DRAFT UPSTREAM SEDIMENT LOAD STUDY
FIELD SAMPLING PLAN
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

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March 2011

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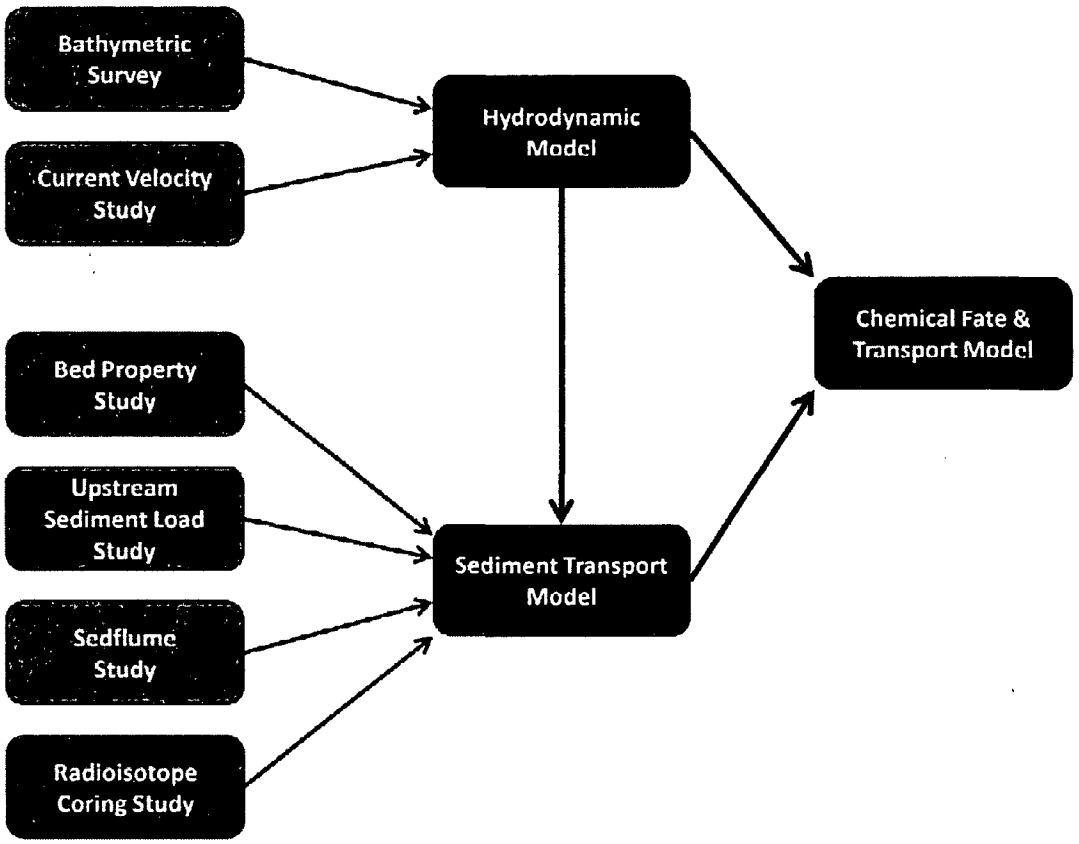
LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA	Anchor QEA, LLC
COC	Chain-of-Custody
DGPS	Differential Global Positioning System
EDI	equal discharge increment
EWI	equal weight increment
EDS	equipment data sheets
FSP	Field Sampling Plan
HASP	Health and Safety Plan
Integral	Integral Consulting Inc.
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SOP	Standard Operating Procedure
TPWD	Texas Parks and Wildlife Division
TSS	total suspended solids
UAO	Unilateral Administrative Order
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

1 INTRODUCTION

This document provides a Field Sampling Plan (FSP) for the upstream sediment load study at the San Jacinto River Waste Pits (SJRWP) Superfund site (the Site). This FSP was prepared as a supplement to the Final Sampling and Analysis Plan Addendum Chemical Fate and Transport Modeling Study (Fate and Transport Addendum; Anchor QEA and Integral 2010b), which is an addendum to the Sampling and Analysis Plan, Sediment Study (Sediment SAP) (Integral and Anchor QEA 2010). The chemical fate and transport modeling study is required by the Remedial Investigation and Feasibility Study (RI/FS) Work Plan (Anchor QEA and Integral 2010a) and describes the sampling and fate and transport modeling efforts to be undertaken in support of achieving the overall RI/FS goals.

Together with the Sediment SAP and the Fate and Transport Addendum, this FSP provides information on field activities and related documentation to meet the requirements of the U.S. Environmental Protection Agency (USEPA) guidance (USEPA 1988, 1992, 2001, and 2002), as required by the Unilateral Administrative Order (UAO) (USEPA 2009). Additional information on the Site history and a summary of existing data are provided in the RI/FS Work Plan (Anchor QEA and Integral 2010a) and Sediment SAP (Integral and Anchor QEA 2010). Information on the geology, physiography, hydrology, and cultural and natural resources of the Site and information on fate and transport is provided in the RI/FS Work Plan (Anchor QEA and Integral 2010a).



The objective of the upstream sediment load study is to estimate the sediment load in the San Jacinto River (Figure 1), by obtaining total suspended solids (TSS) concentration data from river water at regular intervals over a period of time. The TSS concentration data will provide input and calibration data for the sediment transport model, as described in the Fate and Transport Addendum (Anchor QEA and Integral 2010b). This FSP specifically addresses two data collection activities:

- TSS concentration data collection under baseline conditions
- TSS concentration data collection during two high-flow events

1.1 Overview

The sediment load study will be conducted just upstream of USEPA's preliminary Site perimeter (Figure 1). The objective of the study is to determine the baseline and high-flow suspended sediment concentrations in San Jacinto River in the vicinity of the Site. The TSS concentration samples will be collected using an automated sampler installed just upstream of the preliminary Site perimeter (Figure 2). Samples will be collected automatically by the programmed sampler at three-hour intervals over the period of one month, with the goal of collecting data during low-flow conditions and data from two high-flow events of 10,000 cfs flow or greater. It is anticipated that the samples obtained during the sampling period will provide data representative of low-flow and high-flow conditions.

Additionally, TSS concentration samples will be collected during two equal width increment (EWI) sampling events concurrent with the high-flow events described above. The objective of EWI sampling is to obtain an estimate of the average TSS concentration in the river channel and to evaluate data variability across the channel. Using this method, the river channel is divided into equal-width increments in the cross-channel direction. TSS concentration samples are collected within each equal-width increment by lowering and raising a sampler through the water column at the center of each increment. The EWI sampling events will be conducted consistent with USGS methods (Lane et al., 2003; USGS 2006; Wilde et al., 2009) to verify that the TSS concentration data collected with the automated sampler sufficiently represents general river conditions.

The TSS concentration dataset will be evaluated in conjunction with data obtained during the current velocity study (described in detail in the Current Velocity Study FSP [Anchor QEA 2011]) and included in the sediment transport model.

1.2 Project Organization

Detailed project organization is provided in the Sediment SAP (Integral and Anchor QEA 2010). The names and responsibilities of key task-specific personnel for are provided below:

FSP Personnel Quality Assurance Responsibilities

Title	Responsibility	Name	Contact Information
Task Coordinator	Coordination of task project information and related communications with Project Coordinator	Kirk Ziegler	Anchor QEA, LLC 305 W. Grand Avenue Suite 300 Montvale, NJ 07645-1813 (201) 571-0949 kziegler@anchorqea.com
Field Lead Anchor QEA	Field data collection and implementation of the Health and Safety Plan in the field	Daleel Nangju	Anchor QEA, LLC 10707 Corporate Drive Suite 230 Stafford, TX 77477 (281) 565-1133 dnangju@anchorqea.com

1.3 Document Organization

This FSP describes the field methods that will be used to install, operate and maintain the automated sampler and conduct the EWI sampling used to collect water samples for the study. The background, rationale, data quality objectives, and overall study design are described in detail in the Chemical Fate and Transport Addendum (Anchor QEA and Integral 2010b). Section 2 of this FSP describes the field procedures and sample packaging and shipping requirements that will be followed by the technical team during the field study. Section 3 summarizes field documentation and chain-of-custody (COC) procedures. Section 4 discusses field data management and reporting procedures.

The following documents are provided as attachments to the FSP:

- Standard Operating Procedures (SOPs) and Equipment Data Sheets (EDS). The SOPs and EDSs are provided in Attachment 1. These include the information developed to describe automated sampler installation, operation and maintenance, EWI sampling, EWI sampling equipment, sample handling, record keeping, decontamination, and COCs, consistent with the procedures used during the sediment and soil investigations, as applicable. All SOPs included in this document (with the exception of the automated sampler-specific and EWI information) are also provided in the Sediment SAP (Integral and Anchor QEA 2010). They are included here for the convenience of the field team.

- Field Forms. Attachment 2 contains examples of various forms that will be used during field sampling, including a corrective action record, a field change request form, and a COC form.

2 SAMPLING PROCEDURES

The following sections describe the detailed procedures and methods that will be used during the upstream sediment load study, including the schedule, sampling procedures, recordkeeping, sample handling, storage, and field quality control (QC) procedures. All field activities will be conducted in accordance with the Health and Safety Plan (Anchor QEA 2009), which will be amended as needed to support the field tasks and Addendum 1 to the overall HASP: Sediment HASP (Integral 2010). Table 1 summarizes the planned sample IDs and sample analyses.

2.1 Schedule

The start date for the upstream sediment load study will be determined following USEPA approval of this FSP. However, for planning purposes, it is anticipated that the sampling event will begin in April 2011, the earliest practicable implementation timeframe. It is important to note that, as previously discussed in the Fate and Transport Addendum, the sample collection period may be extended if requisite high-flow events do not occur during the initial sampling period.

2.2 Sampling Methods

2.2.1 Sample Location Access

The automated TSS sampler will be located at the dock at the Riverside Inn Marina, see Figures 2 and 3. This sampling location was chosen because it provides a safe and secure location for the automated TSS sampler which is accessible for installation and maintenance. No other locations between Lake Houston dam and the Site had these essential characteristics. Access to the sampling location will be from land using a field truck or vehicle of similar capacity. A small jon boat or skiff may be used to assist in sampler installation if work under the dock or at the water surface is required for sampler configuration and installation. It is anticipated that the sampler will be installed on the dock in an enclosure to protect the sampler from weather, and that sampler maintenance and sample bottle retrieval and replacement will require only normal access from the dock surface. The EWI sampling locations, identified on the closest reasonably accessible, safely

navigable and representative transect, (Figure 4) will be accessed by a specially-equipped sampling vessel.

2.2.2 Automated TSS Sampling Equipment and Supplies

Field equipment and supplies for the automated sampling include: automated TSS sampler, installation tools, fasteners, protective enclosure, decontamination supplies, sample containers, coolers, shipping containers, log books and forms, personal protection equipment, and personal gear. Protective wear (e.g., gloves) is required to minimize the possibility of cross-contamination during sample bottle change out. Additional information on personal protective wear required for the work is provided in the HASP (Anchor QEA 2009 and Integral 2010).

The automated sampler will be an ISCO model 6712 portable full size sampler or equivalent (Attachment 1). This sampler is fully programmable and has numerous bottle configurations, including a 24 one-liter bottle capacity. Samples are collected at user-programmed intervals using dedicated sample tubing with protective intake screen and a heavy duty peristaltic pump. ISCO samplers are commonly used by regulatory agencies, municipalities and private industry for this application as well as waste water, sewer and waste stream sampling programs.

Sample bottles, coolers, and packaging material for the samples will be supplied by the analytical laboratory. Details on the numbers and type of samples containers are provided in Table 2. The field lead and field personnel in charge of sample handling in the field will use a sample matrix table (Table 1) as a QC check to ensure that all samples have been collected. This table includes the total number and type of sample bottles required for each analysis.

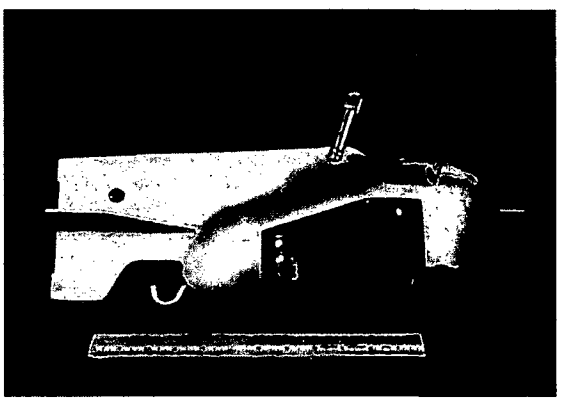
Commercially available, pre-cleaned bottles will be used for the samples, and the testing laboratory will maintain a record of certification from the suppliers. The bottle shipment documentation will include batch numbers. With this documentation, bottles can be traced to the supplier and bottle-wash analysis results can be reviewed. The bottle-wash certificate documentation will be archived in the project file.

Sample containers will be clearly labeled at the time of sampling. Labels will include the task name, sample number, sampler's initials, analysis to be performed, and sample date and time. Sample numbering and identification procedures are described in detail in Sections 3.3 and 3.4.

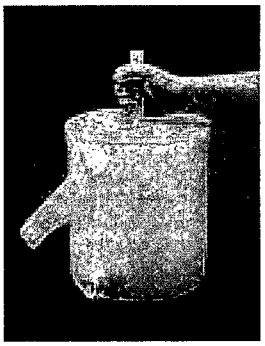
2.2.3 EWI Sampling-Specific Equipment and Supplies

In addition to the general equipment discussed above (i.e., bottles, coolers, protective wear), the EWI sampling events will be conducted using several pieces of specialized equipment, as required by USGS methods, including an isokinetic depth-integrating surface water sampler and a surface water churn sample splitter (based on anticipated suspended sediments of silt and clay-sized particles).

Isokinetic depth-integrating surface water samplers are specifically engineered with an intake nozzle and bottle housing configuration designed for collecting integrated samples over a given depth and water velocity range. The anticipated sampler for the EWI sampling described in this FSP is a DH-76 (shown below).



A churn splitter (shown below) is used for compositing raw water samples for inorganic analyses and with TSS concentrations less than 1,000 mg/L.



The design and operation of the isokinetic sampler and churn splitter will be consistent with USGS methods. Sampling methods using this equipment are summarized further below. Addition equipment information is provided in Attachment 1.

In addition to the EWI sampling equipment described above, a sampling vessel will be used for the EWI sampling activities. The sampling vessel will have navigational lights, anchors, basic sonar, and all safety equipment (i.e., personal floatation devices, whistle or horn, and fire extinguisher) as required by the U.S. Coast Guard (USCG) and Texas Parks and Wildlife (TPWD 2006). The vessel operator will be thoroughly familiar with the area of the river to be navigated and will coordinate with the USCG Vessel Traffic System and Port of Houston security notification procedures, as applicable.

2.2.4 Sample Location Positioning

The automated sampler will be installed at the Riverview Inn Marina dock (Figures 2 and 3), as previously described. This location allows collection of water samples in a relatively secure and protected location. Additionally, the dock at this location allows safe and efficient sampler access, especially during adverse weather conditions that may exist at the time of sampler maintenance.

The location of the EWI sampling transect is shown on Figure 4. This transect location was chosen because of its proximity to the automated TSS sampler location, representativeness of

the river cross section and anticipated relatively safe navigation during the rain events. Sampling will be conducted at the midpoint, as practicable, of each of the ten increments along this transect. The precise sample location in each EWI may require modification based on field conditions (i.e., debris in area, safe anchoring ability).

A differential global positioning system (DGPS) will be used to document the sample locations. The standard projection method to be used during field activities is Horizontal Datum: NAD1983_StatePlane, Texas South Central, FIPS 4204, US feet (see SOP AP-06 Navigation and Station Positioning in Attachment 1). The positioning objective is to accurately determine and record the position of the DH-76 sampler to within ±2 meters (m).

2.2.5 Automated TSS Sampler Installation, Operation and Maintenance

The automated TSS sampler will be installed, operated and maintained in accordance with manufacturer's instructions (Attachment 1). As needed[1], the automated sampler will be assembled, including new tubing and materials that will be in contact with sampled water, and secured at the desired location on the marina dock, as close to the end of the dock as practicable and considering safety of the field crew. Depending on the marina configuration, and upon concurrence with the marina owners, a dedicated 12-volt DC power supply will be provided to the sampler. In the event electrical work is required (i.e., other than connection to an outlet via standard extension cord[s]) to installed the sampler, a properly certified electrician will be contracted. The protective enclosure will also be installed at this time, also in accordance with vendor instructions.

Following installation and intake positioning at approximately mid depth, the automated sampler will be tested to ensure proper sample collection occurs. Upon verification that water samples will be collected automatically and appropriately (i.e., proper volume obtained, sample bottles filled and rotated as required), the sampler will be programmed to automatically collect one water sample every three hours. As the capacity of the sampler allows 24 one-liter bottles, the sample bottle carousel will be changed out once every three days.

[1] The automated sampler may be purchased and installed by Anchor QEA personnel or rented and installed by a qualified contractor. Regardless of installing/operating entity, the manufacturer's instructions will be followed.

Sampler maintenance will consist of regular maintenance procedures, and non-routine maintenance/trouble shooting as needed, as described in the manufacturer's instructions. Regular maintenance includes: removal of filled sample bottles, periodic cleaning of parts, and replacement of worn supplies such as intake tubing. Inspection of the automated sampler every three days, as described above, will provide a routine maintenance schedule and rapid response to any unforeseen issues. Upon initiation of the sampling effort, the sampler will be inspected daily for the first three days of operation and upon regularly-scheduled visits thereafter.

2.2.6 Automated TSS Sampling Program

As stated previously, samples will be collected every three hours for the duration of the sampling event (at least 1 month), but only selected samples will be analyzed for TSS concentration. Samples will be identified for TSS concentration analysis based on hydrologic conditions during the sampling period as follows:

- If no rain occurred during a given three-day period between sampler maintenance (based on HCOEM precipitation station 710), the twelfth water sample collected in the series will be analyzed to obtain a "baseline" TSS concentration measurement for that period.
- If at least 0.1 inch of total continuous rain occurred during a given three-day period between sampler maintenance events (based on HCOEM precipitation station 710), then the precipitation record will be analyzed and samples that were collected during the rainfall event will be submitted for TSS concentration analysis. In addition, the sample collected immediately before the onset of rainfall and all samples collected up to 12 hours after the completion of the rainfall event will be submitted for TSS concentration analysis.

It is a goal of the sampling program to collect TSS concentration data during both baseline (low-flow) and high-flow conditions. It is envisioned that at least two high-flow events will occur during the one-month deployment period. The mean flow rate in the San Jacinto River is 2,200 cfs, and high-flow events with return periods of 2, 10, and 100-years correspond to flow rates of 31,600, 107,000, and 329,000 cfs, respectively. For the purposes of this study, a high-flow event will be considered to be an event with a peak flow rate of

10,000 cfs[2] or greater. If two high-flow events do not occur during the one month period, then the sampling will be extended until the desired number of high-flow events has occurred. If the magnitude of high-flow events during the data collection period does not reflect a suitable range of conditions (as determined by the project technical team), or if baseline conditions are not reestablished between events to sufficiently identify distinct events, the data collection period may be extended on a bi-weekly basis. Once the data from the high-flow events has been processed and the data quality has been verified, collection of TSS concentration samples will be discontinued.

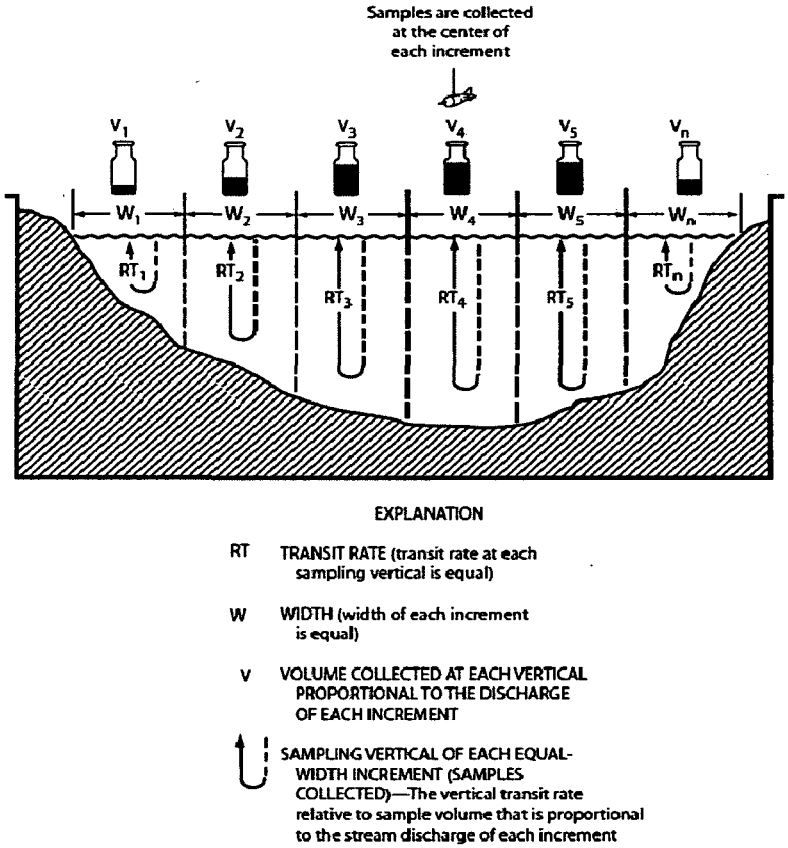
2.2.7 EWI Sampling Program

As discussed above, the EWI sampling will be conducted concurrently with the two anticipated high-flow events. This section summarizes the EWI sampling methodology. Attachment 1 provides the detailed USGS EWI sampling procedures that will be followed.

The EWI sampling study requires obtaining surface water samples at equidistant locations across the river channel, and at a specific collection rate, such that an average TSS concentration value may be obtained that is representative of the entire river channel. To accomplish this, samples are collected at equal width (as practicable) intervals along a transect constructed approximately perpendicular to river flow (Figure 4), and at a collection rate (i.e., transit time) dependent on water depth and flow at the increment of greatest discharge. By maintaining the proper transit rate at each interval, sub-samples representing the TSS concentration in each interval may be collected and composited, resulting in a depth- and flow-integrated composite sample that represents the average TSS concentration value[3] for the channel transect. The following figure from USGS 2006 illustrates the EWI concept.

[2] Flow rates will be measured during the current velocity study conducted simultaneously with the upstream sediment load study, as described in the Current Velocity Study Field Sampling Plan 2011.

[3] The EWI method is described in this FSP, consistent with USGS comments on the Fate and Transport Addendum (Anchor QEA and Integral 2010b). As described in USGS guidance, selection of either an EWI or Equal Discharge Increment (EDI) sampling approach should be based on Site characteristics. It is currently believed that a EWI approach is appropriate for the Site. However, if field or Site conditions are found contrary to this approach, the EDI method may be used. As stated in USGS guidance, the results of both and EWI and EDI sampling effort conducted on the same water body should be identical in theory. As such, EDI procedures provided in the guidance may be interchanged with the EWI approach procedures currently provided in this FSP, if warranted. Changing to an EDI approach would be discussed with USEPA prior to implementation.



The steps for conducting the EWI sampling are provided in detail in Attachment 1 and are summarized here:

- Determine equal width increments – increments should be selected to represent mean discharge in each increment and should be equal to or more than 10 in number if the waterbody is greater than 5 feet wide. The 10 EWIs are presented on Figure 4.
- Determine appropriate transit rate – the transit rate is a function of the maximum discharge interval (depth multiplied by flow rate), allowable transit rates for the remaining intervals, desired bottle fill rate and sampler used. Tables provided in Appendix A4-A of USGS 2006 provide guidance on transit time selection. The same transit rate is to be used at all intervals.
- Collect samples - maintaining the required transit rate, obtain samples at the vertical (midpoint of each interval in each interval, beginning at the vertical used to determine the overall transit rate, transferring samples to the churn splitter as needed for later compositing. Care must be taken when anchoring the sampling vessel to

avoid disturbing sediments upstream of the sampling location and artificially elevating TSS concentration in the sample.

- Composite samples – use the churn splitter to composite subsamples and generate samples (including QA/QC samples) for TSS concentration analysis.
- Prepare and pack samples for shipment, consistent with the procedures discussed above for the automated sampling program.

Detailed sampling procedures are provided in Attachment 1.

2.2.8 *Equipment Decontamination*

Based on the sampling methods, analyte (i.e., TSS concentration) and because the sampling locations are upstream of the Site, equipment decontamination is not expected to be required during this work. New sample tubing and intake screens will be used during automated sampling. The automated TSS sampler includes a rinse cycle prior to sample collection to flush the sample tubing. In the event tubing or intake screen become fouled or dirty, the tubing/screen will be replaced with new materials. With regard to the EWI sampling effort, reusable sampling equipment will be rinsed with potable water to eliminate the possibility of cross-contamination with suspended sediment. Lastly, laboratory-certified clean bottles will be used for all samples.

2.3 Field Quality Control Samples

Field QC samples will be used to assess sample variability and evaluate potential sources of analytes. The types of QC samples that will be collected are described in this section. The estimated numbers of field QC samples to be collected are listed in the sample matrix table (Table 1).

Split samples will be collected to assess the variability associated with sample processing and laboratory variability. Due to the analyte (TSS concentration) and equipment rinse/flush procedures described in the sampling methods above, additional QA/QC samples types are not warranted.

Blind field split samples will be collected at a minimum frequency of one field split (i.e., duplicate) per 20 samples. The automated sampler will be programmed to obtain duplicate sample volume as needed during the sampling program. Duplicate samples will be generated during compositing of EWI samples in the churn splitter. If QC problems are encountered, corrective actions, if appropriate, will be implemented to meet the task's data quality indicators.

2.4 Sample Packaging and Transport

Sample coolers and packing materials will be supplied by the analytical laboratories. Individual sample bottles will be labeled and placed into plastic bags and sealed. Samples will then be packed in a cooler lined with a large plastic bag. Glass bottles will be packed to prevent breakage and separated in the cooler by bubble wrap or other shock-absorbent material. The COC form will be placed into a zip-locked bag and taped to the inside lid of the cooler.

If shipped using a third-party overnight shipping service or courier[4], the shipping containers will be clearly labeled (i.e., name of task, time and date container was sealed, person sealing the cooler, company name and address) for positive identification. These packages and shipping procedures are in accordance with U.S. Department of Transportation regulations (49 CFR 173.6 and 49 CFR 173.24).

2.5 Study-Derived Waste

Contaminated waste materials or decontamination wastes are not anticipated. All disposable materials used for sample collection and processing, such as paper towels and gloves, used tubing, and other sampling materials will be placed in heavyweight garbage bags or other appropriate containers and placed in a normal refuse container.

[4] Samples are anticipated to be hand-delivered to the local laboratory.

3 FIELD DOCUMENTATION

The integrity of each sample from the time of collection to the point of data reporting will be maintained. Proper record-keeping and COC procedures will allow samples to be traced from collection to final disposition. Representative photographs will be taken of the area where samples are collected. Photos of activities and sampler setup/operation from various angles and close-up views of the overall conditions will also be collected initially and during each sampler maintenance event.

3.1 Field Logs

All field activities and observations will be recorded as described by SOP AP-02. The field log book will be a bound document and will contain individual field and sample log forms (Attachment 2). Information will include personnel, date, time, station designation, sampler, types of samples collected, and general observations. Any changes that occur during sampling (e.g., personnel, responsibilities, deviations from the FSP) and the reasons for these changes will be documented in the log book. The log book will identify on-site visitors, if any, and the number of photographs taken at each sampling location. Each field lead is responsible for ensuring that their respective field log book and all field data forms are correct. Requirements for log book entries will include the following:

- Log books will be bound, with consecutively numbered pages.
- Removal of any pages, even if illegible, will be prohibited.
- Entries will be made legibly with black (or dark) waterproof ink.
- Unbiased, accurate language will be used.
- Entries will be made while activities are in progress or as soon afterward as possible (i.e., date and time that the notation is made should be recorded, as well as the time of the observation itself).
- Each consecutive day's first entry will be made on a new, blank page.
- The date and time, based on a 24-hour clock (e.g., 0900 for 9:00 a.m., 2100 for 9:00 p.m.) will appear on each page.

In addition to the preceding requirements, the person recording the information must initial and date each page of the field log book. If more than one individual makes entries on the

same page, each recorder must initial and date each entry. The bottom of the page must be signed and dated by the individual who made the last entry.

Log book corrections will be made by drawing a single line through the original entry, allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation.

The type of information that may be included in the field log book and/or surface sediment collection field data forms includes the following:

- Task name, task location, and task number
- Task start date and end date
- Weather conditions
- Name of person making entries and other field staff
- On-site visitors, if any
- Sampling vessel, if any
- Station number and location
- Date and time of each sample collection event
- The sample number for each sample to be submitted for laboratory analysis
- The specific date and time with corresponding station number associated with the sampling location coordinates derived from the DGPS
- Specific information on each type of sampling activity
- The sample number, date and time of collection, equipment type, and the lot number for the box of filter papers used for field QC samples
- Observations made during sample collection, including water depth, weather conditions, complications, and other details associated with the sampling effort
- Sample description (source and appearance, such as sediment type, color, presence of anthropogenic material, and presence and type of biological structures, other debris, oil sheens, and odor)
- Any visible debris near any of the sampling locations
- Any surface vegetation that is removed from the sampling location prior to sampling
- The number of photographs taken at each sampling location
- A record of Site health and safety meetings, updates, and related monitoring
- Any deviation from the FSP and reasons for deviation.

Copies of sample collection forms are provided in Attachment 2. All log books must be completed at the time that any observations are made. Copies of all log books and forms will be retained by the technical team.

3.2 Chain-of-Custody Procedures

Samples are in custody if they are in the custodian's view, stored in a secure place with restricted access, or placed in a container secured with custody seals. A COC record will be signed by each person who has custody of the samples and will accompany the samples at all times. Copies of the COC will be included in the laboratory QA/QC reports.

At a minimum, the COC form will include the following information:

- Site name
- Field lead's name and team members responsible for collection of the listed samples
- Collection date and time for each sample
- Sample type (i.e., sample for immediate analysis or archive)
- Number of sample containers shipped
- Requested analyses
- Sample preservation information (if any)
- Name of the carrier relinquishing the samples to the transporter, noting date and time of transfer, and the designated sample custodian at the receiving facility

Anchor QEA's field lead (or delegate) will be the designated field sample custodian for their respective sampling events and will be responsible for all sample tracking and COC procedures for the samples that their respective teams collected in the field. The field sample custodian will be responsible for final sample inventory and will maintain sample custody documentation. The field sample custodian will complete COC forms prior to removing samples from the field. Upon transferring samples to the laboratory sample custodian (if a local laboratory is selected) or shipping courier (as appropriate), the field sample custodian will sign, date, and note the time of transfer on the COC form. The original COC form will be transported with the samples to the laboratories. All samples will be shipped to the testing laboratories in either coolers or shipping containers sealed with custody seals.

Each laboratory will designate a sample custodian who will be responsible for receiving samples and documenting their progress through the laboratory analytical process. The sample custodian for each laboratory will establish the integrity of the custody seals upon sample arrival at the laboratory. The laboratory sample custodian will also ensure that the COC and sample tracking forms are properly completed, signed, and initialed upon receipt of the samples.

When the laboratory receives the samples, the laboratory sample custodian will conduct an inventory by comparing sample labels to those on the COC document. The custodian will enter the sample number into a laboratory tracking system by task code and sample designation. The custodian will assign a unique laboratory number to each sample and will be responsible for distributing the samples to the appropriate analyst or for storing samples at the correct temperature in an appropriate secure area.

3.3 Station Numbering

The sampling locations will be assigned a unique identification code based on a designation scheme designed to suit the needs of the field personnel, data management, and data users. Station numbers will include "SJ" to indicate San Jacinto followed by "USL" to indicate the Upstream Sediment Load Study, followed by a three-digit number (e.g., 001, 002). The station numbers will increase as the stations move upstream. The station numbers for this sampling effort will be SJUSL001 for the location of the automated TSS sampler. Locations along the EWI transect will follow this numbering convention, beginning with SJUSL002.

3.4 Sample Identifiers

A sample identifier for each water sample will be created as follows: the station number (e.g., SJUSL001), followed by a two-letter code for the kind of sample collected at a given location (AS = automated sampler, TS = transect sample), followed by a sequential number. This will then be followed by a one letter code designating if the sample collected was a duplicate or normal sample (D = duplicate, N = normal). Example identifiers for the surface water samples would be SJUSL001-AS001-N and SJUSL001-AS001-D.

4 FIELD DATA MANAGEMENT AND REPORTING PROCEDURES

During field operations, effective data management is critical to providing consistent, accurate, and defensible data and data products. Field data management will be performed as described in the Sediment SAP, and in Section 6.2 of Appendix A of the RI/FS Work Plan. Daily field records (a combination of field log books, field forms, if any, and COC forms) will make up the main documentation for field activities. Upon completion of sampling, field notes, data sheets (if any), and COC forms will be scanned to create an electronic record. Field data will be manually entered into the project database. One hundred percent of the transferred data will be verified based on hard copy records. Electronic QA checks to identify anomalous values will also be conducted following entry.

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pharmaceutical, and antibiotic compounds," 5.6.4.A, "Arsenic speciation," and 5.6.4.B, "Low-level Mercury" are provided on the Web page.)

TABLES

Table 1
Surface Water Sampling Matrix

Station ID	Sample ID	Sample Type	Coordinates[a,b]		Sample Matrix	Total Suspended Solids
			X	Y		1L HDPE/EPA 160.2
SJUSL001	SJUSL001-ASxxx-N[c]	Automated Sampler	3211766.53	13858936.16	Water	X
SJUSL002	SJUSL002-EWI00x[d]-N	EWI Sampling Event	3211783.72	13859160.36	Water	X
SJUSL003	SJUSL003-EWI00x-N	EWI Sampling Event	3211818.09	13859608.78	Water	X
SJUSL004	SJUSL004-EWI00x-N	EWI Sampling Event	3211852.46	13860057.19	Water	X
SJUSL005	SJUSL005-EWI00x-N	EWI Sampling Event	3211886.83	13860505.61	Water	X
SJUSL006	SJUSL006-EWI00x-N	EWI Sampling Event	3211921.21	13860954.03	Water	X
SJUSL007	SJUSL007-EWI00x-N	EWI Sampling Event	3211955.58	13861402.44	Water	X
SJUSL008	SJUSL008-EWI00x-N	EWI Sampling Event	3211989.95	13861850.86	Water	X
SJUSL009	SJUSL009-EWI00x-N	EWI Sampling Event	3212024.32	13862299.28	Water	X
SJUSL010	SJUSL010-EWI00x-N	EWI Sampling Event	3212058.69	13862747.69	Water	X
SJUSL011	SJUSL011-EWI00x-N	EWI Sampling Event	3212093.07	13863196.11	Water	X
SJUSLxxx	SJUSLxxx-xxxxx(x)-D		TBD	TBD	Water	X

Notes:

AS = Automated Sampler

EWI = Equal Width Increment

[a]NAD 1983; State Plane Texas South Central FIPS 4204; US feet

[b]Coordinates provided correspond to proposed station locations on Figure 4.
Coordinates for actual station locations will be recorded in the field.

[c]Multiple samples will be collected by the automated sampler, depending on baseline and high-flow event occurrence.

[d]Two EWI sampling events are anticipated. This numerical variable will be "1" or "2", depending on event.

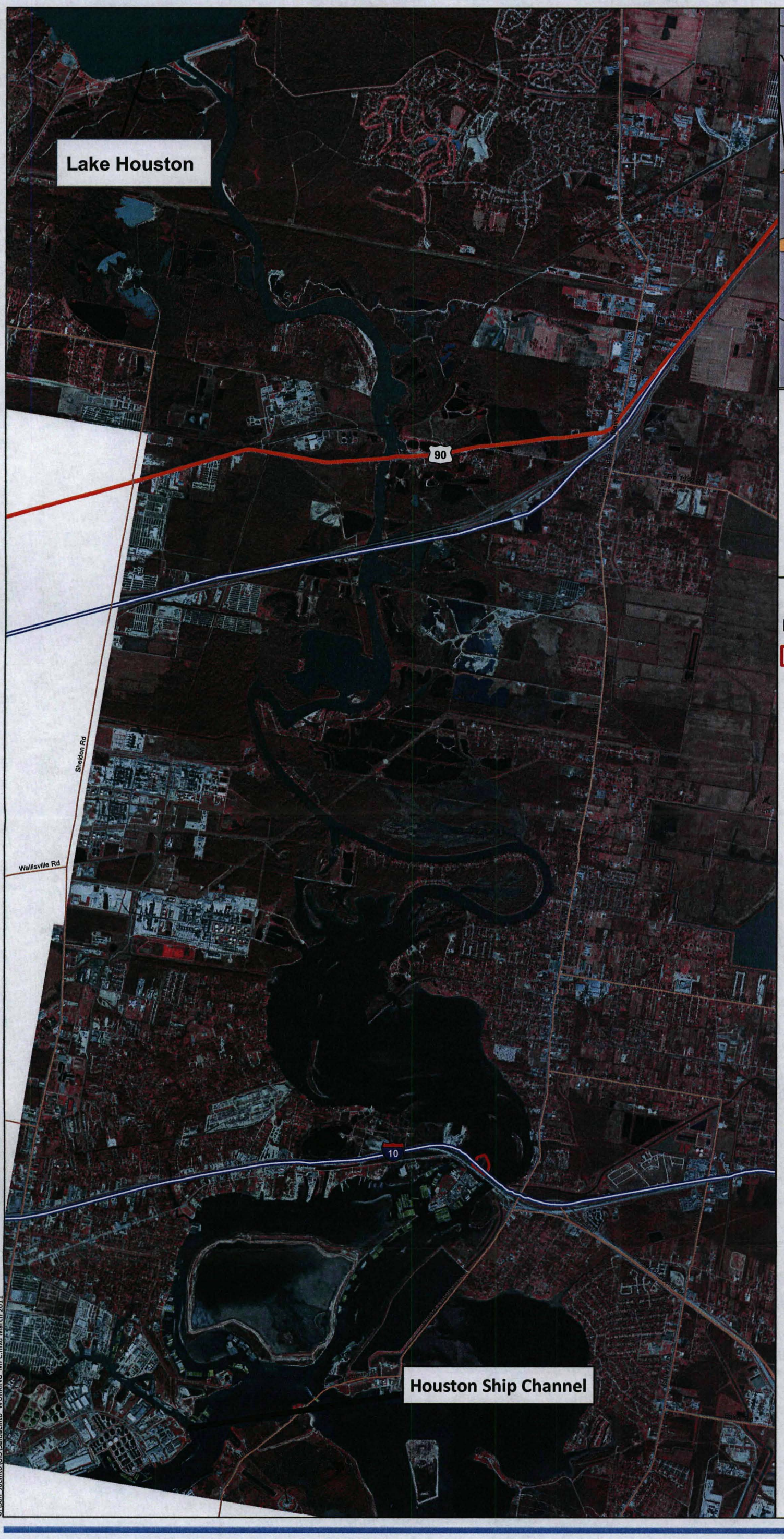
[e]Duplicate samples will be submitted based on number of samples collected and at a 1/20 ratio.

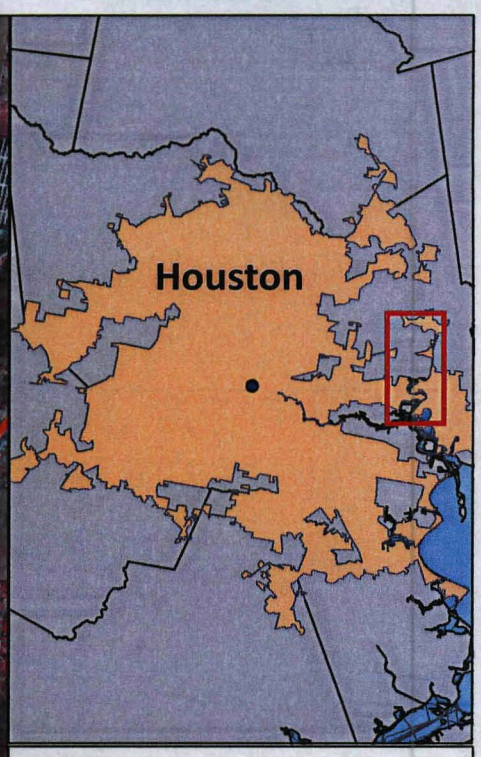
Table 2

Sample Containers, Preservation, and Holding Time Requirements

Parameter	Sample Size	Container Size and Type	Laboratory Method	Holding Time	Sample Preservation Technique
Total Suspended Solids (TSS)	1 liter	HDPE	EPA 160.2	7 days	None

FIGURES





NOTES:

Legend

Original (1966) Impoundments Perimeter

G:\San_Jacinto\GIS\SanJacinto_WORKING_MPC.mxd March 2011

ANCHOR QEA

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Miles
0 0.6 1.2

Figure 1

Site Map

Upstream Sediment Load Field Sampling Plan

SJRWP Superfund/MIMC and IPC

SOURCE: Aerial photograph from Bing Maps 2010.

NOTES: All locations are approximate.

LEGEND:

Automated Sampler Location

0 800'

Approximate Scale in Feet

H:\Syracuse1\Jobs\090557-San Jacinto\090557-01 - San Jacinto\09055701-RP-083.dwg Figure 2

Mar 03, 2011 1:46pm dwodarczyk

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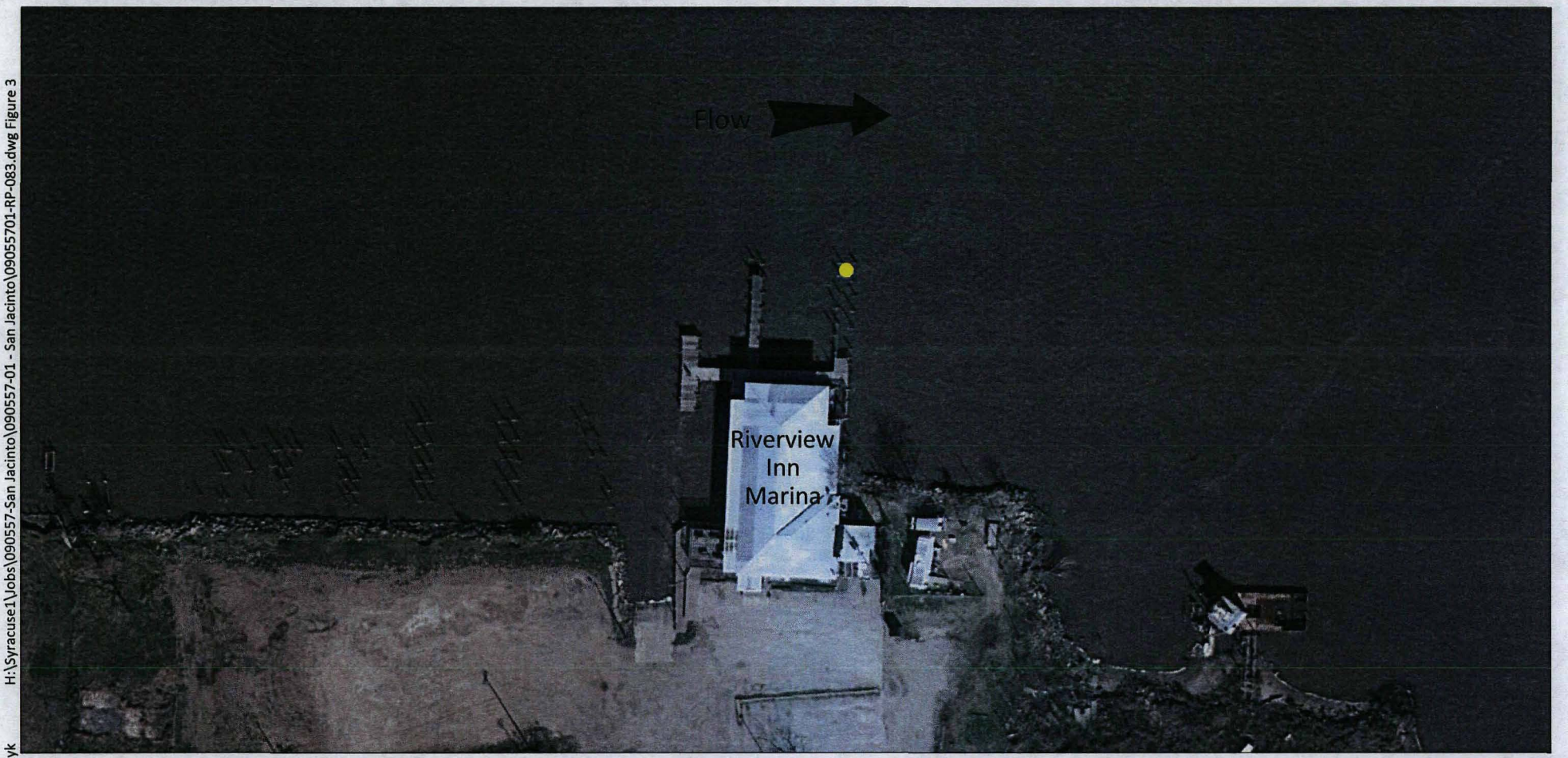
Figure 2

Automated Sampler Location

Upstream Sediment Load Study Field Sampling Plan

SJRWP Superfund Site/MIMC and IP



SOURCE: Aerial photograph from Google Earth 2010.

NOTES:
1. All locations are approximate.
2. Decking currently present on all docks.

LEGEND:

Automated Sampler Location

0 100'

Approximate Scale in Feet

H:\Syracuse1\Jobs\090557-San Jacinto\090557-01 - San Jacinto\090557701-RP-083.dwg Figure 3

Mar 03, 2011 1:45pm dwodarczyk

ANCHOR QEA

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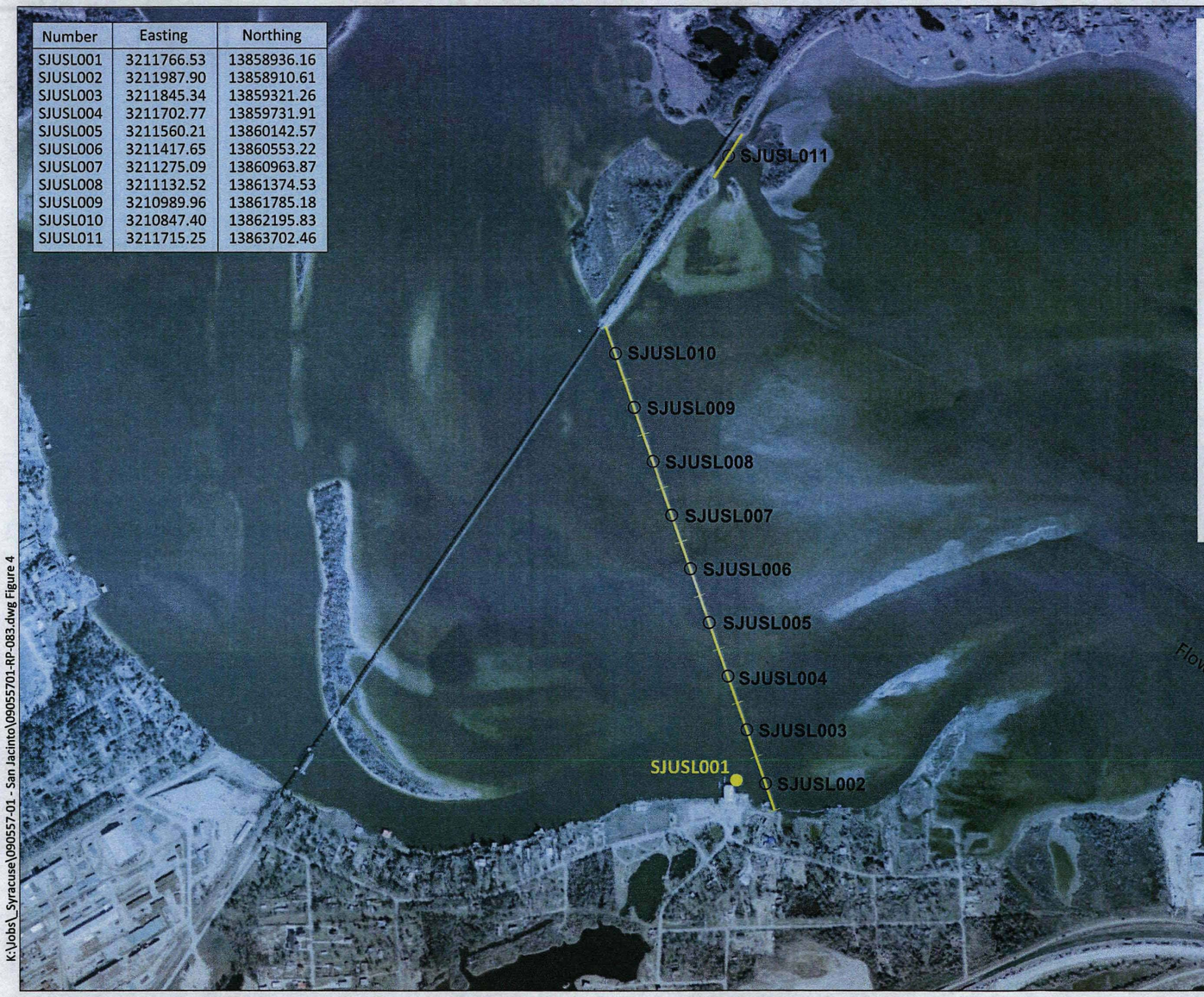
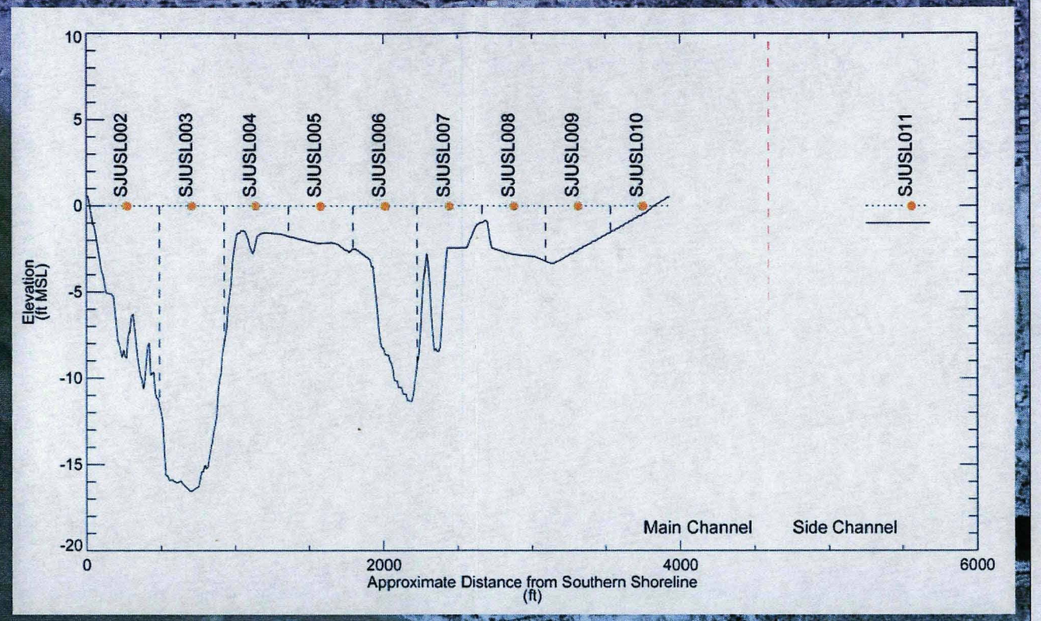
Figure 3
Automated Sampler Location Detail
Upstream Sediment Load Study Field Sampling Plan
SJRWP Superfund Site/MIMC and IP

Number	Easting	Northing
SJUSL001	3211766.53	13858936.16
SJUSL002	3211987.90	13858910.61
SJUSL003	3211845.34	13859321.26
SJUSL004	3211702.77	13859731.91
SJUSL005	3211560.21	13860142.57
SJUSL006	3211417.65	13860553.22
SJUSL007	3211275.09	13860963.87
SJUSL008	3211132.52	13861374.53
SJUSL009	3210989.96	13861785.18
SJUSL010	3210847.40	13862195.83
SJUSL011	3211715.25	13863702.46





K:\Jobs_Syracuse\090557-01 - San Jacinto\090555701-RP-083.dwg Figure 4

Mar 04, 2011 2:02pm ghowell

SOURCE: Aerial photograph from Google Earth, 2009.
HORIZONTAL DATUM: Texas South Central NAD 83, US Survey Feet.
VERTICAL DATUM: NAVD 88.

NOTES: All locations are approximate.

LEGEND:

SJUSL001 Automated sampler Location

Proposed EWI Transect

SJUSL002 Proposed EWI Sample Location

0 1500
Scale in Feet

ANCHOR QEA

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Figure 4
EWI Transect Location
Upstream Sediment Load Study Field Sampling Plan
SJRWP Superfund Site/MIMC and IP

ATTACHMENT 1

STANDARD OPERATING PROCEDURES AND EQUIPMENT DATA SHEETS

6712 Portable Samplers

Installation and Operation Guide

TELEDYNE ISCO
A Teledyne Technologies Company

Part #69-9003-588 of Assembly #60-9004-334
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Revision AA, May 14, 2010

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

Contact Information

Customer Service

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Fax:	(402) 465-3022	
Email:	IscoCSR@teledyne.com	

Technical Support

Phone:	(800) 775-2965	(Analytical)
	(866) 298-6174	(Samplers and Flow Meters)
Email:	IscoService@teledyne.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	

Other Correspondence

Mail to:	P.O. Box 82531, Lincoln, NE 68501-2531
Email:	IscoInfo@teledyne.com
Web site:	www.isco.com

Revised March 17, 2009

General Warnings

Before installing, operating, or maintaining this equipment, it is imperative that all hazards and preventive measures are fully understood. While specific hazards may vary according to location and application, take heed in the following general warnings:

⚠ WARNING

This instrument has not been certified for use in "hazardous locations" as defined by the National Electrical Code.

⚠ WARNING

Avoid hazardous practices! If you use this instrument in any way not specified in this manual, the protection provided by the instrument may be impaired; this will increase your risk of injury.

⚠ AVERTISSEMENT

Éviter les usages périlleux! Si vous utilisez cet instrument d'une manière autre que celles qui sont specifiées dans ce manuel, la protection fournie de l'instrument peut être affaiblie; cela augmentera votre risque de blessure.

This product is often installed in confined spaces. Some examples of confined spaces are manholes, pipelines, digesters, and storage tanks. These spaces may become hazardous environments that can prove fatal for those unprepared. These spaces are governed by OSHA 1910.146 and require a permit before entering.

Hazard Severity Levels

This manual applies *Hazard Severity Levels* to the safety alerts, These three levels are described in the following sample alerts.

⚠ CAUTION

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

⚠ WARNING

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

⚠ DANGER

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

Hazard Symbols

The equipment and this manual use symbols used to warn of hazards. The symbols are explained below.

Hazard Symbols	
Warnings and Cautions	
	The exclamation point within the triangle is a warning sign alerting you of important instructions in the instrument's technical reference manual.
	The lightning flash and arrowhead within the triangle is a warning sign alerting you of "dangerous voltage" inside the product.
	Pinch point. These symbols warn you that your fingers or hands will be seriously injured if you place them between the moving parts of the mechanism near these symbols.
Symboles de sécurité	
	Ce symbole signale l'existence d'instructions importantes relatives au produit dans ce manuel.
	Ce symbole signale la présence d'un danger d'électocution.
	Risque de pincement. Ces symboles vous avertit que les mains ou les doigts seront blessés sérieusement si vous les mettez entre les éléments en mouvement du mécanisme près de ces symboles
Warnungen und Vorsichtshinweise	
	Das Ausrufezeichen in Dreieck ist ein Warnzeichen, das Sie darauf aufmerksam macht, daß wichtige Anleitungen zu diesem Handbuch gehören.
	Der gepfeilte Blitz im Dreieck ist ein Warnzeichen, das Sei vor "gefährlichen Spannungen" im Inneren des Produkts warnt.
	Vorsicht Quetschgefahr! Dieses Symbol warnt vor einer unmittelbar drohenden Verletzungsgefahr für Finger und Hände, wenn diese zwischen die beweglichen Teile des gekennzeichneten Gerätes geraten.

6712 Portable Sampler

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6712 Portable Sampler

Section 1 Introduction

The 6712 Series Samplers are an integral part of Teledyne Isco's comprehensive sampling system. The system includes the 6712 Compact Sampler, the 6712 Standard Sampler and the 6712FR and 6712SR Refrigerated Samplers.

6712 Controller

The 6712 portable samplers are easily moved from site to site. Constructed from durable, corrosion-resistant materials, the samplers withstand the hostile environments of industrial and municipal monitoring sites.

The 6712 Compact differs from the 6712 Standard Sampler only in size and sampling capacity. Both samplers use the same controller and sample-delivery system. Both instruments accept a variety of composite and multiple bottle kits. Because the 6712 Compact and Standard Samplers share many features, this manual includes programming, operation, and maintenance information for both instruments. Except where specifically noted, the contents of this manual apply to both units.

1.1 About this Manual

This manual contains the information you will need to install, program, operate, and maintain a 6712 portable sampler. There are seven sections and five appendices:

- *Section 1, Introduction* lists the features and specifications of the 6712 portable samplers.
- *Section 2, Installation/Preparation* steps you through installing the sampler and preparing it for use.
- *Section 3, Getting Started* describes features that are common to both standard and extended programming modes.
- *Section 4, Standard Programming* shows how to program your sampler using standard programming mode.
- *Section 5, Extended Programming* shows how to program your sampler using extended programming mode.
- *Section 6, SDI-12 Sondes* provides information on setting up sondes to work with the 6712.
- *Section 7, Remote Operation* explains how the 6712 controller can be operated remotely from external devices.
- *Section 8, Maintenance* covers the basic maintenance required to keep your sampler in top operating condition.

The appendices are:

- *Appendix A, Menu Flowcharts*
- *Appendix B, Material Safety Data Sheets*
- *Appendix C, General Safety Procedures*
- *Appendix D, Replacement Parts*
- *Appendix E, Accessories List*

1.2 About 700 Series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. The 700 Series includes:

- 701 pH Parameter Module for monitoring pH and temperature.
- 710 Ultrasonic Module for monitoring a flow stream's level and flow rate with an ultrasonic level sensor.
- 720 Submerged Probe Module for monitoring a flow stream's level and flow rate with a submerged probe.
- 730 Bubbler Flow Module for monitoring a flow stream's level and flow rate with a bubbler system.
- 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate.
- 780 4-20mA Input Module for interfacing to non-Teledyne Isco devices with 4 to 20 milliampere output signals.

The modules are optional accessories. The samplers do not require them for operation. However, the modules offer a number of advantages: they are an economical way to combine flow-rate or parameter monitoring with sampling, and you can program the samplers and modules as a single unit. Finally, the samplers store the readings in memory.

1.3 SDI-12 Sondes

As an option, the sampler accepts up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9 (refer to SDI-12 Sonde Readings, page 1-11, for specific parameters).

The data parameters used by the sensing device (sonde) and recording device (sampler) must match. Certain vendors' sondes have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure. Other sondes can be used, but require manual setup to identify proper data types for each data value reported.

1.4 Memory to Store Monitoring Data

The samplers contain enough memory to store five sampling programs, sampling data, Teledyne Isco 700 Series Module readings, and SDI-12 parameter readings. You can view the readings on your sampler's display.

You can also retrieve the readings and reports so the information can be processed on a personal computer. Readings and reports may be collected with a computer running Teledyne Isco's Flowlink® software. Flowlink can download the information through a direct connection, a modem connection (when the

sampler is equipped with the optional 4200T dial-out modem or connected to the optional digital cellular modem), or from a 581 Rapid Transfer Device (RTD). The RTD is a quick and simple way to transfer the data from the field to your computer. Reports are easily collected with Teledyne Isco's Samplink software.

1.5 Pump Requirements

The sampler's peristaltic pump is extremely powerful. This pump requires a high capacity power source such as Teledyne Isco's model 913 or 923 power pack. Older model power packs do not provide the needed power. A list of recommended power packs and batteries can be found in *Installing a Power Source* on page 2-9.

The pump also requires a pump tube made specifically for the 6712 and 6700 Series samplers. These pump tubes are easily recognized by their blue alignment collars. The 6712 pump tubing is the same as that for Teledyne Isco's 6700 Series samplers, but different from Teledyne Isco's earlier model samplers, such as the 3700 Series. Other types of pump tubing will not work in the 6712. Refer to *Replacing the Pump Tube* on page 8-8.

⚠ CAUTION

This sampler has a high performance pump. As with all such pumps, it relies upon liquid to cool working components. If the sampler is programmed to pump in the absence of liquid in excess of 5 minutes, excessive heat buildup may damage the paddles, rollers, and housing. Ensure that the liquid inlet is completely immersed.

Table 1-1 6712 Standard and Compact Sampler Features

General Features	
Top Cover	• Protects pump, power source, and controller. • Lockable latches.
Controller	• Contains a rechargeable desiccant to prevent moisture damage to the electronics, pump, and distributor systems. • Control panel sloped 15 degrees for easy reading. • Keys labeled with large, vivid icons. • 80-character display (4 lines by 20 columns). • Display has selectable backlight: Always on or always off. Timed, switching off when keypad is inactive for 60 seconds. • Memory for program and data storage. • Flash memory for easy software upgrades. • NEMA 4X and 6 (IP67) ratings.
Center Section	• Secured to tub with lockable latches. • Large handles.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Adjustable Distributor Arm	• A single distributor arm adjusts quickly to fit all bottle kits. Easily removed for composite sampling.
Discharge Tube and Support Spring	• Routes sample liquid from pump tube, through distributor arm to sample bottle.
Composite Tube Guide for Composite Sampling	• Keeps discharge tube in place over composite bottles.
Tub	• Large, comfortable handles. • Both compact and standard samplers accept a variety of bottle kits. • **Compact Tubs Only**: Removable bottle-carrier insert. • **Standard Tubs Only**: Tub drain. • Optional five gallon bottle base: fits the standard sampler
Compatible Teledyne Isco Products	• 581 Rapid Transfer Device • 1640 Liquid Level Actuator • 674 Rain Gauge • 2100 Series Flow Modules • 700 Series Modules • 4100 Series Flow Loggers • SDI-12 Sondes • 4200 Series Flow Meters • Refrigerator Temperature Sensor • Flowlink, Samplink
Real-Time Displays	As the sampler runs a sampling program, it displays the program's status. The status display may include such information as the time of the next sample, the number of the next bottle, or whether the sampler is disabled or stopped. If the sampler encounters an error while running the program, it displays a message alerting you to the problem.
Programming for Modules	Program the modules from the sampler's control panel. The module's program settings become part of the sampling program.
Setup for SDI-12 Sondes	Calibrate and program SDI-12 sondes from the sampler's control panel. The program settings become part of the sampling program. See Section 6.
Memory for Stored Programs and Readings	512 kilobytes of battery-backed RAM (Random Access Memory), to store: • Five sampling programs. • A sampling report from the most recently run program. It records as many as 1000 sampling events; events can be the program start time, enable time, sample event information, etc. • 700 Series module readings. The readings can be: level, flow rate, velocity, pH, temperature, or the data collected by the 4-20 mA module. • Rain gauge and refrigerator temperature readings. • SDI-12 sonde readings.
Five Reports Available	• The Program Settings report, listing current program settings. • The Sampling Results report, listing the events occurring during the program. • The Combined Results report, combining sampling events with readings from a rain gauge, module, or SDI -12 sonde. • The Module Summary report, summarizing flow rate or parameter readings. • The Rainfall Summary report, listing a summary of rainfall readings.
Serial Data Output	• ASCII data output from the interrogator port.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Units of Measure	A variety of metric and English units of measure for length, flow rate, flow volume, and temperature.
External Sampler Enable	Teledyne Isco flow meters and flow loggers have a programmable sampler enable feature that lets them send an electronic signal to a 6712 that enables (starts) or disables (stops) a running sampling program.
Dual Sampler Mode	Dual Sampler Mode operates two samplers.
Command Driven Operation	• Operate sampler functions using RS-232 communications.
Warning Messages	• Pump Tube Warning. The 6712 displays a warning to inspect the tube. • Internal Battery Warning. From the Maintenance screen, the 6712 displays a warning when it is time to replace the internal battery. The internal battery preserves stored data when the 6712 is without external power.
Optional Dialout 4200T Modem	The 6712 controller can be ordered with a factory-installed 2400 baud dialout modem. With the modem you can: • connect to the sampler and download data using Flowlink software. • program the sampler to call a contact list when an “alarm” condition exists. • use the Remote Commands to control the sampler’s operation from a remote location.
On-Line Help Notes	When programming the sampler, press the [?] (Help) key for a brief help note. All help topics appear in the index.
Two Programming Levels	Standard programming lets you set up typical sampling programs quickly. Extended programming includes all features available in standard programming plus additional features.
Sample Delivery System Features	
Peristaltic Pump	• **Benefits**: Liquid moves continuously under pumped flow. The pump has no metering chambers or gravity fed internal tubing to trap sediment or residual liquid. Sample liquid contacts only the strainer, suction line, tube coupling, pump tube, bulkhead fitting, and sample bottles.
LD90 Liquid Detector	• **Non wetted Detection**: Sample liquid never touches the detector.
Two Line Purges in Sampling Cycle	The sampling cycle always includes a pre-sample purge and post-sample purge that clears the suction line of residual liquid.
Easy Grab Samples	Simply disconnect the pump tube from the bulkhead fitting on the center section, and place the pump tube over your sample container.
Vinyl and PTFE® Suction Lines	• 3/8-inch ID (Inside Diameter) vinyl line. • 3/8-inch ID PTFE lined with polyethylene jacket.
Standard Programming Features	
Pacing	• **Uniform Time Pacing**: Sampling at regular time intervals. • **Flow Pacing**: Sampling at regular flow-volume intervals.
Distribution Methods	• **Composite**: Samples deposited in a single large bottle. • **Sequential**: Only one sample placed in each bottle. • **Samples Per Bottle**: Multiple samples placed in each bottle. • **Bottles Per Sample**: One sample deposited in multiple bottles.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Three Flexible Start-Time Settings	• **Start Immediately**: Starts the sampling program immediately. • **Delayed Start**: Starts the sampling program after a user-definable delay of 1 to 999 minutes. • **Clock Time**: Starts the sampling program at a user-definable time on one or more days of the week.
Option for a Continuous Running Program	• **Continuous Sampling**: When sample bottles are regularly replaced, the sample distribution can restart with the first bottle set after the last bottle set is filled, without interrupting the running program.
Extended Programming Features	
Pacing	• **Uniform Time Pacing**: Sampling at regular time intervals. • **Nonuniform Time Pacing**: Sampling at irregular time intervals. • **Random Interval Pacing**: Sampling at unique random time intervals generated by the controller. • **Flow Pacing**: Sampling at regular flow-volume intervals. • **Event Pacing**: Sampling each time a user-definable event occurs.
Flow Proportional Sample Volumes	Allows for sample sizes to be based on flow. (This option is available only with uniform time pacing.)
Distribution Methods	• **Composite**: Samples deposited in a single large bottle. • **Sequential**: Only one sample placed in each bottle. • **Samples Per Bottle**: Multiple samples placed in each bottle • **Bottles Per Sample**: One sample deposited in multiple bottles • **Multiple Bottle Compositing**: A combination of samples per bottle and bottles per sample distribution methods. • **Time Switched Bottles or Bottle sets**: Control the sample distribution using clock times.
Programmable Sampler Enable	A 6712 sampler can be programmed to enable or disable a running sampling program when readings received from a connected rain gauge, module, or SDI-12 Sonde meet certain conditions.
Pauses and Resumes	Create intermittent sampling schedules.
Two-Part Programming	Two-part programming lets you set up a sampling program that divides the bottles into two groups, filling each group according to separate pacing, distribution, sampler enable, and pause and resume settings. This is ideal for storm-water run-off sampling.
Auto Suction Head or Fixed Suction Head	The suction head, is the vertical distance from the flow stream to the liquid detector. Extended programming has two settings. • **Auto-Suction Head**: The head is automatically determined. • **Fixed Suction Head**: A user-definable measurement for the head.
Suction Line Rinses	Program setting for the number of times (0 to 3) that the 6712 rinses the suction line before drawing a sample.
Sampling Retries	Program setting for the number of times (0 to 3) that the 6712 attempts to sample if it fails to deliver the entire sample volume.

Table 1-1 6712 Standard and Compact Sampler Features (Continued)	
Three Flexible Start Time Settings	• **Run Immediately**: Starts the sampling program immediately. • **Delayed Start**: Starts the sampling program after a user-definable delay of 1 to 999 minutes. • **Clock Time**: Starts the sampling program at a user-definable time on one or more days of the week.
Option for a Continuous Running Program	**Continuous Sampling**: When sample bottles are regularly replaced, the sample distribution can restart with the first bottle set after the last bottle set is filled, without interrupting the running program.

Table 1-2 6712 Standard and Compact Sampler Construction Materials	
Item	**Material**
Top Cover **Center Section** **Tubs** **Bottle Inserts** **Plastic Retaining Rings** **Bottle Carriers**	ABS (Acrylonitrile Butadiene Styrene) plastic
Bottle Rack	Powder coated steel
Controller Case **Distributor Arm**	Noryl®
Distributor Arm Nut **Pump Rollers**	Delrin®
Control Panel **Connector Labels**	Polyester
Distributor Shaft **Pump Shaft** **Pump Paddles** **Pump Band** **Bulkhead Fitting** **Latches** **Handles** **Metal Retaining Rings**	Stainless steel
Power-Source Draw Catches:	EPDM (Ethylene Propylene Diene Monomer) rubber
Amphenol Connectors	Cadmium Plated Aluminum
Retaining Ring Draw Cords (inside standard tub)	Polypropylene jacketed rubber with stainless steel clip
Retaining Ring Tie-Down (inside standard tub)	Iridited® aluminum

Table 1-2 6712 Standard and Compact Sampler Construction Materials (Continued)	
Drain Plug **(standard tub only)**	CPVC with polypropylene retaining strap
Webbing for Compact Bottle Carriers	Polypropylene.

Table 1-3 Technical Specifications for the 6712C and Standard Samplers	
General Notes: 1. All weights may vary ±1 lb (±1/2 kg). 2. All dimensions may vary ±1/4 inch (±0.64 cm). 3. Sample delivery specifications valid for the following conditions and ranges, unless otherwise stated: 75 °F (24 °C) ambient, sample liquid–tap water at 50 to 80 °F (10 to 27 °C), sample volumes from 50 ml to 1000 ml, suction line lengths of 25 ft (7.6 m) or less, suction heads from 1 to 20 ft (0.3 to 6.1 m), atmospheric pressure between 29.92 and 31.89 inHg (760 and 810 mmHg), and a power source of a Teledyne Isco High Capacity Power Pack at 12.5 volts DC no load output.	
6712 Controller, Pump, and Tubing: Mechanical Specifications	
Weight of Controller:	Controller only: 13.0 lbs (5.9 kg) With pump tube: 13.2 lbs (6.0 kg)
Weight of Nickel Cadmium Battery:	4.3 lbs (2.0 kg)
Weight of Lead Acid Battery:	5.7 lbs (2.6 kg)
Weight of Power Pack:	6.0 lbs (2.7 kg)
Weight of Battery Backed Power Pack:	6.6 lbs (3.0 kg)
Controller Dimensions:	Length: 10.3 in (26.0 cm) Width: 12.5 in (31.7 cm) Height: 10 in (25.4 cm)
Temperature Ranges:	Operational: 32 to 120 °F (0 to 49 °C) Storage: 0 to 140 °F (–18 to 60 °C)
Maximum Altitude:	2,000 Meters
Installation Category:	II
Pollution Degree:	2
Humidity:	95% RH Maximum
Enclosure:	NEMA 4X and 6 Pump: IP17 Enclosure: IP67
Typical Delivered Volume Accuracy:	(The ability to deliver the programmed sample volume.) ±10 ml or ±10% of programmed value, whichever is greater.
Typical Repeatability:	(The ability to repeat the delivered volume for a set of samples collected under the same conditions.) ±5 ml or ±5% of the average of the maximum and minimum sample volume in a sample set, whichever is greater, at lifts up to 25 feet.

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Typical Pump Flow Rate and Line Transport Velocity:	Suction Head	Flow Rate	Line Transport Velocity
	3 feet	3.9 liters per minute	3.0 ft/s (0.91 m/s)
	5 feet	3.9 liters per minute	3.0 ft/s (0.90 m/s)
	10 feet	3.7 liters per minute	2.9 ft/s (0.87 m/s)
	15 feet	3.6 liters per minute	2.7 ft/s (0.83 m/s)
	20 feet	3.3 liters per minute	2.5 ft/s (0.77 m/s)
	23 feet	3.1 liters per minute	2.3 ft/s (0.71 m/s)
	25 feet	2.8 liters per minute	2.2 ft/s (0.66 m/s)
Maximum Suction Head:	(The maximum suction head is the vertical height at which a sample can be taken.) 28 ft (8.5 m) at 30 inHg (762 mmHg)		
Pump Tube Life:	Tube life may vary depending on the abrasiveness of the sample liquid. Recommended maximum 1,000,000 pump counts. This equates to 912 standard samples. A standard sample is 200 ml at 5 ft (1.5 m) suction head using a 10 ft (3 m) vinyl suction line.		
6712 Controller: Electrical Specifications			
Controller Internal Battery:	5 years minimum (maintains internal logic, program settings & stored data)		
Real Time Clock Accuracy:	1 minute per month		
Program Memory:	Nonvolatile programmable Flash. Can be field updated via interrogator connector.		
Sampler Power Requirements:	Nominal: 12 volts DC by battery or AC power converter Operational: 11 to 13 Volts DC Absolute Maximum: 14.4 Volts DC		
Power Pack Requirements: Use only Teledyne Isco-made power packs certified by UL. (P/N 60-1684-088)	120VAC ±12VAC, 60 Hz., 1.0 Amp. Note: This is the **only** version certified by UL. The line cord (mains connect cable) is the "Disconnect Device."		
Power Pack Requirements: (Use only Teledyne Isco-made CE certified power packs. (P/N 60-3004-190)	230VAC ±23VAC, 2.0 Amp, 50/60 Hz. Note: The line cord (mains connect cable) is the "Disconnect Device."		
Power Consumption[a]			
6712 Controller in Standby			10 mA
Average Current of Accessories			
Controller Display Backlight			228 mA
701 pH Module[b]			11 mA
710 Ultrasonic Module[b]			11 mA
720 Submerged Probe Module[b]			11 mA
730 Bubbler Module[b] — at 2 ft of liquid level — at 10 ft of liquid level			 24 mA 31 mA
750 Area Velocity Module[b]			12 mA
780 4-20 mA Module[b]			10 mA
YSI 600 with pH, DO, Conductivity, and Temperature[b]			11 mA

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Programmable Analog 4-20 mA Output Option[c]	124 mA
CDMA cellular telephone modem — standby current — current while communicating	 35 mA 150 mA
GSM cellular telephone modem — standby current — current while communicating	 62 mA 230 mA

a. Current ratings when input power is 12.5 VDC and ambient temperature is 77 °F (25 °C)

b. Average current when programmed to take readings at 15 minute intervals.

c. Rating for three outputs.

Sampler Only Operating Current:	Approximately 30 mA based on 200 ml sample every hour, 10 ft (3 m) suction line, and 5 ft (1.5 m) suction head.

Teledyne Isco External Battery Capacity:Number of Complete Standard Sampling Routines

	Nickel-Cadmium Battery	Lead-Acid Battery
Sampler Only:	6	9
Sampler with pH Module:	6	9
Sampler with Ultrasonic Module:	6	9
Sampler with Submerged Probe Module:	6	9
Sampler with Bubbler Module (1-2 ft head):	3	5
Sampler with Area Velocity Module:	4	6
Sampler with 4-20 mA Module:	6	9

A Standard Sampling Routine is a 200 ml sample taken every hour in 24 bottle mode, with a 10 foot (3 m) vinyl suction line at 5 feet (1.5 m) of head. The module is set to take a reading every 15 minutes.

Flow Meter Signal Requirement:	5 to 15 volt DC pulse or isolated contact closure of at least 25 millisecond duration. (4 - 20 mA or pulse duration signal may be converted with optional interface unit.)

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

6712 Controller: Software Specifications

Suction Line:	Programmable 3 to 99 ft (1 to 30 m) lengths of: • 3/8" (0.95 cm) I.D. Vinyl • 3/8" (0.95 cm) I.D. PTFE-lined with polyethylene jacket
Sample Frequency:	• From 1 minute to 99 hours and 59 minutes in 1 minute increments between consecutive samples. • Nonuniform times in minute intervals or clock time • Random time intervals between consecutive samples • From 1 to 9,999 flow pulses in single-pulse intervals • Flow paced in volume with attachable flow module
Rainfall Reading Units:	Inches or millimeters

Module Readings:		
pH	8 bits representing pH 16 bits representing temp.	0.1 pH storage resolution 0.1 °C storage resolution
Ultrasonic	16 bits representing level	0.0001 m storage resolution
Submerged Probe	16 bits representing level	0.0001 m storage resolution
Bubbler	16 bits representing level	0.0001 m storage resolution
Area Velocity	16 bits representing level 16 bits representing velocity	0.0001 m storage resolution 0.001 ft/s storage resolution
4–20 mA	16 bits representing percent 16 bits representing level 32 bits representing flow	0.1% storage resolution

SDI-12 Sonde Readings:

Parameter	Range	Resolution	Storage Bytes
Temperature	-40 - 100 °C	0.1 °C	2
Conductivity	0 - 100 mS/cm	0.01 mS/cm	2
Specific Conductance	0 - 100 mS/cm	0.01 mS/cm	2
Total Dissolved Solids	0 - 90 g/l	0.01 g/l	2
Salinity	0 - 70 ppt	0.1 ppt	2
Dissolved Oxygen	0 - 20 mg/l	0.1 mg/l	1
pH	0 - 14	0.1	1
ORP	-999 - 999 mv	0.1 mv	2
Level	0 - 6.5279 m	0.0001 m	2
Ammonium-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
Ammonia-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
Nitrate-Nitrogen	0 - 200mgN/l	0.1 mgN/l	2
Turbidity	0 - 5000 NTU	0.1 NTU	2
Chloride	0 - 1000 mg/l	0.1 mg/l	2
Chlorophyll	0-400 ug/l	0.1 ug/l	2
Other	-99999.0-99999.0	0.0001	4

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)	
Module Reading Conversions:	• Level and 4–20 mA readings converted to flow rate units: gallons per second — gallons per minute million gallons per day — cubic feet per second cubic meters per second — cubic meters per hour cubic meters per day — liters per second • Velocity units: feet per second — meters per second • Totalized flow units: gallons — million gallons cubic feet — cubic meters liters • Devices supported in flow conversion: Weirs: V-notch; 22.5, 30, 45, 60, 90, and 120 degrees Rectangular; with and without end contractions Cipoletti. Flumes: Parshall; 1", 2", 3", 6", 9", 1.5', 2', 3', 4', 5', 6', 8', 10', 12' Palmer-Bowlus; 4", 6", 8", 12", 15", 18", 21", 24", 27", 30", 48" Trapezoidal; LG 60 V, 2" 45 WSC, 12" 45 SRCRC H; 0.5', 0.75', 1', 1.5', 2', 2.5', 3', 4.5' Equation: $Q = a \times H^{b+c} \times H^{d}$ where: Q = flow H = head a,b,c, and d = entered values Manning Formula: Round, U-channel, Rectangular, Trapezoidal Area Velocity: Round, U-channel, Rectangular, Trapezoidal Data Points: 50 level-flow rate points, 50 level-area points
Refrigerator Temperature Sensor	Optional sensor and 5 ft (1.55 m) cable to record temperature readings. Intended for use with fiberglass refrigerated (FR) samplers. Range: -40.0 °C to 100 °C Accuracy specification: ±0.3 °C over a range of 0.0 to 10.0 °C. Reading data is 2 bytes, with a storage resolution of 0.1 °C.
6712 Standard Portable Sampler: Physical Specifications	
Dimensions:	Height: 27 inches (68.6 cm) Diameter: 19.96 inches (50.7 cm)
Sampler Tub Configurations:	• 24 wedge polypropylene bottles, 1,000 ml • 24 round glass bottles, 350 ml • 12 round polypropylene bottles, 1,000 ml • 12 round glass bottles, 950 ml • 8 round polyethylene bottles, 2.0 liters • 8 round glass bottles, 1.8 liters • 4 round polyethylene bottles, 3.7 liters (1 gal) • 4 round glass bottles, 3.7 liters (1 gal) • 1 round polyethylene bottle, 9.4 liters (2.5 gal) • 1 round glass bottle, 9.4 liters (2.5 gal)
Dry Weight:	32 lbs (15 kg)
This includes the top cover, center section, tub, controller, pump tube, distributor arm, distributor arm nut, and discharge tube for the 24 bottle configuration.	

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Dry Weight With:	24 plastic bottles, hold down, no caps	36 lbs (17 kg)
	24 glass bottles, expander ring, no caps	55 lbs (25 kg)
	12 plastic bottles, insert, expander ring, no caps	37 lbs (17 kg)
	12 glass bottles, insert, expander ring, no caps	45 lbs (21 kg)
	8 plastic bottles, insert, hold down, no caps	36 lbs (17 kg)
	8 glass bottles, insert, hold down, no caps	46 lbs (21 kg)
	4 plastic bottles, insert, hold down, no caps	36 lbs (17 kg)
	4 glass bottles, insert, hold down, no caps	45 lbs (21 kg)
	1 plastic bottle and composite tube guide, no cap, arm or nut	34 lbs (16 kg)
	1 glass bottle and composite tube guide, no cap, arm or nut	38 lbs (18 kg)
Filled Bottle Weight:	24 plastic bottles	101 lbs(46 kg)
	24 glass bottles	104 lbs(48 kg)
	12 plastic bottles	89 lbs (41 kg)
	12 glass bottles	95 lbs (43 kg)
	8 plastic bottles	84 lbs (38 kg)
	8 glass bottles	90 lbs (41 kg)
	4 plastic bottles	98 lbs (45 kg)
	4 glass bottles	104 lbs(48 kg)
	1 plastic bottle	90 lbs (41 kg)
	1 glass bottle	94 lbs (43 kg)
This includes everything in the Dry Weight, Dry Weight With, and Ice Capacity specifications, and the bottles are filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.		
Ice Capacity:	24 plastic bottles	12 lbs (5.4 kg)
	24 glass bottles	30 lbs (13.6 kg)
	12 plastic bottles	16 lbs (7.3 kg)
	12 glass bottles	16 lbs (7.3 kg)
	8 plastic bottles	12 lbs (5.4 kg)
	8 glass bottles	12 lbs (5.4 kg)
	4 plastic bottles	28 lbs (12.7 kg)
	4 glass bottles	25 lbs (11.3 kg)
	1 plastic bottle	35 lbs (15.9 kg)
	1 glass bottle	35 lbs (15.9 kg)
$^3/_4$" × $^3/_4$" × $^1/_4$" approximate ice cube size. Ice capacity will vary with the size of the cubes.		

Cooling Capacity Configuration:	Sample Size	Cooling Water	Last Sample	Last Sample Temp
24 plastic bottles	500 ml Sample	61 °F (16 °C)	Sample 24	63 °F (17 °C)
24 glass bottles	175 ml Sample	39 °F (4 °C)	Sample 24	41 °F (5 °C)
12 plastic bottles	500 ml Sample	36 °F (2 °C)	Sample 12	54 °F (12 °C)
12 glass bottles	475 ml Sample	36 °F (2 °C)	Sample 12	54 °F (12 °C)
8 plastic bottles	1,000 ml Sample	50 °F (10 °C)	Sample 8	57 °F (14 °C)
8 glass bottles	900 ml Sample	37 °F (3 °C)	Sample 8	54 °F (12 °C)
4 plastic bottles	1,850 ml Sample	34 °F (1 °C)	Sample 4	34 °F (1 °C)
4 glass bottles	1,850 ml Sample	37 °F (3 °C)	Sample 4	37 °F (3 °C)
1 plastic bottle	12–400 ml Samples	37 °F (3 °C)	Composite Sample	37 °F (3 °C)
1 glass bottle	12–400 ml Samples	36 °F (2 °C)	Composite Sample	36 °F (2 °C)

The cooling capacity is the temperature of the sample and the cooling water 24 hours after the last sample is taken. The amount of ice specified for the ice capacity was used. The temperature of the sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).

Average Thermal Resistance Factor:	R-10

The average R-value for a complete sampler. This includes a tub, center section, top cover, controller, pump tube, distributor arm, and discharge tube.

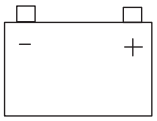
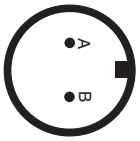
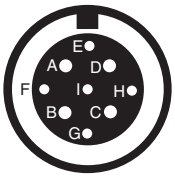
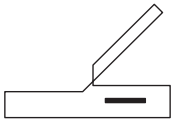
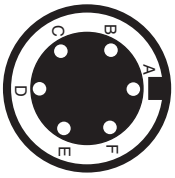
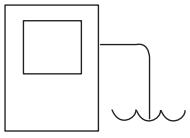
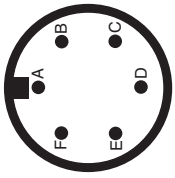
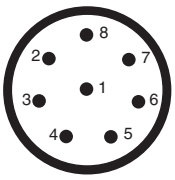
Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

6712 Standard Sampler with Optional 5 Gallon Bottle: Physical Specifications	
Dimensions **Base Alone:** **Assembled Sampler:**	 Height: 15.4 inches (39.1 cm) Diameter: 19.9 inches (50.6 cm) Height: 31.5 inches (80.0 cm) Diameter: 19.9 inches (50.6 cm)
Sampler Tub Configuration:	1 round glass bottle, 5 gallons (18.9 liters)
Dry Weight:	52 lbs (24 kg)
This includes the top cover, center section, bottle base, 5 gallon glass bottle, controller, pump tube, and discharge tube.	
Ice Capacity:	21 lbs (9.5 kg)
3/4" × 3/4" × 1/4" approximate ice cube size. Ice capacity will vary with the size of the cubes.	
Filled Bottle Weight:	115 lbs (52 kg)
This includes everything in the Dry Weight and the Ice Capacity specifications, and the bottle is filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.	
Cooling Capacity:	Sample Size: 12–800 ml Samples Cooling Water: 36 °F (2 °C) Composite Sample Temperature: 36 °F (2 °C)
The cooling capacity is the temperature of the sample and the cooling water 24 hours after the last sample is taken. The amount of ice used is specified in "ice capacity." The sampler is set up to take one sample every hour for twelve hours filling the bottle half full. The temperature of the incoming sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).	
Average Thermal Resistance Factor:	R-10
This is the average R-value for the complete sampler. This includes a bottle base, center section, top cover, controller, pump tube, discharge tube, and composite tube guide.	
6712 Compact Portable Sampler: Physical Specifications	
Dimensions:	Height: 27.6 inches (70.1 cm) Diameter: 17.75 inches (45.1 cm)
Sampler Tub Configurations:	• 24 wedge polyethylene bottles, 500 ml • 12 round polyethylene bottles, 500 ml • 12 round glass bottles, 375 ml • 1 round polyethylene bottle, 9.4 liters (2.5 gallon) • 1 round glass bottle, 9.4 liters (2.5 gallon)
Dry Weight:	31 lbs (14 kg)
This includes the top cover, center section, tub, controller, pump tube, distributor arm, distributor arm nut, and discharge tube for the 24 bottle configuration.	
Dry Weight With:	24 plastic bottles, insert, hold down, no caps 35 lbs (16 kg) 12 plastic bottles, insert, expander ring, no caps 35 lbs (16 kg) 12 glass bottles, insert, expander ring, no caps 43 lbs (20 kg) 1 plastic bottle and composite tube guide, no cap, arm or nut 33 lbs (15 kg) 1 glass bottle and composite tube guide, no cap, arm or nut 37 lbs (17 kg)

Table 1-3 Technical Specifications for the 6712C and Standard Samplers (Continued)

Filled Bottle Weight:	24 plastic bottles	70 lbs (32 kg)		
	12 plastic bottles	62 lbs (28 kg)		
	12 glass bottles	66 lbs (30 kg)		
	1 plastic bottle	66 lbs (30 kg)		
	1 glass bottle	73 lbs (33 kg)		
This includes everything in the Dry Weight, Dry Weight With, and Ice Capacity specifications, and the bottles are filled to the capacities listed in Sampler Tub Configurations. This weight does not include a power source.				
Ice Capacity:	24 plastic bottles	8 lbs (3.6 kg)		
	12 plastic bottles	13 lbs (5.9 kg)		
	12 glass bottles	13 lbs (5.9 kg)		
	1 plastic bottle	12 lbs (5.4 kg)		
	1 glass bottle	15 lbs (6.8 kg)		
3/4" x 3/4" x 1/4" approximate ice cube size. Ice capacity may vary with the size of the cubes.				
Cooling Capacity:				
Configuration:	Sample Size	Cooling Water	Last Sample	Last Sample Temp
24 plastic bottles	250 ml Sample	41 °F (5 °C)	Sample 24	55 °F (13 °C)
12 plastic bottles	250 ml Sample	34 °F (1 °C)	Sample 12	41 °F (5 °C)
12 glass bottles	175 ml Sample	34 °F (1 °C)	Sample 12	43 °F (6 °C)
1 plastic bottle	12–400 ml Samples	43 °F (6 °C)	Composite Sample	43 °F (6 °C)
1 glass bottle	12–400 ml Samples	39 °F (4 °C)	Composite Sample	39 °F (4 °C)
The cooling capacity is the temperature of the sample and the cooling water 24 hour after the last sample is taken. The amount of ice specified for the ice capacity was used. The temperature of the sample liquid is 65 °F (18 °C). The ambient temperature is 75 °F (24 °C).				
Average Thermal Resistance Factor:	R-11			
The average R-value for a complete sampler. This includes a tub, center section, top cover, controller, pump tube, distributor arm, and discharge tube.				

Table 1-4 Connector Specifications

Connector Icon	Pin Location Diagram	Pin Function
POWER SOURCE 	**2-PIN MALE, SEALED** 	A Ground B +12 volts DC
RAIN GAUGE 	**9-PIN FEMALE, SEALED** 	A +12 volts DC B Ground C 5V Programmable I/O1 pin D Rain gauge input E 12V switched F SDI-12 Data recv G SDI-12 Transmit H 5V Programmable I/O2 pin I 5V Programmable I/O3 pin
INTERROGATOR 	**6-PIN FEMALE, SEALED** 	A Switched +12 volts DC B Ground C Connection Sense D Transmit E Receive F NC
FLOW METER 	**6-PIN MALE, SEALED** 	A +12 volts DC B Ground C Flow Pulses In D Bottle Number Out Dual Sampler Out E Event Mark Out F Inhibit In
MODULE (IN MODULE BAY)	**8-PIN MALE, SEALED** 	1 NC 2 +12 volts DC 3 Ground 4 Module Sense 5 Receive 6 Transmit 7 Clock 8 Control

6712 Portable Sampler

Section 2 Installation/Preparation

2.1 Preparing the Sampler

When sampling with a single bottle, the composite tube guide is installed and the discharge tube is threaded through the guide.

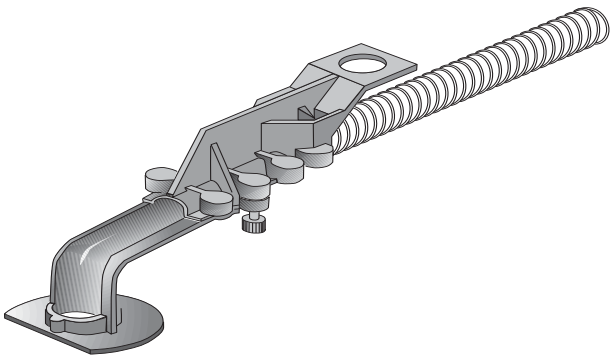
When sampling with multiple bottles, both the compact and standard 6712 Samplers use a distributor arm. It is adjustable so that you can position the discharge tube over the bottles of each kit. Each bottle kit also uses a discharge tube of a specific length. Table 2-1 lists the correct discharge tube lengths for each bottle kit. After installing the distributor arm and discharge tube, run the distributor to each bottle position to ensure proper installation.

If using bulk tubing to cut your own tubes, cut the ends of the tube square, not at an angle, and cut the length accurately.

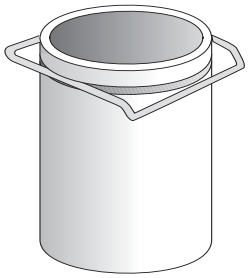
2.2 Installing the Distributor Arm and Discharge Tube

The two-piece distributor arm has four positions, marked on the underside with the letters A, B, C, and D. Adjust the arm to the correct position for the bottle kit being used. Table 2-1 shows the correct position for each kit. Thread the discharge tube through the spring and arm so that the tube protrudes from the arm $^{1}/_{16}$ to $^{1}/_{8}$ inch. If too much tube protrudes from the arm it can catch on bottles and jam the distributor arm.

Attach the arm to the distributor shaft. Secure the arm with the black plastic nut. Slide the free end of the discharge tube onto the bulkhead fitting.



Distributor Arm



Composite Tube Guide

Step 1

The two-piece arm has four positions, marked on the underside with the letters A, B, C, and D. Adjust the arm to the correct position for the bottle kit. Table 2-1 shows you the correct position for each kit.

Thread the discharge through the spring and arm so that the tube protrudes from the arm 1/16 to 1/8 inch.

Step 2

Attach the arm to the distributor shaft. The arm and shaft are keyed so that you can align them correctly. Secure the arm to the shaft with the black plastic nut.

Step 3

Slide the end of the discharge tube onto the bulkhead fitting.

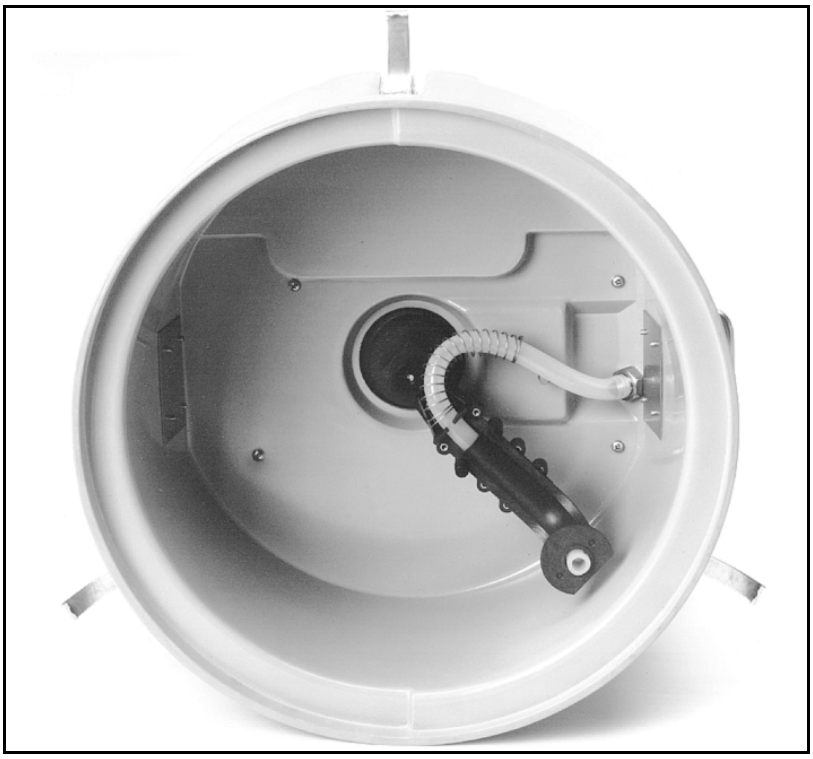


Figure 2-1 Installing the Distributor Arm

Table 2-1 Distributor Arm Adjustments and Discharge Tube Lengths for Bottle Kits

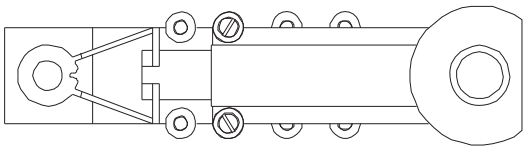
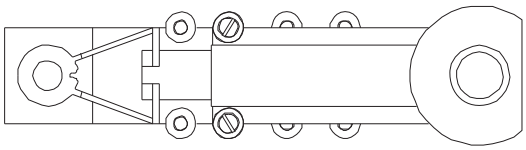
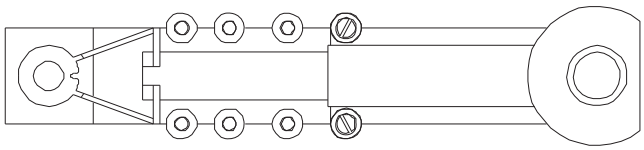
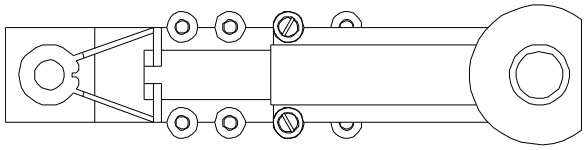
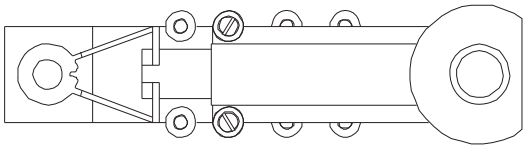
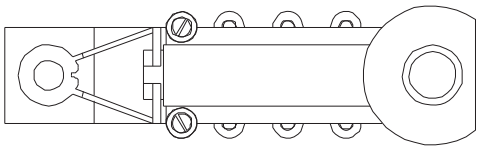
Compact 24-Bottle Kit • 500-milliliter polyethylene bottle Distributor Arm Position: B Discharge Tube: 60-9003-257 Discharge Tube Length: 14 1/4 inches (36.2 cm)	
Compact 12-Bottle Kit • 375-milliliter glass bottles • 500-milliliter polyethylene bottles Distributor Arm Position: B Discharge Tube: 60-9003-257 Discharge Tube Length: 14 1/4 inches (36.2 cm)	

Table 2-1 Distributor Arm Adjustments and Discharge Tube Lengths for Bottle Kits

Standard 24-Bottle Kit • 350-milliliter glass bottles • 1,000-milliliter polypropylene bottles Distributor Arm Position: D Discharge Tube: 60-9003-260 Discharge Tube Length: 17 1/4 inches (43.8 cm)	
Standard 12-Bottle Kit • 950-milliliter glass bottles • 1,000-milliliter polypropylene bottles Distributor Arm Position: C Discharge Tube: 60-9003-262 Discharge Tube Length: 16 1/2 inches (41.9 cm)	
Standard 8-Bottle Kit • 1.8-liter glass bottles • 2.0-liter polyethylene bottles Distributor Arm Position: B Discharge Tube: 60-9003-264 Discharge Tube Length: 15 3/4 inches (40.0 cm)	
Standard 4-Bottle Kit • 3.7-liter (1-gallon) glass bottles • 3.7-liter (1-gallon) polyethylene bottles Distributor Arm Position: A Discharge Tube: 60-9003-266 Discharge Tube Length: 15 inches (38.1 cm)	

2.3 Installing Bottle Kits for Multiplex Sampling

The samplers are shipped from the factory with sample bottles in place. When using the sampler for the first time, you will only need to remove the bottle lids. When installing cleaned bottles or a new kit, keep these guidelines in mind:

- **Never** mix glass and plastic bottles together.
- Install all bottles to insure that they remain in place.
- Align the bottles correctly. If the bottles are misaligned, the sampler may miss the bottle mouth, or the sampler will deposit samples in the “wrong” bottle.

- Each time you change from one size bottle to another, you must adjust the length of the distributor arm and install a discharge tube of the correct length.
- Each time you install a bottle kit, check the program settings for the number of bottles and bottle volume.

You must adjust the distributor arm and use a different discharge tube for each bottle kit. See *Installing Distributor Arm and Discharge Tube*, and Table 2-1 for more information.

2.3.1 Aligning Bottle Kits in the Standard Tub

Figures 2-2 through 2-5 show each kit being installed in the standard tub. Refer to Table 2-1 to adjust the distributor arm to the correct length and use the correct length of discharge tube.

1. Install the bottles then secure the plastic retaining ring with the three draw cords. (For glass bottles use the stainless steel retaining ring).
2. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

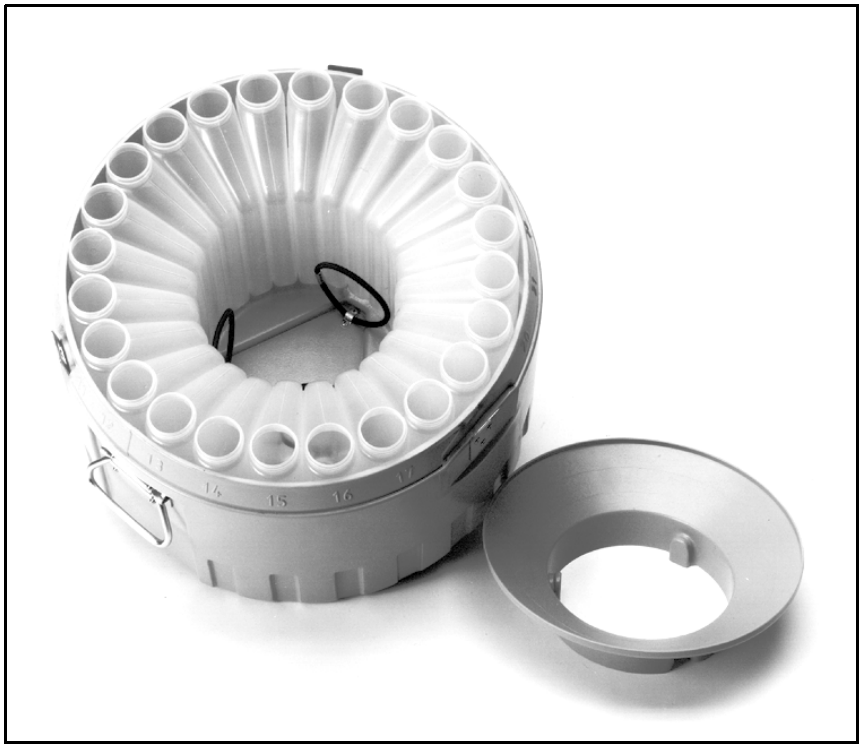


Figure 2-2 Placing the 24-Bottle Kit in a Standard Tub

1. Slide the 12-bottle insert into the tub, aligning the label with the corresponding numbers on the outside of the tub.
2. Place the bottles in the insert. Secure the bottles against the wall with the stainless steel retaining ring.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

Figure 2-3 Placing the 12-Bottle Kit in a Standard Tub

1. Position the 8-bottle insert in the tub, aligning the label with the corresponding numbers on the outside of the tub.
2. Place the bottles in the insert then secure the plastic bottle insert with the three draw cords.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

Figure 2-4 Placing the 8-Bottle Kit in a Standard Tub

1. Place the rack in the tub, aligning the label with the corresponding numbers molded on the outside of the tub.
2. Place bottles in the rack and secure the hold down over the bottles with the three draw cords.
3. Adjust the distributor arm to the correct position, insert the discharge tube, and attach the distributor arm.

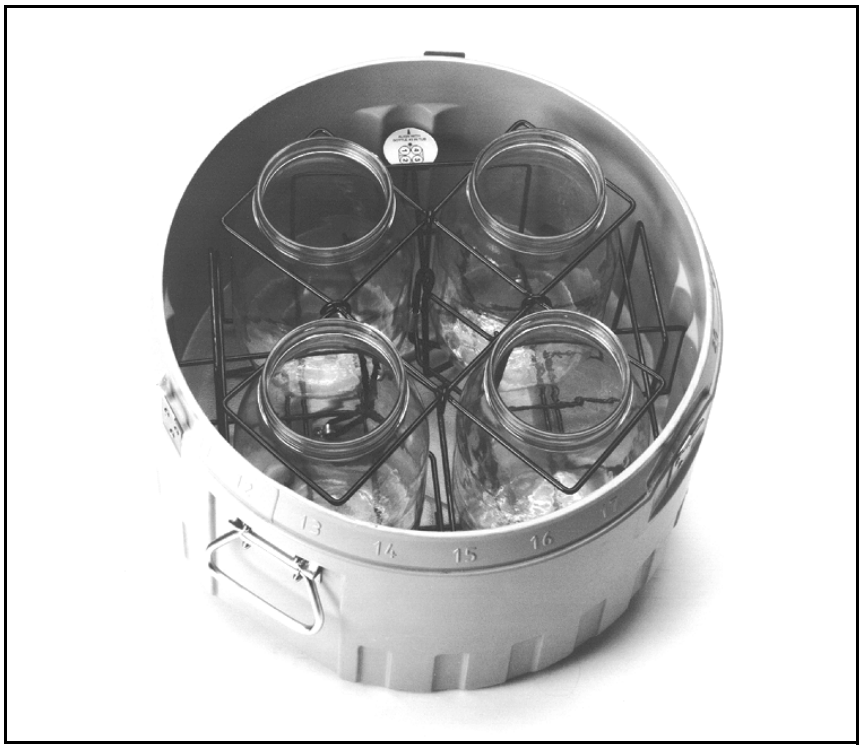


Figure 2-5 Placing the 4-Bottle Kit in a Standard Tub

Compact Sampler Tub Alignment Notches

Aligning the carrier

Figure 2-6 Placing the carrier in the compact tub

2.3.2 Aligning Bottle Kits in the Compact Tub

To align the bottles:

1. Place the bottles in the carrier, and secure them with the appropriate retaining ring.
2. Place the carrier in the tub, aligning it as shown in Figure 2-6. The carrier will drop into the notches when properly aligned.

2.4 Installing Bottle Kits for Composite Sampling

You can install a single $2^1/_2$ gallon bottle in either the standard or compact sampler tub for composite sampling. Single bottle sampling uses a composite tube guide instead of a distributor arm to position the discharge tube over the bottle. Install the composite tube guide and discharge tube as shown in Figure 2-7. Discharge tube part numbers and lengths are listed in Table 2-2.

The compact and standard sampler bottle bases accept a $2^1/_2$ gallon glass or plastic bottle. Place the bottle in the recess formed in the bottle base.

2.4.1 Optional Jumbo Bottle Base

You can install an optional bottle base on the standard sampler to collect larger composite volumes. The optional base replaces the standard tub and holds a 4 gallon (15 liter) polyethylene bottle, 5 gallon (19 liter) glass bottle or 5.5 gallon (20.8 liter) polyethylene bottle. Prepare the sampler as shown in Table 2-2 and Figure 2-7, and place the bottle in the recess formed in the bottle base.

Step 1

Both the compact and standard samplers use the same composite tube guide to hold the discharge tube in place over the composite bottle.

Attach the composite tube guide by firmly sliding it onto the distributor-shaft housing. It will snap in place. The guide has a slot that fits over a key on the housing to align it.

Step 2

Thread the discharge tube through the guide as shown. Attach the tube to the bulkhead fitting.

Removal

To remove the composite tube guide, rotate the metal clip to one side while pulling the guide away from the center section.

Figure 2-7 Installing the Composite Tube Guide

Table 2-2 Discharge Tubes for Composite Sampling		
Configuration	**Discharge Tube**	**Discharge Tube Length**
Compact 1 Bottle • 9.4-liter ($2^1/_2$ gallon) glass bottle • 9.4-liter ($2^1/_2$ gallon) polyethylene bottle	60-9003-258	10 inches (25.4 cm)
Standard 1 Bottle • 9.4-liter ($2^1/_2$ gallon) glass bottle • 9.4-liter ($2^1/_2$ gallon) polyethylene bottle	60-9003-271	12 inches (30.5 cm)
Jumbo Bottle Option • 15 liter (4 gallon) polyethylene bottle • 19 liter (5 gallon) glass bottle • 20.8 liter (5.5 gallon) polyethylene bottle *Standard samplers only. Requires the Jumbo Bottle Base*	60-9003-271	12 inches (30.5 cm)

5 Gallon Glass Composite Bottle | **2.5 Gallon Plastic Composite Bottle** | **2.5 Gallon Glass Composite Bottle**

Figure 2-8 Composite Bottles

2.5 Installing a Power Source

The 6712 Sampler requires 12-volt DC power. Power sources available from Teledyne Isco are listed below.

946 Lead Acid Battery

934 Nickel Cadmium Battery

913 High Capacity Power Pack (120 volts AC, 50/60 Hz)

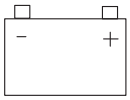
923 High Capacity Power Pack (240 volts AC, 50/60 Hz)

914 Battery Backed Power Pack (120 volts AC, 50/60 Hz)

924 Battery Backed Power Pack (240 volts AC, 50/60 Hz)

(the 924 is not certified for use in Europe)

948 45 Amp Hr Battery



Power Source Connector Icon

Connect the power source to the sampler connector that is labeled with this icon.

To install the smaller batteries or power packs on the sampler:

1. Place the power source in the sampler's battery recess.
2. Secure the power source with the black rubber draw-catches.
3. Attach the power-source cable to the power-source connector on the controller.

⚠ CAUTION

Use only Teledyne Isco-made power packs. If using a power pack with the 6712, Teledyne Isco recommends you use the new 913 or 923 power pack. Older model power packs may not provide sufficient power.

Refer to the *Teledyne Isco Power Products Guide* shipped with your sampler for more information on Teledyne Isco's power sources.

If you use a 120 or 240 volt AC-connected power pack, the AC line cord is the "Disconnect Device." Always install the sampler with the line cord and plug visible and readily accessible, so that power can be disconnected easily.

2.5.1 Connecting an External 12-Volt DC Source

You can also power the sampler with an external 12-volt DC source, such as an automotive battery. Connect the sampler to the battery with the External 12-Volt DC Power Cable.

⚠ CAUTION

Be sure to attach the positive and negative clips to the correct battery terminals. If polarity is reversed, the sampler may be permanently damaged.

2.6 Suction Line

The suction line is the tubing from the sampling point to the pump intake. The 6712 uses a 3/8-inch ID suction line of lengths 3 to 99 feet. Teledyne Isco offers vinyl or PTFE suction lines. The PTFE tubing has a polyethylene jacket to protect it from kinks and abrasions.

Guidelines for Measuring and Cutting the Suction Line:

- Cut the line to the desired length but use the shortest length feasible for the installation.
- Cut the line in 1 foot increments. For instance, 4 feet, not 3 1/2. If using metric units of measure, cut the line in increments of 0.1 meter. Do not include the length of the strainer in the measurement.

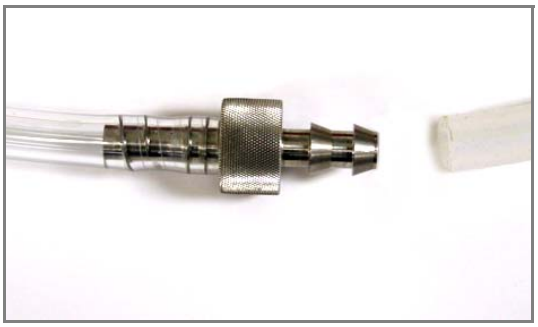
The vinyl line contains a very low parts-per-million level of phenols. If phenol content affects your sample analysis, use the PTFE suction line.

When installing the sampler, be sure the vertical distance between the liquid level and the pump is as small as possible.

2.6.1 Attaching Suction Line to Pump Tube

Attach the vinyl suction line to the pump tube with the 3/8-inch tubing coupler. First, screw the threaded end into the suction line until the flat surface is flush against the suction line (Figure 2-9). Then, push the other end of the coupler into the end of the pump tube until the other flat surface is flush against the tubing.

1.



2.

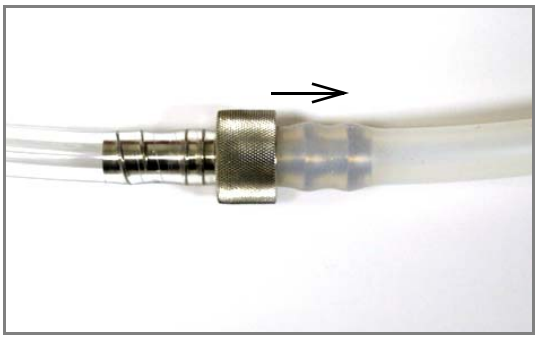


Figure 2-9 Attaching the suction line to the pump tubing

Once the coupler is attached to the pump tube, removal is difficult, and may require cutting the tube.

2.7 Strainers

Teledyne Isco offers three styles of strainer that help prevent solids from clogging the suction line:

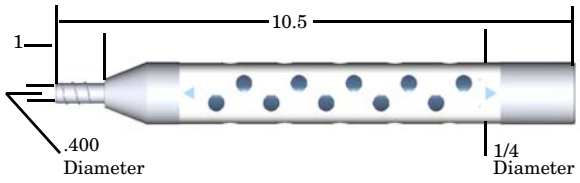
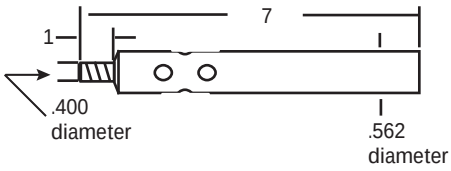
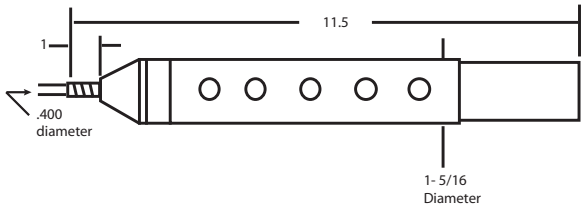
- 3/8-inch standard weighted polypropylene strainer for routine and priority pollutant sampling
- 3/8-inch stainless steel low flow strainer
- 3/8-inch CPVC-coated strainer for acidic liquid sources

To select the right strainer for your application, see Table 2-3. To install the optional stainless strainer in PTFE suction line, heat the end of the suction line to make it more pliable, then carefully screw the strainer's threaded connector into the suction line.

2.7.1 Alternative to Strainers

When sampling from high velocity streams with heavy suspended solids, some field investigations suggest that more representative samples are obtained without the strainer. Consider attaching a short piece of thin walled aluminum tubing to the end of the suction line; anchor the tubing so that the inlet opens upstream. The aluminum tubing's thin wall will not disturb the flow stream, and most sample analyses disregard aluminum ions. Under most conditions, the pre-sample purge removes any debris over the tubing entrance.

