromium, lead and mercury

**Hydrometer** – instrument used to measure the specific gravity of liquid

**Hypoxia** – depletion of dissolved oxygen in an aquatic system

**Ions** - electrically charged molecules; often formed when an electrically neutral molecule is dissolved in water and disassociates

**Jackson Turbidity Unit (JTU)** – standard measure of turbidity produced by adding measured amounts of a reagent to clear distilled water until its clarity is reduced to match that of a water sample; JTUs can be directly equated to NTUs (Nephelometric Turbidity Units)

**Leaching** - the process by which water percolates through a particular solid, usually layers of soil; when water 'leaches' through the soil it often dissolves and then carries away many other substances

**Macro-invertebrate** - animals without a backbone and visible to the naked eye

**Material Safety Data Sheet (MSDS)** – product safety information sheets prepared by manufacturers and marketers of products containing toxic chemicals

**Maximum dissolved oxygen concentration** – the total amount of oxygen that can be dissolved in water of a given temperature and salinity

**Medium** – a substance in which microorganisms can be grown

**Meniscus** – the curved upper surface of a column of liquid

**Molar volume** – a volume of liquid containing one mol of solute per liter of solvent

**Monitoring** – the periodic collection of information through the measurement and observation of natural phenomena

**Motile** - capable of motion, particularly locomotion

**Nephelometric Turbidity Unit (NTU)** – standard measure of turbidity obtained using an electronic Nephelometer; NTUs can be directly equated to JTUs (Jackson Turbidity Units)

**Nitrate (NO<sub>3</sub>)** - a compound of nitric acid and a given alkali

**Nitrite (NO<sub>2</sub>)** – a salt or ester of nitrous acid

**Nitrogen (N)** – one of the major nutrients required for the growth of plants, present usually as organic nitrogen, ammonia, nitrate, and forms of nitrite; excess nitrogen can cause accelerated eutrophication in waterbodies

**Non-point-source pollution** - a source of pollution that cannot be pinpointed, because it comes from many individual places or a widespread area (e.g., urban and agricultural run-off);

**NPDES Permit** – the National Pollutant Discharge Elimination System is the title of section 402 of the Clean Water Act. NPDES is used to describe all permits issued under this section which deals with point sources of pollution

**Nutrient** - derived from living matter and including elements such as nitrogen, phosphorus and sulfur; nutrients are essential for plant growth but can adversely effect land and aquatic ecosystems if present at high levels

**Orthophosphate** – inorganic phosphate that is readily dissolved in water

**Oxidation-Reduction Potential** – the capability of a substance to either release or gain free electrons

**Parameter** – measurable value of a physical, chemical or biological component that is used to help define a natural system and its behavior

**Parts per million (ppm)** - the number of parts by weight of a substance per million parts of liquid

**Pathogenic bacteria** – bacterial capable of causing disease

**Percent of saturation** – a comparison of the measure of dissolved oxygen in a liquid against the maximum dissolved oxygen concentration for that liquid at a given temperature and salinity

**pH** - a numerical measure of the hydrogen ion concentration used to indicate the alkalinity or acidity of a substance – measured on a scale of 1.0 (acidic) to 14.0 (basic) where a value of 7 is neutral; as pH is a logarithmic scale, a pH of 3 is 10 times as acidic as a pH of 4 and 100 times as acidic as a pH of 5

**Phosphate (PO<sub>4</sub>)** - a salt or ester of any phosphoric acid: it provides organisms with phosphorus in a useable form; often used in fertilizers and detergents

**Phosphorus (P)** - a non-metallic element that is an important nutrient for all organisms

**Photosynthesis** - the process by which plants produce organic matter from inorganic chemicals, using solar energy, with the liberation of oxygen

**Pipet** – an eye dropper-like instrument that can measure very small amounts of liquid

**Plankton** - small animals and plants which float or drift in the water body

**Point-source pollution** - a source of pollution that can be pinpointed

**Pollution** – when the level or concentration of any contaminant is high enough to have an adverse affect upon other elements of the ecosystem

**Precipitate** – a substance that is separated out from a solution as a solid by the action of chemical reagents, temperature, etc.