Table 2-3 Selecting the Right Strainer

Strainer	Dimensions	Application	Maximum Depth
3/8 Stainless Steel Ends, Polypropylene Center		Routine applications.	Vinyl Line: 22 feet (6.7m). PTFE Line: 15 feet (4.5m).
3/8 Stainless Steel Low Flow		Low flow applications	Vinyl Line: 22 feet (6.7m). Teflon Line: 15 feet (4.5m).
3/8 CPVC		Highly acidic liquids.	Vinyl Line: 4 feet (1.2m).

Note

- The suction lines will float when filled with air during the purge cycles and when depths exceed the listed ratings. Secure the suction lines when sampling at depths exceeding the maximum ratings.
- All strainer dimensions are in inches.
- PTFE suction line is compatible only with the 3/8 stainless steel strainer.

2.8 How Does the Sampler Work?

When the sampler takes a sample, it draws liquid through the strainer and suction line to the pump tube. The liquid flows through the pump tube and past the liquid detector, which senses the liquid. From the detector, the liquid follows the pump tube through the pump to the bulkhead fitting and then through the discharge tube to the sample bottle.

2.8.1 A Typical Sampling Cycle

1. The sampler moves the distributor arm over the bottle that is to receive the sample.
2. The pump reverses for the pre-sample purge.
3. The pump direction changes, filling the suction line.
4. When the detector senses liquid, the sampler begins measuring the sample.
5. After depositing the sample, the pump again reverses for the post-sample purge.

Sampling cycles vary somewhat according to program settings for distribution. The sampler can move the distributor arm clockwise and counterclockwise, making a number of distribution methods possible. (In this manual, the words “sample event” refer to a full sampling cycle for any distribution.)

Other variations include extended-program settings for suction-line rinses and sampling retries. A sampler running a program with line rinses completes the pre-sample purge and then rinses the line. The suction line is purged after each rinse. When programmed for sampling retries, the sampler will attempt to pump a sample again if it fails on previous attempts.

a. Controller.
b. Peristaltic pump.
c. Liquid Detector.
d. Strainer
e. Suction line
f. Stainless Steel Coupling
g. A pump tube routed from the liquid detector’s intake port through the pump, out the detector’s discharge port, and over the side of the controller to a bulkhead fitting at the top of the center section.
h. Bulkhead fitting.
i. Discharge tube running from the bulkhead fitting on the inside of the center section through the spring and distributor arm.
j. Distributor arm and spring.

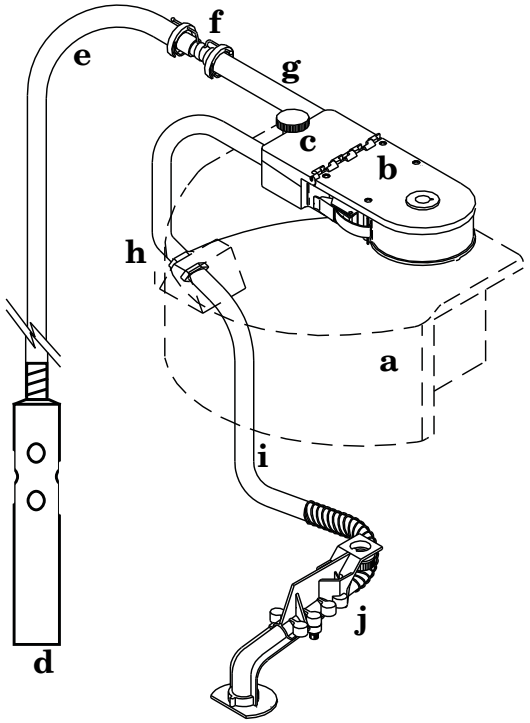


Figure 2-10 Identifying the Sampler Components

2.8.2 Measuring Sample Volume

"Sample volume" refers to the amount of liquid delivered into a bottle. The volume is determined by the programmed value. The volume is dependent on the volume per revolution of the pump, which is dependent on the suction head. The 6712 delivers the sample by counting the pump revolutions and automatically compensating for the suction head.

2.9 Installing the Sampler

The following paragraphs briefly describe initial sampler installation.

⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. Prolonged exposure to this sound could result in hearing loss and requires the use of protective ear plugs.

2.9.1 Icing the Samples

Ice is placed in the center of the bottle kit or around the composite bottle. The ice capacity varies according to the bottle kit. To increase cooling for the multiple-bottle kits use an ice-water bath. Place as much ice as possible in the center of the bottle kit and slowly add cold water. Continually add ice, as the water will melt some ice.

Always use the retaining rings or hold downs. They hold the bottles in position and keep the bottles from floating.

2.9.2 Tips for Routing Suction Line

Route the line so that it runs continuously downhill from the sampler to the liquid source. This helps drain the line during pre-sample and post-sample purges. When the sampler is used in below freezing temperatures, there is a risk of the suction line being frozen. A suitably warm sampling source can usually prevent this, provided there are no loops in the suction line. Some situations may require more protective measures, such as insulation of the suction line, or heat tape. Thoroughly draining the suction line minimizes the possibility of frozen liquid clogging the line.

2.9.3 Intake Placement

For representative samples, place the intake in the main current of the flow stream, not in an eddy or at the edge of flow. Placing an intake at the bottom may produce samples with excess heavy solids and no floating materials, while placement at the top may produce the opposite conditions.

2.9.4 Positioning a Sampler

Place the sampler on a relatively flat, horizontal surface. Placing the sampler on a steep incline may cause the sample to miss the bottle mouth.

When installing the sampler, be sure the vertical distance between the level of the liquid and the pump is as small as possible.

⚠ CAUTION

When using the 6712 sampler with a 750 or 710 module, transmitters such as cell phones or walkie talkies must not be operated within 3 meters of the sampler. If water level readings are fluctuating due to TV/radio station transmitter towers in the area, the sampler must be relocated.

⚠ WARNING

The 6712 samplers have not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ WARNING

If you must enter a manhole or other dangerous location to install the sampler, observe standard safety precautions. Refer to Appendix C for a discussion of safety considerations.

2.9.5 Using the Suspension Harness or ProHanger

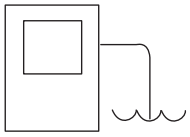
Teledyne Isco has a stainless steel suspension harness to lower or raise the sampler through a manhole or suspend the sampler during operation. You can suspend the harness from any suitable support. Prohanger is an X-shaped bracket that fits inside the lip of a manhole and lets you suspend the sampler using a cable harness.

2.10 Connecting External Instruments

The 6712 sampler can be used in conjunction with several types of external instruments.

2.10.1 Flow Meter

To connect the sampler to a Teledyne Isco open-channel flow meter, 4100 series flow logger, 2100 series flow module, or 1640 Liquid Level Actuator, attach the sampler-to-flow meter cable to the Flow Meter Connector. To connect the sampler to a closed-pipe flow meter, attach a Teledyne Isco 4-20 mA Input Interface device to the sampler's Flow Meter connector. When using the sampler with an external instrument, remember these guidelines:



Flow Meter Connector Icon

- Both the sampler and the flow instrument must be on and running a program.
- If using a flow meter, logger, or module for flow pacing, the sampler and the flow instrument must both run programs with flow pacing settings.
- If using a flow meter or flow logger for trigger pacing, the sampler must run a program with flow pacing settings, and the flow instrument must run a program with trigger pacing settings.
- When the sampler runs an event-paced program, it disregards pacing pulses from a flow meter or flow logger. However, the sampler continues to monitor for enable signals.

2.10.2 Rain Gauge Connector

Connect the rain gauge, SDI-12 Sonde, or Refrigerator Temperature Sensor connect cables to the nine-pin Rain Gauge Connector. When connecting a rain gauge and an SDI-12 Sonde, or rain gauge and a Refrigerator Temperature Sensor, use the appropriate Y-connect cable. See the Accessories appendix at the end of this manual.

Rain Gauge Connector Icon

⚠ WARNING

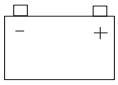
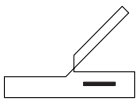
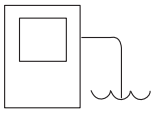
Most Teledyne Isco flow meters are not certified for use in hazardous locations as defined by the National Electrical Code. Contact your Teledyne Isco representative for your equipment's status. Never operate equipment in hazardous locations that has not been certified as safe for such use. Refer to Appendix C in the back of this manual for more safety information

☑ *Note*

Select Extended Programming to use the SDI-12 sonde. (See Switching Between Standard and Extended Modes on page 4-1.)

☑ *Note*

Update the Hardware Setup whenever you add or remove an SDI-12 sonde. (See Section 6.) In Extended Programming, rain gauge and SDI-12 sonde readings are only available if they are selected in the Hardware Setup.

Table 2-4 Connecting Teledyne Isco Instruments to the Sampler	
Connector Icon	**Connect These Instruments:**
Power Source 	12 volt power source
Rain Gauge	674 Rain Gauge Programmable I/O Pins (pins C, H, and I) SDI-12 Sonde Refrigerator Temperature Sensor
Interrogator 	581 RTD (Rapid Transfer Device) IBM PC or compatible computer running FLOWLINK or SAMPLINK External Modem External Data Logger/Controller
Flow Meter 	1640 Liquid Level Actuator 3000 Series Flow Transmitters 2100 Series Flow Modules 4100 Series Flow Loggers 4200 Series Flow Meters Master/Slave Sampler Pulse Duration Input Interface 4-20 mA Input Interface Closed-Pipe Flow Meters (using 4-20 mA Input Interface)

2.11 Locking the Sampler

Teledyne Isco offers stainless steel cables to lock the sampler (standard size – use P/N 68-6700-134; compact – use 68-6710-111). To lock the sampler, place the hook through the center section latch. Repeat this for the other two latches, and then pull the ends of the cables together over the top of the sampler. Lock the loops with the padlock. You can also lock each latch individually, using three padlocks, one for each of the latches.

2.12 Servicing the Sampler

Servicing the sampler includes:

- Recovering the sampler from the monitoring site
- Collecting the filled sample bottles and replacing them with clean bottles
- Replacing a battery, if required
- Collecting the data recorded by the sampler during the program.

Samplers are usually serviced after they complete a sampling program. When working up a service schedule, you will need to estimate the program completion time. You should also be familiar with the program's settings for the start time or if the sampler is programmed for continuous sampling.

Continuous sampling is controlled by the distribution setting entered at the "RUN CONTINUOUSLY?" screen. A "YES" response directs the sampler to reset the distribution sequence and continue the countdown to the next sample event. Appropriate service intervals will prevent overfilled bottles.

2.13 Recovering the Sampler

When recovering the sampler, keep it level to prevent spilling the collected samples.

If the battery's charge is questionable, replace it with a fully-charged battery.

The 6712 has a "fuel gauge" that gives an indication of power usage. The controller keeps track of how much power has been consumed since the last time it lost power. The current power consumption, as well as the previous power consumption, can be accessed by pressing the STOP key while in the main menu.

Keep in mind that the sampler has no idea as to how much charge was originally stored in the battery (or even if a battery is being used), and therefore has no idea as to the remaining capacity of its power source.

2.14 Collecting Sample Bottles

If you return the entire sampler back to the office, place caps on the bottles and drain any water from the carrier or tub. If you leave the sampler at the site and only need to collect the bottles, follow these guidelines for bottle collection.

2.14.1 Compact Sampler Bottle Collection

To collect the bottles from a compact sampler:

1. Open the latches, and lift the center section from the tub. Place caps on the bottles.
2. Remove the bottles by lifting the bottle carrier from the tub. Attach a label to the carrier detailing the location, date, etc.

Removing Bottles From the Compact Sampler

3. Pour any ice water out of the tub.

4. Slide a new bottle carrier filled with clean bottles into the tub.
5. Pour more ice into the carrier or tub.

2.14.2 Standard Sampler Bottle Collection

To collect the bottles from a standard sampler:

1. Open the latches, and lift the center section from the tub. Place caps on the bottles.
2. Drain any ice water from the standard tub by opening tub's drain plug. Remember to replace the plug's cap when done.
3. Attach a label to the tub or on each bottle detailing the location, time, date, etc.
4. Replace the standard tub and/or bottles with a clean set.
5. Pour more ice into the tub.

Drain Plug Location on the Tub

6712 Portable Sampler

Section 3 Programming Introduction

Before programming the 6712, you should become familiar with its keys and how to use the screens.

The 6712 Sampler has two sets of programming modes. The first mode, **Standard Programming**, lets you set up typical sampling programs easily and efficiently. The second mode, **Extended Programming**, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available in standard programming mode are available in extended programming mode. However, extended programming provides many additional features.

Standard and extended programming features are explained in separate sections. This section focuses on some basic features that are common to both programming modes, such as using the menus and setting the clock.

⚠ CAUTION

This sampler has a high performance pump. As with all such pumps, it relies upon liquid to cool working components. If the sampler is programmed to pump in the absence of liquid in excess of 5 minutes, excessive heat buildup may damage the paddles, rollers, and housing. Ensure that the liquid inlet is completely immersed.

3.1 Initial Operation

Turn the sampler on by pressing the Standby key. It is labeled with this icon: ⏻. The start-up screen appears first.

```
6712 SAMPLER
STANDARD PROGRAMMING
For HELP at any
screen press ? key.
```

It remains on the display for about eight seconds or until you press a key. It tells you the type of programming screens the sampler is currently using — standard or extended — and gives you a tip about the on-line help. The main menu screen, shown below, appears next.

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

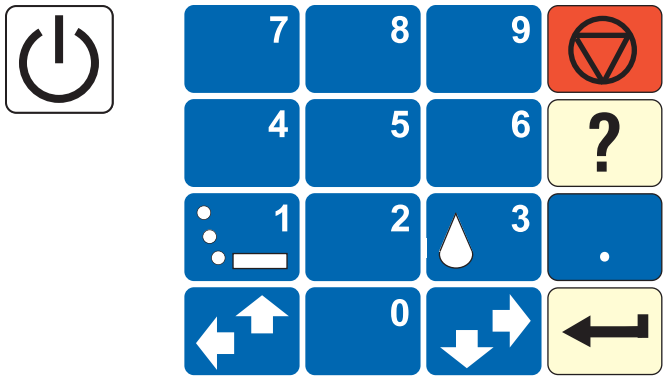
(If a module is attached, a different screen may appear first. See the module manual for more information.)

The sampler will continue to use the program mode you selected, even if the sampler is turned off and on again, until you manually switch to the other programming mode.

With the display backlight activated, the screen will glow for several seconds following your last keystroke.

If you press a key and the screen text does not change, it is probably because the keystroke turned the backlight on, instead of performing its function. Simply press the same key again.

Table 3-1 About the Keypad



Key	Name	Function
	Standby	Turns sampler on or off.
	Stop	Stops the pump or distributor. Pauses a running sampling program. In programming screens, returns to a previous screen.
	Enter	Accepts a menu choice or number entry and goes to next screen.
?	Help	In programming screens, displays a brief help message.
	Down-Right Arrow	Selects the menu option right or below the current choice.
	Up-Left Arrow	Selects the menu option left or above the current choice.
0	Numbers	Types a number.
.	Decimal Point	Types a decimal point.
1	Pump Reverse	Press when at the main menu to run the pump in reverse.
3	Pump Forward	Press when at the main menu to run the pump forward.

The sampler is programmed at the factory so that the standard programming screens appear when you first turn the sampler on. You can switch between programming modes by typing in a numerical command at the main menu:

- At the main menu type **6712.2** to show the extended programming screens.
- At the main menu type **6712.1** to show the standard programming screens.

3.1.1 Selecting a Language

You have the option of having screens display in English or another language. The default is English. At the main menu, type **6712.8:**

```
ENGLISH
SPANISH
```

Use the arrow keys to move between the choices (languages other than those shown above could appear on your unit). When the language choice you want is blinking, press ↵(Enter). The ↵ (Enter) key always accepts the blinking option.

3.2 Using Menus and Entering Numbers

A menu is a list of options. The main menu has four options:

The Main Menu

```
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS
```

- RUN
- PROGRAM
- VIEW REPORT
- OTHER FUNCTIONS

The options identify the operations that can be performed from the menu. For example, to run the sampling program, select RUN; to modify the program, select PROGRAM.

3.2.1 Selecting Menu Options

In menu screens, one menu option always blinks.

- Press ↵ when the blinking option is the one you want; it will accept your choice and go to the next screen.
- Select a different option by pressing an arrow key until the option you want blinks. Then press ↵.

3.2.2 Entering Numbers

Number-entry screens prompt you to enter a value. An example is shown to the left.

To enter a number:

Press the number keys to type the number. Then, press ↵. As soon as you press ↵, the sampler saves your number and moves to the next screen. In some screens, you can use the . (Decimal Point) key in a number.

Some screens display the range of acceptable numbers between parentheses. If an entry is too low or high, the controller beeps and erases the entry. Type a new number and continue.

```
SUCTION LINE LENGTH
IS __ ft
(3-99)
```

• Type the length of the suction line. Acceptable values are shown between the parentheses. Press ↵ to accept the number.

3.3 Quick View Screens

Quick view screens are a special type of menu screen. They show the current program settings and let you move quickly through the program. You must change the programming style to QUICK VIEW/CHANGE to see the quick view screens, as shown below:

1 | RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS | Select OTHER FUNCTIONS.

2 | MAINTENANCE
MANUAL FUNCTIONS
PROGRAMMING STYLE | Select PROGRAMMING STYLE.

3 | PROGRAMMING STYLE
NORMAL
QUICK VIEW/CHANGE | Select QUICK VIEW/CHANGE.

3.3.1 Paging Through Quick View Screens

The arrows in the corners of each quick view screen are menu options that let you move from one quick view screen to another.

Select the up arrow (↑) to go to the previous screen.

Select the down arrow (↓) to go to the next screen.

Press Stop to return to the main menu.

Because the forward arrow is always blinking when the screen appears, you can simply press ↵ to go to the next quick view screen, making it easy to page through the screens.

3.3.2 Changing Settings in a Quick View Screen

Although the quick view screens offer you a quick way to see the program settings, they also provide you with a way to change settings. Using quick view screens to change settings is sometimes a faster way to change a program because you can go quickly to the setting or settings that needs updating.

To change the program settings in a quick view screen:

Press an arrow until the setting blinks. Press ↵. The 6712 then displays the screen used to change the setting.

The Quick View screens below shows you how to change the sample volume. Begin by paging through the quick view screens until you see the screen containing the sample volume setting **200 ml SAMPLES.**

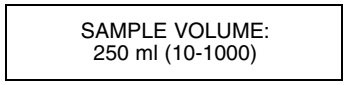
When you change a setting, the sampler stores the new settings and returns to the updated quick view screen. You can repeat this process until all settings shown in the quick view screens have been changed. When you are done, select the screen's forward arrow to move to the next quick view screen, or press Stop to return to the main menu.

Quick View Screens in Standard Programming

- To see the Quick View screens, select PROGRAM.

- Use the keypad's arrow key to select ↓ for the next quick view screen. When ↓ is blinking, press ↵.
- Use the keypad's arrow key to select ↑ for the previous quick view screen. When ↑ is blinking, press ↵.
- Use the keypad's arrow key to select the program setting. When the setting is blinking, press ↵ to display the screen used to change the setting.
- Press Stop for the main menu.
- All quick view screens work the same way.

- Press the arrow key until 200 ml SAMPLES blinks. Then press ↵.



- Type the new sample volume and press ↵.

3.4 Clock and Calendar

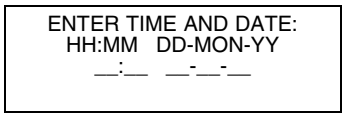
You may have to set the internal clock or calendar. The samplers are shipped with their clocks set to U.S. Central Standard time. If your sampler operates in a different time zone, you will have to reset the clock. The example to the left shows you how to find the time and date screen.

When setting the clock and calendar, use a 24-hour clock for times and the day-month-year format for dates. The illustration at the left shows blanks for each position that accepts an entry. The positions are called fields. When this screen appears on your sampler, the fields will contain the sampler's current settings for the time and date.

- To move from one field to another without changing the setting, press the arrow keys. Use this technique when you want to change only one or two settings.
- Change the setting by typing a new number. Press ↵ to accept the new setting.

For example, to enter 2:00 p.m. (2:00 p.m is 14:00 on a 24-hour clock), type 14. Press ↵. Next, type 0 (zero) for the minutes, and press ↵. To enter a date, such as January 22, 2001, type: 22 ↵ 01 ↵ 01 ↵ .

Entering Times and Dates



- Move from one field to another by pressing the arrow keys.
- Change a setting in a field by typing a number. Press ↵ to accept the new setting.

3.4.1 Setting the Clock and Calendar

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE	Select MAINTENANCE.
3	**SET CLOCK** PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Select SET CLOCK.
4	ENTER TIME AND DATE: HH:MM DD-MON-YY **14:00 22-JAN-01**	Enter the time and date.
5	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press Stop to return to the main menu.

3.4.2 Menu Screens: Clock Start Times

There are four start time settings you can use in a sampling program. This section discusses only one of these settings, the clock start time. A clock start time lets you set up a sampling program that starts at the same time on one or more days of the week. For example, you may want to begin sampling at 6:00 a.m. on Monday through Friday (refer to the screen below).

To select a day or days from the menu:

1. Press an arrow key until the cursor is on the correct day. Then, press ↵.
2. Repeat these steps until each day you want is blinking.
3. Press an arrow until DONE blinks. Press ↵.

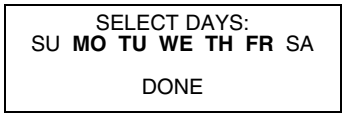
To remove days from the list:

1. Press an arrow key until the cursor is on the day you want to remove. Press ↵ to deselect it.
2. When finished, select DONE and press ↵

Using the Clock Start Time Menu

- Select CLOCK TIME.

- Type the time of day and press ↵.



- Press an arrow key until the cursor is on the correct day. Then, press ↵. To remove a day, move the cursor to it and press ↵ to deselect it.
- Repeat these steps until each day you want is blinking.
- Press an arrow until DONE blinks. Press ↵.

3.5 Menu Screens: Site Descriptions and Program Names

The sampler has two text-entry menus, one for site description and another for an extended-program name. They work in the same way. A site description is commonly a number, address, or other short note that helps identify the monitoring site. Extended programming has a similar screen that lets you enter program names for stored programs.

The example on the next page shows how to change the site description from FACTORY01 to SITE 29. Line 1 contains text between two quotation marks. Lines 2 and 3 contain the menu options — numbers, letters, and punctuation marks — used to spell out the description. In line 3, the space between the ampersand (&) and the double quotes (") is a space character. Line 4 contains two additional options:

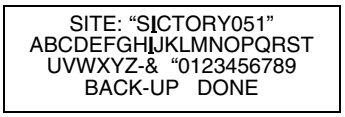
- BACK-UP, an option that moves the cursor on the text line to the left one character.
- DONE, an option that tells the sampler to save the text.

The cursor is the blinking rectangle that identifies the current field. When the screen first appears, the cursor blinks on the first character of the text in line 1. The matching character in line 2 or 3 also blinks.

When you press ↵, the cursor on line 1 moves to the right one position, and, at the same time, the sampler blinks on the matching character on lines 2 or 3.

Changing the Site Name

- Press the Down-Right arrow until the **S** on line 2 blinks. Then, press ↵.

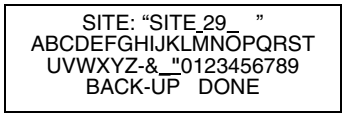


- Press the Up-Left arrow until the I blinks. Press ↵.
- Continue pressing arrow keys to select T, E, and space. Press ↵ after selecting each character.

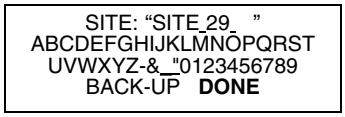
To change any character in the text line:

1. Press the left or right arrow until the replacement character on lines 2 or 3 blinks.
2. Press ↵. The replacement character will appear on the first line, and the cursor will move to the next character.
3. *Repeat steps 1 and 2 until the text in the top line is complete*.
4. Finish the entry by selecting DONE. Then, press ↵.

Some additional tips for using the text-entry menus:

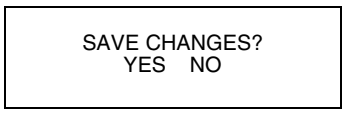


- Press 29 on the keypad, then Up-Left until space blinks. Press ↵.



- Press the Down-Right arrow until DONE blinks. Press ↵.

- Hold an arrow key down for faster movement.
- If your description uses all ten spaces in the text line, the sampler automatically moves to the next screen as soon as you add the tenth character.
- You can enter numbers by pressing the number keys.
- Erase characters by replacing them with a space character.
- Select the BACK-UP option to move the cursor to the left.
- To leave the menu before completing the entry, press Stop. The sampler will display this menu:



Select YES to save any changes made. Select NO to leave the original description (or program name) unchanged.

3.6 Messages

The sampler has four sets of messages that supplement the programming screens. **Information messages** tell you about programming status. **Help Notes** are brief comments associated with programming screens describing the setting or offering assistance. **Warning messages** tell you something is different than Teledyne Isco's standard. **Operation messages** report the sampler's status as it runs a program.

3.6.1 Information Messages

These are brief messages about the programming status, such as " 'ROM' PASSED TEST" or the status message that displays when you first start up the sampler. Information messages are displayed for four seconds, unless they are terminated by pressing any key on the keypad.

3.6.2 Help Notes

To see a Help note:

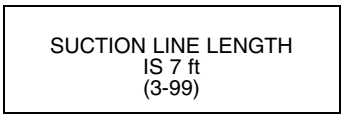
1. Press the ? (Help) key.

2. When the note requires several screens, the word "more" appears in the lower-right corner. Press ↵ for the next note.

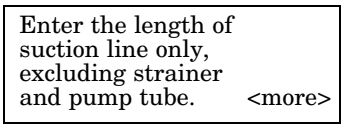
3. Move back and forth between screens by pressing the arrow keys.

4. Press Stop at any time to return to the programming screen.

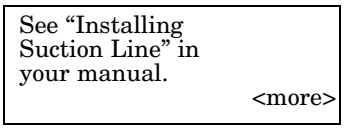
Most help notes refer to a related section in this manual. Screens that require extensive explanation have notes that contain only a reference to the manual. Sections mentioned in the notes appear in the index and the table of contents.



- Press ? (Help).



- Press ↵ or Down-Right to see the next screen.
- Press Stop to return to the programming screen.



- Press ↵ or Down-Right to see the next screen.
- Press Up-Left to see the previous screen.
- Press Stop to return to the programming screen.

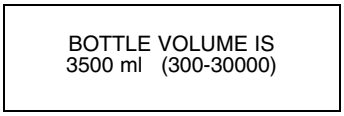
- Press Up-Right to see the previous notes.
- Press Stop to return to the programming screen.

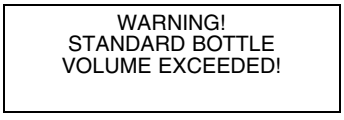
Using Help Notes

Although this example shows the help notes that are associated with the suction-line length screen, you can use the same technique to see help notes for other screens.

3.6.3 Warning Messages

Warning messages appear when the sampler determines something is out of the ordinary. For example, the following warning appears when you type a number that is larger than the standard bottle volume:





The 6712 does accept nonstandard volumes because you might use a nonstandard container occasionally. For a list of recommended volumes for Teledyne Isco bottles press the ? (Help) key at the "Bottle Volume Is" screen, or refer to the Technical Specifications.

The 6712 uses the bottle and sample-volume settings to determine the maximum number of samples that can be deposited without overfilling the bottles. Entering a volume that exceeds the standard volume may cause the sampler to overfill the bottle.

3.6.4 Operation Messages

An operation message reports the sampler's status as it runs a program. An example is shown below.

```
PROGRAM WILL START
AT 06:00   TU   20-FEB

05:56:22   TU   20-FEB
```

3.7 Menu Trees

Selecting a menu option will take you to a number-entry screen or another menu screen. The screens are organized in a branching structure that resembles a tree. Refer to Figure 3-1 for a simple chart of the menu tree for standard programming. The standard programming structure is different — much simpler — than the extended programming structure. Charts that show you most of the sampler's screens appear in *Appendix A, Flowcharts*.

The entire structure changes a little when a module is attached because the sampler adds a set of screens for a module as soon as it detects the module's presence. The manuals for each module contain menu trees for its programming screens.

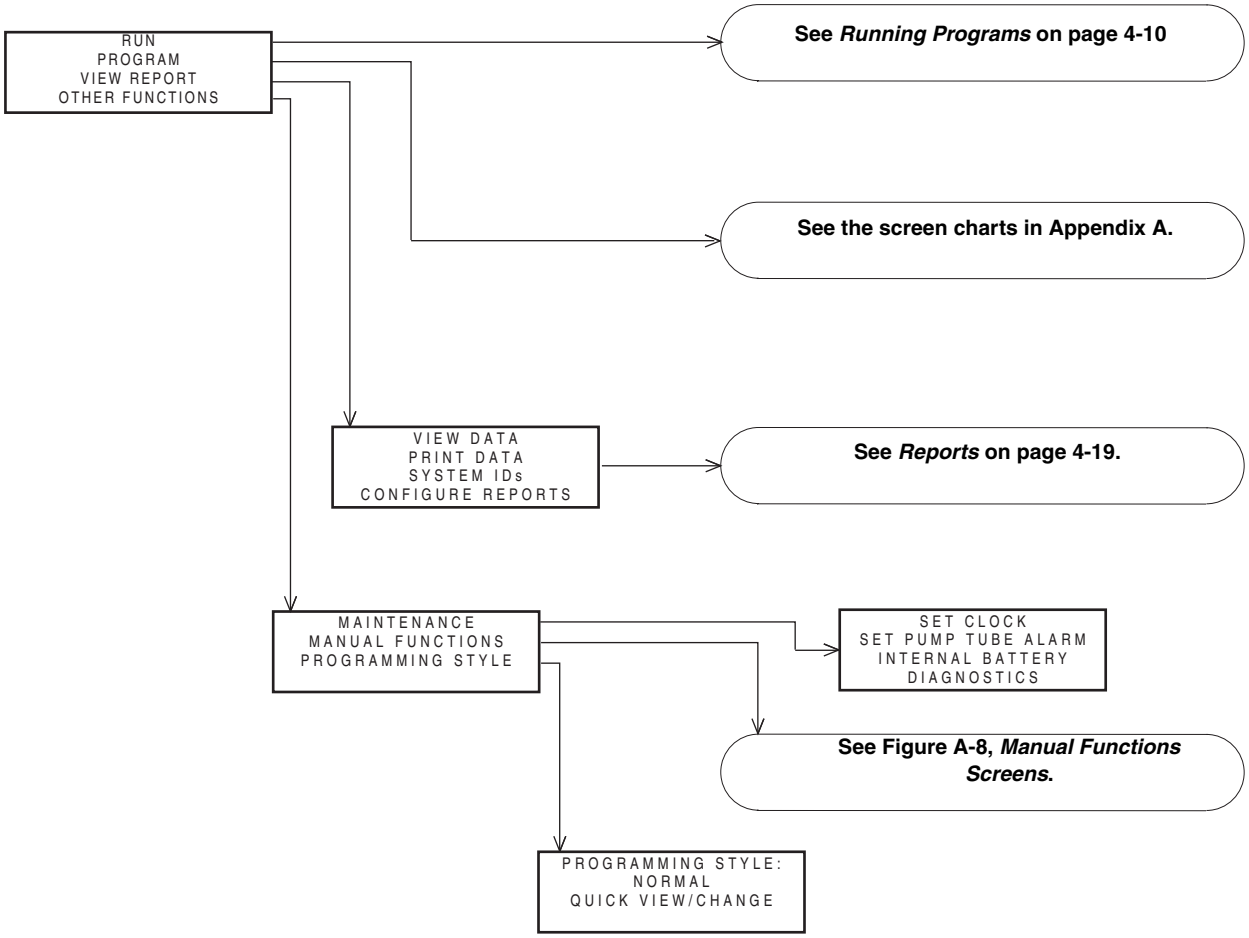


Figure 3-1 Menu Tree for Standard Programming

6712 Portable Sampler

Section 4 Standard Programming

The 6712 Sampler has two sets of programming screens. The first set, called standard programming screens, lets you set up typical sampling programs easily and efficiently. The second set, extended programming screens, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available within the standard programming screens are available in extended programming. However, extended programming provides several additional features which are discussed in the next section. Menu flowcharts for both sets of programming screens are in Appendix A.

4.1 Switching Between Standard and Extended Modes

Factory default settings cause the sampler to begin in standard programming mode the first time you turn it on. The start-up screen tells you which programming mode the sampler is currently using. You can switch between programming modes by entering a numerical command at the main menu:

- At the main menu, type **6712.1** to enter standard programming mode.
- At the main menu, type **6712.2** to enter extended programming mode.

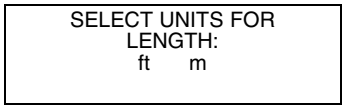
Main Menu

4.2 Language Selection, Units of Length

You have the option of displaying screens in English or Spanish (or possibly another language). The default is English. At the main menu, type **6712.8** to display:

Use the arrow key to move between the two choices. When the desired choice is blinking, press ↵.

If you select the English option, you will advance to a second screen that asks you to select your units of length:



Use the arrow key to move between the two choices, feet or meters. When the desired choice is blinking, press ↵. The default unit of length for the Spanish option is meters.

4.3 Programming Examples

The following table is an example of time-paced sampling. Further details about some of the menu items are provided in later sections.

Table 4-1 Standard Program: Sample Every 15 Minutes, One Sample Per Bottle

1	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	Turn the sampler on by pressing the On/Off key. Press ↵. This screen disappears on its own after 8 seconds.
2	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
3	SITE DESCRIPTION: "FACTORY051" CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn't necessary to change the description.
4	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵. For this example, select 24.
5	BOTTLE VOLUME IS 1000 ml (300-30000)	Type the volume for the bottles in your kit. For this example, 1000 is correct, so simply press ↵.
6	SUCTION LINE LENGTH IS 10 ft (3-99)	Type the length of the suction line, then press ↵. If you change the length, the sampler will display a message, "PLEASE WAIT!. . . GENERATING PUMP TABLES."
7	**TIME PACED** FLOW PACED	Because this example requires samples every 15 minutes, select TIME PACED by pressing an arrow until the option TIME PACED blinks. Then, press ↵.
8	TIME BETWEEN SAMPLE EVENTS 0 HOURS, 15 MINUTES	Type 0 for hours and press ↵. Type 15 for minutes and press ↵. Tip: Move back and forth between hours and minutes by pressing an arrow key.
9	**SEQUENTIAL** BOTTLES/SAMPLE SAMPLES/BOTTLE	Because this program requires one sample in each bottle, select SEQUENTIAL by pressing an arrow until the option SEQUENTIAL blinks. Then, press ↵.
10	RUN CONTINUOUSLY? YES **NO**	For this example, select NO by pressing an arrow until the option blinks. Then, press ↵. Selecting YES allows the program to run indefinitely by repeating the sample distribution. Continuous sampling assumes that filled bottles are replaced with empty bottles at regular service intervals.

Table 4-1 Standard Program: Sample Every 15 Minutes, One Sample Per Bottle (Continued)

11	SAMPLE VOLUME: 200 ml (10-1000)	Type the volume of the sample you want deposited in each bottle. Then, press ↵.
12	NO DELAY TO START **DELAYED START** CLOCK TIME WAIT FOR PHONE CALL	For this example, select DELAYED START by pressing an arrow until the option blinks. Then, press ↵.
13	FIRST SAMPLE AFTER A 5 MINUTE DELAY (1-999)	Type the delay period you want between the time you run the program and the time the sampler takes the first sample. Then, press ↵.
14	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Run the program immediately by selecting YES. Select NO if you want to run the program later by selecting RUN from the main menu. Press ↵ after making your choice. In this example, NO is selected.
15	**RUN** PROGRAM VIEW REPORT OTHER FUNCTIONS	Run the program by selecting RUN and pressing ↵.

The following table is an example of flow-paced sampling.

- Program type: Standard
- Site description: SITE 29
- Bottle kit: 24, 1000 milliliter bottles
- Suction line length: 7 feet
- Pacing: Flow pacing, every two pulses
- Distribution: 2 bottles per sample
- Sample Volume: 250 milliliters
- Start time: Clock Time, 6:00 a.m. on Monday, Wednesday, Friday
- Module: No module installed

Table 4-2 Standard Program: Flow-Paced Sampling, Two Bottles Per Sample

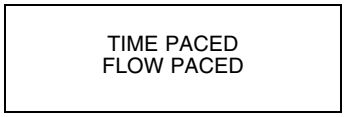
1	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	
2	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM.
3	SITE DESCRIPTION: “FACTORY051“ CHANGE? YES **NO**	Select NO.

Table 4-2 Standard Program: Flow-Paced Sampling, Two Bottles Per Sample (Continued)

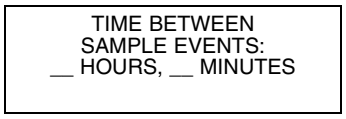
4	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select 24.
5	BOTTLE VOLUME IS 1000 ml (300-30000)	Enter 1000.
6	SUCTION LINE LENGTH IS 10 ft (3-99)	Enter 7.
7	TIME PACED **FLOW PACED**	Select FLOW PACED.
8	FLOW BETWEEN SAMPLE EVENTS: 2 PULSES (1-9999)	Enter the number of pulses between sample events.
9	SEQUENTIAL **BOTTLES/SAMPLE** SAMPLES/BOTTLE	Select BOTTLES/SAMPLE.
10	RUN CONTINUOUSLY? YES **NO**	For this example, select NO by pressing an arrow until the option blinks. Then, press ↵. Selecting YES allows the program to run indefinitely by repeating the sample distribution. Continuous sampling assumes that filled bottles are replaced with empty bottles at regular service intervals.
11	1 BOTTLES PER SAMPLE EVENT (1-24)	Enter 2.
12	NO DELAY TO START DELAYED START **CLOCK TIME** WAIT FOR PHONE CALL	Select CLOCK TIME.
13	START FLOW COUNT AT: 00:00	Enter 6, then enter 0. This is the time at which the sampler will start the pacing countdown.
14	SELECT DAYS: SU **MO** TU **WE** TH **FR** SA DONE	Select MO, WE, and FR. Use the arrow keys and ↵ to select the days. When the correct days are blinking, select DONE and press ↵.
15	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

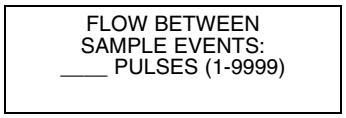
4.4 Pacing

Standard Time Pacing and Flow Pacing Screens for Samplers without Flow Modules



- When programming, you will be asked to select time or flow paced sampling. Depending upon your choice, you will see one of the following screens:





Sample pacing is the rate at which the sampler takes samples. Depending on the type of pacing you select, the rate is controlled by the sampler's internal clock or by inputs received from connected instruments.

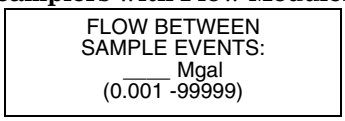
Standard programming provides time pacing and flow pacing (refer to Step 7 in the previous two programming examples). In time-paced sampling, the interval between samples is a constant time interval. When you program the sampler for time pacing, the sampler prompts you to enter the time between sample events in hours and minutes. Time paced programs always take a sample at the start time.

Flow paced sampling requires a flow meter, flow logger, or a module. A flow meter or flow logger paces a sampler by sending an electronic signal to the sampler after measuring a specified volume of liquid. Because each pulse represents a volume interval, flow pacing rates are proportional to the volume of water flowing through the channel.

When you program the sampler for flow pacing and are using a flow meter or flow logger, the sampler prompts you to enter the interval between sample events in pulses. The sampler initiates a sample event when the set number of pulses is received. Programs that are flow paced do not take a sample at the start time.

After setting the program start time, you will be prompted to enter a maximum run time of zero to 999 hours. If you would like the program to run indefinitely, enter 0 (zero) for maximum run time.

Flow Pacing Screen for Samplers with Flow Modules



The flow pacing screens change when you attach a flow module (see example to the left). Because the sampler is more closely integrated with the modules, the standard flow pacing screen prompts you for the flow volume between sample events instead of pulses between events. The flow volume units displayed are what you had previously programmed.

4.4.1 Trigger Pacing

Teledyne Isco 4200 Series Flow Meters and 4100 Series Flow Loggers send pulses for trigger pacing. The flow meter or flow logger sends pulses at two different time intervals when trigger pacing a sampler. Trigger pacing, for example, lets you sample less frequently when the trigger condition — a condition based on level, flow, or rainfall — remains below a set point. The intervals are determined by the flow instrument's program settings for trigger pacing.

When conditions change and readings pass the set point, triggering the new rate, you can sample more frequently. Or, when the trigger condition is a clock setting, the instrument changes the pacing interval according to the time of day. Using a clock trigger condition, for instance, the flow meter or flow logger can pace the sampler slowly at night and more frequently during the day. (For more information about trigger pacing, see your flow meter or FLOWLINK manual.)

The flow meter or flow logger sends the same pulse for both flow and trigger pacing, and the sampler cannot distinguish between them. Therefore, to program a sampler for trigger pacing, simply program it for flow pacing.

4.5 Distribution

Distribution describes how the sampler is to deposit samples. A sample is the volume of liquid deposited in a bottle. A sample event includes the full sampling cycle and may deposit a sample into more than one bottle.

In standard programming, you can program the sampler for these different distribution methods:

- Sequential
- Bottles Per Sample
- Samples Per Bottle
- Composite

4.5.1 Sequential

In sequential distribution, the sampler deposits one sample in each bottle. A sequential sample represents a "snapshot" of the flow stream at a point in time.

4.5.2 Bottles Per Sample

In bottles per sample distribution, the sampler deposits a sample in each of a set of bottles. A bottle set includes at least two bottles but may include all bottles. Use bottles per sample when the volume to be collected is larger than the amount one bottle can hold or when you need identical samples.

4.5.3 Samples Per Bottle

In samples per bottle distribution, the sampler deposits samples from several sample events in a single bottle before moving to the next bottle. Use samples per bottle distribution to collect a series of small composite samples.

4.5.4 Composite

For single bottle configurations, samples per bottle distribution is known as composite sampling. A composite sample represents an average of the flow stream's characteristics during the sampling period.

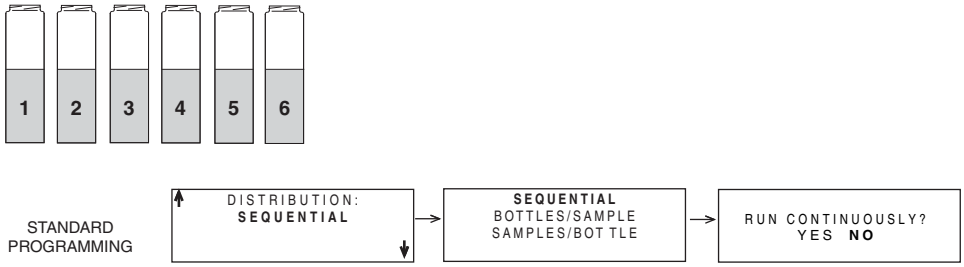
4.5.5 Continuous Sampling

Sample programs can be run indefinitely by selecting "YES" at the "RUN CONTINUOUSLY?" screen. Continuous sampling resets the distribution when the distribution sequence is complete. That is, when the last bottle/set is reached, the next bottle/set is the first bottle/set. All pacing modes except RANDOM are supported.

When running a program continuously, the bottles must be serviced at regular intervals to prevent overfilling the bottles. The sampler assumes that the next bottle/set is empty and ready to receive samples.

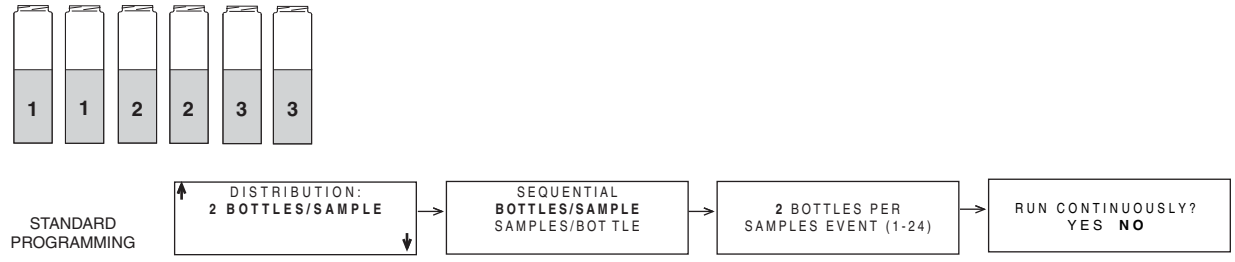
The figure on the next page steps through the programming screens for sequential, bottles per sample, and samples per bottle distribution.

Sequential



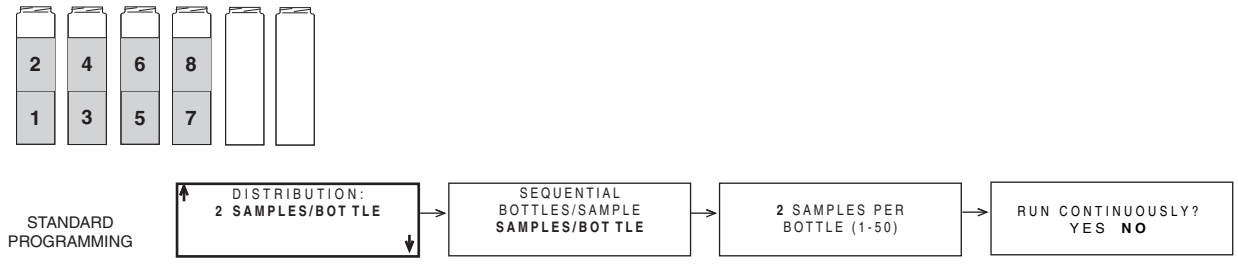
Each bottle receives one sample from one sample event.

Bottles-per-Sample



Multiple bottles receive a sample from one sample event.

Samples-per-Bottle



Each bottle receives a sample from multiple sample events.

Figure 4-1 Sample Distribution

4.6 Start Times

It is important to understand the difference between the time at which you run a program and the program's start time. Running a program simply means selecting RUN from the sampler's main menu. The start time is the time at which the sampler begins the program's first sample interval countdown. The start time is controlled by your selections from the start time screens.

Each program contains start-time settings that tell the sampler when to begin the program. When programming the sampler, you can select one of four start time options: NO DELAY TO START, DELAYED START, CLOCK TIME, or WAIT FOR PHONE CALL.

- Select NO DELAY TO START when you want the sampler to start as soon as you select RUN.
- Select DELAYED START when you want the sampler to delay from 1 to 999 minutes before starting the program.
- Select CLOCK TIME when you want the sampler to begin the program at a specific time on at least one day of the week.
- Select WAIT FOR PHONE CALL when you want the sampler to begin the program after receiving a remote command to start (optional modem required).

4.6.1 How Do Start Times Work?

As soon as you select RUN from the main menu, the sampler checks the program's start time settings. With a "DELAYED START" setting, the sampler starts a countdown to the start time. The period between the time you select RUN and the start time you've specified in the program is called the "delay to start time."

When you run a program with "CLOCK TIME" settings, the sampler also starts a countdown to start time until the day of week and clock times are met.

The sampler may not collect a sample at the start time. The sampler must be enabled, and the pacing selected must call for a sample at start. In any event, the sampler checks the pacing settings and begins the pacing-interval countdown.

Delayed Start Screen

1
NO DELAY TO START
DELAYED START
CLOCK TIME
WAIT FOR PHONE CALL

• Select DELAYED START.

2
FIRST SAMPLE
AFTER A
___MINUTE DELAY
(1-999)

• Enter the number of minutes to delay the countdown to the first sample.

3
START FLOW COUNT
AFTER A
__MINUTE DELAY
(1-999)

• The sampler uses this screen for flow paced programs.

Clock Start Time Menu

1
NO DELAY TO START
DELAYED START
CLOCK TIME
WAIT FOR PHONE CALL

• Select CLOCK TIME.

2
FIRST SAMPLE AT
06:00

• Enter the time of day.

3
SELECT DAYS:
SU **MO TU WE TH FR** SA

DONE

- Press an arrow key until the cursor is on the correct day. Press↵.
- Repeat until each day you want is blinking.
- Press an arrow until DONE blinks. Press ↵.

4.6.2 Sampler Enable/Disable

Teledyne Isco flow meters and flow loggers have a programmable sampler-enable feature that lets them enable (start) or disable (stop) a program according to certain monitored conditions. For example these conditions can be level, flow rate, pH, temperature, percent, rainfall, I/O; or a combination of two conditions.

The 1640 Liquid Level Actuator can also be used, as well as any other instrument that can ground the input to pin F. Grounding the input disables the sampler.

The sampler disregards disable signals during the delay to start time. However, when the sampler detects a disable signal at the start time, it suspends the program until it is enabled. The diagram in Figure 4-2 shows the sampler's responses.

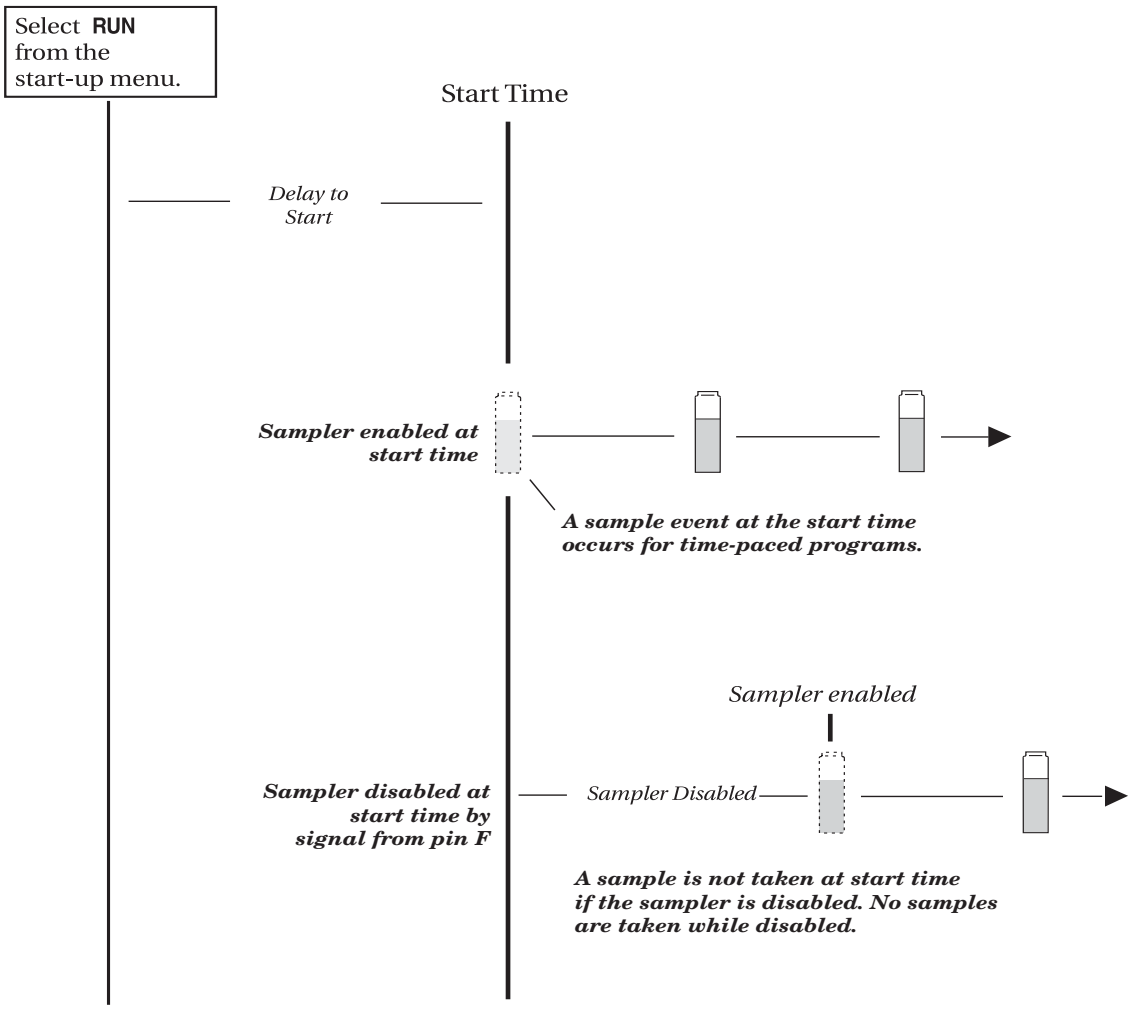


Figure 4-2 Start Time Diagram

4.7 Running Programs

To run a program, select RUN from the main menu. You may also select YES at the RUN THIS PROGRAM NOW? screen at the end of the programming screens.

4.7.1 Run Time Screens

While running a sampling program the sampler displays a variety of messages that report the program's status. For example, if the sampler has not yet reached the programmed start time, it displays the scheduled start time as well as the current time.

Once the program reaches the start time, you can determine the time of the next sample, the next bottle to receive a sample, sample distribution, and other information. Other messages appear while the sampler runs through a sampling cycle and takes a sample. When the sampler needs to report multiple messages, it alternates them, displaying each for one to three seconds.

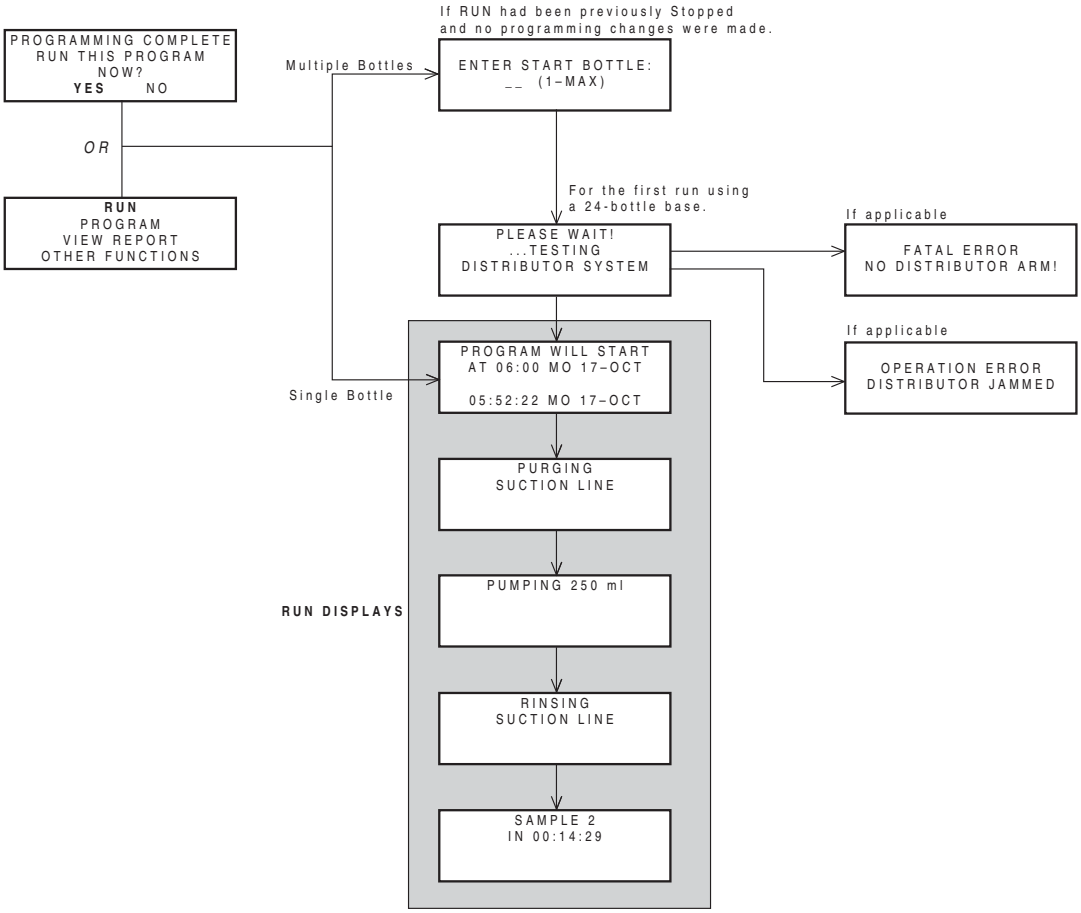
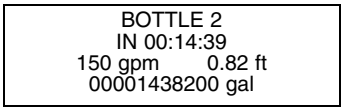


Figure 4-3 Running a Program

4.7.2 Module Readings

Samplers with an attached module display the module's readings: pH and temperature for the pH module; level, percentage, or flow rate for the 4-20 mA module; level, flow rate, and flow volume readings for the flow modules; level, velocity, flow rate, and positive flow volume readings for the area velocity module. Some module screens will alternate with the sampler screens.



The Module readings are updated:

- Every second when displaying the reading during programming.
- Every minute otherwise.

An * (asterisk) appears next to the reading if the module was unable to take a reading. If an asterisk appears, the reading displayed is the last available reading. Flow rates will be reported as zero flow if the error persists for more than five minutes (for a level or velocity reading that flow is calculated from).

```
BOTTLE 2
IN 00:12:00
***** gpm      5.73 ft
00001457600 gal
```

If an entire reading is filled with asterisks, the value exceeds the number of characters that can be displayed. The sampler stores the actual reading in memory, so it may be collected later.

For those programs that have delayed or scheduled start times, the readings will be displayed while waiting for the start time. Keep in mind that any totalizer values will be reset at the start time. Module and sonde readings are also displayed after a program is complete, until a key is pressed.

It is not necessary to run a program to view module or sonde readings. Real time data can be viewed on the display by selecting "VIEW REPORT" from the main menu.

4.8 Interrupting a Running Program

You can interrupt a sampling program by pressing the Stop key while the sampler is waiting for the next sample event. Pressing Stop places the sampler into *Manual Paused* operation and records a manual pause in the sample event log.

In this state, the sampler allows you to access several functions. You can modify the program, reset alarms, take a grab sample, etc., without adversely affecting the running program. Modifying the program is limited to adjusting the pacing intervals, enable conditions and sample volume. The basic program structure, such as the type of pacing, can not be changed.

While in the manual paused state, the sampling program continues to operate as normal, with the exception of taking samples. If a sample was to be taken, it is skipped. The sampler records "sample skipped" in the sample event log and continues to operate as normal.

The manual paused state displays a scrolling menu with several options (see example below). Use the Arrow keys to scroll through the manual paused options and the ↵ key to make a selection. Return to the running program by selecting resume program or pressing the Stop key. If you do not make a selection, the sampler automatically resumes the original sampling program five minutes after the last key was pressed.

```
← STOP PROGRAM
RESUME PROGRAM
VIEW DATA
GRAB SAMPLE →
```

Manual Paused Screen

4.8.1 Stop Program

This option terminates the running program and records program stopped in the sample event log. The program cannot be resumed.

4.8.2 Resume Program

Selecting this option will cause the sampler to exit the manual paused state and return to normal program operation. A manual resume event will be logged.

4.8.3 View Data

This option allows you to view the data recorded by the sampler. See *Reports* on page 4-19 for more information.

4.8.4 Grab Sample

When selected, you will be asked to enter the volume to be pumped. A sample will then be taken as if it is to be *placed into a container outside the sampler base*. Do this by removing the pump tubing from the bulkhead fitting. See *Grab Samples* on page 4-15. A grab sample event will be logged.

4.8.5 Pump Tube Alarm

If the pump tube is changed, this option should be selected to reset the pump counts on the counter. This will remove the "WARNING: REPLACE PUMP TUBING" message that may appear while the program is running. A pump tube replaced message is logged. See Replacing The Pump Tube in Section 7, Maintenance.

4.8.6 Calibrate Volume

When selected, you will be asked to enter the volume to be pumped. A sample will then be taken as if it is to be *placed into a container outside the sampler base*. Do this by removing the pump tubing from the bulkhead fitting.

After the sample has been pumped, you will then be asked to enter the amount actually delivered. Once you have entered the delivered volume and accepted the calibration, a volume delivered event will be logged.

4.8.7 Cal/Adj Parameters

When the sampler is configured for operation with a module, this option becomes available. Selecting this option will display the appropriate level adjustment screens and/or the calibration screens. If the level is adjusted, an adjusted level event is logged. If a parameter is calibrated, an appropriate event is logged.

Calibrating a parameter probe will temporarily "turn off" the partition data storage and the sample enable/disable functions. These functions are disabled during the calibration and for five minutes after the program is resumed. During this time, parameter data normally collected at the data storage interval will be logged as a 252 error message.

4.8.8 Adjust Pacing

This option is available when the running program is paced by Time, Flow Pulses or Flow Volume. If you select this option, you are asked to enter a new pacing interval. The sampler logs an interval changed event.

The original pacing interval continues to count down until you return the sampler to the running program (select resume program). If the new pacing interval is less than the original count remaining, the new interval is used.

If the original count remaining is less than the new pacing interval, the original count will continue to count down to the next sample event. Subsequent samples are then paced by the new interval.

4.8.9 Adjust Volume

Select this option to change the sample volume within the limits of the currently programmed sample distribution. If you change a sample volume, a volume changed event is logged.

4.8.10 Power Used

The 6712 has a "fuel gauge" that gives an indication of power usage. The controller keeps track of how much power has been consumed since the last time it lost power. If the controller is powered by an external battery, this fuel gauge can help you estimate the condition of the battery.

Keep in mind that the sampler has no idea as to how much charge was originally stored in the battery (or even if a battery is being used), and therefore has no idea as to the *remaining capacity* of its power source.

4.9 Other Functions

Other Functions Menu

RUN PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select OTHER FUNCTIONS.

MAINTENANCE
MANUAL FUNCTIONS
PROGRAMMING STYLE

In Standard Programming, the "Other Functions" menu screen includes options for:

- Maintenance (see Section 8).
- Manual Functions (see below).
- Programming Style (see Section 3).

4.10 Manual Functions

The manual functions programming screens let you:

- Take grab samples.
- Calibrate sample volumes.
- Operate the pump manually.
- Move the distributor arm.

4.11 Grab Samples

Taking a Grab Sample

1 | **GRAB SAMPLE**
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

- Select GRAB SAMPLE

2 | SAMPLE VOLUME:
___ ml (10-9990)

- Enter the desired volume

3 | GRAB SAMPLE
PRESS ↵ WHEN READY!

4 | PURGING
SUCTION LINE

5 | PUMPING 200 ml

6 | PURGING
SUCTION LINE

7 | GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

- Press STOP to return to main menu.

Grab samples let you take a single sample on demand, collecting the sample in an external container (Figure 4-4). Keep in mind:

When the sampler delivers a grab sample, it runs through a complete sampling cycle, using the current settings for volume and for line rinses or retries. If it is a two-part program, the sampler uses the settings for part A.

To take a grab sample while the sampler is running a program, you must interrupt the program by pressing the Stop key. Restart the program by running it again.

To take a grab sample:

1. Disconnect the pump tube from the bulkhead fitting.
2. Place the end of the tube over a collection container.
3. Follow the steps in *Taking a Grab Sample* at left.
4. Reconnect the pump tube to the bulkhead fitting.

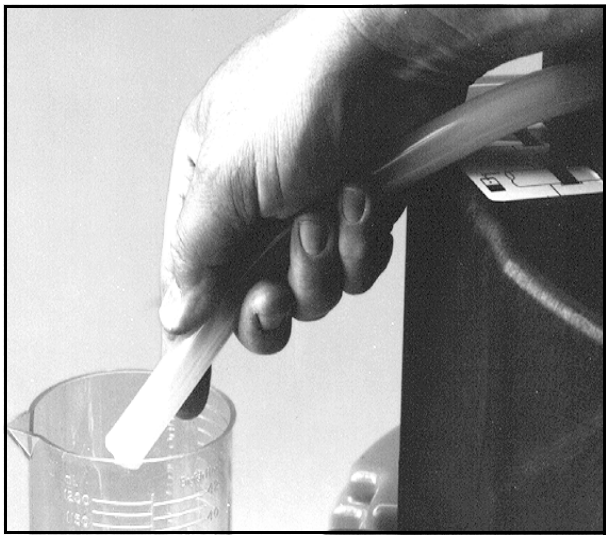


Figure 4-4 Taking a Grab Sample

4.12 Calibrate Volume

The sampler delivers accurate sample volumes without calibration. If you find that sample volumes vary significantly from the programmed values, first check the suction line for proper installation. Be sure it slopes continuously downhill to the liquid source and drains completely after each sampling cycle. Then, compare the actual length of the suction line to the suction line length settings in the program to see that they match. Also check the pump tube for excessive wear and replace it if necessary.

You may want to calibrate when:

- A new pump tube is installed. Run the pump for five minutes before calibrating.
- The sample source is above the sampler.
- Sampling from pressurized lines (15 PSI Maximum).

4.12.1 Calibration Tips

- For the best results, calibrate the sampler after it's installed on site.
- Use a graduated cylinder for volume measurement.
- The sampler clears the previous calibration setting when you reinitialize the sampler.
- You cannot calibrate while the sampler is running a program.
- When the sampler delivers the sample, it runs through a complete sampling cycle, using the current settings for volume line rinses and retries. If it is a two part program, the sampler uses the volume setting for part A.

To calibrate:

1. Disconnect the pump tube from the bulkhead fitting.
2. Place the end of the tube over a collection container.
3. Follow the steps in Calibrating Sample Volumes in the margin.
4. Reconnect the pump tube to the bulkhead fitting.

Calibrating Sample Volumes

1
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select OTHER FUNCTIONS

2
MAINTENANCE
MANUAL FUNCTIONS
MODULE
HARDWARE

• Select MANUAL FUNCTIONS

3
GRAB SAMPLE
CALIBRATE VOLUME
OPERATE PUMP
MOVE DISTRIBUTOR

• Select CALIBRATE VOLUME

4
SAMPLE VOLUME:
___ ml (100-9990)

• Enter the desired volume

5
CALIBRATE VOLUME
PRESS ↵ WHEN READY!

6
PURGING
SUCTION LINE

7
PUMPING 200 ml

8
PURGING
SUCTION LINE

9
VOLUME DELIVERED:
____ml

• Measure the volume delivered and enter the amount here.

10
200 ml
ARE YOU SURE?
YES NO

This screen appears when the amount you entered in step 9 was more than twice, or less than half, the programmed volume.

• Select YES when the volume delivered matches the volume displayed on this screen.
• Select NO to enter the volume delivered.

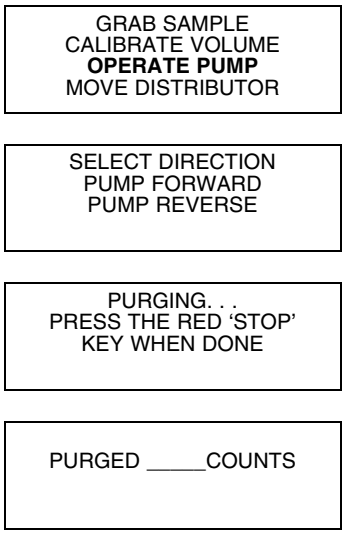
4.13 Operating the Pump

You can manually operate the sampler's pump in the forward or reverse direction. You can do this to test the pump, draw a large sample, or purge the suction line.

When you run the pump manually, the sampler reports the number of pump counts during the pump's operation. Use this feature to obtain an estimate of the pump counts required to purge a nonstandard suction line.

You can also manually run the pump from the main menu. Press the "1" key and then ↵ to run the pump in reverse. Press the "3" key and then ↵ to run the pump forward.

Operating the Pump



⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. PROLONGED EXPOSURE TO THIS SOUND LEVEL COULD RESULT IN HEARING LOSS AND REQUIRES THE USE OF PROTECTIVE EAR PLUGS.

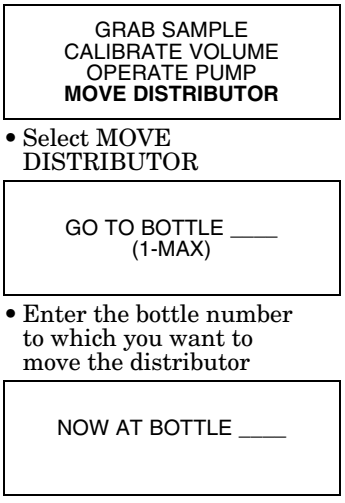
4.14 Moving the Distributor Arm

The sampler lets you reposition the distributor arm. Use this feature to verify a bottle location when installing a bottle kit. You cannot move the distributor arm while the sampler is running a program.

⚠ CAUTION

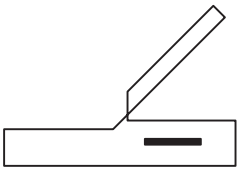
DO NOT rotate the distributor arm manually; this will severely damage the distributor drive gears.

Moving the Distributor Arm



- Select MOVE DISTRIBUTOR
- Enter the bottle number to which you want to move the distributor

4.15 Reports



Interrogator

The 6712 records a variety of data while running a sampling program. It uses the data to produce four reports:

- The Program Settings report, listing the program settings.
- The Sampling Results report, listing the program settings, time of samples and other program events.
- The Combined Results report, combining the sample event times with rainfall or module data.
- The Summary report, listing daily summaries of data collected. The Summary report may be rainfall and/or module data.

The sampler stores the data for each report in memory where they remain until you select RUN. Selecting RUN clears the memory so that it can store the data from the next program.

4.15.1 Collecting Reports

There are a number of ways to collect the reports:

View reports (program settings, sampling results, and abbreviated summary reports) on the sampler's display.

581 RTD

Collect the reports (except for summary reports) with a Teledyne Isco 581 RTD and use a computer running flowlink or samplink to transfer the reports from the RTD to a file on the computer.

Collect the reports (except for summary reports) with an IBM PC or compatible computer running flowlink.

Collect the reports with and IBM PC or compatible computer running samplink.

4.15.2 Viewing the Data

Because the display area is small, the data on the reports will be displayed a little differently from the data that is transferred to and viewed on your computer.

- For the Sampling Report, the sampler displays each program event, one at a time.
- For the Module and Rainfall Data reports, it displays daily summaries, instead of the full reports available with the rtd, Flowlink, or Samplink.

If you select Sampling Report or Rainfall (step 3 in *Viewing Data*, shown in the margin), the sampler begins displaying the report data. The sampler advances automatically through the report items, displaying each item briefly. While the sampler advances automatically through the displays:

- Stop the automatic displays by pressing Stop once. Then, use the arrow keys to move manually through the report.
- Return to the main menu by pressing Stop twice.

At the end of the report, the sampler leaves the last item displayed until you press:

- the arrow keys to move forward or backward manually through the report.
- Stop to return to the main menu.

- ↵ to start the automatic displays again.

Viewing Data

1
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select VIEW REPORT.

2
VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS

• Select VIEW DATA.

3
SELECT DATA TO VIEW:
SAMPLING REPORT
MODULE DATA
RAINFALL DATA

• Select a report or data type.

4
VIEW:
DAILY SUMMARY
CURRENT READINGS

• Select DAILY SUMMARY to view the stored data, or CURRENT READINGS to view real-time data.

If you select Module Data in step 3, the sampler displays the screen shown in step 4. Select the Daily Summary option and the sampler displays the stored data just as the Sampling Report was described above. Selecting the Current Readings option causes the sampler to display real-time readings. When there are multiple screens, they will be displayed alternately. You can quickly advance through the screens by pressing an arrow key or ↵. Pressing Stop exits the Current Readings mode.

4.15.3 Configuring Reports

Configuring Reports

1
RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select VIEW REPORT.

2
VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS

• Select CONFIGURE REPORTS

3
SAMPLINK REPORT
FLOWLINK REPORT
CUSTOM REPORT
ALL REPORTS

• Select the option that matches your data collection software, or tailor the output according to the reports needed.

The Configure Reports option lets you specify which of the Sampling Reports will be included in any output request. Each sampler is shipped with the option Flowlink Report selected.

The Samplink Report and Flowlink Report options allow you to tailor the output to the Teledyne Isco software used to collect the reports. The Samplink Report option provides the Sampling Reports, but disables the output of the detailed partition data.

Flowlink Report provides the Sampling Reports and the detailed partition data. Selecting the Flowlink Report option enables the output of the detailed partition data so Flowlink can add the data to the site's database file.

When you are familiar with the available Sampling Reports, you may want to specify an output containing only the specific data you require. The Custom Report option will allow selection of detailed data. Data collection time and storage space may be optimized using this option.

4.15.4 Sampling Results Report

As the sampler runs a program, it records the program's events. Program events include such items as sample events, program enables and disables, power losses, and so on. Table 4-3 lists each event with a short description. You can view the report by following the steps in *Viewing the Data* on page 4-19 or print the log as the Sampling Results report.

In the text file version of the report, sample-event entries include the time of the event as well as the sample and bottle numbers.

The sample column contains the sample number deposited into the bottle. This information reflects the distribution selected for the program.

The letters in the Source columns are codes for the cause of the event. The letters in the Error column are codes for the causes of missed samples. The source and error codes appear with explanations at the end of the report. A list of codes appears in Table 4-3.

The last column in the Sampling Results report records the pump counts for the sample event. Large variations in pump counts from event to event indicate fluctuating heads, a relocated suction line, or a temporarily clogged strainer.

4.15.5 Combined Results Report

At the time of each sample event, the sampler records the readings from each connected module, rain gauge, or SDI-12 sonde. The Combined Results Report presents the event time, sample and bottle number, and the respective readings from the device.

For flow modules, the readings are level and flow rate. For the pH module, the readings are temperature and pH. For the rain gauge and SDI-12 Sonde, the readings vary according to the selections enabled during the hardware setup in extended programming. When recording four or more sonde parameters, the Combined Results report will exceed the standard 40 character width. To read the additional columns, the data must be collected with Flowlink 4 for Windows software.

4.15.6 Summary Report

This report summarizes the rain gauge or module data. The types of readings are the same as those available to the Combined reports. The sampler compiles the data to present a daily total, the day's average, maximum, and minimum reading, and a listing of hourly averages. The sampler then graphs the day's readings.

Table 4-3 Reports: Program Events, Source Codes, and Error Codes	
* Indicates events and codes that occur in Standard Programming	
Program Events (listed in the order that they most likely would occur)	
*Program Run	The sampler ran the sampling program.
*Program Started	The sampler started the sampling program.
*Program Enabled (Disabled)	The sampler was enabled or disabled according to program settings or an external instrument.
'A'/'B' Enabled (Disabled)	Program part 'A' or 'B' was enabled or disabled according to the program's settings.
Sample	A sample was taken as programmed. (See Source Codes and Error Codes in this table.)
*Sample Switch Time	A sample was taken at programmed switch time.
*Program Done	The sampler finished the sampling program.
'A'/'B' Done	The sampler finished program part 'A' or 'B'.
*Manual Pause	Stop was pressed during the program to enter the Manual Paused state.
*Program Stopped	You selected Stop from the manual paused options, terminating the program.
*Grab Sample	A grab sample was taken while in the Manual Paused state.
Pump Tube Replaced	The pump tube alarm was reset while in the Manual Paused state.
Calibrate Volume	The volume was calibrated.
Calibrate SDI Parameter	An SDI-12 sonde or module parameter was calibrated.
*Adjusted Pacing	The pacing interval was changed while in the Manual Paused state.
*Volume Changed	Sample volume was changed while in the Manual Paused state.
Adjust Enable	Sampler enable thresholds were changed while in the Manual Paused state.
Reset Rain History	The rain history was reset.
Adjust Suction Head	The suction head was changed while in the Manual Paused state.
*Manual Resume	The resume program option was selected from the Manual Paused state.
Program Paused (Resumed)	The program reached a programmed pause or resume time.
'A'/'B' Paused (Resumed)	Program part 'A' or 'B' reached a programmed pause or resume time.
*Power Failed	The power source was disconnected.
*Power Restored	The power source was reconnected.
Alarm Occurred	An alarm occurred.
Alarm Acknowledged	An alarm was acknowledged.
*Missed Password	The password was missed.

Table 4-3 Reports: Program Events, Source Codes, and Error Codes (Continued)

(The Source and Error Codes Listed below refer to why a sample was taken and what happened while it was being taken.)

Source Codes		
*C	Calibrate sample	Sample volume delivered during calibration.
*D	Disable	Sample event at disable time.
*E	Enable	Sample event at enable time.
Ev	Event	Event-paced sample event.
*F	Flow	Flow-paced sample event.
*G	Grab sample	Sample volume delivered as a grab sample.
M	Command driven sample	A command driven sample.
PH	Phone command	Phone command sample.
R	Resume	Sample event at resume time.
*S	Start	Sample event at start time.
Sw	Switch time	Sample event at switch time.
TO	Time Override	Sample event at bottle-switch time.
*T	time	Time-paced sample event.
Error Codes		
*DJ	Distributor Jammed	The distributor jammed.
*IP	sample in progress	Sample in progress when report was printing.
*L	pump latch open	Unable to take sample because the pump band was opened.
*ND	no distributor arm	There is no distributor arm or the stop is damaged.
*NL	No Liquid Detected	The sampler was unable to detect liquid.
LF	Not enough flow	Not enough flow for the minimum sample volume entered for samples with volumes proportional to flow.
*NM	No More Liquid	After the sampler detected liquid and while the sample was being taken, the liquid detector stopped detecting liquid.
M	Bottle Full	The composite bottle is full.
*O	Sampler Shut Off	The sampler was turned off with the On-Off key during the sample event.
Ov	Probable Overflow	The sampler was directed to take a sample that would not fit into the bottle. Occurs for flow paced, time override programs only.
*P	Power Failed	The power supply failed during the sample event. Note: Power failures during five consecutive sample events results in a LOW BATTERY shut-down.
*PJ	Pump Jammed	The pump jammed.
*Sk	Sample Skipped	Sample not taken.
*US	User Stopped	You pressed the Stop key during the sample event.

Figures 4-5, 4-6, 4-7, 4-8, and 4-9 show examples of reports configured to show program settings, sampling results, combined results, and a summary report.

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** PROGRAM SETTINGS ***********
     ----------

 SITE DESCRIPTION:
    "FACTORY051"

     ----------
   UNITS SELECTED:
   FLOW RATE: cfs
 FLOW VOLUME: Mgal

     ----------
   BUBBLER MODULE:
        WEIR
        90
      V-NOTCH
     ----------
  24,  1000 ml BTLS

 10 ft SUCTION LINE

     ----------
      PACING:
    TIME, EVERY
 0 HOURS, 15 MINUTES

     ----------
    DISTRIBUTION:
     SEQUENTIAL


     ----------

   200 ml SAMPLES


     ----------

  5 MINUTE DELAY TO
    FIRST SAMPLE

----------------------------------------
```

Figure 4-5 Report: Program Settings

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** SAMPLING RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
                                      COUNT
                                        TO
SAMPLE  BOTTLE TIME  SOURCE ERROR LIQUID
------- ------ ----      -- --    ------
               15:03  PGM ENABLED
  1,1     1    15:03      S           250
  1,1     2    15:18      T           247
  1,1     3    15:33      T           247
  1,1     4    15:48      T           249
  1,1     5    16:03      T           247
  1,1     6    16:18      T           247
  1,1     7    16:33      T           247
  1,1     8    16:48      T           248
  1,1     9    17:03      T           237
  1,1    10    17:18      T           236
  1,1    11    17:33      T           237
  1,1    12    17:48      T           241
  1,1    13    18:03      T           238
  1,1    14    18:18      T           236
  1,1    15    18:33      T           237
  1,1    16    18:48      T           236
  1,1    17    19:03      T           242
  1,1    18    19:18      T           237
  1,1    19    19:33      T           235
  1,1    20    19:48      T           238
  1,1    21    20:03      T           237
  1,1    22    20:18      T           237
  1,1    23    20:33      T           236
  1,1    24    20:48      T           230
               20:48  PGM DONE 19-DEC


   SOURCE S  ==> START
   SOURCE T  ==> TIME
   ---------------------------------------
```

Figure 4-6 Report: Sampling Results

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
 BUBBLER MODULE: 2215419583
  Hardware: A00000  Software: 1.07
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
```

SAMPLE	BOTTLE	TIME	LEVEL ft	FLOW RATE cfs	TOTAL FLOW Mgal
1,1	1	15:03	0.009	2.495	000000.000
1,1	2	15:18	0.012	2.576	000000.017
1,1	3	15:33	0.012	2.666	000000.035
1,1	4	15:48	0.012	2.773	000000.053
1,1	5	16:03	0.012	2.773	000000.072
1,1	6	16:18	0.012	2.798	000000.091
1,1	7	16:33	0.012	2.798	000000.109
1,1	8	16:48	0.012	2.798	000000.128
1,1	9	17:03	0.012	2.751	000000.147
1,1	10	17:18	0.012	2.773	000000.166
1,1	11	17:33	0.009	2.798	000000.185
1,1	12	17:48	0.012	3.728	000000.207
1,1	13	18:03	0.012	3.728	000000.232
1,1	14	18:18	0.012	3.728	000000.257
1,1	15	18:33	0.009	3.728	000000.282
1,1	16	18:48	0.012	5.273	000000.317
1,1	17	19:03	0.012	5.239	000000.353
1,1	18	19:18	0.012	6.651	000000.397
1,1	19	19:33	0.009	6.651	000000.442
1,1	20	19:48	0.009	6.651	000000.486
1,1	21	20:03	0.012	6.651	000000.531
1,1	22	20:18	0.012	6.651	000000.576
1,1	23	20:33	0.009	3.404	000000.612
1,1	24	20:48	0.012	3.425	000000.634

Figure 4-7 Report: Combined Results

```
SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 1.02
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
                        FR-TEMP
SAMPLE  BOTTLE TIME           C
------- ------ ----         ----
                   NO FR-TEMPERATURE
----------------------------------------



SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 0.01.0127
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml
SAMPLE  BOTTLE TIME
------- ------ ----------- ------ ----
                   NO RAIN GAUGE
----------------------------------------



SAMPLER ID# 3687447734  06:32 19-DEC-02
  Hardware: A0      Software: 0.01.0127
SDI-12 DATA
*********** COMBINED RESULTS ***********
   SITE: FACTORY051
Program Started at 15:03 WE 18-DEC-02
Nominal Sample Volume =  200 ml


                   NO SDI-12 SONDE
----------------------------------------
```

Figure 4-8 Report: Combined Results (continued)

```
SAMPLER ID# 3687447734   16:41 20-DEC-02
   Hardware: A0      Software: 1.02
  BUBBLER MODULE: 2215419583
   Hardware: A00000  Software: 1.07
    SITE: FACTORY051

   Summary Report for 19-DEC-02 (TH)
         Day's Flow:     000000.054 Mgal
      Average Flow Rate:      0.4437 cfs
07:20 Minimum Flow Rate:      0.0237 cfs
13:25 Maximum Flow Rate:      7.0207 cfs
       Hourly Average Flow Rate:
      00:00-01:00:        NO DATA
      01:00-02:00:        NO DATA
      02:00-03:00:        NO DATA
      03:00-04:00:        NO DATA
      04:00-05:00:        NO DATA
      05:00-06:00:        NO DATA
      06:00-07:00:        NO DATA
      07:00-08:00:        NO DATA
      08:00-09:00:      2.519 cfs
      09:00-10:00:      2.747 cfs
      10:00-11:00:      2.791 cfs
      11:00-12:00:      3.456 cfs
      12:00-13:00:      5.385 cfs
      13:00-14:00:      6.651 cfs
      14:00-15:00:      2.591 cfs
      15:00-16:00:      1.593 cfs
      16:00-17:00:        NO DATA
      17:00-18:00:        NO DATA
      18:00-19:00:        NO DATA
      19:00-20:00:        NO DATA
      20:00-21:00:        NO DATA
      21:00-22:00:        NO DATA
      22:00-23:00:        NO DATA
      23:00-24:00:        NO DATA

            *---+---+---+---+---+---+*
      8.00  +                       +
            I                       I
            I                       I
            I             #         I
            I             #         I
      6.00  +             #         +
            I             #         I
            I            ##         I
            I            ##         I
            I            ##         I
      4.00  +            ##         +
            I           ###         I
            I           ###         I
            I         #####         I
            I        #######        I
      2.00  +        #######        +
            I        #######        I
            I        ########       I
            I        ########       I
            I        ########       I
      0.00  +        ########       +
            *---+---+---+---+---+---+*
 Hour Ending:       08:     16:     24:
            Units are 'cfs'
```

Figure 4-9 Report: Summary

4.16 System IDs

System IDs

RUN
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select VIEW REPORT.

VIEW DATA
SYSTEM IDs
CONFIGURE REPORTS

• Select SYSTEM IDs.

SAMPLER
6712 ID _____
HARDWARE: __
SOFTWARE: __

• Displayed briefly

[*MODULE TYPE*]
[*MODEL #*] ID: _____
HARDWARE: __
SOFTWARE: __

• Displayed briefly

SOFTWARE OPTIONS

[*Options List*]

• Press STOP to return to the main menu.

In addition to viewing report data and configuring reports, the View Report option on the main menu lets you view system identification information.

The sampler reports the sampler model number, ID (identification number), and software version number as system identification notes. The sampler also reports the same information for an attached module.

The model and ID numbers remain unchanged through the life of the sampler. The ID numbers appear on the sampler's reports and in files created by flowlink and samplink when they interrogate the sampler. The software packages use the ID number to make sure that data from different samplers is not combined in the same file.

The software version number changes when your sampler's software is updated.

The system will also list any software options that you have activated on your unit. These software options are discussed in Section 5.

4.17 Programming for 700 Series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. These modules are optional accessories that are not required for operation of the 6712. However, the modules offer an economical way to combine flow-rate or parameter monitoring with sampling.

The programming of these modules is integrated with the programming of the sampler, so attachment of a module will cause different screens to be displayed, depending on the type of module and the selections you make while programming.

Two modules that are commonly used are the 730 Bubbler Module, which monitors a flow stream's level and flow rate, and the 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate. The following sets of screens give you an example of what screens you might see while programming the sampler and module. Refer to Table 4-1 (which does not have a module attached) at the beginning of this section to compare the sequence of screen displays.

⚠ CAUTION

Most Teledyne Isco accessories and interfacing equipment are not certified for us in hazardous locations as defined by the National Electrical Code. Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies. Refer to Appendix C in the back of this manual for more safety information.

Table 4-4 Programming Example With 730 Module Installed

1	MODULE INSERTED--- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	With the sampler off, insert the module in the bay on the controller. Turn the sampler on by pressing the On/Off key. Press ↵. Download stored data, if you want to keep it. Pressing DONE erases it and advances to the next screen.
2	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	This screen will now appear for 8 seconds.
3	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
4	SITE DESCRIPTION: "FACTORY051" CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn't necessary to change the description.
5	SELECT UNITS FOR FLOW RATE: **cfs** gps gpm Mgd lps m3s m3h m3d	Select the desired units for the flow rate. For this example, choose cfs. Press ↵.
6	SELECT UNITS FOR FLOW VOLUME: cf gal **Mgal** m3 lit	Select the desired units for the flow volume. For this example, choose Mgal. Press ↵.
7	PROGRAM MODULE? **YES** NO	Select YES to program the module.

Table 4-4 Programming Example With 730 Module Installed (Continued)

8	MODE OF OPERATION: FLOWMETER LEVEL ONLY	If you choose Flowmeter, proceed to screen #9 below. If you choose LEVEL ONLY, proceed to screen #12.
9	**WEIR** FLUME DATA POINTS EQUATION MANNING FLOW-INSERT	When you select Flowmeter, you will have several options for performing the flow conversion. For this example, choose Weir. Press ↵.
10	**V-NOTCH** RECTANGULAR CIPOLLETTI	For this example, choose V-Notch. Press ↵.
11	V-NOTCH WEIR ANGLE: 120 **90** 60 45 30 22.5	For this example, choose a Weir angle of 90. Press ↵.
12	CURRENT LEVEL IS __.__ ft ADJUST LEVEL TO __.__ ft	The current level will be displayed. Enter an adjustment if needed. If the adjustment is different by more than 0.50 ft, you will be prompted "ARE YOU SURE? YES NO" Choose NO to re-enter; select YES if correct. Press ↵.
13	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵. For this example, select 24.
14	BOTTLE VOLUME IS 1000 ml (300-30000)	Type the volume for the bottles in your kit. For this example, 1000 is correct, so simply press ↵.
15	SUCTION LINE LENGTH IS 10 ft (3-99)	Type the length of the suction line, then press ↵. If you change the length, the sampler will display a message, "PLEASE WAIT!. . . GENERATING PUMP TABLES."
16	TIME PACED **FLOW PACED**	Select FLOW PACED. If the module is being used as a flowmeter, you will see screen #17a. If the module is being used for level only, you will see screen #17b.
17a	FLOW BETWEEN SAMPLE EVENTS: **0.075 Mgal** (0.001 - 99999)	If the module is being used as a flowmeter, choose the amount of flow between sample events.

Table 4-4 Programming Example With 730 Module Installed (Continued)

17	FLOW BETWEEN SAMPLE EVENTS: **2** PULSES (1-9999)	If the module is being used for level only, enter the number of pulses between sample events.
18	SEQUENTIAL **BOTTLES/SAMPLE** SAMPLES/BOTTLE	Select BOTTLES/SAMPLE.
19	**2** BOTTLES PER SAMPLE EVENT (1-24)	Enter 2.
20	RUN CONTINUOUSLY? YES **NO**	Select NO.
21	SAMPLE VOLUME: **250** ml (10-1000)	Enter 250.
22	NO DELAY TO START DELAYED START **CLOCK TIME** WAIT FOR PHONE CALL	Select CLOCK TIME.
23	START FLOW COUNT AT: 06:00	Enter 6, then enter 0. This is the time at which the sampler will start the pacing countdown.
24	SELECT DAYS: SU **MO** TU **WE** TH **FR** SA DONE	Select MO, WE, and FR. Use the arrow keys and ↵ to select MO, WE, and FR. When the correct days are blinking, select DONE and press ↵.
25	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

Table 4-5 Programming Example With 750 Module Installed

1	MODULE INSERTED--- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	With the sampler off, insert the module in the bay on the controller. Turn the sampler on by pressing the On/Off key. Press ↵. Download stored data, if you want to keep it. Pressing DONE erases it and advances to the next screen.
2	6712 SAMPLER STANDARD PROGRAMMING For HELP at any screen press ? key.	This screen will now appear for 8 seconds.
3	RUN **PROGRAM** VIEW REPORT OTHER FUNCTIONS	The option PROGRAM will be blinking. Press ↵.
4	SITE DESCRIPTION: "FACTORY051" CHANGE? YES **NO**	The option NO will be blinking. Press ↵. For the purposes of this example, it isn't necessary to change the description.
5	SELECT UNITS FOR FLOW RATE: **cfs** gps gpm Mgd lps m3s m3h m3d	Select the desired units for the flow rate. For this example, choose cfs. Press ↵.
6	SELECT UNITS FOR FLOW VOLUME: cf gal **Mgal** m3 lit	Select the desired units for the flow volume. For this example, choose Mgal. Press ↵.
7	SELECT UNITS FOR VELOCITY: **fps** mps	Select the desired units for the flow velocity. For this example, choose fps. Press ↵.
8	PROGRAM MODULE? **YES** NO	Select YES to program the module.
9	MODE OF OPERATION: **FLOWMETER** LEVEL AND VELOCITY	The 750 can have two different modes of operation: Flowmeter or Level and Velocity. For this example, choose Flowmeter. Press ↵.
10	FLOW CALCULATION: **AREA * VELOCITY** LEVEL TO FLOW RATE	When you select Flowmeter, you will have two options for performing the flow conversion: Area * Velocity or Level to Flow Rate. For this example, choose Area * Velocity. Press ↵.
11	LEVEL TO AREA: **CHANNEL SHAPE** DATA POINTS	For this example, choose Channel Shape. Press ↵.
12	**ROUND PIPE** U-CHANNEL RECTANGULAR CHANNEL TRAPEZOIDAL CHANNEL	For the channel shape, select Round Pipe. Press ↵.

Table 4-5 Programming Example With 750 Module Installed (Continued)

13	ROUND PIPE DIAMETER = 2.00 ft	Enter the diameter of the round pipe. Press ↵.
14	CURRENT LEVEL IS __.__ ft ADJUST LEVEL TO __.__ ft	The current level will be displayed. Enter an adjustment if needed. If the adjustment is different by more than 0.50 ft, you will be prompted "ARE YOU SURE? YES NO" Choose NO to re-enter; select YES if correct. Press ↵.
15	ZERO LEVEL OFFSET: _.___ ft	Enter the amount of zero level offset. Press ↵.
16	MAXIMUM DEPTH FOR VELOCITY MEASUREMENT 2" 3" 4"	(This screen is applicable for standard-sized probes only.) Select the maximum depth for the velocity measurement. Press ↵.
17	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select the number of bottles in your bottle kit by pressing either arrow key until the correct number blinks. Press ↵.
		From this point forward, the screens will be the same as in Table 4-2.

6712 Portable Sampler

Section 5 Extended Programming

The 6712 Sampler has two sets of programming screens. The first set, called standard programming screens, lets you set up typical sampling programs easily and efficiently. The second set, extended programming screens, lets you create sophisticated programs for complex sampling applications.

All of the sampling features available with standard programming screens, discussed in Section 4, are available with extended programming screens. However, the extended screens provide several additional features and some screen display differences which are discussed in this section. The menu flowcharts for both sets of programming screens are in *Appendix A, Menu Flowcharts*.

> ☑ ***Note***
>
> This section assumes that you have read, and are familiar with, the instructions in Section 4, Standard Programming!

5.1 Extended and Standard Mode

The sampler is shipped with factory default settings in standard programming mode when you first turn the sampler on. The start-up screen tells you which programming mode the sampler is currently using. You can switch between programming modes by entering a numerical command at the main menu:

At the main menu type **6712.2** to enter extended programming mode.

At the main menu type **6712.1** to enter standard programming mode.

RUN “EXTENDED 1”
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

Main Menu for Extended Mode

5.2 One-Part and Two-Part Programs

Extended programming lets you set up a “one-part” program or a “two-part” program. One-part programs let you fill all bottles of the tub with one set of pacing, distribution, and enable settings. Two-part programs add an additional set of extended pacing, distribution, and enable screens to the sampling program. Each set of screens is called a program part. The program parts are simply called part ‘A’ and part ‘B’. Both parts share the program settings for suction-line length, suction head, and rinses and retries. They also share one start-time setting.

Each part has its own group of bottles. Because settings for each part are independent of each other, the sampler, when running a two-part program, fills each bottle group as if they were being filled by two different programs. Two-part programs finish when both parts are done.

Two-part programming is ideal for sampling storm events. Many storm-water run-off monitoring permits require a first-flush grab sample within the first 30 minutes of the storm event and flow-paced samples during the remainder of the event. With a two-part program, you can set up part 'A' for the first-flush sample and part 'B' for the remainder. Table 5-2 shows a storm-water sampling program.

5.3 Storage for Extended Programs

The sampler stores five sampling programs: one standard and four extended. Program storage eliminates the need to reprogram the sampler with frequently used settings. This feature is especially useful for complex extended programs such as two-part programs or programs with many nonuniform-time settings.

Teledyne Isco ships the sampler to you with factory programs that you can modify to suit your own needs. All four extended programs are identical to each other.

The stored programs will also save your 700 Series Module program settings and any sampler enable conditions using rain gauge data or SDI-12 sonde parameters. These program settings remain as long as you do not change the type of module, or change the rain gauge or SDI-12 Hardware Setup.

5.3.1 Selecting a Stored Program

When the sampler is in extended programming mode, it always has one current and three noncurrent programs, each occupying a permanent location in memory. The first time you access the extended mode, the current program is "EXTENDED 1," one of the factory extended programs. The name of the current extended program appears in quotations on the first line of the main menu.

The factory programs are named "EXTENDED 1," "EXTENDED 2," "EXTENDED 3," and "EXTENDED 4." You can rename them with more descriptive names, making them easier to identify. The program name is one of the extended program's settings.

After selecting a stored program, review the settings with the quick view screens. Each sampling program stores all the settings required by the sampler to run a program. These settings include the bottle-kit information (number of bottles and the bottle volume), the suction-line length, the site description, start times, and so on.

If you use the same program at two sites — each requiring different bottle configurations, suction line lengths, or other details — always check these settings before running a program. You may need to make minor changes to the program to make sure the settings match your equipment.

The current program is the program you see when you select PROGRAM from the main menu and page through the programming screens. It is the program the sampler uses when you select RUN from the main menu.

You cannot delete programs, but you can modify them as often as necessary. To run a program with different settings without losing the settings in your current program, select a stored program and modify its settings.

For example, assume you have been running the current program, named "EXTENDED 1," at site A for several weeks. This program contains all the settings you need for site A, and you don't want to lose those settings.

Nevertheless, you need another program because you want to move the sampler to site B, so you select "EXTENDED 2" and modify it for site B. The settings in "EXTENDED 1" are preserved automatically. When you return the sampler to site A, you won't need to reprogram the sampler. Merely select "EXTENDED 1" again, double-check the program settings, and run the program. To select an extended program, follow the steps in Table 5-1.

Table 5-1 Selecting a Stored Extended Program

1	6712 SAMPLER, EXTENDED PROGRAMMING For HELP at any screen, press ? key.	Press the On/Off key to turn the sampler on. Press ↵ to clear the start-up message. If the words "STANDARD PROGRAMMING" appear on the second line of the start-up message, the sampler is using the standard programming screens. To see the extended screens, type **6712.2** at the main menu shown in step 2.
2	RUN "EXTENDED 1" **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM from the main menu.
3	PROGRAM NAME: **"EXTENDED 1"** SITE DESCRIPTION: "_____"	Select PROGRAM NAME: "EXTENDED 1" from the quick view menu.
4	**SELECT NEW PROGRAM** CHANGE PROGRAM NAME	Select SELECT NEW PROGRAM to change the program. You can go through QUICK VIEW screens quickly by pressing ↵ at each screen. You can also change settings in quick view screens; see *Changing Settings in a Quick View Screen* on page 3-4.
5	"EXTENDED 1" **"EXTENDED 2"** "EXTENDED 3" "EXTENDED 4"	Select the name of the extended program you want to use. Each program's name appears on the same line. If you inadvertently give two programs identical names, you can still identify them by their location on the screen.
6	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	To run the program immediately, select YES. To run the program later, select NO.
7	**RUN "EXTENDED 2"** PROGRAM VIEW REPORT OTHER FUNCTIONS	

5.4 Programming for 700 series Modules

The bay on the controller's side accepts any of Teledyne Isco's 700 Series Modules. These optional accessories are not required to operate the 6712. However, the modules offer an economical way to combine flow-rate or parameter monitoring with sampling.

The programming of these modules is integrated with the programming of the sampler, so attachment of a module will cause different screens to be displayed, depending on the type of module and the selections you make while programming.

Two modules that are commonly used are the 730 Bubbler Module, which monitors a flow stream's level and flow rate, and the 750 Area Velocity Module for monitoring a flow stream's level, velocity, and flow rate. Section 4 contains two examples of programming for modules. Module programming is the same in Extended as it was in Standard programming.

5.5 Programming SDI-12 Sondes

As an option, the 6712 accepts up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9. The data parameters used by the sonde and sampler must match. Certain vendors' sondes, such as Hydrolab and YSI, have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure. Other sondes can be used, but require manual setup to identify proper data types for each data value reported.

For more information about programming SDI-12 sondes, refer to Section 6.

5.6 Programming Examples

In addition to the features available with standard programming, and discussed in Section 4, extended programming offers:

- Nonuniform time pacing
- Random interval pacing
- Event pacing
- Multiple bottle compositing
- Time switched bottles or bottle sets
- Programmable sampler enable
- Pauses and resumes
- Two-part programming
- Automatic or user-defined suction head
- Suction line rinses
- Sampling retries

This manual provides several programming examples. Some, demonstrating simple tasks, appear in the margins. Others, demonstrating more complex tasks, appear as examples. Table 5-2 on the following pages steps you through a storm water runoff sampling using extended programming.

5.6.1 Storm Water Runoff Sampling

Storm water runoff sampling is an ideal application for two-part programming. Typical monitoring permits require that a series of timed samples be taken during the initial portion of the storm event, followed by flow paced samples during the remainder of the event.

This example assumes that a Rain Gauge and a Bubbler Flow Module are connected to the sampler.

> ☑ ***Note***
>
> To enable the Bubbler Module programming screens, insert the module before turning on the sampler

Using a 24-bottle kit, it divides the bottles into two groups, with six bottles assigned to part 'A' and 18 to part 'B.' The sampler will begin taking samples after being enabled according to programmable enable controls; that is, when the rain gauge detects 0.15 inches of rainfall in 30 minutes, and the module detects a flow stream level of more than 0.25 feet. Because both program parts use the same enable settings, the sampler will enable both parts at the same time. A list of settings for the program follow:

- Program type: Extended.
- Program name: STORM.
- Site description: SITE 54.
- Units: Length – Ft, Flow Rate – gpm, Flow Volume – gal
- Mode of Operation: Flowmeter, Flow-Insert, Round, 12"
- Bottle kit: 24, 1000-milliliter bottles.
- Suction-line length: 5 feet.
- Suction head: Auto suction head.
- Line rinses: None.
- Sampling retries: None.
- Part 'A' and 'B' bottle assignments: Bottles 1 - 6 to part 'A', bottles 7 - 24 to part 'B'.
- Part 'A' pacing: Time pacing, sampling every 5 minutes.
- Part 'A' distribution: Sequential, 1 sample per bottle.
- Part 'A' sample volume: 800 milliliters.
- Part 'A' enable: At least 0.15 inches of rainfall in 30 minutes and a flow stream level of more than 0.25 feet; once enabled, stay enabled, sample taken when the sampler is enabled.
- Part 'A' pause and resumes: None.
- Part 'B' pacing: Flow pacing, sampling every 2,500 gallons.
- Part 'B' distribution: Sequential, 1 sample per bottle.
- Part 'B' sample volume: 500 milliliters.
- Part 'B' enable: At least 0.15 inches of rainfall in 30 minutes and a flow stream level of more than 0.25 feet;

once enabled, stay enabled, no sample taken when the sampler is enabled; first sample taken 20 minutes after the sampler is enabled.

- Part 'B' pause and resumes: None.
- Start time: Delayed start of 1 minute.
- 730 Bubbler Module: Installed

Table 5-2 Storm Water Runoff Sampling

1	6712 SAMPLER EXTENDED PROGRAMMING For HELP at any screen press ? key.	This screen will appear briefly.
2	RUN "EXTENDED 1" **PROGRAM** VIEW REPORT OTHER FUNCTIONS	Select PROGRAM. Note: If the start-up screen displayed "STANDARD PROGRAMMING", type **6712.2** at this menu before selecting PROGRAM.
3	PROGRAM NAME: "EXTENDED 1 " CHANGE? **YES** NO	Select YES. Note: If the quick view screen shows up, press STOP then select OTHER FUNCTIONS, SOFTWARE OPTIONS, QUICKVIEW/CHANGE, NORMAL. Then press STOP and go back to step 2.
4	SELECT NEW PROGRAM **CHANGE PROGRAM NAME**	Select CHANGE PROGRAM NAME.
5	NAME: "**STORM** " ABCDEFGHIJKLMNOPQRST UVWXYZ-& 0123456789 BACK-UP DONE	Enter the word "STORM" for the program name.
6	SITE: DESCRIPTION "FACTORY051" CHANGE? **YES** NO	Select YES.
7	SITE: "**SITE 54** " ABCDEFGHIJKLMNOPQRST UVWXYZ-& 0123456789 BACK-UP DONE	Enter "SITE 54" for the site description.
8	SELECT UNITS FOR LENGTH: **ft** m	Select ft.
9	SELECT UNITS FOR FLOW RATE cfs gps **gpm** Mgd lps m3s m3h m3d	Select gpm.
10	SELECT UNITS FOR FLOW VOLUME cf **gal** Mgal m3 lit	Select gal.

Table 5-2 Storm Water Runoff Sampling (Continued)

11	PROGRAM MODULE? **YES** NO	Select YES
12	MODE OF OPERATION **FLOWMETER** LEVEL ONLY	Select FLOWMETER
13	WEIR FLUME DATA POINTS EQUATION MANNING **FLOW-INSERT**	Select FLOW-INSERT.
14	WEIR/ORIFICE TYPE V-NOTCH **ROUND**	Select ROUND.
15	FLOW INSERT SIZE: 6" 8" 10" **12"**	Select 12.
16	NEW MODULE SETUP-- DOWNLOAD DATA NOW OR LOSE ALL DATA! DONE	Select DONE. Note: Partition memory status message will be displayed briefly.
17	CURRENT LEVEL IS ___.___ ft. ADJUST LEVEL TO ___.___ ft.	Press ENTER.
18	DATA STORAGE INTERVAL IN MINUTES 1 2 **5** 10 15 30	Select 5. (If the data storage interval is different from the current program, you will be informed that the storage interval has changed, and that the stored data will be lost. Download stored data (if desired) and select DONE.
19	NUMBER OF BOTTLES: 1 2 4 8 12 **24**	Select 24.
20	BOTTLE VOLUME IS 1000 ml (300-30000)	Enter 1000.
21	SUCTION LINE LENGTH IS 5 ft (3-99)	Enter 5. The 6712 calculates new pump tables.
22	**AUTO SUCTION HEAD** ENTER HEAD	Select AUTO SUCTION HEAD.

Table 5-2 Storm Water Runoff Sampling (Continued)

23	0 RINSE CYCLES (0-3)	Enter 0.
24	RETRY UP TO 0 TIMES WHEN SAMPLING (0-3)	Enter 0.
25	ONE-PART PROGRAM **TWO-PART PROGRAM**	Select TWO-PART PROGRAM.
26	24 BOTTLES AVAILABLE ASSIGN BOTTLES 1 THRU **6** TO PART 'A' (1-23)	Enter 6. Screen will say "Beginning Part A" before proceeding with screen 27.
27	**UNIFORM TIME PACED** FLOW PACED EVENT PACED NONUNIFORM TIME	Select UNIFORM TIME PACED.
28	TIME BETWEEN SAMPLE EVENTS: 0 HOURS, **5** MINUTES	Enter 0 for hours, 5 for minutes.
29	**1** BOTTLES PER SAMPLE EVENT (1- 6)	Enter 1.
30	SWITCH BOTTLES ON: **NUMBER OF SAMPLES** TIME	Select NUMBER OF SAMPLES.
31	SWITCH BOTTLES EVERY **1** SAMPLES (1-50)	Enter 1.
32	RUN CONTINUOUSLY? YES **NO**	Select NO.
33	DO YOU WANT SAMPLE VOLUMES DEPENDENT ON FLOW? YES **NO**	Select NO.
34	SAMPLE VOLUME **200** ml (10-1000)	Enter 800.

Table 5-2 Storm Water Runoff Sampling (Continued)

35	ENABLE: **RAIN** LEVEL FLOW NONE	Select RAIN. Note: All valid enable options will appear here, so your screen may differ.
36	ENABLE: RAIN **AND** OR DONE	Select AND.
37	ENABLE: RAIN AND **LEVEL** FLOW NONE	Select LEVEL.
38	"RAIN" SET POINT: **0.15** INCHES PER __HOURS, __MINUTES	Enter 0.15 for inches, then enter 30 minutes.
39	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
40	RESET RAIN HISTORY? **YES** NO	Select YES.
41	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
42	"LEVEL" SET POINT **0.25** ft (0.001-30.000)	Enter 0.25.
43	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
44	ONCE ENABLED, STAY ENABLED? **YES** NO	Select YES.
45	SAMPLE AT ENABLE? **YES** NO	Select YES.
46	PAUSE RESUME 1. HH:MM DD HH:MM DD 2. HH:MM DD HH:MM DD CLEAR **DONE**	Select DONE. Screen will say "End of Part A" then "Beginning Part B."
47	UNIFORM TIME PACED **FLOW PACED** EVENT PACED NONUNIFORM TIME	Select FLOW PACED.

Table 5-2 Storm Water Runoff Sampling (Continued)

48	PACED BY: FLOW PULSES **FLOW MODULE VOLUME**	Select FLOW MODULE VOLUME.
49	FLOW BETWEEN SAMPLE EVENTS: 2500 gal (0.001-99999)	Enter 2500.
50	SAMPLE AT START? **YES** NO	Select YES. This will cause the first sample to be taken 20 minutes (the delay to start of sampling specified in Step 67) after the enable for Part B.
51	1 BOTTLES PER SAMPLE EVENT (1- 18)	Enter 1.
52	SWITCH BOTTLES ON: **NUMBER OF SAMPLES** TIME	Select NUMBER OF SAMPLES.
53	SWITCH BOTTLES EVERY **1** SAMPLES (1- 50)	Enter 1.
54	RUN CONTINUOUSLY? YES **NO**	Select NO.
55	SAMPLE VOLUME: **200** ml (10-1000)	Enter 500.
56	ENABLE: **RAIN** LEVEL FLOW 'A' DONE NONE	Select RAIN.
57	ENABLE: RAIN **AND** OR DONE	Select AND.
58	ENABLE: RAIN AND **LEVEL** FLOW 'A' DONE DONE	Select LEVEL.
59	"RAIN" SET POINT: **0.15** INCHES PER __HOURS, __MINUTES	Enter 0.15 for inches, then enter 30 minutes.
60	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.

Table 5-2 Storm Water Runoff Sampling (Continued)

61	RESET RAIN HISTORY? **YES** NO	Select YES.
62	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
63	"LEVEL" SET POINT **0.25** ft (0.100-30.000)	Enter 0.25.
64	ONCE ENABLED, STAY ENABLED? **YES** NO	Select YES.
65	SAMPLE AT ENABLE? YES **NO**	Select NO.
66	START OF SAMPLING AFTER A 15 MINUTE DELAY (1-999)	Enter 20.
67	PAUSE RESUME 1. HH:MM DD HH:MM DD 2. HH:MM DD HH:MM DD CLEAR **DONE**	Select DONE. Screen will say "End of Part B."
68	NO DELAY TO START **DELAYED START** CLOCK TIME WAIT FOR PHONE CALL	Select DELAYED START.
69	START "STORM" AFTER A 72 HOUR "DRY" PERIOD? YES **NO**	Select NO. (Option for samplers using a 0.01 inch tip rain gauge. See Dry Period Option, described on page 5-26.)
70	START "STORM" AFTER A 1 MINUTE DELAY (1-999)	Enter 1.
71	PROGRAMMING COMPLETE RUN THIS PROGRAM NOW? YES **NO**	Select NO.

The above example presented several screens that are not available in standard programming. Descriptions of features available in extended programming follow.

5.7 Suction Head

Extended Screen for Suction Head Settings

```
AUTO SUCTION HEAD
ENTER HEAD
```

If you choose AUTO SUCTION HEAD, the head will be determined for you. If you select ENTER HEAD, the screen below will be displayed so you can enter the suction head.

```
SUCTION HEAD OF
___ ft
(min - max)
```

Suction head is the vertical distance between the surface of the liquid source and the sampler's pump. At each sample event, the sampler determines the suction head automatically.

In extended programming, you can manually enter the suction head if you want. Select ENTER HEAD only when the head remains stable and you can measure it accurately.

5.8 Rinses and Retries

Screens for Line Rinses and Sampling Retries

```
__RINSE CYCLES
(0-3)
```

```
RETRY UP TO __ TIMES
WHEN SAMPLING
(0-3)
```

Rinses and retries are extended programming features. You can program the sampler to rinse the suction line automatically. During a line rinse cycle, the sampler draws liquid through the line to the liquid detector. As soon as it detects liquid, the sampler reverses the pump to purge the line.

The sampling retries feature lets you set the number of times, from 0 to 3, that the sampler tries to detect liquid in the line before skipping the sample.

5.9 Pacing

Extended Pacing Screen

```
UNIFORM TIME PACE
FLOW PACED
EVENT PACED
NONUNIFORM TIME
```

Sample pacing is the rate at which the sampler takes samples. Depending on the type of pacing you select, the rate is controlled by the sampler's internal clock or by inputs received from connected instruments.

Standard programming provides time pacing and flow pacing, which are described in Section 4. Extended programming provides additional pacing types, so its pacing screen (see example in margin) has four items listed instead of two.

"Uniform time" pacing is identical to "time" pacing in standard programming. "Flow paced" is the same for both types of programming. Event paced and nonuniform time pacing are described below.

5.9.1 Event Pacing

To program the sampler for event pacing, select event paced. Refer to Table 5-3 for an example of event paced sampling that uses three event conditions.

Up to fourteen event conditions can be defined (for two-part programs, up to fourteen event conditions can be defined for each part). An event will occur when any of the programmed event

conditions becomes true. The default distribution setting for event-paced sampling is sequential (each time an event occurs, the sampler takes one sample, placing it in one bottle). However, any distribution setting may be used.

If you have programmed multiple conditions, and more than one condition comes true at the same time (within your measurement interval), one sample will be taken and all conditions that caused the event will be noted on reports.

Table 5-3 uses **rate of change** for the event condition (see step 7). This feature enables the event condition under specific circumstances.

In the example below, a rate of change is set so that if the level rises more than one foot in a two hour time period, the event condition would be enabled and a sample taken.

In determining if the rise occurs in this example, the sampler looks back at the previous two hour time period to see if there is a rise of more than one foot between any valley (low point) or peak (high point) within that time period.

Once the condition becomes true (a rise of more than one foot is noted), the event condition is enabled. It will not be enabled again unless the condition becomes false, and then true again, within the two hour time window.

In event pacing, up to three different rate of change event conditions can be programmed (for two-part programs, a total of six rate of change event conditions can be defined, three for each part).

5.9.2 Event Paced Sampling

This example uses a sampler with an attached 730 Bubbler Flow Module, Rain Gauge, and an SDI-12 sonde at address 5 with four parameters.

Table 5-3 Event Paced Sampling

1	UNIFORM TIME PACED FLOW PACED **EVENT PACED** NONUNIFORM TIME	Select EVENT PACED.
2	EVENT01: RAIN **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select the parameters that will trigger the event. Use the arrow keys to move through the parameters. To define the first event for this example, select LEVEL.
3	"LEVEL" CONDITION: **SET POINT** RANGE RATE OF CHANGE	Choose SET POINT.
4	"LEVEL" SET POINT: **1.000** ft (0.001 - 30.00)	Enter a set point of 1 foot.

Table 5-3 Event Paced Sampling (Continued)

5	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
6	EVENT02: RAIN **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select LEVEL again.
7	"LEVEL" CONDITION: SET POINT RANGE **RATE OF CHANGE**	Choose RATE OF CHANGE.
8	CONDITION IS TRUE WHEN "LEVEL" **RISES** FALLS	Choose RISES. This will enable the event condition if a rise occurs within the time frame and above the amount specified in screen #9.
9	"LEVEL" RISES **1.000** ft __HOURS, __MINUTES	Enter 1 ft and press ↵. Then enter 2 hours.
10	EVENT03: RAIN LEVEL FLOW TEMP5 **pH5** SP_CO5 DO5 DONE	Select pH.
11	"pH5" CONDITION: SET POINT **RANGE** RATE OF CHANGE	Select RANGE.
12	"pHx" RANGE: LOWER: **4.00** UPPER: **10.00** (0.00 - 14.00)	Enter 4 for the lower range and 10 for the upper range.
13	ENABLED WHEN: **INSIDE RANGE** OUTSIDE RANGE	Choose INSIDE RANGE.
14	EVENT04: RAIN LEVEL FLOW TEMP5 pH5 SP_CO5 DO5 DONE	You will not be entering a fourth event condition, so use the arrow keys to scroll down, and then select DONE.
15	PACING: EVENT PACED 3 EVENT CONDITIONS	Proceed with the rest of the programming steps.

5.9.3 Nonuniform Time Pacing

The extended time pacing options are uniform time and nonuniform time. "Uniform time" pacing is identical to "time" pacing in standard programming. Nonuniform time pacing uses an irregular interval between sample events; each interval is individually programmable. There are three types of nonuniform time pacing:

- Nonuniform clock time pacing.
- Nonuniform interval pacing.
- Random interval pacing.

5.9.4 Nonuniform Clock Time Pacing

For clock time pacing, enter specific times for each sample event (see screen 2). You can enter as many as 99 clock times, but the interval between times cannot be greater than 24 hours. (Remember to use a 24-hour clock when entering times.) The sampler takes a sample at the start time.

5.9.5 Nonuniform Interval Pacing

For nonuniform interval pacing, enter the number of sample events spaced at intervals of minutes: 12 samples at 5 minute intervals, 6 samples at 10 minute intervals, and so on. The sampler accepts as many as 99 nonuniform interval entries. The sampler takes a sample at start time.

5.9.6 Random Interval Pacing

Time Pacing Screens

1
```
NONUNIFORM TIME:
CLOCK TIMES
INTERVALS IN MINUTES
RANDOM INTERVALS
```

CLOCK TIMES

2
```
TAKE SAMPLES AT:
1. START TIME
2. HH:MM
3. HH:MM
```

INTERVALS IN MINUTES

3
```
FIRST SAMPLE AT
START TIME,
THEN . . .
```

4
```
QUANTITY AT INTERVAL
1. __ AT ___ MIN
2. __ AT ___ MIN
3. __ AT ___ MIN
```

RANDOM INTERVALS

5
```
PROGRAM RUN TIME:
__ HOURS, __ MINUTES
```

To program the sampler for random interval pacing, enter the length of time you want to sample. The run time is the only random programming setting you'll need to enter because the sampler derives the number of sample events required for the program from the distribution settings. (You can combine random pacing with any distribution.) Each time you run the program, the sampler generates a new set of random intervals. This makes each sample event unpredictable from run to run.

In both nonuniform clock time pacing and nonuniform interval pacing, the sampler takes a sample at the start time. For random pacing, however, it takes the first sample at the end of the first interval, not at the start time.

5.10 Distribution

Distribution describes how the sampler is to deposit samples. A sample is the volume of liquid deposited in a bottle. A sample event includes the full sampling cycle and may deposit a sample into more than one bottle. You can program the sampler for five distribution methods:

- Sequential
- Bottles per sample
- Samples per bottle
- Composite
- Multiple Bottle Compositing

5.10.1 Sequential

In sequential distribution, the sampler deposits one sample in each bottle. A sequential sample represents a "snapshot" of the flow stream at a point in time.

5.10.2 Bottles Per Sample

In bottles per sample distribution, the sampler deposits a sample in each of a set of bottles. A bottle set includes at least two bottles but may include all bottles. Use bottles per sample when the volume to be collected is larger than the amount one bottle can hold or when you need identical samples.

5.10.3 Samples Per Bottle

In samples per bottle distribution, the sampler deposits samples from several sample events in a single bottle before moving to the next bottle. Use samples per bottle distribution to collect a series of small composite samples.

5.10.4 Composite

For single bottle configurations, samples per bottle distribution is known as composite sampling. A composite sample represents an average of the flow stream's characteristics during the sampling period.

5.10.5 Multiple Bottle Compositing

Multiple bottle compositing is a combination of bottles-per-sample and samples-per-bottle. At each sample event, the sampler deposits a sample into a set of bottles. It moves to a new bottle set only after each bottle of the first set contains the programmed number of samples. Use multiple-bottle compositing to collect identical sets of composite samples or a composite sample that is larger than the capacity of a single bottle. Multiple bottle compositing is available only in extended programming.

5.10.6 Time Switching

In extended programming, the sampler offers an additional distribution feature, time switching. This feature determines when the sampler fills the next bottle or bottle set, and may be used with time-paced or flow-paced sample programs. Time switching distribution occurs at regular intervals (as programmed in screen 3 in the margin). The switch times are relative to the programmed "FIRST SWITCH TIME" (screen 4).

Switch times occur regardless of the state of the sampler. Be aware that the sampler may leave empty bottles if it becomes disabled. Pause and resumes are an exception; the sampler will not switch bottles during a pause if the current bottle is empty.

Time Switched Distribution

1 2 BOTTLES PER SAMPLE EVENT (1-max)

- Enter the number of bottles that should receive samples at each sample event.

2 SWITCH BOTTLES ON: NUMBER OF SAMPLES **TIME**

- Select TIME.

3 SWITCH BOTTLES EVERY __ HOURS, __ MINUTES

- Enter the time between bottle switches.

4 FIRST SWITCH TIME AT: __:__

- Enter the first bottle switch time.

If the program settings instruct the sampler to take a sample at the start time, the sampler also draws a sample at the switch time. When this occurs, the pacing will also be reset at the switch time.

Time switching is normally used with flow-paced programs that do not take a sample at start. These programs will place a sample in the current bottle if it is empty at the switch time, and then move to the next bottle/set. Pacing intervals are reset at every switch time.

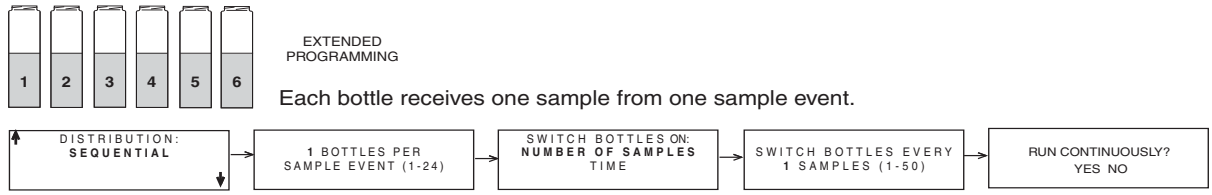
When you use the time switching feature, the volume in each bottle or bottle set may vary. Sample volumes that would exceed the bottle capacity are not taken and a "PROBABLE OVERFILL" message is logged.

5.10.7 Continuous Sampling

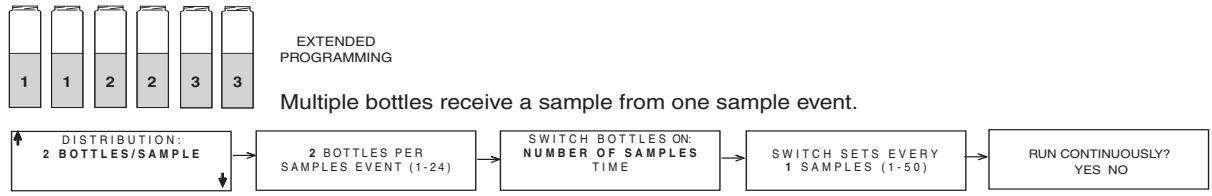
Sample programs can be run indefinitely by selecting "YES" at the "RUN CONTINUOUSLY?" screen. Continuous sampling resets the distribution when the distribution sequence is complete. That is, when the last bottle/set is reached, the next bottle/set is the first bottle/set. All pacing modes except RANDOM are supported.

When running a program continuously, the bottles must be serviced at regular intervals to prevent overfilling the bottles. The sampler assumes that the next bottle/set is empty and ready to receive samples. If you are using this feature with two-part programming, keep in mind that the parts will most likely reset at different intervals.

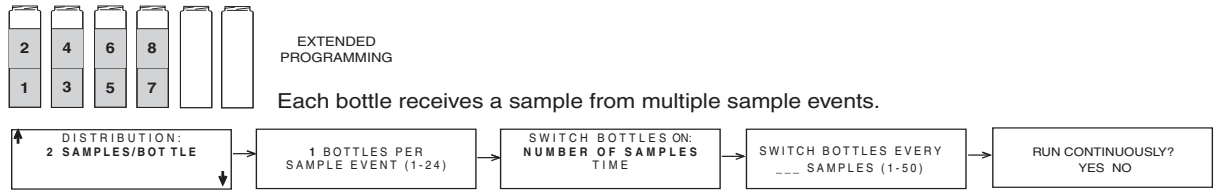
Sequential



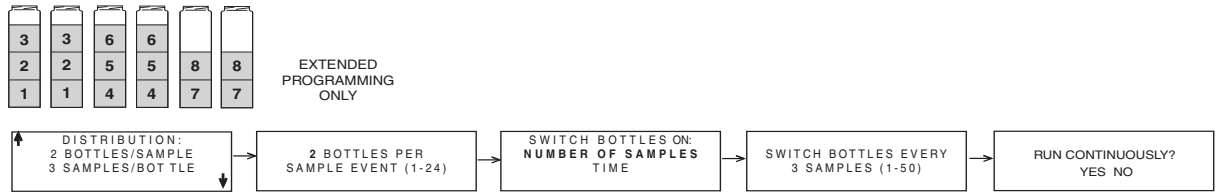
Bottles-per-Sample



Samples-per-Bottle



Multiple Bottle Compositing



Time Switched (Flow-paced, No sample at start)

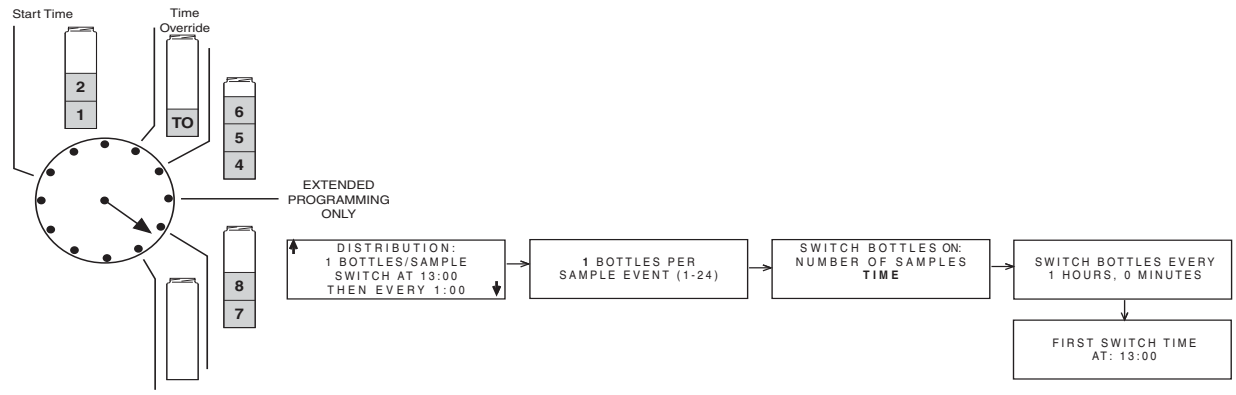


Figure 5-1 Sample Distribution

5.11 Flow Proportional Sample Volumes

The 6712 can collect flow proportional sample volumes. For some sampling protocols, these flow-weighted, variable-volume samples can be more representative of the stream. This is because stream characteristics often change as the flow fluctuates.

Variable-volume sampling is possible when the sampler is programmed for Uniform Time pacing. To enable this feature, select YES at the display asking "DO YOU WANT SAMPLE VOLUMES DEPENDENT ON FLOW?"

```
DO YOU WANT
SAMPLE VOLUMES
DEPENDENT ON FLOW?
YES    NO
```

After answering YES, the sampler displays screens to program the flow proportional volumes. If the sampler has a 700 Series Flow Module inserted, you will be asked which flow measurement should be used to determine the volumes.

```
FLOW PULSES
FLOW MODULE VOLUME
```

To base the volumes on an external flow measurement device attached to the Flow Meter connector, select FLOW PULSES. To base the volumes on the 700 Series Flow Module readings, select FLOW MODULE VOLUME.

Next, the sampler asks for the SAMPLE VOLUME to collect at each time interval. This volume is expressed as 10 ml for every *X* number of pulses, or if using a flow module, for every volume unit.

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ PULSES
```

Refer to section 5.11.1, *Calculating Variable Sample Volume Settings*, for a more detailed discussion on this setting.

The final screen used to program variable-volume sampling is the MINIMUM SAMPLE VOLUME. If the number of flow pulses or flow module volume is not sufficient enough to collect this minimum volume, the sample is skipped and the flow count carries over to the next sample time. This setting ranges from 10 ml to a maximum determined by the bottle volume.

```
MINIMUM
SAMPLE VOLUME
___ ml
(10 - maximum)
```

5.11.1 Calculating Variable Sample Volume Settings

The entry for the SAMPLE VOLUME display can be calculated based on expected flow rates and collection volume requirements.

The number of pulses or flow module volume that you enter should ensure that the minimum volume of liquid required for analysis is collected without exceeding the bottle volume capacity of the sampler. You may find it helpful to determine a range of values by calculating both possibilities. The number you enter would be selected from this range. This range is illustrated in Figure 5-2.

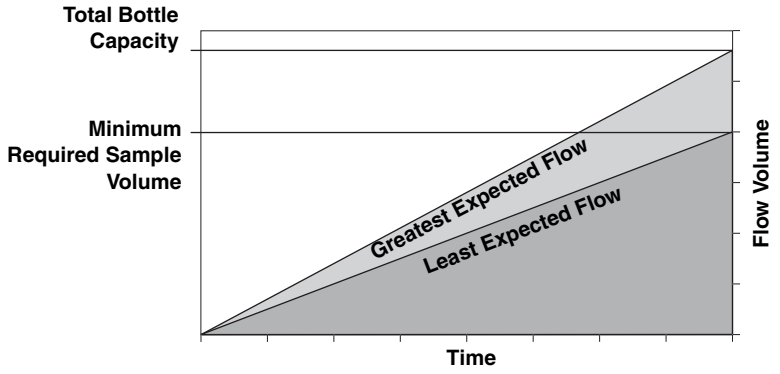


Figure 5-2 Factors Affecting Flow-Weighted Variable-Volume Samples

In other words, at the greatest expected flow, this SAMPLE VOLUME value should be set to prevent filling the bottle before the end of the program. An early full-bottle condition would result in a composite sample that is not representative of the flow stream.

At the lowest expected flow, the SAMPLE VOLUME value should be set to ensure that enough sample is collected. If too little sample liquid is collected, there may not be enough for analysis although it is a representative composite sample.

For example, consider an NPDES sampling program used to collect a flow-proportional composite sample for BOD, TSS, and NH_3-N analysis. The laboratory requires at least 1,000 ml for BOD, 100 ml for TSS, and 400 ml for NH_3-N tests. The minimum composite volume needed for analysis is then 1,500 ml, but to allow for duplicates and spillage, this volume is doubled to 3,000 ml. The samples are to be collected over an eight hour period at 15 minute intervals into a 9,400 ml composite bottle. Flow rates at the site range from 1.5 to 2.0 mgd, the equivalent volume of 500,000 and 666,667 gallons respectively over the eight hour period. This flow is measured by an external flow meter that sends a flow pulse every 100 gallons. Figure 5-3 depicts this scenario.

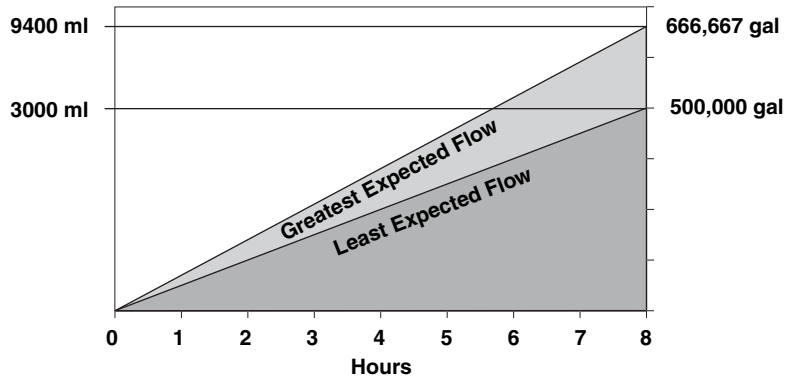


Figure 5-3 Variable-Volume Scenario

5.11.2 Calculations when Using an External Flow Meter

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ PULSES
```

The highest possible SAMPLE VOLUME value is determined by the minimum volume required for analysis and the least expected flow rate over the sampling duration. To calculate the number of pulses at this high end of the range, you should know:

- the least expected flow volume that will pass the flow measurement point
- the flow volume interval between each flow pulse from the external flow meter
- the minimum composite sample volume required for analysis. Allow for duplicates and spillage.

These factors would be applied to the following equation.

$$\text{10 ml for every __ pulses} = \frac{\text{(Least Total Flow Vol) / (Flow Pulse Vol)}}{\text{(Minimum Required Vol) / (10 ml per unit)}}$$

From the scenario we can apply the factors for the equation.

$$\text{10 ml for every 16.7 pulses} = \frac{\text{(500,000 gallons) / (100 gallons per pulse)}}{\text{(3,000 ml / 10 ml)}}$$

Because the SAMPLE VOLUME entry must be in whole numbers, 16.7 is rounded down to 16. It is important to note that this number is inversely proportional to the amount of volume collected. Rounding up would result in less volume collected.

The lowest possible SAMPLE VOLUME value is dependent upon the highest expected flow and the available bottle volume. To calculate the number of pulses or volume at this low end, you should know:

- the greatest expected flow volume that will pass the flow measurement point
- the flow volume interval between each flow pulse from an external flow meter
- the available bottle volume for sample collection.

These factors would be applied to the following equation.

$$\text{10 ml for every __ pulses} = \frac{\text{(Greatest Total Flow Vol) / (Flow Pulse Vol)}}{\text{(Total Bottle Vol) / (10 ml per unit)}}$$

From the scenario we can apply the factors to the equation.

$$\text{10 ml for every 7.0 pulses} = \frac{\text{(666,667 gallons / 100 gallons)}}{\text{(9,400 ml / 10 ml)}}$$

At high flow rates, a number below 7 would overfill the bottle. At low flow rates, a number greater than 16 would collect too little sample. Therefore, a value should be selected between 7 and 16 pulses.

5.11.3 Calculations when Using a 700 Series Flow Module

The same principles discussed in Section 5.11.2 apply. However, the equations differ slightly because the flow module directly measures the stream's flow volumes. The equation for the high end of the range is:

$$\text{10 ml for every __ units} = \frac{\text{(Least Total Flow Vol)}}{\text{(Minimum Required Vol) / (10 ml per unit)}}$$

Using the same scenario the calculations would be:

```
SAMPLE VOLUME:
10 ml FOR EVERY
___ Gallons
```

$$\text{10 ml for every 1667 gallons} = \frac{\text{500,000 gallons}}{\text{(3,000 ml) / (10 ml per gallon)}}$$

The equation for the low end of the range is:

$$\text{10 ml for every __ units} = \frac{\text{(Greatest Total Flow Vol)}}{\text{(Total Bottle Vol) / (10 ml per unit)}}$$

The scenario would be applied as:

$$\text{10 ml for every 709 gallons} = \frac{\text{666,667 gallons}}{\text{(9400 ml) / (10 ml per unit)}}$$

Therefore, a value should be selected between 709 and 1667 gallons for the given scenario.

5.12 Sampler Enable

Certain external instruments can enable (start) or disable (stop) a sampler by sending a signal to pin F of the sampler's flow meter connector. Teledyne Isco flow meters, flow loggers, and the Model 1640 Liquid Level Actuator have a programmable sampler-enable feature that lets them enable or disable the sampler. You can define the condition (such as level, flow rate, pH, temperature, percent, rainfall, and I/O) or combination of conditions that need to be true in order to enable the sampler. Refer to Figure A-12 in Appendix A for details on programming sampler enables.

When the sampler detects that it is disabled at start time, it suspends the program until it is enabled. Once enabled, the sampler collects a sample only when programmed to take a sample at the enable time. The diagram in Figure 5-4 shows the sampler's response when enabled or disabled at the start time.

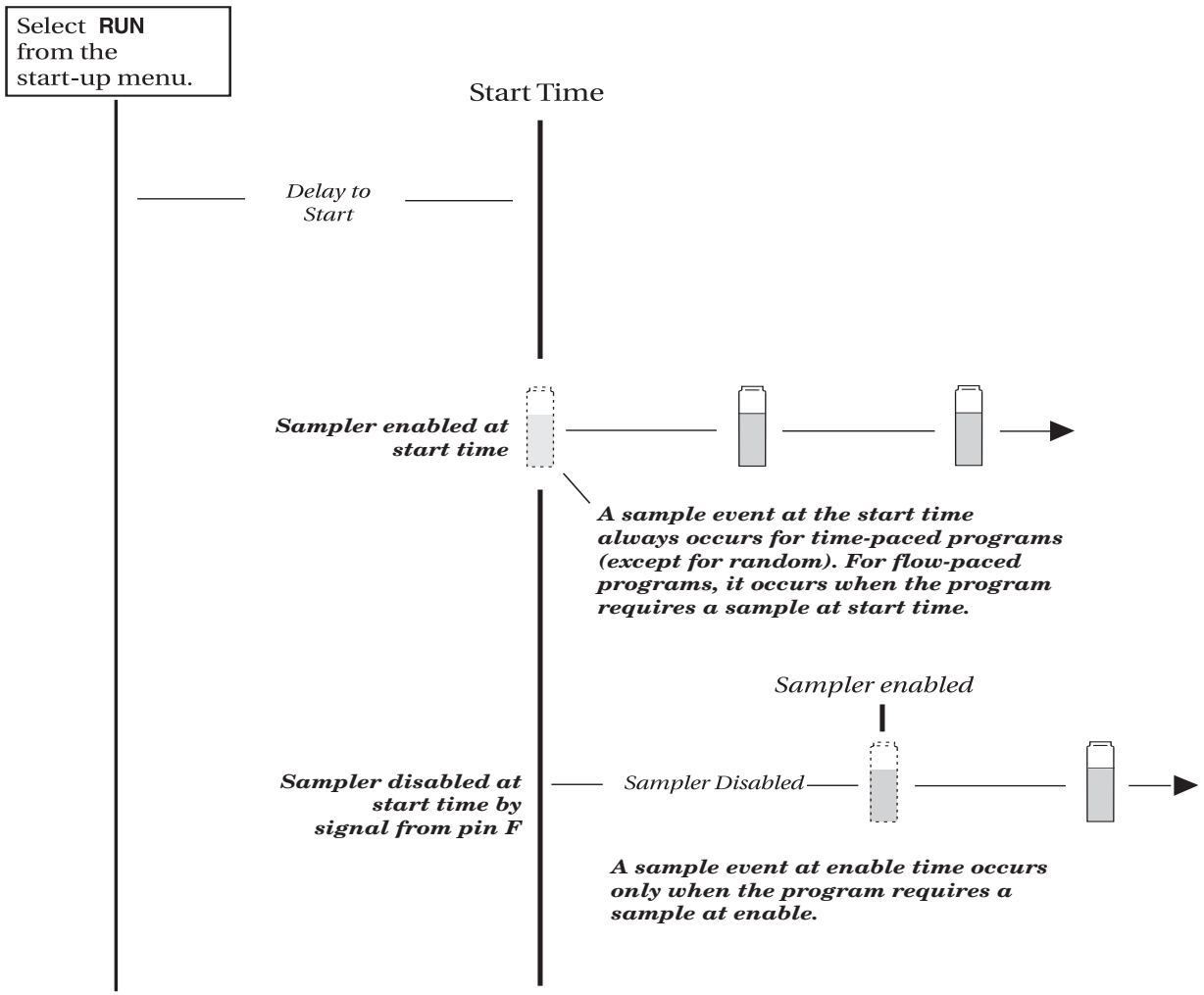


Figure 5-4 Start Time Diagram for Sampler Enable Settings

5.12.1 Sampler Enable

This example uses a sampler with an attached 730 Bubbler Flow Module, Rain Gauge, and an SDI-12 sonde at address 5 with four parameters.

Table 5-4 Sampler Enable

1	ENABLE: NONE PROGRAMMED	In this example, you will be enabling the sampler if it rains .5" in 2 hours and the level goes above 1 foot.
2	ENABLE: **RAIN** LEVEL FLOW TEMP5 pH5 SP_CO5 DO5 NONE	Select RAIN.
3	ENABLE: RAIN **AND** OR DONE	Choose AND.
4	ENABLE: RAIN AND **LEVEL** FLOW TEMP5 pH5 SP_CO5 DO5 DONE	Select LEVEL.
5	"RAIN" SET POINT: **.5** INCHES PER __HOURS, __MINUTES	Enter .5 for the inches of rain. Press ↵ . Enter 2 HOURS.
6	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
7	RESET RAIN HISTORY? **YES** NO	Select YES.
8	"LEVEL" CONDITION **SET POINT** RANGE RATE OF CHANGE	Select SET POINT.
9	"LEVEL" SET POINT: **+1** ft (0.001 - 30.00)	Enter 1 foot.
10	ENABLED WHEN: **ABOVE SET POINT** BELOW SET POINT	Select ABOVE SET POINT.
11	ENABLE: RAIN >0.50" / 2:00 AND LEVEL >1.000 ft	Your enable conditions will be summarized on the display. If correct, press ↵ to continue. If necessary, make changes to the enable conditions.

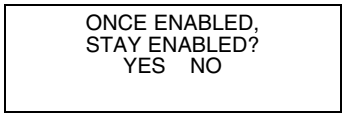
5.13 Sampler Enable Responses

In addition to programming enable conditions, extended programming lets you control the sampler's response to its enable state. You can:

- Stay enabled after the first enable.
- Set up a repeatable enable.
- Take a sample at enable or disable.
- Delay the start of sampling after the enable.
- Reset the sampling interval countdown each time the sampler is enabled.
- Control the sampling interval countdown while disabled.
- Enable Part B of a two-part program when Part A is done.

5.13.1 Once Enabled Stay Enabled

For certain monitoring programs, you may want the sampler to continue to sample, even though the conditions that enabled the sampler no longer exist. When you use the ONCE ENABLED, STAY ENABLED feature, after becoming enabled the sampler takes samples until it reaches the end of its program.



☑ Note

The STAY ENABLED feature works only when the sampler becomes enabled following program start. If you need this feature with enable *prior* to program start, contact Teledyne Isco for details.

5.13.2 Repeatable Enable

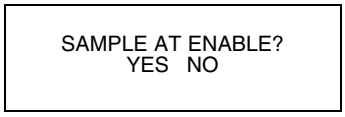
After enabling the sampler, the enabling instrument (or instruments) continues to monitor the conditions and disables the sampler when the conditions are no longer satisfied. If re-enabled, the sampler resumes the sampling program.

☑ Note

Repeatable enable is called "sampler latching" in flow meters, flow loggers, and FLOWLINK. Latching a sampler produces the same results as selecting YES; the difference is that the external instrument controls the latching.

5.13.3 Sample at Enable or Disable

You have the option of directing the sampler to take a sample as soon as it receives the enable and/or disable signal. If you program the sampler to stay enabled and choose to take a sample at enable, the sample interval will be reset at the enable time. Samples at disable do not affect the sample intervals. Standard programs do not take a sample at the enable time.



5.13.4 Delay To Start Of Sampling

If you have selected ONCE ENABLED STAY ENABLED and have chosen to not sample at the enable, you have the opportunity to suspend the start of sampling. This choice is useful for storm programs that require a flow-paced sample taken after the initial grab sample.

```
START SAMPLING
AFTER A
___ MINUTE DELAY
(1-999)
```

5.13.5 "Dry Period" Option

For samplers used with a 0.01 inch tip rain gauge, you can cause the sampler to wait for a "dry" period of under 0.10 inches of rain over a 72-hour period before running the program. At RUN time, the sampler asks if you want to restart the 72-hour period. Select this choice if you want the sampler to disregard any "dry" period that took place prior to the program start. The sampler will wait for up to one year for the "dry" period to occur.

```
START "EXTENDED 1"
AFTER A 72 HOUR
"DRY" PERIOD?
YES   NO
```

5.13.6 Resetting the Sample Interval at Enable

```
RESET SAMPLE
INTERVAL AT ENABLE?
YES   NO
```

If you answer "NO" to the above screen, you will see:

```
CONTINUE COUNTDOWN
WHILE DISABLED?
YES   NO
```

You may want the pacing countdown to start over each time the sampler becomes enabled. To accomplish this, select "YES" when asked if you want to reset the sample interval at enable. The next sample event will occur at the end of a full interval. Furthermore, if the sampler is enabled several times during the program, it resets the countdown each time.

Use the reset-interval feature carefully. For example, avoid resetting the interval when you sample with uniform-time pacing and want to take samples at specific times.

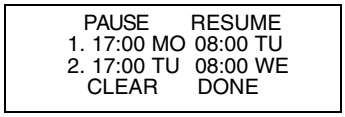
The effects of resetting the interval can be seen in this example: A sampler has been programmed to sample every 15 minutes and to reset the interval when enabled. It receives an enable signal at 10:03 and takes a sample. After resetting the interval, the sampler takes subsequent samples at 10:18 (not 10:15), 10:33 (not 10:30), and so on.

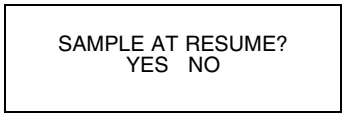
If you select "NO" when asked if you want to reset the sample interval at enable, you will be asked if you want to continue the countdown while disabled. You can have the sampler continue the countdown, repeating it as often as necessary while the sampler is disabled, or you may suspend the countdown while disabled, resuming the countdown as the sampler is enabled. The standard program allows the countdown to continue while disabled.

5.14 Pauses/Resumes

Pause and Resume Screens

Flowcharts containing the pause and resume screen appear in Appendix A.





Pause and resume settings, available in extended programming, create an intermittent sampling schedule. A program with pauses and resumes begins sampling at its programmed start time, continuing until the first pause time and day of the week. It then suspends sampling until the first resume time, when it begins sampling again. If the start time falls within a pause period, the sampler will not begin sampling until the next resume time. Pauses and resumes repeat weekly.

You can enter up to nine pairs of pause and resume times. The pause and resume times shown as examples to the left suspend the program between 5:00 p.m. Monday and 8:00 a.m. on Tuesday and between 5:00 p.m. Tuesday and 8:00 a.m. on Wednesday. If the start time is Monday at 8:00 a.m., the sampler takes samples between 8:00 a.m. and 5:00 p.m. Monday; between 8:00 a.m. and 5:00 p.m. Tuesday; and, continues after 8:00 a.m. Wednesday. To remove pause and resume settings from a program, select CLEAR.

A sampler running a pause/resume program resets the pacing interval at each resume time. You can program the sampler to take a sample at resume times (see screen at left).

5.15 Running Programs

To run an extended program, select run from the main menu. You may also select YES at the RUN THIS PROGRAM NOW? screen at the end of the programming screens.

Extended programs scheduled to start at a clock time will not start until the programmed clock time on or after the *first valid date*.

Note that if you have recently calibrated a parameter probe, the sampler may delay the start and display “PLEASE WAIT” until valid readings are expected from the probe. The delay accounts for the time typically required to install the probe, and lasts for five minutes after you complete the calibration.

5.15.1 Run Time Screens

Run time screens, which report the program’s status while running a program, are explained in Section 4.

5.15.2 Interrupting a Running Program

Interrupting a running program is also explained in Section 4. The scrolling menu that appears during the manual paused state can have two extra options when using extended programming:

Adjust Enable – This option is available for extended sampling programs that have programmed enable conditions. Selecting this option allows you to change the set-points or ranges for the enable conditions. The sampler displays all of the programming screens that define the thresholds of the programmed enables. You cannot change the type of enables used or the way they are combined.

If rain is an enabling condition, you also have the option of resetting the rain history.

Adjust Suction Head – If you have chosen to manually enter the suction head, and are in the manual paused state, the scrolling menu will have an option to adjust the suction head. If you make changes to the suction head value, the sampler logs a changed suction head event.

5.16 Sampling Reports

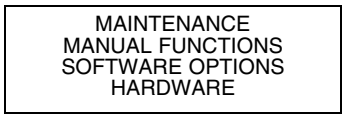
The 6712 records a variety of data while running a sampling program. Sample reports can be found in Section 4.

Section 4, Table 4-3 contains a list of source codes and program events that may be recorded when using either standard or extended programming.

5.17 Other Functions

Other Functions Menu

• Select OTHER FUNCTIONS.



In extended programming, the "Other Functions" menu screen includes options for:

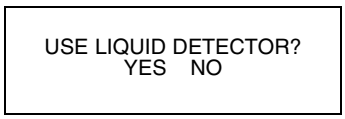
- Maintenance (see Section 7)
- Manual Functions (see Section 4)
- Software Options
- Hardware

5.18 Software Options

The software option screens allow you to set up a number of different software options:

- Liquid Detector Enable
- Normal/Quick View Screens
- Measurement Interval
- Dual Sampler Mode
- Full Bottle Detection
- Display Backlighting
- Event Marks
- Pump Purge Counts
- Serial Output
- Remote Access
- Interrogator Connect Power

5.18.1 Liquid Detector Enable/Disable



Under some conditions (pressurized lines, sampling foam), a more repeatable sample volume may be delivered by disabling the liquid detector. Selecting NO will turn the Liquid Detector off.

If the Liquid Detector is off:

- you must enter the SUCTION HEAD
- no RINSES or RETRIES will be available
- you will not be able to CALIBRATE SAMPLE volumes
- the RESULTS report will read a COUNT TO LIQUID of 0
- A complete purge will occur between samples when using multiple bottles-per-sample distribution.

5.18.2 Programming Style

The sampler has two different styles of programming screens: normal and quick view. These are both explained in Section 3.

When you are in extended programming, the default style is Quick View, which allows you to move more quickly through the screens.

If you prefer a step-by-step display for the screens, switch to the Normal setting.

5.18.3 Measurement Interval

```
MEASUREMENT INTERVAL
  5   15   30   SECONDS
  1    2    5    MINUTES
STORAGE INTERVAL
```

If using a 700 Series module or SDI-12 Sonde parameter for enabling, the sampler will request a Measurement Interval. The Measurement Interval allows the sampler to compare the parameter to the enabling conditions at a rate faster than the Data Storage interval. If the Measurement Interval is equal to or greater than the Data Storage interval, the parameter will be checked at the rate of Data Storage interval.

Normally, there are two considerations when selecting the Measurement Interval: power consumption and duration of the enabling event. This setting for battery powered samplers will require some degree of balance between the need to conserve power yet detect the enabling event before it has passed.

5.18.4 Dual Sampler Mode

Dual Sampler Mode

```
DUAL SAMPLER MODE?
  YES   NO
```

- Select YES to put the sampler in the dual sampler mode. When you no longer need dual samplers, return to this screen to turn the feature off.

Dual Sampler Mode lets you operate two samplers as a pair. The primary sampler disables the secondary one until the primary sampler completes its sampling program. The samplers then reverse roles with the second sampler becoming the primary one.

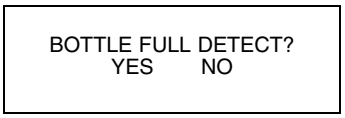
Setting Up Dual Samplers –

1. Turn on the dual sampler mode in both samplers.
2. Install the samplers.
3. Connect the samplers with the Dual Sampler Mode Interconnect Cable by attaching the cable to the sampler's flow-meter connectors. If your installation includes a flow meter or flow logger, use the Dual Sampler Mode to Flow Meter Cable instead.
4. Decide which sampler is to be the primary sampler; the primary sampler should be the sampler with the program you want to run first.
5. Turn the primary sampler on and run its sampling program by selecting RUN. After at least 5 seconds, turn the secondary sampler on and select RUN from its main menu.

How Does It Work? – The primary sampler sends a disable signal out its flow meter connector. The secondary sampler receiving the signal is held disabled until the primary sampler completes its program.

When using a flow meter or flow logger a Dual Sampler Mode to Flow Meter cable must be used. This cable is constructed so that the pacing instrument receives only the event marks. Therefore, a connected flow meter will not receive a bottle number signal, nor will it be able to control the sampler inhibit.

Bottle Full Detect



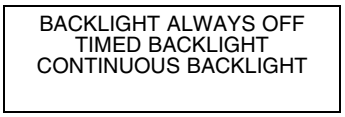
Bottle Full Detection – The sampler can detect a full bottle condition when collecting samples in a single bottle (composite sampling). When the sampler detects a full bottle, it stops the sampling routine.
A BOTTLE FULL condition will also stop a sampling routine that is set to RUN CONTINUOUSLY.

The Bottle Full Detect screen allows you to enable or disable this feature. Selecting "YES" enables the sampler to detect a full bottle and stop the sampling routine. Selecting "NO" disables this feature. The Bottle Full Detect setting is part of the sampling program. Because it is a program setting, full bottle detection can be enabled or disabled for each of the four extended programs. If the Bottle Full Detect setting is critical to your sampling program, always check this Software setting after you select a different Extended Program.

This feature relies on a post-purge after each sample. When using the Bottle Full Detect, make sure that post-sample purges greater than 100 are used.

Bottle Full Detect is always disabled in the Standard Programming mode.

Adjusting the Display Backlighting

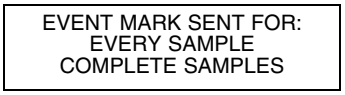


Display Backlighting – The display has a backlight that is adjustable so that the backlight is always off, timed or always on.

In the timed backlight mode the sampler turns the backlight off after detecting no key strokes within 60 seconds. Any keystroke (except ON-OFF) turns the backlighting on again. In this mode the backlight must be on before the sampler accepts a menu choice or number entry. If you press a key and a screen does not respond, it is because the keystroke turned the backlight on.

It is recommended that you use either BACKLIGHT ALWAYS OFF or TIMED BACKLIGHT when using a battery.

Event Marks



Event Marks – The sampler generates an event mark at each sample event, sending it through the flow meter connector to a connected instrument. The event mark may also control an external device; a connected solenoid relay, for example. When using the event mark for a data logger or to control external devices, you may need to adjust the mark by changing the factory settings.

The event mark is adjustable through the software setup screens. You can set up the sampler to generate an event mark for EVERY SAMPLE or for COMPLETE SAMPLES.

If you select COMPLETE SAMPLES, the sampler sends a three-second pulse only after it successfully collects a sample. The sampler will not send an event mark if an error occurs, such as "No Liquid Detected."

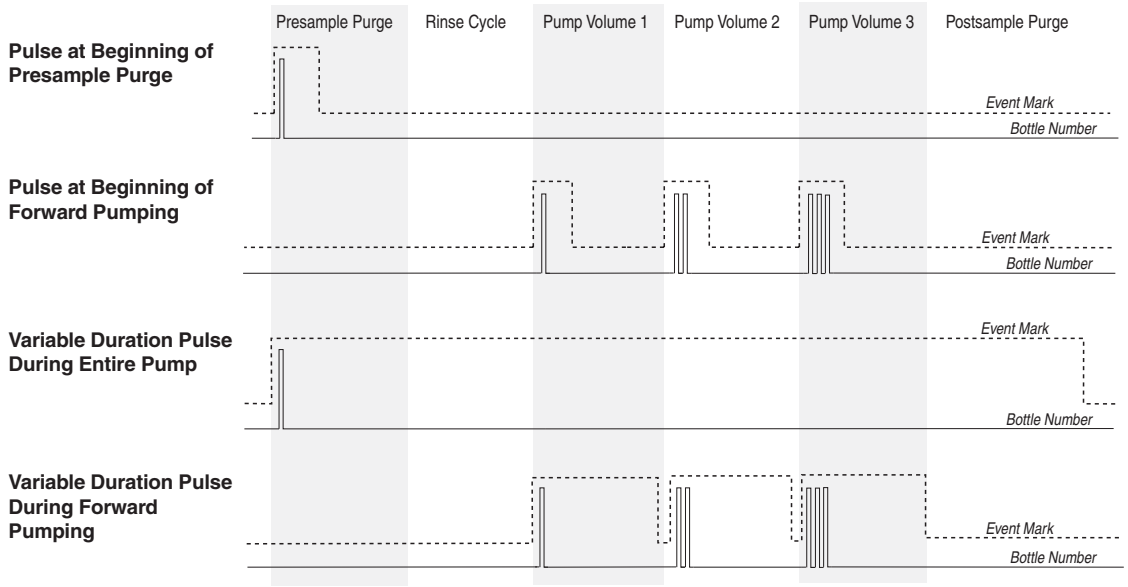
If you select EVERY SAMPLE, the sampler will send an event mark every time a sample is initiated. The event mark signal can be a:

- 3-second pulse at the beginning of the pre-sample purge.

- 3-second pulse at the beginning of forward pumping only, marking the time the sampler deposited the sample.
- Variable duration pulse generated during the pump cycle, from the beginning of the pre-sample purge to the end of the postsample purge.
- Variable duration pulse generated only during forward pumping.

Figure 5-5 shows event mark timing diagrams.

Bottle Number – Concurrent with the event mark, the sampler also sends a bottle number signal. The bottle number signal is a series of pulses. The number of pulses sent represents the bottle currently accepting a sample (see Figure 5-5).



This diagram shows the pulses sent for a bottles-per-sample distribution scheme

Figure 5-5 Event Mark Timing Diagram

5.18.5 Pre-sample and Post-sample Purge Counts

PRE-SAMPLE PURGE:
____COUNTS
(10-9999)

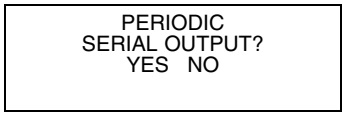
POST-SAMPLE PURGE:
DEPENDENT ON HEAD
FIXED COUNT

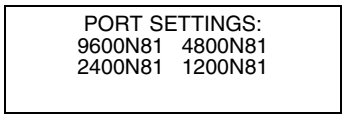
POST-SAMPLE PURGE:
____COUNTS
(10-9999)

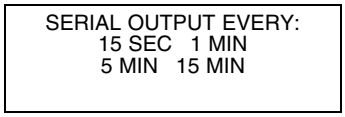
The pre-sample purge is when the pump runs in reverse clearing the strainer of any debris before taking a sample. The pre-sample purge is set at 200 pump counts. After the sample is taken a post-sample purge occurs to clear the liquid from the suction line. The duration of the post-sample purge is determined by the length of the suction line to maximize the battery life. The pre- and post-sample purge can also be manually set.

5.18.6 Serial Output

Programming the serial output







Serial ASCII data can be output through the controller's interrogator port. The output frequency is user-selectable: every 15 seconds, every minute, every 5 minutes, every 15 minutes, or by command.

To receive serial data as a *periodic output*:

1. Select YES at screen asking if you want periodic serial output.
2. Select the appropriate baud rate setting in screen . Note that at all baud rates the data is sent with no parity, eight data bits, and one stop bit. If you have difficulty with the connection, try a slower baud rate.
3. Select the desired output interval in screen.
4. Connect to the 6712 controller's interrogator connector using a standard interrogator cable.

To receive serial data by *command*:

1. Select NO at the screen asking for periodic serial output .
2. Connect your computer to the 6712 controller's interrogator connector with a standard interrogator cable, P/N 60-2544-040 (25 pin) or 60-2544-044 (9 pin).
3. Configure your communications software for a baud rate no higher than 19,200 kb, no parity, 8 data bits, and 1 stop bit.
4. From the computer's keyboard, type "?" repeatedly until the 6712 controller determines the baud rate. Once the baud rate is known, the 6712 returns an identification banner. This banner indicates that the connection is working properly.
5. Type DATA<CR> each time the data string is desired.

The serial data is in comma-separated-value format. Only the values that the sampler is set up to measure will be output in the data string. The string is terminated with a <CR><LF>. To read the data in the string, refer to Table 5-5. This serial data can also be accessed from a remote location using the optional dialout modem (see Section 7).

☑ *Note*

The internal modem is disabled when an interrogator cable is connected to the sampler's Interrogator port. It cannot receive incoming calls, and the alarm dialout is rendered inoperative, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T modem.**

Table 5-5 Serial Data Codes

Identifier	Parameter	Units
B?[1]	Bottle number and time	days since 1-Jan 1900
CR	Current day's rain	tips (rolls over every 256 tips)
CS[2]	Checksum	unsigned long
DE	Description	6712 Sampler
FL	Flow	cubic meters per second
ID	Unit specific identifier	10 digit unsigned long
LE	Level	meters
MO	Model	6712
PE	Percent	percent of full scale
PH	pH	none
PR	Previous day's rain	tips (rolls over every 256 tips)
RA	Rain	tips (rolls over every 256 tips)
RTE	Refrigerator Temperature	degrees celsius
SS	Sampler enable state	logical
TE	Temperature	degrees celsius
TI	Current time	days since 1-Jan-1900
VE	Velocity	meters per second
VO	Volume	cubic meters
VSI	Velocity signal strength	percent
VSP	Velocity spectrum strength	percent
CO_a[3]	Conductivity	milliseimens per centimeter
DO_a	Dissolved oxygen	milligrams per liter
PH_a	pH	none
SA_a	Salinity	parts per thousand
SP_a	Specific Conductance	milliseimens per centimeter
TD_a	Total Dissolved Solids	grams per liter
TE_a	Temperature	degrees Celsius
OR_a	Oxidation reduction potential	millivolts
LE_a	Level	meters
MM_a	Ammonium-nitrogen	milligrams nitrogen per liter
MA_a	Ammonia-nitrogen	milligrams nitrogen per liter
NI_a	Nitrate-Nitrogen	milligrams nitrogen per liter
TB_a	Turbidity	nephelometric turbidity units

Table 5-5 Serial Data Codes (Continued)

Identifier	Parameter	Units
CL_a	Chloride	milligrams per liter
CP_a	Chlorophyll	micrograms per liter
FL_a	Flow rate	cubic meters per second
VO_a	Flow volume	cubic meters
xxD_a[4]	Other data not listed above	

- The three most recent samples will have entries as B?. The "?" will be the first bottle number in the set. If the sample is a grab sample, it will be shown as B0.
- An "a" in the identifier indicates an SDI-12 address.
- "xx" matches the data label for the SDI-12 parameter.
- The checksum does not include the checksum, carriage return, and linefeed.
- The string is terminated with <CR><LF>.

5.18.7 Program Lock

The specialized software option Program Lock (P/N 60-9003-532) may be purchased from Teledyne Isco.

Once activated, the purchased option is always available, even if the software is upgraded at a later time. **The option must be installed at the factory. Consult the factory for further details.**

To view which software options have been activated, select VIEW REPORT>SYSTEM IDs. A Software Options screen will list a code for each active option. The code for Program Lock is **1108**.

PROGRAM LOCK DISABLED

ENABLE PROGRAM LOCK?
YES NO

CHANGE PASSWORD TO

REENTER NEW PASSWORD

The Program Lock adds password security to the 6712 sampling programs. With this option activated, a user-selected password (up to five digits) must be entered before any program changes or run time modifications can be made. Run time modifications include accessing the Manual Pause menu options and shutting off the sampler. You will still be able to run the current program, view reports, and interrogate the sampler without the knowledge of the password.

If three consecutive attempts to enter the password fail, a five minute "time-out" will follow in which most keys are deactivated.

The user-selected password defaults to "6712" and may be changed in the Software options that are available in the Extended Program mode (see example at left). While the password may only be changed in the Extended Program mode, the program lock works for both Standard and Extended programs.

Should you forget your password, a key code can be obtained from Teledyne Isco's Customer Support department for a nominal fee.

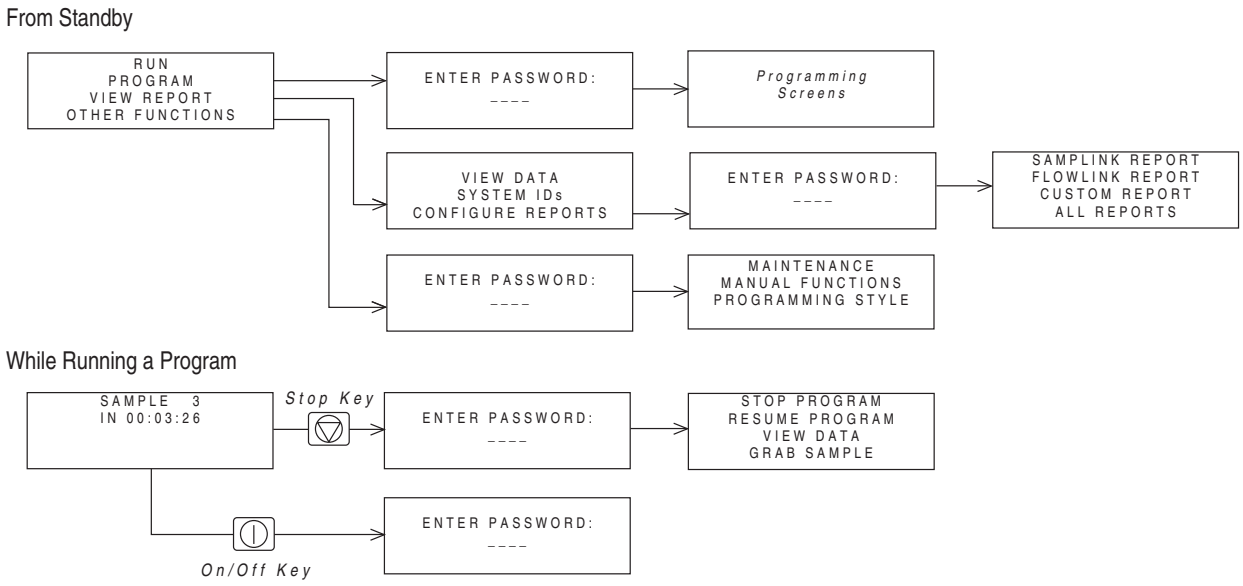


Figure 5-6 Password Protected Functions

5.19 Hardware Setup

The hardware setup screens make adjustments to the sampler's hardware-based features:

RUN "*PROGRAM NAME*"
PROGRAM
VIEW REPORT
OTHER FUNCTIONS

• Select Other Functions

MAINTENANCE
MANUAL FUNCTIONS
PROGRAMMING STYLE
HARDWARE

• Select Hardware

- SDI-12 Sonde Setup
- Rain Gauge Setup
- I/O Pin Programming
- Dialout Alarms
- Pager Numbers
- Text Messaging
- Refrigerator Temperature
- Analog Outputs

5.19.1 SDI-12 Sonde Setup

The 6712 supports SDI-12 sondes. For more information on setting up sondes, refer to Section 6.

5.19.2 Rain Gauge Setup

With standard programming, the sampler does not record rain gauge readings. However, with extended programming, recording the rain gauge readings and the rain enable option can be turned on or off. Enter the hardware setup and follow the screens to the left in the margin.

DO YOU HAVE A
RAIN GAUGE CONNECTED?
YES NO

• Select YES.

When asked if you have a rain gauge connected, select YES to record the rain gauge readings and add RAIN as a sampler enable option. Select the appropriate tip for the rain gauge. The sampler will then create a rain memory partition and update the available sampler enable conditions.

RAIN GAUGE:
0.01 inch TIP
0.1 mm TIP

• The rain gauges are set up to tip on either .01 inch or .1 mm. Select the desired tip.

Select NO to disable the readings and the sampler enable option. When you select NO, the sampler removes the rain memory partition, leaving the memory space available for other reading types.

5.19.3 I/O Pin Programming

Pins C, H, and I on the Rain Gauge Connector are user-configured as I/O1, I/O2, and I/O3 (Input/Output pins) respectively. Each pin can be either an input for sampler enabling, or an output for alarms.

> **Note**
>
> The state of the I/O lines is not defined when the sampler is OFF.

Enable

The enable input requires a pulse signal of 5 to 15 volts. Teledyne Isco offers optional interface modules for converting from a 4-20 mA analog or pulse duration signal.

Alarms

The alarm output can be set for any RUNNING PROGRAM or RUN ERROR state. In addition, the CONDITIONS output can report alarm conditions using the parameters the 6712 is configured to measure. You can set thresholds for one or two conditions and the CONDITIONS output can then trigger alarms when the measured parameters exceed the threshold.

Alarm function requires an alarm interface module, factory-installed talking modem, or external digital cellular modem (see Section 5.19.4 *Dialout Alarms*).

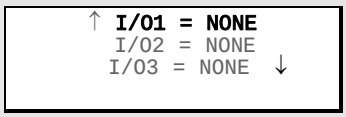
Teledyne Isco offers a module designed to provide one, two, or three contact closures. The alarm module can interface the sampler with many types of non-Isco devices. For more information about the alarm module, contact your Teledyne Isco sales representative.

Example: I/O Pin Programming

Although the screens displayed may vary depending on your site setup, the programming sequence will be the same or similar to the following example.

1. Select OTHER FUNCTIONS to enable the dialout alarm.

2. Select hardware and use the down arrow to scroll to the I/O screen.



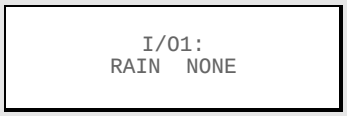
3. Select the first pin to program.

From this screen, your choices are viewed by scrolling with the arrow buttons:

PGM RUNNING
PGM ENABLED
'A' ENABLED
'B' ENABLED
PROGRAM DONE
'A' DONE
'B' DONE
RUN ERROR
FLOW-THRU
CONDITIONS
NONE
I/O ENABLE

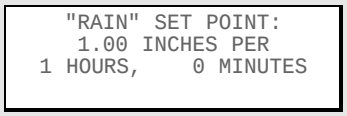
Note: All choices listed are alarm output settings, except for I/O ENABLE. This is the input function to enable the sampler via an external device.

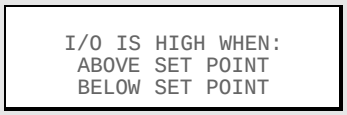
4. If you select CONDITIONS, the sampler will display:



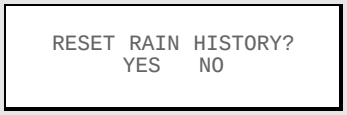
Depending on what equipment is connected to your sampler, you may see other parameters in addition to RAIN, such as LEVEL, FLOW, VELOCITY, etc. Under CONDITIONS, you can program limits for a condition to trigger the alarm when the measured parameter exceeds its limit. You can use one or two conditions to trigger one alarm, using AND or OR operators.

5. When you select a parameter with the arrow keys and Enter, you can then program the limits for alarm triggering. For example, if you select rain, the sampler will display:





"I/O IS HIGH" means "Alarm is triggered." Select ABOVE or BELOW, then select whether or not to reset rainfall history when the alarm is triggered:



Continue with programming I/O2 and I/O3 in the same manner, or if additional alarms are not needed, select NONE.

5.19.4 Dialout Alarms

Dialout alarms require the sampler to be equipped with the factory-installed 2400 baud talking modem, or the external digital cellular CDMA or GSM modem. The dialout alarm allows the sampler to notify a contact list when an "alarm" condition exists (is true).

At the transition to the true state, any programmed I/O output can cause the sampler to warn of the alarm condition. As many as three telephone numbers can be entered. The sampler tries each telephone number in succession until the alarm is acknowledged. For each alarm condition, the sampler will attempt each telephone number entered a maximum of five times, at user specified intervals.

Alarms are set up through the I/O programming menu, shown in Section 5.19.3. "I/O1", "I/O2", and "I/O3" represent the three alarms.

Example: Dialout Alarms

If the controller is equipped with a dialout modem, it can be programmed to notify a telephone or pager contact list when an alarm condition is true.

Before proceeding the I/O conditions must be defined. Refer to section 5.19.4. These steps program a dialout alarm when the condition defined for I/O1 is true.

1. Select YES to enable the dialout alarm.

```
DIALOUT WHEN IO1
  BECOMES TRUE?
    YES     NO
```

   The controller asks the same question for IO2 and IO3. Select NO.

```
DIALOUT WHEN IO2
  BECOMES TRUE?
    YES     NO
```

```
DIALOUT WHEN IO3
  BECOMES TRUE?
    YES     NO
```

2. Using the number entry keys, enter as many as 3 telephone numbers to the contact list.

```
    DIALOUT NUMBERS:
1. 9,55555550001
2. 9,55555550002
3. P5550003
```

   If the phone number requires extended characters, or if you need to designate a number as a pager, press the decimal key. The controller displays:

```
      SELECT CODE
,   #   *   PAGER
```

   Use an arrow key to select a code and press Enter to insert it in the number on the DIALOUT NUMBERS screen.

3. Enter the delay time between each attempt. A delay will allow time between attempts so you can return a call to the controller to acknowledge the alarm condition.

```
      __ MINUTE
DELAY BETWEEN CALLS

      (0-99)
```

Note: Numbers may be removed from the list by advancing the cursor to the very end of the number with the right arrow key, then pressing the left arrow key to erase the number.

When the call is answered, the sampler's modem announces the alarm condition (analog talking modem) or sends a digital text message (external cellular modem), and the sampler's three-digit ID number. To acknowledge the call, press the ✱ (star) key, and the three-digit ID number on your phone. The sampler will reply with an acknowledgment when the keyed entry is correct.

A record of alarms and acknowledgements is available in the Sampling Report. When the sampler detects the alarm condition, it records the type of alarm and the time it occurred. Acknowledgements are a separate Sampling Report entry, recording the time and telephone number that responded to the call.

As mentioned previously, as many as three telephone numbers may be entered. The modem can dial up to 25 digits. Enter numbers using the numeric keys on the sampler keypad. When entering telephone numbers longer than 17 digits, the display will scroll.

Extended characters, the Comma (,), Pound (#), and Star (*), also may be included in the 25 digits. To enter an extended character, press the Decimal Point key on the sampler keypad. The sampler displays a screen used to select and enter the extended characters. Each comma entered will cause the modem to pause for two seconds before proceeding with the remaining digits.

Phone numbers that are no longer needed can be removed. Advance the cursor to the end of the telephone number and then press the Left Arrow key to erase the preceding character. If the cursor is not at the end of the telephone number, the Left Arrow key will only shift the cursor without erasing any characters.

Dialout telephone and pager numbers are included in the Program Settings Report.

> ☑ ***Note***
>
> Connecting either the serial output or the standard interrogator cable to the sampler disables the internal dial-out modem. The interrogator or serial output cable must be disconnected before you can use the modem.

5.19.5 Pager Numbers

The extended character screen contains a pager option that designates the phone number as a pager. When programmed as a pager number, an identification string will be sent seven times after the pager number is dialed, with a three second delay between strings.

An example identification string would be "828-1", meaning "Alarm condition #1 exists at sampler 828". If more than one alarm condition exists, the string would read similar to "828-1-3.

5.19.6 Digital Modem Text Messaging

The sampler can send alarms in the form of text messages containing the same information as that found in voice messages.

To use this option, you must have:

- a cellular phone with text messaging capabilities

- an external digital modem
  recommended: Teledyne Isco's CDMA cellular modem part # 60-5314-489
  or GSM cellular modem part # 60-5314-563

> **Note**
>
> If an internal voice modem is installed, the sampler will use that modem, and text messaging will be disabled.

When you enter each of the (up to three) phone numbers for the sampler to call, if text messaging is active, a request for the TAP (Telocator Alphanumeric Protocol) server number and communications parameters will be made.

As with voice messaging, the sampler will dial each telephone number up to five times per alarm condition, until the message is acknowledged.

5.19.7 Refrigerator Temperature

Teledyne Isco offers a temperature sensor intended for use with the 6712FR Refrigerated Sampler. The optional sensor connects to the Rain Gauge port and uses I/O3 to transmit its temperature readings to the 6712.

> **Note**
>
> If alarms are being used, the temperature sensor is simply plugged into the panel mount on the one- or two-alarm output module. Because the temperature sensor uses I/O3, it cannot be used with a three-alarm output module.

To configure an attached temperature sensor, select "FR-TEMP" as the input for I/O3. The 6712 will display the NEW HARDWARE SETUP screen. Select DONE and the 6712 reconfigures its memory partitions to record the temperature readings.

Temperature readings are updated approximately every 2.5 seconds. The readings are stored as FR-TEMP readings at the data storage interval. You can retrieve a history of temperature readings through the 6712's reports. The temperature data also can be used as a sampler enable condition.

5.19.8 Analog Output

Teledyne Isco offers three analog outputs as a factory installed option. The option is installed inside the controller and includes a six-pin connector to interface with external devices.

The analog outputs can be programmed for either 0-to-20 mA or 4-to-20 mA operation. With the exception of rain, any parameter that the 6712 sampler is currently measuring can be used to control any (or all) of the analog output channels. Programming the outputs requires parameter levels at each end of the analog range and then assumes a linear relationship between those points. MANUAL CONTROL of each output is also available.

> **Note**
>
> The internal analog output can not be installed in a controller that has the internal voice modem also installed. Contact the factory for information regarding external cellular modem options.

Flowcharts for analog output screens appear in Appendix A.

5.20 Memory

The 6712 Sampler contains 512 kilobytes of battery backed RAM (Random Access Memory) that stores:

- Five sampling programs
- The sampling results from the most recent program
- The rainfall data collected from rain gauges
- The data from a refrigerator temperature sensor
- The data collected from a 700 Series module
- Parameter data collected from an SDI-12 Sonde
- Calculated flow information from the current flow module

The sampling results memory stores up to approximately 1004 events (the actual number is dependent on the number of SDI-12 parameters). The program run and start time information is logged as four events. These four entries are held for the duration of the program. The remaining 1000 are for logging sample events, program events, and errors from the currently running program. If the running program exceeds 1000 events, the data will "roll over." That is, the sampler will replace the oldest stored event with the newest event. When using an SDI-12 sonde, the sampler logs additional entries at each sample event.

Module, sonde, refrigerator temperature, and rain gauge readings are stored in memory partitions. The storage capacity depends on the reading types, the number of bytes per reading, and the data storage interval.

The sampler clears the sampling results memory when the site description changes. It is important to collect the sampling results before changing the site description – the data can not be retrieved afterwards. Keep in mind that the description may change when selecting an extended program.

The partition data is cleared when the sampler automatically creates and sizes the memory partitions. This occurs when you:

- Select a new program with a different storage interval
- Change the Data Storage Interval in the current program
- Change the programming mode
- Install a new 700 Series Module
- Change 700 Series Module mode of operation
- Add or remove a rain gauge with the Hardware Setup

- Add or remove a refrigerator temperature sensor as I/O3
- Add or remove a SDI-12 sonde parameter with the Hardware Setup
- Reinitialize the sampler

The stored data is lost as the sampler reformats its memory. As a precaution, before clearing the memory, the sampler display will show the following message:

```
INTERVAL CHANGED --
DOWNLOAD DATA NOW
OR LOSE ALL DATA!
DONE
```

If you want to keep the stored data, download it before proceeding. When DONE is selected, the sampler clears the stored data and reformats the memory partitions. The sampler then displays the new capacity of the partition memory.

```
PARTITION MEMORY
WILL LAST 13 DAYS
```

If the duration is too short, try changing the data storage interval or eliminating unnecessary reading types in the Hardware or Module Setup. For example, a sampler configured with a 730 Bubbler Module and a rain gauge storing data at a one-minute interval, creates level and rainfall partitions that hold 100 days of readings. Changing the storage interval to two minutes extends the storage capacity to 201 days.

The sampler does not have to be running a program to store readings. When the sampler is on, it stores readings at the selected data storage interval. Once the partition is filled, the readings roll over.

When the sampler is running a program, the partitions become “triggered” by the programmed start time or the first enable time, whichever is later. A triggered partition continues to log readings at the selected interval, but will not replace any readings taken after the trigger event. The sampler fills the partition and then stops recording to preserve the data. The first reading preserved in a full partition is one hour before the trigger event. A full partition can be reset by starting another program or changing storage parameters.

If you need continuous readings for analysis, be sure to collect the readings before the partition fills or rolls over to avoid gaps in the data.

5.21 Pressurized Lines

The sampler can obtain samples from pressurized lines, as long as the line pressure remains below 15 PSI (pounds per square inch). Pressures greater than 15 PSI may prevent the sampler from purging the suction line; moreover, extreme pressures can force liquid past the pump, even when the pump is not running.

For more consistent sample volumes from lines under constant pressure, calibrate the samples.

For information about sampling with line pressures greater than 15 PSI, contact Teledyne Isco.

5.22 Command Driven Operation

The 6712 controller can be used as a slave to an external controller. The external controller is responsible for determining when to take a sample, how much volume to pump, and where to put the sample. The external controller directly interfaces to the sampler via an RS-232 communications port at 2,400-19,200 baud, 8 data bits, no parity, and 1 stop bit. A comma-separated-value protocol is used by the external controller to make requests, and by the sampler to report results. Use a standard computer connect cable (see Appendix E) to connect the sampler's interrogator port and the external controller.

For information on serial data codes and their meanings, refer to Table 5-5 Serial Data Codes in this section.

The 6712 Sampler will respond to three commands: Turn Sampler On, GET STATUS, and TAKE SAMPLE. All commands must include the instruction set. The checksum value is optional.

The available commands are:

1. Turn Sampler On: STS,2,CS,582<CR>

- "582" is the byte-by-byte sum of the ASCII values in the string "STS, 1,CS".
- "<CR>" is a carriage return signifying the end of the command.
- If the sampler is OFF, this command will turn it ON before returning status info.

2. Get Status: STS,1,CS,581<CR>

"STS,1" instructs the sampler to return the current status.

- "CS,581" is the optional checksum value. The byte-by-byte sum of the ASCII values in the string "STS,1,CS" is 581.
- "<CR>" is a carriage return signifying the end of the command.

3. Take Sample: BTL,2,SVO,100,CS,1039<CR>

The TAKE SAMPLE command is only valid if the sampler is WAITING TO SAMPLE.

- "BTL,2" instructs the sampler to place the sample in bottle 2.
- "SVO,100" instructs the sampler to take a 100 ml sample.

- "CS,1039" is the optional checksum value. The byte-by-byte sum of the ASCII values in the string "BTL,2,SVO,100,CS," is 1039.
- "<CR>" is a carriage return signifying the end of the command.

5.22.1 Command Driven Sampler Responses

The 6712 Sampler's response string is the same for each of the three commands. A sample response string is shown below:

MO,6712,ID,2424741493,TI,35523.50000,STS,1,STI,35523.41875,BTL,2,SVO,100,SOR,0,CS,xxxx<CR>

Note that the sampler's response is a series of alphabetical and numerical pairs. The alphabetical characters are headings that describe the following numerical value or code. A complete description of each pair is listed below.

MO,6712, is the model number of the sampler.

ID,2424741493, is the sampler's unique identification number.

TI,35523.50000, is the sampler's current time.

STS,1, is the sampler's current status. The possible states are:

1 = WAITING TO SAMPLE.

4 = POWER FAILED (for short time after power is restored).

5 = PUMP JAMMED (must be resolved before continuing).

6 = DISTRIBUTOR JAMMED (must be resolved before continuing).

9 = SAMPLER OFF.

12 = SAMPLE IN PROGRESS.

20 = INVALID COMMAND.

- identifier code is not supported.
- bottle requested is not in current configuration
- sample volume requested is outside its range (10 - 9990 ml)
- day (Set_Time) must be 5 digits and more recent than 1977

21 = CHECKSUM MISMATCH.

22 = INVALID BOTTLE. (bottle requested is not in the current configuration)

23 = VOLUME OUT OF RANGE. (the sample volume requested is outside its range (10-9990 ml)

STI,35523.41875, is the most recent sample time.

BTL,2, is the bottle receiving the most recent sample.

SVO,100, is the most recent sample's volume.

SOR,0, is the results of attempting the most recent sample. The possible results are:

0 = SAMPLE OK.

1 = NO LIQUID FOUND.

2 = LIQUID LOST (not enough liquid to satisfy requirements.)

3 = USER STOPPED (using the Stop Key).

4 = POWER FAILED.

5 = PUMP JAMMED.

6 = DISTRIBUTOR JAMMED.

8 = PUMP LATCH OPEN.

9 = SAMPLER SHUT OFF (while sampling).

11 = NO DISTRIBUTOR.

12 = SAMPLE IN PROGRESS.

CS,xxxx is the byte-by-byte sum of the entire string “MO,...,CS,”

For commands that are not understood (INVALID COMMAND or CHECKSUM MISMATCH) or when no samples have been taken, the most recent bottle information is left off the response string.

6712 Portable Sampler

Section 6 SDI-12 Sondes

In order to provide you with the flexibility to use the water parameter sensors that best meet your needs, Teledyne Isco has implemented support for SDI-12 protocol. Support of this standard allows you to use SDI-12 compatible devices in conjunction with your 6712 sampler in Extended Programming mode.

6.1 SDI-12 Data Parameters

The 6712 Sampler can accept up to 16 parameters from up to ten sensors with SDI-12 addresses from 0 - 9 (refer to chart in Figure 6-1). This data can be used in different ways. Data can be logged at user selectable time intervals for later download and processing by Teledyne Isco's Flowlink™ program. You can set up sampling programs that will be enabled to run only if conditions based on parameters monitored by the connected SDI-12 devices are met. The sampler can also be programmed to take samples each time certain parameter limits are exceeded.

The data parameters used by the sensing device (sonde) and recording device (sampler) must match. Otherwise, the equipment could record the data values for one parameter as another's, such as reporting a pH value as being temperature.

Certain vendors' sondes (such as Hydrolab and YSI) have enhanced commands that facilitate "plug and play" setup. These Teledyne Isco Ready sondes can tell the 6712 what values they have, their order, and units of measure.

Other SDI-12 compatible sondes can be used, but require manual setup to identify proper data types for each data value reported.

This section shows you how to set up both Teledyne Isco Ready and other SDI-12 sondes for use with the 6712.

⚠ WARNING

SDI-12 Sondes have not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before you install any sonde, you must take the proper safety precautions. Refer to Appendix C in the back of this manual. Additional safety considerations may be required. Check applicable guidelines, codes, and regulations of federal, state, city, and county agencies.

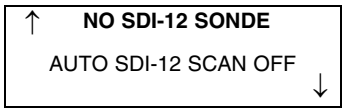
SDI-12 Sonde Data Units:	Parameter	Range	Resolution	Storage Bytes
	Temperature	-40 - 100 °C	0.1 °C	2
	Conductivity	0 - 100 mS/cm	0.01 mS/cm	2
	Specific Conductance	0 - 100 mS/cm	0.01 mS/cm	2
	Total Dissolved Solids	0 - 90 g/l	0.01 g/l	2
	Salinity	0 - 70 ppt	0.1 ppt	2
	Dissolved Oxygen	0 - 20 mg/l	0.1 mg/l	1
	pH	0 - 14	0.1	1
	ORP	-999 - 999 mv	0.1 mv	2
	Level	0 - 6.5279 m	0.0001 m	2
	Ammonium-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
	Ammonia-Nitrogen	0 - 200 mgN/l	0.1 mgN/l	2
	Nitrate-Nitrogen	0 - 200mgN/l	0.1 mgN/l	2
	Turbidity	0 - 5000 NTU	0.1 NTU	2
	Chloride	0 - 1000 mg/l	0.1 mg/l	2
	Chlorophyll	0-400 ug/l	0.1 ug/l	2
	Other	-99999.0-99999.0	0.0001	4

Figure 6-1 SDI-12 Sonde Parameters

6.2 Scanning For Sondes

You must be in Extended Programming to use a sonde with the 6712. The sampler can automatically scan for the presence of sondes if you enable that option:

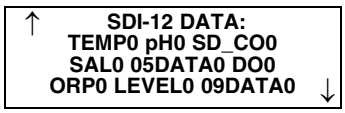
- From the main menu, select OTHER FUNCTIONS.
- Select HARDWARE.
- As you press ↵ to move through the hardware screens, you will see one that looks like the following:



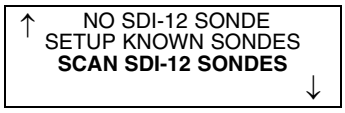
Select “NO SDI-12 SONDE” to scan for sondes. If one is found, you can set it up, and the “AUTO SDI-12 SCAN” option will be switched to yes.

Select the “AUTO SDI-12 SCAN” option to manually turn on (or off) automatic scanning for sondes when the sampler is turned on.

If a sonde has already been connected and set up, the hardware screen will instead display a screen similar to the following:



Press the arrow keys until "SDI-12 DATA" is blinking, then press ↵. You will see the screen below:



Select "SCAN SDI-12 SONDES" and press ↵. The system will scan to see what sondes are connected. If it detects a different sonde, it will indicate so, and advance to the setup screens.

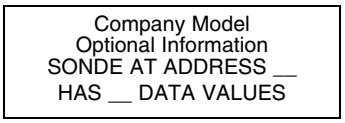
6.3 Teledyne Isco Ready Sondes

Connecting a Teledyne Isco Ready Sonde

1

- Select the address you want to set up.

2



- Wait a few seconds for the above display to disappear, or press ↵.
- You will then be asked if you want to store the parameter data. Refer to "SONDE SETUP - STORING PARAMETER DATA" on page 6-4.

If the 6712 scans for sondes and finds one that is Teledyne Isco Ready, it will automatically recognize the sonde's data types and units. You can then use Hardware options to setup the definitions for data storage and calibrate the sonde.

Even with a Teledyne Isco Ready sonde, the 6712 may find a parameter that is not on its list of supported parameters (Figure 6-1). It can still work with such a parameter. Such a parameter will be identified as something like "05DATA1" and you will have to mentally associate the appropriate data type with that label. However, once such data is brought into Flowlink™, data sets can be manually changed so that reports show the appropriate labels.

6.4 Other SDI-12 Sondes

If you have connected an SDI-12 sonde that is not Teledyne Isco Ready, you will need to define the sonde's data values.

When you select the address of the sonde you want to set up (see screens in the margin), the company model and other information will be displayed along with the number of data values the sonde has.

When you advance to the next screen (see #3 below), the data types will be listed as "OTHER" because you have not defined them yet. Move between the data types using the arrow keys. Select one to change by pressing ↵.

A list of possible parameters will be displayed (see #4 below). Use the arrow keys to move through the options. When the one you want is blinking, press ↵. Repeat the process until you have defined all of the data parameters for your sonde.

Use the arrow key to move to "DONE" and press ↵. You will then be asked if you want to store the parameter data.

Connecting Other SDI-12 Sondes

3
```
SELECT ADDRESS OF
SONDE TO SETUP:
__ __ DONE
```

- Select the address of the sonde you want to set up.

4
```
Company Model
Optional Information
SONDE AT ADDRESS __
HAS __ DATA VALUES
```

- You can wait a few seconds, or press ↵ to advance to the next screen:

5
```
DATA FROM SONDE __
 1 = OTHER
 2 = OTHER
 3 = OTHER              --->
```

- Press an arrow key until the cursor is on the data you want to identify. Then, press ↵. A scrolling screen listing possible parameters will appear.

6
```
    SONDE ___ ,   DATA 1:
<--  pH
    TEMPERATURE (ºC)
    TEMPERATURE (ºF)   --->
```

- Make your selection and press ↵.

3
```
    DATA FROM SONDE __
<--  1 = TEMPERATURE(ºC)
     2 = OTHER
     3 = OTHER              --->
```

- Repeat the process until you have defined all the data. Press "DONE" when finished.

4
```
    DATA FROM SONDE __
<---  4 = pH
      5 = LEVEL
          DONE
```

- You will then be asked if you want to store the parameter data. Refer to "SONDE SETUP - STORING PARAMETER DATA" in the following paragraphs.

6.5 Sonde Setup - Storing Parameter Data

Whether you are using a Teledyne Isco Ready sonde or other SDI-12 compatible sonde, you will need to tell the 6712 if you want to store all of the parameter data or data from selected parameters.

Data is stored in memory partitions. A fixed amount of memory is available to store data. If you are using some parameters to simply trigger an event or enable condition, it is not necessary to store the data.

If **all** of the parameters' data will fit in memory, you will be asked if you want to store all of the parameter data. Answering "NO" will still allow you to selectively store parameter data; otherwise, all data will be stored.

You will be asked to store parameter data during the setup process. You can also manually change the setup using options in the Hardware menu.

To access the setup option in the Hardware menu, select Other Function from the main menu, then choose Hardware. Advance through the screens until you see one that displays SDI-12 DATA.

Select this screen to display the following:

```
NO SDI-12 SONDE
SETUP KNOWN SONDES
SCAN SDI-12 SONDES
```

Select "SETUP KNOWN SONDES" and then indicate the address of the sonde you want to setup. A screen containing the sonde model and number of data values will appear briefly. Then you will be asked to verify, parameter by parameter, what data you want to store. The screens will look similar to the one below:

```
SONDE 5, STORE
TEMPERATURE DATA?
YES NO
LABEL IS: TEMP5
```

Indicate if you want to store the data for that particular parameter and then advance through the rest of the parameter screens. Once you have defined your data storage options, select "DONE."

You will be prompted that you have entered a new hardware setup and asked if you want to erase the stored data. Indicate "YES" or "NO." A partition memory status message will be displayed and (if a parameter exists that can be calibrated) you will then advance to the calibration screen (refer to "SONDE CALIBRATION AND VALIDATION" on this page). If you do not want to calibrate or validate, select "DONE" to return to the Hardware Options screens.

6.6 Sonde Calibration and Validation

It is recommended that calibration of your sonde be done in the lab, according to manufacturer's recommendations. However, for your convenience, the 6712 allows for field calibration of pH, Dissolved Oxygen (DO), and Oxidation Reduction Potential (ORP).

Field calibrations are stored in the sampler, NOT the sonde, and are used to modify readings from the sonde until a new sonde is connected. When a sonde is moved to another sampler, it will retain calibration constants set in the lab, but will not retain any that were set in the field.

Although field calibration is limited to three parameters, you can validate any of the available parameters. Validation allows you to immerse the sonde in a known solution, note the readings, and see if the sonde is functioning properly. The validation process does not modify any readings like calibration does; it merely alerts you to inaccurate ones.

No data will be stored, nor will enable conditions be updated, while calibrations or validations are being performed.

6.6.1 The Calibration Screens

To access the calibration screens from the main menu, select Other Functions, Hardware. Advance through the screens until you see one that displays "SDI-12 DATA." Select this screen to display the following:

```
NO SDI-12 SONDE
SETUP KNOWN SONDES
SCAN SDI-12 SONDES
```

Select "SETUP KNOWN SONDES" and then select "DONE." You will see a screen similar to the following that will list the parameters you can calibrate.

```
SELECT PARAMETER
TO CALIBRATE:
pH5 DO5 ORP5 DONE
```

The sonde's address will appear after the parameter (such as pH0 and pH5). If you have multiple sondes attached, use the arrow key to select the correct one to calibrate.

Depending upon the parameter you selected, a series of screens will be displayed to step you through the calibration process.

- pH - You will be given the choice of three different pH solutions: 4.00, 7.00, and 10.00. After making your selection, rinse the probe and place in the pH buffer. If the reading is off by more than 0.5 pH units, you will asked to verify if the reading is correct.
- DO - For dissolved oxygen, you can choose between two methods: DO Standard and Saturation. The saturation method requires a temperature reading between 0.0° and 47.0° C. You will also need to enter your altitude and barometric pressure.
- ORP - You will asked to enter the value of your calibration standard.

When calibration is complete, select "DONE" to proceed to the validation screen. If you do not want to validate any parameters, select "DONE" again to return to the Hardware options screens.

6.6.2 The Validation Screen

The validation screen appears after you select "DONE" on the calibration screen. It will be similar to the screen shown below.

```
SELECT PARAMETER
TO VALIDATE:
<--    SAL5   05DATA5  DO5
  ORP5   LEVEL5        -->
```

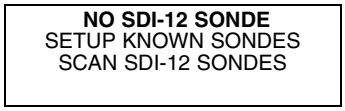
Use the arrow keys to select the desired parameter to validate. Any parameter can be validated. You will be prompted to place the probe in your validation standard. When stable, press ↵. The reading will be displayed at the bottom of the screen.

When you are done validating, select "DONE" to return to the Hardware options screens.

6.7 Disconnecting Sondes

When you have disconnected all sondes, and have interrogated the sampler for all its data, you can indicate that there is no SDI-12 sonde.

From the main menu, select Other Functions, Hardware. Advance through the screens until you see one that displays "SDI-12 DATA." Select this screen to display the following:



Select "NO SDI-12 SONDE." You will advised that you have a new hardware setup:

If you have collected all the data, select "DONE." A partition memory message will be displayed briefly, and you will be returned to the Hardware options screens.

If you do not have a sonde attached, you may want to turn off automatic scanning for sondes. This will eliminate the time taken to scan for sondes whenever the sampler is turned on.

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Section 7 Remote Operation

The 6712 controller can be operated remotely from external devices. External controlling devices may be a computer via RS-232 serial communications or a telephone via touch-tone commands. Remote telephone operation requires the factory-installed 2400 baud talking modem.

> ☑ ***Note***
>
> The internal modem cannot be installed in a controller with the analog output option also installed.

7.1 Computer Operation

The 6712 controller can be operated from a remote location using a computer. There are two different levels of computer control:

Menu control is used to start and stop the current sampler program (or programs if in Extended programming mode) and to access other menu commands. This level of remote operation relies on the sampler program for much of its capabilities.

External program control ignores the sampler's program and current state. Using external control, you can turn on the sampler, take a sample, and request sampler status data. The pump, distributor, and serial data output simply respond to the external commands.

To operate the sampler remotely on either level, you must first establish RS-232 serial communication between the computer and the 6712 controller. To do so:

1. Connect your computer to the 6712 controller's interrogator port with a standard interrogator cable, P/N 60-2544-044 (for 9-pin serial ports).
2. On your computer, open a terminal emulator program such as HyperTerminal, and configure it for:
   - baud rate of 19,200 or less
   - no parity
   - 8 data bits
   - 1 stop bit
   - VT100 terminal emulation
3. Using your communications software, connect to the sampler. Press and hold the question mark (?) on the computer keyboard until the sampler returns its banner string. A caret (>) prompt will appear on the screen when the sampler is ready to accept commands.

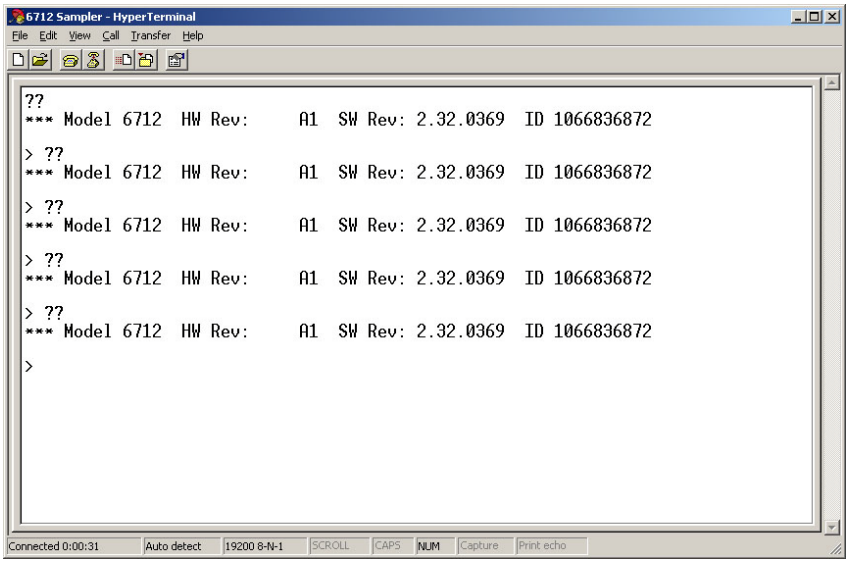


Figure 7-1 Press and hold ?? to connect to the sampler

7.1.1 Menu Control

Once you have remotely connected to the sampler, menu commands can be entered from your computer. These menu commands are listed in Table 7-1.

To access the menu commands, type MENU at the ">" prompt and press ENTER. The screen will return a list of the available options. Note that the current state of the controller will determine the available menu options. Then, type the desired command(s), confirming with ENTER.

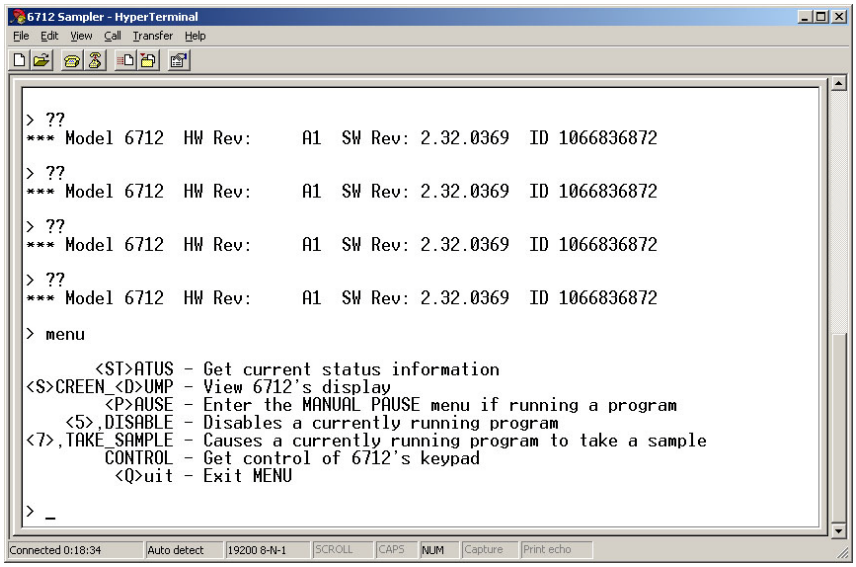


Figure 7-2 Example list of remote menu commands

Table 7-1 6712 Remote Menu Commands

Menu Command	Description
0 or START	This command will immediately start any program set to WAIT FOR PHONE CALL and currently waiting for the remote start command (see Section 4.6).
1 or RUN1	This command will load Program 1 as the sampler's current Extended program, reset partition if the storage interval has been changed, and run the program. RUN1 is valid when the sampler is in standby, or when it is waiting for a start command. RUN1 will also run the current program while in Standard programming.
2 or RUN2 3 or RUN3 4 or RUN4	These commands will load the selected program number as the sampler's current Extended program, reset partition data if the storage interval has changed, and run the program. They are valid when the sampler is in standby, or when it is waiting for a start command. The commands are available for Extended programming only.
5 or DISABLE	This command is similar in functionality to a pin F low signal (a signal typically used to enable or disable the sampler from a flow meter). At run time, the sampler starts with the sampler in the enabled state. DISABLE is valid while a program is running. If successful, a display of REMOTE ENABLE IS FALSE will be returned. A Remote Disable is the highest priority disable. If the sampler is disabled with this command, no condition other than menu command 6, ENABLE, will allow the program to become enabled again.
6 or ENABLE	This command is used to re-enable a disabled sampler. ENABLE is valid while a program is running. If successful, a display of REMOTE ENABLE IS TRUE will be returned.
7 or TAKE_SAMPLE	This command causes the sampler currently running a program to take a sample. The sample will count as one of the program's samples and is placed in the current bottle (Part A's current bottle when using two-part programming). TAKE_SAMPLE is valid while the program is running, after the start time, but not while in the MANUAL PAUSE screens. If successful, a response similar to PUMPING XXML SAMPLE INTO BOTTLE ## will be returned. If not, a response similar to NO SAMPLE, PROGRAM WAITING START will be returned.
ST or STATUS	This command causes the sampler to return its status information and current parameter data.
SD or SCREEN_DUMP	This command causes the sampler to return the information currently displayed on the sampler's screen. The remote screen follows the sampler's display as the information is updated. This mode can be used to observe from a remote location while the sampler is programmed on-site.
P or PAUSE	This command causes a sampler currently running a program to enter the MANUAL PAUSE menu. While you are connected in this mode, the sampler keypad becomes disabled, and your computer's keypad will be redirected to simulate the sampler keypad. The following keys will be activated: <Enter>, decimal point, and number keys. <Esc>, S, or s = STOP. <Backspace>, L or l, and U or u = Left/Up arrows. R or r, and D or d = Right/Down arrows.

Sampling reports

You can retrieve the sampling reports at any time using the same serial connection. Type "Q" to exit the menu. Then at the > prompt, type "REPORT" and press Enter. The sampler controller will send reports as configured.

7.1.2 External Program Control

Under external program control, the sampler operates according to received commands. An external program can be as simple as manually entered commands to collect a sample when needed, or as complex as a user-developed process control program (for SCADA or other systems) that directs sample collection according a system's needs.

The 6712 controller will respond to four commands:

- Turn on the sampler
- Take a sample
- Send status
- Send data

Note that commands and responses are comma-separated pairs. The first set of alpha-characters is an identifier; the second set of numeric characters indicates the value. The 6712 controller will not receive and process the command unless it is followed by a carriage return.

Turn on the sampler – If the sampler is OFF, the sampler responds by placing itself in the ON state and returning a status string to report the new status. (See *Send Status* for a description of this string.)

The command to turn the sampler ON and return status is:

STS,2<CR>

Take a Sample – This directs the sampler to take a sample. The command specifies how much volume to take, and which bottle to place the sample in. The sampler responds by taking a sample and returning a status string that reports the new status.

An example of a command to take a sample is shown below:

BTL,2,SVO,100<CR>

This example instructs the sampler to place the distributor arm over bottle 2 (BTL,2) and take a 100 ml sample (SVO,100).

While most settings of the sampler program (start times, enables, distribution schemes, etc.) are ignored when responding to external commands, the sampler does rely on two program settings that "configure" the sampler. These settings are:

- Number of Bottles–is used to determine the distributor arm position and the acceptable range for the BTL values.
- Suction Line Length–Used with liquid detection to deliver correct sample volumes according to the SVO value.

Send Status – This command causes the sampler to return a data string that identifies the controller and lists its current status.

The command to send current status is:

STS,1<CR>

The status is received as pairs of comma-separated identifiers and values. A complete description of each pair is listed below.

MO,6712, is the model number of the sampler.

ID,2424741493, is the sampler's unique ID number.

TI,35523.50000, is the sampler's current time, shown in a date-time format based on the number of days since 00:00:00 1-Jan-1900, and the time shown as a fraction.

The possible states returned by the STS,1 command are:

1 = WAITING TO SAMPLE.

4 = POWER FAILED (for short time after power is restored).

5 = PUMP JAMMED (must be resolved before continuing).

6 = DISTRIBUTOR JAMMED (must be resolved before continuing).

9 = SAMPLER OFF.

12 = SAMPLE IN PROGRESS.

20 = INVALID COMMAND. Possible causes may be:

- identifier code is not supported.
- bottle requested is not in current configuration
- sample volume requested is outside its range (10 - 9990 ml)
- day (Set_Time) must be 5 digits and more recent than 1977

21 = CHECKSUM MISMATCH. (see "Optional checksum" on page 7-8)

22 = INVALID BOTTLE. (bottle requested is not in the current configuration)

23 = VOLUME OUT OF RANGE. (the sample volume requested is outside its range (10-9990 ml)

STI,35523.41875, is the most recent sample time.

BTL,2, is the bottle that received the most recent sample.

SVO,100, is the most recent sample's volume.

SOR,0, is the results of attempting the most recent sample. The possible results are:

0 = SAMPLE OK

1 = NO LIQUID FOUND

2 = LIQUID LOST (not enough liquid)

3 = USER STOPPED (using the Stop Key)

4 = POWER FAILED

5 = PUMP JAMMED

6 = DISTRIBUTOR JAMMED
8 = PUMP LATCH OPEN
9 = SAMPLER SHUT OFF (while sampling)
11 = NO DISTRIBUTOR
12 = SAMPLE IN PROGRESS

CS,xxxx is the byte-by-byte sum of the entire string "MO,...,CS," (see "Optional checksum" on page 77-8)

Note

For commands that are not understood (INVALID COMMAND or CHECKSUM MISMATCH) or when no samples have been taken, the most recent bottle information is left off the response string.

Send Data – This command causes the sampler to return the Send Status appended with data from any module, rain gauge, or SDI-12 device. Refer to Table 7-2 to interpret the returned string.

Note

This returns the same data as the programmable software option Serial Output, as described in Section 5.18.6 of this manual.

The command to send data is:

DATA<CR>

Table 7-2 Serial Data Codes

Identifier	Parameter	Units
B?[1]	Bottle number and time	days since 1-Jan-1900
CR	Current day's rain	tips[2]
CS[3]	Checksum	unsigned long
DE	Description	6712 Sampler
FL	Flow	cubic meters per second
ID	Unit specific identifier	10 digit unsigned long
LE	Level	meters
MO	Model	6712
PE	Percent	percent of full scale
PH	pH	none
PR	Previous day's rain	tips[2]
RA	Rain	tips[2]
RTE	Refrigerator Temperature	degrees celsius
SS	Sampler enable state	logical
TE	Temperature	degrees celsius

Table 7-2 Serial Data Codes (Continued)

Identifier	Parameter	Units
TI	Current time	days since 1-Jan-1900
VE	Velocity	meters per second
VO	Volume	cubic meters
VSI	Velocity signal strength	percent
VSP	Velocity spectrum strength	percent
CO_ [4]	Conductivity	milliseimens per centimeter
DO_ [4]	Dissolved oxygen	milligrams per liter
PH_ [4]	pH	none
SA_ [4]	Salinity	parts per thousand
SP_ [4]	Specific Conductance	milliseimens per centimeter
TD_ [4]	Total Dissolved Solids	grams per liter
TE_ [4]	Temperature	degrees Celsius
OR_ [4]	Oxidation reduction potential	millivolts
LE_ [4]	Level	meters
MM_ [4]	Ammonium-nitrogen	milligrams nitrogen per liter
MA_ [4]	Ammonia-nitrogen	milligrams nitrogen per liter
NI_ [4]	Nitrate-Nitrogen	milligrams nitrogen per liter
TB_ [4]	Turbidity	nephelometric turbidity units
CL_ [4]	Chloride	milligrams per liter
CP_ [4]	Chlorophyll	micrograms per liter
FL_ [4]	Flow rate	cubic meters per second
VO_ [4]	Flow volume	cubic meters
xxD_ [4, 5]	Other data not listed above	

[1] The three most recent samples will have entries as B?. The “?” will be the first bottle number in the set. If the sample is a grab sample, it will be shown as B0.

[2] Rainfall tips roll over every 256 counts.

[3] The checksum does not include the checksum, carriage return, and linefeed. The string is terminated with <CR><LF>.

[4] A “_” in the identifier indicates an SDI-12 address.

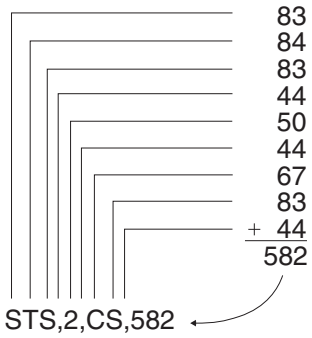
[5] “xx” matches the data label for the SDI-12 parameter.

Optional checksum

Optionally, commands to the sampler can be validated using a checksum. Checksum validation can avoid problems caused by faulty program control or communication lines. When using the checksum, add the CS identifier and a comma at the end of the command, and the checksum value of the string up to the last comma. For example, the command with checksum validation to turn the sampler on would appear as:

STS,2,CS,582<CR>

The numeric value of each character is its ASCII equivalent expressed in decimal format. The checksum of "582" was calculated as shown below.



7.1.3 Remote Control of Sampler Keypad

To control the sampler keypad remotely, type CONTROL at the ">" prompt and press ENTER. The sampler display appears on your computer monitor as you step through the programming screens. While in this mode, the computer keys will be redirected to simulate the sampler's keypad, and the sampler keypad itself will be disabled to avoid any conflict. The active keys and their corresponding functions are given in Table 7-3.

Table 7-3 Remote Control of Sampler Keypad

Computer	Sampler
<Esc>, S, s	STOP
L,l,U,u, <Backspace>	Left / Up
R, r, D, d	Right / Down
O, o	ON
<Enter>, arrows, decimal, numbers	Same as sampler
NOTE: You will not be able to turn the sampler off remotely.	

7.2 Telephone Commands

6712 controllers equipped with an internal voice modem can be operated using telephone commands. This factory-installed option includes a 12 ft (3.6 m) modem cable.

After connecting to the sampler from a touch-tone telephone, command numbers may be entered from the telephone's keypad, followed by the [#] (pound) button. The commands are listed in Table 7-4.

To use telephone commands:

1. Dial the sampler's telephone number. When the sampler connects, it answers with "Teledyne Isco Sampler Site [number]." If the sampler does not receive a touch-tone command in five seconds, it assumes that a computer modem has called and initiates the modem connect sequence. If this occurs you must hang up and try again.
2. Enter the command. For example, to run program 1, press [1] [#].
3. If the command is valid for its current state of operation, the sampler responds with "[command number], please acknowledge." If the command is not valid the sampler responds with the command number followed by three quick beeps. Enter a valid command.
4. Acknowledge the valid command by pressing the number. For the example, press [1].
5. If the number is incorrect, the sampler responds with your entry followed by three quick beeps. You must re-enter the command (step 2).
6. After the command is confirmed, the sampler replies with "[command number] acknowledge" and executes the command.

To enter additional commands, repeat steps 2 through 5. The sampler will hang up after ten seconds of quiet time.

Table 7-4 6712 Remote Phone Commands

Phone Command	Name	Description
[0] [#]	Start	This command will immediately start any program set to WAIT FOR PHONE CALL and currently waiting for the remote start command (see Section 4.6).
[1] [#]	Load and Run Program 1	This command will load Program 1 as the sampler's current Extended program, reset partition if the storage interval has been changed, and run the program. RUN1 is valid when the sampler is in standby, or when it is waiting for a start command. RUN1 will also run the current program while in Standard programming.
[2] [#] [3] [#] [4] [#]	Load and Run Program 2, 3, or 4	These commands will load the selected program number as the sampler's current Extended program, reset partition data if the storage interval has changed, and run the program. They are valid when the sampler is in standby, or when it is waiting for a start command. The commands are available for Extended programming only.

Table 7-4 6712 Remote Phone Commands (Continued)

Phone Command	Name	Description
5 #	Disable	This command is similar in functionality to a pin F low signal (a signal typically used to enable or disable the sampler from a flow meter). At run time, the sampler starts with the phone enable in the enabled state. PHONE DISABLE is valid while a program is running. If successful, a reply of REMOTE ENABLE IS FALSE will be returned. A Remote Disable is the highest priority disable. If the sample is disabled with this command, no condition other than command 6#, ENABLE, will allow the program to become enabled again.
6 #	Enable	This command is used to re-enable a phone-disabled sampler. PHONE ENABLE is valid while a program is running. If successful, a reply of REMOTE ENABLE IS TRUE will be returned.
7 #	Grab Sample	This command causes the sampler currently running a program to take a sample. The sample will count as one of the program's samples and is placed in the current bottle (Part A's current bottle when using two-part programming). TAKE_SAMPLE is valid while the program is running, after the start time, but not while in the MANUAL PAUSE screens. If successful, a response similar to PUMPING XXML SAMPLE INTO BOTTLE ## will be returned. If not, a response similar to NO SAMPLE, PROGRAM WAITING START will be returned.

6712 Portable Sampler

Section 8 Maintenance

This section describes how to maintain and troubleshoot your 6712 sampler. If you think your unit requires repair, or if you have questions concerning its operation or maintenance, contact Teledyne Isco's Technical Service Department:

Phone: (800) 228-4373
(402) 464-0231
FAX: (402) 465-3022

E-mail: IscoService@teledyne.com

8.1 Maintenance Checklist

- Inspect the pump tube for wear. Replace it if necessary.
- Clean the pump tubing housing.
- Change the suction line if necessary.
- Clean the bottles, suction line, strainer and pump tube.
- Check the humidity indicator.
- Check the controller's internal battery status and replace the battery every five years.
- If the keypad label has bubbles under it, the air inside the controller has expanded. To release this pressure, unscrew the flow meter cable or connector cap on the back of the controller. Push down on the label to force the air out, then re-tighten the cable connector or cap.

8.2 Cleaning Guidelines

8.2.1 Controller, Top Cover, Center Section, Retaining Ring, and Tub

Clean the top cover, center section, retaining ring, and tub with warm soapy water or by spraying them with a hose. Avoid using a high-pressure hose to clean the controller, especially around the control panel. Extreme pressures may force water past the control-panel seal.

When cleaning the controller and top cover, cap the connectors at the back of the controller tightly. Keep a power source connected to the power-source connector, or replace the protective cap (shipped with the sampler) over the power source connector, to protect the pins from moisture damage. Make sure the two pump drain holes (located on the bottom right-hand side of the pump, beneath the pump band) are open and free of debris or buildup.

8.2.2 Sample Bottles

The sample bottles have a wide mouth to facilitate cleaning. Wash them with a brush and soapy water, or use a dishwasher. You can autoclave the glass bottles.

8.2.3 Suction Line, Pump Tube, and Discharge Tube

Clean the suction line, pump tube, and discharge tube by placing the end of the suction line in a cleaning solution and pumping it through the delivery system. Rinse with clean water. If these items are severely contaminated, discard them. For critical sampling applications, refer to the following sections.

8.2.4 Strainer

Clean the strainer with a brush and soapy water.

8.3 Cleaning Protocols for Priority Pollutants

Clean sampling equipment is essential for valid laboratory analysis. Teledyne Isco recommends that you develop cleaning protocols in consultation with a laboratory analyst when designing the monitoring program. For example, to clean sample bottles, suction line, and pump tubes, Lair (1974) suggests these protocols used by USEPA Region IV Surveillance and Analysis field personnel engaged in NPDES compliance monitoring. The protocols are based on U.S. Environmental Protection Agency Publications EPA-600/4-77-039 (*Sampling of Water and Wastewater* by Dr. Phillip E. Shelley).

8.3.1 Teledyne Isco Glass Sample Bottles

1. One spectro-grade acetone rinse.
2. Dishwasher cycle (wash and tap water rinse, no detergent).
3. Acid wash with at least 20 percent hydrochloric acid.
4. Dishwasher cycle (wash and tap water rinse, no detergent).
5. Replace in covered Teledyne Isco tubs.

8.3.2 Vinyl Suction Line

- Use new suction line for each new sampling setup, therefore, no cleaning is required.
- Use PTFE suction line when sampling for organic compounds.

8.3.3 Teflon Suction Line

1. Rinse twice with spectro-grade acetone.
2. Rinse thoroughly with hot tap water using a brush, if possible, to remove particulate matter and surface film.
3. Rinse thoroughly three times with tap water.
4. Acid wash with at least 20 percent hydrochloric acid.
5. Rinse thoroughly three times with tap water.
6. Rinse thoroughly three times with distilled water.
7. Rinse thoroughly with petroleum ether and dry by pulling air through the line.
8. Dry overnight in a warm oven (use an oven temperature of lower than 150° F), if possible.
9. Cap ends with aluminum foil.

8.3.4 Teledyne Isco Pump Tube

1. Rinse by pumping hot tap water through the tube for at least 2 minutes.
2. Acid wash the tube by pumping at least a 20 percent solution of hydrochloric acid through the tube for at least 2 minutes.

3. Rinse by pumping hot tap water through the tube for at least 2 minutes.
4. Rinse by pumping distilled water through the tube for at least 2 minutes.

> ☑ ***Note***
>
> For critical sampling applications, consider replacing the suction line, pump tube, and discharge tube. Replacement eliminates the possibility of any cross contamination from previous sampling sites.

8.4 Maintenance Screens

When you select OTHER FUNCTIONS from the main menu, and then select Maintenance, the following screen will be displayed:

```
SET CLOCK
PUMP TUBE ALARM
INTERNAL BATTERY
DIAGNOSTICS
```

Using these options, you can set the sampler's time and date, set the number of pump counts for the pump tube warning, reset the battery warning for the internal battery, and run a set of diagnostic tests for troubleshooting purposes.

8.4.1 Set Clock

Entering Times and Dates