**Quality control** – those activities performed during data collection to produce data of a desired quality in order to document that quality

**Reagent** – a substance or chemical used to indicate the presence of a chemical or to induce a chemical reaction to determine the chemical characteristics of a solution

**Redox** – see oxygen reduction potential

**Riffle** – shallow area in a stream where water flows swiftly over gravel and rock

**Run-off** - the portion of rainfall or irrigation (e.g., lawn sprinkler) water that flows across the land's surface, does not soak into the ground and eventually runs into a water body; it may pick up and carry a variety of pollutants

**Salinity** concentration of salts, measured in parts per thousand or grams per litre

**Salts** compounds that dissociate in water to yield a positively charged ion and a negatively charged acid radical ion

**Saturated** – inundated; filled to the point of capacity or beyond

**Secchi depth** – the greatest depth at which a Secchi disk can be seen through water

**Secchi disk** – a plastic disk, 20 cm in diameter divided into black and white quadrants which is used to measure the turbidity or clarity of water by lowering it on a line to the deepest point where it can still be seen

**Sediment** - insoluble material suspended in water consisting mainly of particles derived from rocks, soil and organic materials; can be a major non-point-source pollutant to which other pollutants may attach

**Sessile** – permanently fixed; immobile

**Sewage** - household and commercial waste-water that contains human waste

**Silt** - fine particles of rock, soil or organic material that can be suspended in water

**Specific Gravity** – a measure of the density of a substance divided by the density of pure water at 4°C

**Stewardship** –caring for the land for both short and long term needs within the capacity of the environment to provide those needs

**Surface water** – precipitation which does not soak into the ground or return to that atmosphere by evaporation or transpiration; it is stored in streams, lakes wetlands, reservoirs and other depressions like puddles and ditches

**Suspended solids** – a mixture of fine particles dispersed in a liquid

**Tidal Stage** – a period in the tidal cycle, ie. high tide, high ebb, ebb, low ebb, low tide, low flood, flood, high flood

**Titration** – the addition of small, precise quantities of a reagent to a sample until the sample reaches a certain endpoint – reaching the endpoint is usually indicated by a color change

**Titration** – syringe-like instrument used to add precise amounts of reagent in the process of titration

**Topographical map** - a map that shows (by means of color and contour lines) the ground surface features of a region

**Toxic** - being harmful, destructive or deadly to organisms

**Tributary** - an inflow of water from a smaller body into a larger one; natural examples include streams and creeks, while human-made examples include drains and sewerage pipes

**Trophic** – relative position in the food web in terms of securing nutrients

**Turbidity** – murkiness or cloudiness of water, indicating the presence of some suspended sediments, dissolved solids, natural or human-made chemicals, algae, etc.

**Upwelling** – a process in the sea whereby subsurface water is displaced toward the surface

**Watershed** – total land area that contributes runoff to a particular waterbody

# **APPENDIX B**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Monitoring Policy Statement**

## **COOK INLET KEEPER MONITORING POLICY**

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1. Each monitoring station or site will have one primary monitor or Team Leader and at least one alternate. If both primary and alternate monitors for any particular site are from the same household, a third person must be assigned as alternate to provide coverage for vacations, etc.
2. In order to maximize site coverage in the event of illnesses or vacations, efforts will be made to avoid assigning the same two monitors to any two sites.
3. All primary and alternate monitors will be at least 16 years old. People under 16 are welcome to attend training and quality control sessions and to assist monitors at the sites.
4. All monitors will complete phases I through III of training prior to monitoring and attend at least one of the two quality control sessions held each year.
5. Each monitoring team will have its own kit. Team Leaders will be responsible for maintaining their kits and for notifying the Monitoring Coordinator of any problems with their equipment. Team Leaders will bring their kits to all quality control sessions.
6. If a Team Leader is not able to monitor on a scheduled date it is their responsibility to locate an alternate monitor and provide them with their monitoring kit. If this is not possible the Team Leader should contact the Monitoring Coordinator to make arrangements, preferably in advance of the sampling session. Monitors are responsible for reporting equipment problems, reagent shortages, etc. to their team leaders or the Monitoring Coordinator.
7. All monitors will take part in monitoring at least once every four (4) months to maintain familiarity with equipment, procedures, and sites.
8. All monitors will have the option of joining an "alternate pool" in addition to their regular teams. The pool will provide coverage when regular monitors are not available at a given site. Only trained monitors may join this pool.
9. All monitors will be responsible for the quality and completeness of the data they themselves collect and for submitting this data to the Monitoring Coordinator on a timely basis. Monitors will also be responsible for maintaining an ample supply of standardized data.
10. The Monitoring Coordinator will be responsible for the overall quality of the data collected by the program. If problems arise with the data collected by any particular monitor, the Monitoring Coordinator will work with the monitor to resolve these problems.