```
ENTER TIME AND DATE:
HH:MM   DD-MON-YY
__:__   __-__-__
```

- Move from one field to another by pressing the arrow keys.
- Change a setting in a field by typing a number. Press ↵ to accept the new setting.

Teledyne Isco ships samplers from the factory with the clocks set to the correct Central Standard Time. Reset the clock when installing the sampler in a different time zone, for daylight savings time, or when needed.

When setting the clock and calendar, use a 24-hour clock for times and the day-month-year format for dates. The illustration at the left shows blanks for each position that accepts an entry. The positions are called fields. When this screen appears on your sampler, the fields will contain the sampler's current settings for the time and date.

- To move from one field to another without changing the setting, press the arrow keys. Use this technique when you want to change only one or two settings.
- Change the setting by typing a new number. Press ↵ to accept the new setting.

For example, to enter 2:00 p.m. (2:00 p.m is 14:00 on a 24-hour clock), type 14. Press ↵. Next, type 0 (zero) for the minutes, and press ↵. To enter a date, such as January 22, 2001, type: 22 ↵ 01 ↵ 01 ↵ .

Table 8-1 Setting the Clock and Calendar

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE	Select MAINTENANCE.
3	**SET CLOCK** PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Select SET CLOCK.
4	ENTER TIME AND DATE: HH:MM DD-MON-YY **14:00 22-JAN-01**	Enter the time and date.
5	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.2 Pump Tube Alarm

The sampler tracks the pump counts in both the forward and reverse cycles with a resettable counter. When the counter reaches the default count of 1,000,000 or the count you have entered, the sampler displays a message, "WARNING! REPLACE PUMP TUBE." The message appears each time you turn the sampler on or run a program until you reset the counter.

After replacing the pump tube (see page 8-8), reset the count to zero so the sampler can begin tallying the pump counts for the new tube. Replacing the pump tube does not reset the counter.

Experience may suggest a significantly different pump tube life. You can change the alarm count to represent the pump tube life for your application. The example below shows how to set the alarm count and reset the pump counts.

Table 8-2 Resetting the Pump Counter

1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE HARDWARE	Select MAINTENANCE.
3	SET CLOCK **PUMP TUBE ALARM** INTERNAL BATTERY DIAGNOSTICS	Select PUMP TUBE ALARM.
4	1024000 PUMP COUNTS, WARNING AT 1000000	The sampler displays this screen briefly to give you the current pump-count information. The first line shows you the pump counts tallied since the counter was last reset. The second line shows the current alarm setting.
5	1024000 PUMP COUNTS, RESET PUMP COUNTER? **YES** NO	To reset the counter to zero, select YES. Always reset the counter after replacing a pump tube. Select NO when merely checking the current count.
6	WARNING AT **10**00000 PUMP COUNTS (1 - 99)00000)	If necessary, change the pump-count alarm setting by typing the first two digits of the new setting. The sampler accepts entries between 1 and 99. For example, to increase the count to 1,500,000, enter 15.
7	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.3 Internal Battery Warning

The internal lithium battery preserves the sampler's memory when power is removed. For an explanation of how to replace the lithium battery, go to Section 8.8.

Table 8-3 Checking and Replacing the Internal Battery

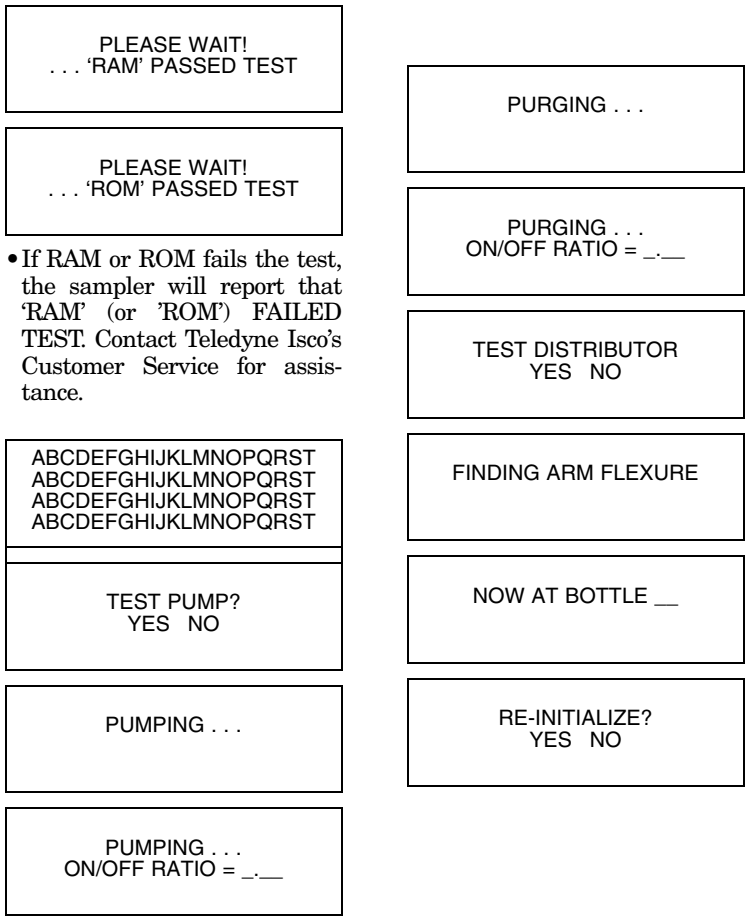
1	RUN PROGRAM VIEW REPORT **OTHER FUNCTIONS**	Select OTHER FUNCTIONS.
2	**MAINTENANCE** MANUAL FUNCTIONS PROGRAMMING STYLE HARDWARE	Select MAINTENANCE.
3	SET CLOCK PUMP TUBE ALARM **INTERNAL BATTERY** DIAGNOSTICS	Select INTERNAL BATTERY.
4	WARNING! REPLACE INTERNAL BATTERY BEFORE 17-OCT-97	The sampler displays this screen briefly to show you the expiration date.
5	DID YOU REPLACE THE INTERNAL BATTERY? YES NO	After replacing the battery, select YES. Select NO only if checking the expiration date. Resetting the alarm directs the sampler to calculate a new expiration date, five years in the future. If you reset the alarm without replacing the battery, the sampler will not be able to alert you to the battery's impending expiration.
6	SET CLOCK PUMP TUBE ALARM INTERNAL BATTERY DIAGNOSTICS	Press STOP to return to the main menu.

8.4.4 Diagnostics

The sampler has several self-diagnostic tests that check the memory (both the RAM and ROM), pump, and the distributor arm position. It also contains screens that let you reset the sampler's program settings and memory to factory settings.

You do not need to run the diagnostic tests on a routine basis. The diagnostic tests are a troubleshooting tool; Teledyne Isco's Customer Service department staff may ask you to run these tests when they work with you in diagnosing problems with your sampler.

Access the diagnostic screens by selecting Other Functions from the main menu, then Maintenance, and Diagnostics. The unit will automatically test the memory and display; you can choose whether it tests the pump and distributor, and whether it reinitializes the unit to its original factory settings.



- If RAM or ROM fails the test, the sampler will report that 'RAM' (or 'ROM') FAILED TEST. Contact Teledyne Isco's Customer Service for assistance.

Memory Test – Screens 1 and 2 at left show you the diagnostic tests for the unit's memory. If either screen shows you a message saying that the memory failed the test, contact Teledyne Isco's Customer Service.

Display Test – Screen 3 shows you the display test. You should see the test pattern illustrated in the screen. If the pattern does not match the illustration, the display or its circuitry require repair.

Pump Test – Screen 4 lets you start the pump test by selecting YES. As the sampler runs the test, it first runs the pump forward for a short period. Next, it displays an ON/OFF ratio number. After displaying the forward pumping ratio, the sampler reverses the pump to obtain a purge ratio. The acceptable range is between 0.80 and 1.25. If either ratio is outside the acceptable range, the pump requires repair. You do not need to pump liquid while running the test, and you can run the test with or without a tube in the pump.

⚠ CAUTION

Tests indicate that the pump produces sound levels in excess of 85db at one meter. Prolonged exposure to this sound level could result in hearing loss and requires the use of protective ear plugs.

Distributor Test – The distributor test is provided for factory personnel to verify the distributor's position as it rotates through the 24 positions. (screens 9 through 11). The distributor arm flexes slightly when it contacts the stop, and the sampler measures this flexure. The sampler uses this measurement to position the arm accurately over each bottle.

Reinitialize Controller – The sampler allows you to reset all the program settings to the settings shipped with the sampler (screen 12). Reinitializing also clears the memory that stores the sampler's event log and module data. **Use this option cautiously.**

8.5 Replacing the Pump Tube

Replace the pump tube only with Teledyne Isco's 6712 pump tubing. **Other pump tubes will not work**. The 6712 pump tubing is easily recognized by the blue alignment collars.

Improper pump tubes include those made for Teledyne Isco's other samplers (3700, GLS, etc.) and tubing from non-Teledyne Isco vendors. Also note that the discharge tube is not the same as the pump tube. You could experience several problems if you install the wrong pump tubing:

- The sampler will not pump the liquid.
- Pump jams
- Inaccurate sample volumes
- Faulty liquid detection

Inspect the pump tube periodically. Replace the tube when it cracks or appears worn. Inspect the tube frequently when the sample liquid contains a high percentage of suspended or abrasive solids.

☑ *Note*

The importance of regular tubing replacement cannot be overstated. The key is to replace the tube before failure, not after. When a pump tube ruptures, grit and other abrasive debris can be driven into the pump shaft seal. Over time, this abrasive material will degrade the pump seal, jeopardizing the NEMA 4x 6 rating of the controller.

Failure to maintain the pump tube may result in permanent damage to the sampler. Check the condition of the pump tube regularly and if the tube shows signs of fatigue or wear, replace it immediately. A properly maintained sampler will provide the years of reliable service that is expected of a Teledyne Isco Sampler.

8.5.1 Checklist For Replacing Pump Tube

1. Disconnect power from the sampler.

⚠ WARNING

The pump's safety lock prevents the sampler from running the pump when the pump band is open. DO NOT tamper with the safety mechanism. The pump is extremely powerful. The pump rollers can injure you severely if the sampler activates the pump while you are working on it or inside it. Disconnect power from the sampler before replacing the pump tube.

2. Loosen the liquid detector's cover by unscrewing the black knob on top of the detector. Unlatch the pump band. (The band is the rounded metal band that holds the tube in the pump.)
3. Pull the tube away from the bulkhead fitting. Pull it from the pump and detector.
4. Clean the pump rollers and the inside of the pump band.
5. Thread the new tubing through the pump so that the tube follows its natural curve around the pump rollers. You may need to move the pump rollers to make the installation easier.
6. The blue collars on the tube help align the tube in the detector and pump. Align the tube by placing the collars in the grooves inside the liquid detector.
7. Close the detector's cover and tighten the black knob. Close the pump strap and latch it.
8. Reset the pump-tube counter. (See example in table 8-2.)
9. Take a "dry" grab sample to test the tube installation.

☑ *Note*

To extend the pump tube life:
• Always use Teledyne Isco pump tubes.
• Install the tube properly, aligning the blue collars correctly in the liquid detector's grooves.
• Follow the natural curve of the tube when wrapping the tube around the pump rollers.
• Minimize the line rinses and sampling retries in the sampling programs
• Use the shortest possible suction line.
Conditions that shorten tube life:
• Improper installation.
• Abrasive materials suspended in sample liquid.
• Frequent line rinses.
• Long purge cycles, such as those used with long suction lines.

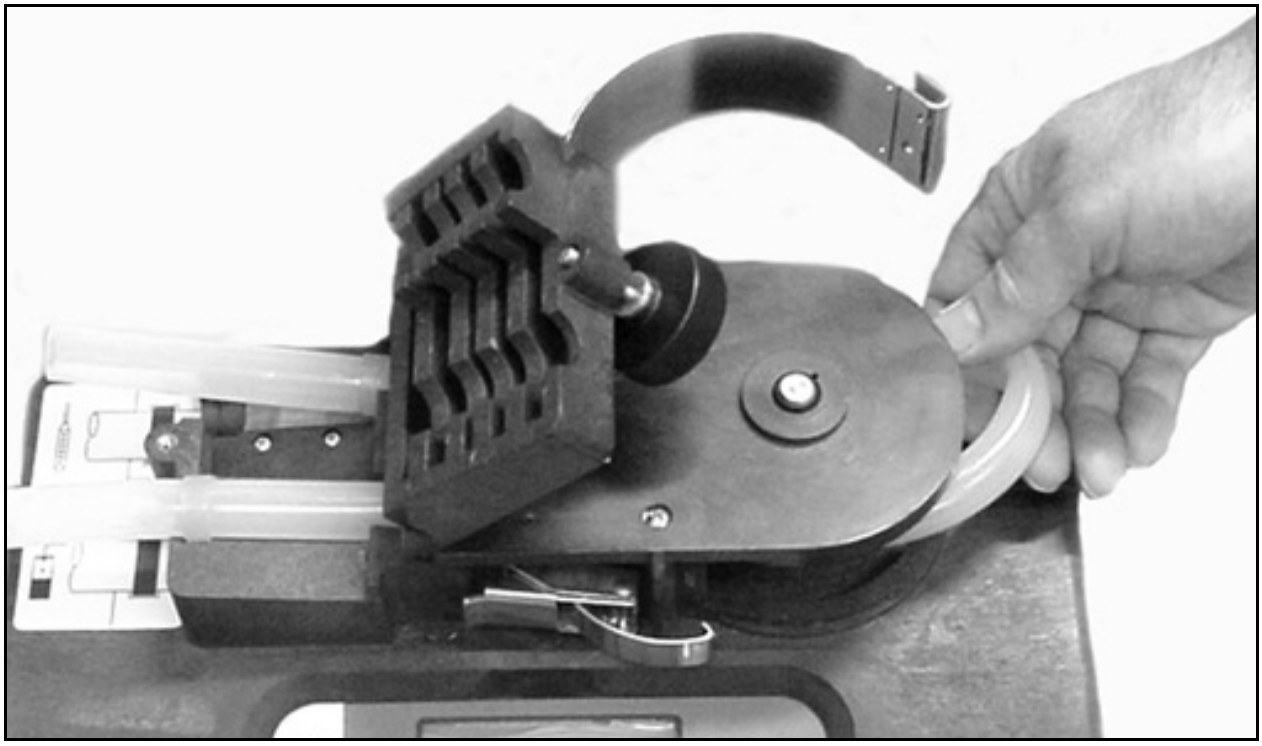


Figure 8-1 Removing and Replacing the Pump Tube

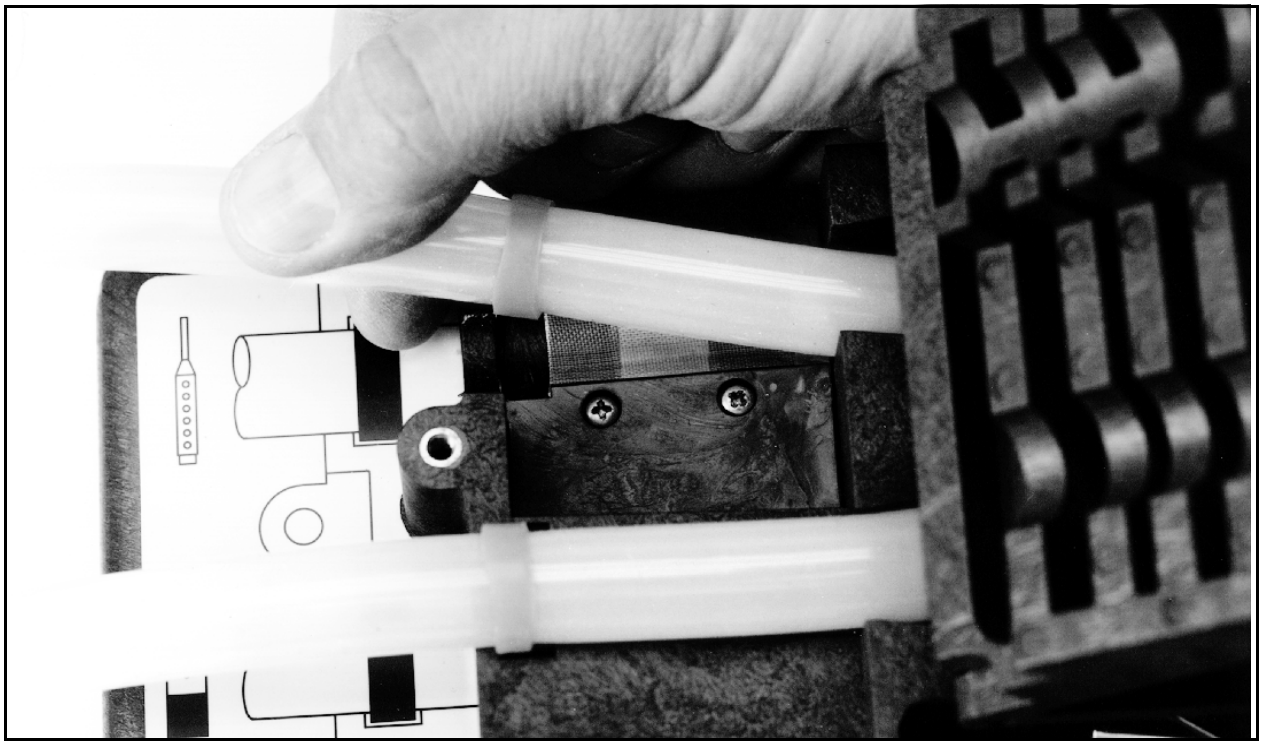


Figure 8-2 Placing the Pump Tube in the Liquid Detector

8.6 Opening the Controller Case

You will need to open the controller case to gain access to:

- The desiccant bag that dries the controller's interior
- The battery that provides backup power to the controller

⚠ CAUTION

The circuit boards can be damaged from a discharge of static electricity. Always use an antistatic mat when opening the controller to protect the circuit boards.

To open the case:

1. Pull the discharge tube and pump tube away from the bulkhead fitting.
2. Remove the distributor arm by unscrewing the nut that attaches the arm to the distributor shaft. DO NOT ROTATE THE DISTRIBUTOR ARM MANUALLY; THIS WILL SEVERELY DAMAGE THE DISTRIBUTOR DRIVE GEARS.
3. Remove the controller from the center section.
4. Open the case by removing the 11 screws that attach the case bottom to the case top.

☑ *Note*

The case top and bottom fit together with a sealed tongue-and-groove joint. Any damage — nicks or cuts — to the tongue, groove, or sealing gasket prevent the case from sealing completely when you close it. Use extreme care when opening the case to avoid damaging the joining surfaces.

Refer to Figure 8-3 for the location of the desiccant box. To gain access to the main circuit board and battery, remove the two distributor connectors and the EMI shield.

8.7 Replacing the Desiccant

A humidity indicator, labeled "INTERNAL CASE HUMIDITY," is located to the right of the keypad. It indicates the amount of moisture present inside the control box. The paper indicator is **blue** when the control box is dry.

The control box is a completely sealed unit. You do not need to open the control box during normal operation. The 6712 Samplers use a desiccant bag inside the controller case to prevent moisture damage to its electronic components. Thus, the humidity indicator should remain blue under normal conditions. If moisture does accumulate, the numbered areas on the indicator will turn light **pink** or **white**, starting with the area numbered "20." This indicates that the relative humidity inside the control box exceeds 20%. As more moisture accumulates, the areas numbered "30" and "40" will turn light pink or white, indicating relative humidities of 30% and 40% respectively.

If the 30% area of the humidity indicator turns light pink or white, open the control unit, inspect it for leaks, and replace the desiccant bag.

⚠ CAUTION

Do not attempt to reactivate the used desiccant. Reactivation may cause desiccant to leak out of the bag, causing mechanical damage inside the controller.

Follow the instructions in Opening the Controller Case in Section 8.6 to open the controller. Remove the bag from the cardboard box (part #69-9003-518) at the front of the case and replace it with a fresh bag of desiccant (part #099-0002-00).

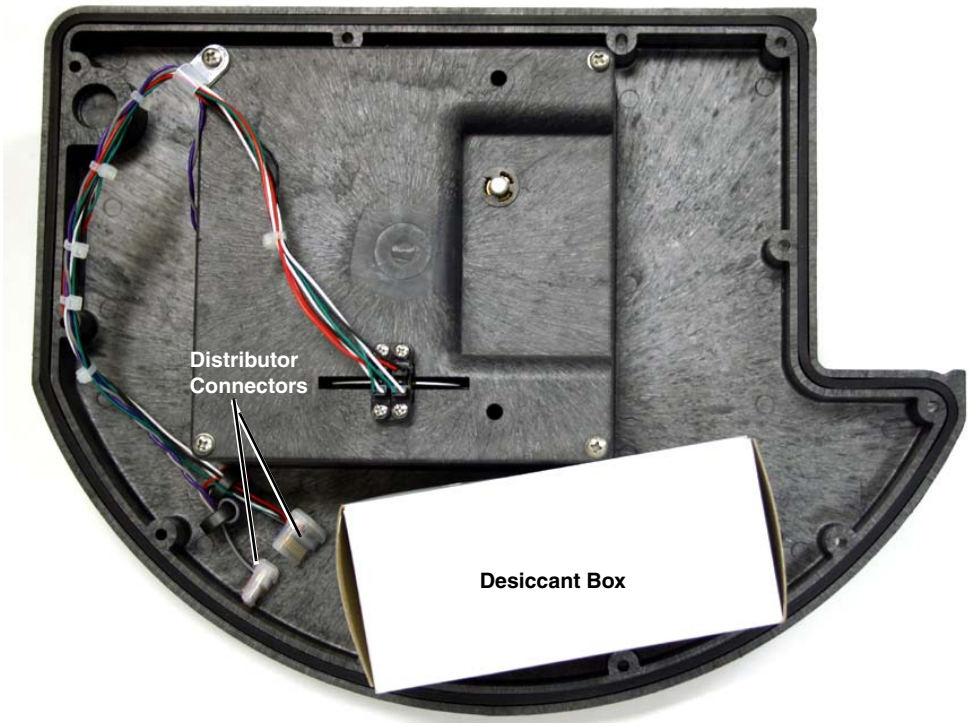


Figure 8-3 Opening the Controller

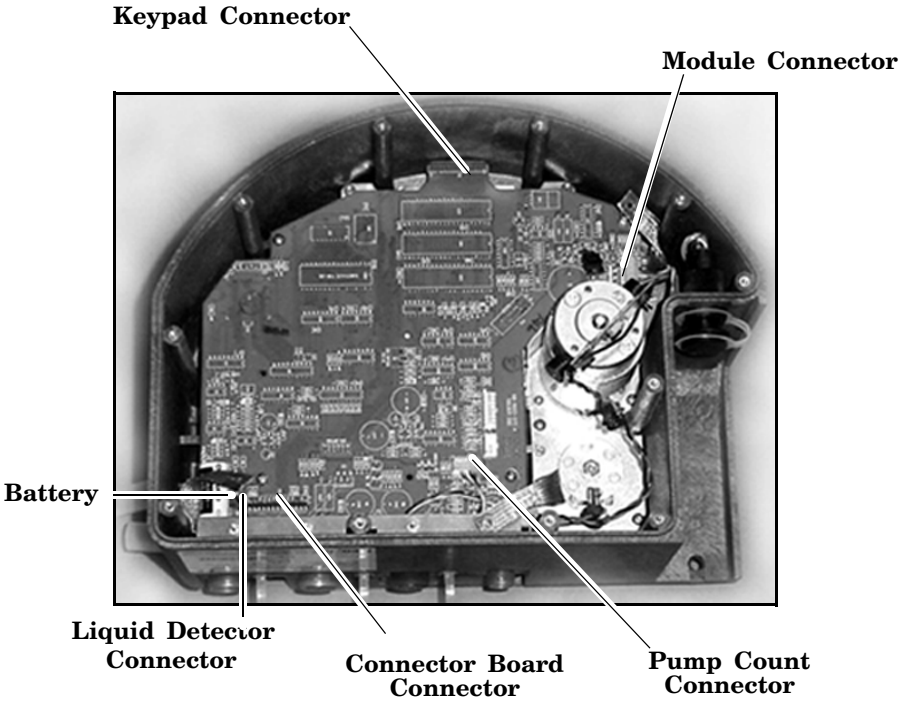


Figure 8-4 Main Circuit Board Connections

8.8 Replacing the Internal Battery

Battery Status Display

WARNING!
REPLACE INTERNAL
BATTERY BEFORE
17-OCT-06

A lithium battery housed inside the controller maintains power to the sampler's memory when the controller is disconnected from a power source. If it discharges completely, the sampler will lose all program settings and all data stored in memory when the external power source is disconnected. The battery requires replacement every five years. The sampler keeps track of the time that has passed since the battery was installed. To view this information, select INTERNAL BATTERY from the Maintenance screen (see example at left). After 5 seconds, the sampler asks if you have replaced the internal battery (see example at left).

Select YES to reset the countdown to 59 months from the current date.

DID YOU REPLACE THE
INTERNAL BATTERY?
YES NO

While replacing the battery, it is likely that the stored readings will be lost and your program will revert to the default program. Before proceeding, retrieve the stored data and record your program settings.

☑ Note

Teledyne Isco recommends you replace the battery every five years, as soon as the battery warning appears. To ensure that the replacement meets Teledyne Isco's specifications, use only Teledyne Isco replacement batteries. (See *Appendix D, Replacement Parts*.)

To replace the internal battery:

1. Open the controller case. Separate the case bottom and top by removing the two distributor connectors.
2. Lift the desiccant box from the case.
3. Remove the EMI shield and grounding straps by loosening the five 1/4-inch stop nuts.
4. Disconnect the module, liquid detector, and pump count connectors from the main circuit board.
5. Remove the three screws and the 1/4-inch stud attaching the main circuit board to the case.
6. Detach the main circuit board from the keypad connector by pulling gently upward on the edges of the board next to the connector. Pull the main board up until the keypad connector is almost even with the edge of the case. Next, detach the main circuit board from the connector board.
7. De-solder the lithium battery, using care to prevent damage to the circuit board. Insert the replacement battery and solder it in place.

☑ *Note*

Poor soldering techniques can easily damage a printed circuit board. The battery should be replaced by a skilled technician.

⚠ WARNING

Danger of explosion if lithium battery is incorrectly replaced. Replace with the same type, ensuring correct polarity. Do not dispose of used lithium battery in fire.

8. Reconnect the main circuit board to the connector board before reconnecting it to the keypad. Replace the 1/4-inch stud and the three screws, and reconnect the module, liquid detector, and pump count connectors.
9. Replace the EMI shield and grounding straps. Reconnect the two distributor connectors.
10. Ensure that all connections and hardware are secure. Replace the desiccant and close the case.
11. Reset the battery alarm.

8.9 Error Messages

If the sampler detects an error that prevents it from taking a sample or continuing the program, it displays an error message.

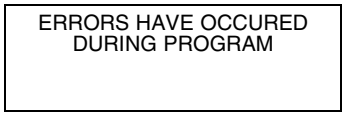
```
OPERATION ERROR:
PUMP JAMMED
```

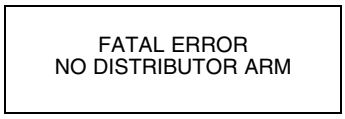
There are messages for the following conditions:

- PUMP JAMMED
- DISTRIBUTOR JAMMED
- PROBABLE OVERFLOW
- POWER FAILED
- LOW BATTERY
- USER STOPPED
- NO DISTRIBUTOR ARM
- NO LIQUID DETECTED
- NO MORE LIQUID
- PUMP LATCH OPEN
- SAMPLER SHUT OFF
- BOTTLE FULL
- SAMPLE IN PROGRESS

Error Messages

Since the sampler may encounter more than one error during a program, it does not display the messages continuously. Instead, it records each error and the time it occurred in the Sampling Results and Combined Results report. It alerts you to the recorded errors by displaying the message, "ERRORS HAVE OCCURRED DURING PROGRAM."





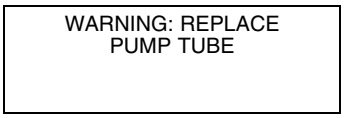
If the sampler detects a low battery condition, it stops the running program and displays the "LOW BATTERY" error message. A low battery condition exists when five consecutive sample events have resulted in a POWER FAILED error message.

Fatal Error – The Fatal Error message will only show up if you are using a multiple bottle configuration and the distributor system fails. Failing the test can indicate any of the following conditions:

- The distributor arm is not attached to the sampler.
- The distributor-arm stop inside the center section is missing or broken.
- The distributor drive mechanism inside the controller is malfunctioning.

8.10 Pump Tube Warning

Occasionally, the sampler displays a warning message to alert you to a potential problem. The warning, REPLACE PUMP TUBE, reminds you to check the condition of the pump tube. Instructions regarding the pump tube can be found elsewhere in this section.



6712 Portable Sampler

Appendix A Menu Flowcharts

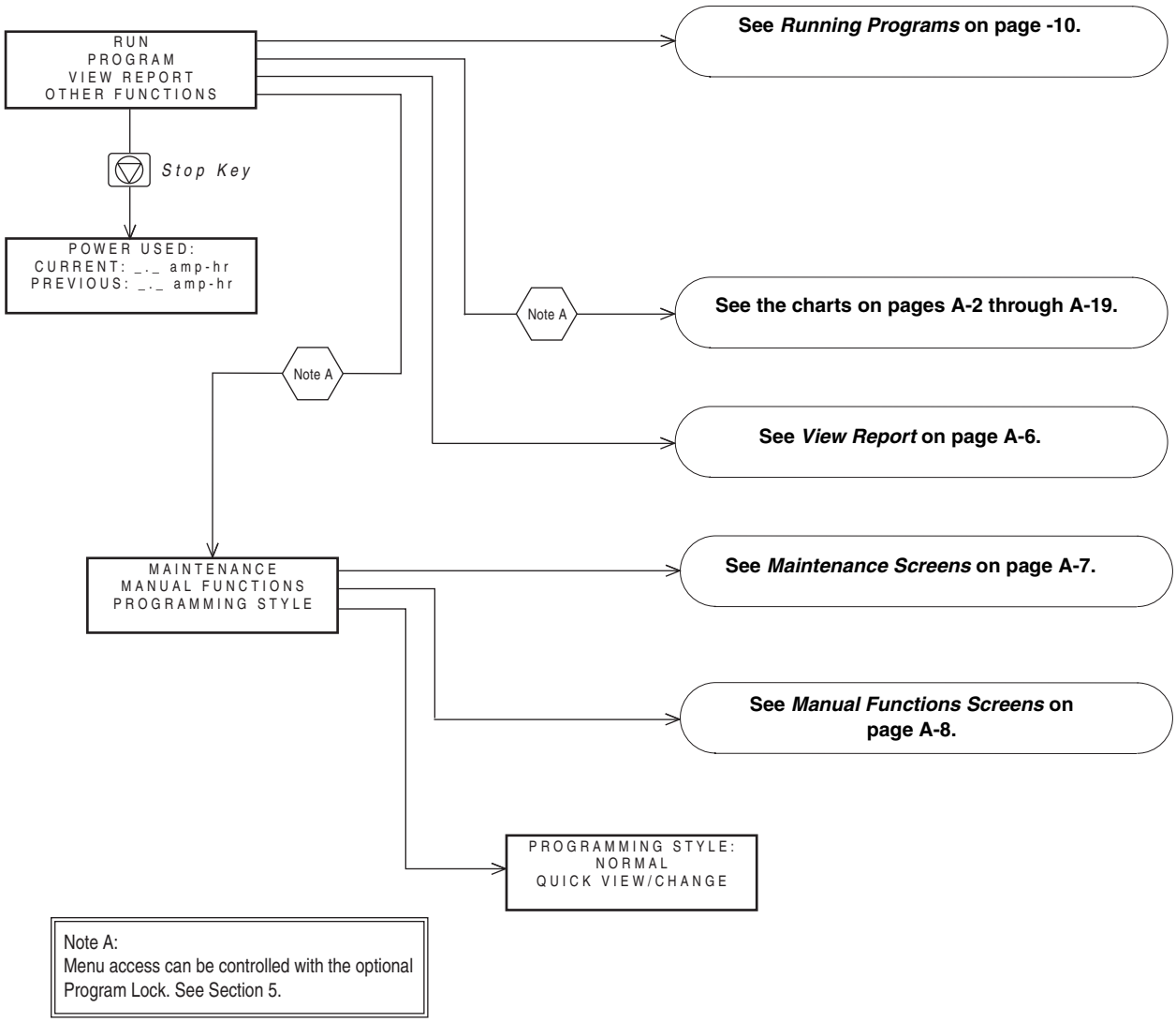


Figure A-1 6712 Menu Tree for Standard Programming

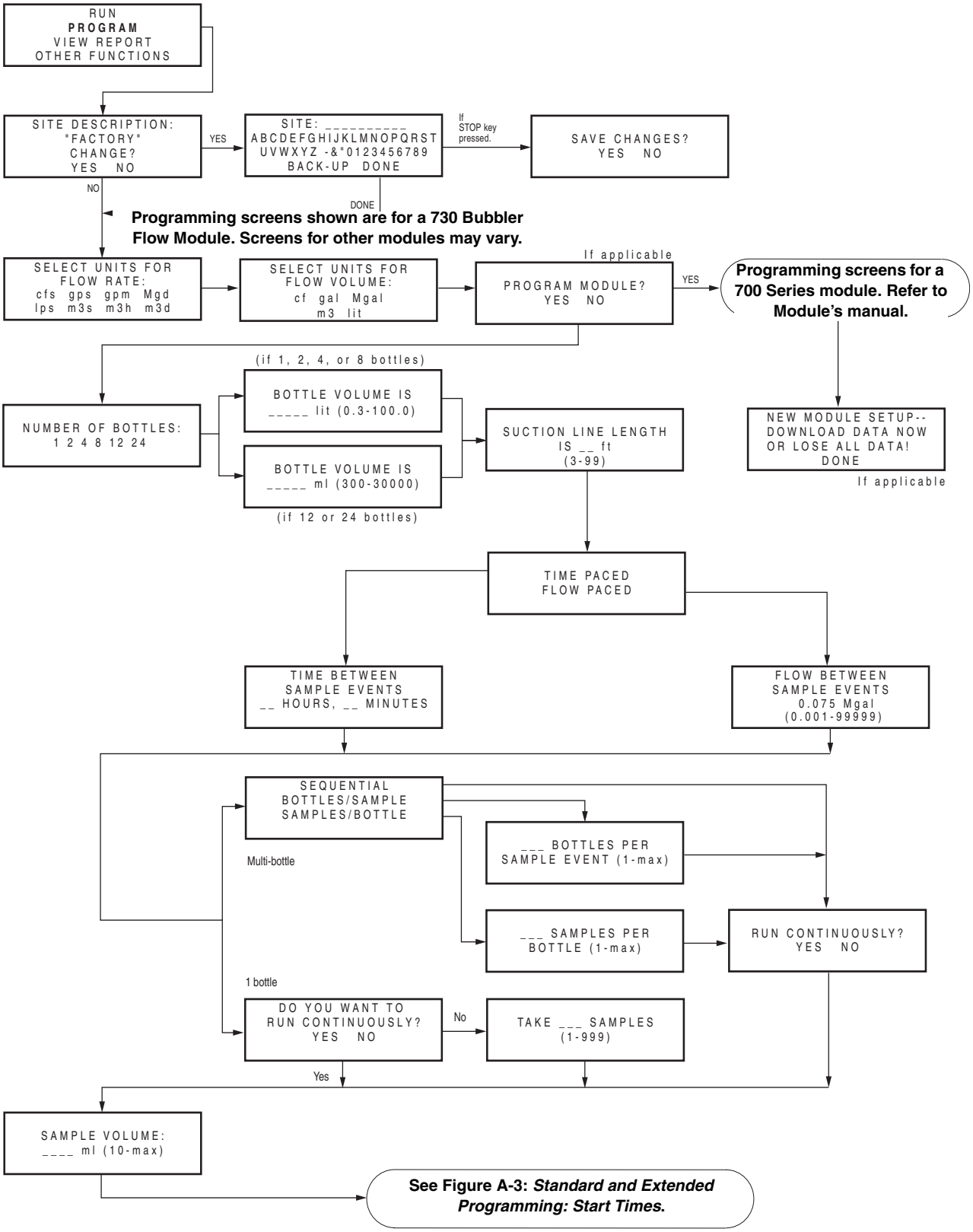


Figure A-2 Standard Programming: Programming Screens

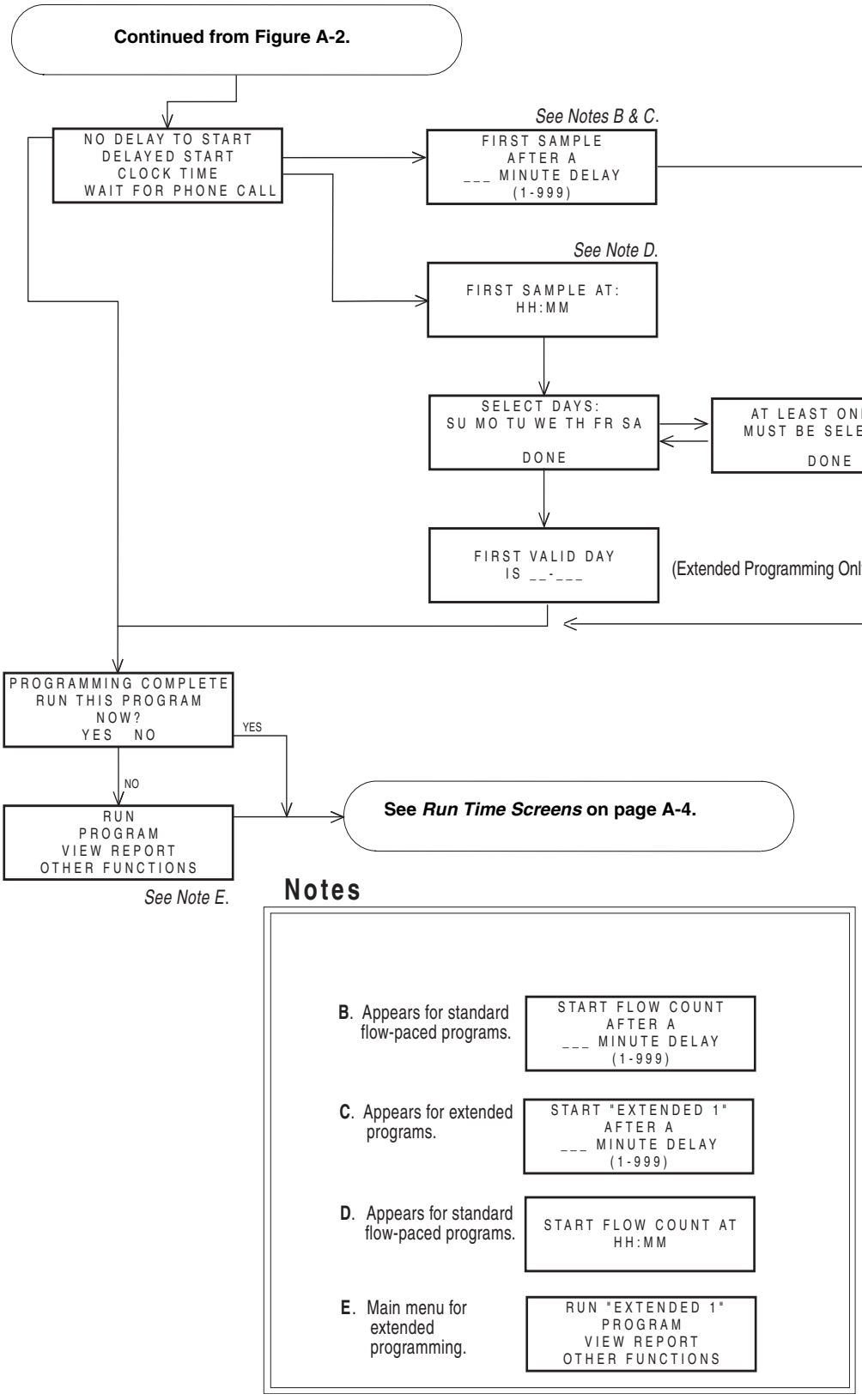


Figure A-3 Standard and Extended Programming: Start Times

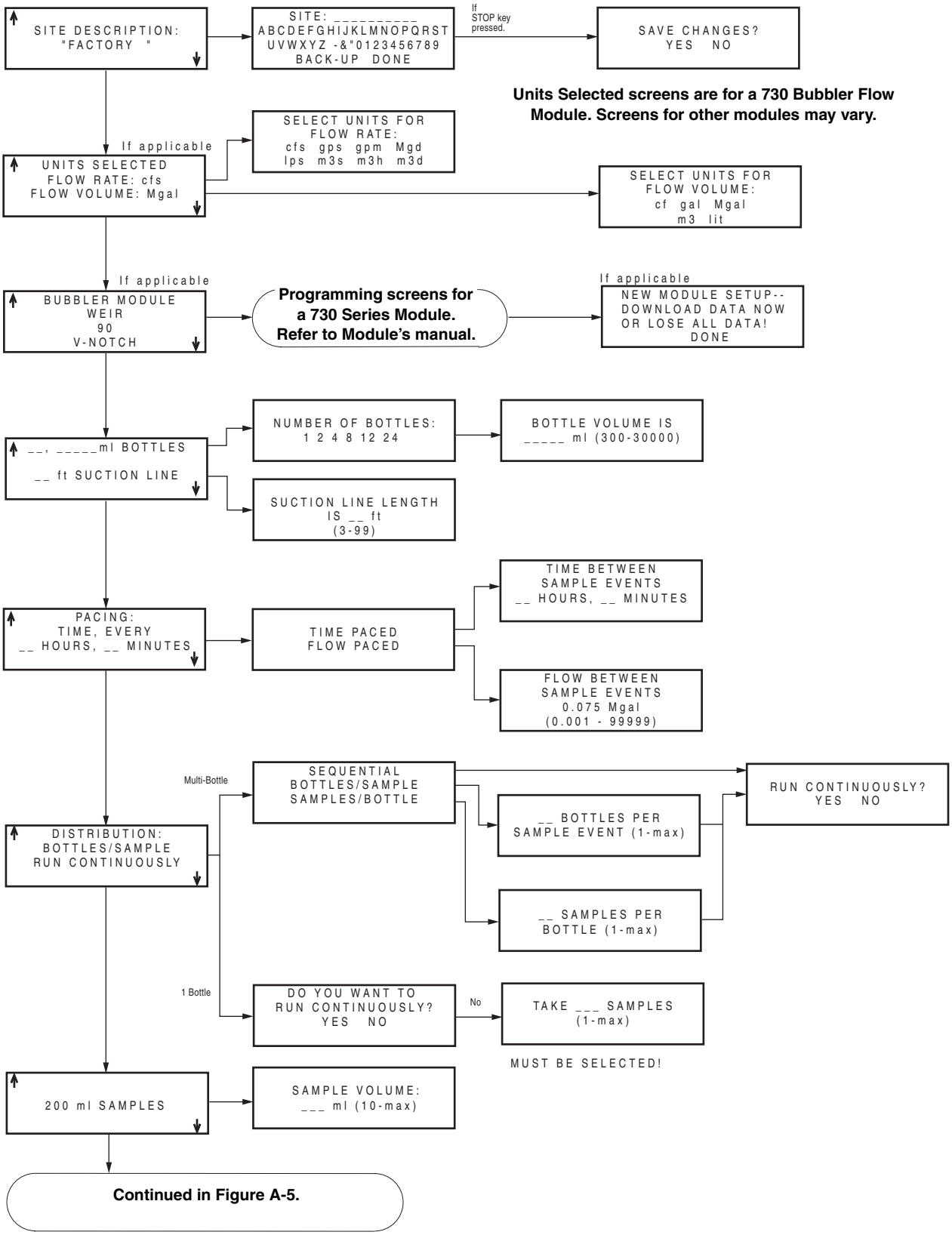


Figure A-4 Standard Programming: Quick View; Programming Screens

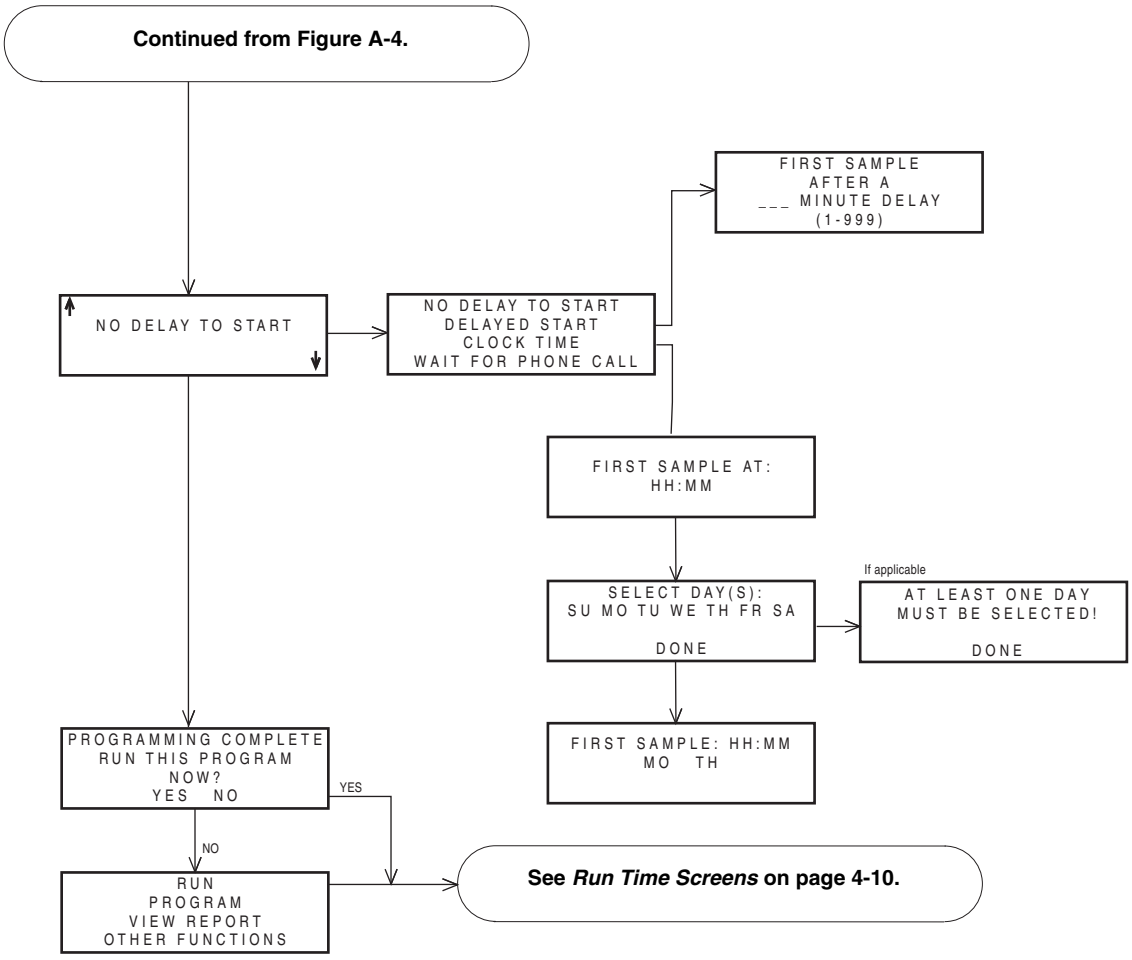


Figure A-5 Standard Programming: Quick View; Start Times

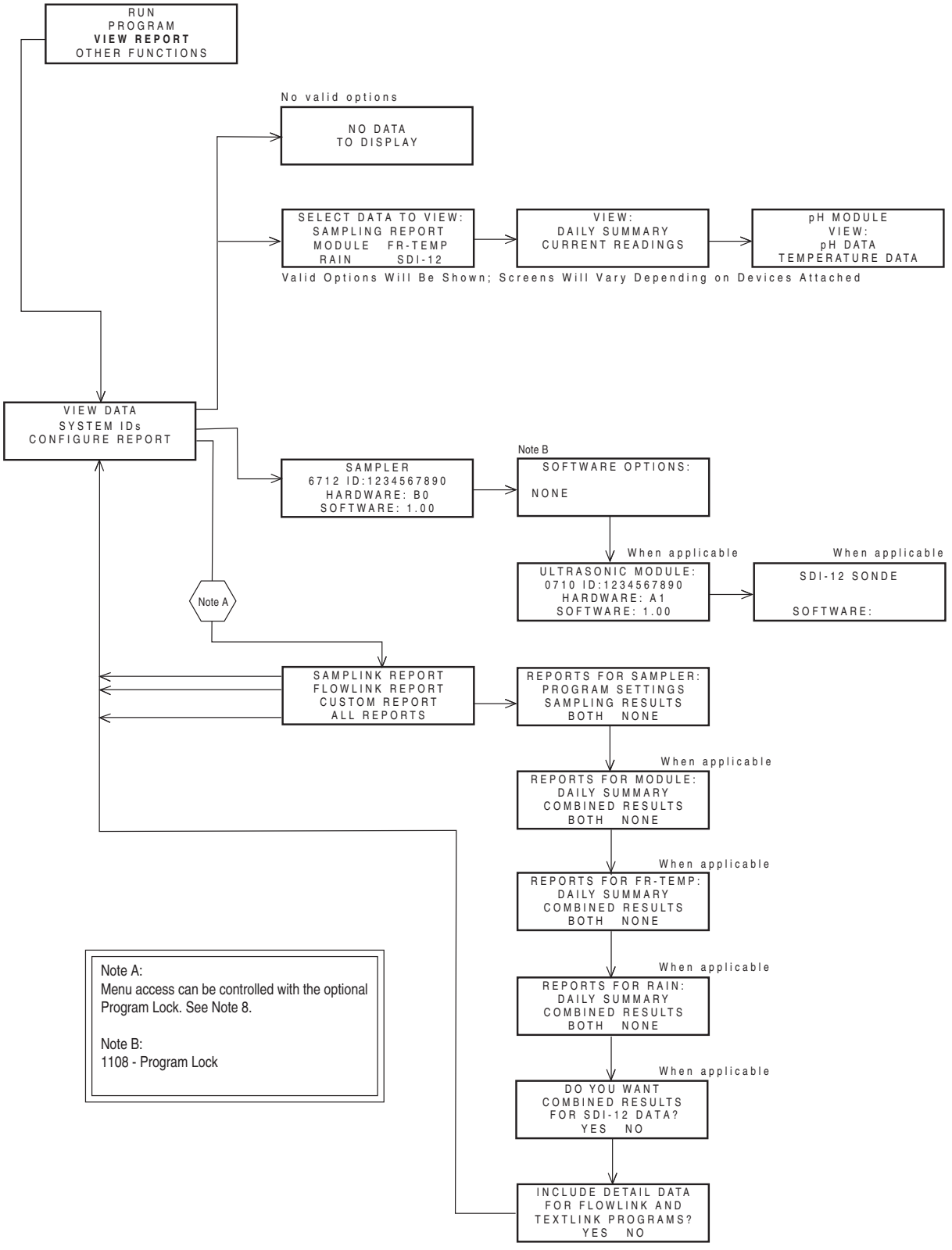


Figure A-6 View Report

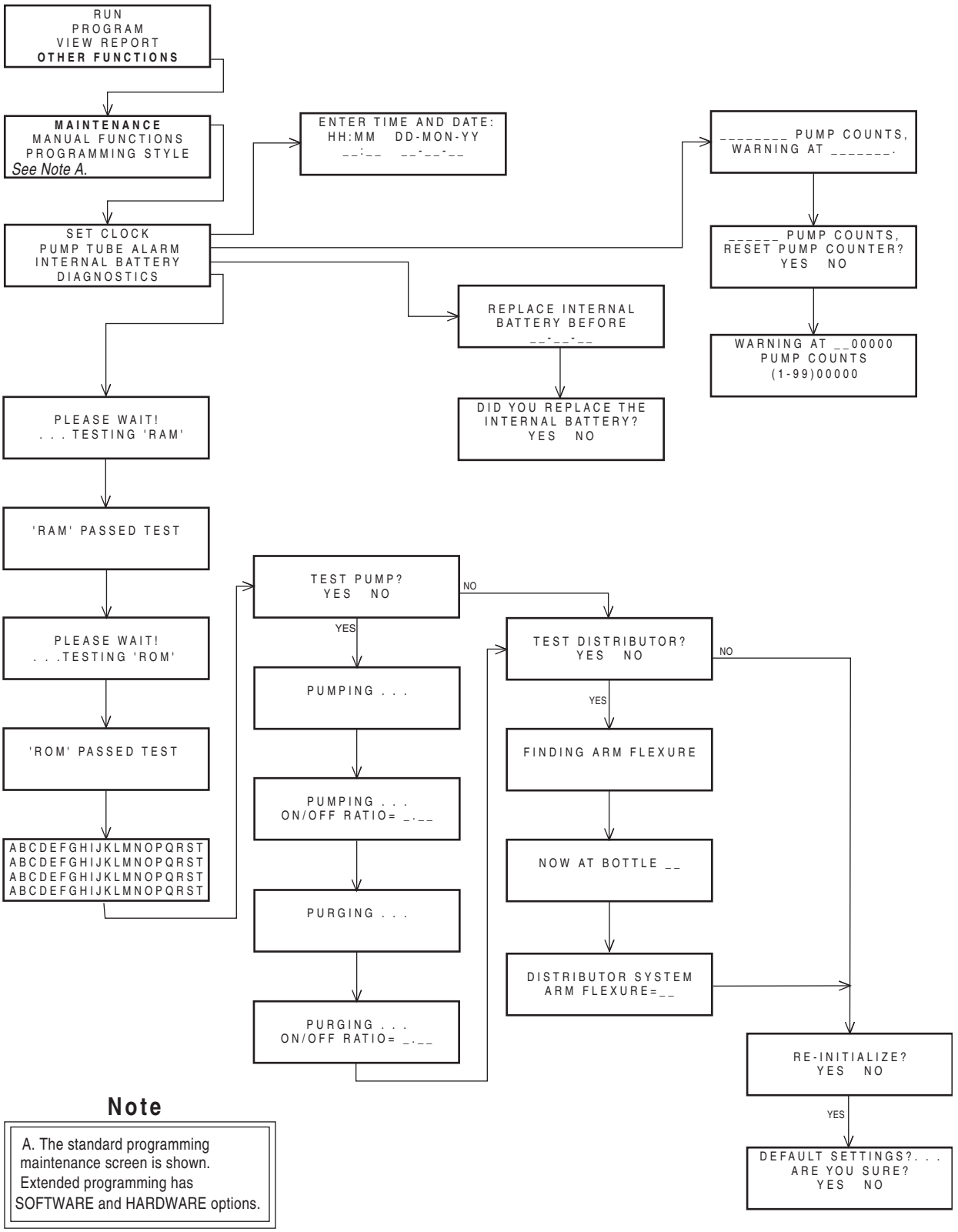


Figure A-7 Maintenance Screens

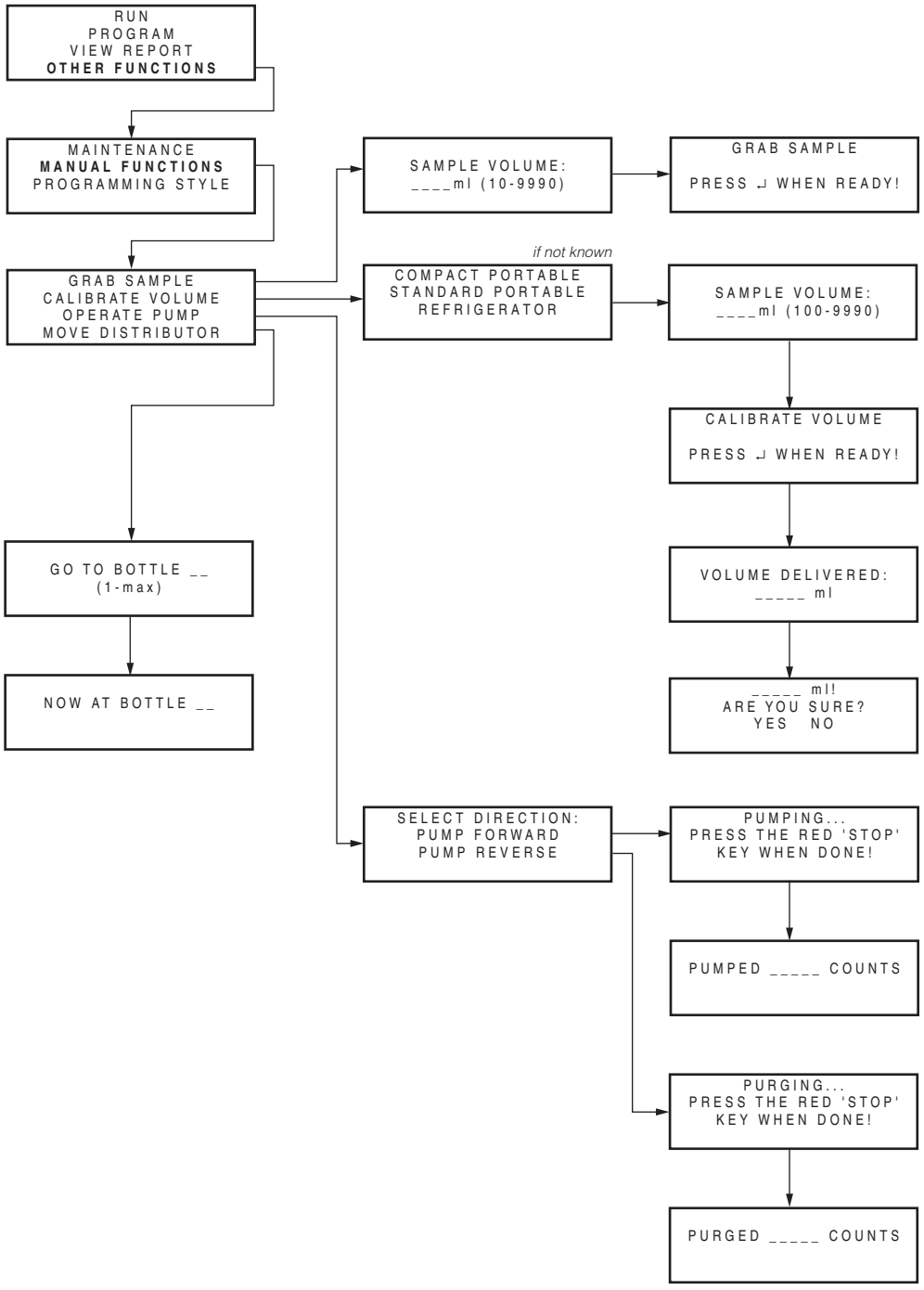


Figure A-8 Manual Functions Screens

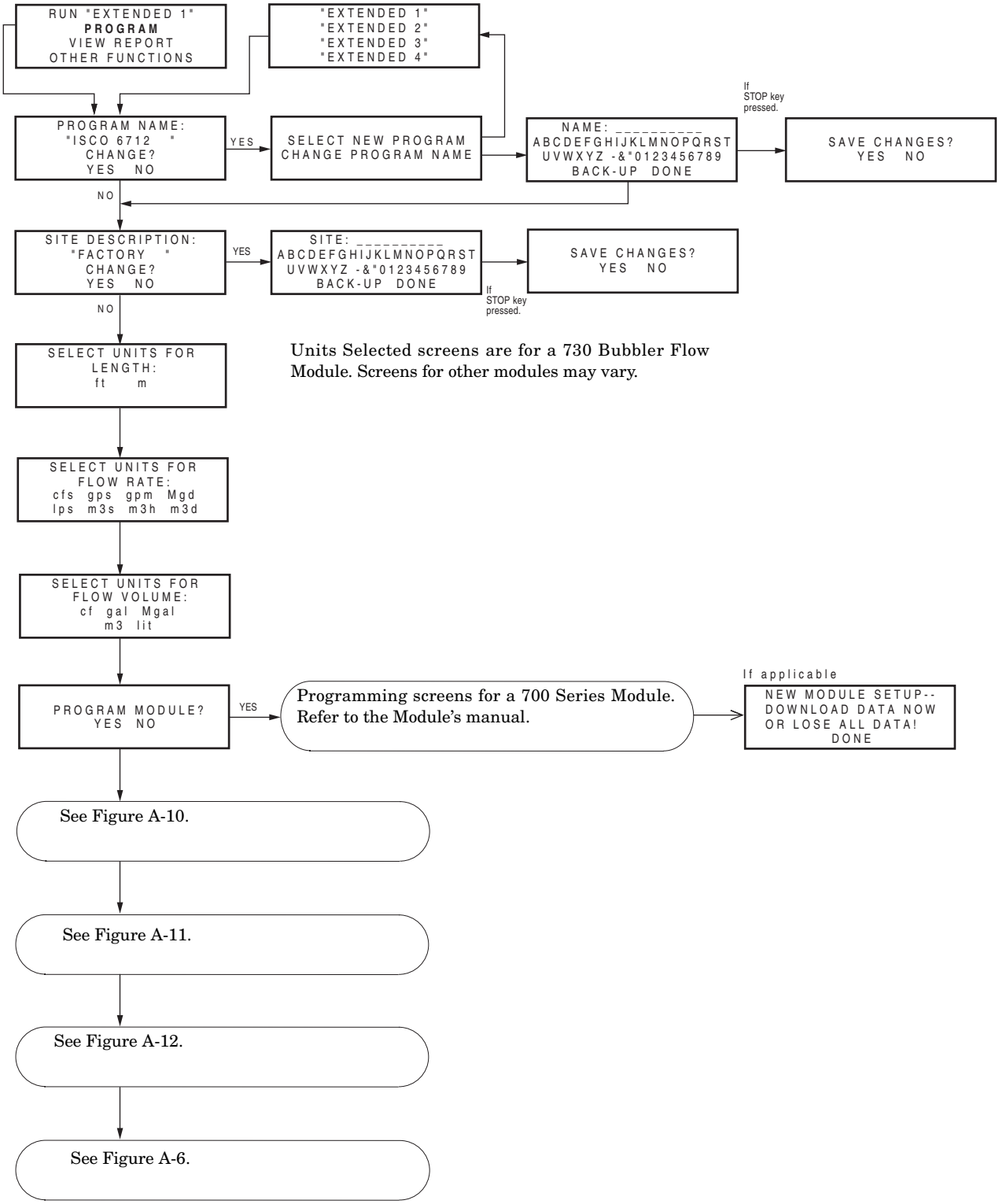


Figure A-9 Extended Programming: Programming Screens

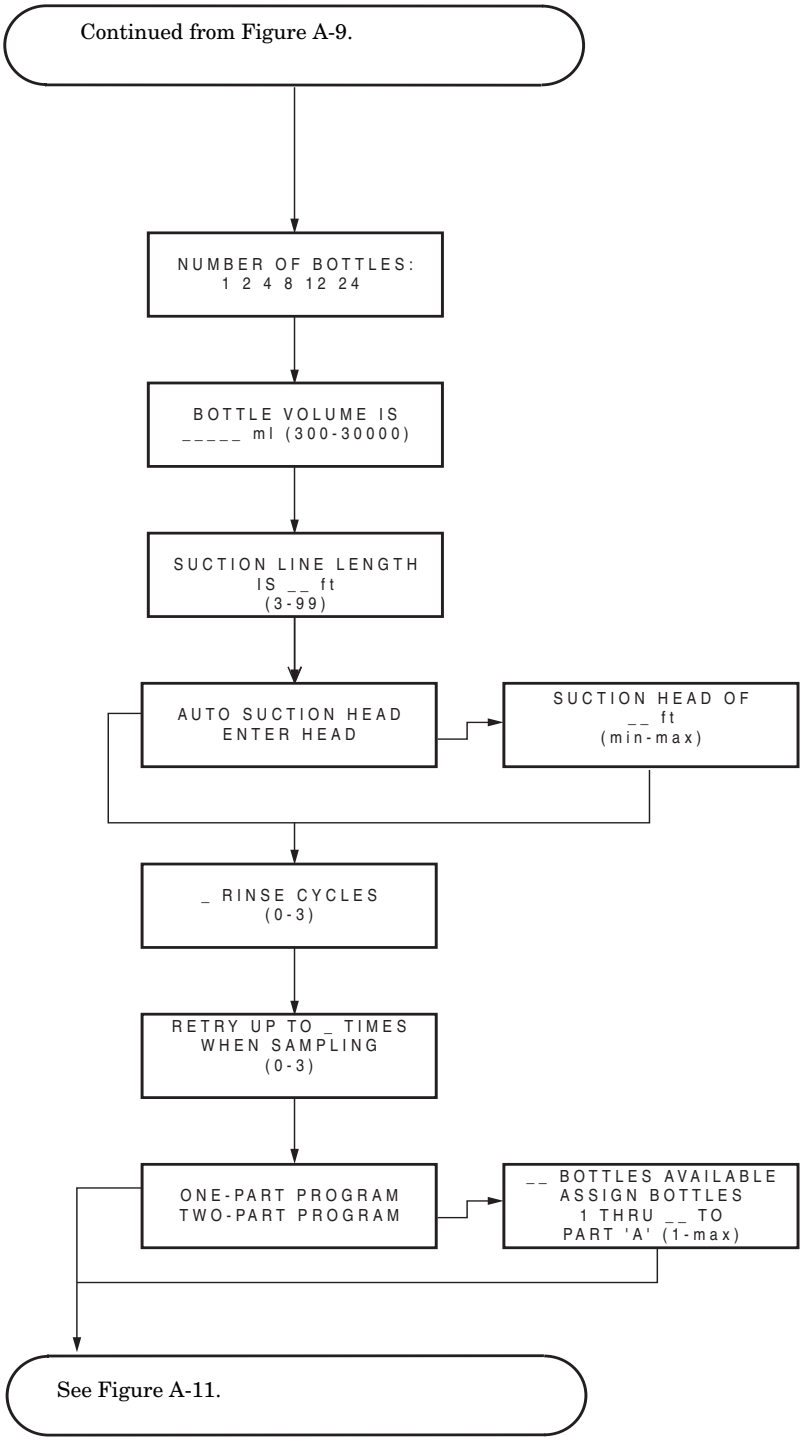


Figure A-10 Extended Programming: Equipment Setup

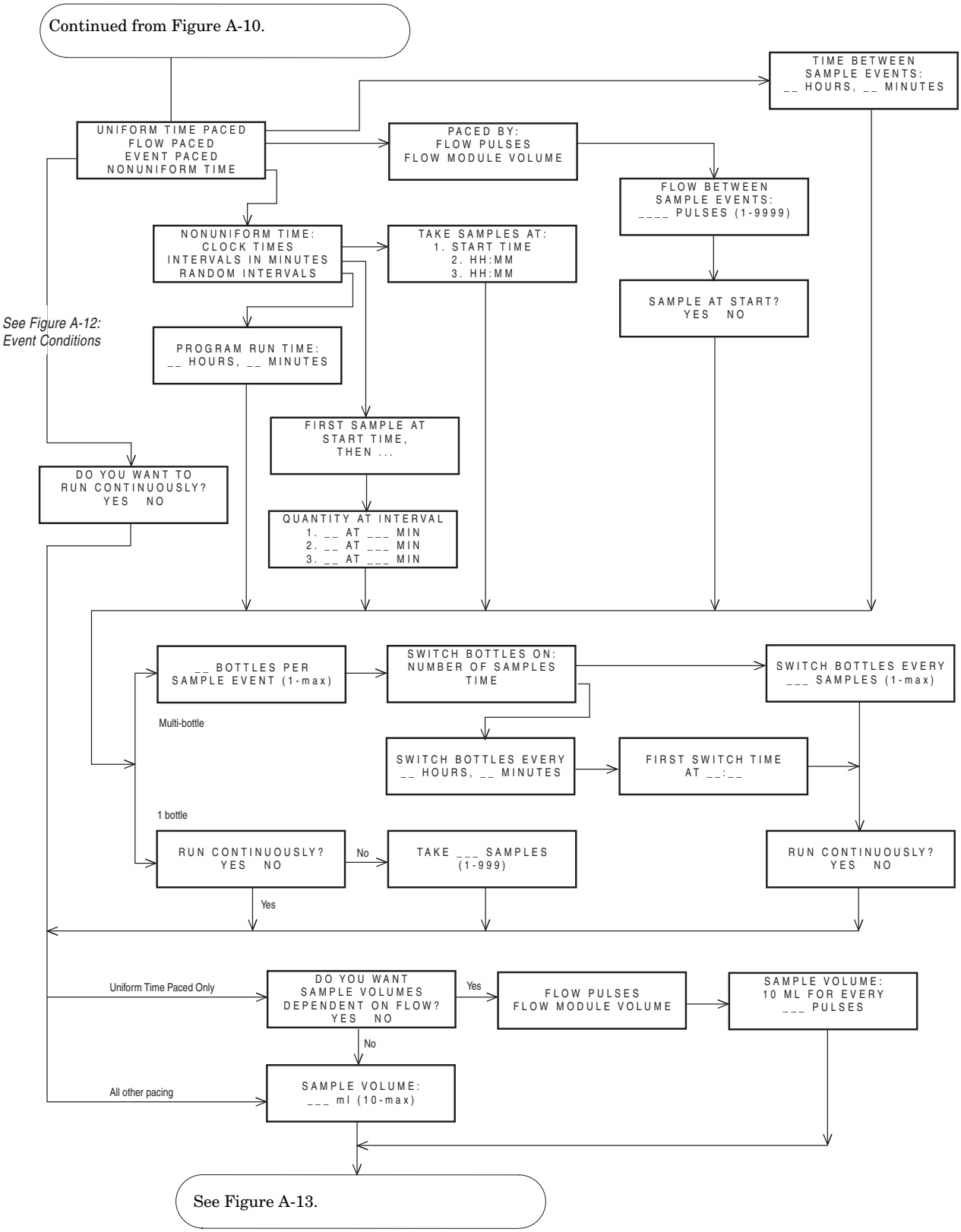


Figure A-11 Extended Programming: Pacing and Distribution

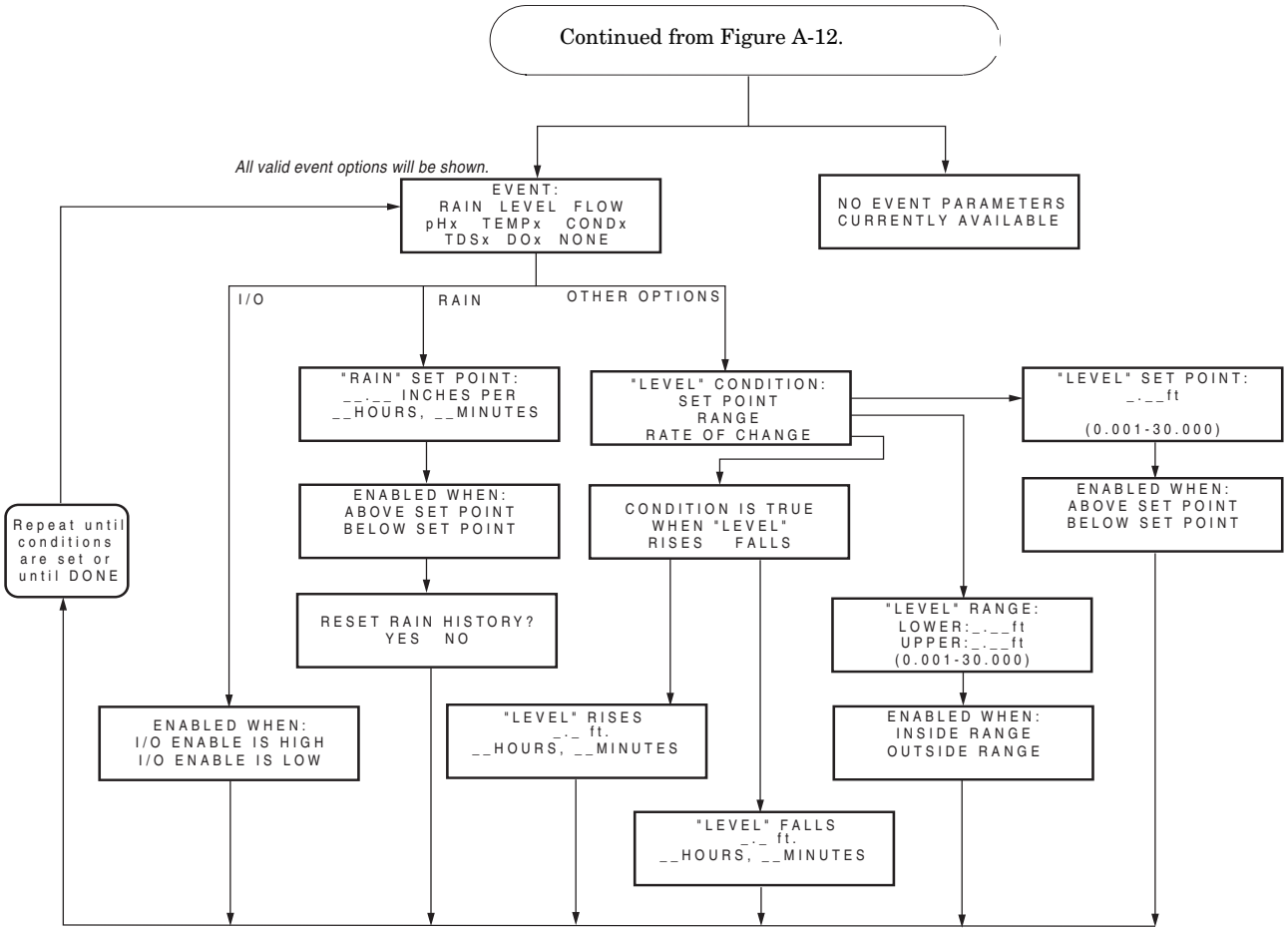


Figure A-12 Extended Programming: Event Conditions

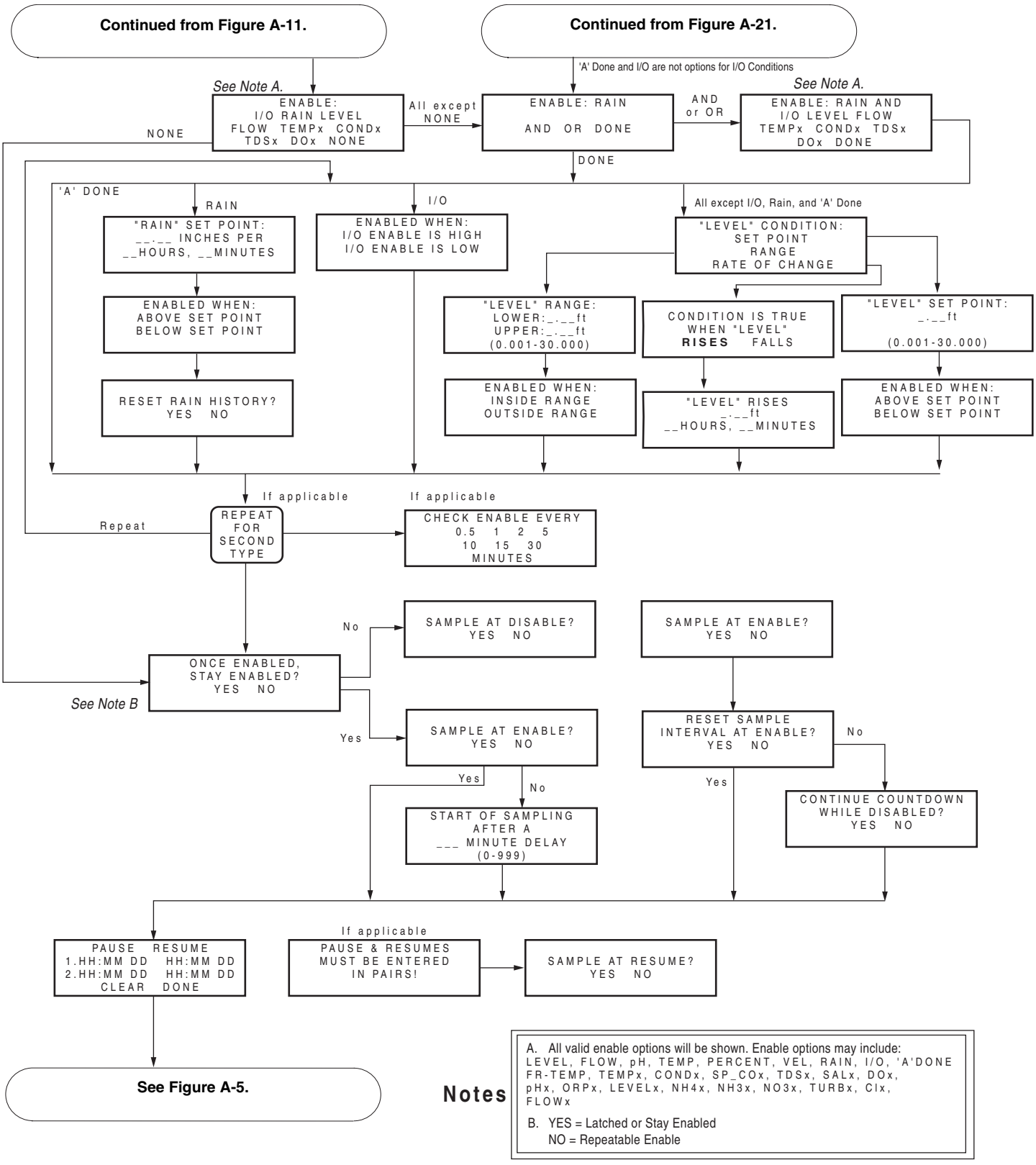


Figure A-13 Extended Programming: Programmed Sampler Enable

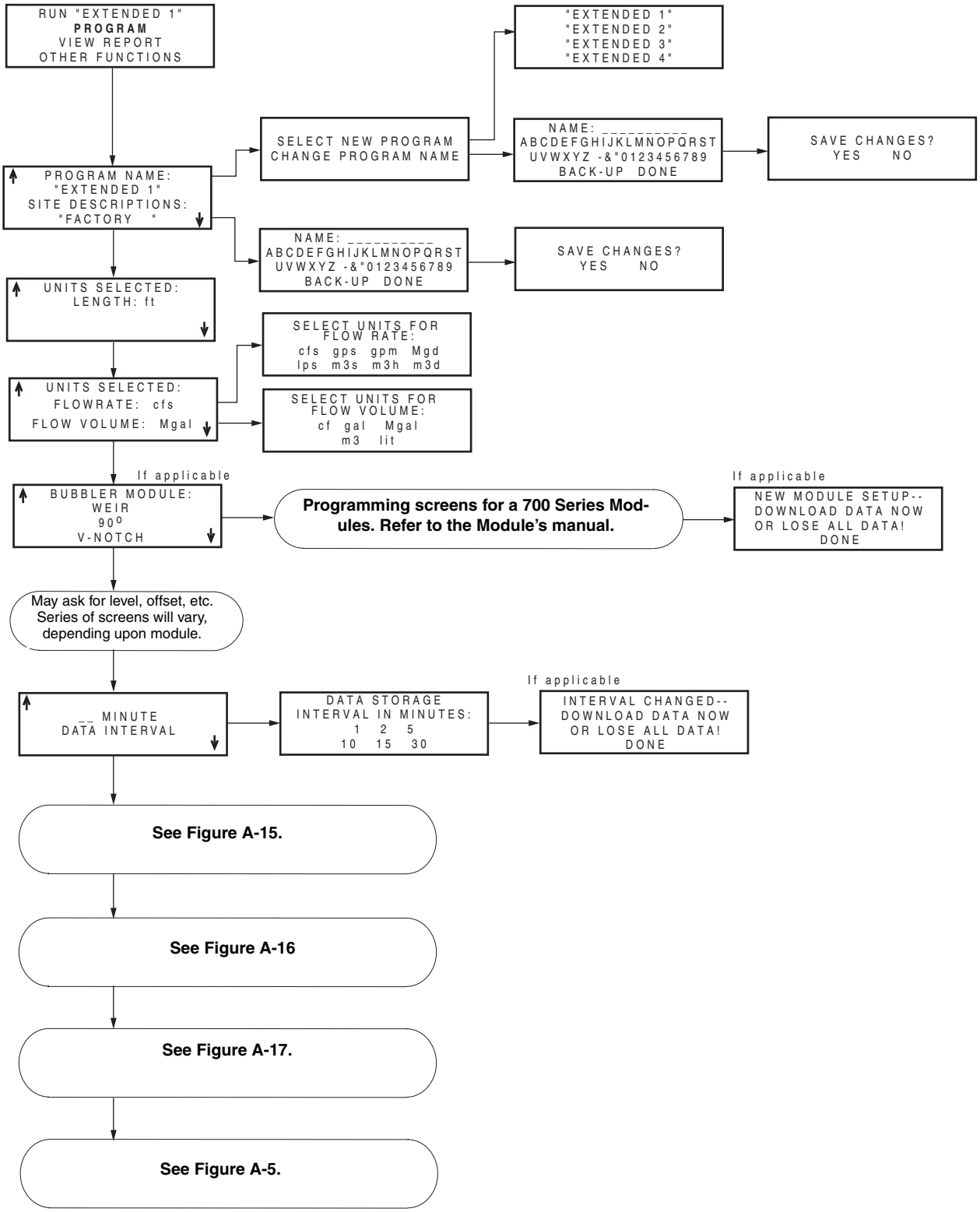


Figure A-14 Extended Programming: Quick View; Programming Screens

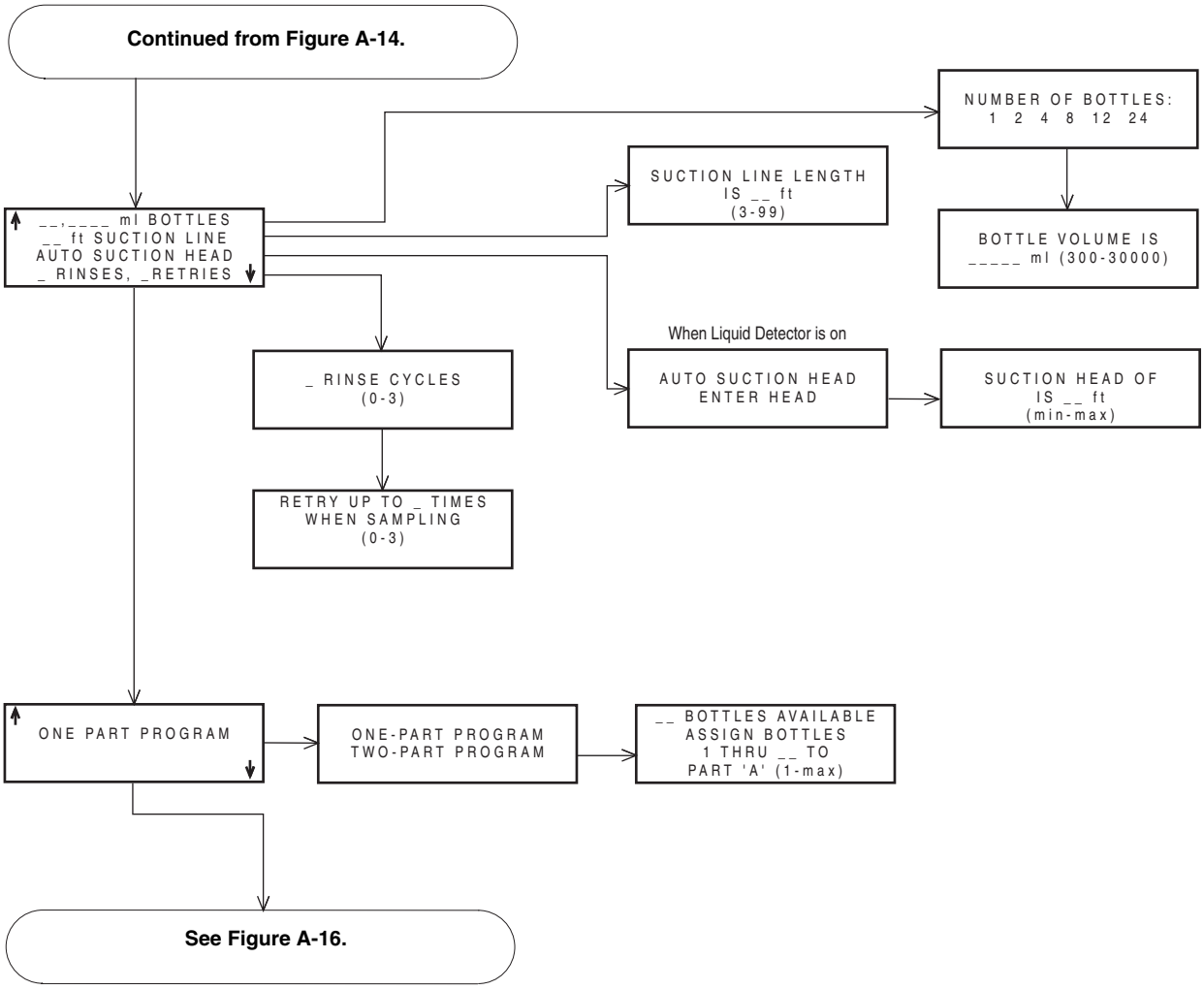


Figure A-15 Extended Programming: Quick View; Equipment Set-Up

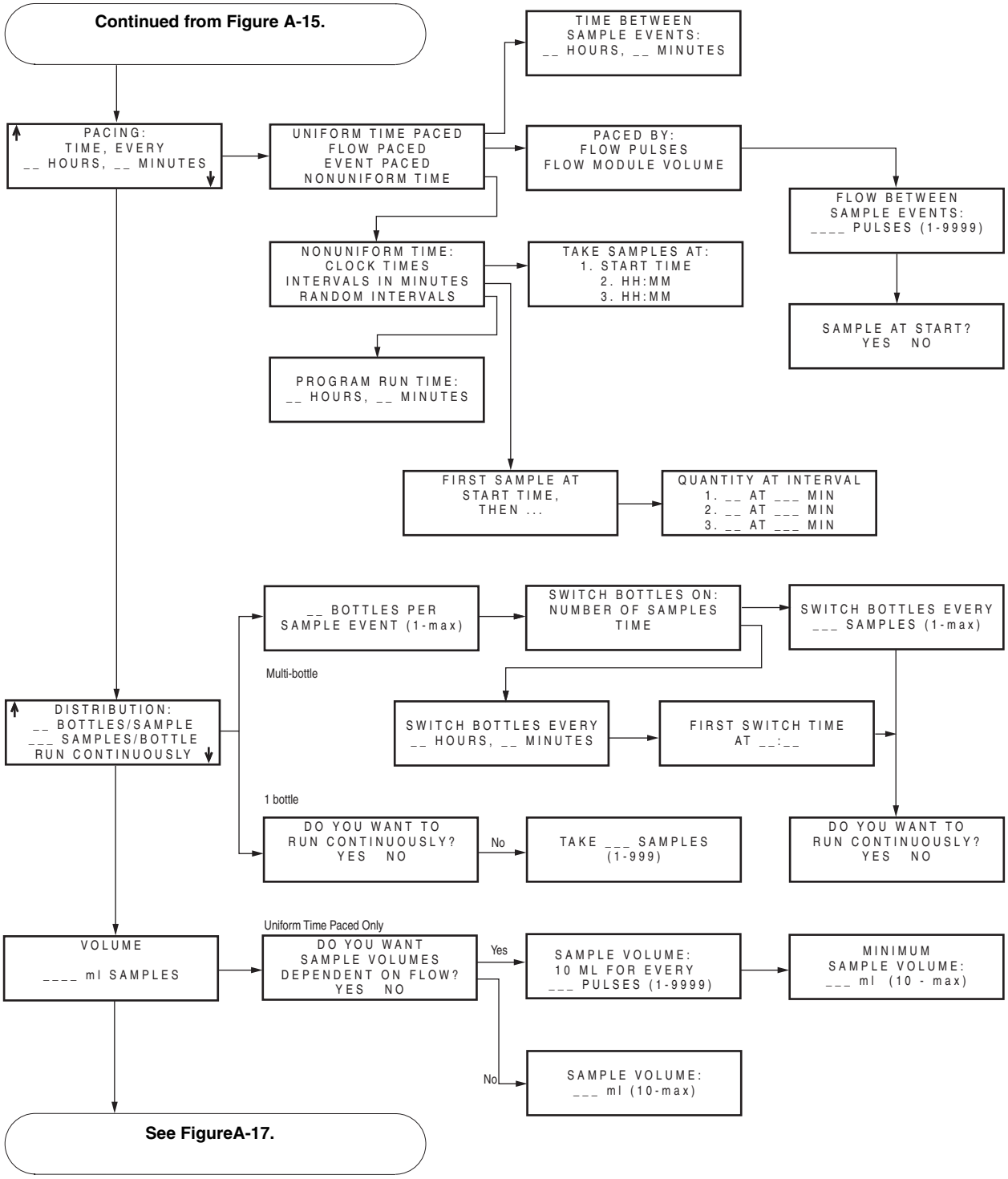


Figure A-16 Extended Programming: Quick View; Pacing and Distribution

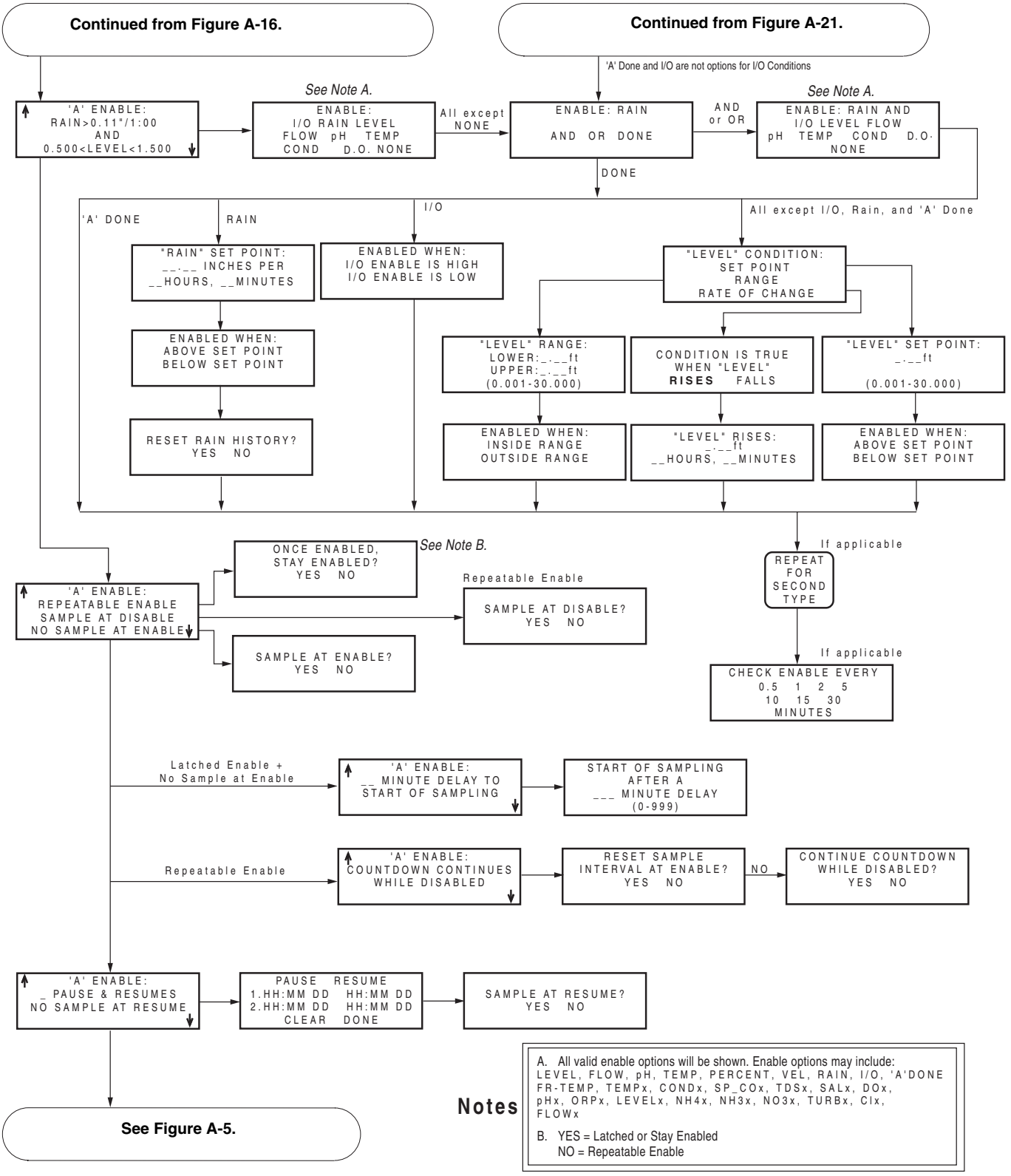


Figure A-17 Extended Programming: Quick View; Programmed Sampler Enable

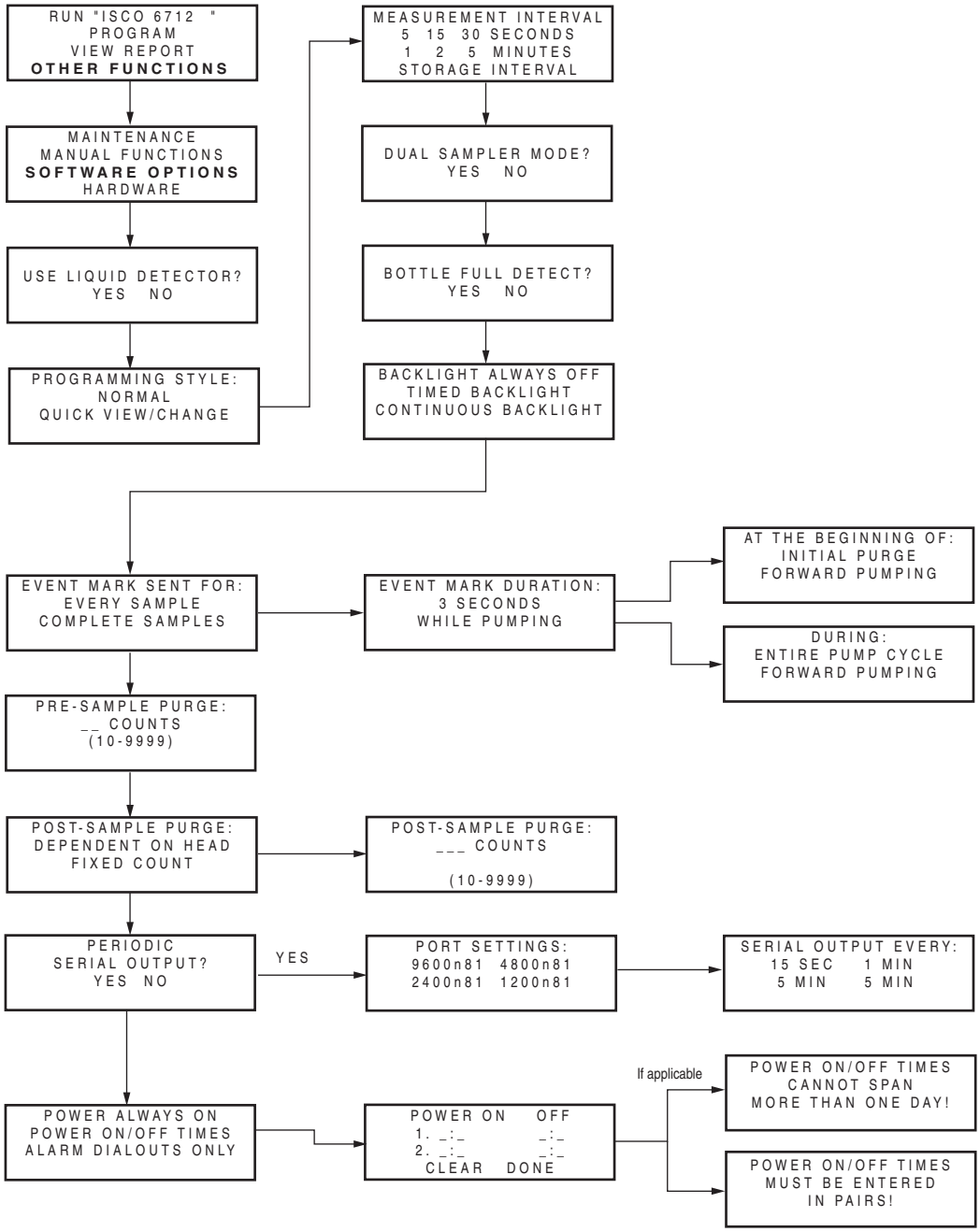


Figure A-18 Extended Programming: Normal View; Software Options

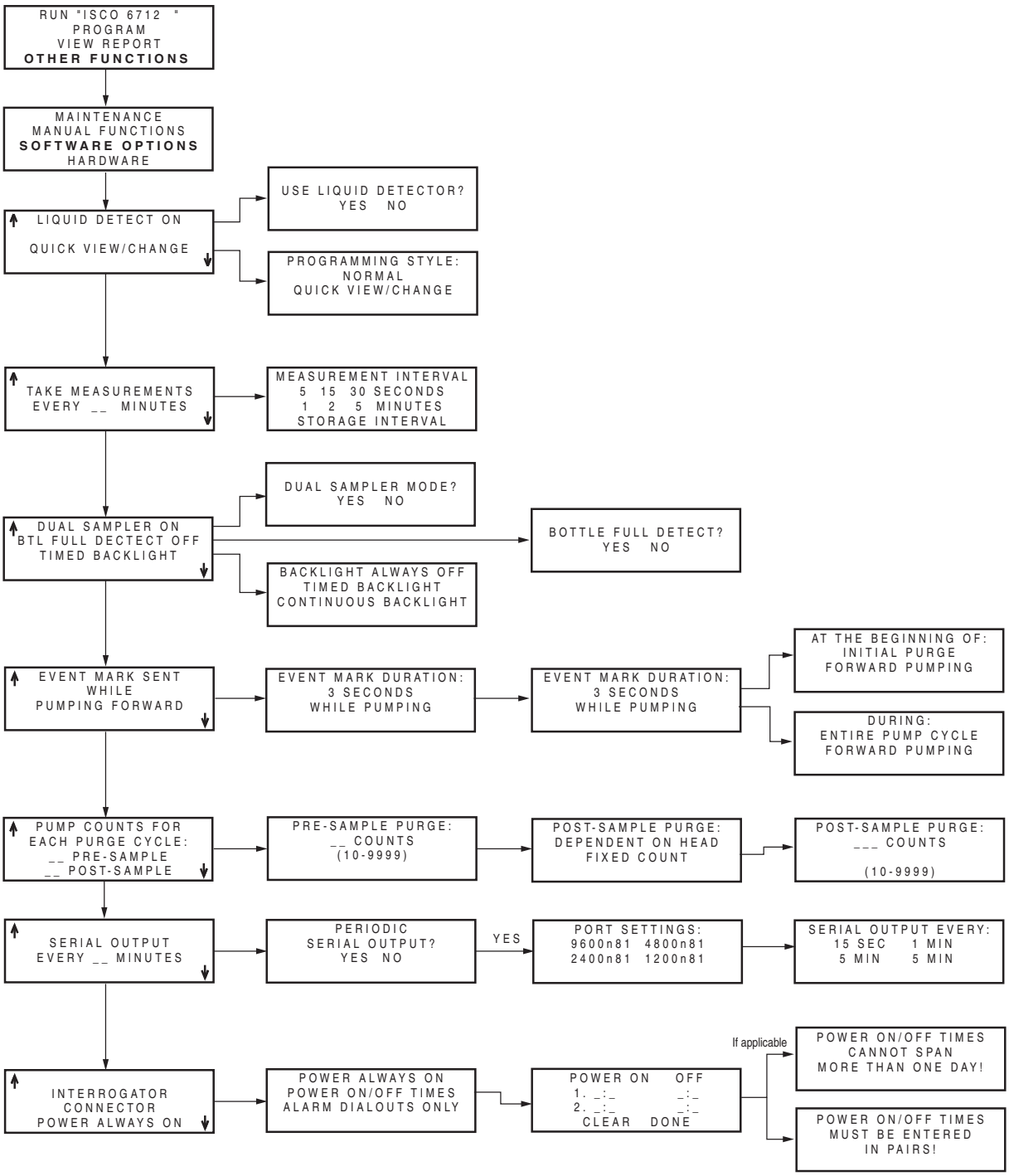


Figure A-19 Extended Programming: Quick View; Software Options

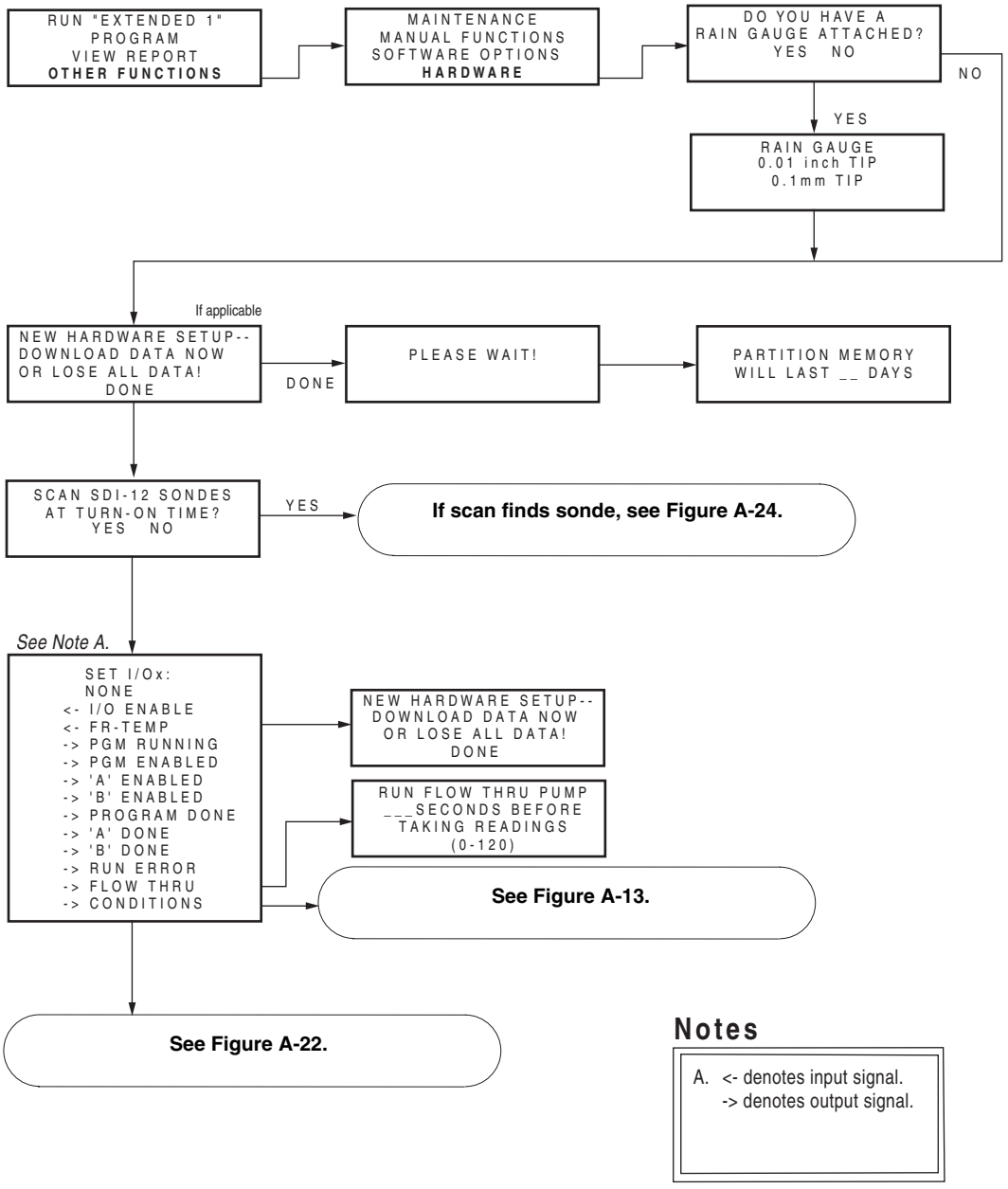


Figure A-20 Extended Programming: Normal View; Hardware

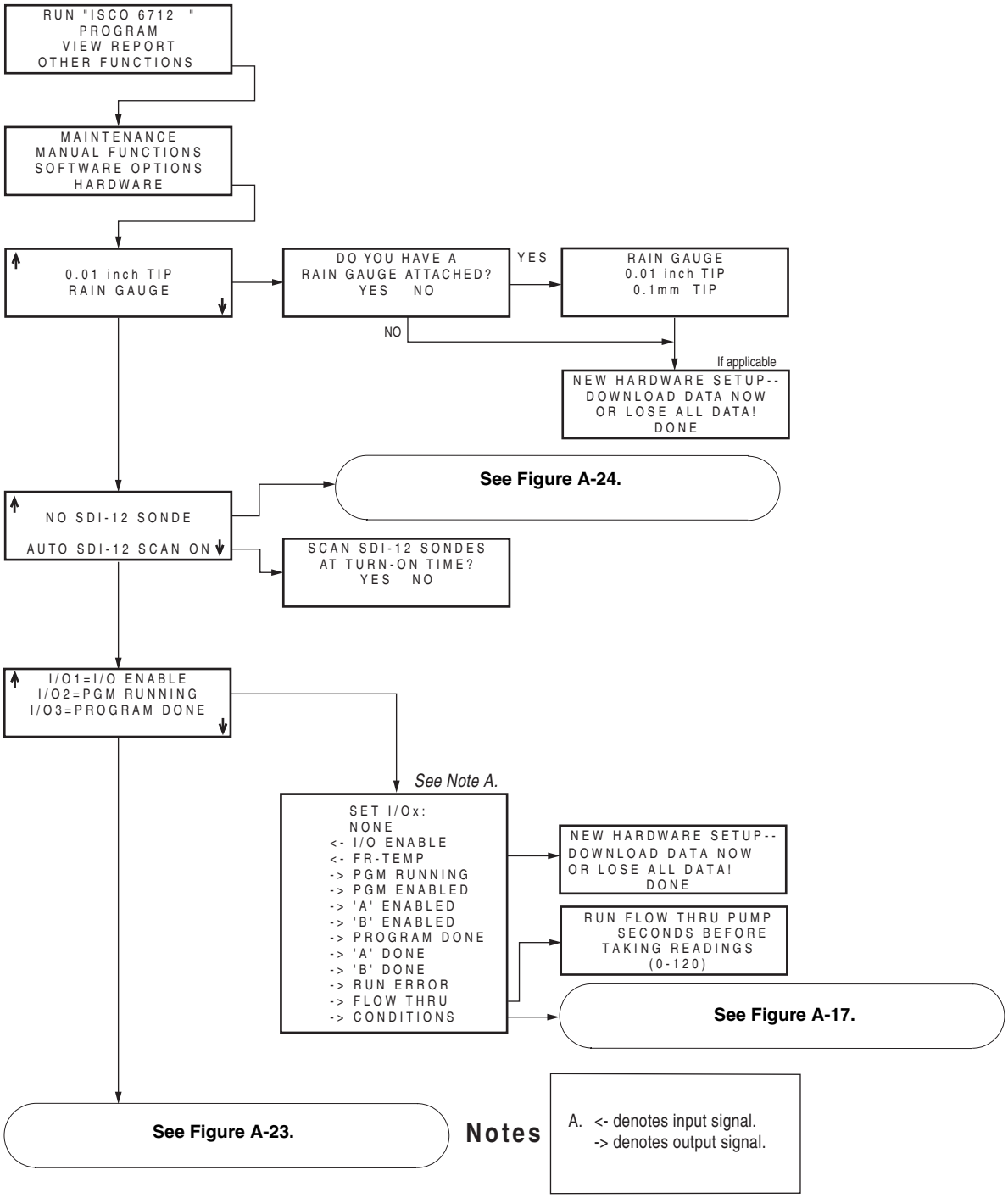


Figure A-21 Extended Programming: Quick View; Hardware

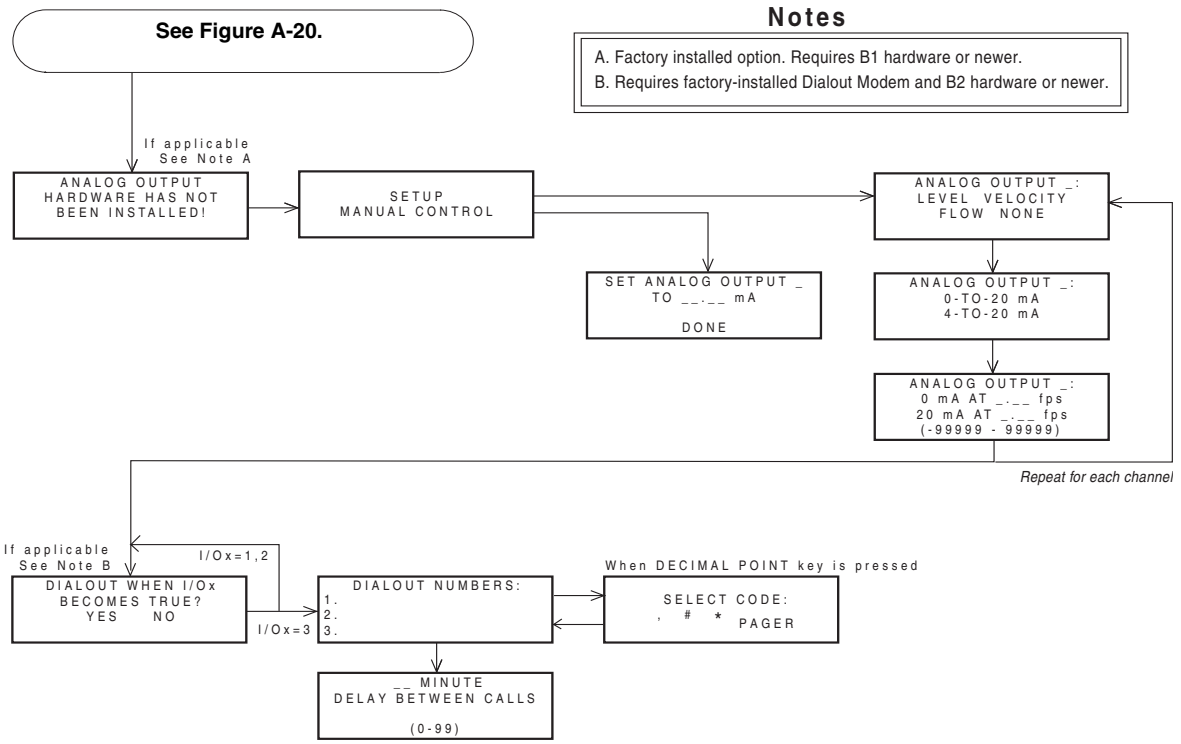


Figure A-22 Analog and Dialout Screens

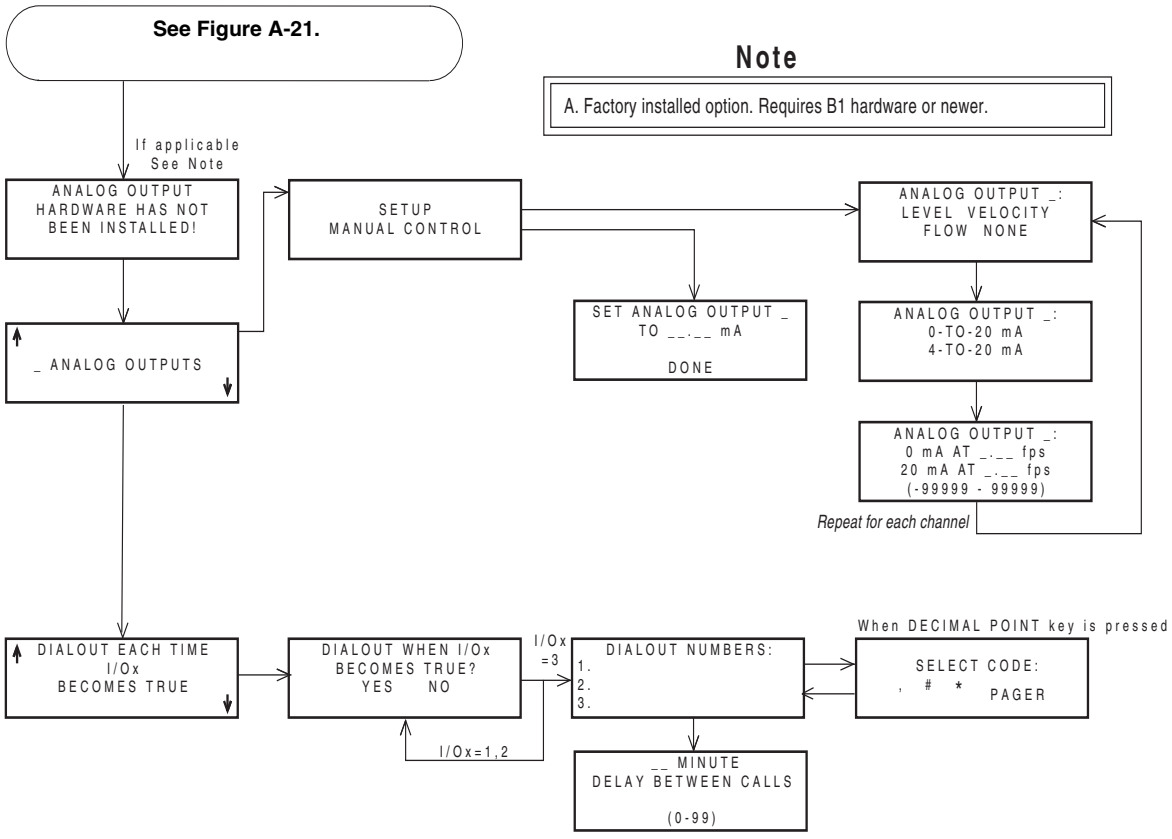


Figure A-23 Analog Output and Dialout Quick View Screens

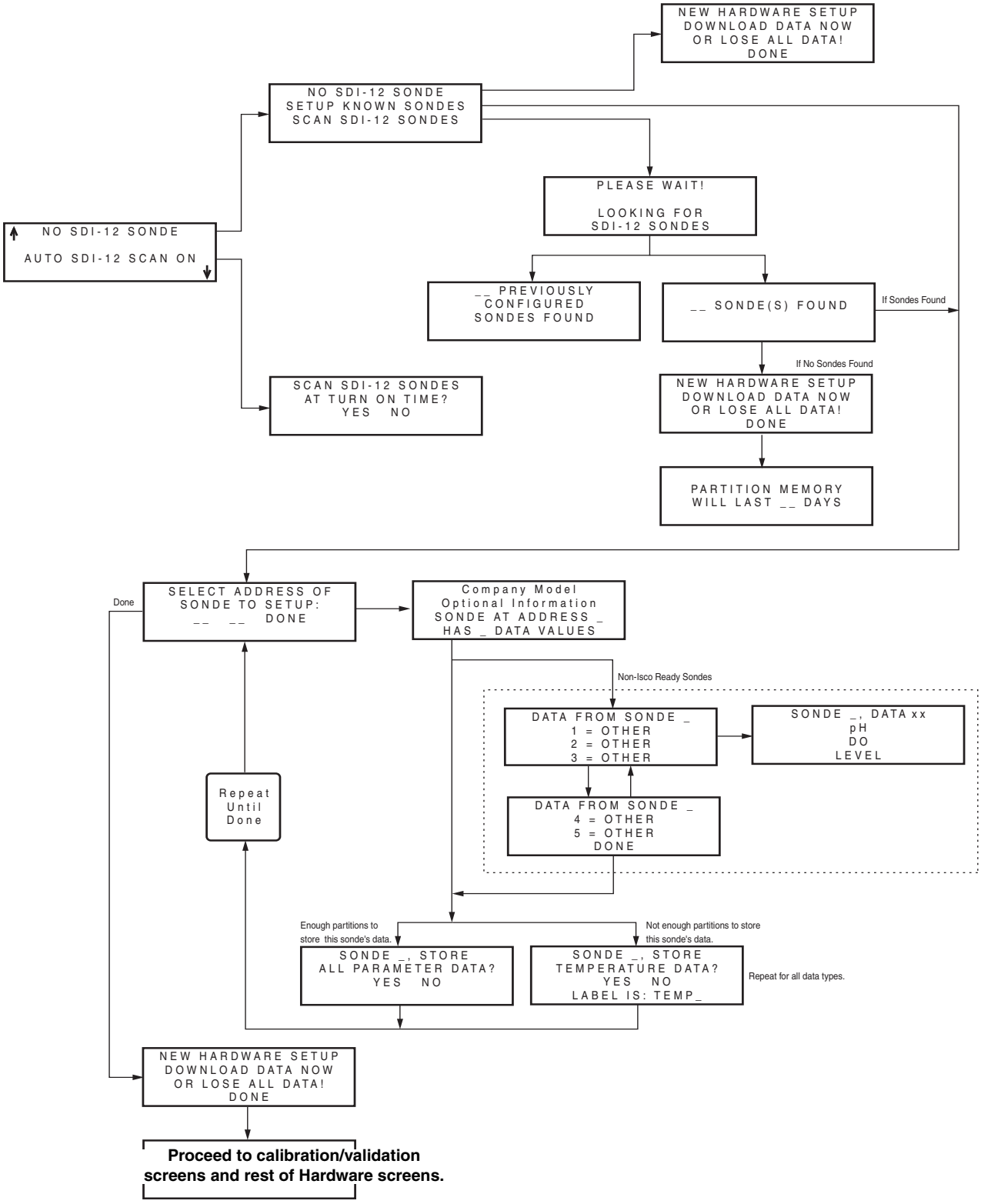


Figure A-24 SDI-12 Sonde Screens

6712 Portable Sampler

Appendix B Material Safety Data Sheets

This appendix provides Material Safety Data sheets for the internal desiccant used in the 6712 sampler.

Specific questions regarding the use and handling of these products should be directed to the manufacturer listed in the MSDS.

101 Christine Drive
Belen, New Mexico 87002
Phone: (505) 864-6691
Fax: (505) 861-2355

SÜD-CHEMIE
Performance Packaging

ISO 9002

MATERIAL SAFETY DATA SHEET -- September 28, 1998
SORB-IT®
Packaged Desiccant

SECTION I -- PRODUCT IDENTIFICATION

Trade Name and Synonyms:	Silica Gel, Synthetic Amorphous Silica, Silicon, Dioxide
Chemical Family:	Synthetic Amorphous Silica
Formula:	$SiO_2.x\ H_2O$

SECTION II -- HAZARDOUS INGREDIENTS

Components in the Solid Mixture

COMPONENT	CAS No	%	ACGIH/TLV (PPM)	OSHA-(PEL)
Amorphous Silica	63231-67-4	>99	PEL - 20 (RESPIRABLE), TLV – 5	LIMIT – NONE, HAZARD - IRRITANT ˝

Synthetic amorphous silica is not to be confused with crystalline silica such as quartz, cristobalite or tridymite or with diatomaceous earth or other naturally occurring forms of amorphous silica that frequently contain crystalline forms.

This product is in granular form and packed in bags for use as a desiccant. Therefore, no exposure to the product is anticipated under normal use of this product. Avoid inhaling desiccant dust.

SECTION III -- PHYSICAL DATA

Appearance and Odor:	White granules; odorless.
Melting Point:	>1600 Deg C; >2900 Deg F
Solubility in Water:	Insoluble.
Bulk Density:	>40 lbs./cu. ft.
Percent Volatile by Weight @ 1750 Deg F:	<10%.

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SECTION IV -- FIRE EXPLOSION DATA

Fire and Explosion Hazard - Negligible fire and explosion hazard when exposed to heat or flame by reaction with incompatible substances.

Flash Point - Nonflammable.

Firefighting Media - Dry chemical, water spray, or foam. For larger fires, use water spray fog or foam.

Firefighting - Nonflammable solids, liquids, or gases: Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in enclosed area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire.

SECTION V -- HEALTH HAZARD DATA

Health hazards may arise from inhalation, ingestion, and/or contact with the skin and/or eyes. Ingestion may result in damage to throat and esophagus and/or gastrointestinal disorders. Inhalation may cause burning to the upper respiratory tract and/or temporary or permanent lung damage. Prolonged or repeated contact with the skin, in absence of proper hygiene, may cause dryness, irritation, and/or dermatitis. Contact with eye tissue may result in irritation, burns, or conjunctivitis.

First Aid (Inhalation) - Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Get medical attention immediately.

First Aid (Ingestion) - If large amounts have been ingested, give emetics to cause vomiting. Stomach siphon may be applied as well. Milk and fatty acids should be avoided. Get medical attention immediately.

First Aid (Eyes) - Wash eyes immediately and carefully for 30 minutes with running water.

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NOTE TO PHYSICIAN: This product is a desiccant and generates heat as it adsorbs water. The used product can contain material of hazardous nature. Identify that material and treat accordingly.

SECTION VI -- REACTIVITY DATA

Reactivity - Silica gel is stable under normal temperatures and pressures in sealed containers. Moisture can cause a rise in temperature which may result in a burn.

SECTION VII --SPILL OR LEAK PROCEDURES

Notify safety personnel of spills or leaks. Clean-up personnel need protection against inhalation of dusts or fumes. Eye protection is required. Vacuuming and/or wet methods of cleanup are preferred. Place in appropriate containers for disposal, keeping airborne particulates at a minimum.

SECTION VIII -- SPECIAL PROTECTION INFORMATION

Respiratory Protection - Provide a NIOSH/MSHA jointly approved respirator in the absence of proper environmental control. Contact your safety equipment supplier for proper mask type.

Ventilation - Provide general and/or local exhaust ventilation to keep exposures below the TLV. Ventilation used must be designed to prevent spots of dust accumulation or recycling of dusts.

Protective Clothing - Wear protective clothing, including long sleeves and gloves, to prevent repeated or prolonged skin contact.

Eye Protection - Chemical splash goggles designed in compliance with OSHA regulations are recommended. Consult your safety equipment supplier.

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Packaged Desiccant

SECTION IX -- SPECIAL PRECAUTIONS

Avoid breathing dust and prolonged contact with skin. Silica gel dust causes eye irritation and breathing dust may be harmful.

* No Information Available

HMIS (Hazardous Materials Identification System) for this product is as follows:

Health Hazard	0
Flammability	0
Reactivity	0
Personal Protection	HMIS assigns choice of personal protective equipment to the customer, as the raw material supplier is unfamiliar with the condition of use.

The information contained herein is based upon data considered true and accurate. However, United Desiccants makes no warranties expressed or implied, as to the accuracy or adequacy of the information contained herein or the results to be obtained from the use thereof. This information is offered solely for the user's consideration, investigation and verification. Since the use and conditions of use of this information and the material described herein are not within the control of United Desiccants, United Desiccants assumes no responsibility for injury to the user or third persons. The material described herein is sold only pursuant to United Desiccants' Terms and Conditions of Sale, including those limiting warranties and remedies contained therein. It is the responsibility of the user to determine whether any use of the data and information is in accordance with applicable federal, state or local laws and regulations.

Material Safety Data Sheet

Indicating Silica Gel

Identity (Trade Name as Used on Label)

Manufacturer : MULTISORB TECHNOLOGIES, INC. (formerly Multiform Desiccants, Inc.)	MSDS Number* : M75
Address: 325 Harlem Road Buffalo, NY 14224	CAS Number* :
Phone Number (For Information): 716/824-8900	Date Prepared: July 6, 2000
Emergency Phone Number: 716/824-8900	Prepared By* : G.E. McKedy

Section 1 - Material Identification and Information

Components - Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
Silica Gel SiO_2	98.0	6mg/m^3 (total dust)	10mg/m^3 (total dust)	
Cobalt Chloride	>2.0	0.05mg/m^3 (TWA cobalt metal dust & fume)	.05mg/m^3 (Cobalt, TWA)	
Non-Hazardous Ingredients				
TOTAL	100			

Section 2 - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20 = 1)	2.1
Vapor Pressure (mm Hg and Temperature	N/A	Melting Point	N/A
Vapor Density (Air =1)	N/A	Evaporation Rate (_____=1)	N/A
Solubility in Water	Insoluble, but will adsorb moisture.	Water Reactive	Not reactive, but will adsorb moisture.
Appearance and Odor	Purple crystals, no odor.		

Section 3 - Fire and Explosion Hazard Data

Flash Point and Methods Used	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume	N/A	LEL	UEL
Extinguisher Media	Dry chemical, carbon dioxide and foam can be used.						
Special Fire Fighting Procedures	Water will generate heat due to the silica gel which will adsorb water and liberate heat.						
Unusual Fire and Explosion Hazards	When exposed to water, the silica gel can get hot enough to reach the boiling point of water. Flooding with water will reduce the temperature to safe limits.						

Section 4 - Reactivity Hazard Data

STABILITY ☐**Stable** ☐**Unstable**	Conditions To Avoid	Moisture and high humidity environments.
Incompatibility (Materials to Avoid)	Water.	
Hazardous Decomposition Products	Carbon dioxide, carbon monoxide, water	
HAZARDOUS POLYMERIZATION ☐May Occur	Conditions To Avoid	None.

*Optional

Section 5 - Health Hazard Data

PRIMARY ROUTES OF ENTRY	☐Inhalation ☐Skin Absorption	☐Ingestion ☐Not Hazardous	**CARCINOGEN LISTED IN**	☐NTP ☐IARC Monograph	☐OSHA ☐Not Listed
HEALTH HAZARDS	Acute	May cause eye, skin and mucous membrane irritation.			
	Chronic	Prolonged inhalation may cause lung damage.			
Signs and Symptoms of Exposure	Drying and irritation.				
Medical Conditions Generally Aggravated by Exposure	Asthma.				
EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.					
Eye Contact	Flush with water for at least 15 minutes.				
Skin Contact	Wash affected area with soap and water.				
Inhalation	Remove affected person to fresh air.				
Ingestion	Drink at least 2 glasses of water.				

Section 6 - Control and Protective Measures

Respiratory Protection (Specify Type)	Use NIOSH approved dust mask or respirator.		
Protective Gloves	Light cotton gloves.	Eye Protection	Safety glasses.
VENTILATION TO BE USED	☐ Local Exhaust	☐Mechanical (General)	☐Special
	☐Other (Specify)		
Other Protective Clothing and Equipment	None.		
Hygienic Work Practices	Avoid raising dust. Avoid contact with skin, eyes and clothing.		

Section 7 - Precautions for Safe Handling and Use/Leak Procedures

Steps to be Taken if Material Is Spilled Or Released	Sweep or vacuum up and place the spilled material in a waste disposal container. Avoid raising dust.
Waste Disposal Methods	Dispose in an approved landfill according to federal, state and local regulations.
Precautions to be Taken In Handling and Storage	Cover promptly to avoid blowing dust. Wash after handling.
Other Precautions and/or Special Hazards	Keep in sealed containers away from moisture. The silica gel will readily adsorb moisture.

*Optional Indicating Silica Gel

6712 Portable Sampler

Appendix C General Safety Procedures

In field installations of Teledyne Isco wastewater samplers and associated equipment, the safety of the personnel involved should be the foremost consideration. The following sections provide safety procedures for working in and around manholes and sewers. the first section offers general safety advice. The second section deals with the special problem of hazardous gases found in sewers.

⚠ WARNING

The 6712 has not been approved for use in hazardous locations as defined by the National Electrical Code.

⚠ CAUTION

Before any sampler is installed, the proper safety precautions must be taken. The following discussions of safety procedures are only general guidelines. Each situation in which you install a flow meter varies. You must take into account the individual circumstances you are in. Additional safety considerations, other than those discussed here, may be required.

C.1 Practical Safety Precautions

The following procedures are those used by Black & Veatch, a respected consulting firm, and are published here by permission.

Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

C.1.1 Hazards

There are many hazards connected with entering manholes. Some of the most common hazards are:

Adverse Atmosphere – The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. Forced ventilation may be necessary.

Deteriorated Rungs – Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

Traffic – Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

Falling Objects – Items placed near the manhole opening may fall and injure a worker in the manhole.

Sharp Edges – Sharp edges of items in or near a manhole may cause cuts or bruises.

Lifting Injuries – Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

C.1.2 Planning

Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

C.1.3 Adverse Atmospheres

[Refer to Table C-1, Hazardous Gases, at the end of this appendix.] Before workers enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Combustible or toxic vapors may be heavier than air, so the tests on the atmosphere must be run at least 3/4 of the way down the manhole.

Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no odor or the manhole has been entered previously.

C.1.4 Entering Manholes

Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip. A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is

overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

C.1.5 Traffic Protection

In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

C.1.6 Falling Objects

All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

C.1.7 Removing the Covers

Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from $^{3}/_{4}$-inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

C.1.8 Other Precautions

Other precautions which should be taken when entering a manhole are:

- Wear a hard hat.
- Wear coveralls or removable outer garment that can be readily removed when the work is completed.
- Wear boots or nonsparking safety shoes.
- Wear rubberized or waterproof gloves.
- Wear a safety harness with a stout rope attached.
- Do not smoke.
- Avoid touching yourself above the collar until you have cleaned your hands.

C.1.9 Emergencies

Every member of the crew should be instructed on procedures to be followed in cases of an emergency. It is the duty of each crew chief to have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

C.1.10 Field Equipment

The following equipment will be available for use:

Blowers	Gloves	Traffic cones
Breathing apparatus	Hard Hats	Coveralls
Harnesses	First aid kits	Manhole irons
Emergency flashers	Pick axes	Flashlights
Rain slickers	Mirrors	Ropes
Gas detectors	Safety vests	Gas masks
Waders”		

C.2 Lethal Atmospheres in Sewers

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of ***Deeds & Data*** of the WPCF. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself.

It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures.

It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

One of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elev. 2,100 meters), where the partial pressure of oxygen is equal to 16.2% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little ‘shortness of breath’ following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%t. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13 percent. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to 'asphyxiation.' This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H_2S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Waste water containing 2 mg per liter of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 PPM H_2S, in the air. This is considered to be a lethal concentration. Many people have died from H_2S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H_2S poisoning before the people were ready to admit that H_2S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H_2S as well as deaths elsewhere in the world.

The presence of H_2S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H_2S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

Electrodes or other similar electrical indicating devices for H_2S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check it at frequent intervals against air containing known H_2S concentrations. A supposed safety device that is unreliable is worse than none at all.

Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H_2S.

Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in

amounts that could cause discomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

Be very careful to avoid high H_2S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H_2S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man's thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out."

C.3 Hazardous Gases

The following table contains information on the properties of hazardous gases.

Table C-1 Hazardous Gases

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Ammonia	NH_3	Irritant and poisonous. Colorless with characteristic odor.	0.60	Causes throat and eye irritation at 0.05%, coughing at 0.17%. Short exposure at 0.5% to 1% fatal.	300 to 500	85	16 25	Near top. Concentrates in closed upper spaces	Sewers, chemical feed rooms.	Detectable odor at low concentrations
Benzene	C_6H_6	Irritant, colorless anesthetic	2.77	Slight symptoms after several hours exposure at 0.16% to 0.32%. 2% rapidly fatal.	3,000 to 5,000	25	1.3 7.1	At bottom.	Industrial wastes, varnish, solvents.	Combustible gas indicator
Carbon Bisulfide	CS_2	Nearly odorless when pure, colorless, anesthetic. Poisonous.	2.64	Very poisonous, irritating, vomiting, convulsions, psychic disturbance.	—	15	1.3 44.0	At bottom	An insecticide	Combustible gas indicator

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Carbon Dioxide	CO_2	Asphyxiant, Colorless, odorless. When breathed in large quantities, may cause acid taste. Non-flammable. Not generally present in dangerous amounts unless an oxygen deficiency exists.	1.53	Cannot be endured at 10% more than a few minutes, even if subject is at rest and oxygen content is normal. Acts on respiratory nerves.	40,000 to 60,000	5,000	— —	At bottom; when heated may stratify at points above bottom.	Products of combustion, sewer gas, sludge. Also issues from carbonaceous strata.	Oxygen deficiency indicator
Carbon Monoxide	CO	Chemical asphyxiant. Colorless, odorless, tasteless. Flammable. Poisonous.	0.97	Combines with hemoglobin of blood. Unconsciousness in 30 min. at 0.2% to 0.25%. Fatal in 4 hours at 0.1%. Headache in few hours at 0.02%.	400	50	12.5 74.0	Near top, especially if present with illuminating gas.	Manufactured gas, flue gas, products of combustion, motor exhausts. Fires of almost any kind.	CO ampoules.
Carbon Tetra-Chloride	CCl_4	Heavy, ethereal odor.	5.3	Intestinal upset, loss of consciousness, possible renal damage, respiratory failure.	1,000 to 1,500	100	— —	At bottom.	Industrial wastes, solvent, cleaning	Detectable odor at low concentrations.
Chlorine	Cl_2	Irritant. Yellow-green color. Choking odor detectable in very low concentrations. Non-flammable.	2.49	Irritates respiratory tract. Kills most animals in a very short time at 0.1%.	4	1	— —	At bottom.	Chlorine cylinder and feed line leaks.	Detectable odor at low concentrations.
Formaldehyde	CH_2O	Colorless, pungent suffocating odor.	1.07	Irritating to the nose.	—	10	7.0 73.0	Near bottom.	Incomplete combustion of organics. Common air pollutant, fungicide.	Detectable odor.
Gasoline	C_5H_{12} to C_9H_{20}	Volatile solvent. Colorless. Odor noticeable at 0.03%. Flammable.	3.0 to 4.0	Anesthetic effects when inhaled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.	4,000 to 7,000	1,000	1.3 6.0	At bottom.	Service stations, garages, storage tanks, houses.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.**
Hydrogen	H_2	Simple asphyxiant. Colorless, odorless, tasteless. Flammable	0.07	Acts mechanically to deprive tissues of oxygen. Does not support life.	—	—	4.0 74.0	At top.	Manufactured gas, sludge digestion tank gas, electrolysis of water. Rarely from rock strata.	Combustible gas indicator.
Hydrogen Cyanide	HCN	Faint odor of bitter almonds. Colorless gas	0.93	Slight symptoms appear upon exposure to 0.002% to 0.004%. 0.3% rapidly fatal.	—	10	6.0 40.0	Near top.	Insecticide and rodenticide.	Detector tube

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air = 1	Physiological Effect*	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air.) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Hydrogen Sulfide	H_2S	Irritant and poisonous volatile compound. Rotten egg odor in small concentrations. Exposure for 2 to 15 min. at 0.01% impairs sense of smell. Odor not evident at high concentrations. Colorless. Flammable.	1.19	Impairs sense of smell, rapidly as concentration increases. Death in few minutes at 0.2%. Exposure to 0.07 to 0.1% rapidly causes acute poisoning. Paralyzes respiratory center.	200 to 300	20	4.3 45.0	Near bottom, but may be above bottom if air is heated and highly humid.	Coal gas, petroleum, sewer gas. Fumes from blasting under some conditions. Sludge gas.	1. H_2S Ampoule. 2. 5% by weight lead acetate solution.
Methane	CH_4	Simple asphyxiant. Colorless, odorless, tasteless, flammable.	0.55	Acts mechanically to deprive tissues of oxygen. Does not support life.	Probably no limit, provided oxygen percentage is sufficient for life.	—	5.0 15.0	At top, increasing to certain depth.	Natural gas, sludge gas, manufactured gas, sewer gas. Strata of sedimentary origin. In swamps or marshes.	1. Combustible gas indicator 2. Oxygen deficiency indicator.
Nitrogen	N_2	Simple asphyxiant. Colorless, tasteless. Non-flammable. Principal constituent of air. (about 79%).	0.97	Physiologically inert.	—	—	— —	Near top, but may be found near bottom.	Sewer gas. sludge gas. Also issues from some rock strata.	Oxygen deficiency indicator.
Nitrogen Oxides	NO N_2O NO_2	Colorless Colorless, sweet odor. Reddish-brown. Irritating odor. Deadly poison	1.04 1.53 1.58	60 to 150 ppm cause irritation and coughing. Asphyxiant. 100 ppm dangerous. 200 ppm fatal.	50	10	— —	Near bottom.	Industrial wastes. Common air pollutant.	NO_2 detector tube.
Oxygen	O_2	Colorless, odorless, tasteless. Supports combustion.	1.11	Normal air contains 20.8% of O_2. Man can tolerate down to 12%. Minimum safe 8 hour exposure, 14 to 16%. Below 10%, dangerous to life. Below 5 to 7% probably fatal.	—	—	— —	Variable at different levels.	Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.	Oxygen deficiency indicator.
Ozone	O_3	Irritant and poisonous. Strong electrical odor. Strong oxidizer. Colorless. At 1 ppm, strong sulfur-like odor.	1.66	Max. naturally occurring level is 0.04 ppm. 0.05 ppm causes irritation of eyes and nose. 1 to 10 ppm causes headache, nausea; can cause coma. Symptoms similar to radiation damage.	0.08	0.04	— —	Near bottom.	Where ozone is used for disinfection.	Detectable odor at 0.015 ppm.

Table C-1 Hazardous Gases (Continued)

Gas	Chemical Formula	Common Properties	Specific Gravity or Vapor Density Air =1	Physiological Effect	Max Safe 60 Min. Exposure ppm	Max. Safe 8 Hour Exposure ppm	Explosive Range (% by vol. in air) Limits lower/upper	Likely Location of Highest Concentration	Most Common Sources	Simplest and Cheapest Safe Method of Testing
Sludge Gas	—***	Mostly a simple asphyxiant. May be practically odorless, tasteless.	Variable	Will not support life.	No data. Would vary widely with composition.		5.3 19.3	Near top of structure.	From digestion of sludge.	See components.
Sulfur Dioxide	SO_2	Colorless, pungent odor. Suffocating, corrosive, poisonous, non-flammable.	2.26	Inflammation of the eyes. 400 to 500 ppm immediately fatal.	50 to 100	10	— —	At bottom, can combine with water to form sulfurous acid.	Industrial waste, combustion, common air pollutant.	Detectable taste and odor at low concentration.
Toluene	C_5H_{12} to C_9H_{20}	Colorless, benzene-like odor.	3.14	At 200-500 ppm, headache, nausea, bad taste, lassitude.	200	100	1.27 7.0	At bottom.	Solvent.	Combustible gas indicator.
Turpentine	$C_{10}H_{16}$	Colorless, Characteristic odor.	4.84	Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.	—	100		At bottom.	Solvent, used in paint.	1. Detectable odor at low concentrations. 2.Combustible gas indicator.
Xylene	C_8H_{10}	Colorless, flammable	3.66	Narcotic in high concentrations. less toxic than benzene.	—	100	1.1 7.0	At bottom.	Solvent	Combustible gas indicator.

* Percentages shown represent volume of gas in air.
** For concentration over 0.3%.
***Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.

6712 Portable Sampler

Appendix D Replacement Parts List

D.1 Replacement Parts Diagrams and Listings

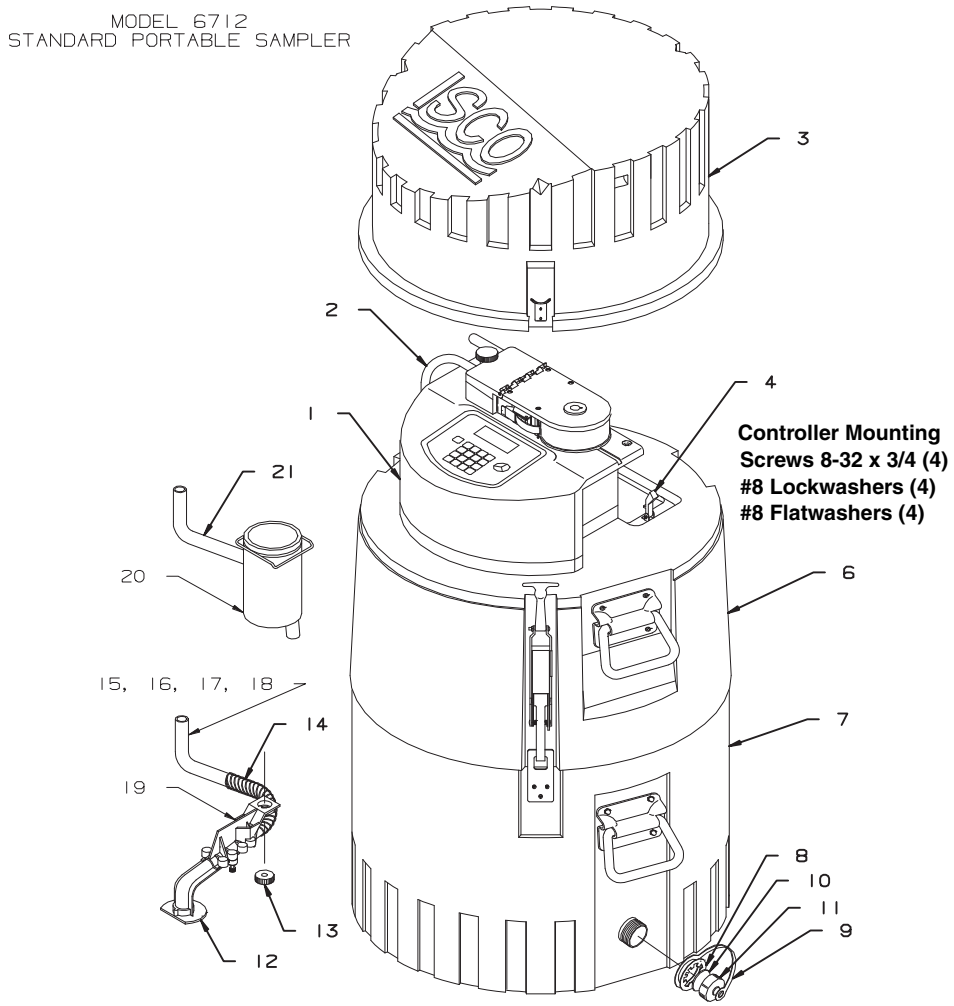
Replacement parts are called out in illustrations in this section. Reference the call-outs in the accompanying tables to determine the part number for the item.

Replacement parts can be purchased by contacting Teledyne Isco's Customer Service Department.

Teledyne Isco, Inc.
Customer Service Department
P.O. Box 82531
Lincoln, NE 68501 USA

Phone: (800) 228-4373
(402) 464-0231
FAX:(402) 465-3022

E-mail:IscoInfo@teledyne.com

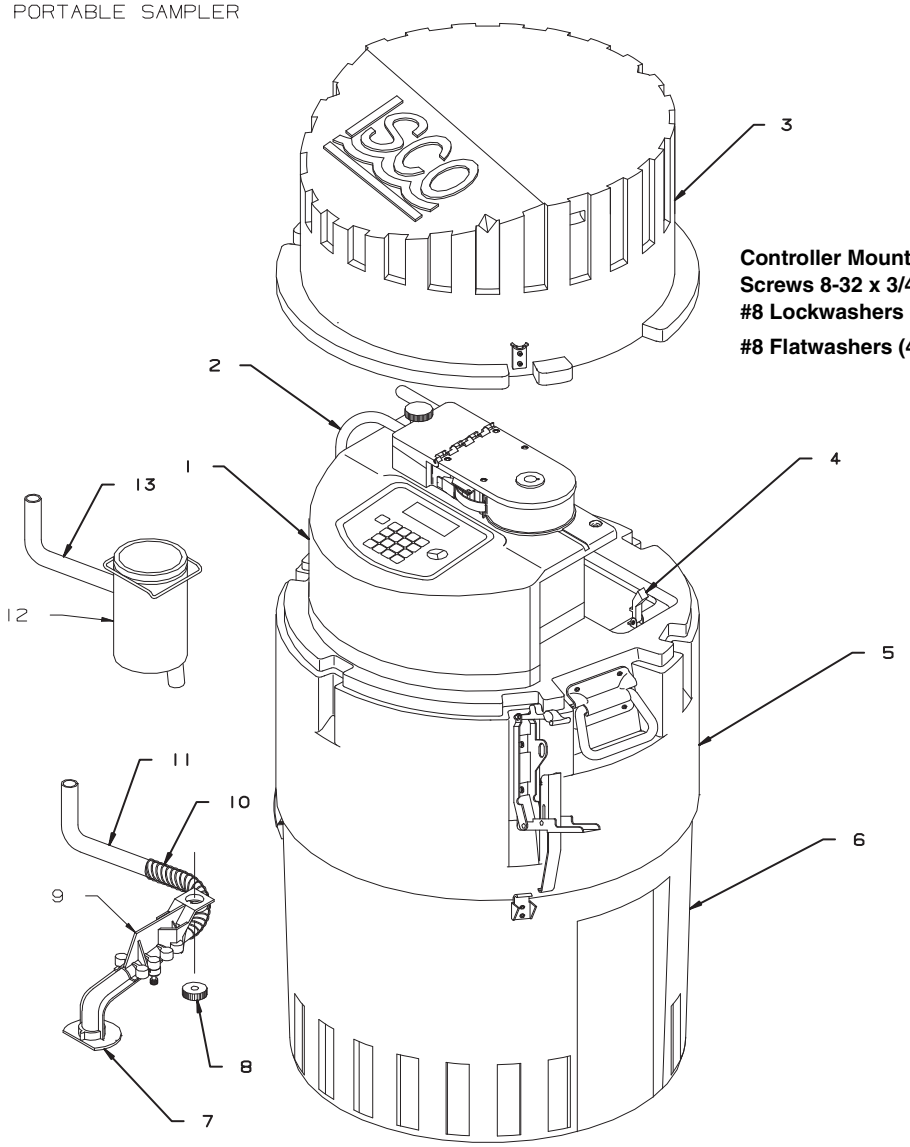


ITEM	INVENTORY NO.	DESCRIPTION
1	609004330	MODEL 6712 CONTROLLER
2	609004157	PUMP TUBE QUICK DISCONNECT
3	609004247	TOP COVER ASSY STD
4	109060503	DRAW LATCH ASSY SMALL
5*	609003088	BULKHEAD FITTING
6	609004246	CENTER SECTION ASSY STD (INCLUDES ITEM 4)
7	609004052	SAMPLE TUB ASSY STD (INCLUDES ITEMS 8-11)
8	209001828	RTNG RING SST .875SFT 1.20D
9	609003250	DRAIN CAP STRAP
10	603113032	GASKET CONNECTOR CAP
11	609003294	DRAIN CAP
12	609004020	DIST ARM ASSY BOTTOM
13	602923007	DISTRIBUTOR ARM NUT
14	609003317	SPRING DISTRIBUTOR ARM
15	609003260	DISCHARGE TUBE FOR STANDARD 24 BOTTLE KIT
16	609003262	DISCHARGE TUBE FOR STANDARD 12 BOTTLE KIT
17	609003264	DISCHARGE TUBE FOR STANDARD 8 BOTTLE KIT
18	609003266	DISCHARGE TUBE FOR STANDARD 4 BOTTLE KIT
19	609004019	DIST ARM TOP ASSY
20	609004051	COMPOSITE TUBE GUIDE (FOR STANDARD AND COMPACT)
21	609003271	DISCHARGE TUBE FOR STANDARD 1 BOTTLE KITS
22*	609004194	5 GALLON BOTTLE BASE

*-NOT SHOWN

DWG 60-9002-065

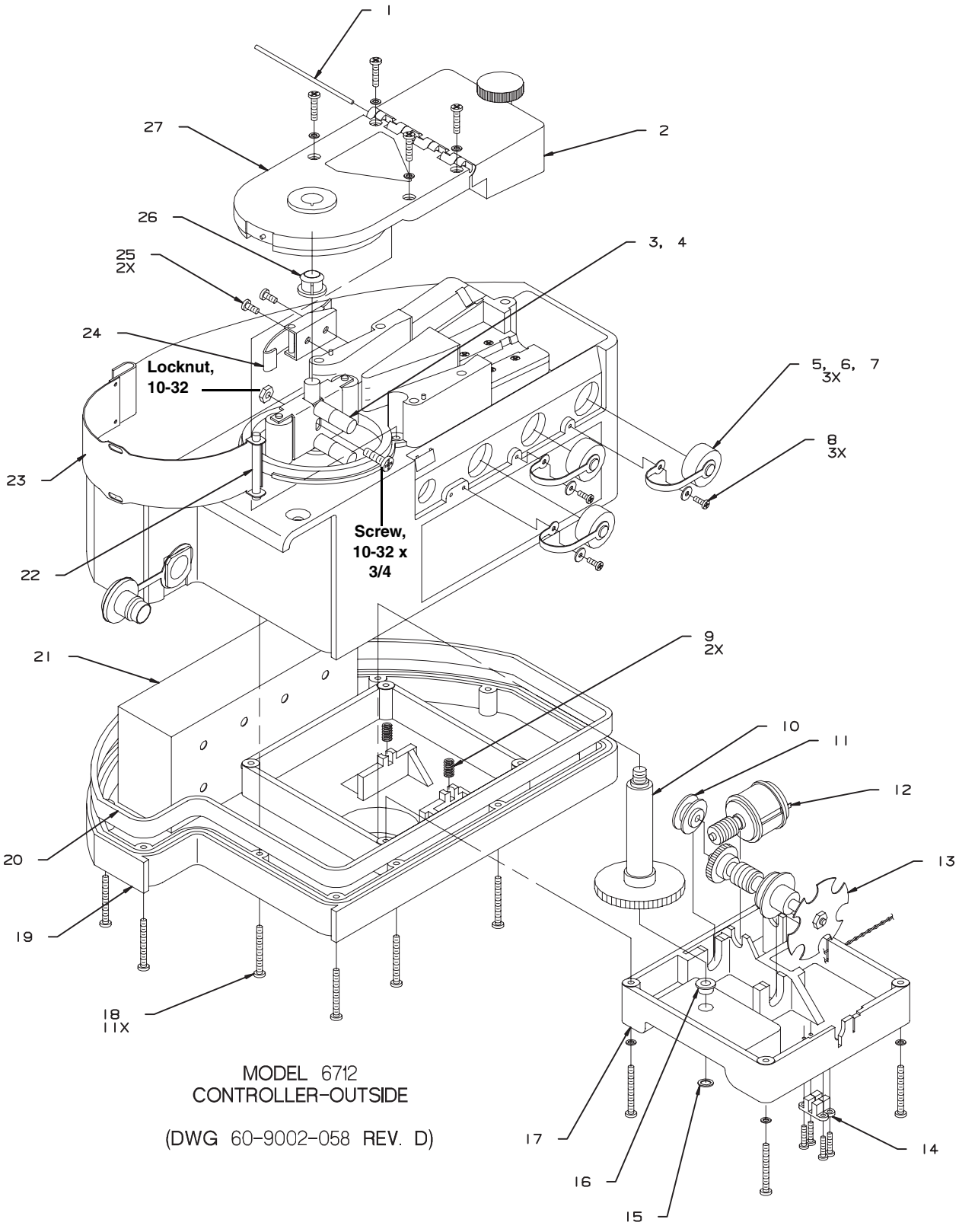
MODEL 6712
COMPACT PORTABLE SAMPLER



ITEM	INVENTORY NO.	DESCRIPTION
1	609004330	MODEL 6712 CONTROLLER
2	609004157	PUMP TUBE QUICK DISCONNECT
3	609004248	TOP COVER ASSY CMPT
4	109060503	DRAW LATCH ASSY SMALL
5	609004245	CENTER SECTION ASSY CMPT (INCLUDES ITEM 4)
6	603704129	SAMPLE TUB ASSY CMPCT
7	609004020	DIST ARM ASSY BOTTOM
8	602923007	DISTRIBUTOR ARM NUT
9	609004019	DIST ARM ASSY TOP
10	609003317	SPRING DISTRIBUTOR ARM
11	609003257	DISCHARGE TUBE FOR COMPACT 24 & 12 BOTTLE KITS
12	609004051	COMPOSITE TUBE GUIDE (FOR STANDARD AND COMPACT)
13	609003258	DISCHARGE TUBE FOR COMPACT 1 BOTTLE KITS
14*	609003088	BULKHEAD FITTING
15*	603704181	MINI BASE ASSEMBLY

*-NOT SHOWN

DWG 60-9002-066

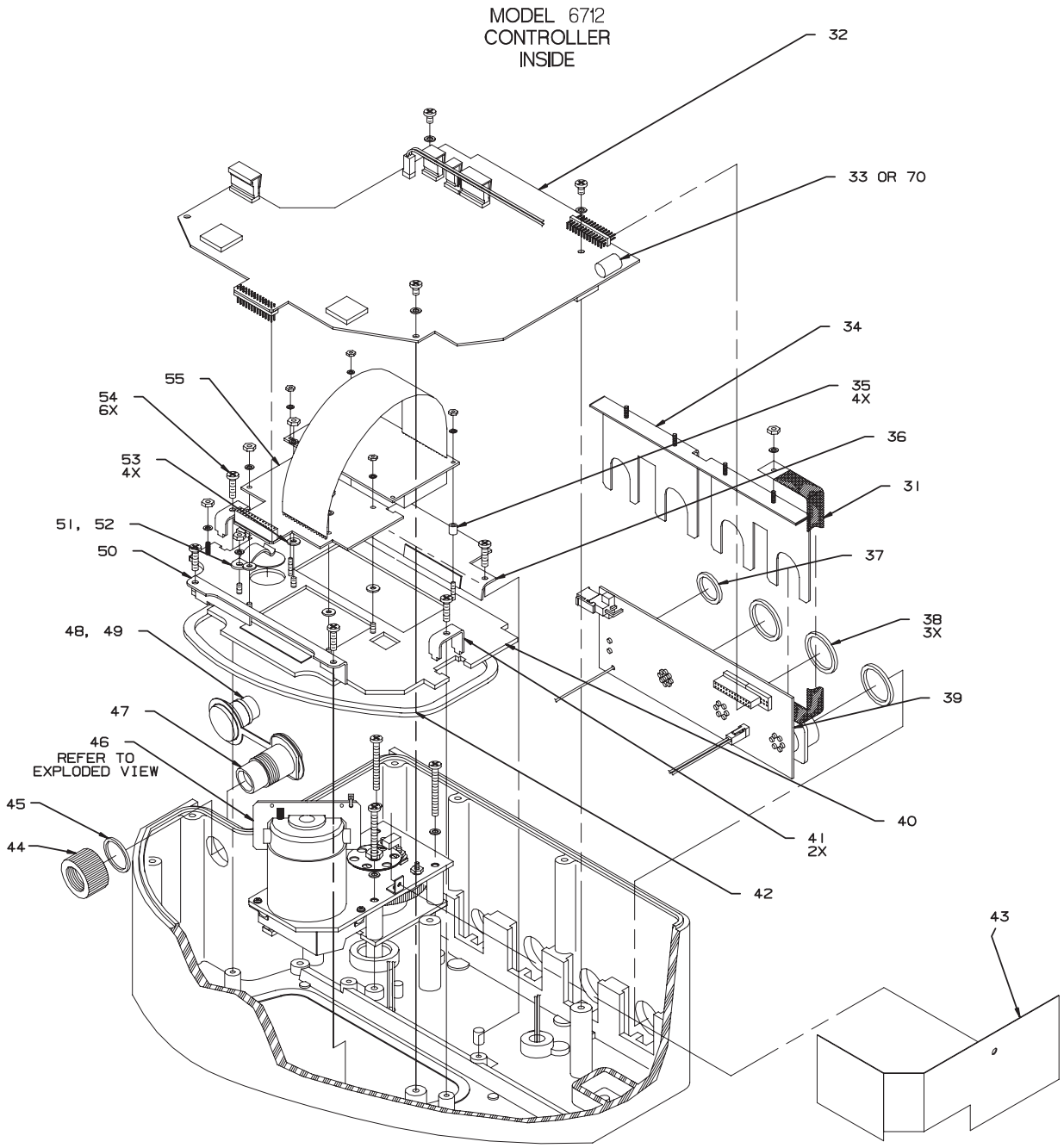


MODEL 6712
CONTROLLER-OUTSIDE

(DWG 60-9002-058 REV. D)

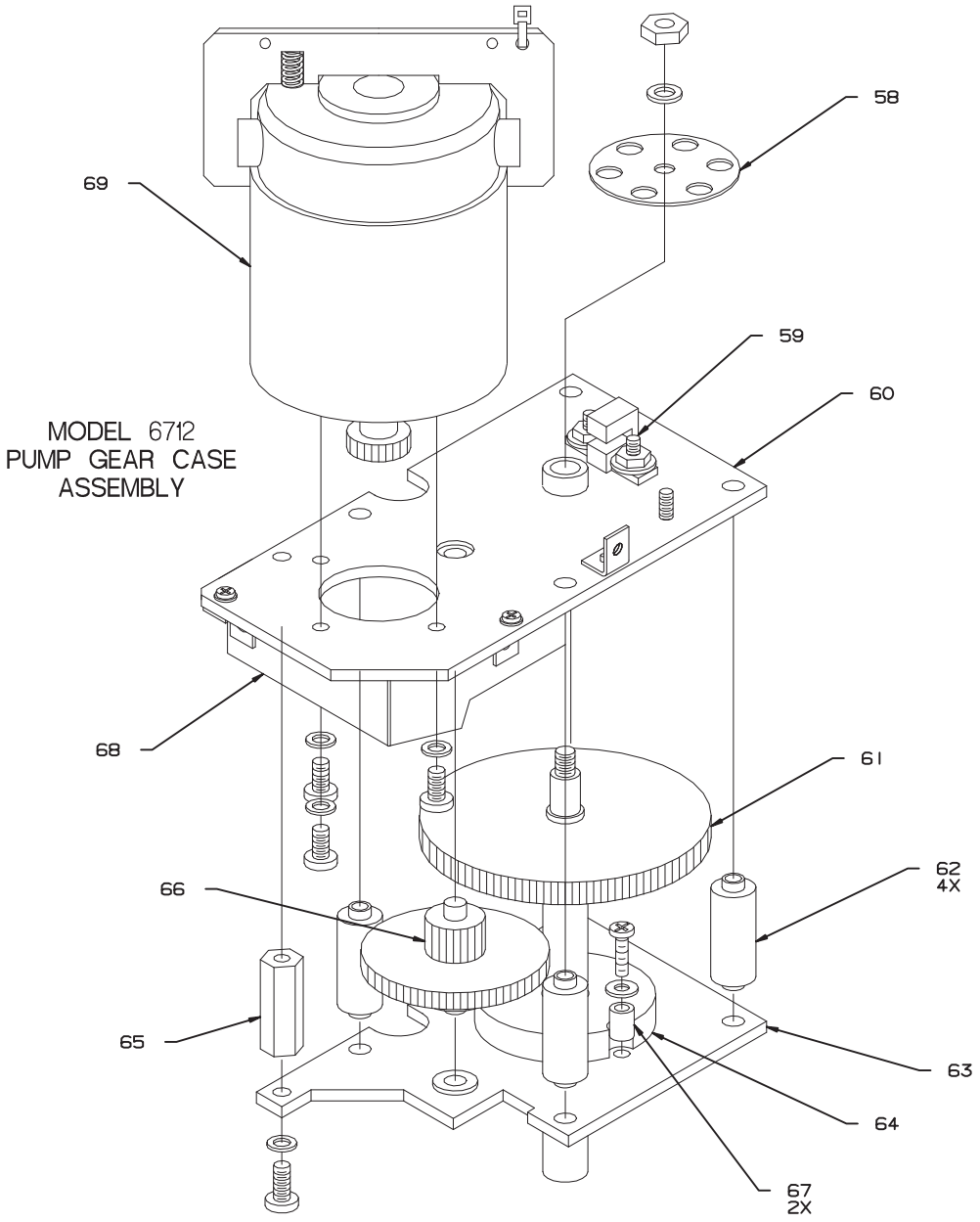
ITEM	INVENTORY NO.	DESCRIPTION
1	609003035	PIN HNG .09X3.635
2	609004013	LID ASSY LIQ DET
3	609004009	PMP PADDLE ASSY
4	23291601	NUT S 10-32
5	603113024	CAP CONN PTCTR MDM
6	603113032	GSKT CONN CAP MDM
7	609003291	STRAP CONN CAP
8	231310106	SCR SLFTPG #4X3/8
9	203012203	SPR CPRSN .042WIRE
10	609004016	SFT ASSY DISTR
11	609003040	BSHG .184 ID
12	609004014	DISTR MOT ASSY
13	609004015	SFT ASSY WORM
14	609004114	OPT SNSR ASSY
15	209000900	RTNG RING EXT.21ID
16	201312300	BRG CYL.250ID.380D
17	609003007	PL TOP DISTR (ENV)
18	231014436	SCR PNH 6-32X1 1/8
19	609004011	CONT BOX S/A BOT
20	609003054	GSKT CONT BOX
21	699003518	BOX 2.88X2.33X5.13
22	609003052	PIN HNG .18X2.000
23	609004300	PMP HSG BND ASSY
24	109080300	LCH DRAW SST
25	231311206	SCR SLFTPG #6X3/8
26	603703278	BSHG PMP (ENV)
27	609004295	PMP COV ASSY
*28	202999100	SEAL .625IDX1.000D

NOTE: * ITEM IS NOT SHOWN IN ILLUSTRATION


MODEL 6712
CONTROLLER
INSIDE
32
33 OR 70
34
35
4X
36
31
37
38
3X
39
40
41
2X
42
43
55
54
6X
53
4X
51, 52
50
48, 49
47
46
REFER TO
EXPLODED VIEW
45
44

ITEM	INVENTORY NO.	DESCRIPTION
31	609003407	STRAP INTCON 3.5"
32	609004324	CBA CPU YSI CE
33	340500000	BAT 2/3A LITHIUM (CYLINDER STYLE)
34	609004201	RTNG CLIP ASSY CE
35	609003077	SPCR .188 X 0.25 L
36	609003132	HLDN CONT PNL TOP
37	202400114	O RING .612ID .103
38	202400118	O-RING .862ID .103
39	609004346	CBA 6712 CONN 2001
40	609004328	CONT PNL ASSY CE
41	609003029	HLDN CONT PNL
42	609003066	GSKT CONT PNL
43	699003554	SHLD MN PCB
44	609003020	NUT CONN
45	202100018	O-RING .739ID .070
46	609004301	PMP GR CS ASSY CE (INCLUDES ITEMS 59 THRU 69)
47	609004206	CONN ASSY 8 PIN CE
48	609003074	STRAP P
49	609003075	P FL MDL CONN
50	609003133	HLDN CONT PNL BOT
51	209902138	CLIP TNSN .375 DIA
52	490001300	HMD INDCTR CARD
53	233040405	WSHR FL .125 NYL
54	231514920	SCR SLFTPG6-19X5/8
55	609004006	DSPL KYPD ASSY
57	232910100	NUT S 4-40
70	340503000	BATTERY .3AH COIN (DISK STYLE)

NOTE: * ITEM IS NOT SHOWN IN ILLUSTRATION



ITEM	INVENTORY NO.	DESCRIPTION
58	609003112	DISK OPT
59	609004203	WGR ASSY PMP SNSR
60	609004296	MOT MTG PL ASSY CE
61	609004304	PMP SFT ASSY
62	602703129	STDF DISTR GR CS
63	609004298	MTG PL ASSY PMP
64	609004305	SPCR 1.38 X 0.31 L
65	237263210	STDF 6-32 X 1.00 L
66	609004303	GR ASSY
67	237012000	SPACER, .140 ID X .313 OD X .312 LONG
68	699003555	SHLD DSPL
69	609004046	MOT ASSY

6712 Portable Sampler

Appendix E Accessories List

E.1 Order Information

Prices available on request. Additional items appear in *Appendix D, Replacement Parts List*. Many other items are available. To order any item, contact your sales representative or the factory. Note that the part name listed on your order acknowledgment and invoice may be different from the item name listed here. When examining these documents, use the part number for reference.

Teledyne Isco, Inc.
P.O. Box 82531
Lincoln, NE 68501
Telephone Within U.S.A.
Toll free: (800) 228-4373
Outside U.S.A.:(402) 464-0231
Fax: (402) 465-3022
IscoCSR@teledyne.com

E.2 Controller, Center Sections, Top Covers, and Tubs

6712 Sampler Controller 68-6710-074
(Includes 2 Pump Tubes)
6712 Portable Sampler Instruction Manual 60-9004-334
6712 Portable Sampler Pocket Guide 60-9003-589
Compact Center Section 60-9004-245
Compact Tub 60-3704-129
Mini-Tub (for use with Compact Tub and multiple bottle carrier only) 60-3704-181
Compact Top Cover 60-9004-248
Standard Center Section 60-9004-246
Standard Top Cover 60-9004-247
Standard Tub 60-9004-052

E.3 Compact and Mini Sampler Bottle Kits

24-Bottle Kit (500-milliliter Polyethylene Bottles) 68-6700-022
(Includes Bottle Carrier, Bottles, Retaining Ring and 2 Discharge Tubes.)
12-Bottle Kit (500-milliliter Polyethylene Bottles) 68-6700-023
(Includes Bottle Carrier, Retaining Ring, Bottles, and 2 Discharge Tubes.)
12-Bottle Kit (375-milliliter Glass Bottles) 68-6700-024
(Includes Bottle Carrier, Retaining Ring, Bottles, and 2 Discharge Tubes.)

E.4 Compact Sampler Bottle Kits

1-Bottle Kit (9.4-liter Polyethylene) 68-6700-025
(Includes Bottle and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Glass Bottle) 68-6700-026
(Includes Bottle and 2 Discharge Tubes.)

E.5 Standard Sampler Bottle Kits

24-Bottle Kit (1,000-milliliter Polypropylene Bottles) 68-6700-006
(Includes Retaining Ring, Bottles, and 2 Discharge Tubes.)

24-Bottle Kit (350-milliliter Glass Bottles) 68-6700-007
(Includes Retaining Ring, Bottles, and 2 Discharge Tubes.)

12-Bottle Kit (1,000-milliliter Polypropylene Bottles) 68-6700-008
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

12-Bottle Kit (950-milliliter Glass Bottles) 68-6700-009
(Includes Insert, Retaining Ring Bottles, and 2 Discharge Tubes.)

8-Bottle Kit (2.0-liter Polyethylene Bottles) 68-6700-010
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

8-Bottle Kit (1.8-liter Glass Bottles) 68-6700-011
(Includes Insert, Bottles, Retaining Ring, and 2 Discharge Tubes.)

4-Bottle Kit (3.7-liter Polyethylene Bottles) 68-6700-012
(Includes Bottles, Rack, and 2 Discharge Tubes.)

4-Bottle Kit (3.7-liter Glass Bottles) 68-6700-013
(Includes Bottles, Rack, and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Polyethylene Bottle) 68-6700-014
(Includes Bottle and 2 Discharge Tubes.)

1-Bottle Kit (9.4-liter Glass Bottle) 68-6700-015
(Includes Bottle and 2 Discharge Tubes.)

4 (15 Liter) Gallon Bottle Configuration 68-6700-080
(Includes Jumbo Base, Polyethylene Bottle, Cap, Two Discharge Tubes, and Composite Tube Guide.)

5 Gallon (19 Liter) Bottle Configuration 68-6700-078
(Includes Jumbo Base, Glass Bottle, Cap, PTFE Cap Liner, Two Discharge Tubes, and Composite Tube Guide.)

5.5 Gallon (20.8 Liter) Bottle Configuration
(Includes Jumbo Base, Polyethylene Bottle, Cap, Two Discharge Tubes, and Composite Tube Guide.)

ProPak Starter Kit 68-6700-112
(Includes 24 holders with caps, 100 liners, retaining ring, instruction video, instruction sheet.)

ProPak Configuration Kit for 6700 Full-size Samplers 68-6700-105
(Includes 25 holders, 1,000 liners, retaining ring, instruction video, instruction sheet.)

ProPak holders with caps, and standard liners (24) 68-6700-087

ProPak disposable liners, 1-liter polyethylene (100) 68-6700-113

ProPak disposable liners, 1-liter polyethylene (500) 68-6700-114

ProPak disposable liners, 1-liter polyethylene (1000) 68-6700-096

ProPak labels (1000) 68-6700-100

ProPak retaining ring for 24 holders 60-9003-475

E.6 Bottle Carriers, Retaining Rings and Racks, Bottle Inserts, Discharge Tubes

Bottle Carrier for Compact 12-Bottle Kits 60-9004-131
Bottle Carrier for Compact 24-Bottle Kits 60-9004-132
Retaining Ring for Compact 12-Bottle Kits 60-2904-062
Retaining Ring for Compact 24-Bottle Kits 60-9003-235
Retaining Ring for Standard 24-Bottle Kit (1000-milliliter Polypropylene Bottles) 60-9003-242
Retaining Ring for Standard 24-Bottle Kit (350 milliliter Glass Bottles) 60-2703-011
Retaining Ring for Standard 12-Bottle Kits 60-3704-112
Bottle Insert for Standard 12-Bottle Kits 60-9004-147
Retaining Ring for Standard 8-Bottle Kits 60-9004-149
Bottle Insert for Standard 8-Bottle Kits 60-9004-146
Retaining Rack for Standard 4-Bottle Kits 60-9004-351
Discharge Tube for Compact 12- Bottle Kit and 24-Bottle Kit 60-9003-257
Discharge Tube for Compact 1 Bottle Kit 60-9003-258
Discharge Tube for Standard 24-Bottle Kit 60-9003-260
Discharge Tube for Standard 12-Bottle Kit 60-9003-262
Discharge Tube for Standard 8-Bottle Kit 60-9003-264
Discharge Tube for Standard 4-Bottle Kit 60-9003-266
Discharge Tube for Standard 1-Bottle Kits 60-9003-271
Bulk Discharge Tube (10 foot Length) 60-6700-046
Bulk Discharge Tube (50 foot Length) 60-6700-047

E.7 Bulk Sets of Bottles with Lids

Set of 24, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-2900-002
Set of 100, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-6700-027
Set of 500, 500-milliliter Polyethylene Bottles with Polyethylene Foam Lined Lids 68-6700-028
Set of 12, 500-milliliter Polyethylene Bottles with Unlined Lids 68-2900-014
Set of 100, 500-milliliter Polyethylene Bottles with Unlined Lids 68-6700-029
Set of 500, 500-milliliter Polyethylene Bottles with Unlined Lids 68-6700-030
Set of 12, 375-milliliter Glass Bottles 68-2900-015
Set of 100, 375-milliliter Glass Bottles 68-6700-031
Set of 24, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-2100-007
Set of 100, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-3700-046
Set of 500, 1,000-milliliter Polypropylene Bottles with Polyethylene Foam Lined Lids 68-3700-047
Set of 24, 350-milliliter Glass Bottles with PTFE Lined Lids 68-2100-001
Set of 100, 350-milliliter Glass Bottles with PTFE Lined Lids 68-3700-048
Set of 12, 1,000-milliliter Polypropylene Bottles with Lids 68-3700-035
Set of 100, 1,000-milliliter Polypropylene Bottles with Lids 68-6700-016
Set of 500, 1,000-milliliter Polypropylene Bottles with Lids 68-6700-017
Set of 12, 950-milliliter Bottles 68-3700-023
Set of 100, 950-milliliter Bottles with PTFE Lined Lids 68-6700-018
Set of 8, 2.0-liter Polyethylene Bottles with Unlined Lids 68-2740-026
Set of 100, 2.0-liter Polyethylene Bottles with Unlined Lids 68-3720-028

Set of 8, 1.8-liter Glass Bottles with PTFE Lined Lids 68-2740-027
Set of 100, 1.8-liter Glass Bottles with PTFE Lined Lids 68-3720-030
3.7-liter Glass Bottles with PTFE Lined Lids 68-6700-147
3.7-liter Polyethylene Bottles with Unlined Lids 68-2910-003
Set of 4, 3.7-liter Glass Bottles with PTFE Lined Lids 68-6700-146
Set of 4, 3.7-liter Polyethylene Bottles with Unlined Lids 68-6700-020
9.4-liter (2 1/2-gallon) Glass Bottle with PTFE Lined Lid 68-2700-005
9.4-liter (2 1/2-gallon) Polyethylene Bottle with Lid 299-0013-04
18.9-liter (5-gallon) Glass Bottle with Cap and
Teflon Liner (for the 5 Gallon Bottle Base) 68-6700-079

E.8 General Accessories: Compact and Standard Samplers

Composite Tube Guide (Recommended for all 1-Bottle Kits) 60-9004-051
Distributor Arm 60-9004-050
Equipment Suspension Platform (For Suspending Samplers In Manhole or
Other Locations). 60-3004-151
Locking Assy, compact 6712 samplers (includes locking cables and padlock) 68-6710-111
Locking Assy, standard 6712 samplers (includes locking cables and padlock). 68-6700-134
Suspension Harness for Compact and Standard Samplers. 60-1394-014
1000-milliliter Plastic Graduated Cylinder 299-0020-00

E.9 Pump Tubes, Suction Line, Strainers

Pump Tube (Qty 5). 68-6700-062
Pump Tube (Qty 10). 68-6700-044
Pump Tube (Qty 25). 68-6700-045
3/8-inch Standard weighted polypropylene strainer with 10 foot Suction Line 60-9004-378
3/8-inch Standard weighted polypropylene strainer with 25 foot Suction Line 60-9004-379
PTFE Suction Line (10 foot length) 60-1683-146
PTFE Suction Line (25 foot length) 60-2703-114
Bulk Vinyl Suction Line (100 foot length) 68-1680-058
Bulk Vinyl Suction Line (500 foot length) 68-1680-059
3/8-inch Vinyl Suction Line Accessory Kit (includes tube coupling,
clamp, and instructions) 68-3700-007
3/8-inch Standard weighted polypropylene strainer. 60-9004-367
CPVC Plastic-coated Weighted Strainer. 60-3704-066
3/8-inch Stainless Steel Low Flow Strainer 69-2903-138
3/8-inch Suction Line Tubing Coupler. 69-4703-106

E.10 Data Collection Devices and Cables

581 Rapid Transfer Device (RTD) 60-9004-027
Power Cable 581 Rapid Transfer Device (RTD) 60-9004-077
Flowlink® for Windows Software – New License . . . . . call factory
Flowlink® for Windows Software – Upgrade . . . . . call factory
SAMPLINK Software (Includes Instruction Manual) 60-3774-013
Computer Connect Cable (25-pin) 60-2544-040
Computer Connect Cable (9-pin) 60-2544-044
Connector to Attach Non-Teledyne Isco Flow Meter to Customer Supplied Cable 68-1680-060
Serial Output Connect Cable (for use with the periodic serial output feature) 60-9004-263
External 12-volt DC Power Cable 60-1394-023
Flow-Meter to Two-Samplers Cable 60-3004-018
Dual Sampler Mode Interconnect Cable 60-3704-065
Dual Sampler Mode to Flow-Meter Cable 60-3704-080
Non-Teledyne Isco Flow-Meter to Sampler Cable 60-1394-077
Sampler to Flow Meter /1640 Liquid Level Actuator "Y" Cable 60-3004-019
Sampler to Flow Meter Cable 60-3004-107
2100 Series Sampler Interface Cable 60-2004-260
Solar Panel "Y" Cable 60-3004-098
Solar Panel/Interrogator Extension Cable 60-2544-028
Solar Panel Cable (25 foot length) 60-3004-097
Rain Gauge/Refrigerator Temperature Sensor "Y" cable 60-9004-294
4200T Modem . . . . . factory installed
(Contact your sales representative or Teledyne Isco Customer Service.)

> **☑ Note**
>
> The modem is disabled when an interrogator cable is connected to the sampler's Interrogator port. It cannot receive incoming calls, and the alarm dialout is rendered inoperative, while this cable is connected. **Disconnect the interrogator cable in order to use the 4200T modem.**

CDMA Digital Cellular Modem 60-5314-489
GSM Digital Cellular Modem 60-5314-563
(Requires the purchase of a SIM card from your preferred provider.)

E.11 Power Sources and Chargers

913 High Capacity Power Pack (120-volt) 60-1684-088
914 Battery-Backed Power Pack (120-volt) 60-3004-130
921 Nickel-Cadmium Battery 60-1684-040
923 High Capacity Power Pack (240-volt) 60-1684-093
924 Battery-Backed Power Pack (240-volt) 60-3004-160
947 Lead-Acid Battery 60-3004-106
948 45-Amp-Hour Battery 68-3000-948
Portable 12-volt DC, 6-Amp Battery Charger for 948 Battery 341-0118-12
961 Battery Charger (120-volt) 60-3004-059

965 Five-Station Battery Charger, 120/240 V, with 120 V cord. 68-3000-965
965 Five-Station Battery Charger, 120/240 V, with 240 V cord. 68-3000-966
Solar Panel Battery Charger, 5-watt. 60-5314-478
Solar Panel Battery Charger, 40-watt. 60-5314-347
Solar Panel Battery Charger, 90-watt. 60-5314-399
Power Products Guide 60-9003-092

E.12 Modules, Rain Gauges, & Interfacing Instruments

(Note: Additional accessories for modules and interfacing instruments appear in the accessories list at the back of the manual for each module or instrument.)

701 pH Module with Double Junction pH Sensor with Temperature Sensor. 68-6700-052
710 Ultrasonic Flow Module 68-6700-049
720 Submerged Probe Module, 10 ft range. 68-6700-068
730 Bubbler Flow Module 68-6700-050
780 Analog Interface Module 60-9004-040
675 Rain Gauge 60-3284-013
1640 Liquid Level Actuator 60-1644-000
4-20 mA Sampler Input Interface 60-3704-075
Refrigerator Temperature Sensor with 5 ft (1.55 m) cable 68-6700-136
Internal three channel 4-20 mA programmable output. 60-9004-266
(Includes multi-analog output cable, 10 ft.)

E.13 SDI-12 Data Acquisition Connect Cables

Note: Y-connect cables can be combined with other Y-connect cables or SDI-12 adapter cables if multiple SDI-12 devices are to be connected.

Rain Gauge Y-Connect Cable 60-9004-294
(This cable allows connection of 2 of the following: rain gauge, SDI-12 adapter cable, SDI-12 Y-connect cable, I/O adapter, temperature sensor.)

YSI SDI-12 Adapter Cable. 60-9004-337
YSI SDI-12 Y-Connect Cable 60-9004-338
(This cable allows connection of a YSI SDI-12 sonde and a Teledyne Isco Rain Gauge.)

Hydrolab Quanta SDI-12 Adapter Cable 60-9004-339
Hydrolab Quanta SDI-12 Y-Connect Cable 60-9004-340
(This cable allows connection of a Hydrolab Quanta SDI-12 sonde and a Teledyne Isco Rain Gauge.)

SDI-12 Adapter Cable (6 foot length, no connector). 60-9004-341
(This is for use with a customer supplied connector to an SDI-12 device.)

SDI-12 Y-Connect Cable (6 foot length, no connector) 60-9004-342
(This is for use with a customer supplied connector to an SDI-12 device and a Teledyne Isco Rain Gauge.)

6712 Portable Sampler

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产品中有毒有害物质或元素的名称及含量

Name and amount of Hazardous Substances or Elements in the product

部件名称 Component Name	有毒有害物质或元素 Hazardous Substances or Elements					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二联苯 (PBDE)
线路板 Circuit Boards	X	O	O	O	O	O
显示 Display	X	O	O	O	O	O
接线 Wiring	O	O	O	O	X	O
内部电缆 Internal Cables	O	O	O	O	X	O
主电源线 Line Cord	O	O	O	O	X	O
直流电机 DC Motor	X	O	O	O	X	O
小键盘 Keypad	O	O	O	O	X	O
接头 Connectors	O	O	X	O	O	O

产品中有毒有害物质或元素的名称及含量：Name and amount of Hazardous Substances or Elements in the product

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在ST/ 标准规定的限量要求以下。

O: Represent the concentration of the hazardous substance in this component's any homogeneous pieces is lower than the ST/ standard limitation.

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出ST/ 标准规定的限量要求。

(企业可在此处，根据实际情况对上表中打"X" 的技术原因进行进一步说明。)

X: Represent the concentration of the hazardous substance in this component's at least one homogeneous piece is higher than the ST/ standard limitation.

(Manufacturer may give technical reasons to the "X"marks)

环保使用期由经验确定。

The Environmentally Friendly Use Period (EFUP) was determined through experience.

生产日期被编码在系列号码中。前三位数字为生产年(207 代表 2007 年) 。随后的一个字母代表月份：A 为一月，B 为二月，等等。

The date of Manufacture is in code within the serial number. The first three numbers are the year of manufacture (207 is year 2007) followed by a letter for the month. "A" is January, "B" is February and so on.

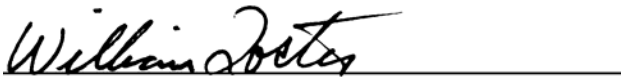
DECLARATION OF CONFORMITY

CE
ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	6712 Sampler
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 61326-1998 EMC Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use EN 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1kV differential mode	B
EN61000-4-6	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
CISPR11/ EN 55011	RF Emissions	Group 1, Class A Industrial, Scientific, and Medical Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of March 6, 2001.



William Foster
USA Representative

TELEDYNE ISCO
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60-9002-068
Rev. A

DECLARATION OF CONFORMITY

CE
ISM1-A

Application of Council Directive:	89/336/EEC – The EMC Directive 73/23/EEC – The Low Voltage Directive
Manufacturer's Name:	Teledyne Isco, Inc.
Manufacturer's Address:	4700 Superior, Lincoln, Nebraska 68504 USA Mailing Address: P.O. Box 82531, Lincoln, NE 68501
Equipment Type/Environment:	Laboratory Equipment for Light Industrial/Commercial Environments
Trade Name/Model No:	4200T Modem
Year of Issue:	2001
Standards to which Conformity is Declared:	EN 55024-1998 EMC Requirements for Information Technology Equipment EN 60950 Safety Requirements for Information Technology Equipment FCC Part 68

Standard	Description	Severity Applied	Performance Criteria
EN61000-4-2	Electrostatic Discharge	Level 2 - 4kV contact discharge Level 3 - 8kV air discharge	B B
EN61000-4-3	Radiated RF Immunity	80 MHz to 1000MHz 80% AM at 1kHz Level 1 – 10V/m	A
EN61000-4-4	Electrical Fast Transient	Level 2 - 2kV on ac lines	B
EN61000-4-5	Surge on AC Lines	2kV common mode, 1kV differential mode	B
EN61000-4-6	Conducted RF on AC lines	150 kHz to 80 MHz, 3V rms, 80% modulated	B
EN61000-4-11	Voltage Dips/Short Interruptions	0.5 cycle, each polarity/100%	B
EN 55022	RF Emissions	Group 1, Class A, Information Technology Equipment	
EN61000-3-2, 3-3	Harmonic, Flicker		

We, the undersigned, hereby declare that the design of the equipment specified above conforms to the above Directive(s) and Standards as of July 5, 2001.

William Foster

William Foster
USA Representative

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60-3212-049
Rev. A

*Teledyne Isco One Year Limited Factory Service Warranty **

Teledyne Isco warrants covered products against failure due to faulty parts or workmanship for a period of one year (365 days) from their shipping date, or from the date of installation by an authorized Teledyne Isco Service Engineer, as may be appropriate.

During the warranty period, repairs, replacements, and labor shall be provided at no charge. Teledyne Isco's liability is strictly limited to repair and/or replacement, at Teledyne Isco's sole discretion.

Failure of expendable items (e.g., charts, ribbon, tubing, lamps, glassware, seals, filters, fittings, and wetted parts of valves), or from normal wear, accident, misuse, corrosion, or lack of proper maintenance, is not covered. Teledyne Isco assumes no liability for any consequential damages.

This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

This warranty applies only to products sold under the Teledyne Isco trademark and is made in lieu of any other warranty, written or expressed.

No items may be returned for warranty service without a return authorization number issued from Teledyne Isco.

The warrantor is Teledyne Isco, Inc.
4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Custo mers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Is co dealer for warranty service.**

In the event of instrument problems, always contact the Teledyne Isco Service Department, as problems can often be diagnosed and corrected without requiring an on-site visit. In the U.S.A., contact Teledyne Isco Service at the numbers listed below. International customers should contact their local Teledyne Isco agent or Teledyne Isco International Customer Service.

Return Authorization

A return authorization number must be issued prior to shipping. Following authorization, Teledyne Isco will pay for surface transportation (excluding packing/crating) both ways for 30 days from the beginning of the warranty period. After 30 days, expense for warranty shipments will be the responsibility of the customer.

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Teledyne Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Technical Support (800)775-2965 (lab instruments)
(866)298-6174 (samplers & flow meters)
Sales & General Information: (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: iscoservice@teledyne.com **Web site:** www.isco.com

March 17, 2009 P/N 60-1002-040 Rev D

TELEDYNE ISCO
A Teledyne Technologies Company

Instructions for Sampling with Depth-Integrating Suspended-Sediment Samplers US D-59 and DH-76

The US DH59 and DH76 suspended-sediment samplers are depth-integrating instruments designed for use in streams not more than about 15 feet in depth. The samplers have streamlined bodies weighing about 24 and 25 pounds respectively, which are recessed to accommodate the round 1 pint milk bottle, and the 1 quart mayonnaise sample containers. Tail vanes to orient the instruments into the direction of flow and air escape passages are cast integrally. The heads of the samplers are drilled and tapped to receive the intake nozzles. Five nylon nozzles (color coded red), two of the 1/4 inch, two of the 3/16 inch, and one 1/8 inch diameter bore, threaded for hand assembly to the head, are supplied with each instrument. In the sampling operation, the head is oriented upstream with the nozzle pointing directly into the current, and the sampler is lowered from the water surface to the stream bed and then raised to a position above the water surface. During the period of submergence a continuous filament of tream flow is collected in the sample bottle. Air displaced from the bottle while the sample accumulates is discharged through the air escape passage which points downstream. A fixed static head differential of 1/2 inch between the intake and exhaust facilitates sampling in low stream velocities and slack waters.

Selection of sampling locations requires evaluation of local conditions, a procedure which will not be discussed here. After the sediment sampling station or cross section has been selected, sediment samples are usually taken at verticals that represent equal fractions of stream discharge. One or more samples may be taken at each sampling vertical. For further guidance in this respect see Reports No. 8 or 14 in the series, "A study of Methods Used in Measurement and Analysis of Sediment Loads in Streams."

Depth-integrating suspended-sediment samplers accumulate a sample of the water-sediment mixture throughout the period of submergence. However, if the container becomes completely filled during a sampling operation, the sample will not be representative and must be discarded. Clean bottles must be used and after sampling they should be covered with suitable caps to prevent contamination or loss of the sample. The capacity of the sample bottle is about 470 cc. in the case of the DH59 and 950 cc. in the case of the DH76. However, because the axis of the bottle is inclined to the vertical, any sample containing more than 440 cc. or 730 cc. respectively, may be in error due to circulation of the water-sediment mixture. The period of submergence should be sufficient to produce a sample volume less than 440 cc. and 730 cc. but greater than 375 cc, 665 cc. in order to obtain a sample large

enough for a laboratory analysis. It is generally preferable to retain an initial sample of less than 375 cc., 665 cc. but greater than 300 cc, 650 cc. rather than to discard the sample and resample into the same bottle. If the initial sample volume is considerable less than 300 cc. 600 cc., the stream vertical may be integrated a second time, or even a third time, each be additive to the same sample bottle. A minimum sample of 350 cc, 650 cc is suggested, but sufficient latitude in minimum sample volume should be permitted to avoid retaking a large number of samples.

The volume of sample collected at a vertical is dependent primarily upon the local stream velocity and the duration of submergence of the instrument. Because the operator has no control over the stream velocity and depth encountered, he must regulate the volume of the sample by selecting a nozzle of appropriate size or by varying the sampling time (total time of submergence of the instrument).

A chart showing the relation between stream velocity and corresponding filling time (time of submergence of the sampler) to produce samples 395 cc. (for pints) and 690 cc. (for quarts) in volume for the three standard nozzle diameters is attached. The filling time in seconds represents the total time of submergence of the instrument, that is, the time involved in traversing the stream vertical in both tge downward and upward directions. Use of these filling time curves will provide acceptable sample volumes and will permit minor variations in the total time of submergence without invalidating the sample. Enter the sampling time curve with the stream velocity and determine the sampling time to secure a sample volume of 395 cc., 690 cc. for the respective nozzle sizes. Then select the largest diameter nozzle that can be traversed conveniently throughout the depth of the stream in the time indicated, at a uniform rate throughout each direction of travel.

If the estimated mean velocity of flow in a stream vertical is 4 feet per second, a sediment sampler equipped with a 1/4 inch diameter intake nozzle will accumulate a sample of 395 cc. in 10 seconds of submergence. The sampler must be lowered from the water surface to the stream bed at a unifrom rate in 5 seconds and raised from the bed of the stream at a uniform rate to break the water surface at the expiration of the remaining 5 seconds. The time used in traversing the stream vertical need not be the same in both directions of travel. However, the rate at which the sampler moves vertically in any one direction must remain uniform. Thus, in the above example, the stream vertical could be traversed at a uniform downward rate in 6 seconds and at a uniform rate upward to clear the water surface in 4 seconds, a total submergence period of 10 seconds. If the 1/4 inch diameter nozzle requires a vertical transit rate greater than allowable for the stream depth than a smaller diameter nozzle should be used.

A clean bottle must be used for each separate sediment sample; at least one suspended-sediment sample is taken at each sampling vertical in the cross section. When a filled sample bottle is removed from the sampler it is immediately capped to prevent contamination and appropriately marked. Pertinent information for every sample should be recorded to include the following:

Name of the stream
Precise location on the stream (vertical)
Location of the cross section
The stream depth covered by the sample
State of the stream (gage height)
Date
Time of day
Identification applied to sampling personnel

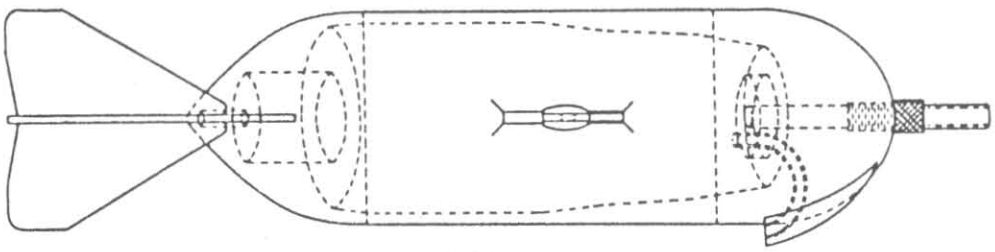
In addition to the above, the following information may be useful also:

Sampling time (sampler submergence time)
Water temperature
Coordination with sample groups
Individual identifying sample number

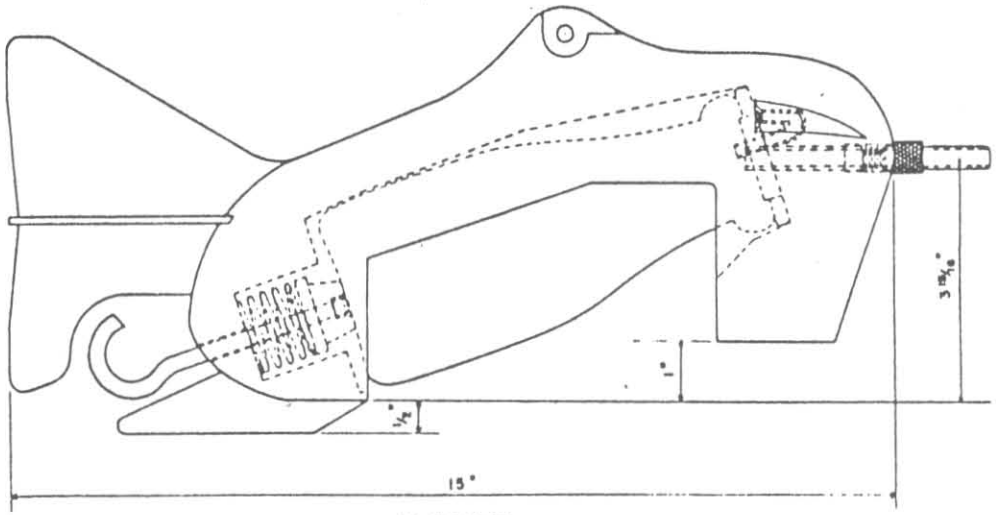
A portion of the exterior of the glass bottle may be etched or otherwise treated to provide a surface suitable for recording all the essential information for each sample.

Methods of analyzing sediment samples are discussed in Reports Nos. 4, 7 and 11 of the series of reports on "A study of Methods Used in Measurement and Analysis of Sediment Loads in Streams," sponsored by the Subcommittee on Sedimentation, Inter-Agency Committee on Water Resources.

March 21, 1981



PLAN



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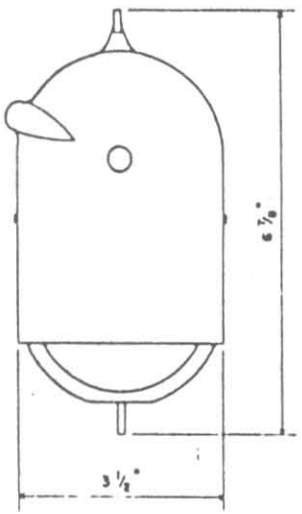
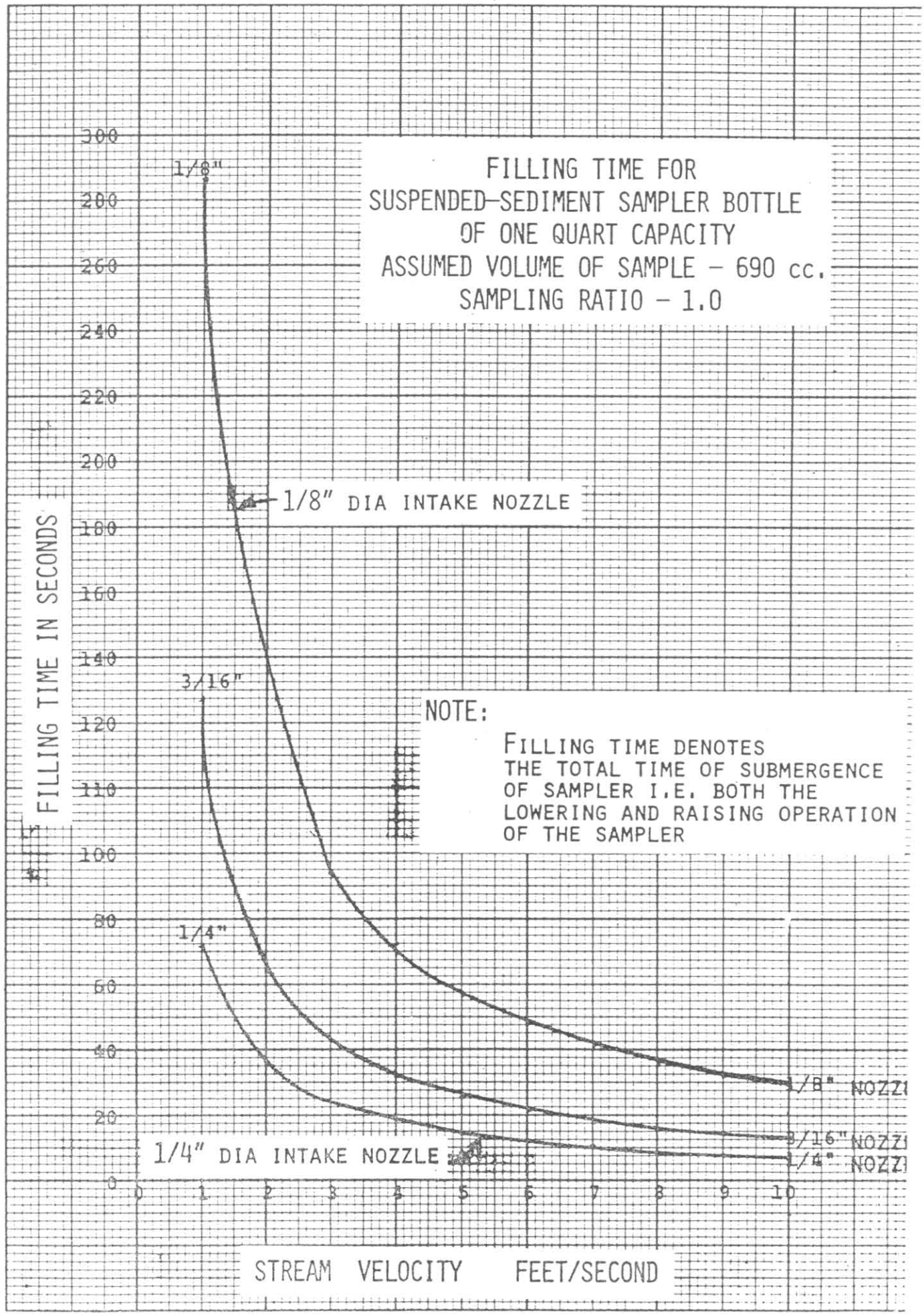


FRONT

DEPTH-INTEGRATING HAND LINE SAMPLER, US DH-59



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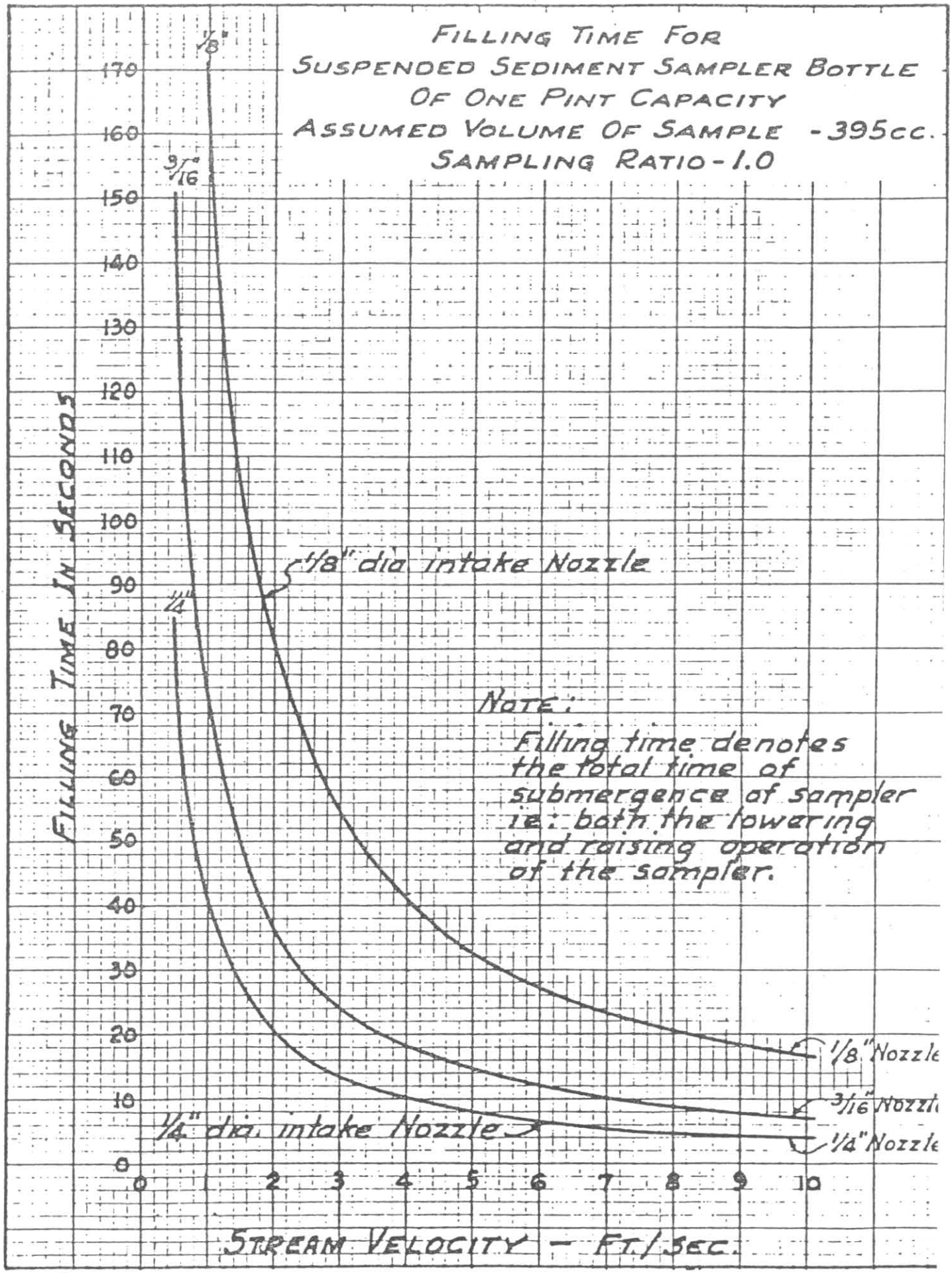
FILLING TIME FOR
SUSPENDED SEDIMENT SAMPLER BOTTLE
OF ONE PINT CAPACITY
ASSUMED VOLUME OF SAMPLE - 395cc.
SAMPLING RATIO - 1.0
FILLING TIME IN SECONDS
STREAM VELOCITY - FT./SEC.
1/8"
3/16"
1/4"
1/8" dia intake Nozzle
1/4" dia. intake Nozzle
1/8" Nozzle
3/16" Nozzle
1/4" Nozzle
NOTE:
Filling time denotes the total time of submergence of sampler ie: both the lowering and raising operation of the sampler.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
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Techniques of Water-Resources Investigations

Book 9
Handbooks for Water-Resources Investigations

National Field Manual for the Collection of Water-Quality Data

Chapter A2.

SELECTION OF EQUIPMENT FOR WATER SAMPLING

Revised by **Susan L. Lane, Sarah Flanagan, and Franceska D. Wilde**

Edited by **Franceska D. Wilde, Dean B. Radtke, Jacob Gibs, and Rick T. Iwatsubo**

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Foreword

The mission of the Water Resources Discipline of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems. These data are used for environmental and resource assessments by the USGS, other government and scientific agencies, and the general public. Reliable and objective data are essential to the credibility and impartiality of the water-resources appraisals carried out by the USGS.

The development and use of a *National Field Manual* is necessary to achieve consistency in the scientific methods and procedures used, to document those methods and procedures, and to maintain technical expertise. USGS field personnel use this manual to ensure that data collected are of the quality required to fulfill our mission.

(signed)

Robert M. Hirsch
Associate Director for Water

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SELECTION OF EQUIPMENT FOR WATER SAMPLING

A2.

National Field Manual for the Collection of Water-Quality Data

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Chapter A2. SELECTION OF EQUIPMENT FOR WATER SAMPLING

Revised 2002 by **Susan L. Lane, Sarah Flanagan, and Franceska D. Wilde**

Edited by **Franceska D. Wilde, Dean B. Radtke, Jacob Gibs, and Rick T. Iwatsubo**

ABSTRACT

The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols and provides guidelines for U.S. Geological Survey (USGS) personnel who collect data used to assess the quality of the Nation's surface-water and ground-water resources. This chapter of the manual addresses the selection of equipment commonly used by USGS personnel to collect and process water-quality samples.

Each chapter of the *National Field Manual* is published separately and revised periodically. Newly published and revised chapters will be posted on the World Wide Web on the USGS page "National Field Manual for the Collection of Water-Quality Data." The URL for this page is http://pubs.water.usgs.gov/twri9A/ (accessed March 20, 2003).

INTRODUCTION

As part of its mission, the U.S. Geological Survey (USGS) collects data needed to assess the quality of our Nation's water resources. The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols (requirements and recommendations) and provides guidelines for USGS personnel who collect those data on surface-water and ground-water resources. Chapter A2 provides information about equipment used to collect and process water samples. Requirements, recommendations, and guidelines are described that pertain to the selection and use of field equipment by USGS personnel. **Formal training and field apprenticeship are needed in order to correctly implement the requirements and recommendations described in this chapter.**

The *National Field Manual* is Section A of Book 9 of the USGS publication series "Techniques of Water-Resources Investigations" and consists of individually published chapters. Chapter numbers are preceded by an "A" to indicate that the report is part of the *National Field Manual*. Chapters of the *National Field Manual* are referred to in the text by the abbreviation "NFM" followed by the chapter number (or chapter and section number). For example, NFM 4 refers to chapter 4 on "Collection of Water Samples," and NFM 4.1 refers to the section on surface-water sampling methods.

PURPOSE AND SCOPE

The *National Field Manual* is targeted specifically toward field personnel in order to (1) establish and communicate scientifically sound methods and procedures, (2) provide methods that minimize data bias and, when properly applied, result in data that are reproducible within acceptable limits of variability, (3) encourage consistent use of field methods for the purpose of producing nationally comparable data, and (4) provide citable documentation for USGS water-quality data-collection protocols.

The purpose of chapter 2 of the *National Field Manual* is to provide a description of the requirements, recommendations, and guidelines routinely used for equipment selection in USGS studies involving the collection and processing of water-quality samples. (The terms "required" and "recommended," as used in this report, are explained below under "Requirements and Recommendations.") The information provided covers topics fundamental to the collection and processing of surface-water and ground-water samples that are representative of the ambient environment. This chapter does not attempt to encompass the entire spectrum of data-collection objectives, site characteristics, environmental conditions, and technological advances related to water-quality studies. Descriptions of equipment used to collect and process samples for analysis of biological indicators or suspended solids are given in chapters 7 and 8, respectively, of the *National Field Manual*.

REQUIREMENTS AND RECOMMENDATIONS

As used in the *National Field Manual*, the terms **required** and **recommended** have USGS-specific meanings.

Required (require, required, or requirements) pertains to USGS protocols and indicates that USGS Office of Water Quality policy has been established on the basis of research and (or) consensus of the technical staff and has been reviewed by water-quality specialists and selected District[1] or other professional personnel, as appropriate. Technical memorandums and other documents that define the policy pertinent to such requirements are referenced in this manual. Personnel are instructed to use required equipment or procedures as described herein. Departure from or modifications to the stipulated requirements that might be necessary to accomplish specific data-quality requirements or study objectives must be based on referenced research and good field judgment, and be quality assured and documented in permanent and readily accessible records.

Recommended (recommend, recommended, recommendation) pertains to USGS protocols and indicates that USGS Office of Water Quality policy recognizes that one or several alternatives to a given procedure or equipment selection are acceptable on the basis of research and (or) consensus. References to technical memorandums and selected publications pertinent to such recommendations are cited in this chapter to the extent that such documents are available. Specific data-quality requirements, study objectives, or other constraints affect the choice of recommended equipment or procedures. Selection from among the recommended alternatives should be based on referenced research and good field judgment, and reasons for the selection must be documented. Departure from or modifications to recommended procedures must be quality assured and documented in permanent and readily accessible records.

[1]"District" refers to an organizational unit of the USGS in any of the States or Territories of the United States.

FIELD MANUAL REVIEW AND REVISION

This is Version 2.0 of Chapter A2, "Selection of Equipment for Water Sampling," dated March 2003. Each chapter of the *National Field Manual* is reviewed and revised periodically to correct any errors, incorporate technical advances, and address additional topics. These updated chapters or chapter sections will be reissued in electronic format only. Version 2.0 of this chapter is the first reissue of this report. Subsequent minor changes will be designated as a new version by the number that follows the decimal point. When an NFM chapter incorporates additional topics or major technical changes, the chapter is reissued electronically and reprinted as a new edition. The version or edition number appears in the footer of each page.

To make comments or suggest updates to the NFM, go online to http://pubs.water.usgs.gov/twri9A/ and click on "NFM-GNATS," and then on "Submit a new problem report." Select the "category" by scrolling through the options until you find the chapter and sections that pertain to your report, and fill out the fields indicated. Alternatively, comments or corrections can be sent to nfm-owq@usgs.gov. Newly revised and reissued chapters or chapter sections will be posted on the World Wide Web on the USGS page "National Field Manual for the Collection of Water-Quality Data." The URL for this page is http://pubs.water.usgs.gov/twri9A/ (accessed March 20, 2003). This page also contains a link to the NFM "Comments and Errata" page that chronicles changes to each chapter.

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The information included in the original and revised versions of chapter 2 of the *National Field Manual* is based on existing manuals, various reference documents, and a broad spectrum of colleague expertise. D.A. Evans, R.G. Fay, R.T. Iwatsubo, and W.C. O'Neal, whose professional insight, knowledge, and

experience were instrumental in improving the accuracy of the revised version of this chapter, are gratefully acknowledged. The technical content of the original version of this report was enhanced by expertise from B.A. Bernard, Dallas Childers, Jr., T.K. Edwards, G.D. Glysson, J.R. Gray, A.J. Horowitz, H.E. Jobson, K.K. Fitzgerald, J.W. LaBaugh, R.W. Lee, S.W. McKenzie, R.H. Meade, Jr., W.C. O'Neal, R.L. Rickman, S.K. Sando, J.V. Skinner, R.L. Snyder, and Y.E. Stoker. Valuable editorial assistance was provided by I.M. Collies and M.S. Ashman. Production assistance from G.H. Comfort, A.M. Weaver, and M.V. Bonito was instrumental in maintaining the quality of this report.

In addition to the references provided, important source materials included USGS handbooks, manuals, and technical memorandums. The following USGS personnel developed the manuals or protocols that provided the foundation for this *National Field Manual*: M.E. Dorsey, T.K. Edwards, W.B. Garrett, W.J. Gibbons, R.T. Kirkland, L.R. Kister, J.R. Knapton, M.T. Koterba, C.E. Lamb, W.W. Lapham, R.F. Middelburg, Jr., J. Rawson, L.R. Shelton, M.A. Sylvester, and F.C. Wells.

Appreciation is extended to the following companies who granted permission to publish their illustrations in this manual: Bennett Sample Pumps, Inc., Amarillo, Tex.; Cole-Parmer Instrument Company, Vernon Hills, Ill.; Fultz Pumps, Inc., Lewistown, Penn.; Gelman Sciences, Ann Arbor, Mich.; GeoTech Environmental Equipment, Inc., Denver, Colo.; Grundfos Pumps Corporation, Olathe, Kans.; Savillex Corporation, Minnetonka, Minn.; Swagelok Company, Solon, Ohio; Timco Manufacturing Company, Prairie du Sac, Wis.; US Filter/Johnson Screens, St. Paul, Minn.; and Wildlife Supply Company, Saginaw, Mich.

Special thanks go to T.L. Miller and S.K. Sorenson for providing the ongoing support needed to produce and maintain a national field manual for water-quality studies.

Chapter A2. SELECTION OF EQUIPMENT FOR WATER SAMPLING

Revised 2002 by **Susan L. Lane, Sarah Flanagan, and Franceska D. Wilde**

Edited by **Franceska D. Wilde, Dean B. Radtke, Jacob Gibs, and Rick T. Iwatsubo**

This chapter provides information to assist field personnel in selecting the sample-collection and -processing equipment[2] that are appropriate for study objectives, data-quality requirements,[3] and site conditions for water-quality investigations. Selection of equipment for collecting or processing water-quality samples depends on the physical constraints and safe operation of the equipment and on its suitability with respect to achievement of study objectives.

[2]Equipment used for field measurements of physical or chemical properties of water (temperature, dissolved oxygen, specific electrical conductance (conductivity), pH, reduction-oxidation potential, alkalinity, and turbidity) is described in NFM 6; equipment used for biological indicator determination is described in NFM 7; equipment used for bottom-material sampling is described in NFM 8; and safety equipment is described in NFM 9.

[3]As used in this publication, the term data-quality requirements refers to that subset of data-quality objectives pertaining specifically to the analytical detection level for concentrations of target analytes and the variability (or error brackets) allowable to fulfill the scientific objectives of the study.

Criteria for selecting equipment for water sampling depend on (1) the mechanical constraints of the equipment to perform adequately under given environmental conditions, (2) the adequacy of equipment operation to obtain water-quality samples that represent the environmental conditions of the sample source, and (3) the adequacy of the equipment materials and construction to maintain sample integrity and not to be a source of leaching and sorption of target analytes.

- **Always operate equipment safely.**
- Be thoroughly familiar with requirements for equipment operation and maintenance.
- Be aware of the limitations as well as applications of the equipment with respect to your field site.
- Maintain and test equipment on a regular schedule.

CHEMICAL COMPATIBILITY WITH THE WATER SAMPLE 2.0

By **D.B. Radtke, F.D. Wilde, S.L. Lane, and Sarah Flanagan**

The materials used to construct and contact equipment can alter sample chemistry (table 2-1). Equipment designed for water-quality work commonly is constructed of a combination of materials, the most inert being used for components that will contact the sample. Nonsample-wetted components and manual contact with sampling equipment also can be a source of sample contamination. Field personnel must wear gloves and use other techniques to minimize potential contamination, implement quality-assurance procedures, and quantify potential effects by analyzing quality-control samples collected using laboratory-certified deionized and blank water.

When planning equipment use, consider having several sets of precleaned equipment available. A clean set of equipment for each sampling site prevents cross contamination between sites, helps to eliminate the need for time-consuming equipment cleaning in the field, and serves as a backup should equipment break or become contaminated.

Check that the equipment to be used will not affect the sample chemistry.

Table 2-1. General guidelines for selecting equipment on the basis of construction material and target analyte(s)

[✓, generally appropriate for use shown; Fl, fluoride; Si, silica; Cr, chromium; Ni, nickel; Fe, iron; Mn, manganese; Mo, molybdenum; $^3H/^3He$, tritium/helium-3; CFC, chlorofluorocarbon; SF-6, sulfur hexafluoride; B, boron]

Construction material for sampling equipment (does not apply to well casing)		Target analyte(s)	
Material	**Description**	**Inorganic**	**Organic**
Plastics[1]			
Fluorocarbon polymers[2] (other varieties available for differing applications)	Chemically inert for most analytes.	✓ (potential source of Fl)	✓ (Sorption of some organics.)
Polypropylene	Relatively inert for inorganic analytes.	✓	Do not use.
Polyethylene (linear)	Relatively inert for inorganic analytes.	✓	Do not use.
Polyvinyl chloride (PVC)	Relatively inert for inorganic analytes.	✓	Do not use.
Silicone	Very porous. Relatively inert for most inorganic analytes.	✓ (potential source of Si)	Do not use.
Nylon	Relatively inert for inorganic analytes.	✓	Do not use. Exception: CFCs
Metals[3]			
Stainless steel, 316-grade (SS 316)	SS 316—metal having the greatest corrosion resistance. Comes in various grades. Used for submersible pump casing.[3]	✓ (potential source of Cr, Ni, Fe, and possibly Mn and Mo, if corroded[4]) Do not use for surface-water sampling: equipment must have a plastic coating (does not apply to submersible pumps).	✓ Do not use if corroded.[4]
Stainless steel, 304-grade (SS 304)	Similar to SS 316, but less corrosion resistant.	Do not use.	✓ Do not use if corroded.[4]
Other metals: brass, iron, copper, aluminum, and galvanized and carbon steels	Refrigeration-grade copper or aluminum tubing are used routinely for collection of $^3H/^3He$, CFC, and SF-6 samples.	**Do not use** (except as noted for isotopes).	✓ Routinely used for CFCs. Do not use if corroded.
Glass			
Glass, borosilicate (laboratory grade) Ceramic	Relatively inert. Potential sorption of analytes.	✓ (glass is potential source of B and Si)	✓

[1]Plastics used in connection with inorganic trace-element sampling must be uncolored or white (Horowitz and others, 1994).
[2]Fluorocarbon polymers include materials such as Teflon®, Kynar®, and Tefzel® that are relatively inert for sampling inorganic or organic analytes.
[3]Most submersible sampling pumps have stainless steel components. One can minimize effects on inorganics samples by using fluorocarbon polymers in construction of sample-wetted components (for example, for a bladder, stator, impeller) to the extent possible.
[4]Corroded/weathered surfaces are active sorption sites for organic compounds and can leach trace elements.

EQUIPMENT MATERIALS 2.0.1

Materials used in equipment can include plastics, glass, ceramics, and metals. Chemical reactivity varies widely within the same group of materials, depending on the chemical composition, the physical configuration, and the manufacturing process. Thus, regarding reactivity with water and most other chemical substances, fluorocarbon polymers are less reactive than plastics such as polyethylene; 316-type stainless steel (SS 316) is less reactive than brass, iron, or galvanized steel (table 2-1). For plastics and metals in general:

- The softer or more flexible forms of any plastic or metal are more reactive than the rigid forms.
- The more polished the surface, the less reactive the material tends to be.

2.0.2 DISPOSABLE GLOVES

Use of disposable, powderless gloves is required when handling equipment for collecting and processing water-quality samples. Wearing gloves serves to protect field personnel from contact with contaminants and chemical preservatives, and protects the sample from contamination transmitted by sample handling.

Although common glove types include those made of vinyl, latex, and nitrile, nitrile is in standard use for USGS sampling work because of its resistance to most of the chemicals to which it typically will be exposed, for the length of exposure (usually under 15 minutes). Field personnel are cautioned that direct contact with materials such as latex or nitrile can cause severe allergic reactions in some individuals and should be monitored.

- Wear powderless nitrile gloves when handling equipment and chemical solutions. **Do not allow the water that enters the sample bottle to contact gloved (or bare) hands.**
- Check the manufacturer's chemical resistance chart for any compound, such as acid, base, or organic solvent, to which the glove might be exposed.

Physical properties to consider when selecting disposable gloves are glove length, slip protection, puncture resistance, heat and flame resistance, cold protection, and comfort. These factors can vary between manufacturers.

Gloves should be inspected visually for defects. Check for tears, punctures, and other flaws that can prevent the glove from being an effective shield. After putting the gloves on, rinse them with water while gently rubbing hands together to remove any surface residue before handling sampling equipment.

BLANK WATER AND CHEMICAL REAGENTS 2.0.3

USGS personnel must use the blank water designated by the USGS National Water Quality Laboratory (NWQL) and available through the USGS "One-Stop Shopping." Blank water for quality-control samples must have a laboratory-certified analysis to document the chemical composition and chemical concentration. Several grades of blank water are available, and selecting the appropriate grade depends on the sample analysis to be performed.

- **VPBW** (Volatile/Pesticide-Grade Blank Water): Blank water that is suitable for collecting blank samples to be analyzed for volatile organic compounds, pesticides, and organic carbon; purge with nitrogen gas.
  .
  - Shelf life of unopened bottle of VPBW for analysis of volatile organic compounds (VOCs) is 2 weeks after VPBW has been purged of VOCs, and 1 year for other constituents.
  - VPBW also is referred to as N_2-purged Universal Blank Water—see Office of Water Quality Technical Memorandum 2002.14.
- **PBW** (Pesticide-Grade Blank Water): Blank water that is suitable for collecting blank samples to be analyzed for pesticides, and organic carbon.
  - Shelf life of unopened bottle is 1 year after date of laboratory (NWQL) certification.
  - PBW also is referred to as Universal Blank Water when used instead of IBW.
- **IBW** (Inorganic-Grade Blank Water): Blank water that is suitable for collecting blank samples to be analyzed for inorganic trace elements, major ions, and nutrients.

Replacement page 3/30/2009. See Comments and Errata.

Deionized water (DIW), including ASTM International (formerly known as American Society for Testing and Materials) Type 1 water from other sources, is not an acceptable substitute for the blank water described above. DIW that has been quality-controlled may be used as a cleaning solution, as described in NFM 3.

Unopened bottles of blank water must be stored in a location where there is no exposure to vehicle exhaust, cleaning fluids, or other solvents. No open bottles of blank water are to be stored for later use to collect blank samples to be analyzed for either inorganic or organic analytes.

SAMPLE COLLECTION 2.1

By **S.L. Lane, Sara Flanagan, Jacob Gibs, D.B. Radtke, W.E. Webb, and F.D. Wilde**

Guidelines for selecting sample-collection equipment and related supplies differ, depending on the chemical nature of the target analyte and on whether samples are collected for surface water or ground water. Routine use should be made of checklists, field forms (see NFM 6.0.1 and 6.0.2), and logbooks. Examples of checklists for sample-collection equipment and supplies are provided in section 2.4.

A logbook must be maintained that is dedicated to keeping calibration and maintenance records for each field-measurement, field-analysis, and multiparameter instrument. A field book in which the equipment and methods used for project activities and field-site observations are recorded also is strongly recommended. Logbooks and other records documenting field activities may be requisitioned if the project data are a likely candidate for litigation. Documentation of equipment use and extra quality-control analyses are necessary if study objectives or site conditions result in a departure from published USGS required or recommended procedures.

- Logbooks must be bound so that pages are not readily removable (no loose leaf or spiral notebooks), and pages should be preprinted with consecutive numbers.
- Entries in logbooks or on field forms must be in ball-point pen or permanent non-smudge marker (not pencil or liquid ink) and dated.
- Do not erase incorrect entries or mistakes: draw a single line through the mistake and initial and date it.

All equipment should be maintained and tested on a regular schedule (NFM 6). For example, thermistor thermometers should be checked every 3 to 4 months, along with an annual 5-point calibration (NFM 6.1.2). Equipment checks, calibrations, maintenance, and repair must be entered into the logbook.

2.1.1 SURFACE-WATER EQUIPMENT

Study objectives, flow conditions, and structures (such as a bridge, cableway, or boat) from which sample-collection equipment (a sampler) is deployed must be considered when determining which equipment to use. The equipment selected also depends on whether the stream can be waded or not. To determine whether stream depth and velocity are too great to safely wade the stream (NFM 9), follow this rule of thumb:

RULE OF THUMB: Do NOT wade in flowing water when the product of depth (in feet) multiplied by velocity (in feet per second) equals 10 or greater.

Application of this rule varies among individuals according to their weight and stature, and depends on the condition of the streambed.

Two primary types of surface-water samplers are used by the USGS:

- Isokinetic depth-integrating samplers
- Nonisokinetic samplers

2.1.1.A ISOKINETIC DEPTH-INTEGRATING SAMPLERS

An isokinetic depth-integrating sampler is designed to accumulate a representative water sample continuously and isokinetically (that is, stream water approaching and entering the sampler intake does not change in velocity) from a vertical section of a stream while transiting the vertical at a uniform rate (ASTM, 1999; see NFM 4, Appendix A-4-A). Isokinetic depth-integrating samplers are categorized into two groups, based on the method of suspension: hand-held samplers and cable-and-reel samplers.

Types and pertinent characteristics of isokinetic depth-integrating samplers recommended for sampling in flowing water are summarized in table 2-2, illustrated on figure 2-1, and described below. For detailed descriptions of isokinetic depth-integrating samplers, refer to Szalona (1982), Ward and Harr (1990), Horowitz and others (1994), Edwards and Glysson (1999), and Federal Interagency Sedimentation Project at http://fisp.wes.army.mil (accessed March 20, 2003).

For collection of an isokinetic sample, minimum stream velocity must be greater than 1.5 feet per second (ft/s) for a rigid-bottle depth-integrating sampler, or 2.0 ft/s for a US D-96 or US D-99 bag sampler.

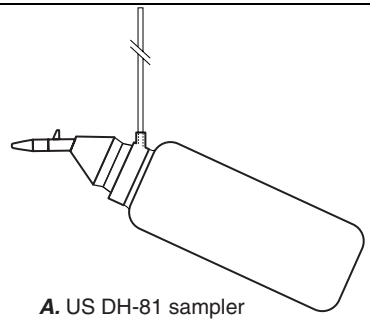
The maximum allowable transit rate (R_t) relative to mean velocity (V_m) for a given sampler varies with nozzle size and sample-bottle size (equipment properties were designed using English units; refer to page CF-1 for conversion to metric units) (table 2-2). **Do not exceed the listed R_t/V_m ratio for the given nozzle and bottle size.** A lower R_t/V_m is better for ensuring that a representative velocity-weighted sample is collected, but care must be taken to not overfill the sampler bottle. **Do not exceed the 15 ft (approximately 4.6 meters (m)) maximum depth of deployment for a rigid-bottle sampler.**

Table 2-2. Isokinetic depth-integrating water-quality samplers and sampler characteristics

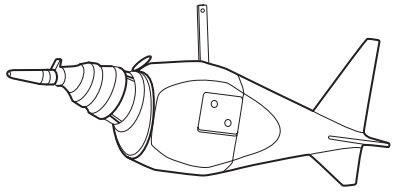
[R_t, transit rate in feet per second (ft/s); V_m, mean stream velocity in the vertical being sampled, in ft/s; DH, depth-integrating hand-held sampler; PN, polypropylene cap and plastic (Delrin®) nozzle; PFA, perfluoroalkoxy bottle or bag; C&N, cap and nozzle; PC, plastic coated; PT, polypropylene or PFA bottle; PDC, plastic dip coated; D, depth-integrating sampler; P, plastic nozzle; TFE, tetrafluoroethylene nozzle]

Sampler designation	Sampler construction material	Sampler dimensions			Distance of nozzle from bottom, in inches	Suspension method	Maximum calibrated velocity, in feet per second	Maximum depth, in feet	Sampler container size, in liters	Nozzle intake size,[1] in inches	Maximum transit rate ratio,[2] R_t/V_m
		Length (inch)	Width (inch)	Weight (pound)							
US DH-81	PN or PFA-C&N	[3]6.5	3.2	[3]0.5	[4]4	Hand-held (PC)	7.6	15 15 13.3	1 (PT)	3/16 1/4 [1]5/16	0.2 .3 .4
US DH-95	Bronze (PDC) with PN or PFA-C&N	22	6.6	29	4.8	Hand-held or reel and cable	7.4	15 15 13.3	1 (PT)	3/16 1/4 5/16	.18 .32 .4
US D-95	Bronze (PDC) with PN or PFA-C&N	26	6.7	64	4.8	Reel and cable	6.7	15 15 13.3	1 (PT)	3/16 1/4 [1]5/16	.18 .32 .4
US D-96	Bronze (PDC) with P or TFE nozzle	35	8	132	4	Reel and cable	12.5	110 60 39	3 (PFA)	3/16 1/4 5/16	.4 .4 .4
US D-99	Bronze (PDC) with P or TFE nozzles	47	10	275	9.5	Reel and cable	15	220 120 78	6 (PFA)	3/16 1/4 5/16	.4 .4 .4

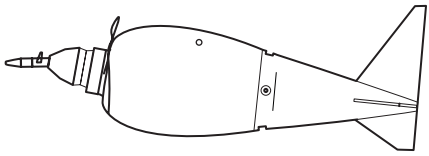
[1]Nozzle sizes are those recommended for the application shown.
[2]Refer to NFM 4, Appendix A, for maximum transit-rate ranges, and to Office of Surface Water Technical Memorandum 94.05, dated January 31, 1994.
[3]Length, width, and weight will depend on specific bottle dimensions. Weight indicated is for cap and nozzle only. Handle is plastic coated with clear heat-shrinking tubing.
[4]Distance of nozzle from the bottom will depend on specific bottle dimensions.



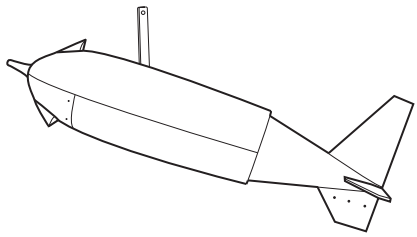
A. US DH-81 sampler



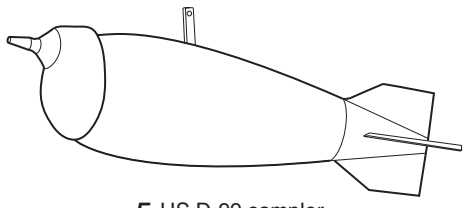
B. US DH-95 sampler



C. US D-95 sampler



D. US D-96 sampler



E. US D-99 sampler

Not to scale

Figure 2-1. Isokinetic depth-integrating samplers: (*A*) US DH-81, (*B*) US DH-95, (*C*) US D-95, (*D*) US D-96, and (E) US D-99. (Illustrations courtesy of Federal Interagency Sedimentation Project, Waterways Experiment Station, Vicksburg, Miss.)

The cap-and-nozzle assembly is available in fluoropolymer and polypropylene materials. The same cap and nozzle can be used for the US DH-81, US DH-95, and US D-95 samplers. +

- Use the US DH-81, US DH-95, US D-95, US D-96, or US D-99 samplers (fig. 2-1) to collect samples in flowing waters for all analyses except inorganic gases and volatile organic compounds.
  - — Samples of water for determination of trace elements must contact only noncontaminating materials, typically fluorocarbon polymer or polypropylene.
  - — Samples of water for determination of organic compounds must contact only noncontaminating materials, typically a metal (such as stainless steel), fluoropolymers or fluorocarbon polymers (such as Teflon®[4]), or ceramics (such as hard-fused microcrystalline alumina).
- Discontinue use of the US DH-48, US DH-59, US DH-76, US D-49, US D-74, US D-77, US D-77 Bag, Frame Bag (FB), US P-61, US P-63, and US P-72 samplers for collecting trace-element samples (refer to Office of Water Quality Technical Memorandum 2002.09 for details): testing indicates that these samplers contaminate samples with measurable concentrations of trace elements. +
  - — Some of these samplers may be acceptable for major ions, nutrients, and suspended sediments.
  - — Collect additional quality-control samples if it is necessary to use any of these samplers (Horowitz and others, 1994).

+

[4]Teflon is a registered trademark of the DuPont Corporation.

Hand-held samplers

The US DH-81 (fig. 2-1*A*) or US DH-95 (fig. 2-1*B*) sampler is used to collect water samples where flowing water can be waded or where a bridge is accessible and low enough from which to sample. The sampler components (cap, nozzle, and bottle) are interchangeable. Both inorganic and organic samples can be collected with either sampler as long as the construction material of the sampler components (table 2-1) does not affect ambient concentrations of target analytes. Isokinetic depth-integrated samples for bacteria analysis also can be collected with these samplers because the cap, nozzle, and bottle can be autoclaved. All hand-held samplers should be tested and maintained as described on table 2-3. The checklist also applies to cable-and-reel samplers.

Table 2-3. Prefield checklist for hand-held and cable-and-reel samplers

✓	Sampler items	Comment
	Mechanical operation	Test the working condition of the sampler. If tail fin is damaged or broken, sampler will not swim correctly.
	Nozzles	Replace nozzles that have burrs or are damaged. Use only nozzles purchased from the Federal Interagency Sedimentation Project.
	Plastic coating	If plastic coating is damaged or any metal parts are exposed, recoat or touch up with a plastic dip product.
	Sampler is clean	Before field work, clean appropriate parts of the sampler according to procedures described in NFM 3 and store in plastic for transport to the field site.
	Laboratory results from analysis of sampler blank	Make sure the sampler has been quality assured with an annual equipment blank and certified for water-quality use (see NFM 1 and NFM 4).
	Separate sets of sampler components and backup equipment	If at all feasible, for a given field trip when collecting multiple water samples, prepare and use separate sets of sampler bottles, caps, and nozzles for each sampling site. Have backup equipment available on-site.
	Field-cleaning supplies and blank water	If separate sets of sampler components are not available, then clean equipment between sampling sites (see NFM 3) and be prepared to process the number of field blanks needed to document that equipment was adequately cleaned.

When using the US DH-81 (fig. 2-1*A*):

- Use a 3/16-, 1/4-, or 5/16-in. nozzle.
- Make sure that flow velocity exceeds 1.5 ft/s (~0.46 m/s) but does not exceed 7.6 ft/s (~2.32 m/s) (to collect an isokinetic sample).
- Maximum depth of deployment must be within 15 ft (~4.6 m) if using a 3/16- or 1/4-in. nozzle, and within 13.3 ft (~4 m) if using a 5/16-in. nozzle.
- Use caution when sampling in depths that exceed 13.3 ft (~4 m) to avoid overfilling the sampler.

When using the US DH-95 (fig. 2-1*B*):

- Use the 1-L bottle. Use caution when sampling in depths that exceed 13.3 ft (~4 m) to avoid overfilling the sampler.
- To collect an isokinetic sample when using a 3/16-in. nozzle, flow velocity must be between 2.1 to 6.2 ft/s (~0.64 to 1.9 m/s) and depth of deployment should not exceed 15 ft (~4.6 m).
- To collect an isokinetic sample when using a 1/4-in. nozzle, flow velocity must exceed 1.7 ft/s (~0.52 m/s) but be no greater than 7.4 ft/s (~2.25 m/s), and depth of deployment should be within 15 ft (~4.6 m).
- To collect an isokinetic sample when using a 5/16-in. nozzle, flow velocity also should be between 1.7 and 7.4 ft/s (~0.52 and 2.25 m/s), and depth of deployment should not exceed 13.3 ft (~4 m).

Cable-and-reel samplers

Cable-and-reel samplers are used to collect water samples where flowing water should not be waded. These include the US D-95, US D-96, and US D-99 samplers. (Refer to table 2-2 for sampler characteristics and sampling limitations.) Like the hand-held US DH-81 and US DH-95, these cable-and-reel samplers can be used for collecting inorganic and organic samples; however, appropriate sampler components (cap, nozzle, and bottle or bag) must be selected so as not to bias concentrations of target analytes. Isokinetic depth-integrated samples for bacteria analysis also can be collected with these samplers because the cap, nozzle, bottle, and bags can be autoclaved.

The US D-96 Bag sampler uses a perfluoroalkoxy (PFA) or polyethylene bag that is placed in a sliding tray that supports the bag and holds the nozzle holder with nozzle in place. The bag is attached to the nozzle holder with a hook-and-loop strap. The US D-99 Bag sampler uses a 6-L PFA or polyethylene bag that is placed in a chamber behind the nozzle, through an access door.

Metal parts of the US D-95 Bottle sampler and US D-96 Bag and US D-99 Bag samplers must be coated with plastic (for example, Plasti Dip®) and recoated periodically to prevent possible sample contamination from metallic surfaces. **All cable-and-reel samplers should be tested and maintained before use, as described on table 2-3.**

When using the US D-95 Bottle sampler (fig. 2-1*C*):

- Use a 3/16-, 1/4-, or 5/16-in. nozzle. US DH-81 and DH-95 nozzles can be used.
- Make sure that flow velocity exceeds 1.7 ft/s (~0.52 m/s), but no greater than 7.4 ft/s (~2.25 m/s), depending on the nozzle diameter used.
- Use in water less than 13.3 to 15 ft (~4 to 4.6 m) deep (at sea level), depending on the nozzle used and altitude at the site for an isokinetic, depth-integrated sample.

When using the US D-96 Bag sampler (fig. 2-1*D*):

- Use a 3/16-, 1/4- or 5/16-in. nozzle. The nozzles needed are unique to the D-96 sampler and mounts.
- Make sure that flow velocity exceeds 2 ft/s (~0.61 m/s), but is no greater than 12.5 ft/s (~3.8 m/s).
- Use in water with a maximum depth between 39 and 110 ft (~11.9 and 33.5 m), depending on nozzle diameter for an isokinetic, depth-integrated sample.
- Water temperature must be at or greater than 4°C. The sampler has been tested at temperatures of 39°F (4°C) and found to function properly.

When using the US D-99 Bag sampler (fig. 2-1*E*) **for isokinetic sampling:**

- Use a 3/16-, 1/4- or 5/16-in. nozzle and mount (do not use a 1/8-in. nozzle that is designed for the D-99 sampler).
- Make sure that flow velocity exceeds 3.0 ft/s (~0.9 m/s).
- Use in water with a maximum depth between 78 and 220 ft (~23.8 and 67 m), depending on nozzle diameter, for an isokinetic, depth-integrated sample.
- Water temperature must be at or greater than 4°C.

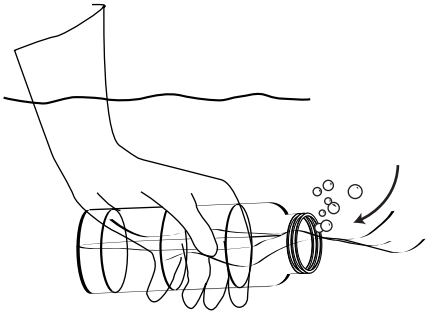
2.1.1.B NONISOKINETIC SAMPLERS

Nonisokinetic samplers are sampling devices in which the sample enters the device at a velocity that differs from ambient stream velocity. All of the isokinetic samplers described in 2.1.1.A can be used to collect depth-integrated, although nonisokinetic, samples, when used beyond the minimum and maximum ranges of velocity and depth (table 2-2). As with all samplers, the materials that contact the sample must not bias concentrations of target analytes by sorbing or leaching target analytes.

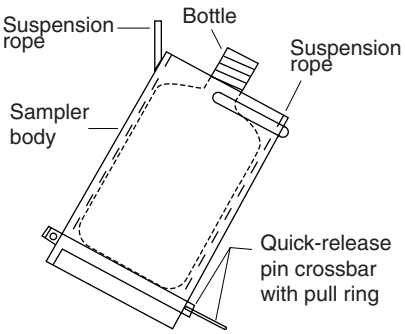
Open-mouth samplers

Open-mouth samplers used for the collection of water samples include the hand-held bottle, the weighted-bottle sampler, the biochemical oxygen demand (BOD) sampler, and the volatile organic compound (VOC) sampler (fig. 2-2).

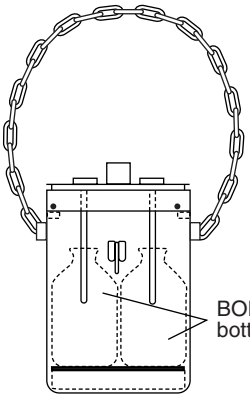
- **The hand-held bottle sampler** is the simplest type of open-mouth sampler. A bottle is dipped to collect a sample (fig. 2-2*A*) where depth and velocity are less than the minimum requirements for depth-integrating samplers.
- **The weighted-bottle sampler** is available in stainless steel (US WBH-96) (fig. 2-2*B*) or polyvinyl chloride. The weighted-bottle sampler can be used to collect samples where flow velocities are less than the minimum requirement for isokinetic depth-integrating samplers and where the water body is too deep to wade. An open bottle is inserted into a weighted holder that is attached to a handline for lowering. Sampling depth is restricted by the capacity of the bottle and the rate of filling.
- **The BOD sampler and the VOC sampler** (fig. 2-2*C-D*), respectively, are open-mouth samplers designed to collect nonaerated samples.
  - The BOD sampler accommodates 300-milliliter (mL) glass BOD bottles specifically designed to collect samples for dissolved-oxygen determination (American Public Health Association and others, 1992, p. 4-99).
  - The VOC sampler is specifically designed to collect nonaerated samples in 40-mL glass septum vials for determination of volatile organic compounds.



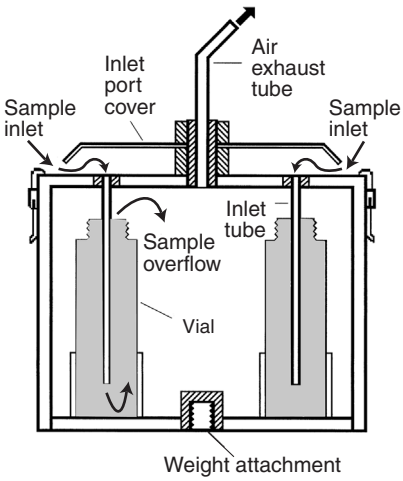
A. Hand-held open-mouth bottle sampler



B. US WBH-96 weighted-bottle sampler



C. BOD sampler



D. VOC sampler

Not to scale

Figure 2-2. Nonisokinetic open-mouth samplers: (*A*) hand-held open-mouth bottle sampler, (*B*) US WBH-96 weighted-bottle sampler, (*C*) biochemical oxygen demand (BOD) sampler, and (*D*) volatile organic compound (VOC) sampler. (*A*, from U.S. Environmental Protection Agency, 1982b; *B*, courtesy of Federal Interagency Sedimentation Project, Waterways Experiment Station, Vicksburg, Miss.; *C*, published with permission of Wildlife Supply Company; *D*, from Shelton, 1997.)

Thief samplers

Thief samplers are used to collect instantaneous discrete samples. Thief samplers have been used primarily to collect samples from lakes, reservoirs, and some areas of estuaries. Smaller versions, designed to collect ground-water samples, also have been used in still and flowing surface water. The most commonly used thief samplers are the Kemmerer sampler, Van Dorn sampler, and double check-valve bailer with bottom-emptying device (fig. 2-3). These samplers are available in various sizes, mechanical configurations, and in various types of construction material (such as stainless steel, glass, polyvinyl chloride, fluorocarbon polymer). Disposable fluorocarbon polymer bailers also are available. For descriptions of additional thief samplers, see U.S. Environmental Protection Agency (1982b), Ward and Harr (1990), and American Public Health Association and others (1992) or consult the manufacturer of environmental sampling equipment.

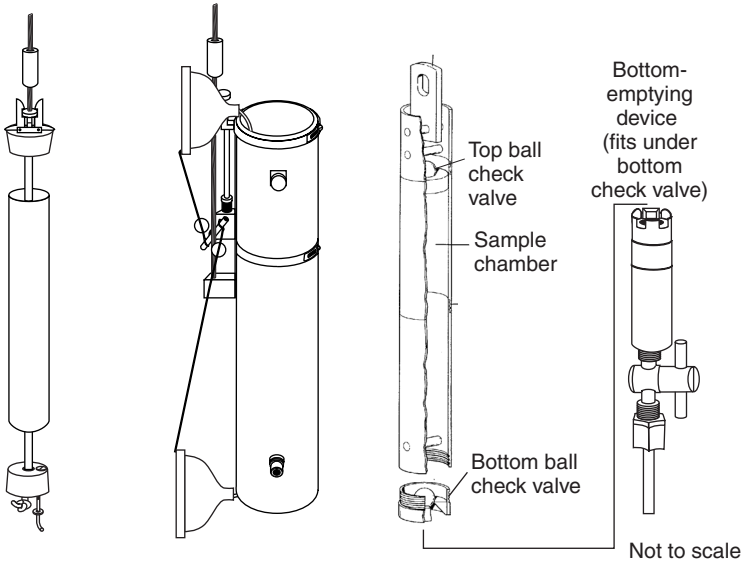
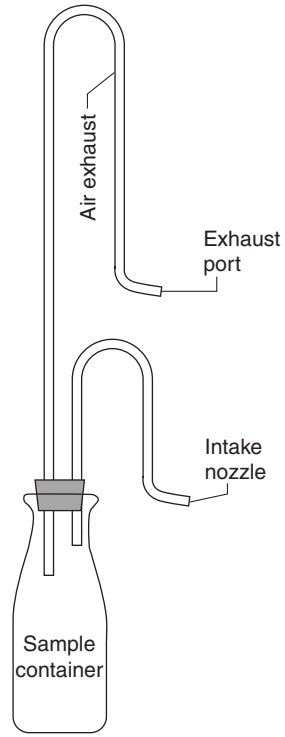


Figure 2-3. Nonisokinetic thief samplers: (*A*) Kemmerer sampler, (*B*) Van Dorn sampler, and (*C*) double check-valve bailer with bottom-emptying device. (*A-B*, from *Standard Methods for Examination of Water and Wastewater*, 18th Edition. Copyright 1992 by the American Public Health Association, the American Water Works Association and the Water Environment Federation. Used with permission. *C*, published with permission of Timco Mfg. Inc.)

Single-stage samplers

Single-stage samplers such as the US U-59 (fig. 2-4*A*) are designed to obtain suspended-sediment samples from streams at remote sites or at streams where rapid changes in stage make it impractical to use a conventional isokinetic depth-integrating sampler. Single-stage samplers can be mounted above each other to collect samples from different elevations or times as streamflow increases and the hydrograph rises (fig. 2-4*B*). (Edwards and Glysson, 1999.)

- **The US U-59** is a sample container mounted to collect a water sample as stage rises above the sampler intake.
  - The vertical-intake sampler is used to sample streams carrying sediments finer than 0.062 millimeter (mm). The vertical intake is less likely to become clogged or fouled by floating solid materials compared to a horizontal-type intake.
  - The horizontal-intake sampler is used to sample streams carrying sediment coarser than 0.062 mm.
- **The US U-73,** which can be used to sample water during either rising or falling stage, is constructed to provide some protection form trash or other solids that could clog or foul the intake.



A.

B.

Figure 2-4. US U-59 sampler: (*A*) single stage, and (*B*) a bank of U-59 samplers installed on a plank post. (A, from Edwards and Glysson, 1999; B, photograph by J.C. Mundorff.)

Automatic samplers and pumps

Automatic pumping samplers (autosamplers) with fixed-depth intake(s)[5] are sometimes used to collect samples at remote sites; from ephemeral, small streams; or from urban storm drains where stage rises quickly (American Public Health Association and others, 1992; Edwards and Glysson, 1999). These samplers can be programmed to collect samples at preset time intervals or at selected stages, thus reducing the personnel requirements for time-intensive sampling. Whenever automatic samplers or pumps are used, the sample is considered to be a point-integrated sample.

Pumps used for water sampling are grouped into two general categories: suction-lift pumps and submersible pumps. Pumps can be used to collect water samples from lakes, reservoirs, and estuaries (Radtke and others, 1984; Radtke, 1985; Ward and Harr, 1990). Suction-lift and submersible pumps are described in section 2.1.2, "Ground-Water Equipment."

SUPPORT EQUIPMENT 2.1.1.C

Much of the equipment used to measure streamflow also can be used as support equipment when collecting water samples in water bodies that cannot be waded. Examples of commonly used support equipment are listed in section 2.4.

Clean Hands/Dirty Hands techniques described in NFM 4 are required when sampling for trace elements (Horowitz and others, 1994) and are recommended as a general practice in sample collection, particularly when using heavy-duty support equipment.

[5]Automatic pumping samplers are available through commercial manufacturers, such as American Sigma, ISCO, and Manning.

Use of a vertical transit rate pacer, such as the US VTP-99, can help to ensure an accurate flow-weighted sample, after the appropriate transit rate has been determined (Edwards and Glysson, 1999, p. 53–60). Once programmed, the pacer produces an audible signal for pacing the raising and lowering of either hand-held or mechanically hoisted samplers. The pacer is small enough to be carried in a shirt pocket, and the tone is audible for several feet in a quiet environment. The US VTP-99 can be used with a miniature phone-type monaural headphone jack; neither the jack nor the headphones are supplied. Tables for using the pacer when sampling with either a hand-held sampler or type "A," "B," or "E" reel can be found in the publication "Using the US VTP-99 vertical transit rate pacer."[6]

Exercise great care to avoid sample contamination when using support equipment to handle samplers for collecting trace-element samples.

2.1.2 GROUND-WATER EQUIPMENT

The type of sampler or sampling system selected depends on the type and location of well, depth to water from land surface, physical characteristics of the well, ground-water chemistry, and the analytes targeted for study. Selecting the appropriate equipment for collecting ground-water samples is important in order to obtain data that will meet study objectives and data-quality requirements. Ground-water sampling equipment is available from commercial sources. Support equipment (for example, tubing, valves, manifolds) is available commercially or, for USGS personnel, through the Hydrologic Instrumentation Facility (HIF).

[6]The publication is available at the URL http://fisp.wes.army.mil/Instructions%20US%20VTP-99%20990722.pdf (accessed March 20, 2003).

Ground water most commonly is collected using either pumps designed specifically for water sampling from monitoring wells, pumps installed in supply wells, or a bailer or other point or thief-type sampler.[7] General considerations for selecting ground-water equipment are listed in table 2-4.

- Monitoring wells: Samplers can be portable, dedicated, or permanently installed in the well.
  - Portable equipment is commonly used at multiple well sites and cleaned after each use.
  - Portable samplers and sample tubing commonly are dedicated to be used only at a site with large contaminant concentrations.
  - Some types of portable equipment can be installed in a well for the duration of the monitoring program. Remove the sampler periodically for cleaning.
- Supply wells (for domestic, public (municipal), industrial or commercial, and agricultural use): Equipment selection is limited as such wells normally are equipped with permanent, large-capacity pumps.
  - Choice of equipment usually depends on well configuration and type of pump installation (permanent or temporary).
  - Modifications to the well and ancillary equipment attached at the wellhead are necessary in some cases (see section 2.1.2.A.)

[7]Additional categories of sampling equipment not described in this report include multilevel collection systems (LeBlanc and others, 1991; Smith and others, 1991; Gibs and others, 1993); samplers designed to collect ground water under natural-gradient flow conditions (Margaritz and others, 1989); and pump-and-packer systems.

Table 2-4. General requirements and considerations for selecting ground-water sampling equipment (pumps or thief samplers)

Requirements	Considerations
Construction materials	• Is the sampler constructed from materials that (initially or over time) could leach targeted analytes? If left in the well, is the sampler constructed of materials that will degrade appreciably within the lifetime of the study? • Can the sampler be cleaned? Can it withstand the level of decontamination needed and subsequently produce clean equipment blanks?
Operation, capabilities, and limitations	• Could operation of the sampler compromise sample integrity with respect to study objectives or data quality? For example, does the sampler heat or aerate the sample, or subject it to negative pressure, leading to volatilization of purgeable organic compounds, oxidation of target analytes, or changes in partial pressure of carbon dioxide or other gases? • Is the sampler capable of evacuating standing water (that is, can it be used for purging in addition to sample collection)? • Is the sampler capable of providing flow or sample volumes sufficient for sample collection and in a manner that minimizes suspension of sediments or colloids that could bias chemical measurements? • Is the sampler mechanically capable of withdrawing formation water from the desired depth?
Power requirements	• What are the power requirements of the sampler or the manner in which it will be deployed? Will it require electrical power (alternating or direct current), gasoline or other fuel-powered generators, or compressed gas such as air or nitrogen? • Will the capacity of the power source be sufficient to allow the sampler to run continuously throughout purging and sample collection? • Could the power source contaminate samples? (For example, gasoline-powered generators or compressors are a potential source of volatile organic compounds.) • Could the fuel be changed to a noncontaminating type (for example, convert a gasoline-powered generator to propane fuel)?
Transport	• Is the sampler easily transported to remote sites and rugged enough for field use?
Sampler repair	• Can the sampler be repaired in the field?
Availability and cost	• Are the available samplers suitable for study use? Are funds available to purchase, operate, and maintain the sampler? • Are funds available to purchase a spare pump head? This would allow for continuous use of a sampling pump while one pump head is being repaired.

Sampling equipment must not be a source of contamination or otherwise affect analyte concentration (table 2-1). Of specific importance for ground-water sampling is a potential change in ground-water chemistry due to atmospheric exposure.

- Select equipment that minimizes sample aeration.
- Select equipment that will not leach or sorb significant concentrations of the target analytes, with respect to data-quality requirements.
  - Samplers that tested successfully[8] for inorganic constituents[9] were the Grundfos Redi-Flo2®, Fultz SP-300, Bennett, and several bladder pumps (with Teflon® bladders), submersible pumps, and double check-valve fluorocarbon polymer bailers.
  - Samplers tested that achieved a greater than 95-percent recovery of volatile organic compounds were Grundfos Redi-Flo2®, Fultz SP-300, bladder pumps, and the Bennett pump. Recovery for double check-valve fluorocarbon polymer bailers was less than 95 percent (U.S. Geological Survey, 1992a, b).

Choice of equipment is constrained by many factors, including equipment construction and specifications. For example, it is necessary to consider the power requirements, lift capability, and discharge capacity of submersible pumps. Ideal equipment for sample collection might not exist, and compromise is often necessary. **Field personnel must understand the application, advantages, disadvantages, and limitations of the available equipment with respect to study objectives and site characteristics, and must document how any compromises made might affect the data and data-quality objectives.**

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[8]Unpublished results of testing by the USGS confirmed that commonly used sampling equipment does not, in general, affect sample concentrations of inorganic constituents or organic compounds (U.S. Geological Survey Office of Water Quality, written commun., 1994). (The samplers tested were precleaned and fitted with new, cleaned tubing and had fluorocarbon polymer interior parts, where available.)

[9]Trace-element concentrations in blank samples processed through these samplers were within the margin of analytical variability at a method reporting level of 1 microgram per liter.

2.1.2.A PUMPS

Pumps transport water from depth to land surface either by suction lift or positive pressure.[10] The pumping mechanism for most suction-lift pumps (peristaltic, jet, and some nonsubmersible centrifugal pumps) is at land surface. Positive-pressure pumps (helical rotor, gear, bladder, piston, inertial submersible, and centrifugal) are grouped together as submersible pumps because they are placed below static water level.

Supply-well pumps

Jet (venturi) pumps and above land-surface centrifugal pumps (fig. 2-5), as well as high-capacity submersible pumps and turbine pumps are common in domestic, municipal, and other supply wells.

- Be aware that large- and small-capacity pumps used in supply wells can affect analyte concentrations. (See NFM 1 and Lapham and others, 1997.)
  - — Erroneous data produced as a result of using these pumps are most likely for dissolved gases, VOCs, and reduction-oxidation (redox) chemical species.
  - — Oil in the water column is common for oil-lubricated pumps.
  - — Chemical treatment systems, pressure tanks, and holding tanks can compromise sample integrity.

[10]For more detailed information on pumps, refer to manufacturers' instructions and specifications and to U.S. Environmental Protection Agency (1982b), Morrison (1983), Driscoll (1986), Imbrigiotta and others (1988), Ward and Harr (1990), American Public Health Association and others (1992), Gibs and others (1993), Sandstrom (1995), Koterba and others (1995), and Edwards and Glysson (1999).

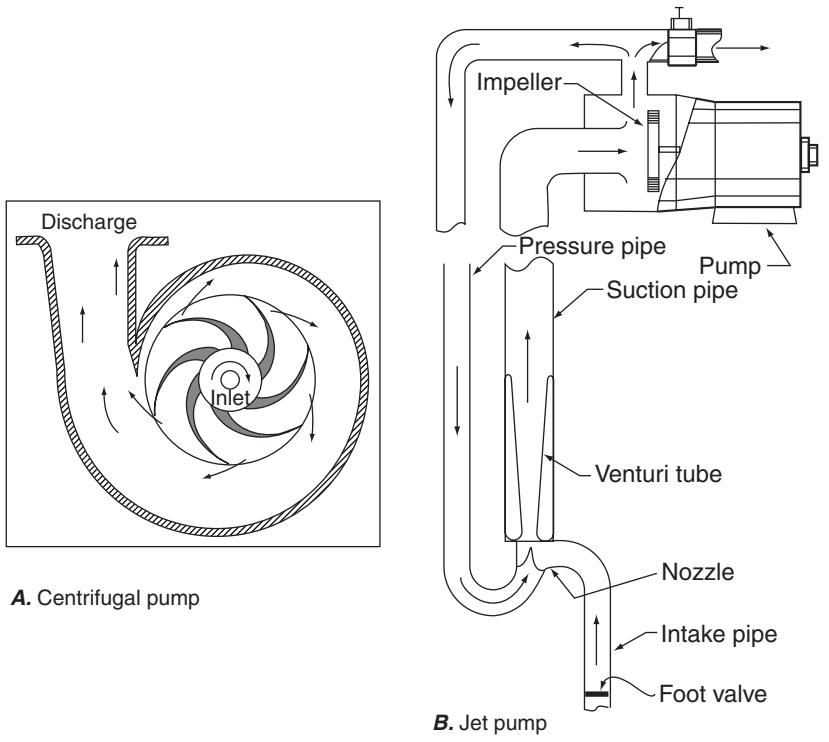


Figure 2-5. Pumps typically used to obtain water from supply wells: (*A*) centrifugal pump, and (*B*) jet pump. (From Driscoll, 1986, and published with permission of US Filter/Johnson Screens.)

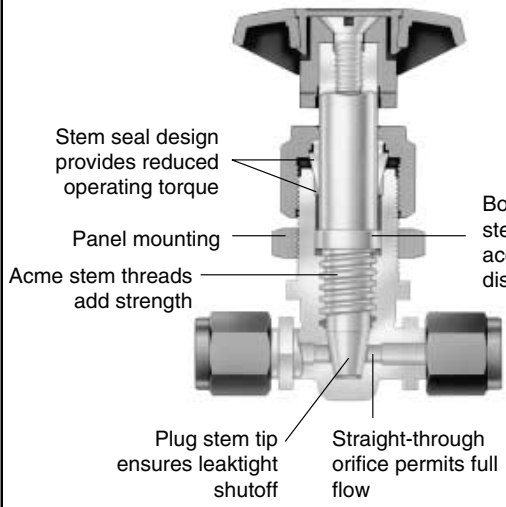
- Install a hookup system for transfer of sample from the wellhead to the chamber or area where samples will be processed (NFM 4 and 5). Clean such equipment of oils and other manufacturing and shipping residues (NFM 3) before use.

  — Ensure that the point of sample discharge from the hookup system on supply wells is ahead of chemical treatments or holding tanks. Obtain permission to modify the discharge point by installing a spigot or other plumbing appropriate to preserve the quality of the sample, if possible. Otherwise, do not use the well. The spigot or other plumbing also must be cleaned before use.

  — Install an anti-backsiphon device in line with the hookup system.

  — Install an optional needle valve with flow-regulating capabilities in line with the hookup system (fig. 2-6*A*).

A. Swagelok® PFA Needle Valve number PFA-4RPS8 (fits 1/2-inch tubing)



B. Materials of Construction

Component	Material Grade/ASTM Specification
1 Handle insert	PFA 440-HP/ D3307
2 Screw	
3 Handle	
4 Packing nut	
5 Upper packing	
6 *Lower packing*	
7 *Stem stop*	
8 Panel nut	
9 *Stem*	
10 *Body, ferrules*	
11 Nut	
Lubricant	PTFE based

Wetted components listed in *italics*.

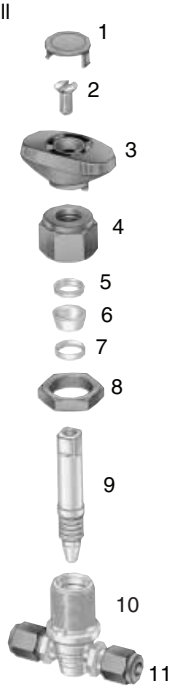


Figure 2-6. Swagelok® perfluoroalkoxy needle valve: (*A*) front view and (*B*) exploded view.

Monitoring-well pumps

Suction-lift and positive-displacement pumps are commonly used to collect water samples from monitor (monitoring) wells. Field personnel should consider the criteria and guidelines listed in tables 2-4 and 2-5 when selecting a pump for sampling from monitoring wells.

- Suction-lift pumps create a vacuum in the intake line that draws the sample up to land surface (fig. 2-7*A*).
  - The vacuum can result in the loss of dissolved gases and VOCs.
  - Intake tubing could diffuse atmospheric gases sufficiently to affect some target analytes unless thick-walled low-diffusion tubing is used.
  - Use of a peristaltic pump (1- to 2-L/min pumping rate) is limited to wells in which depth to water is less than about 25 ft (approximately 9 m). The operational lift may be as small as 20 ft.
  - Peristaltic pumps have the advantages of few moving parts, easily replaceable tubing and heads, and portability.
  - Provided that data quality is not compromised, properly operated peristaltic pumps can be used to obtain samples from shallow wells, especially those that produce small volumes of water.
- Submersible pumps (positive pressure or other types of positive-displacement pumps) designed specifically for collection of water samples from monitoring wells generally are preferred because they do not create a vacuum (fig. 2-7*B–F*).

- In general, do not use submersible pumps for well development. This can ruin the pump, shorten its functional life, or damage smooth internal surfaces, causing leaching of target analytes.
  - Install an anti-backsiphon device in-line to prevent backflow from contaminating the ground water.
  - Select suitable materials for sample line, sample-line connectors (see “Pump Tubing,” section 2.2.4), and sample-line reels (see “Support Equipment,” section 2.1.2.C, and "Lists of Equipment and Supplies," section 2.4) for use with portable submersible pumps.
- The suitability and application of commonly used submersible pumps depends on pump and well characteristics and on practical constraints (tables 2-4 and 2-5). It is necessary to determine that:
  - the rate of pumping is suitable for a given lift (table 2-5),
  - the maximum lift of the pump at the water surface is greater than the lift to land surface,
  - the power source and pump characteristics are sufficient to allow the pump to run continuously throughout purging and sample collection,
  - the height of the water column must be at least 5 ft above the top of the submersible pump (to avoid setting the pump intake too close to the bottom of the well), and
  - the pumping rate will not cause excessive drawdown, resulting in intersection of the water level with the well screen or open interval or causing the well to go dry.

- The pump used to purge and sample the well generally is not appropriate for well development or redevelopment (Lapham and others, 1997). Using a pump designed for sample collection as a well-development tool can shorten the pump life or damage smooth internal surfaces, causing leaching of target analytes. If the well should be redeveloped in preparation for collecting a representative sample, two options that are available include use of an inertial lift pump or use of an air-suction lift pump.

Portability and repairability are important logistical considerations when selecting a pump. All the pumps shown in figure 2-7 are made for transport to and from the field, but fuel or electrical power requirements make some more awkward to transport and operate at remote sites than others (not shown is the inertial-lift pump, which has no fuel or electrical power requirement when operated manually). Ruptured bladders for bladder pumps can be replaced easily in the field. Fluorocarbon polymer impellers used in gear pumps are easily abraded and can be ruined by particulate-laden water. Such impellers can be replaced in the field, but usually with some difficulty. Submersible centrifugal pumps and piston pumps generally are not easily repaired in the field and can be awkward to transport, but include features such as variable-speed capability that make them favored for many applications. When selecting a pump for sampling, consider purchasing an additional pump head (the submerged motor component) since most repairs involve the pump head. The pump heads for some pump types or models (such as the Fultz pump) are constructed for quick connect and disconnect, to ease pump head replacement under field conditions.

Table 2-5. Examples of pump capability as a function of well and pump characteristics in a 2-inch-diameter well

[Table modified from Koterba and others (1995), p. 18-19. ft, foot; gal, gallon; TDH, total dynamic head; gal/min, gallon per minute; ~, approximately; ---, not available]

Well characteristics			Pump characteristics			
			Example: Fultz SP-300 (lift capacity is exceeded at ~150 ft)		Example: Grundfos RediFlo2® (lift capacity is exceeded at ~260 ft)	
Water-column height (ft)	Lift or TDH[1] (ft)	Three-well-volume purge protocol[2] (gal)	Pumping rate at lift or TDH shown (gal/min)	Maximum volume after 2 hours pumping[3] (gal)	Pumping rate at lift or TDH shown (gal/min)	Maximum volume after 2 hours pumping (gal)
20	25	10	1.0	120	7.0	840
40	160	20	---	---	~4.8	538

[1]In these examples, the lift is equivalent to TDH and is estimated as the depth to water in the well (see Koterba and others, 1995, for explanation).
[2]Standard procedure is to purge a minimum of three well volumes while monitoring field measurements (NFM 4, NFM 6): purge volume = V=0.0408HD^2, where H is water-column height (in feet) and D is the well diameter (in inches).
[3]Maximum pumped volume is calculated from the pumping rate for a given pump system (from manufacturer's specifications) at the lift (or TDH) multiplied by an assumed total purging time of 2 hours (see Koterba and others, 1995).

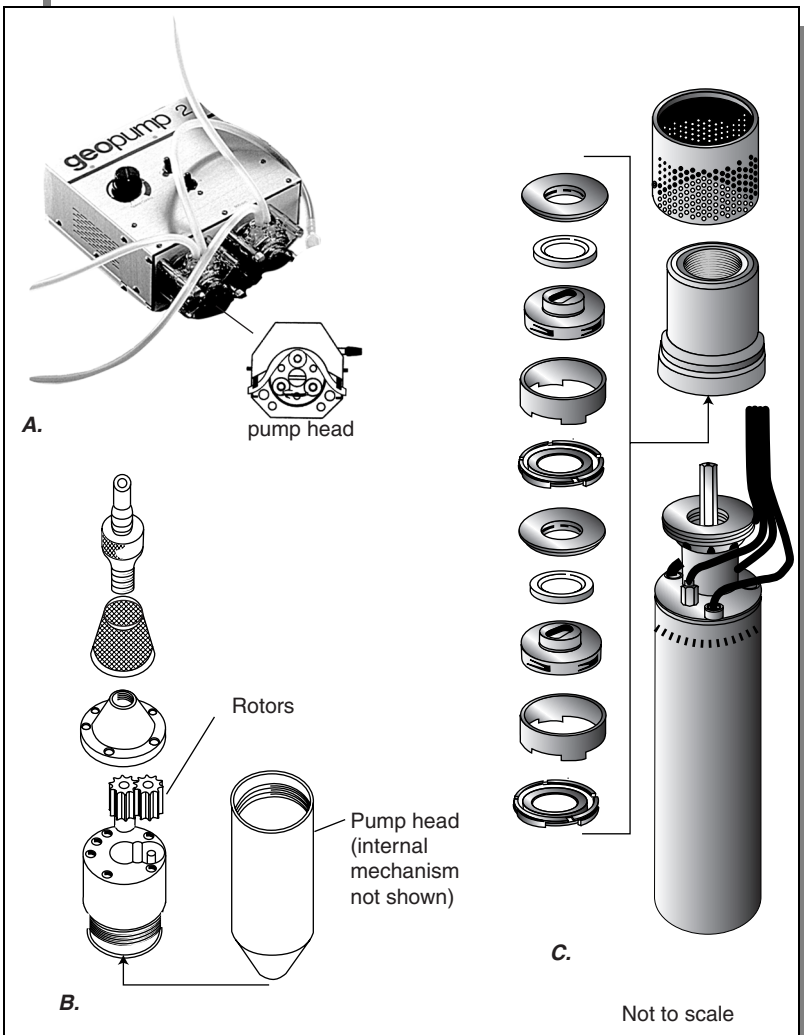


Figure 2-7. Pumps typically used for withdrawal of water samples from monitoring wells: (*A*) peristaltic suction-lift pump and (*B-F*) examples of submersible positive-displacement pumps. (*A*) peristaltic pump showing detail of pump head, (*B*) electrical gear or rotor pump, (*C*) electrical centrifugal impeller pump showing detail of impeller assembly. (Illustrations published with permission: *A*, GeoTech Environmental Equipment, Inc., with pump head from Cole-Parmer Instrument Company; *B*, Fultz Pumps, Inc.; *C*, Grundfos Pumps Corporation.)

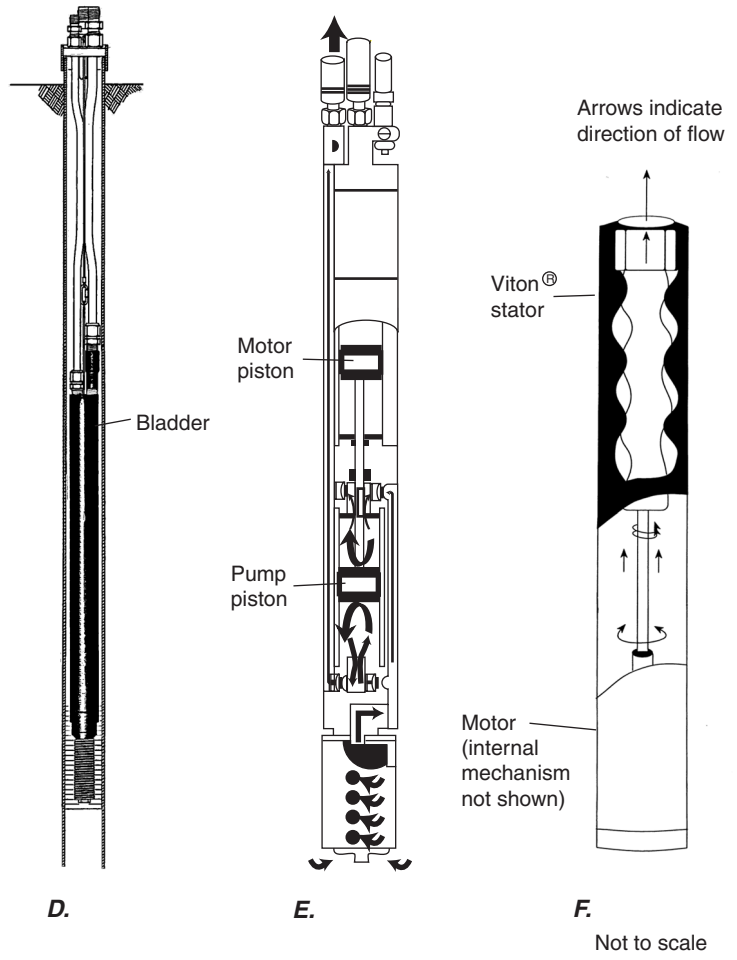


Figure 2-7. Pumps typically used for withdrawal of water samples from monitoring wells: (*A*) peristaltic suction-lift pump, and (*B-F*) examples of submersible positive-displacement pumps—*Continued*. (*D*) bladder pump, (*E*) reciprocating piston pump, and (*F*) progressive cavity pump. (Illustrations published with permission: *D* and *F*, GeoTech Environmental Equipment, Inc.; *E*, Bennett Sample Pumps, Inc.)

Well-development pumps

Wells need to be developed after construction to remove sediment and other debris at the bottom of the well and to improve hydraulic connection to the aquifer. Wells might need to be redeveloped after long periods of inactivity before water-quality samples are collected. Sounding of the well (confirming the well depth) may indicate that the well should be redeveloped in preparation for collecting a representative sample. The pump used to purge and sample the well, in general, is not appropriate for well development or redevelopment (Lapham and others, 1997).

- Use of inertial pumps fitted with a surge block (for example, the Waterra Inertial Pump, Model 404), is an effective and easily operated method for well development or redevelopment. The Waterra Pump consists of a riser tube (5/8-in. or 1.58-cm outer diameter (OD) polyethylene or similar tubing) with a one-way valve at the bottom of the tubing and a surface hand- or mechanical-pumping mechanism. The valve allows water to enter the tubing as it is pushed downwards, and retains the column of water when the riser tube is pulled upward again. Adding a surge block to the riser tube and valve creates a strong churning effect that helps to remove sediment that collected at the bottom of the well. Such a pump works well in silty/sandy environments, and can be successfully operated in wells with depths ranging up to 100 ft (~30.6 m) when using a hand pump, 200 ft (~61 m) when using a pump powered by an electric motor, and 250 ft (~76 m) when using a pump powered by a gasoline motor.

- Another inexpensive option to consider in well development is to use inexpensive disposable plastic (clear or white) tubing with a suction-lift pump. This method, however, is limited to shallow wells with water table depths less than 25 ft (~7.6 m) from the land surface. To aid in removing sediments from the bottom of the well, add a surge block and one-way valve to the bottom of the tubing as described above. The tubing can be physically raised and lowered, producing a purging effect. To prevent cross-contamination of wells, new tubing, surge block, and valve should be used for each well that is developed or redeveloped.

- Wells can also be developed by the air-lift or gas-lift method. This method is not recommended for shallow wells, but may be the only method available for very deep wells, especially for wells that approach 2,000 ft (~610 m) in depth. In this method, compressed air is forced down the well and replaces the water and debris in the casing. The displaced water and debris in the well casing is then forced up and out of the well. **However, care must be taken to ensure that air is not forced from the well screen into the surrounding aquifer system. Air introduced into the aquifer can change its geochemistry, either temporarily or permanently.**

2.1.2.B BAILERS, THIEF SAMPLERS, AND PASSIVE DIFFUSION BAG SAMPLERS

Use of a bailer or other thief sampler disturbs the water column, especially when it is raised and lowered repeatedly, and is not recommended for this reason. The disturbance can result in stirring up or mobilizing particulate matter, including colloidals or mineral precipitates that are artifacts of well construction and are not part of the ambient ground-water flow. This, in turn, can result in analysis of substantially greater than ambient concentrations of trace elements and hydrophobic organic compound(s). This is not a concern with passive diffusion bags.

Bailers and thief samplers

Bailers can have some necessary and useful applications, even though they are not generally recommended for ground-water sampling. Bailers are the only option available for sampling some ground-water systems, especially at great depth. Use of a bailer is preferred at sites where concentrations of contaminants are extremely large, because bailers are easier to clean (some are disposable and therefore do not require cleaning) and less expensive to replace than pumps. The following recommendations apply in situations where bailers are the only reasonable choice for sampling wells.

- Select bailers with double check valves (fig. 2-3*C*), to ensure that a point sample has been collected and to help prevent sample aeration. The material of choice normally is fluorocarbon polymer (Teflon®) because it can be used when sampling for both organic and inorganic analytes, and can be readily cleaned.
- Consider using disposable fluorocarbon polymer bailers at sites where concentrations of contaminants are large. Discard disposable equipment after one use.
- Use a bottom-emptying device through which the rate of sample flow can be controlled. Place the bailer into a holding stand while emptying sample from the bailer through the bottom-emptying tube.
- Use either fluorocarbon polymer-coated or colorless (white) polypropylene line for lowering the sample; keep the line on a reel. Polypropylene is easy to clean and inexpensive, and can be discarded after one use.

Specialized sealed downhole samplers, grouped loosely under the thief-sampler category (fig. 2-3), are designed to capture and preserve in situ ground-water conditions by precluding sample aeration and pressure changes from sample degassing (escape of VOCs) or outgassing (escape of inorganic gases). Such sampling equipment includes syringe samplers (Gillham, 1982), true thief samplers (Ficken, 1988), samplers using hermetic isolation methods (Gibs and others, 1993; Torstensson and Petsonk, 1988), chlorofluorocarbon (CFC) samplers (Busenberg and Plummer, 1992), and a combined well-bore flow and depth-dependent water sampler (Izbicki and others, 1999).

Passive diffusion bag samplers

Water-filled passive diffusion bag (PDB) samplers are suitable for obtaining samples to be analyzed for selected volatile organic compounds (VOCs).[11] A typical PDB sampler consists of a low-density polyethylene (LDPE) lay-flat tube closed at both ends and containing deionized water. The sampler is positioned at the target horizon of the well by attachment to a weighted line or fixed pipe. Sampler construction and application are described in Vroblesky (2001).

2.1.2.C SUPPORT EQUIPMENT

The support equipment used during ground-water sampling depends on the type and size of the pump or sampler used, field conditions, and depth to water or to sampling interval in the well. A reel should be used for efficient and clean deployment of the sample line. Commonly used support equipment is listed in section 2.4. A detailed description of the various types of support equipment is beyond the scope of this manual.

[11]PDBs are not suitable when collecting samples to be analyzed for inorganic ions, methyl-*tert*-butyl, acetone, or phthalates, and have limited applicability for other non-VOCs.

SAMPLE PROCESSING 2.2

By **S.L. Lane, Sara Flanagan, M.W. Sandstrom, K.K. Fitzgerald, F.D. Wilde, and D.B. Radtke**

Water samples must be processed as quickly as possible after collection. The equipment most commonly used for sample processing includes sample splitters, disposable capsule filters, filtration assemblies, solid-phase extraction systems, and chambers in which samples are processed and treated with chemical preservatives. Having several sets of cleaned processing equipment on hand is recommended. The equipment and supplies commonly used to process surface-water and ground-water samples are listed in section 2.4.

SAMPLE SPLITTERS 2.2.1

The collection of surface water generally results in a single composite sample. A ground-water sample generally is not collected as a composite; instead, the sample is pumped directly into separate bottles for designated analyses. There are exceptions. For example, ground water withdrawn using a bailer or thief sampler can be collected as a composite sample, provided that sample integrity for the analytes of interest can be maintained.

A composite sample often is subdivided (split) into subsamples for analysis. Each whole-water subsample should contain suspended and dissolved concentrations of target analytes that are virtually equal to those in every other subsample. Use of polypropylene/polyethylene (plastic) churn splitters, the fluorocarbon polymer churn splitter, and the cone splitter are discussed in sections 2.2.1.A and 2.2.1.B, respectively. Testing and comparative data between the splitters are described in Capel and Larson (1996), Horowitz and others (2001), and in Office of Water Quality Technical Memorandum 97.06. Advantages and limitations among the fluoropolymer churn splitter, plastic churn splitter, and cone splitter are shown in table 2-6.

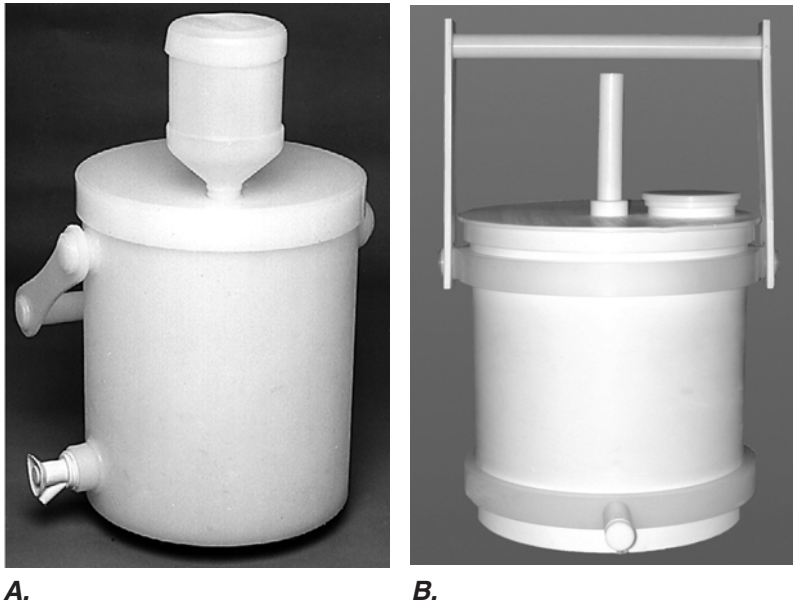
Table 2-6. Advantages and limitations of sample splitters

[L, liter; mg/L, µm, micrometer; milligrams per liter; mL, milliliters; >, greater than; ≤, less than or equal to]

Splitter	Advantages	Limitations
Fluoropolymer churn splitter	Can be used to process samples for both inorganic and non-volatile organic analyses. Simple to operate. Easy to clean. No modification of the splitter design is necessary.	Although it can be used to split samples with particle sizes ≤ 250 µm and suspended-sediment concentrations ≤ 1,000 mg/L, splitting accuracy becomes unacceptable for particle sizes >250 µm and suspended-sediment concentrations >1,000 mg/L. Sample volumes less than 4 L or greater than 13 L cannot be split for whole-water subsamples from this 14-L churn. Samples for bacteria determinations are not to be taken from a churn splitter because the splitter cannot be autoclaved.
Plastic (non-fluorocarbon polymer) churn splitter	Simple to operate. Easy to clean.	Plastic (nonfluorocarbon polymer) churn splitters must not be used to composite samples for determination of organic compounds. Although it can be used to split samples with particle sizes ≤ 250 µm and suspended-sediment concentrations ≤ 1,000 mg/L, splitting accuracy becomes unacceptable for particle sizes >250 µm and suspended-sediment concentrations >1,000 mg/L. When using the 14-L churn, sample volumes that total less than 4 L or greater than 13 L cannot be split for whole-water subsamples. Requires a modified spigot and construction of a funnel assembly. Samples for bacteria determinations are not to be taken from a churn splitter because the splitter cannot be autoclaved.
Fluorocarbon-polymer cone splitter	Used to process samples with suspended-sediment concentrations from 0 to 10,000 mg/L. Samples containing sediment particles ranging in size from very fine clay and silt (1 to 10 µm) to sand-size particles (250 µm) can be split. Samples as small as 250 mL can be split into 10 equal subsamples. Samples greater than 13 L can be processed. Can be used to process samples for both inorganic and nonvolatile organic analyses.	Accuracy of the volume equivalents must be verified before using a new or modified cone splitter. Splitter is awkward to operate and clean in the field. Sample is vulnerable to contamination from atmospheric sources or from improper operation. Splitting accuracy for sediment particles >250 µm or sediment concentrations >10,000 mg/L must be quantified by the user. Samples for bacteria determinations are not to be processed through the cone splitter because the splitter cannot be adequately sterilized. The cone splitter must be level for proper operation.

CHURN SPLITTER 2.2.1.A

The churn splitter is available in either polypropylene and polyethylene plastic (fig. 2-8*A*) or in fluoropolymer plastic (fig. 2-8*B*). Both churn types come in the 14-L size, but the plastic churn also is available in an 8-L size. Splitter advantages and limitations are described in table 2-6. The 8- or 14-L plastic churn splitter is recommended to composite and split surface-water samples for inorganic analyses. The 14-L fluoropolymer churn splitter is recommended to composite and split samples for either inorganic or nonvolatile organic analyses.



A. ***B.***

Figure 2-8. Churn sample splitters: (*A*) Plastic churn splitter (from Capel and Larson, 1996) and (*B*) Fluoropolymer churn splitter (from Federal Interagency Sedimentation Project Catalog: accessed December 9, 2002, at http://fisp.wes.army.mil/Catalog%20Page%20US%20SS-1.htm).

- **Trace-element samples:** Do not collect or extract samples for trace-element analyses from a metal container. Use either the plastic or fluoropolymer churn splitter.

- **Organic compound samples:** Use only the fluoropolymer churn to collect or extract samples for organic-compound analysis. Stainless steel and glass containers also can be used to composite samples for dissolved organic compound analysis. Do not use a plastic churn or container.

- **Churn covering:** To keep the entire churn-splitter assembly clean during sampling and prevent potential contamination, the churn splitter is placed inside two pliable, clear plastic bags (double bagged). These bags should be large enough to completely enclose the churn splitter, including funnel and churn handle, with enough excess material so that the bag openings can be gathered, folded over, and kept closed.

- **Churn carrier:** The carrier is a white plastic container, with lid, large enough to hold the double-bagged churn splitter assembly.

  — The lid of the carrier serves both as a seal for the carrier and as a windbreak when the collected subsample is poured into the churn funnel.

  — The purpose of the carrier is to minimize contamination during transport. In exposed areas, such as bridges and roadways, the carrier can protect against atmospheric sources of contamination, particularly material from motor vehicles.

- **Volume of sample needed:**

  — Subsamples totaling 10 L can be withdrawn from the 14-L churn for whole-water analysis, whereas subsamples totaling 5 L can be withdrawn from the 8-L churn for whole-water analysis.

— Do not use the 4 L remaining in the 14-L churn and the 3 L remaining in the 8-L churn for total, total recoverable, or suspended-material subsamples. However, the sample mixture remaining in either churn can be used for filtered subsamples for the determination of dissolved constituents.

The spigot and lid of the plastic churn splitter must be modified, as described below:

- The original spigot contains a metal spring that introduces a potential source of metal contamination and should be replaced (Horowitz and others, 1994). Purchase the modified spigot from OWQRL, or replace the metal spring with a piece of tubing as follows:

  (1) Cut a 7/8-in. length of 6424-03 Masterflex® tubing. This length is very important to ensure proper operating of the modified spigot. Cut the tubing with a utility knife or something that will cut a straight edge; if edge is jagged, water may leak past the button and possibly contaminate samples.

  (2) Pop button off spigot with a small-blade screwdriver (or push the button in and pull the shaft away from the back).

  (3) Slide the tubing over the sleeve on the inside of the button.

  (4) Slide the tubing that is now attached to the button over the stopper shaft, and compress until the button locks into place.

- Funnel assembly for plastic churn lid: To meet requirements for trace-element sampling, a funnel assembly is inserted into a 1-in.-(2.54 cm-)diameter hole drilled through the lid of the churn splitter (fig. 2-8).

  — The funnel is used when pouring whole-water samples into the churn splitter so that the churn lid can be left on, thus minimizing exposure of the composite sample to atmospheric contamination.

  — To make the funnel assembly, cut the top section (at the shoulder line) from a 1-L polypropylene sample bottle and insert it into the hole drilled in the churn lid. Cut the bottom two-thirds from a 1-L Nalgene® or other larger diameter sampler bottle and use as a funnel cap.

2.2.1.B CONE SPLITTER

The cone splitter is a pour-through device constructed entirely of fluorocarbon polymers (fig. 2-9), and thus can be used to process samples for inorganic and nonvolatile-organic analytes. **The cone splitter may be used to process samples with particle sizes ≤250 micrometers (μm) and suspended-sediment concentrations ≤10,000 milligrams per liter (mg/L) (table 2-6).** The primary function of the cone splitter is to divide the sample simultaneously into as many as 10 equal-volume samples. Some cone splitters have a 2-mm mesh screen in the reservoir funnel to retain large debris, such as leaves and twigs, that could clog or interfere with the splitting process. Below the funnel is a short standpipe that directs sample water in a steady stream, into a splitting chamber that contains a notched, cone-shaped splitting head with 10 equally spaced exit ports around its base. There should be no ridges, benches, or surfaces inside the splitting chamber that could retain material or interfere with the splitting process. The cone splitter is supported either by tripod legs or with an adjustable clamp and stand.

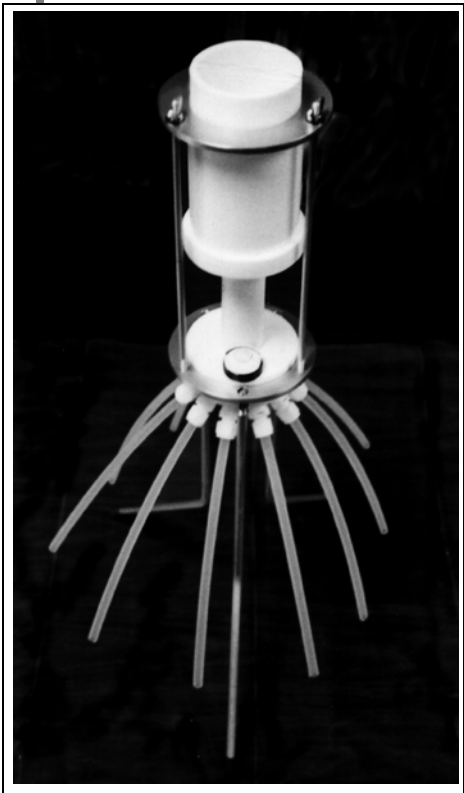


Figure 2-9. Cone splitter (from Capel and Larson, 1996).

The cone splitter is built to very close tolerances in order to achieve accurate and reliable operation. Bias to data can result from splitter imperfections or improper operation; therefore, calibration and proper use is necessary when processing samples.

Before using a new or modified cone splitter, test the splitter to be used as follows (Office of Water Quality Technical Memorandum 80.17):

1. Inspect the cone splitter housing and outlet ports. They should be smooth and symmetrical without any visible burrs or chips. **The cone splitter must be clean.**
2. Place the cone splitter on a stable platform or bench. **The splitter must be level for proper operation.** Use a bull's-eye level to check leveling and recheck during use; the level will change as personnel move inside the field vehicle.
3. Connect 10 discharge tubes to the outlet ports. The tubes must be the same length, and as short as possible. Label the outlets from 1 to 10.
   - All tubes must be pushed in as far as possible to the machined surface in the Swagelok® fitting in the cone-splitter ports. The ends should be flush with the bottom of the inside of the port.
   - Tubes need only extend into the receiving containers sufficiently to prevent spillage.
   - Tubes must not extend in so far that the ends become submerged.
4. Wet the cone splitter by pouring several liters of deionized water through it.
   - Lightly tap the system to dislodge adhering water drops, then discard the water.
   - Place an empty sample bottle under each outlet tube.
5. Accurately measure 3 L of deionized water into a 1-gallon narrow-mouth plastic bottle.
6. Rapidly invert the 1-gallon bottle over the reservoir, letting deionized water flow out as fast as possible. For proper operation, the standpipe must be discharging at its full flowing capacity.
7. After all deionized water has passed through the splitter, tap the assembly several times to dislodge adhering water drops.

Check for spills and leaks. If any are observed, stop the test, correct the problem, and repeat steps 1-7.

8. Measure the volumes of the 10 subsamples carefully, within an accuracy of ±1.0 mL. Record the volumes for each outlet on a form similar to table 2-7.

9. Repeat the test a minimum of three times. Use the same initial volume for each test.

Calculate and document the results of the cone-splitter accuracy test as follows:

1. Referring to the example in table 2-7, calculate the mean volume of each subsample ($\bar{x}$) and standard deviation (S_x):

$$\bar{x} = \frac{\Sigma x_i}{n} \text{ and}$$

$$S_x = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}},$$

where

x_i is the measured volume for each subsample and

n is the number of subsamples (outlet ports).

2. Calculate the standard deviation in percent (E_x):

$$E_x = \frac{S_x}{\bar{x}} \text{ x } 100.$$

3. Calculate the error for each subsample (E_i):

$$E_i = \frac{x_i - \bar{x}}{\bar{x}} \text{ x } 100.$$

4. Compute the mean standard error ($\overline{E_{\bar{x}}}$) for the three tests and document the maximum and minimum errors (E_i) for all tests in field notes.

5. If data-quality requirements warrant, note the error patterns for individual outlets to determine which outlets produce consistent bias and label them with their mean percent bias error. Depending on the objectives of the sampling effort, this pattern of error may not be of concern.

A cone splitter is considered acceptable for sample processing if the mean standard error ($\overline{E_{\bar{x}}}$) for the three tests is 3 percent or less, and no individual error (E_i) exceeds ±5 percent.

Table 2-7. Example of six cone-splitter accuracy tests using deionized water

[Modified from Office of Water Quality Technical Memorandum 80.17]

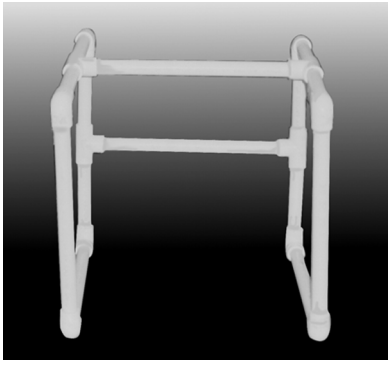
Test number Initial sample weight (grams)	1 2,499.4		2 2,499.5		3 2,499.5		4 2,499.5		5 2,499.5		6 2,499.4		Averages	
Outlet number	Outlet volume (x_i)	Percent (E_i)	Outlet volume (x_i)	Percent (E_i)	Outlet volume (x_i)	Percent (E_i)	Outlet volume (x_i)	Percent (E_i)	Outlet volume (x_i)	Percent (E_i)	Outlet volume (x_i)	Percent (E_i)	Mean volume (x_i)	Percent (E_i)
1	248.4	-0.5	249.5	-0.1	247.4	-0.9	248.1	-0.7	247.8	-0.8	249.2	-0.2	248.4	-0.5
2	246.8	-1.2	246.8	-1.2	245.6	-1.6	248.4	-.6	246.3	-1.4	246.7	-1.2	246.8	-1.2
3	249.4	-.1	251.0	.5	250.6	.4	251.1	.5	249.8	0	248.7	-.4	250.1	.1
4	250.7	.4	252.6	1.1	252.5	1.1	251.3	.6	251.8	.8	250.5	.3	251.6	.7
5	248.1	-.6	248.3	-.6	249.8	0	249.3	-.2	250.2	.2	248.1	-.6	249.0	-.3
6	252.2	1.0	250.3	.2	252.7	1.2	252.0	.9	252.7	1.2	250.6	.4	251.8	.8
7	245.7	-1.6	246.2	-1.4	246.0	-1.5	246.3	-1.4	246.6	-1.3	245.9	-1.5	246.1	-1.5
8	252.7	1.2	254.2	1.8	252.9	1.3	253.3	1.4	253.1	1.3	254.6	2.0	253.5	1.5
9	248.7	-.4	247.3	-1.0	247.5	-.9	247.1	-1.1	248.2	-.6	249.5	-.1	248.0	-.7
10	253.9	1.7	252.1	.9	251.8	.8	250.6	.3	251.7	.8	253.0	1.3	252.0	1.0
Final sample weight	2,496.6		2,498.3		2,496.8		2,497.5		2,498.2		2,496.8		2,497.4	
Sample loss	2.8		1.2		2.7		2.0		1.3		2.6			
Mean weight ($\bar{x}$)	249.7		249.8		249.7		249.8		249.8		249.7		249.8	
Standard deviation (S_x)	2.7		2.7		2.8		2.3		2.5		2.7			
Error percent (E_x)	1.1		1.1		1.1		.9		1.0		1.1			

2.2.2 PROCESSING AND PRESERVATION CHAMBERS

Working within sample-processing and -preservation chambers reduces the possibility of random atmospheric contamination during sample bottling, filtering, and preserving with chemical reagents. **Use of these chambers is required for samples for trace-element analyses** (Horowitz and others, 1994), and is recommended for most other analytes, such as major and minor inorganic ions and organic compounds. The processing chamber serves as a collection chamber into which sample water is pumped and either filtered or directly collected in sample bottles. There is no standard design for either fixed or portable chambers; however, to prevent contamination of inorganic samples with metals, the materials used in their construction should be either nonmetallic or completely covered by or embedded in nonmetallic material. Although bench testing of plastic chamber components, including the clear plastic cover, revealed no emission of volatile organic substances, this can be further substantiated by analyzing an ambient blank for VOC analysis that is collected within the chamber(s).

Fixed sampling chambers typically are enclosures that are permanently installed in a field vehicle for the sole purpose of sample collection/processing and preservation and must not be used as a storage area. Fixed and portable chambers need to be cleaned between uses. The portable chamber illustrated is inexpensive and easily constructed with ≤1/2-in.-diameter white polyvinyl chloride (PVC) pipe or tubes, which are used to support a transparent plastic-bag covering (fig. 2-10; Appendix). The transparent bag forms a protective tent within which to work while collecting, processing, or preserving samples. Another option is to purchase or construct a fixed or portable glove box. The glove box should have no metal parts to which a sample for metals analysis might be exposed. Use glove boxes that can be filled with an inert gas such as nitrogen or argon when samples need to be strictly isolated from contact with atmospheric gases.

- The processing chamber either sits over a fixed or portable sink or contains a basin to which a waste-disposal funnel or hose has been attached, allowing excess water to drain readily to waste. The sample tubing is inserted through a hole in the top of the chamber, and can be connected to a filtration device inside the chamber.
- The preservation chamber also consists of the frame and bag cover, but without provision for sample tubing. The bottled sample is passed from the processing chamber into the preservation chamber, in which chemical treatment is added to the sample. A suitable container placed inside the preservation chamber is needed in which spent preservative ampoules are contained (see NFM 5).



A.

B.

Figure 2-10. Example of (*A*) a polyvinyl chloride frame of a processing or preservation chamber, and (*B*) a sample being processed within the chamber.
(*A*, Photograph by B.A. Bernard; *B*, photograph by Jacob Gibs.)

Use of separate chambers for sample collection/processing and sample preservation generally is the most efficient approach. Space permitting, multiple preservation chambers can be used, each dedicated to a specific chemical treatment. Otherwise, use of a single preservation chamber dictates a change in the bag covering for each change in chemical treatment.

If there is insufficient space in which to set up both the processing and preservation chambers, the processing-chamber frame can also function as a preservation-chamber frame provided that the cover is changed before sample preservation, is clipped to the outside of the chamber frame rather than supported over the frame, and is changed every time the preservation procedure requires a change in gloves (NFM 5).

2.2.3 FILTRATION SYSTEMS

Filtration separates particulate substances (solid-phase and biological materials) from the solute or aqueous phase of a water sample. Water samples are filtered for analysis of inorganic constituents, organic compounds, and biological materials to help determine the environmental fate and quantify the transport of these target analytes. Additional information relevant to selection of filtration systems can be found in Kennedy and others (1976), Ward and Harr (1990), Horowitz and others (1994), Koterba and others (1995), and in NFM 5.

For surface-water applications, the most common filtration system consists of a reversible, variable-speed battery-operated peristaltic pump or a metering pump that forces the whole-water sample through tubing into a filtration assembly. For ground water, the sample ordinarily is pumped through a sample line directly into a disposable capsule filter or other filtration assembly. If the sample is collected by bailer, the sample is bottom-emptied through fluorocarbon-polymer tubing and either is composited in a churn or other vessel first or is transferred directly to the filtration assembly by means of a peristaltic pump. Some bailers can be directly connected to a filtration device and hand-pump system.

TECHNICAL NOTE: Separation of solid from aqueous phases can be achieved by methods other than filtration, and data requirements may dictate the need for an alternative method such as centrifugation, ultracentrifugation, dialysis or lipid-membrane separation, or reverse-flow osmosis and tangential-flow filtration.

The filtration assembly and filter material to be used depends on the class of target analyte(s) (table 2-8), as discussed below.

- Inorganic Samples—The filter membrane (filter) for filtering samples for analysis of inorganic constituents typically comprises material such as polyethersulfone, cellulose nitrate, or polycarbonate polymer. Polyethersulfone is the membrane material used in the disposable capsule filter that currently is in routine use by the USGS water-quality program.

- Organic Samples—Samples for organic-compound analysis are filtered through discs composed of glass fiber (microfiber) material. Organonitrogen-herbicide samples also can be filtered through disposable nylon membranes (Sandstrom, 1995). The membrane material described above for inorganic samples should not be used for organic samples.

- Organic-Carbon Samples—Samples to be analyzed for dissolved organic carbon either can be filtered through glass-microfiber filter (GF/F) discs or through the disposable capsule (polyethersulfone) filter; the choice of filter depends on study objectives and protocols. Any sample to be analyzed for total particulate carbon (TPC) must be filtered through a GF/F disc.

A filtered sample is defined operationally by the nominal pore size of the filter (membrane or disc).

- The filter pore size selected depends on study objectives, data requirements, and industry standards.

- The standard pore sizes of filters used by the USGS are:
  - 0.7 µm for pesticides, most other organic compounds, and some bacteria (NFM 7).
  - 0.45 µm for inorganic constituents (including major ions, radiochemicals, and trace elements), some bacteria (NFM 7), and dissolved organic carbon.
  - 0.2 µm or less for trace-element samples to be analyzed for some geochemical applications and interpretive studies and for nutrient samples for which exclusion of bacteria at the 0.2-µm threshold is desirable.
- See NFM 7 for a description of filters for biological analysis.

INORGANIC CONSTITUENTS 2.2.3.A

The standard device for filtering samples for analysis of inorganic constituents is the disposable capsule filter, which has replaced routine use of the plate-filter assembly for most applications (table 2-8). **Construction materials of filtering systems must not be a source of sample contamination with respect to the substances for which the sample will be analyzed.**

Disposable capsule filter

The protocol for filtering a sample for analysis of inorganic constituents requires using a disposable capsule filter[12] such as the Pall-Gelman AquaPrep 600 ground-water sampling capsule with pleated polyethersulfone (Supor®) filter membrane material (hereafter referred to as "capsule filter") (fig. 2-11).

[12]The disposable capsule filter with polyethersulfone membrane also may be used for processing samples for analysis of dissolved organic carbon (section 2.2.3.B, NFM 5.2.2.C).

Horowitz and others (1994) concluded that the disposable capsule filter would not be a probable source of sample contamination for inorganic constituents, including trace elements, major ions, nutrients, stable isotopes, and radiochemicals (**table 2-8**) if prerinsed with a minimum of 1,000 mL (l L) of inorganic-grade blank water.

- Capsule filters are sealed units; hence, the likelihood of contamination is reduced because the filter membrane is not handled.
- The surface area of the capsule-filter membrane is roughly three times that of the 142-mm plate filter and is less subject to clogging.
- Cleaning the filtration device is not necessary because each capsule filter is discarded after one use.
- OWQRL checks the quality of each lot of capsule filters and provides a certificate of analysis with each filter.

Figure 2-11. Disposable capsule filter with 0.45-µm polyether- sulfone pleated filter membrane (published with permission of Gelman Sciences).

Do not reuse filters—discard the disposable polyethersulfone capsule filter after each sample.

Table 2-8. Capsule filter requirements and recommendations for processing of surface-water and ground-water samples

[Table modified from Horowitz and others (1994) and includes only those constituents evaluated in the experiments described in the reference and in Office of Water Quality Technical Memorandum 2000.08]

Disposable capsule filter required[1]		Disposable capsule filter recommended[2]
Aluminum	Lead	Anions (chloride, sulfate)
Antimony	Lithium	Calcium
Barium	Manganese	Magnesium
Beryllium	Molybdenum	Nutrients (nitrogen, phosphorus)
Boron	Nickel	Radiochemicals (excluding radon gas)
Cadmium	Silver	Silica
Chromium	Thallium	Sodium
Cobalt	Uranium	Strontium
Copper	Zinc	Dissolved organic carbon
Iron		

[1]The requirements for surface-water sampling described in Horowitz and others (1994) are generally applicable to ground-water studies.
[2]The plate-filter method is acceptable, contingent on use of equipment-cleaning protocols (NFM 3) and project data objectives.

Plate-filter assemblies

Before 1994, the most common filtration assembly used for USGS studies for filtering inorganic samples was the nonmetallic backflushing plate-filter assembly designed to hold a 142-mm filter. Because this method allows greater exposure of the sample to the air and because the assembly is time-consuming to field clean, this equipment generally is not recommended for routine filtering of inorganic samples (table 2-8).

- Types of plate-filter assemblies available for inorganic samples include:
  - Fluorocarbon polymer filtration assembly designed for 47-mm-diameter filters; can be used for in-line filtering of inorganic or organic samples by using an appropriate filter membrane.
  - Plastic vacuum filtration assembly for a 47-mm-diameter filter; used with either a hand vacuum pump or a peristaltic pump.
  - Plastic backflushing assembly, available for 142-mm- and 293-mm-diameter filters (no longer in common use for USGS studies) (fig. 2-12).

- A smooth-tipped plastic forceps is needed to transfer the filter to the plate of the filter assembly. Kennedy and others (1976) give detailed instructions for use of the plate-filter assembly.

Figure 2-12. Nonmetallic backflushing plate-filter assembly for 142-millimeter-diameter filter membrane. (Illustration reproduced with permission of Gelman Sciences.)

2.2.3.B ORGANIC COMPOUNDS

Filtering whole-water samples isolates suspended solid-phase substances from the aqueous phase, thus allowing separate determinations of organic compounds in each phase. Filtering also helps to preserve samples for organic determinations by removing microorganisms that could degrade compounds in the sample (Ogawa and others, 1981).

- Hydrophobic compounds are analytes that preferentially partition to particulate matter. Filtering concentrates particulate matter on the disc (filter), enhancing extraction efficiency and lowering analytical detection limits. This is especially useful for whole-water samples with small concentrations of suspended material and for which large volumes of sample (4 to 40 L) must be filtered to provide an analyzable mass of suspended materials.

- Hydrophilic compounds are analytes that are water soluble. Filtering is used to remove suspended material or other particulate matter from the water sample, to identify concentrations of dissolved analytes, and to remove any solid-phase substances containing constituents that could interfere with the analysis and that could be co-extracted with target analytes.

Equipment needed to filter samples for determination of trace organic compounds, such as pesticides, is described in detail in Sandstrom (1995) and includes a positive displacement pump, an aluminum plate-filter assembly (or other appropriate or designated filtration assembly), the filter, and metal forceps. All equipment and components used for filtering whole-water samples for trace organic determinations should be made of materials (a) that will not contaminate the sample or sorb analytes, and (b) that can withstand organic cleaning solvents without being damaged. Such materials include stainless steel or aluminum, fluorocarbon polymer, glass, and nonporous ceramics (hard-fused microcrystalline alumina). Use of plastics, rubber, oils, and other lubricants is to be avoided because it can result in sample contamination, analytical interference, and (or) sorptive losses.

Metering pump

The valveless piston metering pump consists of a pump head with a reciprocating piston driven by a 12-volt direct current (DC), variable-speed motor (fig. 2-13). It has a delivery rate of up to 500 mL per minute.

The pump head and all wetted parts are constructed of ceramic, fluorocarbon polymer, or stainless steel components, which are resistant to organic solvents. These pumps can tolerate some suspended materials in the sample being pumped, but large concentrations of suspended materials can cause excessive wear of pump parts and strain on the pump motor.

The ceramic piston and shaft of these pumps will break if motor amperage exceeds 4 amps. To avoid this, either a 4-amp DC circuit breaker connected in-line with the pump power line, or an alternating to direct current converter with 4-amp maximum output, should be used.

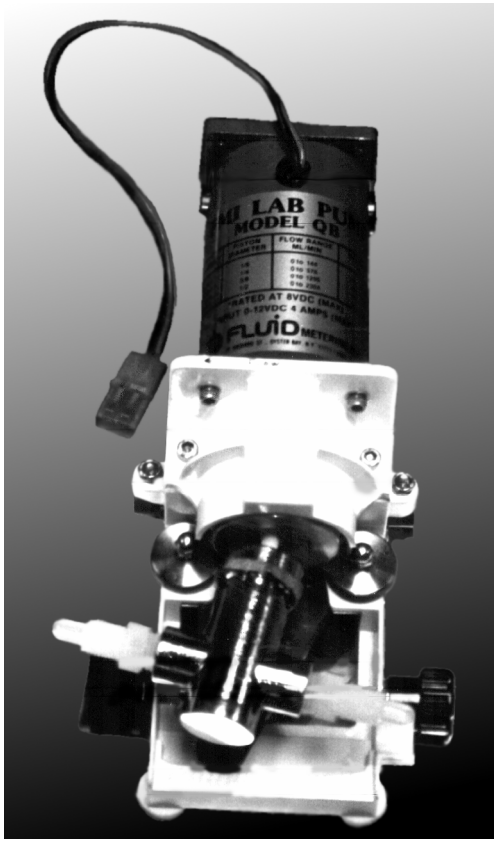
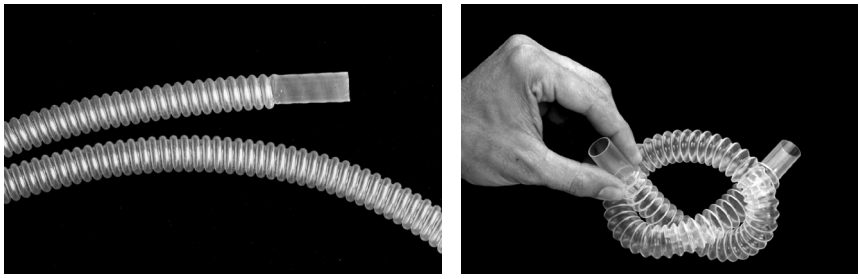


Figure 2-13. Valveless piston metering pump. (Photograph by B.A. Bernard, 1998).

The pump and filtration assembly are connected by 1/4-in.-diameter convoluted fluorinated ethylene polypropylene (FEP) tubing (fig. 2-14) with appropriate fittings. The convoluted tubing does not crimp when bent.



A. Convoluted (spiral) design

B. Corrugated (parallel) design

Figure 2-14. Flexible fluorinated ethylene polypropylene (FEP) tubing: (*A*) convoluted design and (*B*) corrugated design. (Published with permission of Cole-Parmer Instrument Company: *A*, Copyright 1992. *B*, Copyright 1987. Cole-Parmer does not warrant these illustrations to be current, accurate, or suitable for any purpose.)

Filtration assemblies

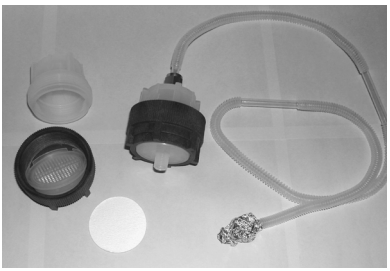
The filtration equipment described below includes various types of plate-filter assemblies. Their use depends on the analysis to be requested or the field method selected. Plate-filter assemblies are available for filters with disc diameters ranging from 13 to 293 mm. The size selected is determined by the sample volume to be filtered and by the concentration of suspended materials in the sample. When collecting samples for analysis of organo-nitrogen herbicides and dissolved organic carbon, filtration options include specific types of disposable capsule filters.

- **Trace organic compounds:** Typical plate-filter assemblies used for pesticides and other selected trace organic analytes include either the three-legged aluminum (or stainless steel) plate-filter assembly (fig. 2-15*A*) or the PFA in-line filter-holder assembly (fig. 2-15*B*). The aluminum plate-filter assembly consists of two machined aluminum or stainless steel plates (designed to contain a 142-mm-diameter filter) held together by locking bolts or a locking ring.

    — The plates have fluorocarbon polymer-coated silicone or Viton® O-rings set in grooves to seal the filtration assembly. A stainless steel screen on the lower plate supports the filter. A valve is built into the upper plate to exhaust trapped air. Connectors are built into the center of the top and bottom plates so that inlet and outlet fluorocarbon polymer tubing can be attached.

— Teflon® in-line filter-holder assembly: PFA filtration assembly with Tefzel® ETFE clamp nut holds a 47-mm-diameter GF/F (0.7-µm nominal pore size). (Similar assemblies are available currently from commercial manufacturers, such as Savillex, Cole-Parmer, and Berghof.)

A. Aluminum plate-filter assembly



B. PFA filter holder

Figure 2-15. (*A*) Aluminum plate-filter assembly for 142-millimeter-diameter filter disc and (*B*) PFA filter holder for 47-millimeter-diameter filter. (Cole-Parmer EW-06621-40 PFS filter holder shown. Photograph published with permission of GeoTech Environmental Equipment, Inc.)

- **Organonitrogen herbicides:** Samples for analysis of organonitrogen herbicides may be filtered using an in-line 25-mm disposable nylon filter unit (nylon filter), as explained in the indented items that follow. (Alternatively, either a plate-filter assembly or PFA in-line filter-holder assembly can be used, as described above under "Trace organic compounds"). Although filtration devices made of plastic components should not be used to process water-sediment samples for determination of organic compounds, the nylon filter has been approved and is an efficient option for a specific solid-phase extraction (SPE) method for samples for organonitrogen-herbicide analysis (Sandstrom and others, 1994).

  — The in-line disposable nylon filter consists of a 25-mm-diameter nylon membrane, nominal 0.45-µm pore diameter, enclosed in a nylon housing with Luer-Lok inlet and outlet fittings. **The nylon filter must be discarded after one use.**

  — For detailed information regarding tubing connectors and other equipment needed for the nylon filter, and on how to connect the nylon filter to the sampling system, refer to NFM 5 and Sandstrom and others (1994).

  — The 25-mm filter unit is appropriate for the SPE method because the required volume of filtered sample is only about 100 mL.

- **Dissolved and particulate carbon:** Dissolved organic carbon (DOC) samples are processed through either a Savillex florinated ethylenepropylene (FEP) pressure-filtration assembly, or a disposable Supor® capsule filter, depending on other carbon analyses required (NFM 5.2.2.C). Total particulate carbon (TPC) samples are processed through a Savillex pressure filtration assembly (fig. 2-16), loaded with a baked 25-mm, 0.7-micron pore size, glass-microfiber filter (GF/F) on a 25-mm stainless steel or polysulfone filter-support screen.

- Either a hand-pressure pump or a peristaltic pump fitted with clean tubing can be used to move the TPC and particulate inorganic carbon (PIC) sample through the Savillex filtration assembly. Pressure can also be exerted using organic-free nitrogen gas in a pressure tank with a regulator.
- A persitaltic pump or submersible ground-water pump can be used to move the DOC sample through the capsule filter.

A detailed description of the methods and equipment needs for carbon-analysis sampling can be found in NFM 5.2.2.C, "Procedures for processing samples for carbon analysis." See also the equipment lists provided below in section 2.4.

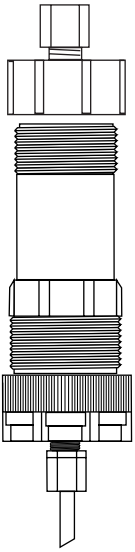


Figure 2-16. Fluorinated ethylene-propylene pressure-filtration (FEP) assembly for processing samples for analysis of total particulate carbon and dissolved organic carbon. (Published with permission from the Savillex Corporation.)

Filter material

Tortuous-path depth filters made of borosilicate glass fibers are used to filter most samples for organic determination because the material is basically inert, can withstand organic solvents, and can withstand laboratory preparation (being baked at 450°C). **Membrane filters (cellulose, polycarbonate, or polyethersulfone polymers) commonly used to process samples for determination of nutrients and other inorganic constituents are not suitable for filtering samples for most organic determinations,** mainly because they are not resistant to organic solvents used to preclean the sampling and processing equipment. DOC samples, however, may be processed through the polyethersulfone capsule filter (disposable Supor® filter) (NFM 5) if study objectives permit.

- Use glass microfiber filters (GF/F) with 0.7-µm nominal pore size that has been baked at 450°C for at least 2 hours. (USGS personnel can obtain baked 142-mm- and 25-mm-diameter GF/F from OWQRL.) The 25-mm GF/F is used in the Savillex filtration assembly.
- Use only filters without binders. (Acrylic resin binders might leach from the filter and contaminate samples, or might not be completely combusted when baked at 450°C.) Binder-free glass-fiber filters are available in various diameters ranging from 13 to 293 mm.
- For the filter material used in processing organonitrogen herbicides and dissolved organic carbon see the previous section on "Filtration assemblies." For the DOC sample, use a 25-µm, 0.7-mm GF/F if the Savillex unit is used.

2.2.4 PUMP TUBING

Pump tubing refers to the sample lines used with peristaltic, metering, and submersible pumps. Field personnel are cautioned to evaluate possible artifacts in a sample associated with pump tubing and tubing connections. For filtering ground-water samples that are pumped directly from the well to a filtration assembly, C-Flex® or fluorocarbon polymer tubing is generally recommended.

- Tubing connectors and connections that contact the sample should be made of inert material, to the extent possible. Stainless steel connections must be the highest grade available (SS 316). If flexible copper, aluminum, or stainless steel tubing is used for chlorofluorocarbon (CFC) sampling, it should be refrigeration grade. Such fittings ordinarily are delivered with coatings of machining lubricants, which must be removed by cleaning before use.

  — Greaseless fittings can be ordered. Fluorocarbon polymer, silicone, C-Flex® pump tubing commonly are used with portable submersible pumps and with peristaltic or metering pumps. Use of a fluorocarbon polymer material generally is recommended because fluorocarbon polymers are relatively inert with respect to many inorganic and organic analytes (table 2-9).

- Silicone tubing is suitable when sampling for inorganic analytes only, and only after appropriate cleaning (see NFM 3).
  - — Measurable concentrations of silica (0.09 to 0.24 mg/L) have been detected in blank samples passed through silicone tubing (Horowitz and others, 1994). These concentrations are likely to be significant only if low ionic-strength water is being sampled.
  - — Silicone tubing was not designed for use with acids.
  - — Silicone tubing is gas permeable and very sorptive of organic compounds.

Table 2-9. Common varieties and characteristics of fluorocarbon polymer tubing

FEP (fluorinated ethylene polypropylene) • Most transparent • Best abrasion resistance • High flexibility • Least expensive of the Teflon® varieties
PFA (perfluoroalkoxy) • Less transparent than FEP • Virtually nonporous (nonpermeable) • Most expensive of the Teflon® varieties
PTFE (polytetrafluoroethylene) • Least transparent; milky to white • Most flexible • Midpriced between FEP and PFA
Kynar® (polyvinylidene fluoride) • Translucent • Not very flexible • Less expensive than the Teflon® varieties
Tefzel® (Ethylene tetrafluoroethylene) • Withstands higher pressure than Teflon® • Most expensive

- C-Flex® tubing is made from a thermoplastic elastomer and is suitable for use when sampling for all inorganic analytes and DOC.
  - C-Flex® is relatively resistant to acid. Acid resistance is a factor because dilute hydrochloric acid is required in some cleaning procedures (see NFM 3).
  - C-Flex® is less permeable to gas than silicone tubing.
- Fluorocarbon polymer tubing is recommended when sampling for most inorganic and organic analytes. Fluorocarbon polymer tubing is available in corrugated and convoluted, as well as in straight-wall configurations (fig. 2-14).
  - Fluorocarbon polymer tubing premolded to the shape of the pump head is available.
  - Convoluted fluorocarbon polymer tubing is flexible and easy to handle. Attach convoluted tubing to each end of the premolded tubing.
  - Fluorocarbon polymer tubing sheathed in another plastic is available at lower cost but is not recommended because the fluorocarbon polymer twists, constricts, and readily cracks.

- Polyvinyl chloride (PVC) tubing (Tygon®) is suitable for inorganic samples only, and must be appropriately cleaned prior to contact with inorganic samples.
  - PVC tubing can be washed with dilute acid.
  - PVC tubing has the lowest gas permeability of any peristaltic pump tubing.
  - When used with a peristaltic pump, PVC tubing has a shorter life than silicone, C-Flex®, or Norprene®.
  - PVC tubing may leach plasticizers.
- Nylon, polyethylene, and polypropylene are all inexpensive, rigid tubing that can withstand high pressure and are suitable for sampling inorganic analytes. Nylon tubing is more resistant to organic compounds than other plastic tubing, but has not been tested as a source of trace-element or organic-compound contamination.

- Norprene® tubing is made from a thermoplastic elastomer (a polypropylene base with USP mineral oil) and is suitable when sampling for inorganic analytes only. It must be appropriately cleaned prior to contact with samples collected for inorganic analysis. (Norprene® tubing has the longest life of any manufacturer-recommended tubing material.)
  - Norprene® tubing can be washed with dilute acid.
  - Norprene® tubing may leach USP mineral oil.
  - For use with a peristaltic pump.
  - The gas permeability of Norprene® tubing is lower than that of silicone tubing and greater than that of PVC tubing.

FIELD VEHICLES 2.3

By **S.L. Lane, Sarah Flanagan, and D.B. Radtke**

Water samples should be processed within vehicles that are designed, designated, prepared, and dedicated for that purpose. If a multiple-use vehicle must be used for water-quality work, then use of portable processing and preservation chambers is mandatory, and additional quality-control samples must be collected to document that the quality of the data has not been compromised. Contamination of some target analytes is much more likely when multiple-use vehicles are used for collection of water-quality data.

Whether using a field vehicle dedicated for water-quality work or a multi-use vehicle, every effort must be made to keep the work area clean and to eliminate sources of sample contamination.

- Keep metallic objects, such as surface-water and ground-water sampling support equipment, out of the inorganic sample-processing and -preservation area.
- Install a dustproof barrier between the vehicle's cab and the sample-processing and -preservation area.
- Cover metallic surfaces (cabinets or shelving that cannot be replaced) with plastic sheeting. Replace the sheeting periodically.
- Store chemical substances so that chemical fumes will not enter the sample-processing and -preservation area.
- If transporting a nitrogen tank, make sure the tank is fastened securely to the vehicle with a bracket. Gas-supply outfits sell brackets specially designed for gas tanks/cylinders.

For additional discussions of field-vehicle recommendations and requirements, refer to Horowitz and others (1994), Shelton (1994), and Koterba and others (1995).

CAUTION: Store acids, bases, and solvents in separate storage areas so that the chemicals cannot mix if a spill occurs (NFM 9).

LISTS OF EQUIPMENT AND SUPPLIES 2.4

By **S.L. Lane, Sarah Flanagan, and D.B. Radtke**

Checklists of the equipment and supplies commonly used to collect and process water samples are provided in the tables that follow (tables 2-10 through 2-17) to aid field personnel in selecting equipment needed to prepare for a water-quality field trip. These lists are not exhaustive and should be modified to meet specific study needs. Many of the items listed are explained in greater detail in other NFM chapters, as indicated. Refer to other chapters of this *National Field Manual* series for lists of equipment and supplies for field measurements (NFM 6), biological indicators (NFM 7), and bottom-material samples (NFM 8). Equipment must be cleaned and tested before field work begins (NFM 3).

Do not forget backup equipment.

Table 2-10. Support equipment for surface-water sampling

[A detailed description of the various types of support equipment is beyond the scope of this manual; refer to Corbett and others (1943), Buchanan and Somers (1969), and Rantz and others (1982).]

Cranes		
✓	**Type**	**Sampler maximum recommended weight (pounds)**
	Type A	100
	Type E	300[1]
	Bridge board	50
	Other	

Crane Bases		
✓	**Type**	**Sampler maximum recommended weight (pounds)**
	Three-wheel	100
	Four-wheel	150

✓	Miscellaneous
	Battery or hydraulic power motor system for B-56 or E-53 reel
	Hanger bars, connectors, and pins for connecting sampler to cable
	Counterweights for four-wheel crane base
	Safety equipment (flotation jacket, cable cutter, bridge safety plan, traffic cones, and warning signs)
	Vertical transit rate pacer (US VTP-99)
	Other

Reels[2]						
✓	**Reel**	**Cable diameter (inches)**	**Maximum weight (pounds)**	**Cable capacity (feet)**	**Brake**	**Operation type**
	A-55	0.084 .10	50 100	95 80	No	Hand
	B-56	.10 .125	150 200	144 115	Yes	Hand or power
	E-53	.10 .125	150 300	206 165	Yes	Power
	Other					

[1]CAUTION: As of this publication date, a 275- to 300-pound sampler has not been tested for use with 275- to 300-pound weights.
[2]Selection of type of reel should be based largely on maximum cable length needed and weight of sampler that must be supported.

Table 2-11. Support equipment for ground-water sampling

✓	Ground-water support equipment
	Handline or manual/power reel with line
	Tripod assembly with manual or power reel
	Wellhead guide for flexible sample line to pump
	Wheeled carts to transport portable sampling equipment
	Energy source for reels and pumps (batteries, compressor, or generator)
	Other

Table 2-12. Sample-collection equipment for (*A*) surface water and (*B*) ground water

[NFM, *National Field Manual for the Collection of Water-Quality Data*]

✓	(*A*) Surface-water-quality sample collection (refer to NFM 4)
	Weighted bottle and handline (plastic or stainless steel) bottle
	US D-95 (plastic dipped) Bottle (1 liter) Nylon or fluorocarbon polymer nozzle[1] (3/16, 1/4, or 5/16 inch) and cap
	US DH-81 (handle and collar) Nylon or fluorocarbon polymer nozzle[1] (3/16, 1/4, or 5/16 inch) and cap Plastic or fluorocarbon polymer bottle (0.5 or 1 liter)
	US DH-95 (plastic dipped) Bottle (1 liter) Nylon or fluorocarbon polymer nozzle[1] (3/16, 1/4, or 5/16 inch) and cap
	US D-96 Bag and US D-96-A1 (plastic dipped) Slotted bottle (plastic) Nylon or fluorocarbon polymer nozzle[1] (3/16, 1/4, or 5/16 inch) and cap PFA (perfluoroalkoxy) bag
	US D-99 Bag (plastic coated) Nylon or fluorocarbon polymer nozzle[1] (3/16, 1/4 or 5/16 inch) PFA bag
	Crane with 3- or 4-wheel base and counterweights
	Reel, hanger bars, and pins
	Current meter for US DH-95, US D-95, US D-96, US D-96-A1, and US D-99
	Bridge board and reel
	Plastic sheeting with weighted corners to cover bridge rail, 2 millimeters thick
	Vertical transit rate pacer
	Biochemical Oxygen Demand sampler
	Volatile Organic Compound sampler
	Thief sampler
	Pumping sampler(s)
	Other

Table 2-12. Sample-collection equipment for (*A*) surface water and (*B*) ground water—*Continued*

✓	(*B*) Ground-water-quality sample collection (refer to NFM 4)
	Positive-displacement submersible pump, discharge line, and reel
	Water-supply-well sample line and garden-hose threaded adaptor
	Thief-type sampler. (Examples: bailer, single or double-check valve, and bottom emptying device)
	Suction-lift pump (peristaltic or centrifugal)
	Antibacksiphon device
	Sample-water manifold to split sample water flow
	Flowthrough chamber for field-measurement electrodes (pH, conductivity, dissolved oxygen, water temperature, oxidation/reduction)
	Tubing, appropriate for type of pump and target analytes
	Tubing connectors, compatible with tubing and target analytes
	Water-level measuring tape, steel or electric, and bleach solution[2]
	Water-level indicator (blue chalk for steel tape)
	Weight, to attach to water-level measuring tape or sample line. **Do not use lead.** Use stainless steel or other relatively noncontaminating material.
	Power source for pump or reel; batteries for electronic sounder
	Graduated bucket (to measure rate of discharge) and stopwatch
	Containers for disposal of purge water
	Flow controller for sampling pump
	Plastic sheeting, 2 millimeters or thicker
	Other

[1]Use only nozzles purchased from the Federal Interagency Sedimentation Project.
[2] If measuring water level from a drinking-water well, decontaminate equipment by dipping the wetted section into a 10-percent bleach/water solution, followed by rinsing with deionized water. Dry the steel tape to prevent rusting.

Table 2-13. Sample-processing equipment and supplies

[NFM, *National Field Manual for the Collection of Water-Quality Data;* L, liter; mm, millimeter; µm, micrometer; in., inch; g, gram; mL, milliliter]

✓	Sample splitters (refer to NFM 5)