# **APPENDIX C**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **References & Further Reading**

## References & Further Reading

### **Some References used in Preparing This Manual Include:**

Water Quality Monitoring Manual (1996)  
Friends of Casco Bay  
2 Fort Road  
South Portland, ME 04106

Volunteer Environmental Monitoring Manual (1992)  
Texas Watch  
Texas Natural Resources Conservation Commission  
P.O. Box 13087  
Austin, TX 78711-3087

Volunteer Manual (1992)  
The Delaware Riverkeeper Network  
P.O. Box 753  
Lambertville, NJ 08530

Volunteer Stream Monitoring Methods Manual  
(1995)  
Clean Water Initiative  
Tennessee Valley Authority  
1101 Market Street, CST 17D  
Chattanooga, Tennessee 37402-2801

The Monitor's Handbook (1992)  
LaMotte Company  
P.O. Box 329  
Chestertown, MD 21620

Volunteer Estuary Monitoring:  
A Methods Manual (1993)  
U.S. Environmental Protection Agency  
Office of Water  
Office of Wetlands, Oceans and Watersheds  
Oceans and Coastal Protection Division  
401 M Street, SW (4504F)  
Washington, DC 20460

Standard Methods for the Examination of Water and  
Wastewater (19<sup>th</sup> Edition, 1995)  
American Public Health Association, et.al.  
1015 Fifteenth Street, NW  
Washington, DC 20005

Volunteer Stream Monitoring:  
A Methods Manual  
U.S. Environmental Protection Agency  
Office of Wetlands, Oceans and Watersheds  
Volunteer Monitoring (4503F)  
401 M Street, SW  
Washington, DC 20460

### **Other Valuable Resources for Volunteer Monitors Include:**

Streamkeeper's Field Guide (5<sup>th</sup> Edition, 1996)  
Paul Murdoch & Martha Cheo  
Adopt-A-Stream Foundation  
600 – 128<sup>th</sup> Street SE  
Everett, WA 98208

Water Resource Handbook (1996)  
Larry W. Mays, Editor-in-Chief  
Department of Civil and Environmental Engineering  
Arizona State University  
Tempe, Arizona

Volunteer Lake Monitoring:  
A Methods Manual (1991)  
U.S. Environmental Protection Agency  
Office of Water  
Office of Wetlands, Oceans and Watersheds  
Assessment & Watershed Protection Division  
WH-553  
401 M Street, SW  
Washington, DC 20460

The Volunteer Monitor (Biannual Publication)

Eleanor Ely, Editor  
The Volunteer Monitor  
1318 Masonic Ave.  
San Francisco, CA 94117

Field Manual for Water Quality Monitoring (1990)

Mark K. Mitchell & William B Stapp  
2050 Delaware Ave.  
Ann Arbor, MI 48103

Laboratory Manual for Marine Science Studies  
(1993)

LaMotte Company  
P.O. Box 329  
Chestertown, MD 21620

Handbook of Hydrology (1993)

David R. Maidment, Editor-in-Chief  
McGraw-Hill, Inc.  
Princeton Road, S-1  
Highstown, NJ 08520

An Introduction to Environmental Chemistry  
(1996)

J.E. Andrews, P. Brimblecombe  
T.D. Jickells and P.S. Liss  
School of Environmental Science  
University of East Anglia  
Norwich NR4 7TJ, UK

The HarperCollins Dictionary of  
Environmental Science (1992)