	Plastic churn splitter, 8 L or 14 L, modified spigot and funnel (NFM 2.2.1.A) (inorganic analytes) Fluoropolymer churn splitter, 14 L (organic and (or) inorganic analytes) Modified spigot or Master Flex 6424-03 tubing to modify metal-spring spigots
	Churn carrier
	Cone splitter • Splitting chamber for cone splitter • Bull's-eye bubble level and shims for cone splitter
	Large clear plastic bags: protective • Covering for transporting clean churn splitter or cone splitter
	Subsample bottle kits for whole-water samples
	Other: Gloves (powderless, disposable nitrile)
✓	**Filtration systems for inorganics (refer to NFM 5)**
	Peristaltic pump and batteries
	Pump tubing for ground-water and peristaltic pump (C-Flex™, silicone, fluorocarbon polymer)
	Filtration assembly (disposable capsule, plate-type, other)
	Filter membranes and discs (various diameters, pore sizes, and materials)
	Forceps (plastic or ceramic)
	Subsample bottle kits for filtered inorganic samples
	Deionized water: Inorganic grade blank water (IBW) or Universal blank water (UBW)
	Other: Gloves (powderless, disposable nitrile)
✓	**Filtration systems for organics (refer to NFM 5)**
	Plate-filter assembly, aluminum or stainless steel, for 13-, 142-, or 293-mm-diameter filter disc or PFA filter holder for 47-mm-diameter filter disc
	Filter disc, borosilicate glass fiber (GF/F), 0.7-µm pore size, baked 142-mm, or 13-, 47-, or 293-mm-diameter filter disc, as required
	Pump, ceramic piston valveless metering, with fluorocarbon polymer convoluted tubing or ground-water pump tubing, and batteries
	Filtration assembly, 25-mm-diameter, in-line, with disposable nylon filter
	Subsample bottle kits
	Volatile/pesticide-grade blank water (VPBW)
	Pesticide-grade blank water (PBW)
	Forceps (metal or ceramic)
	Other: Gloves (powderless, disposable nitrile)
✓	**Miscellaneous processing equipment and supplies**
	Sample processing chamber; supply of transparent plastic covers (bags) for portable chamber and disposable nonpowdered gloves to handle equipment
	Other: Gloves (powderless, disposable nitrile)

Table 2-13. Sample-processing equipment and supplies—*Continued*

✓	**Filtration system for carbon analysis (refer to NFM 5)**
	Fluorocarbon-polymer filtration assembly and baked glass-microfiber filter discs (25 mm, 0.7-µm pore size)
	Disposable capsule filter for dissolved organic carbon sample analysis, if consistent with study protocols and objectives
	Hand pressure or peristaltic pump
	C-flex tubing with in-line 0.2-µm air filter
	Cylinder, graduated, glass
	Holding stand, ring, and medium three-prong clamp
	Forceps, stainless steel
	Whirl-Pak bags (6 ounce and 18 ounce)
	Aluminum foil squares
	Cooler and ice
	Organic grade water
	Power source for pump (battery, generator, other)
	Other: Gloves (powderless, disposable nitrile)
✓	**Solid-phase extraction (SPE) system (refer to NFM 5)**
	Valveless piston metering pump (ceramic) with fluorocarbon polymer convoluted tubing
	Fluorocarbon polymer tubing, 1/8-in. outside diameter
	Various tubing fittings, adaptors, connectors, and unions
	Portable balance, 1 to 6,000 g
	Graduated glass cylinders
	Beaker (plastic), 1,000 mL
	Spike mixture and micropipette kit
	Surrogate mixture and micropipette kit
	SPE column (C-18 or Carbopac-B™); checklist and reporting form
	Methanol, ascorbic acid, sodium chloride, and pesticide-grade organic water, all in fluorocarbon polymer dispenser bottles
	Gloves (powderless, disposable nitrile)
	Stopwatch
	Aluminum foil

Table 2-13. Sample-processing equipment and supplies—*Continued*

✓	**Tritium/Helium-3 ($^3H/^3He$) age dating sampling system (see NFM 5)**
	Copper sample tubes; two tubes per well[1]
	500-mL safety-coated glass bottle with polycone seals
	Back-pressure-valve assembly[2]
	• Whitey valve SS-1RS6, 3/8-in. stainless steel valve • Swagelok 3/8-in. nylon ferrule sets, NY-600 set (10 each set) • A small length of 3/8-in. clear tubing (allows you to watch for air bubbles)
	Reducing union to connect sample line to 3/8-in. sample tube
	Socket wrench with 13-mm socket is used to turn the bolts that close the pinch-off clamps
✓	**Passive diffusion bag (PDB) samplers for investigating selected volatile organic compounds (see NFM 5)**
	1- to 2-ft-long low-density polytheylene (LPDE) lay-flat tube[3]
	Polyethylene mesh (sleeve for PDB)
	Deionized water (used to initially fill the PDB before deployment)
	Weighted line or fixed pipe (to hold PDB in place in well)
	Cable ties or stainless steel spring clamps (to hold PDB to weighted line or fixed pipe)
	Heat source to seal ends of PDB

[1]Obtain information online at Reston Chlorofluorocarbon Laboratory by completing a Sample Tube Request Form (http://water.usgs.gov/lab/cfc) (accessed 5-12-2003). Samples are shipped to Lamont-Doherty Earth Observatory in Palisades, NY, for analysis.
[2] NWQL Technical Memorandum 97.04S provides photographs and diagrams of sampling equipment.
[3] Vroblesky (2001) includes photographs of sampling equipment and deployment.

Table 2-14. Sample-preservation equipment and supplies

[NFM, *National Field Manual for the Collection of Water-Quality Data*; N, normal; HCl, hydrochloric acid]

✓	Preservation equipment and supplies (refer to NFM 5)
	Preservation chamber(s)
	Chamber covers (large, transparent bags)
	Waste containers for spent preservative ampoules, dedicated for each chemical used
	Chemical reagents (such as nitric, hydrochloric, and sulfuric acids) and project requirements for sample preservation for the analytes targeted and analytical method selected. Note that although several analytes might require the same type of acid preservative, the normality, volume, and grade specified by the laboratory may differ; it is important to follow explicit laboratory directives concerning the chemical treatment of a sample.
	Nitric acid (analytical grade)
	6N ultrapure hydrochloric acid vial (for mercury sample)
	Sulfuric acid
	HCl for volatile organic compound sample
	Phosphoric acid/cupric sulfate
	Sodium hydroxide
	Ascorbic acid
	Zinc acetate
	Phytoplankton kit
	Radon kit
	Cooler, ice or chilling agent
	Other: for example, apron, goggles, gloves (powderless, disposable nitrile)

Table 2-15. Cleaning and quality-control sampling equipment and supplies

[NFM, *National Field Manual for the Collection of Water-Quality Data;* FEP, fluorinated ethylene polypropylene]

✓	General cleaning equipment and supplies (refer to NFM 3)
	Basins or standpipes (clear or white plastic, fluorocarbon polymer, stainless steel)
	Brushes (nonmetallic, clear or white)[1]
	Detergent, laboratory phosphate-free (0.1 to 2 percent by volume)
	Tap water
	Deionized water, District-produced or equivalent (ASTM International Type 1) (Office of Water Quality Technical Memorandum 92.01), distilled water purchased from commercial supplier
	Wash bottles
	Material Safety Data Sheet for each chemical to be used
	Sealable plastic bags without color closure strips and large plastic storage bags
	Other safety equipment, for example • Laboratory coat or apron • Goggles • Gloves • Eyewash station • Acid spill kit; solvent spill kit • Safety shower
✓	**Inorganic constituents**
	Hydrochloric acid, analytical grade (5 percent by volume)
	Neutralization container and marble chips
	Wash bottle for hydrochloric acid
	Inorganic-grade blank water (IBW) (see footnote 2) (National Water Quality Technical Memorandum 92.01)
	Large plastic bags (clear or white)
	Plastic sheeting (clear or white)

Table 2-15. Cleaning and quality-control sampling equipment and supplies—*Continued*

[NFM, *National Field Manual for the Collection of Water-Quality Data;* FEP, fluorinated ethylene polypropylene]

✓	Organic Compounds
	Methanol, pesticide grade[3]
	Waste container, methanol[3]
	Wash bottle, methanol (FEP-grade plastic)[3]
	Aluminum foil
	Fluorocarbon polymer bags/sheeting
	Pesticide- or volatile-grade blank water (PBW or VPBW)[2]
	Deionized water, district-produced or equivalent (ASTM International Type 1)

[1]Restaurant-supply stores are an excellent source for these types of brushes.
[2].
USGS personnel should obtain blank water from the "One-Stop Shopping" Web site using the following item numbers:
IBW - Q378 FLD
VPBW - N1580 or N1570
and
PBW - N1590 or N1600
[3] Methanol supplies must not be used for contact with samples for organic carbon analysis.

Table 2-16. Shipping equipment and supplies

[NFM, *National Field Manual for the Collection of Water-Quality Data*]

✓	Shipping equipment and miscellaneous shipping supplies (refer to NFM 5)
	Coolers, 1 to 5 gallon
	Boxes (sturdy)
	Packing material (foam sleeves, bubble wrap)
	Ice
	Large plastic bags for lining coolers and boxes
	Sample-bottle labels
	Analytical Services Request (ASR) form
	Return-address label and account number
	Sealable plastic bag for forms and return label
	Tape, fiber
	Shipping label (forms)

Replacement Page 3/30/2009. See Comments and Errata.

Table 2-17. Miscellaneous field supplies

[NFM, *National Field Manual for the Collection of Water-Quality Data*]

✓	Miscellaneous field supplies (refer to NFM 5)
	Notebook and pen (indelible ink)
	Field instruments (NFM 6; Office of Water Quality Technical Memorandum 94.02)
	Calibration logbook for each instrument (NFM 6)
	Field folder(s) with station, site, and well information and permission form
	Field documentation forms
	Calculator and extra batteries
	Watch
	Tagline
	Stopwatch and headset for discharge measurement
	Hip boots
	Chest waders
	Rain gear
	Personal flotation device
	Traffic safety vest, cones, signs, warning lights
	First aid kit
	Highway emergency kit
	Tool kit
	Tape (electrical, fiber, fluorocarbon polymer, other)
	Plastic-coat spray
	Fire extinguisher
	Flashlight with extra batteries
	Backup batteries for sampling devices
	Keys to sampling site, security locks, and vehicle (extra set)
	Weather report
	Field trip itinerary (copy to supervisor); sampling and safety plans, Job Hazard Analysis form
	Cellular phone or two-way radio
	Camera with extra film and batteries
	Work gloves
	Shovel, ice chisel/auger
	Boat, motor, gasoline, oil, paddle, oars
	Drinking water
	Soap (antibacterial)
	Paper towels (lint free)
	Safety plan(s) (NFM 9)
	Map(s)
	Locations and phone numbers of hospitals and other emergency facilities (NFM 9)
	USGS photo ID should be with all field personnel at all times in the field.
	Other

CONVERSION FACTORS, SELECTED TERMS, AND ABBREVIATIONS

CONVERSION FACTORS

Multiply*	By	To obtain
inch (in.)	25.4	millimeter (mm)
square inch (in^2)	645.16	square millimeter (mm^2)
foot (ft)	0.3048	meter (m)
gallon (gal)	3.785	liter (L)
pound, avoirdupois (lb)	0.4536	kilogram
meter (m)	3.281	foot
centimeter (cm)	0.3937	inch
micrometer (μm)	3.9372×10^{-5}	inch
millimeter (mm)	0.03937	inch
liter (L)	0.2642	gallon
milligrams per liter (mg/L)	0.5841	grains per gallon
milliliter (mL)	0.0338	ounce, fluid
milliliter (mL)	2.64×10^{-4}	gallon
milligram (mg)	3.527×10^{-5}	ounce, avoirdupois
gram (g)	0.03527	ounce, avoirdupois
kilogram (kg)	2.205	pound

*__Example:__ 1 in. x 25.4 = 25.4 mm.

Vertical datum: Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). (The term "sea level" is no longer used to express vertical datum in publications of the Water Resources Discipline of the U.S. Geological Survey.)

Temperature: Water and air temperature are given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

SELECTED TERMS

Analyte (target analyte): "Substances being determined in an analysis" (from Bennett, Harry, ed., 1986). The term "target analyte" is used in this report to refer to any chemical or biological substance for which concentrations in a sample will be determined. Target analyte does not include field-measured properties such as temperature, conductivity, dissolved-oxygen concentration, pH, Eh, alkalinity, color, or turbidity.

Fluorocarbon polymers and fluoropolymers: Fluorocarbon polymers (polyfluorocarbons) or fluoropolymers are composed of monomers (smallest repeating compound segment of polymer) consisting of carbon, fluorine, hydrogen, and, for one polymer, oxygen. The fluoropolymers have tradenames that include, for example, Teflon® and Tefzel® (ethylene tetrafluoroethylene) (products of the DuPont Company) and Kynar® (a polyvinylidene fluoride, a product of the Atofina Chemicals Company). Common types of fluoropolymers include FEP (fluorinated ethylene polypropylene), PFA (perfluoroalkoxy), PTFE (polytetrafluoroethylene), and PVDF (polyvinylidene fluoride). Each fluorocarbon polymer has different chemical and physical properties; however, all are relatively nonreactive chemically at ambient temperatures and do not leach monomers.

Trace element(s): For the purpose of this report and to maintain consistency with common usage, the term "trace element(s)" is used to refer to metals and other elements such as arsenic, antimony, selenium, and tellurium that usually are present in natural surface- and ground-water systems in concentrations less than 1 mg/L (modified from Hem, 1985). Common usage of this term, as defined above, is inexact and not rigorous with respect to the aqueous chemistry discipline.

Whole water: Water as sampled from its source and not subjected to filtration or other phase-separation process. Common synonymous terms include: raw (water) sample and unfiltered (water) sample.

SELECTED SYMBOLS

~	approximately
>	greater than
≤	less than or equal to
±	plus or minus

ABBREVIATIONS

BOD	biochemical oxygen demand
CFC	chlorofluorocarbon
DC	direct current
DIW	distilled/deionized water
DOC	dissolved organic carbon
ETFE	ethylene-tetrafluorethylene
ft/s	feet per second
FEP	fluorinated ethylene polypropylene
gal/min	gallon per minute
GF/F	glass microfiber filters
HIF	USGS Hydrologic Instrumentation Facility, Stennis Space Center, Mississippi
IBW	inorganic-grade blank water
L/min	liter per minute
lb/in^2	pounds per square inch
mg/L	milligrams per liter
NFM	*National Field Manual for the Collection of Water-Quality Data*
NWQL	USGS National Water Quality Laboratory
PBW	pesticide-grade blank water (water certified free of pesticide compounds)
PDB	passive diffusion bag sampler
PFA	perfluoroalkoxy

Replacement page 11/16/2004. See Comments and Errata.

ABBREVIATIONS—*Continued*

PIC	particulate inorganic carbon
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
SPE	solid-phase extraction
SS	stainless steel
TPC	total particulate carbon
TWRI	Techniques of Water-Resources Investigations
USGS	U.S. Geological Survey
USP	United States Pharmacopeia
VOC	volatile organic compounds
VPBW	volatile/pesticide grade blank water

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Water Quality

Memo No.	Title	Date
qw78.06	WATER QUALITY: Field filtering of water samples for chemical analysis	April 5, 1978
qw80.17	EQUIPMENT AND SUPPLIES: New sample splitter for water-quality samples	July 3, 1980
qw92.01	Distilled/Deionized Water for District Operations	December 20, 1991
qw94.02	EQUIPMENT: Discontinuance of field use of mercury liquid-in-glass thermometers	November 22, 1993
qw97.06	Comparison of the suspended-sediment splitting capabilities of the churn and cone splitters	May 5, 1997
qw2000.05	Particulate organic carbon	April 28, 2000
qw2000.08	New method for particulate carbon and particulate nitrogen	June 1, 2000
qw2002.09	Water-quality field methods phaseout of US D-77 and Frame-type samplers	January 25, 2002
qw2002.14	Availability of universal blank water for inorganic and organic analyses	April 18, 2002

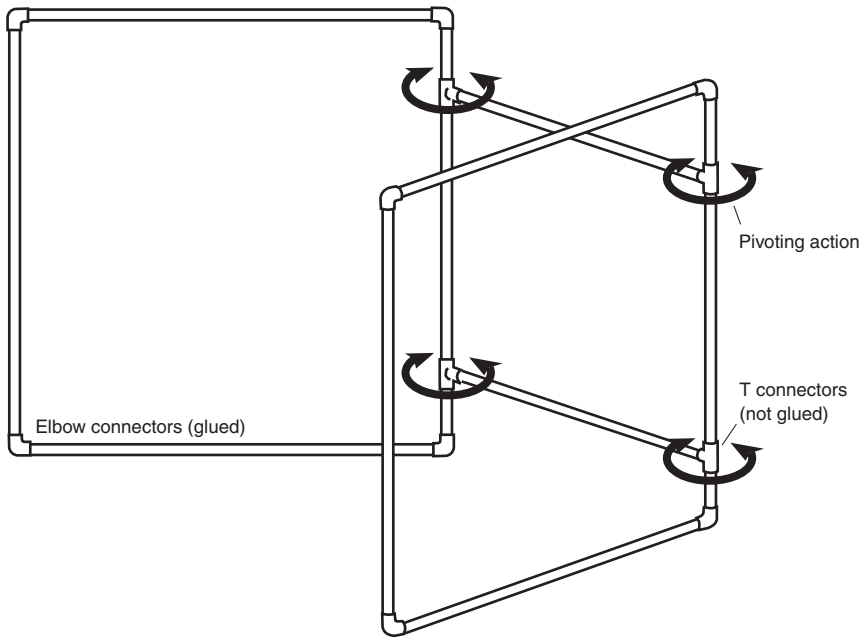
Surface Water

Memo No.	Title	Date
sw94.05	Maximum sampling depths and transit rates for suspended sediment and water-quality samplers	January 31, 1994

National Water Quality Laboratory (NWQL)

Memo No.	Title	Date
92.01	Availability of equipment blank water for inorganic and organic analysis	March 25, 1992
97.04S	Collection, processing, and analysis of ground-water samples for tritium/helium-3 dating	April 7, 1997

APPENDIX: CONSTRUCTION OF A COLLAPSIBLE SAMPLE-PROCESSING/PRESERVATION CHAMBER



This frame can be pulled apart at the 4 joints that are left unglued, and will swivel or fold at these joints. Schedule 40 polyvinyl chloride pipes can be used for greater rigidity. Dimensions of chamber depend on its use (processing or preservation) and the space available in the vehicles.

U.S. Geological Survey
Techniques of Water-Resources Investigations

Book 9
Handbooks for Water-Resources Investigations

National Field Manual for the Collection of Water-Quality Data

Chapter A4. COLLECTION OF WATER SAMPLES

Revised 2006

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
DIRK KEMPTHORNE, *Secretary*

U.S. GEOLOGICAL SURVEY
Mark D. Myers, *Director*

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Foreword

The mission of the Water Resources Discipline of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems. These data are used for environmental and resource assessments by the USGS, other government agencies and scientific organizations, and the general public. Reliable and quality-assured data are essential to the credibility and impartiality of the water-resources appraisals carried out by the USGS.

The development and use of a *National Field Manual* is necessary to achieve consistency in the scientific methods and procedures used, to document those methods and procedures, and to maintain technical expertise. USGS field personnel use this manual to ensure that the data collected are of the quality required to fulfill our mission.

Robert M. Hirsch
Associate Director for Water

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National Field Manual for the Collection of Water-Quality Data

Chapter A4.

COLLECTION OF WATER SAMPLES

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Chapter A4. COLLECTION OF WATER SAMPLES

Revised 2006

Franceska D. Wilde, Editor

ABSTRACT

The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols and provides guidelines for U.S. Geological Survey (USGS) personnel who collect data that are used to assess the quality of the Nation's surface-water and ground-water resources. This chapter addresses preparations and appropriate methods for the collection of surface-water, ground-water, and associated quality-control samples. Among the topics covered are considerations and procedures to prevent sample contamination; establishing site files; instructions for collecting depth-integrated isokinetic and nonisokinetic samples at flowing- and still-water sites; and guidelines for collecting formation water from wells having various types of construction and hydraulic and aquifer characteristics.

INTRODUCTION

As part of its mission, the U.S. Geological Survey (USGS) collects the data needed to assess the quality of our Nation's water resources. The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols (requirements and recommendations) and provides guidelines for USGS personnel who collect those data on surface-water and ground-water resources. Chapter A4 provides information about the collection and quality control of water samples for investigations and assessments of environmental water quality. **Formal training and field apprenticeship are necessary in order to implement correctly the procedures described in this chapter.**

The *National Field Manual* is Section A of Book 9 of the USGS publication series "Techniques of Water-Resources Investigations" (TWRI) and consists of individually published chapters designed to be used inconjunction with eachother. Chapter numbersare preceded by an "A" to indicate that the report is part of the *National Field Manual*. Other chapters of the *National Field Manual* are referred to in this report by the abbreviation "NFM" and the specific chapter number (or chapter and section number). For example, NFM 6 refers to Chapter A6 on "Field Measurements" and NFM 6.4 refers to the section on field measurement of pH.

The procedures described in this chapter represent protocols that generally are applicable to USGS studies involving the collection of water-quality data. Modification of required and recommended procedures to fulfill study objectives or to enhance data quality must be documented and published with the data and data interpretation.

PURPOSE AND SCOPE

The *National Field Manual* is targeted specifically toward field personnel in order to (1) establish and communicate scientifically sound methods and procedures, (2) provide methods that minimize data bias and, when properly applied, result in data that are reproducible within acceptable limits of variability, (3) encourage consistent use of field methods for the purpose of producing nationally comparable data, and(4) provide citable documentation for USGS water-quality data-collection protocols.

The purpose of this chapter of the *National Field Manual* is to provide field personnel and other interested parties with a description of the requirements, recommendations, and guidelines routinely used in USGS studies involving the collection of water-quality samples from bodies of surface water and ground water. The information provided covers topics fundamental to the collection of water samples that are representative of the ambient environment. The information provided does not attempt to encompass the entire spectrum of data-collection objectives, site characteristics, environmental conditions, and technological advances related to water-quality studies. Also beyond the scope of this chapter is discussion of procedures to collect samples for analysis of suspended or biological materials. Collection of data related to onsite measurements such as pH and alkalinity is addressed in NFM 6, while collection of biochemical and microbiological data is addressed in NFM 7.

REQUIREMENTS AND RECOMMENDATIONS

As used in the *National Field Manual*, the terms **required** and **recommended** have USGS-specific meanings.

Required (require, required, or requirements) pertains to USGS protocols and indicates that USGS Office of Water Quality policy has been established on the basis of research and (or) consensus of the technical staff and has been reviewed by water-quality specialists and other professionals who have the appropriate expertise. Technical memorandums or other documents that define the policy pertinent to such requirements are referenced in this chapter. USGS personnel are instructed to use required equipment or procedures as described herein. Departure from or modifications to the stipulated requirements that might be necessary to accomplishing specific data-quality requirements or study objectives must be based on referenced research and good field judgment, and be quality assured and documented.

Recommended (recommend, recommended, recommendation) pertains to USGS protocols and indicates that, on the basis of research and (or) consensus, the USGS Office of Water Quality recognizes one or several acceptable alternatives for selecting equipment or procedures. Specific data-quality requirements, study objectives, or other constraints might affect the choice of recommended equipment or procedures. Selection from among the alternatives must be based on referenced research and good field judgment, and reasons for the selection should be documented. Departure from or modifications to recommended procedures must be quality assured and documented.

FIELD MANUAL REVIEW AND REVISION

Chapters of the *National Field Manual* are reviewed, revised, and reissued periodically to correct any errors, incorporate technical advances, and address additional topics. Comments or corrections can be mailed to NFM-QW, USGS, 412 National Center, Reston, VA 20192 (or by e-mail to nfm-owq@usgs.gov). Newly published and revised chapters are posted on the USGS Web page "National Field Manual for the Collection of Water-Quality Data." The URL for this page is: http://pubs.water.usgs.gov/twri9A/. The page contains links to an errata page and to the chapters of the *National Field Manual*. Information regarding the status and any errata of this or other chapters can be found near the beginning of the Web page for each chapter. Near the bottom of each chapter's Web page are links to archived versions.

ACKNOWLEDGMENTS

The information included in this chapter of the *National Field Manual* is based on earlier manuals, various reference documents, and a broad spectrum of colleague expertise. Individuals in the USGS–too numerous to mention by name–developed the field and training manuals that provided the foundation for information on the collection and processing of water samples, and others have contributed through peer and editorial reviews to the technical quality of this document. Editorial assistance provided by Iris M. Collies and production assistance from Loretta J. Ulibarri have been indispensible in maintaining and enhancing the quality of this report.

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Franceska D. Wilde
Managing Editor

A4. COLLECTION OF WATER SAMPLES

This chapter of the *National Field Manual* (NFM) describes standard USGS methods (sampling strategies, techniques, requirements, and recommendations) for the routine collection of representative water samples. Sample collection forms a continuum with sample processing; therefore, the information in this chapter overlaps with some of the information in NFM 5, *Processing of Water Samples*.

SAMPLING:
The act of collecting a portion of material for analytical purposes that accurately represents the material being sampled with respect to stated objectives.

Modified from Standard Methods, 1060A
(APHA and others, 2001)

Before sample collection begins, field personnel must take steps to ensure that the samples collected will be representative of the aqueous system being investigated. A representative sample is one that typifies ("represents") in time and space that part of the aqueous system to be studied, and is delineated by the objectives and scope of the study.

Obtaining representative samples is of primary importance for a relevant description of the environment. In order to collect a representative sample that will yield the information required, (1) study objectives, including data-quality requirements,[1] must be understood in the context of the water system to be sampled, and (2) artifacts of the sampling process must be minimized.[2] Field personnel must be alert to conditions that could compromise the quality of a sample.

- **Collect a representative sample.** Use appropriate methods and quality-assurance measures to ensure that the field sites selected and the samples collected accurately represent the environment intended for study and can fulfill data-quality objectives.

- **Think contamination!** To ensure the integrity of the sample, be aware of possible sources of contamination. Contamination introduced during each phase of sample collection (and processing) is additive and usually is substantially greater than contamination introduced elsewhere in the sample-handling and -analysis process. **Therefore, collect a sufficient number of quality-control samples, appropriately distributed in time and space, to ensure that data-quality objectives and requirements are met (section 4.3).**

[1] As used in this report, data-quality requirements refer to that subset of data-quality objectives pertaining to the analytical detection level for concentrations of target analytes and the variability allowable to fulfill the scientific objectives of the study.

[2] The degree to which a sample can be considered representative of a water body depends on many interrelated factors including, for example, temporal and spatial homogeneity of the water body, sample size, and the method and manner of sample collection.

4.0 RESPONSIBILITIES, FIELD PREPARATIONS, AND PREVENTING SAMPLE CONTAMINATION

This section of the NFM presents guidelines, requirements, and recommendations for USGS field personnel as they prepare for sample collection at field sites. Collecting comparable data over the duration of the sampling effort and among sampling sites is necessary for a valid analysis and interpretation of the data. This usually requires consistent use of the methods and equipment selected and collection of sufficient quality-control data to verify the quality and comparability of the data collected.

USGS data-collection efforts often take a whole-system approach, meaning that the data-collection methods used are designed so that the entire stream reach or aquifer volume is represented. A modified approach is needed for studies in which samples are representative of a specific portion or aspect of an aqueous system; for example, a study of aquatic ecology may establish nearshore boundaries on the system of study, and an oil-spill study may target only the surface of a water-table aquifer.

- **What do your data represent?** Data collectors need to know what questions the data being collected are meant to address, and understand the level of accuracy and precision that are needed in the data to answer those questions. The data are no better than the confidence that can be placed in how well the sample represents the aqueous system (Horowitz and others, 1994). Therefore, understand the purpose for which the various types of data will be collected and the aqueous system that each sample should represent.
- **Are your data of appropriate quality?** Quality-control samples yield information by which confidence brackets can be applied to the environmental data. Field quality control is vital for data interpretation and assessment and yields different information than laboratory-performed quality-control checks.

Data quality begins before the first sample is collected, by taking care to use proper equipment, being aware of data-quality requirements, and being alert to potential sources of sample contamination.

4.0.1 RESPONSIBILITIES AND FIELD PREPARATIONS

Field personnel are responsible for their safety and for the quality of the work performed.

- **Never compromise the safety of field personnel.** Be familiar with the safety requirements and recommendations described in NFM 9. Get the appropriate training and certification needed if you will be working at sites designated as hazardous.
- **Collect data of known quality.** Fundamental to water-quality sampling is the fact that the quality of the analytical results can be no better than the quality of the sample on which the analyses were performed. The sample collector has primary responsibility for the quality and integrity of the sample up to the time that the sample is delivered to the analyzing laboratory or office. Data quality is determined from analysis of quality-control data.
- **Know what you need to do.** Before departing for field work, review the workplan, and plan for the types of measurements and samples specified.
  - — Be thoroughly familiar with your study objectives and requirements. Sampling plans, including quality-assurance and equipment requirements, need to be prepared and reviewed in advance. Some programs require a prescribed format for sampling, quality-assurance, and safety plans. Some projects require chain-of-custody documentation.
  - — Review and understand the USGS protocols for collecting and processing your samples before field work begins. Obtain and keep current with training and the laboratory requirements associated with your data-collection activities.

All details of a field trip need to be planned well in advance (fig. 4-1). Adequate time must be scheduled in the workplan to review data requirements and make field-trip preparations; a common mistake is to put off these activities until the last minute (table 4-1).

- **Make reconnaissance trips** before selecting repeat sampling sites, if possible.
  - — Note conditions that could affect sampling operations (such as the seasonal high or low streamflow, flowing or low-flow wells, or site-access peculiarities).
  - — Evaluate potential sources of contamination at the site, based on the analytes[3] to be targeted in the sample analysis.
- **Review site files and field folders** (see sections 4.1.1 and 4.2.1). Check the site location, description, and access. Review any previously collected physical, chemical, and biological data.
- **When selecting field equipment**, understand the physical and chemical limitations of each piece of equipment, in order to meet data-collection objectives and data-quality requirements (refer to NFM 2). Verify and test, if possible, the operational range of the sampling equipment to be used.

[3]"Target analyte" refers to any chemical or biological substance for which concentrations in a sample will be determined. Target analyte does not include field-measured properties such as temperature, specific electrical conductance (conductivity), dissolved-oxygen concentration, pH, Eh, alkalinity, color, or turbidity. The *Concise Chemical and Technical Dictionary*, 4th edition (Bennett, 1986) defines "analyte" as "Substance being determined in an analysis."

- **Prepare a workplan and checklists**.
  - The workplan delineates study activities and establishes the timeframe in which the activities are to be completed (table 4-1).
  - Checklists help ensure that equipment and supplies will be ordered on time, that data-collection activities will be completed appropriately, and that data-quality requirements will be met (fig. 4-1). Generic checklist items apply to most studies, and the checklist customized for specific study requirements (for example, special equipment or supplies, quantities of equipment and supplies, number of batteries, and types of sample bottles and other equipment).
- **Data management.** Field personnel also are responsible for providing the necessary information to establish USGS National Water Information System (NWIS) site files for each sampling site and for checking to see that the site file is functional, that the information it contains is correct, and that updates are made promptly. NWIS is the hydrologic data base for the USGS, and includes the following subsystems in which study site files are to be maintained:
  - **Quality-of-Water Data (QWDATA)** – contains field and laboratory data.
  - **Automatic Data Processing System (ADAPS)** – contains time-series information.
  - **Ground-Water Site Inventory (GWSI)** – contains aquifer and ground-water site information.

PLAN AHEAD! Take adequate time to prepare.

Table 4-1. Example of work-schedule elements

Work-schedule elements	Examples of items or activities in checklists	Completed by
Calendar of planned field trips	Prepare calendars/checklists that include sampling dates, members of field team, vehicle(s) to be used.	
Presampling activities	Prepare checklists (see figs. 4-1 and 4-7). Prepare NWIS site files.	
Postsampling activities	Update field folders and computer files. Log in samples (Analytical Services Request form). Store and dispose of hazardous materials properly. Check that all equipment is clean and properly stored.	
Field equipment and supplies	Prepare lists of equipment/supplies for each field site (see NFM 2). Prepare a list of items to be ordered.	
Equipment/supplies maintenance and testing	Prepare a checklist of maintenance/testing for field-measurement instruments (see NFM 6). Test sample-collection and processing equipment. Charge or replace batteries.	
Sample-collection, -processing, -shipping, and -documentation information and supplies	Prepare headers on forms (such as field, chain-of-custody, and Analytical Services Request forms); prepare bottle labels. Prepare lists of chemical constituents, with respect to: analytical schedules, methods, laboratory codes; bottle type and volume; sample handling, chemical treatment and preservation procedures; sample shipment; quality-control samples.	
Field-folder contents	Prepare a list of logistical information needed for each site, such as permission to access site, keys, maps.	
Safety equipment and information	Keep a copy of NFM 9 for field use and list special considerations for the site, such as personal flotation devices.	

FIELD-TRIP PREPARATIONS

PROJECT: _____

SITES: _____DATE:_____

✓	Prefield activity	Comments
	Order supplies	Ordered 3 cases Ultrex for site #2 Completed on _____ , by _____ .
	Prepare deionized water (in-house system) Check prior laboratory analysis	Last change of cartridges, on _____ Last chemical analysis on _____ , by _____ , Conductivity checks out , by _____
	Check expiration dates on reagents	Need _____ conductivity standard(s) Need pH _____ buffer(s)
	Clean and test equipment	Completed on _____ , by _____ Problems _____
	Collect equipment blanks	Completed on _____ , by _____ Results reviewed by _____ (Water-quality specialist or project chief)
	Clean sample bottles	Completed on _____ , by _____
	Label sample bottles, prepare field forms	Completed on _____ , by _____
	Obtain permission for site access	Completed on _____ , by _____
	Check field vehicle for safety equipment and supplies, such as material safety data sheets, flares, and remote communications system (NFM 9)	Completed on _____ , by _____
	Charge/replace batteries	Completed by _____
	Update field folder	Completed by _____
	Make travel reservations, arrangements	Completed by _____
	Provide supervisor with field-trip and call-in (check-in) schedule	Provided on _____ to _____
	Vehicle maintenance	Check fluids, battery, tires, lights, cleanliness.
	Other	

Figure 4-1. Example of a presampling activities checklist.

PREVENTING SAMPLE CONTAMINATION 4.0.2

The USGS prescribes specific protocols for avoiding contamination of water samples. In addition, collection of quality-control samples (section 4.3) – scaled as appropriate to the objectives of the study and site conditions – is mandated to check for, address, and measure sample contamination and any resulting bias to the data. The most common causes of sample contamination during sample collection include poor sample-handling techniques, input from atmospheric sources, inadequately cleaned equipment, and use of equipment constructed of materials inappropriate for the analytes targeted for study. To prevent or minimize sample contamination from these sources:

- **Implement good field practices**, summarized on table 4-2.

- **Use Clean Hands/Dirty Hands sampling techniques,** summarized on table 4-3.

USGS clean-sampling procedures (sometimes called the parts-per-billion or ppb protocol) involve (1) using equipment that is constructed of noncontaminating materials (NFM 2) and that has been cleaned rigorously before field work and between field sites (NFM 3); (2) handling equipment in a manner that minimizes the chance of altering ambient sample composition; (3) handling samples in a manner that prevents contamination; and (4) routinely collecting quality-control (QC) samples. **Good Field Practices and Clean Hands/Dirty Hands (*CH/DH*) are an integral part of routine USGS water-quality field work.**

The nine major elements that comprise Good Field Practices are listed on table 4-2. Four of the principles are further clarified below.

Field rinse equipment. Field rinsing of equipment used to collect or process samples should not be confused with the procedures used for equipment cleaning or decontamination; directions for field rinsing specific types of surface-water and ground-water equipment are described in sections 4.1.3 and 4.2.2.C, respectively. Collection of equipment blanks and field blanks is necessary to help identify potential sources of sample contamination (section 4.3). The same equipment that is used for collecting and processing environmental samples is used for collecting and processing blanks and other types of quality-control samples; however, equipment-cleaning and -rinsing procedures differ somewhat.

Follow a prescribed sampling order. One dictate of Good Field Practices is to follow a prescribed order for collecting samples. An aspect of this is that cross-contamination between sites can be avoided by planning the order in which field sites will be sampled. Sites should be sampled in the order of least to greatest potential for equipment fouling or contamination, if possible. The cleanest sites are often – although not always – those that are in pristine environments, in areas where concentrations of dissolved solids are low, or upstream or upgradient from known or suspected sources of contamination.

RULE OF THUMB: Collect samples first at sites having the least contamination or lowest chemical concentrations.

Table 4-2. Good field practices for collection of water-quality samples

[Modified from "Rules for Trace-Metal Sampling" by Howard Taylor, U.S. Geological Survey, written communication, 1992; NFM, *National Field Manual for the Collection of Water-Quality Data*]

- Be aware of and record potential sources of contamination at each field site.
- Wear appropriate disposable, powderless gloves:
  - Change gloves before each new step during sample collection (and processing).
  - Avoid hand contact with contaminating surfaces (such as equipment, coins, food).
  - Gloved as well as ungloved hands must not contact the water sample.
- Use equipment constructed of materials that are relatively inert with respect to the analytes of interest (NFM 2).
- Use only equipment that has been cleaned according to prescribed procedures (NFM 3).
- Field rinse equipment, but only as directed. Some equipment for organic-compound and other analysis should not be field rinsed.
- Use correct sample-handling procedures:
  - Minimize the number of sample-handling steps.
  - Use Clean Hands/Dirty Hands techniques (table 4-3) as required for parts-per-billion trace-element sampling. Adapt Clean Hands/Dirty Hands techniques for other sample types, as appropriate. Obtain training for and practice field techniques under supervision before collecting water samples.
- Collect (and process) samples in enclosed chambers so as to minimize contamination from atmospheric sources.
- Collect a sufficient number of blanks and other types of quality-control samples.
- Follow a prescribed order for collecting samples.

Table 4-3. Clean Hands/Dirty Hands techniques for water-quality sampling

- Clean Hands/Dirty Hands techniques require two or more people working together.
- At the field site, one person is designated as Clean Hands (*CH*) and a second person as Dirty Hands (*DH*). Although specific tasks are assigned at the start to *CH* or *DH*, some tasks overlap and can be handled by either, as long as the prescribed care is taken to prevent contaminating the sample.
- *CH* and *DH* wear appropriate disposable, powderless gloves during the entire sampling operation and change gloves frequently, usually with each change in task. (Wearing multiple layers of gloves allows rapid glove changes.) **Gloves must be appropriate to withstand any acid, solvent, or other chemical substance that will be used or contacted.**
- *CH* takes care of all operations involving equipment that contacts the sample; for example, *CH*
  - Handles the surface-water sampler bottle
  - Handles the discharge end of the surface-water or ground-water sample tubing
  - Handles the inner protective bag on the churn splitter
  - Transfers sample to churn or cone splitter
  - Prepares a clean work space (inside vehicle)
  - Sets up processing and preservation chambers
  - Places equipment inside chambers (for example, sample bottles, filtration and preservation equipment)
  - Works exclusively inside chambers during collection/processing and preservation
  - Changes chamber covers, as needed
  - Sets up field-cleaning equipment and cleans equipment
- *DH* takes care of all operations involving contact with potential sources of contamination; for example, *DH*
  - Works exclusively exterior to processing and preservation chambers
  - Prepares and operates sampling equipment, including pumps and discrete samplers, peristaltic pump switch, pump controller, manifold system
  - Operates cranes, tripods, drill rigs, vehicles, or other support equipment
  - Handles the compressor or other power supply for samplers
  - Handles tools such as hammers, wrenches, keys, locks, and sample-flow manifolds
  - Handles single or multiparameter instruments for field measurements
  - Handles the churn carrier, including outer protective bags
  - Handles stream-gaging or water-level equipment
  - Sets up and calibrates field-measurement instruments
  - Measures and records water levels and field measurements

Use Clean Hands/Dirty Hands (*CH/DH*) sampling procedures. *CH/DH* procedures were developed for collecting (and processing) samples vulnerable to contamination. *CH/DH* procedures separate field-duty chores and dedicate one individual (designated as Clean Hands or *CH*) to tasks related to direct contact with sample-wetted equipment and sample containers (table 4-3). Implementation of this protocol requires hands-on training and field-team coordination.[4]

- **Requirement:** *CH/DH* procedures are required when collecting samples for analysis of metals and other inorganic trace elements (hereafter referred to collectively as trace elements), as follows:
  - For trace elements with ambient concentrations at or near 1 µg/L.
  - For iron, aluminum, or manganese with ambient concentrations to about 200 µg/L.

- **Recommendation:** *CH/DH* procedures are recommended when collecting samples for analysis of most trace elements with concentrations to about 100 µg/L.

- **Recommendation:** *CH/DH* procedures are recommended when collecting samples for analysis of trace-organic compounds and major inorganic elements, particularly when the target analyte could be subject to contamination from field or laboratory procedures at a level that could exceed data-quality requirements.

[4]A detailed description of Clean Hands/ Dirty Hands techniques for surface-water sampling can be found in Horowitz and others (1994). Clean Hands/Dirty Hands techniques have been incorporated in the procedures for ground-water sampling (refer to section 4.2), equipment cleaning (NFM 3), and sample processing (NFM 5).

Minimize atmospheric contamination. Water bodies that are isolated from the atmosphere or that have dissolved-oxygen concentrations that are substantially less than that of air can be found in surface-water systems (deeper sections of stratified lakes and reservoirs, for example), but are more common in ground-water systems. For such sites, exposure of the sample to the atmosphere can increase dissolved-oxygen concentrations, causing reduced metal ions to oxidize and precipitate as a hydroxide.

Collection of environmental samples from water bodies for which concentrations of dissolved gases differ substantially from atmospheric concentrations might require special field equipment or procedures. Equipment and procedures should be selected that minimize contact with the atmosphere or minimize the effect of pressure changes from the source of the sample to the point of field measurement or sample processing. Sampling methods and equipment for preventing contact of anoxic and suboxic water samples with atmospheric gases are described in section 4.2.2.C.

> **TECHNICAL NOTE:** Exposure of anoxic or suboxic samples to atmospheric oxygen can cause reduced metal ions to oxidize and precipitate as a hydroxide (for example, oxidation of iron species from ferrous (Fe^{+2}) to ferric (Fe^{+3}) iron). Precipitation of an iron (or other metal) hydroxide can occur either before or during sample filtration, thereby lowering concentrations of soluble iron and co-precipitating metals in the sample. Examples of nonmetal analytes for which atmospheric exposure can compromise sample integrity include volatile organic compounds (VOCs), pH, alkalinity, sulfide, chlorofluorocarbons (CFCs), and some bacteria species.

SURFACE-WATER SAMPLING 4.1

The methods used to collect surface-water samples depend not only on flow characteristics of the surface-water body but also on the following considerations: safety of field personnel (NFM 9); suitability of the equipment with regard to the analytes of interest as well as that of the anticipated hydraulic conditions (NFM 2); field-measurement profiles (NFM 6); temporal and spatial heterogeneity; physical setting; ecological characteristics; weather conditions; fluvial-sediment transport; point and nonpoint sources of contamination; and study objectives, including data-quality requirements. Each sampling site needs to be selected and sampled in a manner that minimizes bias caused by the collection process and that best represents the intended environmental conditions at the time of sampling.

- Before beginning field work, USGS study teams should be thoroughly familiar with procedures and requirements described in this *National Field Manual* and in USGS Office of Water Quality Technical Memorandum 99.02.[5] Additional references that provide descriptions of surface-water sampling techniques include: Federal Interagency Sedimentation Project (1986), Ward and Harr (1990), and Edwards and Glysson (1999).
- Study requirements for collection of equipment blanks, field blanks, concurrent samples, and other relevant QC samples must be prepared for before field work begins (section 4.3). Equipment and supplies must be selected that are appropriate for the use intended.
- Ensure that the field team is staffed and equipped adequately. For example, additional personnel and equipment are required for collection of concurrently collected samples (concurrent replicate samples, section 4.3). Use of safety equipment and procedures is mandatory (NFM 9).
- Prior to sample collection, the study team must establish a NWIS site file and field folder for each sampling location (section 4.1.1).

[5]The U.S. Geological Survey (USGS) technical and policy memorandums referenced in this manual are available on the Web; see "Selected References and Documents" for numbered memorandum titles, dates, and the Web address.

4.1.1 SITE FILES

Field personnel are responsible for establishing and maintaining electronic and paper site files and ensuring their accuracy and completeness. The information required for establishing electronic records in NWIS and for creating field folders for surface-water sampling sites is summarized below.

4.1.1.A NWIS Files

USGS policy requires specific information on surface-water sampling sites to be stored in the site file in NWIS (Hubbard, 1992; USGS Water Resources Policy Memorandum 92.59). Site files should be established as soon as the sampling site has been selected. The minimum information required for establishing electronic files in NWIS for surface water is listed in table 4-4. Individual studies and USGS Water Science Center offices may have additional data-storage requirements.

- Results of chemical water analyses are stored in the water-quality file (QWDATA) of NWIS (Gellenbeck, 2005).
- The Automatic Data Processing System (ADAPS) contains continuous records of water levels and water quality (Bartholoma, 2003).

Once the site location has been established:

- Check the NWIS site file before each field trip.
- Update the files promptly after the field trip.
- Fill in information that is needed by, or could be useful to, the study in addition to the information shown on table 4-4. For guidance, refer to "Data Elements for Reporting Water Quality Results of: Chemical and Microbiological Analyses" (http://wi.water.usgs.gov/methods/tools/wqde/, accessed July 7, 2006).
- If real-time data are being served on the Web, ensure that current policies and quality-assurance measures are understood and implemented (USGS Water Resources Policy Memorandum No. 99.34, at http://water.usgs.gov/admin/memo/policy/wrdpolicy99.34.html (accessed July 7, 2006).

Before starting field work:
Make sure that the NWIS file has been established.
After field work:
Input updates to NWIS files promptly and have a second or third party check the input.

Table 4-4. Minimum information required for electronic storage of site and surface-water-quality data in the U.S. Geological Survey (USGS) National Water Information System (NWIS)

[GWSI, Ground-Water Site Inventory; QWDATA, Quality of Water Data]

Required information for creation of a surface-water site in NWIS[1, 2]		
Data description	**Component (C) number for data entry into GWSI**	**Example (Description of code)**
Agency code	C4	USGS
Station Identification Number	C1	11530500
Station Name	C12	Klamath River near Klamath, Calif.
Latitude	C9	413052
Longitude	C10	1235957
USGS Water Science Center /User State	C6	06 (California)
County	C7	06 (California)
Agency Use	C8	015 (Del Norte)
Station Type	C803	A (Active)
	C802	SW

Required information for storage of sample analyses in the water-quality file of NWIS (QWDATA)[1]		
Data description	**Alpha parameter code**	**Sample data (Description of code)**
Agency code	AGNCY	USGS
Station Identification Number	STAID	11530500
Sample Medium	MEDIM	9 (surface water)
Sample Type	STYPE	9 (regular sample)
Hydrologic (“Hydro”) Event	EVENT	9 (routine sample)
Hydrologic (“Hydro”) Condition	HSTAT	9 (stable stage)
Date (year/month/day)	DATES	20070909
Time (standard 24-hour clock time)	TIMES	1530 hrs
Analysis Status	ASTAT	H (initial entry)
Analysis Source	ASRCE	9 (USGS laboratory and field)

[1]Numerous additional data fields are available in NWIS that can be useful for data analysis or mandatory for meeting study objectives; for example, indicating whether a non-USGS agency collected the data.
[2]Modified from Ground-Water Site Inventory Schedule Form 9-1904-A, Revised June 2004, NWIS 4.4.

4.1.1.B Field Folders

Information that is needed for reference while working at a surface-water site is kept in a field folder. The field folder is taken along on each sampling trip. It includes all the information necessary for efficient field operations; for example, directions to and description of the site, safety precautions relevant to the site, and the specifics for sample collection and processing at the site. General contents of the field folder are listed on the field-folder checklist (fig. 4-2), but the folder should be customized according to study needs.

Field-folder checklist: surface-water quality		
✓	Item	Comments
	Station description: • Location of gaging station (if one is present). • Location of sample-collection sites: high and low streamflows. • Hydrologic and geologic sections. • Name of landowner, tenant, or other responsible party. • Site access instructions (for example, call owner or site operator before arrival at site, obtain key to unlock security gate). • Photographs to document site conditions.	
	Maps to site (State and local)	
	Profiles of cross section of stream channel at sampling location(s). • Stream-bottom geometry. • Physical and chemical measurements.	
	Safety information (NFM 9): • Nearest emergency facilities. • Phone numbers (home) of study chief or supervisor. • Traffic condition and traffic plan showing where to park, placement of flags and cones. • Location of power lines. • Environmental hazards, such as weather and animals.	
	Sampling schedule: • Laboratory analyses to be requested and associated codes. • When to collect samples (high or low flow).	
	Bottle types needed for each analytical schedule.	
	Analytical Services Request form(s) and example of a completed form.	
	Sampling instructions: • Cumulative-discharge curves at about 10-, 50-, and 90-percent duration. • Velocity cross sections at about 10-, 50-, and 90-percent duration. • Equipment to use at various flows. • Flow-duration curve. • Discharge rating curves and (or) tables.	
	Shipping instructions: • Amount of ice to use. • Mailing labels to and from laboratory. • Location of nearest post office or shipping agent.	
	Surface-water field form and an example of completed form.	
	A tabulation sheet for each type of bacteria enumerated at the site (include example with date of sample, streamflow, volumes filtered, dilutions, plate counts).	
	Plots of field-measured data (last 5-10 years of record); if there is a good enough relation to show outliers, include: • Conductivity versus streamflow. • Conductivity versus alkalinity. • Temperature versus time.	
	Statistical summary of historical water data: • Seasonal, maximum-minimum values. • Discharge-related maximum-minimum values.	
	Special equipment needed to address site-specific conditions: • Sampling. • Safety.	

Figure 4-2. Checklist for contents of a field folder for surface-water sampling.

4.1.2 SELECTION OF SURFACE-WATER SAMPLING SITES

The study team is responsible for selecting sampling sites, including the specific point(s) or transect(s) at which samples will be collected. The guiding principle for site selection is that data can be collected that accurately represent the intended conditions (such as time of year and flow rate or stage) of the aqueous system being studied with respect to study objectives. Generic guidelines for selecting flowing-water and still-water sites are described in this section.

- Each body of flowing and still surface water has a unique set of conditions that needs to be identified and considered in the site-selection process.
- Field personnel must be trained in the correct and current water-quality data-collection procedures and must exercise judgment gained from field experience to make site selections.
- Careful and complete documentation of site information and the data collected must be input to electronic and paper files.

In most bodies of flowing or still water, a single sampling site or point is not adequate to describe the physical properties and the distribution and abundance of chemical constituents or biological communities. Location, distribution, and number of sampling sites can affect the quality and applicability of the resulting data.

When selecting surface-water sampling sites:

- Consider the study objectives, types of data and quality of data needed, equipment needs, and sampling methods.
- Obtain all available historical information.
- Consider physical characteristics of the area, such as size and shape, land use, tributary and runoff characteristics, geology, point and nonpoint sources of contamination, hydraulic conditions, climate, water depth, and fluvial-sediment transport characteristics.
- Consider chemical and biological characteristics of the area (aquatic and terrestrial).
- Note the types of equipment that will be needed.

4.1.2.A Flowing-Water Sites

Flowing-water sites can refer to streams (fast or slow, intermittent, ephemeral, or perennial), canals, ditches, and flumes of all sizes and shapes, or to any other surface feature in which water moves unidirectionally. All or parts of reservoirs and estuaries that flow unidirectionally are considered to be flowing water. Determine latitude and longitude from maps or by land-survey techniques. Global-positioning system (GPS) equipment is useful to identify sampling-site location.

Flowing-water sampling sites optimally are located:

- At or near a streamgaging station, to obtain concurrent surface-water discharge data required for computing constituent-transport loads and to determine discharge/constituent-concentration relations. (Measure discharge at time of sampling if a streamgaging station is not at or near the sampling site or if discharge cannot be rated or estimated with sufficient accuracy.)
- In straight reaches having uniform flow, and having a uniform and stable bottom contour, and where constituents are well-mixed along the cross section.
- Far enough above and below confluences of streamflow or point sources of contamination to avoid sampling a cross section where flows are poorly mixed or not unidirectional.
- In reaches upstream from bridges or other structures, to avoid contamination from the structure or from a road surface.
- In unidirectional flow that does not include eddies. (If eddies are present within the channel, sample only the unidirectional flow.)
- At or near a transect in a reach where other data are collected (such as data for suspended sediment, bedload, bottom material, or biological material) and (or) for which historical data are available.
- At a cross section where samples can be collected at any stage throughout the period of study, if possible.

After a tentative selection of a sampling site, develop a preliminary profile of field measurements[6] at various locations along the cross section (section 4.1.3.A). Final site selection is based on a comparison of field measurements with the data requirements of the study.

> **TECHNICAL NOTE:** The preferred sampling method and number of verticals to be sampled within the stream cross section that are needed to obtain a sample that is sufficiently representative depends on stream homogeneity as indicated by the field-measurement profile and stream-discharge or other data, as well as by study objectives. Note that the field-measurement profile is a useful guideline, but might not be representative of chemical homogeneity for the analytes of interest. Also, it might be desirable to move to a sampling site upstream or downstream to adjust for seasonal variation or extreme flow conditions.

The guidelines used for selecting sampling sites on ephemeral and intermittent streams are the same as those for perennial streams. Ephemeral and intermittent stream sites need additional planning and examination to account, for example, for conditions related to rapidly changing stage and discharge that can occur as a result of flash flooding or urban runoff.

CAUTION: Any stream, including an ephemeral or intermittent stream, can rapidly become too deep and swift to wade safely.

[6]The profile of the cross section usually includes field measurements for specific electrical conductance (conductivity), pH, temperature, dissolved oxygen, and turbidity.

Still-Water Sites 4.1.2.B

Still-water sites refer to all sizes and shapes of lakes, reservoirs, ponds, swamps, marshes, riverine backwaters, or any other body of surface water where water generally does not move unidirectionally. All or parts of reservoirs that do not flow unidirectionally could be considered to be still water.

When locating still-water sampling sites:

- Use in situ field measurements to help determine vertical and spatial distribution of sampling locations.
- Avoid areas near structures such as harbors, boat ramps, piers, fuel docks, and moored houseboats (to avoid point sources of contamination), unless these structures are part of the study.
- Select sites with a record of historical data, if possible.

SAMPLING AT FLOWING-WATER AND STILL-WATER SITES 4.1.3

Flowing streamwater is collected using either isokinetic, depth-integrating or nonisokinetic sampling methods. At flowing-water sites, collection of an isokinetic, depth-integrated, discharge-weighted sample is standard procedure; however, site characteristics, sampling-equipment limitations, or study objectives constrain how a sample is to be collected and could necessitate use of other methods. If the QC plan calls for collection of concurrent samples, then the relevant procedures and equipment needs (section 4.3) must be reviewed before field work begins.

- Isokinetic, depth-integrating methods (section 4.1.3.A) are designed to produce a discharge-weighted (velocity-weighted) sample; that is, each unit of stream discharge is equally represented in the sample, either by dividing the stream cross section into intervals of equal width (EWI) or equal discharge (EDI) (USGS Office of Water Quality Technical Memorandum 99.02).
  - The analyte concentrations determined in a discharge-weighted sample are multiplied by the stream discharge to obtain the discharge of the analyte.
  - If used correctly and the sample is collected within the limitations of the sampling device being used, the EWI and EDI methods result in samples that have identical constituent concentrations.
- Nonisokinetic sampling methods (section 4.1.3.B), such as those involving use of an automated point sampler, generally do not result in a discharge-weighted sample unless the stream is completely mixed laterally and vertically. Thus, the analytical results cannot be used to directly compute analyte discharges.

Still-water samples generally also are collected at multiple locations in the water body and at multiple depths (section 4.1.3.C). The probability is small that any body of still water (lake, reservoir, pond, lock, storage pool) is relatively homogeneous with regard to any water-quality characteristic. Therefore, a single sampling point generally is not adequate to describe the physical and chemical properties of the water body, or the distribution and abundance of the inhabiting biological community. The number of sampling locations selected and the depths where samples will be collected depend on study objectives and the physical, chemical, and biological characteristics of the water body (Ward and Harr, 1990).

Document the sampling method used on the appropriate field form for each sample.

On-site preparations

When arriving at the field site, take the appropriate measures to avoid sample contamination, such as fumes from traffic or other sources and proper handling and care of sampling equipment. The selection and care of equipment employed for isokinetic and nonisokinetic surface-water sampling are described in NFM 2, while standard USGS equipment-cleaning procedures are detailed in NFM 3. Selection, maintenance, and proper cleaning of sampling equipment are of paramount importance in preventing sample contamination and these protocols should be carefully reviewed and consistently implemented. Only clean equipment should be transported to the field.

Once field work has begun, and before samples are collected, the sample-wetted portions of most of the collection and processing equipment require a field rinse with native water. Field rinsing helps to condition, or equilibrate, sampling equipment to the sample environment. Rinsing also serves to ensure that all cleaning-solution residues have been removed.

- The Clean Hands team member is responsible for field rinsing the equipment whenever *CH/DH* procedures are used.
- The use and field-rinsing procedures are summarized below for sampling devices and for sample-compositing and sample-splitting equipment. Samples for bacteria analysis are not to be taken from a churn splitter unless it has been sterilized as described in NFM 7.1.1, and has no metal parts in the spigot unit.
  - **Churn splitter:** The 14-L churn can be used to split samples with particle sizes 250 µm and suspended-sediment concentrations 1,000 mg/L; however, splitting accuracy becomes unacceptable for particle sizes >250 µm and suspended-sediment concentrations >1,000 mg/L. Sample volumes less than 4 L or greater than 13 L cannot be split for whole-water subsamples. Churn lid requires a covered opening. To split a sample into subsamples for nonvolatile organic-compound analyses, use a Teflon-coated churn.
  - **Cone splitter:** Used to process samples with suspended-sediment concentrations from 0 to 10,000 mg/L, and to split samples containing sediment particles ranging in size from very fine clay and silt (1 to 10 µm) to sand-size particles (250 µm). Samples as small as 250 mL can be split into 10 equal subsamples. A Teflon cone splitter can be used to process samples with volume greater than 13 L and samples to be analyzed for inorganic constituents and nonvolatile organic compounds.

To field rinse a bottle sampler or bag sampler:

1. Put on appropriate disposable, powderless gloves (gloves).
2. Partially fill and rinse the sampler with the water to be sampled (rinse water).
   - Avoid getting sand in the rinse water.
   - To avoid suspended sand particles, collect water for rinsing at the edge of the stream in an area of low-flow turbidity.
3. Shake or swirl and then drain the rinse water from the sampler through the nozzle.
4. **For bag samplers** – the bag must be removed from the sampler to properly discard the final rinse water.
   a. Fill the bottom of the bag with approximately 100 to 200 mL of sample.
   b. Gently pull the bag into a tube-like shape and loosely fold over the top opening.
   c. Slosh the sample water back and forth from the bottom to the top of the bag.
   d. Keeping the bag in a tube-like shape, hold it horizontally and rotate it, making sure that the water flows into all of the folds of the Teflon® bag.

To field rinse a churn splitter:

1. Put on gloves.
2. Pour 2 to 4 L of rinse water from the sampler into the churn splitter (churn) through the top funnel.
3. Remove the churn from the churn carrier, leaving the outer plastic bag inside the carrier. Move the churn disk up and down several times to ensure that the inside of the churn is thoroughly wetted, then swirl the rinse water vigorously in the churn.
4. Pierce a hole through the inner plastic bag to expose the churn spigot and drain the rinse water through the spigot. **If sand is present**, swirl water vigorously in the churn, open the plastic bag, and partially lift the churn cover to pour the rinse water out of the top of the churn. (Draining the rinse water through the spigot will not adequately remove sand.)
5. After draining the rinse water from the churn, rotate the churn in the plastic bag so that the spigot is not exposed. Place the inner plastic bag holding the churn into an outer plastic bag and place into the churn carrier.

To field rinse the cone splitter:

1. Put on gloves.
2. Uncover the splitter reservoir and pour or pump 2 to 4 L of rinse water into the cone-splitter reservoir, one liter at a time.
3. Lightly tap the splitter to dislodge adhering water drops. Discard rinse water.
4. Cover the splitter.

Isokinetic, Depth-Integrated Sampling Methods at Flowing-Water Sites 4.1.3.A

Collection of isokinetic, depth-integrated samples involves using either an equal-width-increment (EWI) orequal-discharge-increment (EDI) sampling method. The EWI or EDI methods usually result in a composite sample that represents the discharge-weighted concentrations of the stream cross section being sampled.

The EWI and EDI methods are used to divide a selected cross section of a stream into increments having a specified width. The term vertical refers to that location within the increment at which the sampler is lowered and raised through the water column.

- EWI verticals are located at the midpoint of each width increment.
- EDI verticals are located at the centroid, a point within each increment at which stream discharge is equal on either side of the vertical.

If properly implemented, EDI and EWI methods should yield identical results. The uses and advantages of each method are summarized below and in table 4-5. Isokinetic samplers usually are used to obtain a discharge-weighted sample along the stream cross section. **When using an isokinetic sampler there should be no change in velocity (speed and direction) as the sample enters the intake** (fig. 4-3).

Table 4-5. Uses and advantages of equal-width-increment (EWI) and equal-discharge-increment (EDI) sampling methods

EWI method	Advantages of the EWI method
EWI is used when information required to determine locations of sampling verticals for the EDI method is not available, and (or) the stream cross section has relatively uniform depth and velocity. **Use EWI whenever:** • The location of EDI sampling verticals changes at the same discharge from one sampling time to another. This situation occurs frequently in streams with sand channels.	• EWI method is easily learned and implemented for sampling small streams. • Generally, less time is required onsite if the EWI method can be used and the information required to determine locations of sampling verticals for the EDI method is not available.
EDI method	**Advantages of the EDI method**
EDI is used when information required to determine locations of sampling verticals for the EDI method is available. **Use EDI whenever:** • Small, nonhomogeneous increments need to be sampled separately from the rest of the cross section. The samples from those verticals can be analyzed separately or appropriately composited with the rest of the cross-sectional sample. (Have the sampling scheme approved.) **or** • Flow velocities are less than the isokinetic transit-rate range requirement. A discharge-weighted sample can be obtained, but the sample will not always be isokinetic. **or** • The EWI sampling method cannot be used. For example, isokinetic samples cannot be collected because stream velocities and depths vary so much that the isokinetic requirements of the sampler are not met at several sampling verticals. **or** • Stage is changing rapidly. (EDI requires less sampling time than EWI, provided the locations of the sampling verticals can be determined quickly.)	• Fewer increments are necessary, resulting in a shortened sampling time (provided the locations of sampling verticals can be determined quickly and constituents are adequately mixed in the increment). • Sampling during rapidly changing stages is facilitated by the shorter sampling time. • Subsamples making up a sample set may be analyzed separately or may be proportionally composited with the rest of the cross-sectional sample. • The cross-sectional variation in constituent discharge can be determined if subsample bottles are analyzed individually. • A greater range in velocity and depths can be sampled isokinetically at a cross section. • The total composite volume of the sample is known and can be adjusted before sampling begins.

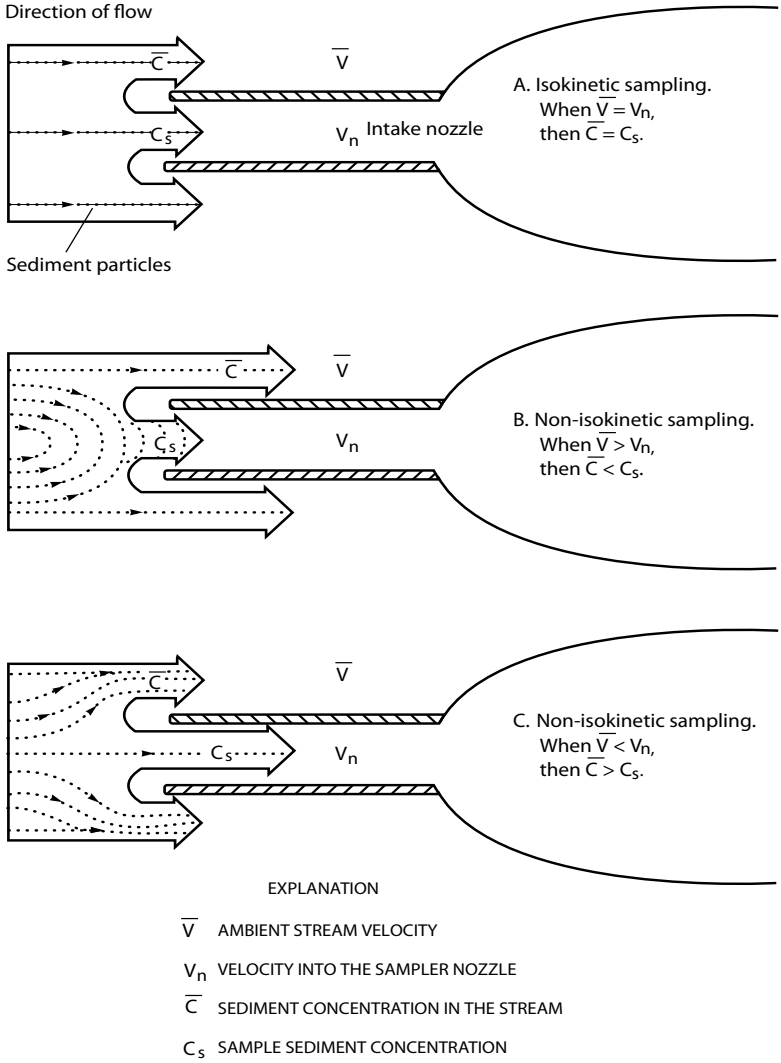


Figure 4-3. Relation between intake velocity and sediment concentration for isokinetic and nonisokinetic collection of water samples that contain particulates greater than 0.062 millimeters (modified from Edwards and Glysson, 1999, p. 14).

- Collect isokinetic, depth-integrated samples by using a standard depth- and width-integrating method if analysis of a representative sample from a cross section of flowing water is required for discharge computations. Appendix A4-A and Edwards and Glysson (1999, figures 39-43), provide detailed information about isokinetic, depth-integrating transit rates for collecting samples.
- For isokinetic sampling, the mean velocity of the vertical that is sampled must exceed the minimum-velocity requirement of an isokinetic sampler—the minimum velocity requirements are 1.5 ft/s for a bottle sampler, 2 ft/s for a 1- or 3-liter bag sampler, or 3 ft/s for a 6-liter bag sampler (Appendix A4-A).
  - The transit rate (the rate at which the sampler is lowered or raised) used to collect an isokinetic, depth-integrated sample is mainly a function of the nozzle diameter of the sampler, volume of the sampler container, stream velocity, and sampling depth (Appendix A4-A). The maximum allowable transit rate for a bag sampler is 0.4 multipied by the mean stream velocity.
  - An error in concentrations of suspended particulates coarser than 62 mm can be important when the velocity of the sample entering the nozzle and the stream velocity differ significantly. Too fast a transit rate will cause a sampler to undersample sand-sized particulates (Edwards and Glysson, 1999).
  - The transit rate must be kept constant during sampler descent through a vertical and also during sampler ascent through a vertical.

The number of increments needed in order to get a discharge-weighted sample at a site is related primarily to data objectives (for example, the accuracy needed) and how well-mixed or heterogeneous the stream is with respect to the physical, chemical, and biological characteristics of the cross section. The recommended number of increments for EWI and EDI methods are discussed in the sections to follow. Edwards and Glysson (1999) describe a statistical approach for selecting the number of increments to be used, based on sampling error and suspended-sediment characteristics.

Selecting the number of increments

- Examine the variation in field-measurement values (such as specific electrical conductance, pH, temperature, and dissolved oxygen) along the cross section (NFM 6).
- Consider the distribution of streamflow (discharge), suspended-materials concentration and particle-size distribution, and concentrations of other targeted analytes along the cross section. Consider whether the streamflow distribution or analyte concentrations will change during sample collection.
- Consider the type of sampler that will be used and the volume of sample that will have to be collected for the analysis of the target analytes.
- Avoid side-channel eddies. EDI and EWI methods cannot be used at locations with upstream eddy flow.

RULE OF THUMB: For isokinetic, depth-integrating sampling, do not exceed the designated maximum transit rate.

Equal-width-increment (EWI) method

For the EWI sampling method, the stream cross section is divided into a number of equal-width increments (fig. 4-4). Samples are collected by lowering and raising a sampler through the water column at the center of each increment. (This sampling location is referred to as the vertical.) The combination of the same constant transit rate used to sample at each vertical and the isokinetic property of the sampler results in a discharge-weighted sample that is proportional to total streamflow.

- **Isokinetic sampling is required for the EWI method.** Use isokinetic, depth-integrating sampling equipment (NFM 2.1.1.A).
  - **Use the same size sampler container (bottle or bag) and nozzle** at each of the sampling verticals (fig. 4-4).
  - **Collect samples using the same transit rate** at each vertical during descent and ascent of the sampler. The transit rate must be constant and within the operational range of the sampler (Appendix A4-A).
- Composite the subsamples from all verticals in a churn splitter or process subsamples through the cone splitter (NFM 2.2.1 and NFM 5.1.1).

Do not use EWI when stream velocities are less than the minimum velocity required for the isokinetic sampler selected:

1.5 ft/s for the bottle sampler.

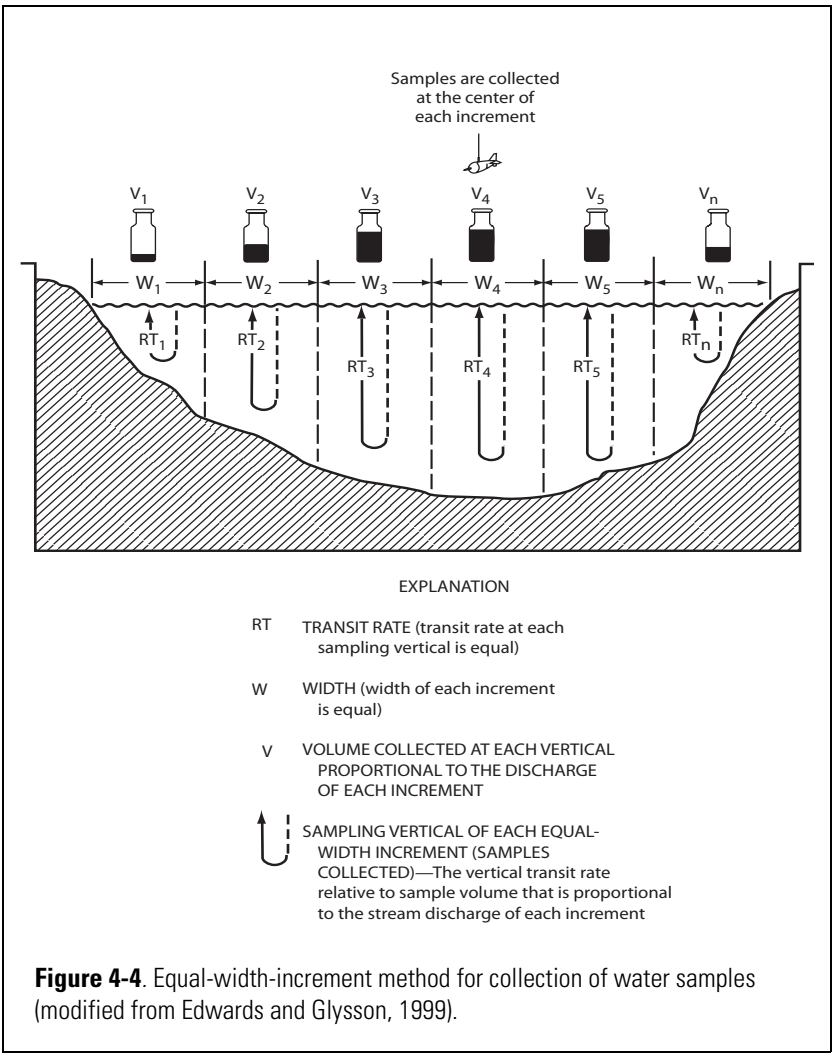
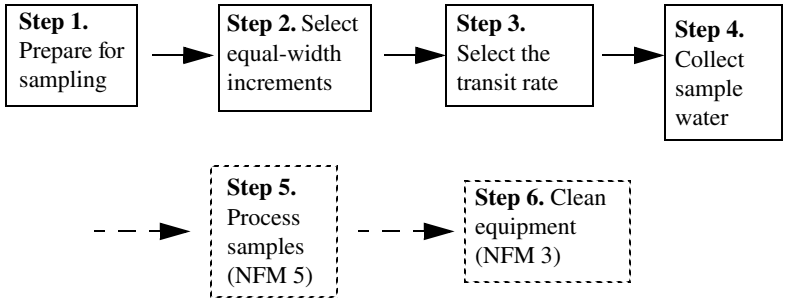


Figure 4-4. Equal-width-increment method for collection of water samples (modified from Edwards and Glysson, 1999).

Steps for the EWI sampling method



Be sure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies.

Step 1. Prepare for sampling[7]

a. Upon arrival at the field site, set out safety equipment such as traffic cones and signs. Park vehicle in a location and direction so as to prevent sample contamination from vehicle emissions.

b. Assemble sampling equipment and set up a clean work space.

- **Organic compounds**. Select equipment with fluorocarbon polymer, glass, or metal components if components will directly contact samples to be analyzed for organic compounds. **Do not use plastics other than fluorocarbon polymers.**
- **Inorganic constituents**. Select equipment with components made of fluorocarbon polymer or other relatively inert and uncolored plastics or glass if components will directly contact samples to be analyzed for inorganic constituents. **Do not use metal or rubber components for trace-element sampling.**
- **Microbiological analyses**. Collect samples for microbiological analyses using equipment and techniques described in NFM 7.

[7]Preparations for water sampling are described in NFM 2 and 3. Consult NFM 5 for sample processing, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material sampling, and NFM 9 for field safety.

Step 2. Select the number and width of equal-width increments.

a. Visually inspect the stream from bank to bank and longitudinally, observing velocity, width, and depth distribution, and apparent distribution of sediment and aquatic biota along the cross section. Note and document the location of stagnant water, eddies, backwater, reverse flows, areas of faster than normal flow, and piers or other features along the cross section.

b. Determine stream width from a tagline or from distance markings on a bridge railing or cableway.

c. At sites with little sampling history, measure and record the cross-sectional variation of field measurements (such as specific electrical conductance, pH, temperature, and dissolved oxygen). Review the magnitude of the variations along the cross section.

d. Determine the width of the increment. To obtain the number of increments, divide the stream width by the increment width. **The number of increments must be a whole number**. Increment width is based on study objectives, variation in field measurements and flow, and stream-channel characteristics along the cross section.

   - Collect the subsample at the center of each equal-width increment (the vertical).
   - If the subsample does not represent the mean value for that increment, decrease the increment width until the mean value for the increment is represented. This will increase the number of increments sampled.

e. Locate the first sampling vertical at a distance of one-half of the selected increment width from the edge of the water. Locate all the other verticals at the center of each remaining equal-width increment along the cross section.

   Example:

   - If a stream 56 ft wide has been divided into 14 increments of 4 ft each, the first sampling vertical would be 2 ft from the water's edge and subsequent verticals would be at 6, 10, 14 ft from the water's edge, and so forth.
   - Even if streamflow is divided, as in a braided channel, equal-width increments must be identical from channel to channel, and the same constant transit rate must be used at each vertical.

f. Make slight adjustments to sampling locations, if necessary, to avoid sampling where the flow is affected by a pier or other obstruction.

TECHNICAL NOTE: Sampling near or downstream from large in-stream obstructions such as bridges and piers could result in artificially elevated concentrations of suspended sediments if the sampler is immersed in an eddy that is caused by the obstruction. If it is necessary to include an eddy in the cross section to be sampled, consider treating the eddy as a solid obstruction: subtract the eddy width from that of the total cross section, and determine the width of the increments based on the remaining stream width.

RULE OF THUMB

When selecting the number of equal-width increments:

- Cross-sectional width ≥ 5 ft—use a minimum of 10 equal-width increments
- Cross-sectional width <5 ft—use as many increments as practical, but equally spaced at a minimum of 3 inches apart.

Equipment limitations also constrain the number of increments selected; for example:

- When using a 1-L bottle sampler at maximum depth with a 14-L churn splitter, EWI samples can be collected at no more than 14 to 17 verticals.
- If an 8-L churn splitter is used, samples can be collected at no more than 10 verticals.
- A cone splitter must be used if the total volume collected will exceed the recommended volume for the churn splitter.

Step 3. Select the transit rate.

a. Refer to Appendix A4-A for guidelines for determining the transit rates for collecting isokinetic, depth-integrated samples. Unless the mean velocity is actually determined, use the trial-and-error method to determine the minimum transit rate.

b. Locate the equal-width increment containing the largest discharge (largest product of depth times velocity) by sounding for depth and either measuring or estimating velocity. At the vertical for this increment, use of the minimum transit rate results in the maximum allowable filling of the sampler bottle or bag during one vertical traverse.

c. Determine the minimum transit rateat this vertical for the type of sampler (bottle or bag), size of sampler nozzle, and the desired sample volume.

- Approximate the mean velocity of the vertical in feet per second by timing a floating marker (such as a peanut) as it travels a known distance. (A known length of flagging tape tied to the cable where the sampler is attached often is used to measure the distance.) Divide the distance (in feet) by the time (in seconds) and multiply by 0.86.
- Make sure that the transit rate does not exceed the maximum allowable transit rate to be used at any of the remaining verticals along the cross section. This can be determined by sampling the slowest increment. **If the minimum volume of sample (relative to depth of the vertical) is not collected at this vertical, then the EWI method cannot be used at this cross section to collect a discharge-weighted sample (Appendix A4-A).**
- Remember that you must keep the transit rate unidirectional, constant, and within the isokinetic transit range of the sampler when collecting isokinetic samples at each centroid.

Guidelines for selecting the transit rate for EWI sampling

- The descending and ascending transit rate must be constant in each direction and must be the same for each vertical along the cross section.
- **Do not exceed the maximum allowable transit rate if using EWI.** If the transit rate must exceed the maximum allowable rate, use EDI instead of EWI.
- The transit rate selected must be sufficiently rapid to keep from overfilling the sampler. The sampler is overfilled when the water surface in the sampler container is above the bottom edge of the nozzle when the sampler is held in the sampling position.
- The same size sampler nozzle and container must be used at all verticals along the cross section.
- If the total volume collected will exceed the recommended volume for the churn splitter, then a cone splitter must be used.

Step 4. Collect sample water.

The sample-collection procedure is the same whether you are wading or using the reel-and-cable suspension method. When sampling from a bridge, deploy the sampler from the upstream of the bridge, if possible, to avoid bridge-related contamination of the sample. **Use *CH/DH* techniques, as required (section 4.0.2). Always follow safety procedures (NFM 9)**.

a. Move to the first vertical (midpoint of first EWI near edge of water) and field rinse equipment (section 4.1.3). Collect the rinse water at the edge of the stream in a section of low stream velocity to minimize including suspended sediment.

b. Record start time and gage height.

c. Lower field-rinsed sampler at the predetermined constant transit rate until slight contact is made with the streambed. **Do not pause** upon contacting the streambed. Raise the sampler immediately at the same constant transit rate until sampler completes the vertical traverse.

   - Take care not to disturb the streambed by bumping the sampler on it; bed material may enter the nozzle, resulting in erroneous data.
   - Do not overfill the sampler container. Overfilling results in a sample that is not isokinetic and that could be enriched with heavy particulates because of secondary circulation of water through the sampler (from nozzle through air exhaust). This enrichment will result in an artificially increased sediment concentration and will bias particle-size distribution toward heavier and larger particulates.
   - Do not underfill the sampler container (Appendix A4-A). Underfilling will result in a sample that is not isokinetically collected because the maximum transit rate has been exceeded.
   - If the required volume cannot be collected, use the EDI method to obtain discharge-weighted samples.

d. Inspect each subsample as it is collected, looking for overfilling or underfilling of the sampler container and (or) the presence of anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection. **If you note any of these conditions, discard the sample, making sure there are no residual particulates left in the container, and resample.**

e. Move sampling equipment to the next vertical. Maintain the selected transit rate. The volume of the subsample can vary considerably among verticals. Subsamples can be collected at several verticals before emptying the sampler container, as long as the maximum volume of sample in a bottle or bag sampler has not been exceeded. If the container is overfilled, it is necessary to resample.

> **TECHNICAL NOTE:** The tables in Appendix A4-A apply to the first complete round-trip transit, starting with an empty sampler container. These tables cannot be used if the sampler is not emptied between verticals.

f. Continue to the next vertical until no more samples can be collected without overfilling the sampler container. Empty the subsample into a field-rinsed churn or cone splitter and repeat sample collection in the same manner until subsamples have been collected at all the verticals.

- If the total volume of the subsamples to be collected will exceed the operational capacity of the churn, select from the following options: use a smaller nozzle; or, use a cone splitter; or, use the EDI method, if appropriate.
- To ensure that all particulates are transferred with the sample, swirl the subsample gently to keep particulates suspended and pour the subsample quickly into the churn or cone splitter.
- Sample EWI verticals as many times as necessary to ensure that an adequate sample volume is collected as required for analysis, **but sample at each vertical an equal number of times.** (The composite cross-sectional sample will remain proportional to flow at the time of sampling.)
- If flow is stable during sampling, then multiple samples can be collected at each vertical during a single traverse along the cross section. If flow is changing, however, study objectives should determine whether to collect multiple samples at each vertical during a single traverse or to collect one sample at each vertical during multiple traverses along the cross section. Document on field forms the method used.

g. Record the following information after all samples have been collected:

- Sampling end time.
- Ending gage height.
- All field observations and any deviations from standard sampling procedures.

Step 5. Process Samples → Refer to NFM 5.

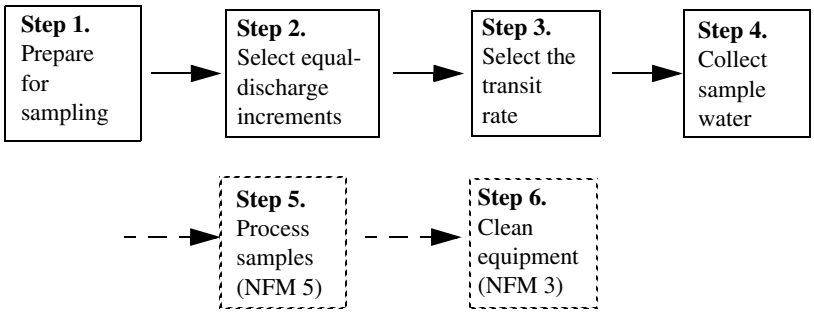
Step 6. Clean Equipment → Refer to NFM 3.

- If the sampler will not be reused during a field trip, rinse sampler components with deionized water before they dry and place them into a plastic bag for transporting to the office laboratory to be cleaned.
- If the sampler will be reused during the field trip, rinse the components with DIW while still wet from sampling and then field-clean while at the sampling site using the prescribed procedures (NFM 3). Reassemble the sampler.
- Collect a field blank, if required, after sampling equipment has been cleaned at the sampling site.
- Place the cleaned sampler into a plastic bag and seal for transport to the next site.

Equal-discharge-increment (EDI) method

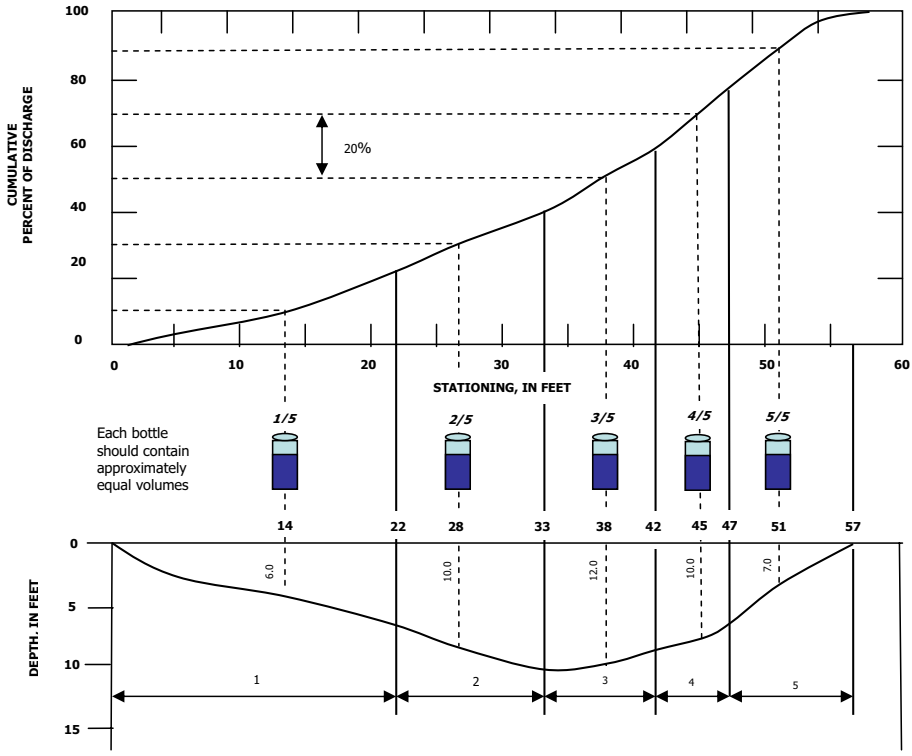
The objective of the EDI method is to collect a discharge-weighted sample that represents the entire flow passing through the cross section by obtaining a series of samples, each representing equal volumes of stream discharge. The EDI method requires that flow in the cross section be divided into increments of equal discharge. Equal-volume, depth-integrated samples are collected at the centroid of each of the equal-discharge increments along the cross section (fig. 4-5). Centroid is defined as that point in the increment at which discharge is equal on both sides of the point.

Steps for the EDI sampling method



Be sure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies.

Example: Sampler D95; nozzle size 3/16 inches ID (inside diameter); 1-liter sampler bottle; width, 57 feet; maximum depth, 12 feet; maximum velocity, 6.1 feet per second (ft/s); width of section containing 20 percent of flow is variable, 5 to 22 feet; 20 percent of flow per section will give 5 sampling verticals; transit rate variable, 0.2 to 0.8 ft/s.



Sampling vertical/ bottle number	Percent discharge	Increment centroid from left edge of water, in feet	Increment depth, in feet	Mean velocity, in feet per second	Transit rate to give 800 milliliters, in feet per second
1/5	20	14	6	2.5	0.2
2/5	20	28	10	3.0	0.4
3/5	20	38	12	3.1	0.5
4/5	20	45	10	6.1	0.8
5/5	20	51	7	4.8	0.5

Figure 4-5. Equal-discharge-increment method for collection of water samples (modified from Bruce Ringen, U.S. Geological Survey, written commun., 1978).

Step 1. Prepare for sampling for inorganic and organic analytes.[8]

a. Upon arrival at the field site, set out safety equipment such as traffic cones and signs. Park vehicle in a location and direction so as to prevent sample contamination from vehicle emissions.

b. Assemble equipment needed and set up a clean work space.

- **Organic compounds**. Select equipment with fluorocarbon polymer, glass, or metal components if components will directly contact samples to be analyzed for organic compounds. **Do not use plastics other than fluorocarbon polymers.**
- **Inorganic constituents**. Select equipment with components made of fluorocarbon polymer or other relatively inert and uncolored plastics or glass if components will directly contact samples to be analyzed for inorganic constituents. **Do not use metal or rubber components for trace-element sampling.**
- **Microbiological analyses**. Collect samples for microbiological analyses using equipment and techniques described in NFM 7.

Step 2. Select the number and location of equal-discharge increments.

The number and location of equal-discharge increments should not be determined arbitrarily. Selection of increments for a sampling site is governed by factors described in a, d, and e below.

a. Visually inspect the stream from bank to bank, observing velocity, width, and depth distribution, as well as apparent distribution of sediment and aquatic biota along the cross section. Document location of stagnant water, eddies, backwater, reverse flows, areas of faster than normal flow, and piers or other obstructions along the cross section.

b. Determine stream width from a tagline or from distance markings on bridge railings or on a cableway.

[8]Preparations for water sampling are described in NFM 2 and 3. Consult NFM 5 for sample processing, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material sampling, and NFM 9 for field safety.

c. At sites with little sampling history—measure, record, and review the cross-sectional variation of field measurements (for example, specific electrical conductance, pH, temperature, and dissolved oxygen).

d. Measure discharge at the cross section to be sampled or use an existing EDI graph prepared from current or historical discharge measurements (fig. 4-5) (Edwards and Glysson, 1999). An existing EDI graph can be one prepared for the site that shows, for example, cumulative discharge or cumulative percent of discharge versus stationing.

e. Determine volume of discharge that will be represented in each EDI, based on data objectives for the study, variation in field measurements, flow and stream-channel characteristics along the cross section, and volume of sample required for analyses of target analytes.

f. Divide the cross section into equal-discharge increments.

- When determining the number of increments to be sampled, keep in mind that the subsample collected at the centroid of each EDI must represent the mean streamflow measured for that increment. If mean streamflow for the increment is not represented, increase the number of increments by decreasing the volume represented by each discharge increment until the mean streamflow value for the increment is represented.
- As a guide, a minimum of 4 sampling increments is recommended; the number of increments is usually less than 10.

g. Determine the location of the centroid of flow within each increment from the discharge measurement by (1) constructing a curve using cumulative discharge or cumulative percentage of discharge (fig. 4-5) plotted against cross-section stationing, or (2) determining EDI locations directly from the discharge measurement sheet (fig. 4-6; an explanation of this method and definition of midpoint are described in Edwards and Glysson, 1999). Centroid-of-flow locations also can be determined from an EDI graph, as described below and in the TECHNICAL NOTE that follows the example below.

Station: 11482500 Redwood Creek at Orick, CA

Far-Mid Point	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	Velocity: At point	Velocity: Mean in vertical	Adjusted for hor. angle or	Area	Discharge: Q	Discharge: ΣQ	
4	0	4	0	.6	LEW		0			0	0	0	
12	8	8	1.00		30	47	1.41			8.0	11.3	11.3	
20	16	8	1.80		30	44	1.51			14.4	21.7	33.0	
28	26 24	8	2.00		50	44	2.50			16.0	40.0	73.0	62.2
36	32	8	2.00		60	45	2.92			16.0	46.7	119.7	
44	40	8	2.30		50	48	2.29			18.4	42.1	161.8	
52	50 48	8	2.25		40	44	2.00			18.0	36.0	197.8	186.6
60	56	8	2.25		40	40	2.20			18.0	39.6	237.4	
68	64	8	2.30		40	40	2.20			18.4	40.5	277.9	
76	74 72	8	2.30		50	45	2.44			18.4	44.9	322.8	311.0
84	80	8	2.20		40	45	1.96			17.6	34.5	357.3	
92	88	8	2.00		40	43	2.05			16.0	32.8	390.1	
100	96	8	1.90		50	47	2.34			15.2	35.6	425.7	
108	102 104	8	2.00		40	42	2.10			16.0	33.6	459.3	435.4
116	112	8	2.00		40	40	2.20			16.0	35.2	494.5	
124	120	8	1.90		30	43	1.54			15.2	23.4	517.9	
132	128	8	1.80		40	40	2.20			14.4	31.7	549.6	