Gareth Jones, Alan Robertson  
Jean Forbes, Graham Hollier  
HarperCollins Publishers  
10 East 53<sup>rd</sup> Street  
New York, NY 10022

McGraw-Hill Series in Water Resources  
and Environmental Engineering (1991)

Terence J. McGhee  
McGraw-Hill, Inc.  
Princeton Road, S-1  
Highstown, NJ 08520

Water on Tap: A Consumer's Guide  
to the Nation's Drinking Water (1997)

U.S. Environmental Protection Agency  
Office of Water (4601)  
Washington, DC 20460

McGraw-Hill Encyclopedia of  
Ocean and Atmospheric Sciences (1977)

Sybil P. Parker, Editor-in-Chief  
McGraw-Hill, Inc.  
Princeton Road, S-1  
Highstown, NJ 08520

# **APPENDIX D**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

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# **APPENDIX E**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Liability Release Form**

**COOK INLET KEEPER**  
**Liability Release Form**

**LIABILITY**

The Cook Inlet Keeper (Keeper) Citizens' Environmental Monitoring Program (CEMP) intends that volunteers participating in any Keeper activity are not acting on behalf of Cook Inlet Keeper or any Keeper partner in any capacity. As such, it is Cook Inlet Keeper's intent that volunteers are not authorized to be considered agents, employees, or authorized representatives of Keeper or any Keeper partner for any purpose, and that volunteers are not entitled to the same benefits received by employees of Keeper or any Keeper partner.

Volunteers must recognize the potential for injuries to themselves and their real and personal property which may result from volunteer activities conducted with the Cook Inlet Keeper Citizens' Environmental Monitoring Program or other activities sponsored or organized by the Keeper. Keeper and all Keeper partners intend that the volunteers expressly assume all risks and liability for any injuries to, or caused by, volunteers under this program.

**Liability Release**

In consideration of the foregoing, I, myself, my heirs, and executors do hereby release and discharge Cook Inlet Keeper and all Cook Inlet Keeper supporting organizations for all claims, damages, actions and whatever in any manner arising or growing out of my participation in said monitoring program or other activities sponsored or organized by Keeper.

Date \_\_\_\_\_

\_\_\_\_\_  
Volunteer Printed Name

\_\_\_\_\_  
Parent or Guardian Printed Name

\_\_\_\_\_  
Volunteer Signature

\_\_\_\_\_  
Parent or Guardian Signature

Address \_\_\_\_\_

Telephone Number \_\_\_\_\_

**EMERGENCY CONTACTS:**

\_\_\_\_\_  
Name Relationship Telephone Number

\_\_\_\_\_  
Name Relationship Telephone Number

**Special Instructions:** \_\_\_\_\_

# **APPENDIX F**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Materials Safety Data Sheets**

# **APPENDIX G**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Property Access Form**

**COOK INLET KEEPER**  
**Property Access Form**

Monitoring Site Name: \_\_\_\_\_ Site Number: \_\_\_\_\_

Site Location: Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_ Elevation: \_\_\_\_\_

Site Description: \_\_\_\_\_

Description of Access Route to Site: \_\_\_\_\_

Property Ownership – Site: \_\_\_\_\_

Property Ownership – Access Route: \_\_\_\_\_

If site or site access route is located on private property, the primary monitor must obtain signed authorization from the property owner before sampling can begin. The monitor should approach the property owner(s), explain the purpose of their monitoring activity and request permission to access property owner’s land. Each private property owner involved will need to grant permission and sign a Property Access Form before monitoring can begin. Monitors should respect private property and property owners at all times and make every effort to minimize impact to private lands.

**Landowner Permission Form & Liability Waiver**

I, (print name) \_\_\_\_\_ am the legal owner of property described above. I understand that, \_\_\_\_\_, a volunteer water quality monitor for Cook Inlet Keeper (Keeper) will require access to this property, once monthly throughout winter months and twice monthly during summer months, in order to sample and test water quality at the water quality monitoring site designated above. I hereby grant my permission for said access to \_\_\_\_\_, or an alternate water quality monitor designate by Keeper for the sole purpose of water quality monitoring. I grant this permission on the condition that the Cook Inlet Keeper organization, and all its water quality monitors do hereby release me from any and all legal and other responsibilities and liabilities, including, but not limited to physical and other harms which might befall Keeper volunteers or staff while using this land for the purpose of monitoring water quality. It is also understood that said water quality monitors will not cause undue damage or negative impact on this property in the course of their monitoring activities.