140	134 136	8	1.70		50	44	2.50			13.6	34.0	583.6	559.8
148	144	8	1.60		50	44	2.50			12.8	32.0	615.6	
156	152	8	1.00		20	54	.827			8.0	6.6	622.2	
160	160	4	0	.6	REW		0			0	0	622.2	
	160	160								290.4	622.2		

EDI Centroid Location — EDI Cumulative Discharge

Figure 4-6. Example of discharge-measurement field notes used to determine the equal-discharge-increment centroid locations based on cumulative discharge and far-midpoint stationing (from Edwards and Glysson, 1999, p. 45).

Example:

In this example, each EDI equals 20 percent of discharge.

i. If the stream cross section will be divided into five equal-discharge increments, divide stream discharge by five to determine the discharge increment.

ii. Locate the centroid of the initial EDI where cumulative discharge equals half the discharge increment (10 percent). This is the location of the vertical from which the first subsample is collected.

iii. Locate each of the remaining centroids (four in this example) by adding the discharge increment (20 percent) to the previous centroid discharge (20 + 10 = 30) and determining where that cumulative discharge occurs along the cross section.

iv. The EDI centroids will correspond to locations of 10, 30, 50, 70, and 90 percent of the cumulative discharge along the cross section. In figure 4-5, these percentages of cumulative discharges correspond to locations at 14, 28, 38, 45, and 51 ft from the left edge of the water, whereas in figure 4-6, the centroid locations of the equal-discharge increments are at 26, 50, 74, 102, and 134 ft.

TECHNICAL NOTE: If the stream channel is stable at the cross section to be sampled, graphs of cumulative discharge or percentage cumulative discharge at various stages can be based on historical discharge measurements. Location of EDI centroids can be determined from these EDI graphs so that discharge measurements do not have to be made before each sampling. Linear interpolation based on discharge can be made between curves for different discharges on the EDI graphs. **EDI graphs require periodic verification by being compared to recent discharge measurements.**

Step 3. Select the transit rate.

a. Determine the sampling depth and the mean stream velocity at the centroid of each equal-discharge increment.

b. Determine the transit rate for each centroid that will yield subsamples with approximately the same volume (within 10 percent) using sampling depth, mean stream velocity, and information in Appendix A4-A. When compositing subsamples, the minimum volume for every equal-discharge increment is the minimum volume for the deepest vertical.

Guidelines for selecting the transit rate for EDI sampling

- Collect samples of equal volumes at each centroid. This is required for EDI if the sample will be composited (fig. 4-5). Generally, transit rates vary from centroid to centroid in order to collect equal volumes.
- Keep the transit rate unidirectional, constant, and within the isokinetic transit range of the sampler when collecting isokinetic samples at each centroid.
- **Do not exceed the maximum transit rate** (Appendix A4-A). The maximum transit rate will be exceeded if the minimum sample volume associated with stream velocity and the selected nozzle and bottle size is not collected. Exceeding the maximum transit rate will affect the concentration of particulates ≥ 0.062 millimeters.

Step 4. Collect sample water.

The procedures are the same whether you are wading or using a reel-and-cable suspension method. **Use *CH/DH* techniques, as required (section 4.0.2), and implement safety procedures (NFM 9).**

- Collect microbiological samples using equipment and techniques as described in NFM 7.
- Collect subsamples at EDI centroids as many times as necessary to ensure collection of sufficient sample volume for analysis. If the sample is to be composited, care must be taken to obtain approximately the same total volume (± 10 percent) from each EDI centroid so that the composited cross-sectional sample will be proportional to flow at the time of sampling.
- Stay within the isokinetic transit-rate range of the sampler at each centroid. If flow velocity is less than the isokinetic transit-rate range of the sampler, a discharge-weighted sample still can be obtained by collecting equal volumes at each centroid; however, this sample will not be isokinetic.

  a. Move sampling and support equipment to the centroid of the first increment to be sampled. Field rinse the sampling equipment (section 4.1.3). Collect the rinse water at the edge of the stream in a section of low stream volocity, to minimize including suspended sediment.

  b. Read and record the starting gage height. Record sampling start time.

c. Lower the sampler at the predetermined transit rate until slight contact is made with the streambed.

   - **Do not pause upon contacting the streambed.** Raise the sampler immediately at a constant transit rate to complete the vertical traverse. The descending transit rate does not have to equal the ascending transit rate, but each rate must be unidirectional, constant, and within the isokinetic transit range of the sampler.
   - Take care not to disturb the streambed with the sampler. Disturbing the streambed could cause bed material to enter the nozzle, resulting in erroneous data.
   - Ensure that the sampler container has not overfilled. Overfilling will result in enrichment of the sample with heavy particulates due to secondary circulation of water through the sampler (from nozzle through air exhaust). This enrichment will result in an artificially increased sediment concentration and will bias particle-size distribution towards heavier and larger particulates.

d. Inspect each subsample, looking for overfilling and (or) the presence of anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection. If you note either or both of these conditions, discard the sample, making sure there are no residual particulates left in the container, and resample.

e. Ensure that the sampler container is not underfilled (that the minimum volume indicated in Appendix A4-A has been collected). Underfilling will result in a subsample that is not isokinetically collected—usually because the maximum transit rate has been exceeded.

f. Depending on study objectives, either process and (or) analyze the subsample collected at the initial centroid as a separate sample, composite this subsample with other subsamples collected along the cross section, or split the subsample for further processing.

   - If the total volume of the subsamples that will be collected will exceed the operational capacity of the churn or cone splitter, decrease the number of increments or use a smaller nozzle.
   - Ensure that all particulates in the sampler bottle or bag are transferred with the sample by swirling the sample gently to keep particulates suspended, and quickly pouring the sample into the churn or cone splitter.

g. Move equipment to the next vertical.

- Determine the transit rate for this vertical. If the subsamples are composited, the total volume collected at each centroid must be equal.
- Repeat procedures, steps 4 c-f.
- Repeat this process at the remaining verticals along the cross section.

h. Record the following information after all samples have been collected:

- Sampling end time.
- Ending gage height.
- All field observations and any deviations from standard sampling procedures.

Step 5. Process samples → Refer to NFM 5.

Step 6. Clean equipment → Refer to NFM 3.

- If the sampler will not be reused during a field trip, rinse the components with deionized water before they dry and place them into a plastic bag for transport to the office laboratory to be cleaned.
- If the sampler will be reused during the field trip, rinse the components with deionized water while still wet from sampling, and then follow the prescribed cleaning procedures while at the sampling site (NFM 3). Reassemble the sampler.
- Collect a field blank, if required, after sampling equipment has been cleaned at the sampling site.
- Place cleaned sampler into a plastic bag and seal for transport to the next site.

Single vertical at centroid-of-flow (VCF) method

Samples may be collected at a single vertical at the centroid of streamflow if the section is known to be well mixed laterally and vertically with respect to concentrations of target analytes.

The VCF method for collecting water samples is identical to the EDI method except that there is one centroid of flow for the stream cross section and therefore only one vertical is sampled.

EDI and EWI methods are preferred for most USGS field applications. Do not use VCF unless you know your stream section to be well mixed with respect to your target analytes.

Guidelines for using the VCF method:

1. Measure discharge along the cross section where sampling is to be done. (This is not necessary if the section is stable and accurate historical discharge measurements are available.)
2. Locate the centroid of flow from the discharge measurement.
   - Either (a) construct an EDI graph using cumulative discharge or cumulative percentage of discharge plotted against cross-section stationing (for example, in fig. 4-5, the centroid location is station 38, which corresponds to 50 percent of cumulative flow), or (b) determine centroid location directly from the discharge measurement sheet (for example, in fig. 4-6, the centroid location is station 74).
   - EDI graphs of cumulative discharge at various stages can be based on historical discharge measurements if the stream channel is stable at the cross section to be sampled. The location of centroids can be determined from these EDI graphs so that discharge measurements do not have to be made before each sampling. **EDI graphs require periodic verification.**
3. Examine the cross section for uniformity of appearance.
4. Measure the cross-sectional variation of field measurements (such as specific electrical conductance, pH, temperature, and dissolved oxygen) at sites with little sampling history. Record and review variations along the cross section.
5. Evaluate data from steps 1–4 to decide if the VCF method is appropriate. Use either the EDI or the EWI sampling method if streamflow, field-measurement, or chemical-analysis data do not confirm that the stream section is well mixed vertically and laterally.
6. If the VCF method is used, follow steps 3 and 4 of the instructions for the EDI method for selecting transit rate and collecting samples.
7. **Process samples** → Refer to NFM 5.
8. **Clean equipment** → Refer to NFM 3, and to the information under Step 6 in either the preceding EDI or EWI methods.

4.1.3.B Nonisokinetic (Dip, Discrete, and Pump) Sampling Methods at Flowing-Water Sites

Most nonisokinetic samplers cannot be used to collect representative discharge-weighted samples from streams transporting sand-size or larger particulates. These samplershave important uses for unattended stream sampling and for sampling to determine constituent occurrence and distribution, but they have limited value for collecting samples used to calculate constituent discharge.

Guidelines for nonisokinetic sampling methods

Use nonisokinetic sampling methods when:

- Velocity of flow is so high that an isokinetic sampler cannot be lowered through the vertical properly and safely.
- Extreme low-flow conditions render use of an isokinetic sampler impractical. For example, when water depth is equal to or less than that of the unsampled zone or when stream velocity is less than the minimum velocity requirement for an isokinetic sampler (1.5 ft/s for bottle samplers, 2 ft/s for bag samplers).
- Automatic pumping samplers are needed for specific situations; for example, time-dependent regulatory monitoring, sampling at remote sites, or sampling of floods or urban runoff when discharge is rapidly changing and a large number of samples are needed from several locations within a relatively short time.
- Periods of extreme cold cause the nozzle or air-exhaust vent to freeze, rendering isokinetic, depth-integrating samplers inoperable.
- Study objectives dictate use of nonisokinetic sampling methods.

Three nonisokinetic sampling methods most commonly used are the dip (weighted-bottle), discrete, and pump methods. Ward and Harr (1990) and Edwards and Glysson (1999) provide detailed information on these sampling methods. General instructions are provided below.

- **Dip sampling method**. Dip sampling involves either (1) dipping a narrow-mouthed bottle into a water body, or (2) using either the DH-81 or D-95 sampler as described below. To use a DH-81 or D-95 sampler in a stream with velocity less than 1.5 ft/s, remove the nozzle from the sampler and proceed to sample the entire vertical. This is especially useful at a deep-water site. When sampling with a hand-held bottle, stand downstream of the bottle while it is being filled. Dip sampling is not recommended for discharge-weighted sampling when it is possible to obtain a depth-integrated, isokinetic sample. **The error introduced by dip sampling can be substantial if the target analytes are sorbed onto suspended materials that are not uniformly distributed along the cross section.** Care must be taken to avoid collecting particulates that are resuspended as the result of wading or bumping the sampler on the streambed.

  — To collect a dip sample in water that is too shallow to submerge an isokinetic, depth-integrating sampler, wade to where the sample(s) will be collected and immerse a hand-held, narrow-mouth bottle at the centroid of flow or at multiple locations along a cross section.

  — To collect a dip sample where water is too deep to wade and volocity is too great for use of an isokinetic sampler: lower a weighted-bottle sampler at the centroid of flow or at multiple locations along a cross section.

  — Collecting samples for biochemical oxygen demand (BOD) and volatile organic compounds (VOCs) are special cases of dip sampling that require special equipment. Instructions for BOD sampling can be found in NFM 7.0. **Instructions for VOC sampling are described at the end of this section 4.1.3.B under "Instructions for collecting VOC samples at flowing-water sites."**

- **Discrete sampling method**. Discrete (point) sampling involves either (1) lowering a sampler to a specified depth and collecting a sample by first opening, then closing the sampler, or (2) using a single-stage sampler, which fills when stream stage rises to a predetermined height.

  — Thief-type samplers are the most common point samplers used for collecting water-quality samples (NFM 2.1.1.B). Although these samplers are designed primarily to sample still waters, they can be adapted for slow-flowing water by attaching them to a weighted line. Samples can be collected at the centroid of flow or at multiple verticals and at selected depths along the cross section.

— Isokinetic point samplers (for example, the P-61 and P-63 described in Edwards and Glysson, 1999) are available for collecting samples for suspended-sediment concentration and particle-size determination, and for selected chemical constituents. **The P-61 and P-63 samplers are not suitable for collecting samples for organic-compound or trace inorganic-constituent analyses.**

— Single-stage samplers, such as the U-59 (NFM 2.1.1.B) and U-73 are useful for collecting samples for analysis of sediment and selected chemical constituents at stations located on streams or other locations susceptible to flash floods or where it is otherwise difficult to reach a station to manually collect samples (Edwards and Glysson, 1999). Before single-stage samplers can be installed, some knowledge of the seasonal stage characteristics of the stream is needed so that an appropriate sequence of samples can be obtained for a given storm season. The stream-stage and flow-velocity characteristics not only affect the design with respect to the vertical spacing of the samplers but also the support necessary for the samplers (Inter-Agency Committee on Water Resources, Subcommittee on Sedimentation, 1961, "The Single Stage Sampler for Suspended Sediment," St. Anthony Falls Hydraulic Laboratory Report 13). These samplers have not been certified as appropriate for collection of uncontaminated trace-element or trace-organic samples.

▶ **Pump-sampling method**. Pump sampling involves either suction-lift or submersible pump systems designed to collect water-quality samples (NFM 2.1.1.B). Pump systems can be portable or can be permanently installed and automated for sampling (see TECHNICAL NOTE below).

— Pump samplers generally are not used to collect isokinetic samples because of the difficulty in controlling the sample velocity through the sampler intake relative to the flow rate and direction of suspended particulates in the stream.

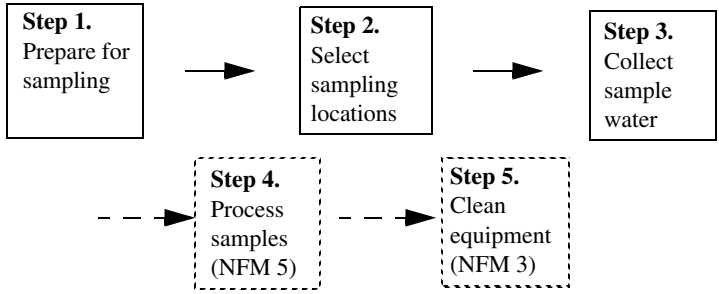
— Portable-pump samplers generally are used to collect a point sample by lowering the pump to a selected depth. A suction pump, such as a peristaltic pump, has a maximum lift of 30 ft or less. Refer to the manufacturer's instructions for the lift capacities of other types of pump samplers.

— A portable pump also can be used to collect a nonisokinetic, depth-integrated sample by continuous pumping at a constant rate as the intake is being lowered through the vertical.

Collection of useful data, especially with the use of automated pumping samplers, requires intensive planning and quality assurance, including careful site selection, selection of the type and construction material of the sampler, a review of historical hydrologic information, and collection of an adequate number and types of quality-control samples. The physical, chemical, and biological characteristics of the cross section, study objectives, and pump limitations must be considered when determining how and where to collect samples.

> **TECHNICAL NOTE:** The selection, deployment, use, and maintenance of automated samplers (auto samplers), such as those manufactured by ISCO, require training and detailed instructions that have not been incorporated into this manual; follow the manufacturer's instructions. Some tips for collecting autosampler samples appear in the steps below.

Steps for nonisokinetic sampling methods



Be sure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies.

Step 1. Prepare for sampling for inorganic and organic analytes.[9]

a. Upon arrival at the field site, set out safety equipment such as traffic cones and signs. Park vehicle in a location and direction so as to prevent sample contamination from vehicle emissions.

[9]Preparations for water sampling are described in NFM 2 and 3. Consult NFM 5 for sample processing, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material sampling, and NFM 9 for field safety.

b. Assemble equipment and set up a clean work space.

- **Organic compounds**. Select equipment with fluorocarbon polymer, glass, or metal components if components will directly contact samples to be analyzed for organic compounds. **Do not use plastics unless they are fluorocarbon polymers.**
- **Inorganic constituents**. Select equipment with components made of fluorocarbon polymer or other relatively inert and uncolored plastics or glass if components will directly contact samples to be analyzed for inorganic constituents. **Do not use metal or rubber components for trace-element sampling.**
- Collect samples to be analyzed for sediment concentration and (or) particle-size distribution using a separate set of clean sample bottles. Sediment samples generally are not field composited.
- Collect samples for microbiological analyses using equipment and techniques described in NFM 7.
- Calibrate field instruments as described in NFM 6.

Step 2. Select sampling locations.

Review data objectives to ensure they will be met at the sampling location(s) selected. If discharge-weighted samples are needed and the stream section is well mixed with respect to target analytes, locate multiple sampling points along the cross section using the EDI method.

a. Measure discharge at the cross section where samples will be collected.

b. At sites with very little sampling history, measure the variation within each field measurement (specific electrical conductance, pH, temperature, and dissolved oxygen) along the cross section and review these data.

c. Locate the centroid of flow if distribution of streamflow and the field-measurement data indicate that the section is well mixed (refer to the description of the VCF sampling method at the end of this section (4.1.3.A)).

Step 3. Collect sample water.

By applying EDI sampling methods and collecting equal-volume samples at the centroid of each equal-discharge increment, a sample can be collected that is discharge-weighted although it is not isokinetic. Using CH/DH techniques, as required (section 4.0.2):

a. Move sampling and support equipment to the first sampling location. Field rinse equipment (section 4.1.3).

b. Record starting gage height and sampling start time.

c. To collect a nonisokinetic sample with a dip or pump sampler:

- If a discrete sample is to be collected, lower the dip sampler to the desired depth, then sample.
- If a vertical traverse is made to collect the sample, **do not pause when contact with the streambed occurs**, but raise the dip sampler immediately until the traverse is completed. Take care not to disturb the streambed with the sampler, as bed material entering the sampler results in erroneous data.
- If a pump is used to collect a sample, lower the pump intake to the desired depth and pump about three sample-tubing volumes to field rinse sample tubing and then collect the sample.

d. Move to the next vertical (if more than one vertical will be sampled along the cross section).

i. Record the time and repeat sample collection as described in step 3c above.

ii. Inspect each sample, looking for anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection. If such a condition is observed, discard the sample, making sure there are no residual particulates left in the container, and resample.

iii. Depending on data objectives, either composite the samples collected or set aside each sample to be independently processed and analyzed.

- If pumped samples will be composited, pump the samples directly into the churn splitter.
- If transferring the subsample to a churn or cone splitter, ensure that all particulates in the sampler are transferred with the sample by swirling the sample gently to keep particulates suspended and pouring the sample quickly into a sample splitter.

e. After all the samples have been collected:

- Record sampling end time and gage height.
- For automated samplers: record beginning and ending dates and times for the sampling period. Retrieve samples from automated pumping samplers at the earliest possible time to reduce the chance of chemical or biological alteration of the sample. (Automatic samplers with refrigeration are available to help maintain sample integrity.) Samples collected by automatic samplers often are combined as a composite sample.
- Document all field observations and any deviations from standard sampling procedures.

Step 4. Process samples → Refer to NFM 5.

Step 5. Clean equipment → Refer to NFM 3.

- If the sampler will not be reused during a field trip, rinse the sampler components with deionized water before they dry and place them in a plastic bag for transport to the office laboratory to be cleaned.
- If the sampler will be reused during the field trip, rinse the components with DIW while still wet from sampling and then field-clean while at the sampling site using the prescribed procedures. Reassemble the sampler.
- Collect a field blank, if required, after sampling equipment has been cleaned at the sampling site.
- Place the cleaned sampler into a plastic bag and seal for transport to the next site.

Instructions for collecting VOC samples at flowing-water sites:

Samples for analysis of volatile organic compounds (VOCs) are collected as a single-vertical point sample in a flowing stream. The VOC sampler should be deployed where the stream velocity represents the average flow, which typically is near mid-channel in the cross section. When collecting samples for VOC analyses, special care must be taken to avoid contamination from any oily film and debris floating on the stream surface.

1. VOC samples are collected directly into laboratory-supplied prebaked 40-mL amber-glass vials. If the stream is deep enough, use the VOC sampler described in NFM 2.1.1.B (fig. 2-2). If the sampler will not be used, skip to step 7.

   a. **Do not clean or field rinse the glass VOC vials – these are supplied by the laboratory ready to use.**

   b. The VOC sampler must be cleaned after each use and field rinsed before use. **To field rinse the sampler, either submerge it in the stream for several minutes or dowse it three times with native water before inserting the VOC vials.**

2. Change gloves. In an area protected from any direct source of contamination (preferably within a sample-processing chamber), uncap four 40-mL unlabeled VOC vials and place them into the VOC sampler. Secure and lock the sampler top in position. Store the vial caps in a clean, protected area.

3. Lower the sampler into the stream near mid-channel to about one half of the total depth at that vertical. Add weights to the sampler if the stream velocity is great enough to pull the sampler downstream. Use weights made of steel or other noncontaminating material; do not use lead weights.

4. Hold the sampler in one position until the sampler is full. Air bubbles will rise to the surface while the sampler is being filled, but may be difficult to see. This takes about 3 to 4 minutes. The sample will be retained in the vials during the last 15 to 20 seconds of sampling.

5. Remove the sampler when bubbles are no longer present or after about 5 minutes, and return it to the sample-processing chamber or other protected area.

6. Open the sampler carefully. Using metal tongs, slowly lift each vial from the sampler reservoir. Do this carefully to avoid losing the convex meniscus on each vial.

7. **To collect a VOC sample without the sampler:** Wearing gloves, submerge a capped VOC vial into the stream section; remove the cap underwater, let the vial fill to overflowing, and then firmly recap the vial underwater. Repeat this for each of the VOC vials. Check each vial for bubbles, as described in step 8.

8. Quickly cap the vial, then shake it. Invert, and check carefully for air bubbles. Discard the entire vial if bubbles are present. Three vials from the sampler set are required for one complete sample. Resample if two or more of the vials have air bubbles. If the sample is to be preserved with chemical treatment, refer to the procedure described in NFM 5.

9. Dry and label the sample vials. Place each vial into a foam sleeve, and store on ice for transport to the laboratory.

10. Clean the sampler and store it properly (see 4.0.2, "Preventing sample contamination").

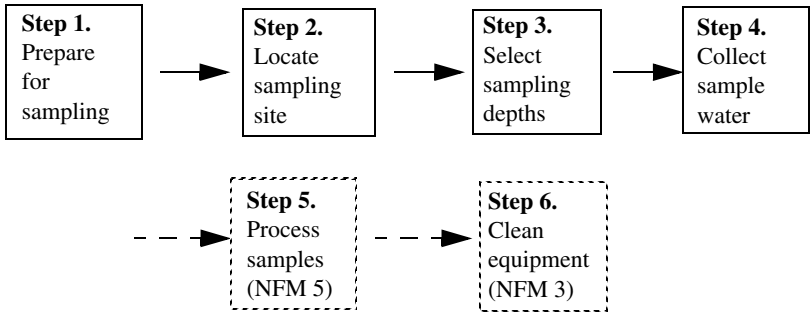
4.1.3.C Guidelines for Sampling at Still-Water Sites

In still water, samples generally are collected at multiple sites and at multiple depths. The number of sampling sites and the depths where samples will be collected should be dictated by study objectives and the physical, chemical, and biological characteristics of the water body (Ward and Harr, 1990).

Thief-type samplers usually are used to collect still-water samples; however, pumping samplers also can be used. A disadvantage of collecting a sample by pumping is that if a thin stratum of water is being sampled, water can move radially from unknown depths and distances into the pump.

- Samples must be collected at a known depth.
- Sample integrity must be maintained to the degree possible while samples are being brought to the surface for further processing.

Steps for sampling at still-water sites



Be sure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies.

Step 1. Prepare for sampling of inorganic and organic analytes.[10]

a. Upon arrival at the field site, set out safety equipment such as traffic cones and signs. Park vehicle so as to prevent sample contamination from emissions.

b. Assemble equipment and set up a clean work space.

- **Organic compounds**. Select equipment with fluorocarbon polymer, glass, or metal components if components will directly contact samples to be analyzed for organic compounds. **Do not use plastics other than fluorocarbon polymers.**
- **Inorganic constituents**. Select equipment with components made of fluorocarbon polymer or other relatively inert and uncolored plastics or glass if components will directly contact samples to be analyzed for inorganic constituents. **Do not use metal or rubber components for trace-element sampling.**
- **Microbiological analyses**. Collect microbiological samples using equipment and techniques described in NFM 7.

Step 2. Locate sampling site.

a. Locate the first sampling point and maintain a sampling platform position at the site.

b. Record depth to bottom.

[10]Preparations for water sampling are described in NFM 2 and 3. Consult NFM 5 for sample processing, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material sampling, and NFM 9 for field safety.

Step 3. Select sampling depths.

a. Make field measurements (such as specific electrical conductance, pH, temperature, and dissolved oxygen) in situ to obtain a vertical profile of field-measurement variation.

b. Measure light penetration (if applicable).

c. Select and record sampling depth(s) based on study objectives and the variation in field measurements for the vertical.

Step 4. Collect samples.

Field rinse sampling equipment first (section 4.1.3). Collect samples by using the procedures listed below under Step 4A for a thief-type sampler and under Step 4B for a pump sampler.

Step 4A. Thief-type sampler.

The instructions listed below are for samplers that operate with an open/close mechanism. If the sampler operates as a point-source bailer, follow steps a and c through g below. Pulling the bailer up will trigger the upper check valve to seal off the sample from the water overlying the targeted depth.

a. Lower opened sampler to the desired depth while minimizing disturbance of the water column.

b. Isolate the sample by activating the mechanism that closes the sampler.

c. Raise the sampler from the water body.

d. Dispense sample to sample bottle or compositing/splitting device using *CH/DH* techniques.

- If using a bailer, drain sample through the bottom-emptying device.
- If sample compositing and (or) splitting is required, ensure that all particulates in the sampler are transferred with the sample by swirling the sample gently to keep particulates suspended and pouring the sample quickly into the churn or cone splitter.

e. Repeat steps a through d if more sample is needed from the same depth for that vertical section.

f. Repeat steps a through e for each depth to be sampled in that vertical section. If a second sample from a different depth or vertical section will be composited, either (1) clean and field rinse the splitter after processing the first sample and before collecting the second sample, or (2) use another clean splitter.

g. Move to the next site if another vertical section will be sampled. Repeat steps a through f.

Step 4B. Pump sampler.

a. Lower the pump or pump-sample tubing (attached to a weighted line) to the desired sampling depth.

b. Turn on the pump and pump about three sample-tubing volumes to field rinse the pump, tubing, and other sample-collection or -processing equipment. Discard rinse water.

c. Direct sample flow into collection container(s) until sufficient sample volume has been collected.

d. Repeat Step 4B, steps a through c, if another depth and (or) vertical section is to be sampled. If a second sample from a different depth or vertical section will be composited, either (1) clean and field rinse the splitter after processing the first sample and before collecting the second sample, or (2) use another clean splitter.

Step 5. Process samples → Refer to NFM 5.

Step 6. Clean equipment → Refer to NFM 3.

- If the sampler will not be reused during a field trip, rinse the sampler components with deionized water (DIW) before they dry and place them in a plastic bag for transporting back to the office laboratory to be cleaned.
- If the sampler will be reused during the field trip, rinse the components with DIW while still wet from sampling and then field-clean while at the sampling site using the prescribed procedures. Reassemble the sampler.
- Collect a field blank, if required, after sampling equipment has been cleaned at the sampling site.
- Place the cleaned sampler into a plastic bag and seal for transport to the next site.

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GROUND-WATER SAMPLING 4.2

Collecting samples of ground water that accurately represent aquifer conditions requires sampling at appropriate wells and using equipment and methods that maintain the integrity of the sample with respect to the physical, chemical, and biological characteristics of interest. This section provides guidance and protocols for (a) site reconnaissance and establishing site files, (b) avoiding collection of bad data, and (c) ground-water withdrawal up to the point of bottling or processing the sample. USGS procedures for collecting raw or filtered ground-water samples into bottles, sample preservation, and other sample-processing and handling activities are addressed in Chapter A5 (NFM 5), "Processing of Water Samples." Because ground-water sample collection is a continuous process, the information in this chapter overlaps somewhat with that of NFM 5.

For USGS studies, ground-water samples typically are collected either at monitor wells or at public or domestic water-supply wells.[11]

- **Monitor wells** are observation wells[12] that are installed principally for the collection of water samples to assess the physical, chemical, and biological characteristics of formation (aquifer) water. Samples from monitor wells are collected either with portable, low-capacity pumps or with other types of sampling devices designed for water-quality work. Sampling devices can be dedicated for use at a given well or can be installed in the well for the duration of the monitoring effort. (The terms "monitor well" and "monitoring well" are used interchangeably in this field manual.)

[11]Ground-water samples collected using passive or natural-gradient methods or direct-push or cone penetrometer systems are not addressed in this chapter.

[12]Observation wells are wells or piezometers that are installed (usually without a dedicated pump) for the purpose of collecting hydrologic data. The term generally has been applied to wells installed to observe and determine hydrologic characteristics of an aquifer (Lapham and others, 1997).

- **Water-supply wells** are wells that are installed primarily for supply of public, domestic, irrigation, commercial, or industrial water and usually are equipped with a dedicated high-capacity pump. Pumps installed in supply wells generally deliver a large volume of water that is subsampled for water quality. (Although the guidance in this manual focuses on sampling at public or domestic supply wells, similar principles and procedures apply when sampling at irrigation, commercial, or industrial wells, with the caveat that additional safety precautions need to be identified and implemented and equipment requirements reviewed.) Note that supply-well construction materials and methods and the pumps installed can have long-lasting effects on the chemistry of water entering the well from the aquifer (Lapham and others, 1997).

4.2.1 SITE INVENTORY AND SITE FILES

Information about the well and field site is compiled in the office and during site-reconnaissance visits. The information compiled is used by study personnel to help determine site suitability for conducting sampling activities. Site files are then established in the USGS National Water Information System (NWIS) electronic data base[13] and the information compiled is entered into NWIS and is used to create a file for use in the field.

[13]NWIS is the public portal to USGS water resources data (Hubbard, 1992; USGS Water Resources policy memorandum 92.59). NWISWeb displays real-time water-level data (http://waterdata.usgs.gov/nwis/gw), and real-time water-quality data for selected wells (http://waterdata.usgs.gov/nwis/qw) (website accessed June 2, 2006).

Site inventory – In an office inventory, the study team identifies existing wells or candidate sites at which to install wells, examines well-construction records, and compiles additional background information and site or well records. The field evaluation, or site reconnaissance, is used to verify well location, select or reject candidate well(s), determine the suitability of the site to meet study objectives, and become aware of equipment or other requirements needed to address specific site conditions (table 4-6). Site-reconnaissance visits also are used to identify areas of ground-water recharge and discharge; test field equipment; test well-purging and sampling procedures; conduct aquifer tests; make preliminary field measurements (see NFM 6); and identify the presence of target analytes, sources of contamination, and potential matrix interferences.

When conducting site inventories:

- Be familiar with study objectives and requirements for data collection and quality.
- Be familiar with the considerations for well selection and (or) installation (table 4-6).
- Be alert to changes over time that might affect the suitability of the well to meet study needs.
- Keep in mind the primary criteria for all water-quality studies:
  - The sample must represent the system, in time and space, intended for study.
  - Sample integrity must be maintained.

Review safety plans and procedures before leaving for the field (NFM 9).

Table 4-6. Example of ground-water site-inventory activities

Before the site visit
Review considerations for well selection and installation (section 4.2.2; Lapham and others, 1997).
Review background information collected.
Obtain permission to gain access to the site and to collect samples from the well.
Update well files: record changes in ownership and land use.
Contact utility companies (gas, water, and electric) before digging or drilling.
Determine whether the pump may or may not be removed from the well by field personnel (removal is not recommended, as personal safety could be compromised). The owner's permission is required to remove a pump—you could be liable for damage to pump or well.
Be sure that you get information needed about the site that could interfere with or interrupt sampling. For example, • Hours of pump operation and scheduled downtime. • Pumping rate or rates. • Holding tanks or chemical treatments. • Electrical service to the site. • Scheduled maintenance for pumps or related equipment. • Scheduled site maintenance, such as painting, construction, and defoliation. • Seasonal water-level declines that make the well unusable. • Times of denied access; for example, no access while the owner is out of town. • Special site-access needs; for example, clearance with a site owner or site operator, keys to unlock access to the site, animals. • Restrictions on the location.
Before and during the site visit
Record conditions that could compromise study objectives, including potential point or nonpoint sources of contamination. For example, • Nearby wells that could affect well hydraulics. • Condition of well—for example, rusting or punctured casing, poor surface seal. • Has the well been adequately developed? Could well-development artifacts compromise sample integrity? • Land use and land cover or changes in land use and land cover. • Application of salt on nearby roads during winter, or application or use of herbicides and pesticides. • Landfills or other waste-management facilities. • Industrial, commercial, and agricultural complexes and discharges.
During the site visit
Measure water level in each well. Record water-level measurements on the appropriate field form(s), and into the Ground-Water Site Inventory (GWSI) and Quality of Water Data (QWDATA) data bases.
Identify potential difficulties with the type of equipment and sample-collection methodology to be used. (Note that sampling plans will have to be modified accordingly.)
Update field folders. • Note site conditions that could affect the quality of data collected from that well. • Note change(s) in land use.
Verify well identification number and make sure that it is clearly and permanently labeled. • Check that identification corresponds with what is in the field folder and on site and location maps. • Correct any mistakes or uncertainty about well identification and well location.

Table 4-6. Example of ground-water site-inventory activities—*Continued*

During the site visit—*Continued*
Verify type of pump, well diameter, and use of holding tanks, pressure tanks, chemical treatments. • Check whether oil is floating on the water column in a well equipped with an oil-lubricated pump. • Make sure that the downhole treatment system is turned off before collecting water samples. • Determine if the intended sampling device is suitable for use.
Establish optimum pumping rate(s) for purging and sample collection and decide where to route excess discharge. • Adjust pumping rate to ensure adequate purging of the well without entrainment of atmospheric gases due to excessive drawdown. • Route water away from the well to prevent (1) creating muddy and slippery conditions and (2) damage to or defacement of the property to which you were granted access.
Check that well structure is intact. • Wells used for ground-water studies should be "sounded" annually to check whether depth to bottom corresponds with well-construction information or whether the well is filling with loose materials (U.S. Geological Survey, 1980; Lapham and others, 1997). A decrease in depth to bottom could indicate that the well casing is collapsing, or that there is a breach or corrosion of well screen or casing, or that the well is improperly designed to retain aquifer materials. • Borehole caliper and downhole-camera video logs can identify a damaged or broken well casing. A downhole camera can identify a plugged screen or accumulation of sediment in the well. • Aquifer tests, such as slug tests, can be used to check thehydraulic connection between the well and the aquifer. Aquifer tests, however, are generally beyond the scope of site reconnaissance. • The surface seal of a USGS monitoring well should be intact and the well should be capped. Concrete pad should be repaired if cracked or separated from outer casing. A tight-fitting well cap should have a small ventilation hole.
Check well access for sample-collection points. • Sample-collection points need to be near the wellhead, ahead of where water enters pressure tanks, holding tanks, or treatment systems. • At wells where an access point close to the well is not available, it might be possible to install a hose bibb or tap at the wellhead. Because it usually is not possible to control the pumping rate of a supply well, the field person may need to set up a hose-and-valve system to control the rate at which water is sampled and to reduce the likelihood of backflow of water stored in plumbing lines.
Check well access for water-level measurements. The construction of some supply wells makes water-level measurements difficult or impossible. • Although it is often possible to slip a weighted steel or electric well tape below the pump to get a water-level measurement, the pump can be damaged if the weight or tape becomes entangled in the pump. The weight should be attached so that it will snap off of the tape under stress. • Water levels can be estimated through the air line on some wells. • Sometimes field personnel are permitted to remove the pump from the well to get a measurement; however, pump removal can be difficult and time consuming, is potentially unsafe, and could damage the pump. • A note should be made in the well file if there is no access for a depth measurement.

NWIS files – USGS policy requires that specific information collected for each ground-water sampling site and event will be stored in one or more subsystems of NWIS (USGS Office of Water Quality (OWQ)/Office of Ground Water (OGW) Technical Memorandum 2006.01). In addition, paper documents (such as agreements between the well owner and the USGS for well use, access, or construction), field forms and logs, and any ancillary information that is collected are stored in well files and field folders (USGS Office of Ground Water Technical Memorandum 2003.03). Much of the information needed to set up files for existing wells can be obtained from well owners, drillers, records from state or local jurisdictions, and well-construction logs. Information needed to set up well files for new wells is compiled by field personnel as part of their responsibilities associated with well installation (Lapham and others, 1997).

- **NWIS –** Within the NWIS system, well information, ground-water levels, and water-quality data are stored in three subsystems: the Ground-Water Site Inventory (GWSI), Quality of Water Data (QWDATA), and the Automatic Data Processing System (ADAPS). Individual studies and USGS Water Science Center offices may have additional data-storage requirements.
  - GWSI primarily contains (1) descriptive information about the site and well, (2) construction information, and (3) noncontinuous water-level data. A GWSI site file (table 4-7) must be established for each well at which water-level and other data are collected (table 4-7) (Hoopes, 2004; USGS OWQ/OGW Technical Memorandum 2006.01). When creating or updating a GWSI site-file record, field personnel should fill in as much information as is available in addition to the required information. For example, the GUNIT (geologic unit) code provides important information for interpretation of ground-water data.
  - QWDATA contains (1) results of field and laboratory water-quality sample analyses and measurements, (2) non-continuous water-level data, and (3) other data related to water-quality samples or sample analyses (Gellenbeck, 2005). A subset of the information entered into GWSI is entered into QWDATA, as appropriate to meet the needs of the study (USGS OWQ/OGW Technical Memorandum 2006.01).
  - ADAPS contains continuous records of water levels and water quality (Bartholoma, 2003).

- **Field Folder –** The field folder contains information that is necessary or useful to have onsite during the field effort, and includes a well file for the well at which data will be collected (fig. 4-7).
  - — A well file is established for each well selected or installed for the study. The well file is the repository of the information compiled for the well, and it should contain documentation for site selection, well inventory, well installation, and sample collection.
  - — The field folder (fig. 4-8) is taken along on each site visit and includes site-location maps and a site sketch (fig. 4-9). Files taken to the field should not contain original data records.

To prepare location maps and site sketches:

1. Locate the ground-water site in the field on an aerial photograph, or a town plat/lot number map. Transfer the location of the site to a USGS 7.5 minute topographic quadrangle map.
2. Determine the ground-water site latitude and longitude to the nearest second using a USGS 7.5 minute latitude-longitude scale or a digitizer or Global Positioning System (GPS), and record the latitude and longitude accuracy as one second.
3. Prepare a detailed sketch map. Orient the ground-water site on the sketch map relative to north using a compass. The sketch map should contain enough detail so that the site can be found again by a person who has never visited it. All distances should be made in feet from permanent landmarks, such as buildings, bridges, culverts, road centerline, and road intersection.

RULE OF THUMB:

- **Before starting field work make sure the site file is established in NWIS.**
- **Keep field files current.**
- **After field work, update NWIS promptly.**

Table 4-7. Minimum information required for electronic storage of site and ground-water-quality data in the U.S. Geological Survey National Water Information System

[NWIS, National Water Information System; GWSI, Ground-Water Site Inventory; USGS, U.S. Geological Survey; QWDATA, Quality of Water Data]

Required information for creation of a ground-water site in NWIS[1, 2] (GWSI)		
Data description	**Component (C) number for data entry into GWSI**	**Example (Description of code)**
Agency code	C4	USGS
Station Identification Number (Latitude/longitude/sequence no.)	C1	394224075340501
Station Name	C12	KE Be 61
Latitude	C9	394224
Longitude	C10	0753405
Country	C41	US
Lat/Long Accuracy	C11	S (seconds)
Lat/Long Method	C35	M (Map)
Lat/Long Datum	C36	NAD83
Time Zone	C813	EST
Daylight Savings Time Flag	C814	Y (Yes)
USGS Water Science Center/User	C6	24 (Maryland)
State	C7	10 (Delaware)
County	C8	003 (Sussex)
Station Type	C802	6 (Well)
Data Reliability	C3	C (Field Checked)
Site Type	C2	W (Well)
Use of site	C23	O (Observation)
Required information for storage of sample analyses in the water-quality subsystem (QWDATA)[1]		
Data description	**Alpha parameter code**	**Sample data (Description of code)**
Agency code	AGNCY	USGS
Station Identification Number	STAID	394224075340501
Sample Medium	MEDIM	6 (ground water)
Sample Type	STYPE	2 (blank sample)
Hydrologic (“Hydro”) Event	EVENT	9 (routine sample)
Hydrologic (“Hydro”) Condition	HSTAT	A (not determined)
Date (year/month/day)	DATES	20060909
Time (standard 24-hour clock time)	TIMES	1530 hrs
Analysis Status	ASTAT	H (initial entry)
Analysis Source	ASRCE	9 (USGS laboratory and field)

[1]Numerous additional data fields are available in GWSI and QWDATA that can be useful for data analysis or mandatory for meeting study objectives; for example, indicating whether an agency other than the U.S. Geological Survey collected the data.
[2]From GWSI Schedule Form 9-1904-A, revised June 2004, NWIS 4.4.

WELL-FILE CHECKLIST, Page 1 of 2

Project name and identification number:_____
Latitude-longitude: _____ Sequence number: _____
Other site or well ID:_____ Station name: _____

Indicate use of water/site: Public Supply Irrigation
Domestic Observation
Commercial Monitoring
Industrial Other _____

Item in well file	Date item filed
Criteria for well selection or installation	_____
Station Analysis	_____
Station Description	_____
ADR (Automatic Data Recorder) Manuscript	_____
Ground-Water Site Inventory (GWSI) data entered into National Water Information System (NWIS)	_____
Paper copy of GWSI form (9-1904-A)	_____
Copies of agreement to complete activity (drilling, sampling, etc.) _____	_____
List agreements _____	_____
Copies of field forms and logs:	
Well-drilling record	_____
Driller's log	_____
Lithologic log: Cuttings	_____
Cores	_____
Aquifer tests: (list types) _____	_____
_____	
Geophysical logs: (list types) _____	_____
_____	
Well-construction record	_____
Well-development record	_____
Well-maintenance checks: (list types) _____	_____
_____	
Well-location information:	
Latitude-longitude, datum, method of determination, and any changes	_____
Well-location map(s)	_____
Site-sketch map	_____
Written description of location	_____
Well-casing elevation (elevation, and method and date of determination)	_____
Photographs of well and vicinity (with measuring/sampling points identified)	_____
Land use/land cover form (Lapham and others, 1997)	_____

Figure 4-7. Example of a checklist for a well file.

WELL-FILE CHECKLIST, Page 2 of 2

Item in well file	Date item filed
Water-quality records for each sampling event (for example, purging, field measurements, field forms, sampling history) and copies of laboratory analyses requested	_____
	_____
	_____
	_____
	_____
Water-level measurements - current:	_____
	_____
	_____
Water-level measurements - historical:	_____
	_____
	_____
Record of well leveling (survey)	_____
Datum corrections	_____
Pumping schedule/history	_____
Type of pump in well and location of intake	_____

Description of measuring point for water levels: _____
_____
_____

Description of collection point for samples from
Supply wells _____
_____
Monitoring wells_____

Other information (for example, geologic unit, aquifer name): _____
_____
_____
_____

Figure 4-7. Example of a checklist for a well file—*Continued.*

Field-folder checklist: ground-water quality		
✓	**Item**	**Comments**
	Forms (new forms and (or) examples of completed forms): • Permission forms—must be signed by proper authority. • Analytical Services Request form(s). • Ground-water field form and well-inventory form.	
	Equipment and supplies checklists.	
	Field-techniques manuals.	
	Safety information: • Nearest emergency facilities; home phone number of supervisor. • Diagram of where to park, placement of flags and cones. • Traffic conditions; location of power lines. • Environmental hazards such as weather and animals.	
	Site location and description: • Maps showing location and identification number of well(s). • Name of landowner, tenant, or other responsible party. • Site access instructions (call owner; get keys or tools needed for security gate, well house, well protective casing). • Photographs and land use/land cover form to document site conditions. • Well dimensions and construction logs.	
	Sampling schedule and instructions: • Laboratory analyses, codes, and bottle types. • Preservation requirements, including chilled samples. • Quality-control samples. • Location of sampler intake during sample collection. • Pumping rate for purging and sampling.	
	Purging instructions: • Number of well volumes. • Rate of pumping; containment and discharge of purge water. • Location of sampler intake during purging. • Field measurements and stability protocols. • Previous field-measurement and purge-volume records. • Discharge of purge water.	
	Water-level measurements: • Location of measuring point. • Previous records from well.	
	Ancillary information: • Geologic section(s). • Hydrologic section(s). • Borehole geophysical logs.	
	Shipping instructions: • Mailing labels; location of nearest post office or shipping agent. • Ice and holding time requirements.	

Figure 4-8. Checklist for contents of a field folder for ground-water sampling.

A. Example of site and well-location maps.

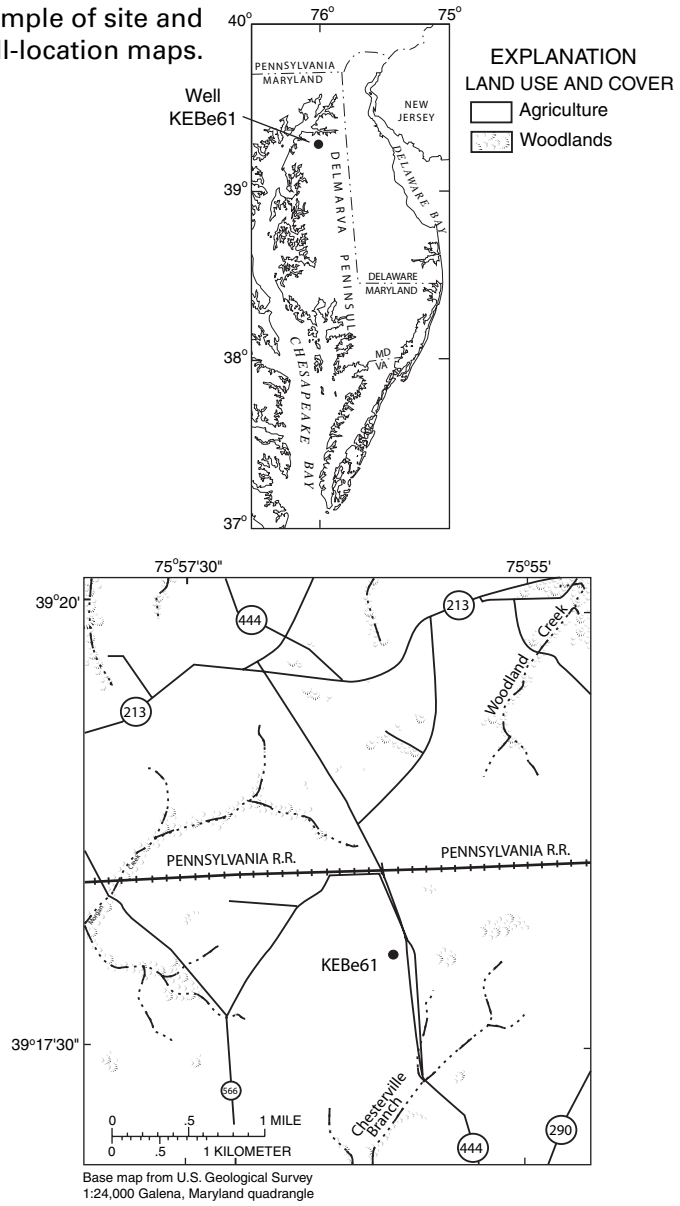
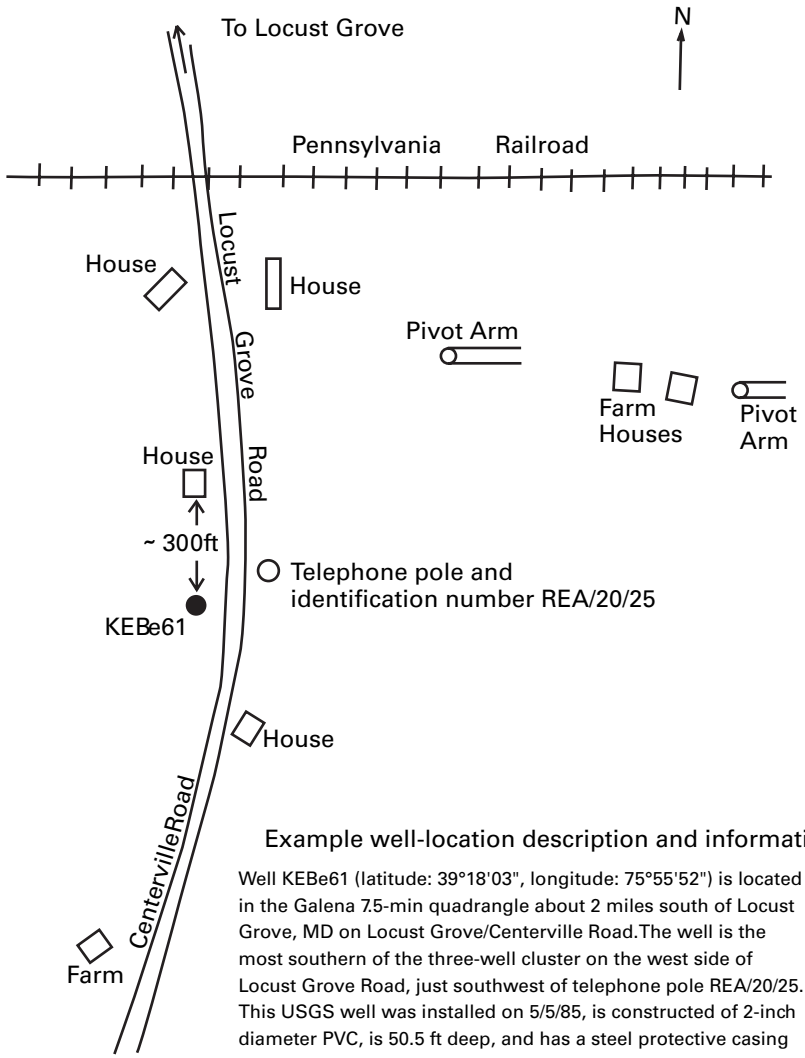


Figure 4-9. Example of (*A*) site- and well-location maps and (*B*) well-site sketch.

B. Example of well-site sketch (with well-site information).



Example well-location description and information:

Well KEBe61 (latitude: 39°18'03", longitude: 75°55'52") is located in the Galena 7.5-min quadrangle about 2 miles south of Locust Grove, MD on Locust Grove/Centerville Road.The well is the most southern of the three-well cluster on the west side of Locust Grove Road, just southwest of telephone pole REA/20/25. This USGS well was installed on 5/5/85, is constructed of 2-inch diameter PVC, is 50.5 ft deep, and has a steel protective casing with a USGS lock. Contact property owner at ( )___-____ one day before sampling.

Figure 4-9. Example of (*A*) site- and well-location maps and (*B*) well-site sketch—*Continued.*

4.2.2 CONSIDERATIONS FOR COLLECTING REPRESENTATIVE SAMPLES AT WELLS

The study team must ensure that the wells to be sampled will yield samples that accurately represent the water chemistry of the hydrogeologic system targeted for study. To help prevent data biases that could compromise study objectives, field personnel must be aware of how specific well characteristics and field activities can affect sample chemistry. These considerations are addressed as follows:

- Table 4-8 summarizes factors that can compromise sample integrity and general strategies for maintaining the integrity of ground-water samples. Table 4-9 lists considerations for selection or installation of wells at which water-quality will be monitored that relate to the quality or representativeness of the samples to be collected.
- Section 4.2.2.A discusses adverse effects on sample chemistry from introducing air and other fluids into the borehole during well construction, and the importance of monitoring the communication of the well with the aquifer for signs of deterioration.
- Section 4.2.2.B describes the effect of pumping rates, well yield, and aquifer heterogeneity and anisotropy on the sampling effort and how these factors can limit the types of sample analyses to be performed.
- Section 4.2.2.C focuses on the vulnerability of ground-water samples to contamination from atmospheric gases, standing fluids and bottom detritus in the borehole, and equipment use.

Some wells might not be suitable for water-quality monitoring. The ultimate decision as to when and if a well should be sampled rests with the study or program personnel and depends on the specific sampling and data-quality requirements of the study. Field personnel need to be alert to the conditions that might cause a change in the suitability of the well over time, whether because of well characteristics, land-use conditions, or other factors. **In general, avoid sampling:**

- Wells that cannot produce a continuously pumped sample or wells at which water-level recovery takes longer than 24 hours after being pumped.
- Wells at which purging will stir up bottom detritus that can bias analytical results. This often is the case in wells having 5 ft or less of water. Any reported interpretations of chemical analyses when sampling under such conditions must be clearly qualified and the well conditions documented.
- Wells at which field measurements have not met stabilization criteria (section 4.2.3), unless the study sampling and (or) quality-assurance plans provide for alternative protocols.
- Wells in which the water column within the sampling interval is in contact with and mixes with atmospheric gases, unless the analytes of concern will not be affected.
- Wells at which the water withdrawn must pass through holding tanks or chemical treatments.

Table 4-8. Considerations for maintaining the integrity of ground-water samples

Factors that can compromise sample integrity
• **Time.** Chemical and microbial reactions that affect target-analyte concentration can be rapid. • **Loss of pressure.** Pressure in ground water can be much greater than atmospheric pressure. As the sample is brought to land surface, depressurization of the sample can cause changes in sample chemistry. • **Leaching or sorption.** Chemical substances can be leached from or sorbed by the equipment that contacts the sample. • **Exposure to the atmosphere.** Atmospheric gases and particulates that enter the sample can affect the water chemistry. • **Temperature.** Ground-water temperature is often lower than the atmospheric temperature at land surface. As the sample is brought to land surface, an increase in temperature can increase chemical reaction rates and microbial activity and cause degassing.
Strategies to maintain sample integrity
• **Plan sampling at sites in a sequence that avoids contamination.** Start with pristine sites or those least contaminated or with lowest concentrations of dissolved solids or target analytes. End at the site with the highest concentrations of target analytes. • **Clean equipment.** Sample only with decontaminated equipment and quality assure the efficacy of the cleaning procedures (collect equipment blanks). • **Purge the well of standing water.** Purge the well to reduce artifacts from well installation or sampler deployment. If possible, pump at a rate that does not overly stress the aquifer, creating drawdown and mobilizing particulates. Protocols for purging and pumping rate can depend on well type and study objectives. • **Isolate the sample.** For example, use packers downhole and processing and preservation chambers at land surface. • **Avoid temperature changes.** Keep sample tubing as short as possible and shaded from direct sunlight. • **Avoid sample aeration.** Filter in-line; use thick, nonpermeable sample tubing; completely fill filtration assemblies and sample tubing with sample; fill sample bottles from bottom up to overflowing whenever appropriate; handle anoxic water under an inert gas atmosphere, if necessary (section 4.2.2.C). • **Collect quality-control samples.** Review the analytical results and adjust field procedures, if necessary, before the next sampling.

Table 4-9. Considerations for well selection and well installation

[Modified from Lapham and others, 1997]

Well location
• Location conforms to the study's network design for areal and depth distribution. • Land-use/land-cover characteristics, if relevant, are consistent with study objectives. • Site is accessible for equipment needed for well installation and sample collection. • Well elevation has been determined.
Hydrogeologic unit(s)
• Hydrogeologic unit(s) that contribute water to the well can be identified. • Depth and thickness of targeted hydrogeologic unit(s) are known or can be determined. • Yield of water is adequate for sampling (typically, a minimum of 1 gallon (3.785 liters) per minute).
Well records, description, design, materials, and structure
• Available records (for example, logs of well drilling, completion, and development) have sufficient information to meet the criteria established by the study. • Borehole or casing/screen diameter is adequate for equipment. • Depth to top and bottom of sample-collection (open or screened) interval is known (to determine area contributing water to well); well depth and other well-construction and well-development information is available. • Length of well screen is proportional to the vertical and areal scale of investigation. • Well has only one screened or open interval, if possible. (Packers can be used to isolate the interval of interest, but packers might not completely isolate zones in unconsolidated or highly fractured aquifers. If packers are used, materials of construction must be compatible with analytes to be studied.) • Top of well screen is several feet below mean annual low-water table to reduce chances of well going dry and to avoid sampling from unsaturated intervals. • Filter pack is of a reasonable length (a long interval compared with length of screened or open interval usually results in uncertainty as to location of the source of water to well). • Well-construction materials do not leach or sorb substances that could alter ambient target-analyte concentrations. • Well-structure integrity and communication with the aquifer are sound. (Checks include annual depth-to-bottom measurements, borehole caliper and downhole-camera video logs, and aquifer tests.)
Pump type, materials, performance, and location of sampler intake
• Supply wells have water-lubricated turbine pumps rather than oil-lubricated turbine pumps. (Avoid suction-lift, jet, or gas-contact pumps, especially for analytes affected by pressure changes, exposure to oxygen, or that partition to a gas phase.) • Pump and riser-pipe materials do not affect target-analyte concentrations. • Effects of pumping rate on measurements and analyses have been or will be evaluated. • Sampler intake is ahead of where water enters treatment systems, pressure tanks, or holding tanks.

4.2.2.A Well Construction and Structural Integrity

Lapham and others (1997) describe common well-drilling, well-completion, and well-development methods and the importance of checking the structural integrity of the well periodically. Study personnel should be aware of the effects that well installation and the potential failure of the well structure can have on the data being collected.

Effects of well construction

Well-drilling, well-completion, and well-development methods can have long-range effects on sample chemistry (Lapham and others, 1997). Field personnel should review the well-construction methods and materials used, in addition to the length and diameter of the well screen and casing and how the well was completed.

- Circulation in the borehole of air and fluids such as water, bentonite, and biochemical slurries can infiltrate the aquifer, thereby altering water chemistry or biochemistry. For example, studies indicate that samples collected for chlorofluorocarbon (CFC) and sulfur hexafluoride (SF_6) analyses at monitor wells drilled in fractured-rock aquifers using air-rotary methods can be biased for those analyses 12 months or longer after being drilled (L.N. Plummer, U.S. Geological Survey, written commun., 2006), although a three-well-volume purge protocol is used (section 4.2.3). Well development by air injection also is likely to bias CFC and SF_6 analyses and produce faulty interpretations with respect to ground-water ages (Shapiro, 2002). High-capacity, high-yielding, or frequently pumped supply wells are less likely to be affected. Claassen (1982) discusses how mud-rotary drilling, grouting, and other well-construction practices also can have a relatively long-lasting effect on major-ion compositions and chemical properties of ground water, and provides methods by which to analyze these effects.
- Mixing of waters with different quality can occur in wells with long or multiple screens because of well-bore flow. On the other hand, wells with short screens relative to the total thickness of an aquifer might be screened at intervals that miss major zones of interest, such as zones with high transmissivity or contamination.

Selection of the appropriate well design depends on study objectives. For example, if samples withdrawn from an unconfined aquifer will be analyzed for volatile organic compounds, dissolved gases, or trace metals, the top of the screened or open interval should be located far enough below the lowest anticipated position of the water table (3 ft (~1 m) or more) so that the screened interval will not be intersected by the water table during drawdown. The purpose of this design is to avoid gaseous diffusion into the sample from a partially saturated or open interval. On the other hand, the well might be designed specifically to screen across the water table to better assess the thickness of oil or other light non-aqueous phase liquids (LNAPL) floating on the water surface.

Deterioration of the well structure

The integrity of the well's construction can deteriorate or the well can "silt in" over time. The structural integrity of monitor wells and their hydraulic connection with the aquifer should be checked at least annually or as described below. Checking well integrity should be scheduled to occur during a nonsampling site visit, if possible. If the well integrity will be checked during a sampling field trip, do this only after completing sample collection to avoid stirring up particulates that could enter the sample and cause a bias in analysis of trace metals, polychlorobiphenyls (PCBs), or other analytes that tend to associate with particulate matter.

- Inspect the integrity of the surface casing and seal routinely when visiting the well.
- Inspect the subsurface casing (this can be done using a borehole televiewer).
- Note any changes in depth to the bottom of the well; this measurement should be made annually at wells with recurring water-level or water-quality data collection. In addition, the well should be tested for hydraulic connection to the aquifer every 3 to 5 years.
- Purge well water laden with particulates until turbidity values return to background or near-background levels; that is, the final turbidity value recorded after the well has been properly developed. Typically, the turbidity value measured at a properly constructed and developed well is about 10 turbidity units, although it is common for background turbidity in ground water to be 5 turbidity units (the threshold for visible turbidity). Turbidity values that cannot be improved to less than about 25 units after purging or well redevelopment can indicate failure of the well structure or that the well was improperly constructed. If possible, a different well should be selected or a new well installed.

4.2.2.B Well-Hydraulic and Aquifer Characteristics

Hydraulic characteristics of the well and the structural and material properties of the aquifer can impose specific constraints on the sampling effort and achieving results that can be interpreted within a defined measure of quality. These considerations affect the selection of the equipment and sampling methods to be used, and ultimately may result in determining that a well is unsuitable for the intended data-collection effort.

Pumping rate

The pumping-rate capability of a given well-and-pump system is related to well capacity. Compared with pumping rates at supply wells, pumping rates at domestic wells are low. Advantages and disadvantages associated with low- and high-capacity wells are described in Lapham and others (1997). When reviewing study objectives, consider the effect of the proposed pumping rate on the aquifer with respect to what the water quality of the samples to be collected will represent.

- Pumping a few tens of gallons per minute can induce substantial leakage from confining beds if drawdown is rapid (formation materials are low-yielding). By contrast, pumping at a rate of thousands of gallons per minute from high-yielding materials is not likely to induce such leakage.
- Pumping at a high rate can cause turbulence and thus turbidity in the water column, resulting in biased data.
- Pumping at a low rate (for example, 1 to 4 gal/min, or 3.8 to about 15 L/min) in deep wells might result in the sample taking several hours to reach land surface. A long residence time of water within the sample tubing may compromise sample integrity.

- Be aware that pumping at any rate draws water preferentially from the most transmissive intervals, whether in fractured rock or unconsolidated media. Since the wellbore has a much higher hydraulic conductivity than the formation, the sample collected represents a flux-weighted average of the various inflow locations and the location of the pump intake does not affect this result (A.M. Shapiro, U.S. Geological Survey, written commun., 2006; Gibs and others, 2000; Reilly and LeBlanc, 1998; Gibs and others, 1993; Reilly and Gibs, 1993).
- The rate of pumping during purging should remain constant and be maintained as the pumping rate for sample withdrawal and collection. Fluctuations in pumping rate affect sample quality (Gibs and others, 2000).

Low-yield wells

A yield of at least 1 gal (3.75 L) per minute without causing drawdown of about 2 ft or more below the top of the open or screened interval is recommended for adequate sampling at monitor wells with a diameter of 2 in. or greater (Lapham and others, 1997). Wells that yield less than 100 mL/min frequently incur substantial drawdown during well purging. **Low-yielding wells, especially those that exhibit slow recovery or are pumped dry, are not recommended for water-quality sampling.** Situations may occur, however, that necessitate use of such wells.

- Low yield may be a function of poor well construction. Try to improve the well yield by redeveloping the well. Mechanical surging methods commonly produce the best results and avoid introduction of contaminating fluids; however, such methods must be employed in a manner to avoid damage to the structure of the well (Lapham and others, 1997). Pumping or over-pumping methods usually are not as effective for increasing the well yield. It is advisable to consult with an experienced and reputable well driller
- When drawdown occurs across the open interval, contamination from atmospheric gases or other inputs can affect subsequent water chemistry; for example, VOC loss, contamination of ambient CFC and SF_6 concentrations, and increase in turbidity.

- Wells must be purged before sampling (see section 4.2.3). After purging, the water level in the well should recover to approximately 90 percent of its starting level before sampling should commence. In low-yield wells this can take several hours or longer, requiring potentially multi-day visits to complete a three-well-volume purge. The longer the recovery time, the lower the confidence that the sample to be collected can be considered representative of ambient aquifer water composition. The actual volume of well water purged needs to be documented if it is less than the standard three-volume protocol.

RULE OF THUMB:

Do not sample wells at which recovery of water level after purging to 90 percent exceeds 24 hours.

- Consider whether packers can be used to seal off the interval to be sampled; in this case, only the isolated interval needs to be purged. This assumes that the interval selected is sufficiently transmissive to yield the volume needed of formation water. **CAUTION:** installing packers within a well screen can result in drawing in water from above or (and) below the packed-off interval through the filter pack in the annular space.
- Weigh several factors when selecting the sampler to withdraw water from a low-yield well. If possible use a low-volume submersible pump (for example, a Bennett pump).
  - — Bailers may stir up particulate matter and compromise specific analyses of interest.
  - — Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in loss of volatile analytes.
  - — Operating variable-speed, electrical submersible pumps at low flow rates may result in heating of the sample as it flows around and through the pump; this also can result in sample degassing and VOC loss, in addition to changes in other temperature-sensitive analytes.

Aquifer media with defined paths of preferential flow

In order to make a relevant interpretation of the sample chemistry, it is necessary to take into account the aquifer interval or intervals that yield substantial contributions of water to the well and understand the hydraulic conditions within the well that result from (a) ambient flow in the aquifer to the well, and (b) the conditions induced by sampling (Shapiro, 2002).

- **Regardless of the pumping rate or location of the pump intake**, water will be withdrawn first from the borehole and only later in time from the aquifer. The heterogeneity and anisotropy within the (consolidated or unconsolidated) aquifer interval being sampled dictates the paths of permeability through which formation water enters the well.

- **Flow dynamics within the well must be understood to determine if and when the water being withdrawn represents fresh formation water.** Differences in head (from contributing paths of flow within the aquifer) and differences in solution density from these contributing areas of flow will result in flow within the borehole.

4.2.2.C Vulnerability of Ground-Water Samples to Contamination

Because guidance cannot account for every potential threat to data quality, the responsibility lies with the field personnel to (a) be aware of the factors that can compromise the quality of the ground-water samples collected (table 4-8), and (b) use appropriate techniques and strategies to minimize and account for bias in the resulting data (section 4.3). The most common sources of sample contamination result from improperly cleaned equipment; contact or random particulate input from the atmosphere; and sample-water contact with hands, fumes, or other extraneous matter during sample-handling activities (Horowitz and others, 1994).

- Implement "good field practices" and collect quality-control samples (section 4.0).
- Use Clean Hands/Dirty Hands sampling techniques (table 4-3).
- Use equipment-selection and equipment-cleaning procedures that are described in NFM 2 and NFM 3, respectively.
- Withdraw sample water in a manner that avoids turbulence, contact with the atmosphere, and changes in temperature and pressure.
- Avoid sampling at wells that have less than 5 ft of water column, to prevent inclusion of detritus from the bottom of the well.
- As a rule, collect, process, and preserve samples within clean, enclosed chambers.
- Review the results of equipment blanks, field blanks, and other quality-control (QC) information well in advance of sampling. Use this information to adjust sampling plans and procedures, or to otherwise prepare for field work.

Standing borehole water

The chemical composition of standing water in a borehole is affected by well-construction practices, as described above, by contact with the initial and overlying air within the borehole, by geochemical and biochemical processes occurring in the borehole water, and by the vertical as well as horizontal borehole flow. Borehole flow is partially a function of hydraulic head differences within zones of preferential flow in the aquifer; consequently, water can move up or down vertically as well as into and out of the aquifer horizontally (Shapiro, 2002).

Formation water that is stored in a filter (gravel) pack within the annular space between the well casing (screen) and aquifer is not necessarily representative of formation-water chemistry, but can take on the mineral signature of gravel materials and can cause a change in pH values. Assuming that the well has been appropriately developed, the well also should be purged of standing water each time before samples are withdrawn (see section 4.2.3).

Atmospheric and dissolved gases

Exposure of anoxic or suboxic samples to the atmosphere can increase dissolved-oxygen (DO) concentrations to a well above ambient concentrations, causing bias not only in the DO data but also in the results of analyses for particulate and dissolved metals, sulfide, VOCs, CFCs, SF_6, microorganisms, and measurements of pH and alkalinity. Minimize or isolate the sample from atmospheric contact, using the following procedures, as appropriate.

- If pumping, only use pumps that can deliver a smooth, nonturbulent flow in-line to the sample collection/processing chamber (NFM 2.1.2). The same pumping technique applies for making field-measurement determinations (NFM 6.2), whether pumping while using a multi-parameter instrument for in situ measurements or to deliver the sample to a flowthrough chamber.

- Avoid sampling at monitor wells in which the sampler intake is drawing in water that has mixed with the overlying air column. If sampling at such wells cannot be avoided, samples should not be collected for analysis of dissolved gases such as VOCs, CFCs, and SF_6. The accuracy of trace-element data from such samples also may be in question. Check the list of analytes and data-quality requirements to determine if samples of the appropriate quality can be acquired.
- Use transparent sample-delivery tubing. Avoid entraining bubbles in the tubing by filling it to capacity; if bubbles form, tap the tubing with a blunt object to dislodge them and move them out.
- Fill sample containers within a processing chamber.
  - An effective bottle-filling method is to insert the discharge end of clean sample tubing to the bottom of the bottle so that the sample fills the container from the bottom up to overflowing. Cap the bottle quickly. This method is not practical for every sample type.
  - Atmospheric oxygen can be completely removed from the processing chamber (or glove box) by filling it with a clean, inert gas, especially one that is heavier than air, such as argon. Alternatively, good results have been documented by passing inert gas over the sample bottle opening while filling the bottle or by filling the bottle (and capsule filter, if used) with the inert gas beforehand.

To fill a chamber with inert gas:

1. Insert a desiccant pack in-line between the gas tank and the processing chamber.
2. If using a processing chamber, add a "T" fitting at the top to secure the small-diameter gas delivery hose, which is then inserted through the chamber cover.
3. Seal the chamber cover closed by twisting and tightly clipping it or using some other sealing method.
4. Start the flow of inert gas into the chamber.
5. Cut slits through the top (this is not needed if using a glove box) to allow access with gloved hands. Note that the entry of gas drives air out of the chamber through the slits.

Ground-water samples with ambient concentrations of dissolved gases (for example, methane) should be collected so as to avoid degassing. Degassing can occur from an increase in water temperature as the sample is brought to the surface, or because of leaks in the sampling and pressure system.

- Effervescent waters or samples collected for dissolved-gas analysis should use a Kemmerer or other sampling device designed to maintain ambient pressure. Collect CFCs and SF_6 samples using the procedures described on the USGS Reston Chlorofluorocarbon website, http://water.usgs.gov/lab/ (accessed July, 2006).
- Check that all equipment connections and fittings are airtight.

Use of sampling equipment

The type of equipment used for well purging and sample withdrawal can affect the quality of the sample and how the data are interpreted. Samples of ground water from monitor wells generally arewithdrawn using a submersible pump, a peristaltic or valveless metering pump, or a point sampler such as a bailer, thief sampler, or syringe; supply-well pumps generally are permanently installed and should not be removed unless absolutely necessary and with the owner's permission (NFM 2). Equipment to be used for sampling – the materials of construction and the manner of operation – must be checked against the list of target analytes and the characteristics of the well in order to determine whether the equipment is appropriate to meet study requirements. Select and prepare equipment using the guidelines and protocols described in NFM 2, 3, and 6[14] and shown on figure 4-10.

- The sample-wetted parts of the equipment must be constructed of materials that will not contaminate the sample with respect to target analytes (NFM 2). Collect an equipment blank before field activities begin to test the suitability of the equipment for its intended use.

[14]NFM 2, "Equipment selection for water sampling;" NFM 3, "Equipment cleaning for water sampling;" NFM 6, "Field measurements."

- All sampling equipment must be cleaned and the efficacy of the cleaning or decontamination procedures should be confirmed with analyses from quality-control samples (NFM 3). Document in field notes the cleaning and quality-assurance procedures used, along with the analytical results for equipment-blank samples collected to test cleaning procedures.
- A flow-splitting manifold (fig. 4-10) constructed of noncontaminating materials is recommended for directing the pumped-sample flow to the point of sample collection (usually a sample-collection or sample–processing chamber).
- When setting up a pump system that requires a hydrocarbon-fueled generator, take note of the wind direction and locate the generator downwind from the sampling operation.
- Pump tubing should be kept as short as possible (to avoid changes in sample temperature) and should extend directly into a processing chamber or glove box to avoid sample contamination from the atmosphere. Set up sample chambers before beginning sample collection (a flowthrough chamber, if used for field measurements (NFM 6); and processing and preservation chambers for sample collection and filtration, and preservation, respectively).
- The sampling device should be conditioned with the well water before being used to collect samples.

To condition or field rinse a ground-water sampler:

1. Wearing disposable gloves, gently lower the sampler through the water column in the well to the selected sampling depth interval. Take care to minimize disturbance in the water column and minimize disturbance of sediments at the bottom of the well.
    - If using a pump sampler, field rinsing is accomplished with well purging, provided that the well will be purged with the same equipment to be used for sample withdrawal. Water should be pumped through the sample tubing to achieve the equivalent volume of three equipment rinses.
    - If using a point sampler, fill the sampler partially with the water to be sampled; shake or swirl it to cover all interior parts of the sampler. Drain the rinse water through the nozzle or bottom-emptying device. Repeat this procedure three times.
2. Discard or contain the well-water rinsate (including purge water) as appropriate, to comply with waste-disposal regulations; this is especially critical if the water is known or suspected to contain toxic levels of chemical substances.

Well-bottom detritus

Incorporating sediment or other detritus from the bottom of the well into the sample can result in data that do not represent the composition of native aquifer water. To avoid this:

- Lower the pump or other sampler slowly and smoothly to the desired point of sample intake; that is, without creating turbulence and without stirring up bottom detritus.
- Keep the sampler intake far enough above the bottom of the well to avoid drawing in bottom detritus.
- Maintain a pumping rate that is not so high as to draw in bottom detritus.

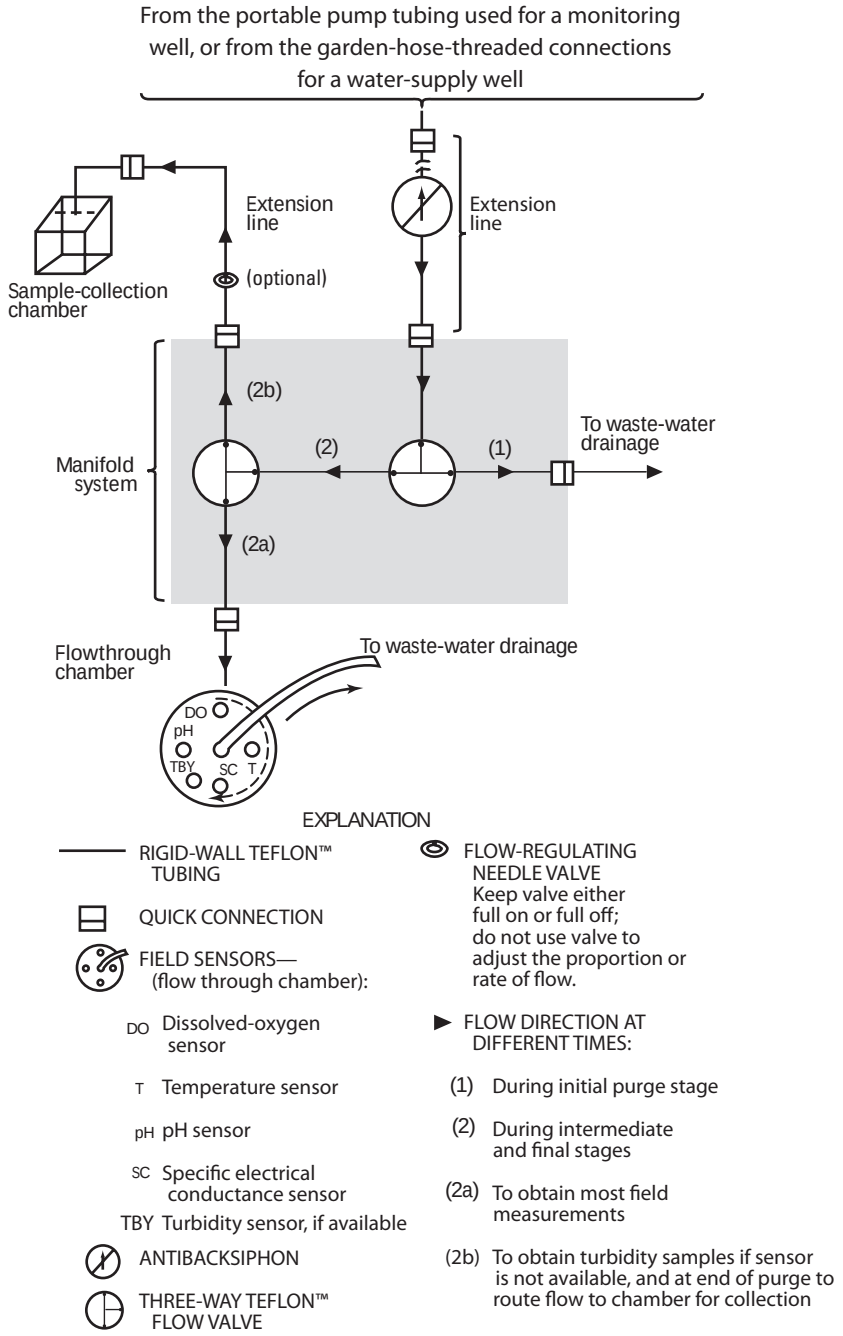


Figure 4-10. Example of a manifold used for well purging and sample collection (modified from Koterba and others, 1995).

WELL PURGING 4.2.3

Well purging removes standing water from the borehole. The purpose of purging is to reduce chemical and biochemical artifacts caused by the materials and practices used for well installation, well construction, and well development, and by reactions occurring within an open borehole or annular space between a well casing and borehole wall.[15] Purging also serves to condition the sampling equipment with well water. The purging process forms a continuum with that of sample withdrawal. Sample withdrawal is the process by which sample water is transported for collection and processing, after the well has been purged.

Standard purge procedure 4.2.3.A

As a rule of thumb, the standard USGS purge procedure removes three or more well volumes of standing water while monitoring the water level and the stabilization of routine field measurements as a function of time, pumping rate, and the volume of water being removed (figs. 4-11 and 4-12). Routine field meaurements include pH, temperature, specific electrical conductance, dissolved oxygen, and turbidity. Inherent in the purge procedure is an assumption that stabilization of field properties indicates that the discharge water represents ambient formation water. Field personnel should examine this assumption for each well, using their knowledge of the well and aquifer hydraulics. Review of the purging history, including physical and chemical data monitored, can save time and help determine how the well should be purged.

[15]Passive sampling methods may not require purging of the well prior to sample collection (Vroblesky, 2001; Powell and Puls, 1993; and Ronen and others, 1987).

- When calculating a purge volume for a cased well:
  - — Include an estimate for the volume of water stored in the annular space between the casing and borehole wall, using knowledge of the borehole diameter. It is mandatory to evacuate at least one borehole volume (that is, casing volume plus that of the annular space), whether that space has been backfilled with formation materials or with a gravel pack.
  - — Make the calculation of casing volume using the height of the water column to the bottom of the well, instead of the water column height to the top of the screen.

- The number of well volumes to be evacuated relies on confirming the time over which field measurements stabilize, using knowledge of the well and aquifer hydraulics.
  - — To the extent practical, field personnel should apply an understanding of the borehole and aquifer hydraulics for the well to determine when the water being withdrawn from the borehole will likely be dominated by formation water (Shapiro, 2002; Claassen, 1982).
  - — Values for field properties are recorded sequentially and at regular time intervals. The frequency of these measurements depends on the purging rate, which in turn is a function of well depth and diameter, and aquifer transmissivity. Field-property stabilization should be plotted as a function of a logarithmic time scale rather than a linear time scale, to best determine the point at which the contribution of aquifer water dominates pump discharge (see Shapiro, 2002). Field-measurement procedures are detailed in NFM 6.
- Purging should not cause substantial drawdown in monitor or supply wells when pumping at a rate of at least 1gal (3.75 L) per minute. Ideally, drawdown will be at a steady state, with the water level remaining above the top of the open or screened interval.
- Use of a borehole packer system or well liner is recommended for wells in fractured or low-yield media, to isolate zones of highest hydraulic conductivity or of particular interest. Transducers should be installed above and below the packers to monitor head differences.

.

Well volume = $V = 0.0408\ HD^2$ =___ gallons,
where
V is volume of water in the well, in gallons,
D is inside diameter of well, in inches, and
H is height of water column, in feet

Purge volume = (n)(V) = _____ gallons,
where
n is number of well volumes to be removed during purging

Q = estimated pumping rate = _____ gallons per minute

Approximate purge time = (purge volume)/Q = _____ minutes

Well casing diameter (D) (in inches)	Gallons per foot of casing
1.0	0.04
1.5	.09
2.0	.16
3.0	.37
4.0	.65
4.5	.83
5.0	1.02
6.0	1.47
8.0	2.61
10.0	4.08
12.0	5.88
24.0	23.50
36.0	52.90

Explanation:
Well volume: Volume of water in a borehole or cased well.

Well volumes: For cased wells, the actual number of well volumes should account for evacuation of at least one volume of water stored in the annular space between the casing and borehole wall. This can be estimated from knowledge of the drilled well diameter.

Approximate purge time: Actual purge time depends also on field-measurement stabilization (use fig. 4-12).

Figure 4-11. Estimation of purge volume and purge time.

RECORD OF WELL PURGING

Date: _____ By: _____
SITE ID _____ STATION NAME _____

HEIGHT OF WATER COLUMN_____ DEPTH OF WELL_____
PUMP INTAKE (ft or m below MP): Start_____ End _____
WELL-PURGING METHOD AND PUMP TYPE (describe):_____
_____

TIME	WATER LEVEL below *MP LS	DRAW-DOWN	TEMPER-ATURE	CONDUC-TIVITY	pH	DISSOLVED OXYGEN	TURBID-ITY	APPROX. PUMPING RATE
HR:MIN	*ft or m	*ft or m	°Celsius	µS/cm	standard units	mg/L	**	*gpm or L/min

*Circle the unit used; MP, measuring point; LS, land surface; HR:MIN, hour and minutes; ft, feet; m, meter; µS/cm, microsiemens per centimeter at 25°C; mg/L, miligrams per liter; gpm, gallons per minute; L/min, liters per minute.
**Select the appropriate turbidity unit from http://water.usgs.gov/owq/turbidity_codes.xls.

Well volume = $V = 0.0408\ HD^2$ = ____ gallons. **Purge volume** = $(n)(V)$ = ____ gallons.
V = volume of water in well, in gallons; D = inside well diameter, in inches; H = height of water column, in feet; n = number of well volumes to purge.
Well volume is 0.16 gallons per foot for a 2-in. casing diameter.

FIELD MEASUREMENT	STABILITY CRITERIA[1]
pH	± 0.1 standard units
Temperature (T) (in degrees Celsius)	± 0.2°C (thermistor thermometer) ± 0.5°C (liquid-in-glass thermometer)
Specific electrical conductance (SC)	± 5%, for SC ≤ 100 µS/cm ± 3%, for SC > 100 µS/cm
Dissolved-oxygen concentration (DO)	± 0.3 mg/L
Turbidity (TBY)[2]	± 10%, for turbidity < 100

[1]Allowable variation between 5 or more sequential field-measurement values.
[2]Select appropriate TBY unit from http://water.usgs.gov/owq/turbidity_codes.xls

Figure 4-12. Example of a field log for well purging.

Exceptions to the Standard Purge Procedure 4.2.3.B

Site characteristics, well characteristics, or study objectives could require modification of the standard purge procedure by changing the number of well volumes removed or by changing or adding types of field measurements and analyses. **Any modification to the standard well-purging procedure must be documented.** When standard purge volumes cannot be removed, (1) sufficient water must be withdrawn from the well to evacuate at least one borehole volume and to field rinse the sampler and sample tubing—alternatively, flush the pump and tubing system with the equivalent of three tubing volumes of DIW and purge the DIW from the tubing with clean nitrogen gas; and (2) field measurements should be determined before collecting samples, if possible. A lesser purge volume or other procedures may be modified, for example, when:

- A supply well to be sampled is being pumped continuously or daily at regular intervals and long enough to have removed three casing volumes of water—go directly to monitoring field properties.
- The sample-collection interval is sealed with packers (the interval to be sampled should be purged of three volumes).
- Water-level recovery from drawdown to approximately 90 percent of the original volume in the well cannot be achieved within a reasonable timeframe (not to exceed 24 hours; see the previous discussion on low-yield wells).
- The study will customize the protocol for field-determined properties or constituent analyses to address specific study objectives; however, the routine suite of field-measurement values should be determined.

> **TECHNICAL NOTE:** Target or indicator analytes may be added to the purge criteria to address study objectives. The analysis can be performed onsite using portable analytical equipment or a mobile laboratory. The acceptable variability in analyte measurements to define stabilization and minimum number of readings is defined by the study (ASTM International, 2005).

- One or more field measurement keeps drifting, and sampling at that well cannot be avoided—NFM 6 provides suggestions for poor field-measurement stabilization, including extending the purge time and purge volume. Field personnel must make a decision based on their understanding of study objectives whether to extend purge time. Such decisions should be documented in field notes.
- Use of low-flow purging techniques is a stipulated study requirement: for a detailed description of the low-flow purge technique, refer to ASTM standard procedure D6452-99 (ASTM International, 2005).

TECHNICAL NOTE: Low-flow purging procedures are designed to minimize the volume of purge water and disturbance of the water column and maximize the contribution of formation water from a given interval of interest (Puls and Barcelona, 1996; Unwin and Huis, 1983). Minimizing purge volume is especially useful when regulating authorities mandate containment of purge water.

Low-flow purging is based on the theory that water moving through the well intake is representative of formation water surrounding the intake, and assumes that pumping at a low flow rate isolates the column of standing water so that only formation water is drawn into the intake. The typical flow rates for this method are on the order of 0.1 to 0.5 L/min; however, in formations of coarse-grained materials the flow rate may be as high as 1 L/min (ASTM International, 2005).

Select a low-flow purge-and-sampling technique with caution and with an understanding of aquifer and well hydraulics. The assumption should not be made that water withdrawn using a low-flow procedure represents ambient aquifer water at the targeted (intake) interval (Varljen and others, 2006), because the conductivity of well-bore flow within the specified interval is greater than that of the aquifer (Shapiro, 2002). Even where well-bore flow does not occur, aquifer heterogeneity over the length of the specified interval results in water being drawn preferentially through zones of highest permeability.

STEPS FOR SAMPLING AT WELLS 4.2.4

Develop a systematic agenda well in advance of the field effort that follows the sampling plan and quality-assurance protocols. Offsite preparations in addition to the steps needed to carry out onsite activities need to be included in planning for field work. Review the requirements and recommendations for site inventory (reconnaissance) and site file setup (section 4.2.1) .

Field-trip preparations. Adequate time must be scheduled to plan sampling activities, review data requirements, and make field-trip preparations. Prepare a checklist of equipment and supplies that will be needed, and order what is needed well before the field effort (fig. 4-13). Refer to NFM 2, Section 2.4, for lists of equipment and supplies commonly used for ground-water field activities. Review electronic and paper site files and make sure that they are kept up to date.