\_\_\_\_\_  
Signature of legal owner of property described as: \_\_\_\_\_

\_\_\_\_\_  
Date signed: \_\_\_\_\_

\_\_\_\_\_  
Signature of primary monitor for Keeper monitoring site # \_\_\_\_\_

\_\_\_\_\_  
Steve Hackett, Monitoring Coordinator  
Cook Inlet Keeper

# **APPENDIX H**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Beaufort Scale**

## BEAUFORT WIND SCALE

Beaufort Number or Force	Wind Speed		World Meteorological Organization Description	Estimating Wind Speed Effects Observed
	knots	mph		
0	under 1	under 1	calm	Calm; smoke rises vertically
1	1-3	1-3	light air	Smoke drift indicates wind direction; vanes do not move
2	4-6	4-7	light breeze	Wind felt on face; leaves rustle; vanes begin to move
3	7-10	8-12	gentle breeze	Leaves and small twigs in constant motion; light flags extended
4	11-16	13-18	moderate breeze	Dust, leaves, and loose paper raised up; small branches move
5	17-21	19-24	fresh breeze	Small trees in leaf begin to sway
6	22-27	25-31	strong breeze	Larger branches of trees in motion; whistling heard in wires
7	28-33	32-38	near gale	Whole trees in motion; resistance felt in walking against wind
8	34-40	39-46	gale	Twigs and small branches broken off trees; progress generally impaired
9	41-47	47-54	strong gale	Slight structural damage occurs; slate blown from roofs
10	48-55	55-63	storm	Trees broken or uprooted; considerable structural damage occurs
11	56-63	64-72	violent storm	Usually accompanied by widespread damage
12	64 and over	73 and over	hurricane	

# **APPENDIX I**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Monitor Data Sheet**

# **APPENDIX J**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Hydrometer Conversion Chart**

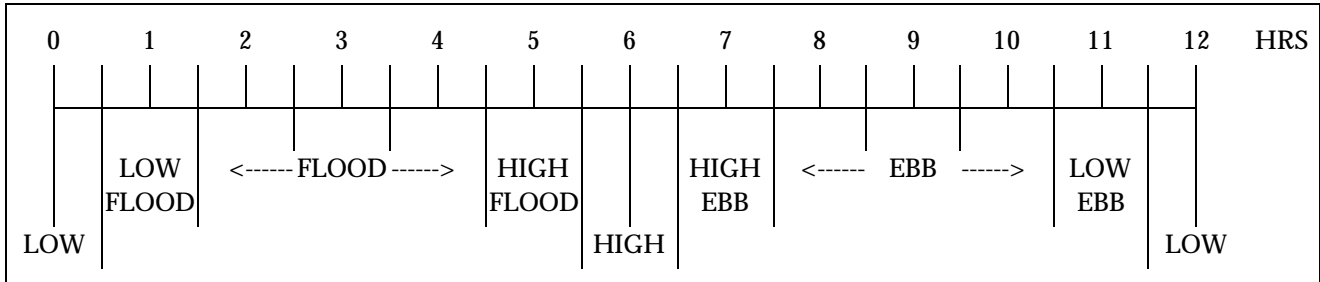
# **APPENDIX K**

## **COOK INLET KEEPER**

Citizens' Environmental  
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Volunteer Training Manual

### **Tidal Stage Guide**

## GUIDE TO TIDAL STAGES



For example, if high tide were at 14:00 (2:00 PM) and you were sampling two hours earlier at 12:00 noon, the tidal stage would be "flood." If you were sampling one hour earlier, the stage would be "high flood"; one hour later would be "high ebb" and two hours later would be simply "ebb." Only the period from 1:30 PM to 2:30 PM would be considered "high."

# **APPENDIX L**

## **COOK INLET KEEPER**

Citizens' Environmental  
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### **Odor Identification Chart**

## Odor Identification Chart

A system of qualitative descriptions helps monitors describe and record detected odors. The following classifications are included in the tenth edition of Standard Methods.

NATURE OF ODOR		DESCRIPTION, SUCH AS ODOR OF:
Aromatic (spicy)	camphor, cloves, lavender, lemon	
Balsamic (flowery)	geranium, violet, vanilla	
Chemical	industrial wastes or treatments	
	chlorinous	chlorine
	hydrocarbon	oil refinery wastes
	medicinal	phenol and iodine
Disagreeable (pronounced, unpleasant)	sulfur	hydrogen sulfide (rotten eggs)
	fishy	Uroglenopsis, Dinobryon (dead algae)
	pigpen	Anabaena algae (visit a pig farm to sample this distinctive odor)
	septic	stale sewage
Earthy	damp earth	
	peaty	peat
Grassy	crushed grass	
Musty	decomposing straw	
	moldy	damp cellar
Vegetable	root vegetables	

# **APPENDIX M**

## **COOK INLET KEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

### **Sample Custody For**

**Figure 2: Sample Chain of Custody Form**

<b>Cook Inlet Keeper</b>						<b>CHAIN OF CUSTODY RECORD</b>				Page ____ of ____		
<b>PROJECT:</b>						<b>COLLECTOR(S):</b> <i>(Signatures)</i>						
<b>LOCATION:</b>												
<b>DISTRIBUTION:</b> · ORIGINAL - To accompany all samples						· COPY - To Program Coordinator						
Station Number	Replicate	Date	Time	Sample Type	Container		Preservative	Analysis Required	Due Date	Remarks	Results of Analysis	
					Vol.	Type						
<b>Relinquished by:</b> <i>(Signature)</i>				<b>Received by:</b> <i>(Signature)</i>				<b>Date</b>	<b>Time</b>	<b>Method of Shipment:</b>		
<b>Relinquished by:</b> <i>(Signature)</i>				<b>Received by:</b> <i>(Signature)</i>				<b>Date</b>	<b>Time</b>			
<b>Relinquished by:</b> <i>(Signature)</i>				<b>Received by:</b> <i>(Signature)</i>				<b>Date</b>	<b>Time</b>	<b>Destination:</b>		
<b>Dispatched by:</b> <i>(Signature)</i>				<b>Date</b>	<b>Time</b>	<b>Received for Laboratory by:</b> <i>(Signature)</i>				<b>Date</b>	<b>Time</b>	

# **APPENDIX N**

## **COOK INLETKEEPER**

Citizens' Environmental  
Monitoring Program  
Volunteer Training Manual

## **Pollution Response System**

# **COOK INLET KEEPER**

## **Pollution Response System**

In order to raise awareness about the impacts of human activities on Cook Inlet ecosystems and to ensure effective response to pollution events, Cook Inlet Keeper has initiated a Pollution Response System. Keeper is organizing citizens to be its “eyes and ears” to help identify and address pollution and habitat destruction in the vast Cook Inlet watershed.

Citizens are encouraged to take note of any environmentally harmful activities they observe. Keeper has published a Cook Inlet Watershed Directory listing all government agencies and other organizations involved with caring for Cook Inlet. When you call our **Toll-free Hotline (1-888-MY INLET)** between 9:00AM and 6:00PM, Monday through Friday a staff person will take your report and help direct you to the regulatory agency responsible for responding to your concern.

Keeper will record the information you provide about the nature and location of the pollution event and enter it into our database. Our computerized database will help track pollution throughout the watershed and allow us to follow agency response. If the relevant agency does not respond effectively and in a timely manner, Keeper may conduct an on-site investigation, advocate to governmental officials on your behalf or help you organize your neighbors to compel action.

The local, state and federal agencies charged with protecting our environment cannot possibly monitor every potentially harmful activity in an area as large as Cook Inlet watershed and recent budget cuts have made it ever more difficult for agencies to operate effectively. Alaska’s water resources belong to all its citizens. Keeping our water clean for future generations will require all Alaskan to become involved in pollution prevention.