Before selecting and implementing purging methods, review table 4-8 to determine how maintaining sample integrity applies to the study and site.

- Consider whether modifications of standard USGS methods might be needed to address issues specific to the field site or program or study objectives. Document any deviation from the standard protocols.
- Review the types of quality-control (QC) samples planned for the study. Certain types of blank samples are required for all USGS studies. Review the most recent analyses of blank samples collected through the equipment to be used for sampling before field work begins.
- Determine if water level and well yield are sufficient to produce a representative sample.
- Decide how to determine or constrain the interval(s) from which the sample should be collected. Consider whether packers will be used and whether screen lengths are sufficiently short or long to meet the sampling objective. Determine the major sources of flow contribution to the well, if sampling in fractured or anisotropic formation materials.

Before leaving for the field site, review reconnaissance notes from the site inventory (table 4-6), and determine the number and types of environmental and QC samples to be collected (Appendix A4-C).

- Prepare the field forms that will be needed (for example, water-level, purging, field-measurement, analytical services request, and chain-of-custody forms). Fill out as much information as possible, including the equipment to be used and numbers and types of samples to be collected.
- Check equipment requirements (NFM 2). When assembling the equipment, test that equipment is in good working condition. Take backup equipment, as appropriate.
  - **Organic-compound samples.** Use fluorocarbon polymer (Teflon), glass, or metal for equipment components that will be in contact with samples to be analyzed for organic compounds. **Exception:** if collecting CFC samples, do not use Teflon sampler components or Teflon tubing (NFM 5).
  - **Inorganic-constituent samples.** Use fluorocarbon polymer or other relatively inert and uncolored plastics or glass for any equipment components that will be in contact with samples to be analyzed for inorganic constituents. Do not use metal or rubber components for trace-element sampling. Stainless-steel sheathed pumps are generally acceptable, but can leach low concentrations of chromium, molybdenum, nickel, and vanadium to the sample. **Collect an equipment blank to be analyzed before sampling begins, to demonstrate the acceptability of the data to be collected.**
- Set up a clean workspace (usually in the water-quality field vehicle) and the sample-processing and -preservation chambers. Place the filter unit and other necessary supplies for sample collection and processing into the processing chamber. **The generator and gas tanks must not be stored or transported in the water-quality field vehicle.**

Plan ahead. Take adequate time for site recon, and to prepare sampling plans, order supplies, test equipment, and get the training needed.

✓	Checklist for ground-water site setup and well-sampling preparations[1]
	Antibacksiphon device (one-way or check valve)
	Chemical reagents (for sample preservation and field analyses) and ice
	Deionized water and blank water
	Disposable, powderless, laboratory-grade gloves
	Equipment cleaning, decontamination, and disinfectant supplies
	Field forms (for example, ground-water-quality, water-level, and chain-of-custody forms) - electronic or paper; indelible ballpoint pen (black or blue ink)
	Field manual, sampling and quality-control plan(s)
	Filtration units and supplies
	Flow-regulating valve (needle valve or pinch clamps)
	Flow-splitting valve(s) for manifold system
	Flowthrough cell or chamber and field-measurement instrument(s) (single parameter or multiparameter); standard and buffer solutions; Kimwipes (see NFM 6)
	Keys (for locked facilities)
	Microbiota sampling supplies (see NFM 7)
	Photoionization detector (PID or sniffer)
	Sample processing and preservation chambers in which samples are bottled and treated, respectively, and associated supplies
	Safety equipment
	Sample containers (precleaned)
	Sampling device(s) (precleaned, portable equipment or other, as appropriate) and power supply (if needed); spare batteries
	Sample tubing (precleaned, several lengths)
	Shipping containers and supplies
	Stopwatch and calibrated bucket to measure pumping rate
	Tarp or plastic sheeting to place around well
	Threaded fittings, male/female, such as hose-type connectors (precleaned)
	Tools (such as wrenches to remove well cap)
	Tubing to direct waste discharge offsite or into sample container
	Water-level measurement equipment

[1]See NFM 2.4 for more detailed examples of equipment and supply checklists for sampling.

Figure 4-13. Example of checklist of equipment and supplies to prepare for sampling ground water at wells.

Steps for sampling. The standard USGS procedure for collecting ground-water samples consists of the following six basic steps and the activities needed to carry them out. The procedures needed for supply wells differ somewhat from those used for monitor wells. Steps 1 through 4 are detailed in this section. Steps 5 and 6 are described in NFM 5 ("Processing of Water Samples") and NFM 3 ("Cleaning of Equipment for Water Sampling"), respectively.

Step 1. Implement safety precautions and site preparations

Act with common sense. Be aware of existing and impending environmental conditions and hazards. Field personnel must be familiar with the guidance and protocols provided in NFM 9, "Safety in Field Activities." Organized and orderly procedures for setting up a site for sampling should be routine and helps to prevent mistakes that could compromise personnel safety as well as sample integrity.

Step 2. Measure water level

Procedures for water-level measurement can differ for supply wells and monitor wells. Detailed procedures for various methods of measuring water levels are documented by the U.S. Geological Survey (1980, p. 2-8), and additional information can be obtained from the USGS Office of Ground Water (http://water.usgs.gov/ogw). Refer to Appendix A4-B for a summary of water-level-measurement methods.

- Procedures and equipment for water-level measurement can differ, depending on the type, construction, and design of a well.
- Clean well tapes after each use at a well as described in NFM 3.3.8. Document in field notes if oil is floating on the water table. Review equipment-cleaning and sample-collection strategies and revise as needed if oil is present, to prevent contamination of samples. A dual-phase sonde can be used to determine the thickness of the oil layer, as well as the depth to water.
- Record discrete water-level measurements on field forms and in GWSI (USGS Office of Water Quality Technical Memorandum 2006.01).

Step 3. Purge the well and monitor field measurements

As discussed in Section 4.2.3, purging the well of standing water is generally required to ensure that the sample water will be withdrawn directly from the aquifer. Exceptions to the well-purging protocol may apply more commonly to water-supply wells, although exceptions for some monitor wells also have been described in the previous section. Regardless of the purge procedure followed, enough water must be withdrawn from the well to field rinse sampling equipment and to make measurements of field properties (field measurements). Purging and field-measurement information must be recorded, either on electronic or paper field forms (fig. 4-12). Specific guidance for use of field-measurement instruments is described in detail in NFM 6.

Step 4. Withdraw the sample

As a rule, pumping is the preferred method for withdrawal of groundwater samples. In this case, purging and sample withdrawal form a continuous process. Field measurements are monitored during purging with sample collection following immediately after final field measurements have been recorded. Equipment is selected that channels flow in-line to a field-measurement chamber and then, without stopping, to a sample collection/processing chamber; the sample is never exposed to the atmosphere during this process (fig. 4-10).

Depending on field conditions and study objectives, samples may be withdrawn using a thief-type sampler. Lower and raise the sampler smoothly at a constant rate, keeping the suspension line clean and off the ground. A bailer or other thief-type sampler generally is not recommended for trace-element or volatile organic compound (VOC) sampling. Bailing can mobilize particulates and, unless designed for VOC sampling, can allow VOCs to escape.

- Measurements at a monitoring well
  - The standard purging procedure usually is appropriate (section 4.2.3.A). Exceptions to the standard purging procedure are described in section 4.2.3.B.
  - Either a downhole or a flowthrough-chamber system can be used for field measurements (NFM 6). If samples will be collected, use the flowthrough chamber instead of the downhole system in order to avoid bias of chemical analyses from sample contact with downhole instruments.

- Measurements at a supply well
  - The standard purging procedure may not be appropriate (see section 4.2.3.B).
  - Identify well-construction materials and any equipment permanently installed in the well (such as a pump) that can affect the logistics and quality of the field measurement or sample.
  - Use a flowthrough-chamber type of field-measurement system (NFM 6).
  - Connect the field-measurement system to the wellhead at a point before the sample would pass through holding tanks, backflow pressure tanks, flow meters, or chemical treatment systems.

If more than one well will be sampled during a field trip, each site and (or) a field vehicle must be set up for onsite cleaning of the sampling equipment. Field personnel should design the most efficient field-cleaning system, appropriate for the sites to be sampled and in accordance with the equipment-cleaning guidelines described in NFM 3.

Step 5. Process the sample

Sample processing involves, in part, sample filtration, sample collection into appropriate containers, and sample preservation. Standard USGS procedures for sample processing are described in general and according to analyte type in NFM 5.

Step 6. Clean the equipment

Standard USGS procedures for cleaning (or decontamination) and QC of specific types of equipment used for collecting and processing organic and inorganic analytes are detailed in NFM 3. Field personnel should design the most efficient field-cleaning system, appropriate for the sites to be sampled and in accordance with wastewater disposal regulations.

Practice safe sampling.

Supply Wells 4.2.4.A

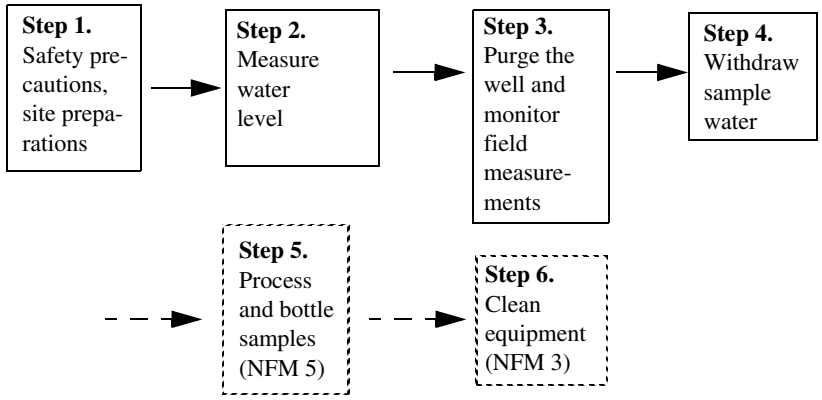
Collection of samples from water-supply wells with permanently installed pumps requires specific considerations, preparations, and precautions. Refer to NFM 9 for safety precautions. Field personnel should be aware of the potential sources of contamination to samples withdrawn from supply wells (table 4-10).

- Do not sample the well if it is not possible to bypass any holding tank or chemical treatment system.
- Document all field observations and any deviations from standard sampling procedures.
- Obtain permission for access to and collection of samples and data from the well.

Table 4-10. Advantages and disadvantages of collecting water samples from supply wells with permanently installed pumps

Advantages
• Cost of well and pump installation is not a factor. • Samples from domestic and municipal wells (for studies of the quality of potable water supplies) are collected directly from the resource being studied. • Pumps are dedicated to the site; therefore, - cross-contamination of other wells from pumping equipment is not a problem, and - field time and effort otherwise expended in operating and cleaning portable pumps can be allocated to other tasks. • In-service supply wells generally require a minimal amount of purging at the time of sampling.
Disadvantages
• The well and the open or screened intervals might not isolate the aquifer zone where water-quality information is needed. • Materials of well and pump construction may affect concentrations of the analytes targeted for study. • Pumps with high capacities can alter the water chemistry of a sample if the pump is lubricated with oil. The water chemistry of a sample also can be altered by aeration and degassing caused by high-velocity pumping, suction lift, and cavitation. • Access for water-level measurements might be unavailable; or, access might be indirect (through an air line), thus yielding less accurate measurements.

Steps for sampling from water-supply wells



Ensure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies. Implement good field practices and *CH/DH* techniques, as applicable (duties typically performed by Clean Hands (*CH*) and Dirty Hands (*DH*) are indicated in the steps that follow). Check that you have the correct site and well folders, and a document (preferably signed) granting site access and well sampling and purging permission.

Step 1. Supply-well sampling: Safety and site preparations.

a. Upon arrival, set out safety equipment such as traffic cones and signs, as needed. Park vehicle in a position to prevent sample contamination from vehicle and traffic emissions and the prevailing wind.

   - Check the well identification number and compare it with the number in the well file and in field notes (section 4.2.1).
   - Assign *CH/DH* tasks.

b. Describe well and site conditions in field notes and on field forms, as appropriate (*DH*).

c. Check site for hazardous conditions (NFM 9) (*DH*).

   - Test for toxic fumes if the well is in an enclosed structure or if there is reason to suspect the presence of organic vapors.
   - Examine the area for evidence of animal infestation and other potential safety hazards.

d. Prepare an area to be used for field cleaning of equipment *(DH)*.

e. Set up equipment and instruments for field measurements and ground-water withdrawl *(DH)*.

- Calibrate field-measurement instruments (*DH*). Refer to NFM 6 for calibration information and instructions.
- Wearing disposable gloves, set up the sample-processing and sample-preservation chambers (usually in the water-quality field vehicle). *Change gloves*. Place the filter unit and other supplies that will be needed for the first sample into their respective chambers *(CH)*.

f. Spread clean plastic sheeting (polypropylene tarp, for example) on the ground around the well to keep sampling equipment, the well tape, and sample tubing off of the ground. Prepare area to be used for field cleaning of equipment (*DH*). Take care not to trample on the sheeting.

g. Determine the location and method of tubing hookup to the well. Connect sample tubing as close as possible to the wellhead *(DH)*.

i. There must be no water-storage tanks, holding or pressurization tanks, or chemical disinfection or water-softening systems connected in-line between the pump and tap/faucet to which sample tubing will be connected. Obtain written permission to install a tap if it is necessary for bypassing a holding tank or treatment system.

ii. Select a faucet without an aerator or obtain written permission to remove the aerator (replace it after sampling). Use connectors and sample tubing that will not contaminate the sample with respect to target analytes.

- Use only precleaned sample-contacting connectors and tubing.
- Check that you have the correct size and configuration of connector fittings, as compatibility varies amont types of plumbing.
- At highly contaminated sites, sample-contacting equipment either should be dedicated for that site or should be disposable.

iii. Connect a short length of sample tubing (2 to 3 feet) between the tap/faucet fitting and the antibacksiphon valve *(DH)*.

iv. Connect sample tubing from the antibacksiphon valve to the manifold; and from manifold to theflowthrough chamber, the sample-processing chamber, and the waste outlet.

- Select transparent, nonporous sample tubing and tubing to the flowthrough chamber for field measurements to be able to check for bubbles or sediment entrained in the sample flow. Sample tubing must be clean and of the appropriate material with respect to study objectives; flowthrough-chamber tubing can be of any material if used only in connection with field measurements. Keep the discharge end of the sample tubing sealed until use.
- Tubing used solely to discharge purge water to waste can be of any material (garden hose, for example), but must be long enough to transport wastewater away from the work area.

Step 2. Measure water level *(DH)*.

Procedures and equipment for water-level measurement depend on well type and construction and the presence of nonaqueous liquid phases. Important considerations and method limitations are described in Appendix A4-B.

a. Put on gloves if chalking a steel tape. Using a weighted steel or electric tape in a nonpumping well, measure water level to the nearest 0.01 ft (for wells <200 ft to water), starting at the permanent measuring (reference) point. Repeat the measurement until precision is within 0.02 ft (U.S. Geological Survey, 1980). At wells deeper than 200 ft, calculate the compensation factor to account for streching of the tape.

- Do not allow the well tape to contact the ground before inserting it into the well.
- Care must be taken not to entangle the well tape in the pump discharge pipe or intake.
- Do not use lead weights; use stainless steel or other noncontaminating material. An unweighted tape might be necessary if the weight cannot fit past the pump apparatus.
- At some supply wells, the water level only can be estimated using the less accurate air-line method. As a last resort if no water-level measurement can be made, use the measurement recorded on the driller's well log in order to calculate an estimated purge volume.

b. Water-level measurements must be recorded on field form(s) and in GWSI forms. On the field form, note any deviations from standard water-level measuring procedures. It is useful also to record water level in QWDATA (USGS Office of Water Quality Technical Memorandum 2006.01).

c. Clean the tape after each use to avoid cross-contamination of wells (see NFM 3.3.8).

Step 3. Purge the well and monitor field measurements *(DH).*

a. Calculate or estimate the well volume (the depth to the bottom of the well and the inside casing diameter must be known):

$$\mathbf{V = 0.0408 \times H D^2}$$

where,

V is volume, in gallons
H is height of water column
$\mathbf{D^2}$ is the inside well diameter squared, in inches.

b. Begin pumping to purge the well according to study objectives. Discharge the initial well water through the waste line until sediment is cleared from the flow.

- Supply-well pumps commonly are either on or off, with no variable-speed capability. To regulate the flow, use a manifold with a needle valve, if possible.
- Open any additional valves or taps/faucets to ensure that the pump will operate continuously and reduce the possibility of backflow stored in ancillary plumbing lines; keep these open throughout purging and sample withdrawal.
- The pump should produce a smooth, solid stream of water with no air or gas bubbles and without pump cavitation during field measurements and sample withdrawal.
- **Do not halt or suddenly change the pumping or flow rate during the final phase of purging or while sampling.**
- Contain and dispose purge waters according to Federal, State, or local regulations. Do not discharge purge water from one well into another without proper authorization. Discharge purge water far enough away from the well or well cluster so as not to enter or affect water quality in the well, and to prevent muddy and slippery work conditions.

TECHNICAL NOTE: A supply well that is in regular service and that is pumping continuously or that has been operating long enough to have removed three casing volumes of water within several hours of sample collection does not require removal of three well volumes. Before withdrawing sample in this case, flush sample water through the tubing and monitor measurements.

- Field personnel could request a site operator or homeowner to start pumping the well before personnel arrive onsite.
- If the pump has been turned off but three well volumes were removed within 24 hours before sampling and samples only will be analyzed for nutrient or major-ion concentrations, additional purging is not necessary.
- Purging immediately before sampling is recommended if samples for trace elements and volatile organic compounds will be collected.

c. When the water runs clear, divert flow to the flowthrough chamber for field measurements (unless a downhole instrument is in use). Once the flow is constant (see instructions in step b), begin monitoring field measurements (refer to NFM 6 for detailed instructions); in addition, record the number of well volumes being discharged, the start and end times of purging, the pumping rate, water level, and location of the pump intake (fig. 4-12).

- To control the flow rate from the maniford, use a flow-regulating valve, such as a faucet or needle valve.
- Keep three-way valves either completely open or closed (partially open three-way valves can create a vacuum or air bubbles, and can draw in contaminating water). **Do not use a two- or three-way valve to regulate the flow.**
- **Recommended:** To ensure a representative sample, maintain the water level in the well above the screened or open interval.

d. As the final well volume (commonly the third well volume) is purged, calculate the final pumping rate and record on field forms at least five sets of field measurements determined at regularly spaced intervals while pumping at this rate. Referring to the instructions provided in NFM 6, check the field-measurement data against the measurement-stability criteria (fig. 4-12).

- To record the pumping rate of water flowing through more than one conduit, sum the rate of flow through each conduit.
- Routine field measurements for USGS studies include water temperature, conductivity, pH, dissolved oxygen, and turbidity.
- The final pumping rate, used during the final five sets of field measurements, also should be used during sample collection.

Step 4. Withdraw ground water (*CH*).

Maintain the same rate of pumping throughout sample withdrawal and collection as the rate used during withdrawal of the final purge volume.

a. Put on disposable gloves. Check that the sample tubing is properly secured within the sample-processing chamber.

b. Direct sample flow through the sample tubing to the processing chamber and channel two tubing volumes of the water to waste.

- **If samples will be collected for organic carbon analysis through equipment and tubing that previously was methanol-rinsed, flush at least five tubing volumes of sample water through the tubing (or collect the organic-carbon sample using a separate, non-methanol-rinsed sampler) before proceeding to Step 5.**
- Use the needle valve at the manifold to adjust sample flow as appropriate for the target analysis. Depending on the site-specific logistics, a second needle valve can be installed after the outlet end of the manifold and close to the sample-processing chamber. Avoid splashing or pooling water inside the chamber while processing sample and filling sample bottles.

Flow should be constant and uninterrupted while purging and sampling.

Step 5. Collect and process the sample → Refer to NFM 5, *Processing of Water Samples*, for instructions regarding the field rinse of sample bottles, sample filtration, and the collection and preservation of wholewater and filtered samples.

RULE OF THUMB: The rate of flow for filling sample bottles should not exceed

- 500 mL/min for bottles 250 mL or greater in volume,

or

- 150 mL/min for 40-mL VOC vials.

Step 6. Clean equipment→ Refer to NFM 3, *Cleaning of Equipment for Water Sampling*. Sampling equipment must be cleaned as instructed in NFM 3 before leaving the field site.

At sites at which the level of contamination is suspected or known to exceed drinking-water standards or health advisories, use sample tubing that is disposable or dedicated to that site in order to minimize the risk of cross contamination between wells. Wear gloves while cleaning and handling sampling equipment.

- Rinse sampling equipment with deionized water before the equipment dries.
- Clean equipment to be used at another well during the same field trip after rinsing it and before moving to the next site.
- Collect field blanks to assess equipment-cleaning procedures directly after the sampling equipment has been cleaned in the field or after moving to the next site and before sampling, as dictated by the data-quality requirements of the study (section 4.3).

Monitor Wells 4.2.4.B

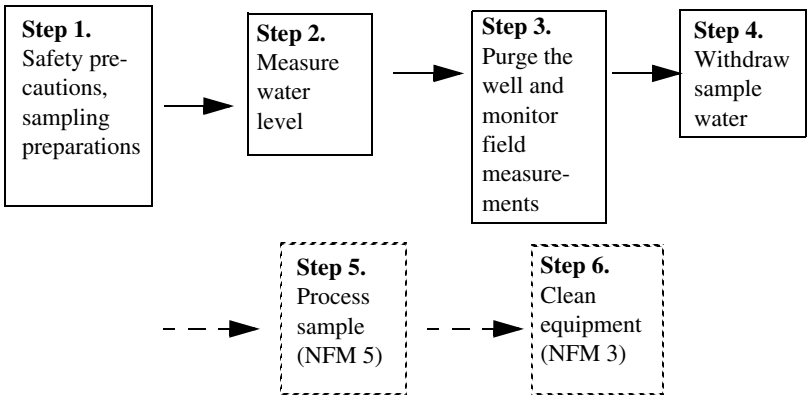
When selecting purging equipment for monitor wells, site conditions need to be considered. In general, a portable, submersible nonaerating pump that also will be used for sampling is recommended. The specific equipment and well-purging method selected, however, can depend on depth to water, length of the open interval, well construction, and site contamination. For example, to reduce the volume and time required for purging, especially in deep wells or in wells for which purge water is contaminated and must be contained, inflatable packers can be used to isolate the aquifer interval of interest.

In addition:

- When the water table is deeper than 250 ft and (or) a large volume of water must be purged, a dual-pump system can be used: position, in series, a submersible pump downhole and a centrifugal pump at the surface.
  - Water discharging from the slow-pumping submersible pump is used for field measurements and sample collection, whereas the centrifugal pump removes the required volume of purge water at a faster rate. Changes in pumping rate might increase turbidity.
  - Dissolved-oxygen concentration, Eh, or turbidity should not be measured while using a dual-pumping system. Record measurements while operating only the submersible pump.
- When the water table is less than 25 to 30 ft from land surface, a peristaltic pump can be used for small-diameter wells. A peristaltic pump or other comparable suction device can affect dissolved-oxygen concentrations and Eh measurements unless low gaseous-diffusion tubing such as Tygon® is used (NFM 2).
- An inflatable packer sometimes is set above and below the screened/open interval, with a pump intake located within the screened/open interval.
  - Packers sometimes fail to form a complete seal between aquifer intervals, and should be used with pressure transducers located directly above and below the isolated interval to indicate whether water is leaking past the packers or short circuiting in the aquifer.
  - The materials of which the packer is made also might affect sample chemistry by leaching or sorbing target analytes.

- A bailer is not recommended for purging. The plunging action of the bailer can release orstir up particulates that are not ambient in groundwater flow, resulting in biased measurements and analyses.

Steps for sampling at monitoring wells



Step 1. Monitor-well sampling: safety and site preparations.

a. Upon arrival, set out safety equipment such as traffic cones and signs, as needed. Park vehicle in a position to prevent sample contamination from vehicle and traffic emissions and prevailing wind.

   - Check well-identification number (this should be indelibly marked on the well casing) and compare it with the well file and field notes (section 4.2.1).
   - Assign *CH/DH* tasks.
   - If a gasoline-powered generator is used, locate it downwind of sample collection or elsewhere to avoid sample contamination from fumes.
   - Prepare an area to be used for field cleaning of equipment (*DH*)

b. Describe well and site conditions on field forms, as appropriate (*DH*).

c. Check site for hazardous conditions (NFM 9) (*DH*).

   - Test for toxic fumes if the well is in an enclosed structure or if there is reason to suspect the presence of organic vapors.
   - Examine the area for evidence of animal infestation and other potential safety hazards.

d. Spread a clean plastic sheeting (polypropylene tarp, for example) on the ground around the well tokeep sampling equipment, the well tape, and sample tubing clean (*DH*). Take care not to trample on the sheeting.

e. Set up equipment and instruments for field measurements and ground-water withdrawal (*DH*). Locate a power supply source, if needed.

- Set up the pump and generator (if needed) in a location to avoid sample contamination from generator fumes.
- Calibrate field-measurement instruments (*DH*). (Refer to NFM 6 for calibration information and instructions.)
- Wearing disposable gloves, set up the sample-processing and -preservation chambers (usually in the water-quality field vehicle). Keep sample tubing as short as is practical and shaded from direct sunlight (to minimize changes in the temperature of the sample). *Change gloves.* Place the filter unit and other supplies that will be needed for the first sample into their respective chambers *(CH).*

f. Remove the well cap. Verify clear access downhole by lowering a section of blank pipe through the depth interval to be sampled and raising it slowly. **Take care not to drop the pipe or otherwise stir up particulates in the process of lowering and raising the pipe** (*DH*)**.**

i. Connect the antibacksiphon valve in-line between pump and manifold (the antibacksiphon valve is a standard component of some submersible pumps).

ii. Use connectors and sample tubing that will not contaminate the sample with respect to target analytes.

- Use only precleaned sample-contacting connectors and tubing.
- At contaminated sites, sample-contacting equipment either should be dedicated for that site or should be disposable.

iii. From the manifold, connect the appropriate tubing to the flowthrough chamber, the sample-processing chamber, and the waste outlet.

- Select transparent, nonporous sample tubing and tubing to the flowthrough chamber for field measurements to be able to check for bubbles or sediment entrained in the sample flow.
- Tubing that transfers sample to the processing chamber must be clean and of noncontaminating material. Keep the discharge end of the sample tubing sealed until use.
- Flowthrough-chamber tubing can be of any material if used only in connection with field measurements.
- Tubing used solely to discharge purged water to waste can be of any material (garden hose, for example), but must be long enough to transport wastewater away from the work area.

Step 2. Measure water level (*DH*).

Procedures and equipment for water-level measurement depend on well type and construction and the presence of nonaqueous liquid phases. Important considerations and method limitations are described in Appendix A4-B-3, 4, and 5. Each well must have a designated measuring point that is indicated permanently on the well (Appendix A4-B-1).

a. Put on gloves before chalking a steel tape. Using a weighted steel or electric tape in a nonpumping well, record two or more consecutive water-level measurements to the nearest 0.01 ft (for wells of < 200 ft to water), starting at the permanent measuring (reference) point. Repeat the measurement until precision is within 0.02 ft (U.S. Geological Survey, 1980).

   - Do not allow the well tape to contact the ground before inserting it into the well. After measuring the water level, clean the tape (NFM 3.3.8) to avoid cross contaminating the next well.
   - Do not use lead weights, but weight the tape with stainless steel or another relatively noncontaminating material.
   - At wells deeper than 200 ft, calculate the compensation factor to account for stretching of the tape.

b. Record water-level measurement on field forms and in GWSI (USGS Office of Water Quality Technical Memorandum No. 2006.01). Note any deviations from standard water-level measuring procedures on field forms (fig. 4-12). It is useful also to record water-level data into QWDATA.

c. Set up a system to measure water levels throughout purging. Electrical tapes or submersible pressure transducers are recommended—repeated measurements with a steel tape can be cumbersome and can generate turbidity in the water column. If a packer system is used, installpressure transducers above and below the packer.

d. Clean the tape after each use to avoid cross contamination of wells (NFM 3.3.8).

RULE OF THUMB: The initial water-column height should be greater than 4 ft plus the length of the sampling device.

Step 3. Purge the well and monitor field measurements (*DH*)**.**

Purge monitor wells, preferably using a variable-speed pump (see the TECHNICAL NOTES listed at the end of step 6). Operate the pump in a manner that avoids or minimizes turbidity. **Do not use a bailer for purging** unless the well characteristics or other constraints exclude alternatives and the turbidity during and afterbailing is at the background level. **Recommendation:** Measure water levels throughout purging to document drawdown and the location of the water level with respect to the screened/open interval and the pump intake.

- Use the same pumping equipment for purging that will be used to collect samples, if possible.
- **Avoid refueling or changing equipment, and do not stop the pump during the final phase of purging and sample collection.** Be aware of study objectives and potential sources of contamination. For example, avoid fueling the generator on the same day that samples are collected for VOC analysis. Do not transport a generator or gas tanks in the water-quality field vehicle.
- Adjust the flow rate at the pump if using a variable-speed pump. If a constant-speed pump is used, adjust the flow rate using a needle valve.
  - — Pump at a rate that does not substantially lower the water level. Ideally, well yield should be sufficient so that the water level is maintained above the screened or open interval.
  - — Flow should not be halted or the flow rate changed suddenly during the final phases of purging and sampling.

a. Calculate the well volume. For a cased well, the depth to the bottom of the well and the inside casing diameter must be known:

V=0.0408 x HD2

where,
V is volume, in gallons
H is height of water column
D^2 is the inside well diameter squared, in inches

Note that for a cased well, the volume of water stored within the annular space between the well screen and borehole well also should be evacuated at least once.

b. Lower a submersible pump, followed by a water-level sensor, to the desired location of the pump intake. (The pump position is fixed if the monitoring well has a permanently installed sampling system.) Move the equipment slowly and smoothly through the water column to avoid stirring up particulates. The intake can be either lowered continually while purging to the final depth desired or placed immediately at its final position. **Note that the final pump intake position always is at the point of sample collection.**

   - Position the pump intake about 3 ft (about 0.9 m) below static water surface and a minimum distance above the top of the screened/open interval of 7 to 10 times the well diameter (for example, 14 to 20 in. for a 2-in. well diameter), if the sample is to represent the entire screened or open interval of aquifer. The location of the intake might be different if the study objective requires collecting the sample from a point within the screened/open interval or from wells in which packers are installed.
   - Place water-level sensor (electric tapes) a maximum of 1 ft (about 0.3 m) below the water surface.

c. Position the pump intake.

   - **If final intake position is above the screened or open interval, do not exceed 1 ft (about 0.3 m) of drawdown.**
   - **If final intake position is within the screened or open interval, do not exceed 0.5 ft (about 0.15 m) of drawdown.** The final pumping rate should be as slow as necessary to avoid causing turbidity.

d. Start the pump, channeling initial discharge to waste. Discharge the initial well water through the waste line until sediment is cleared from the flow.

   - Gradually increase and (or) adjust the pumping rate to limit drawdown to between 0.5 and 1 ft (about 0.15 to 0.3 m), if possible.
   - **If using a variable-speed pump, adjust the rate of flow at the pump.** If using a constant-speed pump, control the flow rate using a needle valve (fig. 4-10).

- **Do not use a three-way valve or flow-splitting valve to adjust flow rate.** It is necessary to keep the two- or three-way valves either completely open or completely closed (partially open three-way valves can create a vacuum or air bubbles, and can draw in contaminating water).
- **Contain and dispose of purge waters according to Federal, State, or local regulations.** Do not discharge purge water from one well into another without proper authorization. Discharge purge water far enough away from the well or well cluster so as not to enter or affect water quality in the well, and to prevent muddy and slippery work conditions.

e. When the water runs clear, divert flow through the manifold to the flowthrough chamber (unless a downhole instrument is being used for field measurements.

- **The flow should be a smooth, solid stream of water with no air or gas bubbles and without pump cavitation** during field measurements and sample withdrawal. Adjust the pumping rate to eliminate air or gas bubbles or cavitation, but do not halt or suddenly change the flow rate.
- **Record the start time of purging, the pumping rate(s), water level(s), and final location of the pump intake** (fig. 4-12). If water is flowing through more than one conduit (such as valve and manifold lines), calculate the flow rate by summing the flow rate through each conduit.
- **Begin monitoring field measurements** (refer to NFM 6 for instructions) once flow to field-measurement instruments is constant (see instructions above).
- **Do not move the pump or change the rate of pumping during field measurements or sample collection after setting the intake at its final depth location.**

f. **Purge a minimum of three well volumes or the purge volume dictated by study objectives.** (Check exceptions to the three-well-volume procedure described in section 4.2.3.B).

- Record water levels and field measurements at regular time intervals (fig. 4-12; NFM 6). Routine field measurements for USGS studies include water temperature, conductivity, pH, dissolved-oxygen concentration, and turbidity. Check for special instructions regarding field-measurement or field-analysis requirements based on study objectives.
- As the final well volume (commonly the third well volume) is purged, check the field-measurement data against the measurement-stability criteria (fig. 4-12). Record at least five sets of field measurements determined at regularly spaced intervals, which indicate that measurement values are relatively constant (have "stabilized") or that stabilization cannot be achieved in the given time interval (NFM 6).

Step 4. Withdraw the sample (*CH*).

Pumped samples—

Maintain the same rate of pumping throughout sample collection as the rate used during withdrawal of the final purge volume.

a. Put on disposable gloves. Check that the sample tubing is properly secured within the sample-processing chamber.

b. Direct sample flow through the sample tubing to the processing chamber and channel two tubing volumes of the water to waste. Use the needle valve at the manifold (fig. 4-10) to adjust sample flow as appropriate for the target analysis.

- Depending on the site-specific logistics, a second needle valve can be installed after the outlet end of the manifold and close to the sample-processing chamber.
- The flow should be smooth and non-turbulent. Avoid splashing or pooling water inside the chamber while processing sample and filling sample bottles.
- **If samples will be collected for organic carbon analysis through equipment and tubing that previously was methanol-rinsed, flush at least five tubing volumes of sample water through the tubing (or collect the organic-carbon sample using a separate, non-methanol-rinsed sampler) before proceeding to step 5.**

Remember, flow should be constant and uninterrupted while purging and sampling.

RULE OF THUMB: When using a pump, the rate of flow for filling sample bottles should not exceed

- 500 mL/min for bottles 250 mL or greater in volume,

or

- 150 mL/min for 40-mL VOC vials.

Nonpumped samples—

a. Field rinse the sampler (typically, a bailer) and sampler emptying device (and compositing device, if used) three times before collecting the sample. Deploy the sampler so as to minimize disturbance to the water column and aquifer materials.

   i. Use a reel to keep sampler line clean and untangled.

   ii. Lower sampler smoothly, entering water with as little disturbance as possible.

   iii. Allow sampler to fill, then withdraw sampler smoothly.

   iv. Shake water in sampler vigorously to rinse all interior surfaces.

   v. Attach sample-delivery tube or bottom-emptying device to sampler and drain the rinse water through the sampler.

   vi. Repeat rinse procedure at least twice.

b. Repeat steps (a) i-iii to withdraw ground water for the sample.

   TECHNICAL NOTE: When a device is lowered and raised through the water column, the disturbance to the water column can result in outgassing or degassing of ambient dissolved gases and an increase in concentrations of suspended particulates. Repeated movement of the device through the water column exacerbates these effects and can result in substantial modification of the ambient water composition and chemistry.

c. Set up the bailer in an enclosed or protected space.

Step 5. Process/collect the sample →Refer to NFM 5, *Processing of Water Samples*, for instructions regarding the field rinse of sample bottles, sample filtration, and the collection and preservation of whole-water and filtered samples.

Step 6. Clean equipment →Refer to NFM 3, *Cleaning of Equipment for Water Sampling*. Sampling equipment must be cleaned as instructed in NFM 3 before leaving the field site.

At contaminated sites, use sample tubing that is disposable or dedicated to that site in order to minimize the risk of cross contamination between wells. Wear gloves while cleaning and handling sampling equipment.

- Rinse sampling equipment with deionized water before the equipment dries.
- Clean equipment to be used at another well during the same field trip after rinsing it and before moving to the next site.
- Collect field blanks to assess equipment-cleaning procedures directly after the sampling equipment has been cleaned in the field or after moving to the next site and before sampling, as dictated by the data-quality requirements of the study (section 4.3).

QUALITY CONTROL 4.3

Collection and analysis of quality-control (QC) samples are mandated components of USGS water-quality field studies. The goal of QC sampling is to identify, quantify, and document bias and variability in data that result from the collection, processing, shipping, and handling of samples. **The bias and variability associated with environmental data must be known for the data to be interpreted properly and be scientifically defensible** (Horowitz and others, 1994; Koterba and others, 1995; Mueller and others, 1997). This section addresses quality control for aqueous samples to be analyzed for inorganic and organic analytes (see NFM 7 for quality control of microbiological sampling and analysis). Quality-assurance terminology in general, and quality-control terminology in particular, can differ within and among organizations; see "*Conversion Factors, Selected Terms, and Abbreviations*" for a glossary of definitions as used in this report.

Bias: systematic, directional error measured by the use of blank, spike, or reference-material samples.

Variability: random error measured by the use of environmental or QC sample replicates.

The types of QC samples to be collected and their temporal and spatial frequency and distribution depend on study objectives, data-quality requirements, site conditions, and management or regulatory policy. QC sampling is part of an overall strategy for quality assurance of the data collected and generally is described in the Quality Assurance Plan (QAP) or Sampling and Analysis Plan (SAP). QC samples of various types can be used to measure environmental data quality (for example, assign error bars to measurement sets), identify data-quality problems, and locate the sources or causes of data-quality problems. **Field personnel need to understand the purpose for each QC sample type (Appendix A4-C) and how the resulting QC data will be used so they can account for and accommodate QC needs that arise from unforeseen site conditions.**

- **Basic QC samples** are collected routinely to document the quality of the environmental data and to identify whether data-quality problems exist. They are designed to measure most sources of error that affect environmental samples. Basic QC samples include field blanks, field matrix spikes, and field replicates.
- **Topical QC samples** address specific QC needs or topics and commonly are designed to (1) help determine when sampling should commence; (2) locate the cause and source of data-quality problems; and (3) assess comparability among field methods. Topical QC samples include all the QC sample types not specifically designated "basic" QC samples.

Good science requires consideration of measurement errors – such as bias and variability – in data analysis.

The field team or person collecting samples should be involved in assessing the analytical results of the QC samples collected, because only they have all of the information about the site conditions and procedures that were followed. This knowledge could be crucial in understanding QC sample results. For any water-quality sampling event, USGS field personnel must:

- Be knowledgeable about and alert to potential sources of contamination (table 4-11). When in doubt, it usually is wisest to collect additional QC samples and decide later whether to have them analyzed.
- Collect field QC samples at approximately the same time as environmental samples are collected, using the same equipment.
- Document in the field log as complete a description of the sampling event as possible. Include how, when, where, and why the QC sample was collected, and observations about site or sampling conditions.
- Implement the prescribed procedures for equipment cleaning and QC sample collection and processing.

- Use chemical preservatives from the same lot number for a given set of environmental and associated QC samples. Record the preservative lot number on field forms and in field notes.
- Store QC data in an electronic database devoted to QC data. For USGS studies, this should be a QC-designated data base within NWIS.

Use Good Field Practices (table 4-2) and Clean Hands/Dirty Hands techniques (table 4-3) when collecting and processing QC samples.

Table 4-11. Common sources of contamination related to field activities

[SPMDs, semi-permeable membrane devices; DIW, deionized/distilled water of ASTM grade one or better; DEET, N,N-diethyl-meta-toluamide (the active ingredient commonly used in insect repellents)]

Contaminant source type	Examples
Sampling environment	Airborne particulates; precipitation; dust, soil, solid particles; fumes from engine exhaust, chemical preservatives, upwind industrial emissions.
Sample-collection equipment	Pumps, isokinetic samplers, bailers, sample tubing, SPMDs.
Sample-processing equipment	Filtration devices, churn splitter, cone splitter, bottles, water (DIW, tap, blank).
Sample-cleaning processes	Cleaning equipment (basins, brushes); carryover from cleaning solutions or tainted water; methanol carryover; insufficient decontamination or rinsing.
Transport and shipping	Field vehicles; coolers or other shipping containers; improperly closed or protected sample bottles.
Storage	Warehouse; refrigerator; field vehicle; office laboratory; office storage space.
Personnel	Dirty hands; sweat; sunscreen; DEET; nicotine, caffeine, and alcohol (breath); dirty gloves; gloved or ungloved contact with the sample to be analyzed; shedding clothing; hair and dandruff.

How, when, where, and why a QC sample was collected must be known to understand the sources of error measured.

4.3.1 BLANK SAMPLES

The primary purpose of a blank sample ("blank") is to measure the magnitude of contaminant concentration (for analyte(s) of specific interest) that might have been introduced into the sample as a result of sampling-related activities (table 4-11 and Appendix A4-C). Various types of blanks can be used or customized to identify the source of sample contamination (table 4-12 and Appendix A4-C). Appendix A4-D provides examples for estimating the volume of blank solution needed.

It is necessary to obtain blank water of the quality and type appropriate for the chemical analysis to be performed on the sample. Blank water is strictly defined within the USGS as specially prepared distilled/deionized water (DIW) that is laboratory produced, quality-controlled, and that carries a certificate of analyte concentrations for each grade and lot of water produced. USGS water-quality projects obtain quality-assured blank water through the One-Stop Shopping system of the National Water-Quality Laboratory (NWQL).

- I**norganic-grade blank water (IBW**) is required for blanks that will be analyzed for inorganic constituents (major and minor ions including nutrients, trace elements) and suspended sediments.
- **Pesticide-grade (PBW)** is required for blanks that will be analyzed for pesticide compounds and organic carbon.
- **VOC/Pesticide-grade (VPBW)** has been purged with nitrogen gas (N_2) and is required for blanks that will be analyzed for volatile organic compounds. VPBW is appropriate as a blank sample for analysis of pesticides, organic carbon, and suspended sediments.

Before collecting blank samples, the laboratory certification of concentration for each analyte in the blank water should be compared with the expected concentration in the environmental samples and with the detection limit of the laboratory method to be used for sample analysis**. The laboratory certificate of analysis for each lot of blank water should be kept on file with project records, and the lot number(s) used for each sample should be recorded on field forms.**

Wear clean, powderless, disposable gloves and conform meticulously to other Clean-Hands practices when working with blank solutions.

Table 4-12. Common types of blank samples and the questions they address
[QC, quality control; IBW, inorganic-grade blank water; PBW, pesticide-grade blank water; VPBW, volatile-organic-compound and pesticide-grade blank water]

Type	Targeted Source(s) of Bias[1]
Field blank	Sample-collection, -processing, -transport process ***Basic QC sample****: Was my sample contaminated as a result of field activities and exposure?*
Equipment blank	Sample-collection and processing equipment system ***Topical QC sample***: *Does an initial equipment assessment[2] confirm the suitability of the equipment to provide samples within my data-quality requirements?* ***Topical QC sample***: *Is my equipment-cleaning protocol adequate?*
Sampler blank	Sampling device (for example, the D-95 sampler, Fultz pump, or peristaltic-pump tubing) ***Topical QC sample***: *Is my sampling device the source of contamination?*
Filter blank	Filtration device (for example, the capsule filter, in-line filter holder, aluminum plate filter) ***Topical QC sample***: *Is my filtration device the source of contamination?*
Ambient blank	Exposure to atmospheric outfall or other conditions ***Topical QC sample***: *Was sample exposure to the atmosphere a contaminant source?*
Source-solution blank	The blank water used (for example, IBW, PBW, or VPBW) ***Topical QC sample***: *Was my blank water tainted with respect to my analyte(s) of interest?*

[1]The bias and variability measured includes that from laboratory handling, processing, and analysis of the sample in addition to the targeted source listed.
[2]An equipment blank is required for U.S. Geological Survey investigations to determine the equipment suitability to provide the analyte data needed to meet study objectives.

To prepare for processing blank samples:

1. Label the capped, precleaned sample bottle with the site identification number, laboratory sample designation code (NFM 5), date and time, or affix the proper bar-code label to the sample container, as appropriate. Record this information on field forms.
2. Put on gloves. Place each stock container of the blank solution to be used (IBW, PBW, and VPBW) into a clean plastic bag. If pumping blank water from a standpipe, change gloves and then rinse the precleaned standpipe three times using a small volume of blank solution of the type selected. Keep standpipe covered until use.
3. Change gloves. Place precleaned, labeled sample bottle(s) and the stock of blank solutions to be used into processing chamber (or standpipe).
    - IBW blanks—Discard the deionized water that half fills the precleaned polyethylene sample bottle. Rinse the sample bottle with a small quantity of blank solution and discard rinsate before filling with IBW.
    - PBW or VPBW blanks—Do not prerinse the sample bottle. Use glass bottles or vials as received precleaned from the laboratory.

Do not substitute DIW for IBW.

Pre-Field Blanks 4.3.1.A

The source-solution and initial equipment blanks are common types of blank samples that are collected by the study field team in preparation for environmental sampling. **Collection of an equipment blank is mandated by USGS policy before the sampling phase of the study begins**, to determine if the sample-wetted components of the equipment proposed for use could be a source of contamination by introducing the study's target analytes to a blank or environmental sample. Collection of pre-field equipment blanks is recommended annually, or as appropriate for the sampling schedule of the study.

- **Source-solution blank**. Collect in a designated clean, draft-free area of the office laboratory, such as under a laminar-flow hood or laminar-flow bench. Do not collect the source-solution blank in a fume hood. Submit the sample for analysis along with or after the equipment blank and field-collected samples, depending on study objectives and the data resulting from other blank samples.
- **Equipment blank (pre-field)**. Collect in a designated clean area of the office laboratory at least 4 weeks before using the equipment in the field to allow enough time for sample analysis and review of the resulting data.

A variety of other types of blank samples that are collected in the controlled office-laboratory environment can be designed to test some aspect of sample handling not related to the field environment. Examples of these types of blanks include the refrigerator blank, the shelf blank, and the preservation blank (Appendix A4-C).

4.3.1.B Field Blanks

Field blanks are collected and processed at the field site in the same manner and using the same equipment as the environmental sample(s). Equipment must be cleaned meticulously before field blanks are collected (NFM 3).

- A single field blank is a "basic" QC sample that represents the entire sampling system. The feld blank is collected routinely for basic quality control of the sampling process, rather than identifying the specific source of the contamination. The field blank consists of an aliquot of blank water processed sequentially through each component of the sampling system (fig. 4-14 and Appendix A4-C). The field blank provides a measure of the total contamination (bias) present in the sample.
- To address topical quality-control questions, blanks can be collected onsite that represent components of the sampling system; for example, the sampler blank (surface water), splitter blank, filter blank, or pump or bailer blank (ground water). Such topical field blanks can be used to trace the specific source of contamination.
- When collecting field blanks for inorganic and organic analyses after sampling at a site, use the following sequence and the protocols described in NFM 3 and shown in NFM 3, fig. 3-1 for equipment cleaning.
  1. Clean equipment for inorganic-constituent sampling: detergent → tapwater/DIW → acid, if needed → DIW.
  2. Rinse equipment with IBW at least three times.
  3. Collect the IBW blank sample for analysis of inorganic constituents.
  4. Resume equipment cleaning for organic-compound sampling: methanol, if needed → air-dry exposed surfaces →IBW or PBW, as appropriate. Remove methanol from pumps, tubing, and other equipment, as described in NFM 3.
  5. Rinse equipment at least three times with the appropriate organic-grade blank water (VPBW or PBW).
  6. Collect the VPBW (or PBW) blank sample for analysis of organic compounds.

The process of producing a field blank can be designed to collect simultaneously blanks for each component of the sampling system (fig. 4-14). If laboratory analysis of the analytes being quality controlled is not time dependent, the sequential blank samples representing components of the sampling system, as well as any associated source-solution and ambient blanks, normally can be stored for up to 6 months.

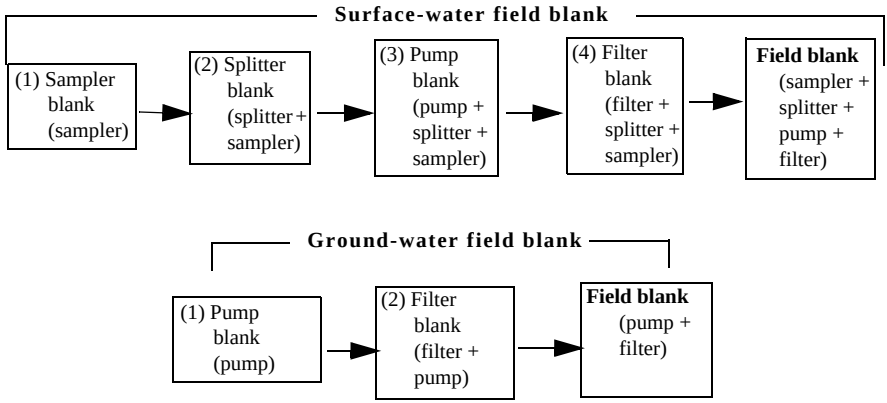
- If the field-blank data indicate constituent concentrations at acceptable levels, then the associated set of sequential blanks can be discarded. (Be sure to use appropriate means for disposing of chemically treated solutions.)
- If laboratory data indicate greater than acceptable concentrations:
  - Submit the source-solution blank, ambient blank(s), and equipment-component blank(s) (the sampler blank, splitter blank, pump blank, and so forth) to the laboratory for analysis.
  - Use the data from equipment-component blank samples to identify the source(s) of contamination detected in the field blank.
- Once the source of contamination has been identified, take the measures needed to mitigate or eliminate the contamination for future sampling efforts.

Prevent contamination of the source-solution and blank sample by capping the respective bottles immediately after decanting the volume of blank solution needed.

EXAMPLE OF FIELD-BLANK SAMPLE COLLECTION

A set of blanks can be generated that is associated with the field blank to help determine which equipment component in the system could be a source of contamination. The **field blank** is the final sample that represents all equipment components of the sampling system. After each blank sample is collected, preserve and store sample as required.

- → **Surface-water field blank: follow steps 1 through 4.** In this example, the equipment used includes a US D-95 sampler, 8-liter (L) churn splitter, peristaltic pump, and filter assembly.
- → **Ground-water field blank: follow steps 1 and 2.** In this example, the equipment used includes a submersible pump and a filter assembly.



Sampler Blank. Using the blank water selected, rinse and then fill the sampler; attach sampler cap and nozzle; pour the required volume through nozzle into sample bottle.

Splitter Blank.[1] Rinse churn splitter with blank water. Pour the blank water remaining in the sampler through the sampler nozzle and into the 8-L churn splitter. Refill sampler, repeat until churn contains 3 to 5 L of blank water. Process the required blank-sample volume through the churn spigot into the splitter-blank bottle. (If a cone splitter is used instead of a churn splitter, the blank sample is processed through the exit port tubes.)

Pump Blank.[1]

- **Surface-water example:** Using the peristaltic pump, thread the intake end of clean tubing into churn splitter through the funnel, and cap the funnel loosely. Insert the discharge end of the pump tubing into a processing chamber and pump blank water through the tubing for an initial rinse, discharging rinse water to waste. After the rinse, pump the required volume of blank water from the churn splitter into the pump-blank bottle.
- **Ground-water example:** Rinse a precleaned, noncontaminating standpipe with blank water and discard rinse water. Place submersible pump into the standpipe and pour in blank water—keep water level above the pump intake. Insert discharge end of pump tubing into a processing chamber. Circulate blank water through pump and tubing to rinse, discharging rinse water to waste. Pump the required volume of blank water from the standpipe into the pump-blank bottle.

Field Blank. The **field blank** in this example is identical to the **filter blank**[1] because the filter assembly is the final component of the equipment system through which the blank is processed. Working in the processing chamber, precondition the filter with blank water (NFM 5).

- **Surface-water example:** Pump the required volume of blank water from the churn splitter through the prerinsed filter assembly into the field-blank bottle.
- **Ground-water example:** Pump the required volume of blank water from the standpipe through the prerinsed filter assembly into the field-blank bottle.

[1]These are special cases of a splitter blank, pump blank, and filter blank, respectively, because the equipment component named is the final component but not the only component contacting the blank sample.

Figure 4-14. Example procedure for collecting a field-blank quality-control sample.

REPLICATE SAMPLES 4.3.2

The primary purpose of replicate samples is to identify and (or) quantify the variability in all or part of the sampling and analysis system. Replicates—environmental samples collected in duplicate, triplicate, or greater multiples—are considered identical or nearly identical in composition and are analyzed for the same chemical properties. Common types of replicates are described below and summarized in Appendix A4-C. Field personnel should be careful to keep detailed notes on exactly how the replicate samples were collected and processed, to help distinguish the sources of variability that affected the samples.

Replicate samples are collected simultaneously or close in time with the associated environmental sample, using identical procedures.

Concurrent Replicates 4.3.2.A

Concurrent replicates are two or more samples of environmental water that are collected simultaneously or at approximately the same time. Concurrent replicates provide basic QC data for surface-water sampling and incorporate, for example, the total variability introduced from collection, processing, and shipping of the sample; the variability inherent in the aqueous system across a short distance in space and time; and the variability inherent in laboratory handling and analysis of the samples.

Depending on study objectives, duplicate samples can be collected concurrently by using two sampling devices of the same type or by filling separate sample-compositing containers using the same sampling device.

The following procedure, adapted from Horowitz and others (1994), is used at surface-water sites to fill two or more sample-compositing containers (usually churn splitters):

1. Complete equipment field-rinsing procedures (surface water, section 4.1.3; ground water, section 4.2.2.C), using two clean churn splitters. Label the sample bottles appropriately. Change gloves.
2. At the first vertical of an EWI or EDI section, collect a sample and pour it into the churn splitter 1 (section 4.1).
3. Using identical technique, resample at the first vertical and pour the sample into churn splitter 2.
4. Move to the second vertical, collect the sample, and pour it into churn splitter 2.
5. Using the identical technique, resample at the second vertical and pour the sample into churn splitter 1.
6. Collect and pour samples into each churn splitter in this manner for each of the remaining verticals, alternating churn splitters as described in steps 2 to 5 above.
7. Using identical technique, process and preserve a sample from churn splitter 1 and then from churn splitter 2.

4.3.2.B Sequential Replicates

Sequential replicates are samples of environmental water – commonly ground water – that are collected consecutively (one after the other) from the same sampling site and that are subjected to identical laboratory analysis. The sequential replicate can be collected, for example, as a sample pumped from a well or stream. Sequential replicates are used to assess variability among samples that result from field activities (collection, processing, and shipping procedures). Because sequential replicates are not collected simultaneously, inhomogeneities in the water resource are incorporated into the variability measured. Also included is the variability inherent in laboratory handling and analysis of the samples.

When collecting sequential replicates for whole-water samples:

1. Use identical sampling procedures and supplies, collecting the sample for each analysis one after the other.

2. Preserve the replicate-sample set in the same order as the order in which the samples were collected.

When collecting sequential replicates for filtered samples, use the procedure that best fits study objectives:

1. Trace-element samples or sample set for inorganic and nutrient analyses that includes trace metals:[16]
   a. For each replicate prepare a capsule filter unit as described in NFM 3 and NFM 5.2. Two replicates, for example, require two precleaned capsule filters.
   b. Install "Filter A" and follow filtration procedures and analyte sequence described in NFM 5.2. Trace-element (FA) samples are filtered first, passing no more than 200 mL of sample water through the capsule filter.
   c. Remove and discard Filter A. Change gloves.
   d. Install "Filter B." Use identical procedures and sampling sequence as were used for the "Filter A" sample set.
   e. Continue with this procedure for each additional replicate. This procedure helps assess the variability in sample chemistry over the time period of sample collection that results from sampling and laboratory procedures, including a potential effect from using different capsule filters. Potential effects from using different filter units is considered insignificant compared to those from particulate loading of the filter (Horowitz and others, 1994; USGS Office of Water Quality Technical Memorandums 92.13 and 93.05).

2. Pesticides and other filtered organic-compound samples:
   - If there is minor or no visible loading of particulate matter on the filter, then replicate samples can be collected one after another without changing filters.
   - If filter loading is observed, using a different filter in the manner described above for trace-element samples is recommended. The decision, however, depends on the data-quality requirements of the study and professional judgment.

[16]This method fulfills the objective to maintain the operational pore-size definition of the filtered-sample for trace-element analysis; one filter unit is designated per trace-element sample set in order to maintain comparable particulate loading on the filter.

4.3.2.C Split Replicates

Split replicates are samples obtained by dividing one sample that is designated for a specific laboratory analysis into two or more subsamples (replicates), each of which is submitted to one or more laboratories for identical analysis. Split replicates can be collected for different purposes, depending on the procedures employed and whether the purpose is to determine variability from field plus laboratory processes (the field-replicate split sample) or from laboratory procedures (the lab-replicate split sample).

When collecting split replicates, sample bottles must be labeled carefully, and the sequence of procedures used must be recorded.

- **Lab-replicate split sample**. A sample collected in a single bottle that is split into two or more replicates **after** having been processed and preserved is used to answer the question: "What is the variability associated with laboratory handling and analysis of the sample?" This type of split replicate sample typically is prepared from filtered samples; it is not appropriate, generally, for whole-water samples containing noticeable concentrations of suspended material.

  To collect a lab-replicate split sample (adapted from Horowitz and others, 1994):

  1. Wearing disposable, powderless gloves and working inside a processing chamber, start with a full bottle of sample[17] to which the appropriate chemical treatment has been added. Shake the sample thoroughly to mix.
     - For inorganic samples only, use a bottle rinsed at least twice with IBW and then field rinse the bottle with a small volume of processed sample.
     - Do not prerinse bottles for organic samples.
  2. Transfer the entire contents of the first bottle to the second bottle. Cap and shake the second bottle.
  3. Uncap the second bottle and pour its entire contents back into the first bottle. Cap and shake.
  4. Uncap the bottles and pour one-half of the sample from the first bottle into the second bottle. Cap both bottles tightly.

[17]The volume of sample collected and that of the split replicates depends on the volume of sample required by the laboratory for the analysis desired.

▶ **Field-replicate split sample.** A sample split into subsamples by use of a churn splitter, cone splitter, or T-valve (such as that used on a ground-water manifold device, fig. 4-10), for example, can be used to answer the question, "What is the variability associated with the entire sampling (including any sample collection, processing, preservation, shipping, and laboratory handling and analysis) processes?" Bottles of the replicate samples must be labeled appropriately, and the sequence of procedures used must be recorded. To split concurrent replicate samples that were processed through separate compositing devices (such as churn splitters), follow the procedure shown in steps 1-4 above and label the samples as follows:

To collect a field-replicate split sample (adapted from Horowitz and others, 1994):

Churn splitter 1: first bottle "Site (X), Sample 1, Split A"
"Site (X), Sample 1, Split B"

Churn splitter 2: first bottle "Site (X), Sample 2, Split A"
"Site (X), Sample 2, Split B"

4.3.3 SPIKE SAMPLES

A "spike" sample is an environmental sample to which target compounds (the field-matrix spike mixture) are added after the sample has been processed. Field-spike samples are used to measure bias and answer the question "What loss or gain of target analytes occurred because of degradation and water-matrix characteristics?" Bias determined from spikes is termed "recovery" and reflects the amount of analyte(s) measured expressed as a percentage of the amount spiked.

Spike samples can be customized to address the source of the bias (water matrix, degradation, laboratory method performance) in the data. To address bias from degradation, samples should be spiked in the field as soon as possible after collection. A combination of a laboratory spike, field spike, and field-spike replicate provides the most information, but may not be needed for a given study.

RULE OF THUMB:

Spike when target compounds are expected to be low; specifically, when target compounds are at least a factor of two less than the spiking level.

The numbers and types of spike samples to be selected depend on study objectives and data-quality requirements. However, **an unspiked environmental sample must accompany each spiked environmental sample to correct the data for background concentrations.** Training is required before personnel attempt to spike samples. USGS personnel obtain spike solutions, spike kits, and instructions through the NWQL One-Stop Shopping system.

Field-matrix spike mixtures are prepared in a laboratory and commonly are added to environmental samples designated for organic-compound analysis.

- Short-term use: keep matrix-spike ampoules chilled at all times. Spike compounds are unstable and degrade rapidly at room temperature.
- Long-term use: store spike mixtures in a freezer.
- Spike mixtures contain toxic compounds. Dispose of waste materials in accord with current local and State regulations and USGS Science Center guidelines.

When preparing field-spiked samples for pesticides or VOCs, follow the procedure listed below:

1. Samples should be processed, spiked, and chilled immediately after collection. If spiking is delayed, keep sample chilled until and after it is spiked. Check that the sample bottles are labeled appropriately:
   - FS = field-spiked sample
   - FSR = field-spiked replicate
   - LS = lab-spiked sample

2. Wearing disposable gloves and working in a preservation chamber, follow the laboratory instructions for spiking the sample. Be sure that the spike mixture is the one intended for the sample, in terms of analytes, volume, and concentration.
3. Chill field-spiked samples to 4°C or below without freezing, and handle in a manner identical to that of the unspiked environmental sample.
4. Record the following information related to the spike sample on field and NWQL Analytical Services Request forms: lot number of spike solution, volume of spike solution, and source of spike solution.

CAUTION: Spike mixtures can be toxic and might cause cancer or other diseases. Follow the laboratory-prescribed spiking instructions meticulously. Work in a well-ventilated area and avoid inhalation and skin and eye contact.

4.3.4 REFERENCE SAMPLES

Standard-reference-water samples (SRS) and reference-material samples that are submitted by field personnel for laboratory analysis can be used to answer questions, such as "What are the bias and variability associated with field-handling, shipping, and laboratory procedures"? Reference samples typically are submitted from the field as blind samples (section 4.3.5) and as split replicate samples (section 4.3.2.C) because the composition is known, thus eliminating guesswork regarding the accuracy of the analytical results.

Reference samples for inorganic analytes in a natural water matrix currently are available to USGS personnel from the USGS Branch of Quality Systems. The National Institute of Standards and Technology and some commercial laboratories also supply reference materials.

When preparing reference samples, follow the procedure listed below:

1. **Prepare this sample before leaving for the field site.**

    a. Relabel the reference-sample bottle with the site identification code and a field date and time. The sample should appear as if it is an environmental sample.

    b. Process SRS or reference-material samples in a clean environment in the office laboratory, under a laminar-flow hood or other protective chamber, to avoid atmospheric contamination. **Do not process these QC samples under a fume hood.**

    c. Rinse each sample bottle three times with a small volume of SRS or reference-material sample, fill the bottle with the reference solution, and cap securely.

2. Prepare an Analytical Services Request (ASR) form; record the SRS or reference-material sample identification code (from the original container) in field notes.

3. Pack the sample and the accompanying ASR form to take to the field site.

4. Ship SRS or reference-material samples in the same container with the environmental and other QC samples collected at the field site.

4.3.5 BLIND SAMPLES

For blind samples, the source and chemical composition of the samples are known to the submitter but typically not known to the analyst; therefore, blanks, SRS, or reference material often are used as blind samples. Blind samples can be designed to answer questions such as "What bias and variability are introduced by procedures used within a single laboratory or among laboratories?" Replicate or spike samples sometimes are used to answer a similar question, but with greater potential for more variability.

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CONVERSION FACTORS, SELECTED TERMS, AND ABBREVIATIONS

CONVERSION FACTORS

Multiply By		To obtain
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
inch (in.)	25.4	millimeter
meter (m)	3.281	foot
micrometer (µm)	3.281×10^{-6}	foot
millimeter (mm)	0.03937	inch
milligram (mg)	3.527×10^{-5}	ounce, avoirdupois
microgram (µg)	3527×10^{-5}	ounce
liter (L)	0.2642	gallon
milliliter (mL)	2.64×10^{-4}	gallon

Temperature: Water and air temperature are given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

SELECTED TERMS

Accuracy: The degree of agreement of a measured value with the true or expected value (Taylor, 1987).

Analyte (target analyte): "Substances being determined in an analysis" (from Bennett, 1986). The term target analyte is used in this report to refer to any chemical or biological substance for which concentrations in a sample will be determined. The definition for target analyte does not include field-measured parameters such as specific electrical conductance, pH, temperature, dissolved oxygen, Eh, alkalinity, color, or turbidity.

Aquifer: "A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients" (Freeze and Cherry, 1979).

Area-weighted sample: A sample that contains an equal volume from each unit of area sampled.

Bias: Systematic error inherent in a method or caused by some artifact or idiosyncrasy of the measurement, collection, or processing system; systematic directional error measured by the use of blank, spike, and reference-material samples. The error can be positive (indicating contamination) or negative (indicating loss of analyte concentration) (from Taylor, 1987).

Bag samplers: Samplers whose containers are bags that instantly transmit the ambient pressure to the interior of the sample container and do not have opening or closing valves.

Bottle samplers: A rigid sample container that does not instantly transmit the ambient pressure to the interior of the sample container and has neither pressure compensation nor opening and closing valves. Point samplers described in Edwards and Glysson (1999) use rigid bottles but have pressure compensation and opening and closing valves and are not considered bottle samplers for the purposes of this document. **The tables in Appendix A4-A were not designed for use with point samplers.**

Centroid (as used to designate a special case of stream-sampling location for the equal-discharge-increment method): The vertical in the increment at which discharge is equal on both sides of the vertical (G. Douglas Glysson, U.S. Geological Survey, written commun., 1997).

Contaminant: Biological, chemical, or physical substances or properties added to the medium of concern through human activity or natural processes and that corrupt its ambient composition.

Contamination (of water): Corruption of ambient water composition or attributes by the addition of biological, chemical, or physical substances as a result of human activity or natural processes. Addition of such substances can degrade the quality of the water resource.

Data-quality requirements: That subset of data-quality objectives pertaining specifically to the analytical detection level for concentrations of target analytes and the variability allowable without compromising achievement of the scientific objectives of the study.

Depth-integrated sample: A sample collected when each vertical portion of the stream depth is represented in the sample in proportion to the desired sampling scheme.

- **Depth integration.** "A method of sampling at every point throughout a given depth (the sampled depth) whereby the water-sediment mixture is collected isokinetically so that the contribution from each point is proportional to the stream velocity at the point. This process yields a sample with properties that are discharge weighted over the sampled depth" (ASTM, 1990).
- **Depth integration for a discharge-weighted sample.** "A discharge-weighted (velocity-weighted) sample of water-sediment mixture collected at one or more verticals in accordance with the technique of depth integration; the discharge of any property of the sample expressible as a concentration can be obtained as the product of the concentration and the water discharge represented by the sample" (ASTM, 1990). For a discharge-weighted sample, the water-sediment mixture is collected isokinetically so that the contribution from each point is proportional to the stream velocity at the point (that is, the sample contains an equal volume from each unit of discharge sampled).

- **Depth integration to collect an area-weighted sample.** The ASTM definition of depth integration does not accommodate the concept of an area-weighted sample. Area weighting is similar in concept to discharge weighting, except that the water-sediment mixture is collected so that the contribution from each point is proportional to the stream area at the point (that is, contains an equal volume from each unit of area sampled). Area-weighted sampling is used to obtain a sample that contains the average concentration of a property that is observed in a cross section. Averaged in situ field measurements of streams are more nearly area weighted than discharge weighted. The product of an area-weighted property concentration and the stream discharge would not yield the discharge of the property unless the stream contained the same property concentration at every point.

Discharge-weighted sample: A sample that contains an equal volume from each unit of discharge sampled.

Equal-width-increment (EWI) and **equal-discharge-increment (EDI) sample-collection methods:** Methods specifically designed to result in the collection of discharge-weighted, depth-integrated, isokinetic samples (Edwards and Glysson, 1999). When either method is used properly, the resulting samples contain the same property concentrations.

Isokinetic sampling: A sample collected in such a way that the water-sediment mixture moves with no change in velocity as it leaves the ambient flow and enters the sampler intake (ASTM, 1990).

Precision: The degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions (Taylor, 1987).

Purging: Refers to removal of water standing in a cased well or borehole before water samples are collected for analysis.

Quality Assessment: Overall process of assessing the quality of the environmental data by reviewing the application of the quality-assurance elements and the analysis of the quality-control data.

Quality Assurance (QA): A system of protocols and procedures implemented to meet expected standards of quality needed to fulfill study objectives and control unmeasurable components of a study, such as sampling at the right place and (or) time using the correct equipment and techniques.

Quality Control (QC): A system of activities (such as collection of blank or replicate samples) whose purpose is to assess the quality of environmental data by generating a set of data that will be used to estimate the magnitude of the bias and variability resulting from the procedures used for obtaining the data.

Raw sample: A whole-water (unfiltered) sample that has not been processed through a filter or other phase-separation device.

Transit: To move the sampler from the stream surface to the streambed or from the streambed to the surface.

Transit rate: The rate at which the sampler is passed through the water from the stream surface to the streambed or from the streambed to the surface.

Unsampled zone: The unsampled portion of the sampling vertical, usually assumed to be the zone from the streambed to the sampler intake. Generally, sampler intakes are 4 to 7 inches above the streambed, depending on the kind of sampler used.

Variability: Random error in independent measurements as the result of repeated application of the process under specific conditions; random error measured by the use of environmental or QC-sample replicates.

Vertical: Refers to that location within the increment at which the sampler is lowered and raised through the water column.

Water Science Center: An office of the USGS, Water Resources Discipline, located in any of the States or territories of the United States.

Wholewater sample: (*see* Raw sample).

ABBREVIATIONS

~	approximately
=	equal to
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
+	plus
±	plus or minus
ft/s	feet per second
gal/min	gallon per minute
L	liter
L/min	liter per minute
µg/L	microgram per liter (equivalent to parts per billion)
µs/cm	microsiemens per centimeter
mg/L	milligram per liter
mL/min	milliliter per minute
ppb	parts per billion (equivalent to micrograms per liter)
ADAPS	Automatic Data Processing System
ASR	Analytical Services Request
ASTM	ASTM, International
BOD	biochemical oxygen demand
CFC	chlorofluorocarbon
CH/DH	Clean Hands/Dirty Hands
DIW	distilled, deionized water
DO	dissolved oxygen
DOC	dissolved organic carbon
EDI	equal-discharge increment
EWI	equal-width increment
FS	field-spiked sample
FSR	field-spiked replicate sample
GPS	global positioning system
GWSI	ground-water site inventory database, a subsystem within the USGS National Water Information System (NWIS)
IBW	inorganic-grade blank water
ID	identification number that is unique to a field site, station, or well

LNAPL	light non-aqueous phase liquid
LS	laborabory-spiked sample
MP	measuring point on a ground-water well
NAWQA	National Water-Quality Assessment Program (USGS)
NFM	*National Field Manual for the Collection of Water-Quality Data*
NFSS	National (USGS) Field Supplies Service (also referred to as "One-Stop Shopping")
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NWIS	National Water Information System of the USGS
NWQL	National Water Quality Laboratory
OGW	Office of Ground Water, USGS
OWQ	Office of Water Quality, USGS
PBW	pesticide-grade blank water
PCB	polychlorobiphenyls
Q	rate of discharge
QA	quality assurance
QADATA	quality-assurance database within NWIS
QAP	Quality Assurance Plan
QC	quality control
SF_6	sulfur hexafluoride
SAP	Sampling and Analysis Plan
SPMD	semi-permeable membrane device
SRS	Standard reference water sample
TBY	turbidity
TOC	total organic carbon
TU	turbidity unit
URL	Uniform Resource Locator
USGS	U.S. Geological Survey
VPBW	volatile-organic-compound and pesticide-grade blank water, purged with nitrogen gas
VCF	single vertical at centroid of flow
VOC	volatile organic compound

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TECHNICAL MEMORANDUMS OF THE U.S. GEOLOGICAL SURVEY, WATER DISCIPLINE

The following U.S. Geological Survey Branch of Quality Systems (formerly Branch of Quality Assurance), Office of Water Quality, National Water Quality Laboratory, and Water Resources Policy Memorandums are available on the World Wide Web at http://water.usgs.gov/admin/memo/.

Memo No.	Title	Date
	Branch of Quality Systems	
90.03	ADP—Storage of water-quality, quality-assurance data in NWIS	undated
92.01	ADP—Storage of water-quality, quality-assurance data in NWIS	undated
95.01	ADP—Storage of water-quality quality-assurance data in NWIS	October 28, 1994
	Office of Ground Water	
03.03	Agreement forms for gaging station and observation well installations and transfers	September 17, 2003
06.01	Storage of water-level data for ground water	February 2, 2006
	Office of Water Quality	
92.02	FIELD TECHNIQUES—Field preparation of containers for aqueous samples	December 20, 1991
92.13	Trace element contamination: findings of studies on the cleaning of membrane filters and filtration systems	July 17, 1992
93.05	Programs and Plans—Evaluation of capsule filters	January 21, 1993
94.08	Collection, handling, and analysis of environmental samples in support of regulatory projects	January 14, 1994
94.09	Revision of new Division protocol for collecting and processing surface-water samples for low-level inorganic analyses	January 28, 1994

97.06	Comparison of the suspended-sediment splitting capabilities of the churn and cone splitters	May 5, 1997
99.02	Guidance for collecting discharge-weighted samples in surface water using an isokinetic sampler	October 28, 1998
00.10	Discrete water-quality data in NWISWeb	September 15, 2000
01.02	Guidance for verifying and interpreting field blank determinations that indicate high pesticide or trace-element concentrations or that show large numbers of detections	November 14, 2000
01.03	Collection and use of total suspended-solids data	November 27, 2000
02.11	Policy for storing and reporting significant figures for chemical data	February 14, 2002
02.13	Water-quality field methods/National Field Manual for the Collection of Water-Quality Data	March 15, 2002
06.01	Storage of water-level data for ground water	February 2, 2006

National Water Quality Laboratory

02.04	Requirements for the proper shipping of samples to the National Water Quality Laboratory	September 23, 2002

Water Resources Policy Memorandums

90.34	Policy for permission to sample	March 26, 1990
92.59	Policy for management and retention of hydrologic data of the U.S. Geological Survey	undated [1992]
94.008	LEGAL—Agreement forms 9-1482, 9-1482A, and 9-1483	February 18, 1994
99.03	SAFETY—Water Resources Division hazardous waste site operations—Revised safety policy and guidance	November 17, 1998
99.32	SAFETY—Water Resources Division policy for safety associated with measurements, sampling, and related streamgaging	August 17, 1990
99.34	Quality assurance measures for serving real-time water data on the World Wide Web	February 28, 2000

APPENDIXES

APPENDIX A4-A
Transit Rate and Volume Guidelines and Filling Times for Isokinetic Samplers

The tables in Appendix A4-A apply to the first complete round-trip transit starting with an empty sampler container. **These tables are valid only if the sampler is emptied between verticals.**

Tables 1 through 5 show:

1. Isokinetic transit rates and volumes for a 1-liter bottle sampler (US DH-81, US DH-95, US D-95) with a

   a. 3/16-inch nozzle

   b. 1/4-inch nozzle

   c. 5/16-inch nozzle

   The designations in the RATE column of tables 1a, 1b, and 1c are defined as follows:

   Slowest The transit rate that fills the sampler to its maximum volume.

   Safe full volume The transit rate that will result in a volume in a bottle sampler such that, if the sampler nozzle is tipped 10 degrees down from the horizontal, no sample will spill from the nozzle.

   Fastest The transit rate that is the fastest rate to avoid compression problems in bottle samplers or to not exceed a transit rate that is more than 0.4 times the stream velocity for bag samplers.

2. Isokinetic transit rates and volumes for a US DH-2 sampler (1-liter bag) with a

   a. 3/16-inch nozzle

   b. 1/4-inch nozzle

   c. 5/16-inch nozzle

3. Isokinetic transit rates and volumes for a US D-96 sampler (3-liter bag) with a

   a. 3/16-inch nozzle

   b. 1/4-inch nozzle

   c. 5/16-inch nozzle

4. Isokinetic transit rates and volumes for a US D-99 sampler (6-liter bag) with a

   a. 1/4-inch nozzle

   b. 5/16-inch nozzle

5. Filling times, in seconds, for isokinetic samplers

   a. US DH-81

   b. US DH-95

   c. US D-95

   d. US DH-2

   e. US D-96

   f. US D-96 A-1

   g. US D-99

APPENDIX A4-A–Table 1a. Isokinetic transit rates for a 1-liter bottle sampler with a 3/16-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Volume (mL)
		1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	
1	slowest	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.1	0.1	0.1	0.1	1,000
1	safe full volume 0	.02	0.03	0.03	0.04	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	800
1	fastest	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	130
2	slowest	0.03	0.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	1,000
2	safe full volume 0	.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	800
2	fastest	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	240
3	slowest	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	1,000
3	safe full volume 0.	1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	800
3	fastest	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	340
4	slowest	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	1,000
4	safe full volume 0.	1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	800
4	fastest	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	420
5	slowest	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	1,000
5	safe full volume 0.	1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.5	0.6	800
5	fastest	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	500
6	slowest	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	1,000
6	safe full volume 0.	1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	800
6	fastest	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	560
7	slowest 0.	1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	1,000
7	safe full volume 0.	1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	800
7	fastest 0.	2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.9	1.0	1.1	610
8	slowest 0.	1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	1,000
8	safe full volume 0.	2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.7	0.8	0.9	1.0	800
8	fastest 0.	2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.2	670
10	slowest 0.	2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1,000
10	safe full volume 0.	2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.2	800
10	fastest 0.	2	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	760
12	slowest 0.	2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.8	0.9	1.0	1.1	1,000
12	safe full volume –		--	--	--	--	--	--	--	--	--	--	--	--
12	fastest 0.	2	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.1	1.3	1.4	830
14	slowest 0.	2	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	1,000
14	safe full volume –		--	--	--	--	--	--	--	--	--	--	--	--
14	fastest 0.	3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.53	900
15	slowest 0.	2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1,000
15	safe full volume –		--	--	--	--	--	--	--	--	--	--	--	--
15	fastest 0.	3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.6	920

APPENDIX A4-A–Table 1b. Isokinetic transit rates for a 1-liter bottle sampler with a 1/4-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Volume (mL)
		1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	
1	slowest	.03	0.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	1,000
1	safe full volume	.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	800
1	fastest	02	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	130
2	slowest	01	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	1,000
2	safe full volume	01	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	800
2	fastest	02	0.3	0.4	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.3	1.4	240
3	slowest	01	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	1,000
3	safe full volume	01	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	800
3	fastest	03	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.5	340
4	slowest	01	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7	1,000
4	safe full volume	02	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	800
4	fastest	03	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.6	420
5	slowest	01	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	1,000
5	safe full volume	02	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.9	1.0	1.1	800
5	fastest	03	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	500
6	slowest	02	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1,000
6	safe full volume	02	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	800
6	fastest	03	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.7	1.9	560
7	slowest	02	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.8	0.9	1.0	1.2	1,000
7	safe full volume	03	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.5	800
7	fastest	03	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.5	1.7	2.0	620
8	slowest	02	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	1,000
8	safe full volume	03	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.7	800
8	fastest	03	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.1	670
10	slowest	03	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.7	1,000
10	safe full volume	04	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.5	1.7	1.9	2.2	800
10	fastest	04	0.5	0.6	0.8	0.9	1.0	1.1	1.3	1.5	1.8	2.0	2.3	760
12	slowest	03	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.6	1.8	2.0	1,000
12	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
12	fastest	04	0.6	0.7	0.8	1.0	1.1	1.3	1.4	1.7	1.9	2.2	2.5	840
14	slowest	04	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.6	1.8	2.1	2.3	1,000
14	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
14	fastest	05	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.8	2.1	2.4	2.7	900
15	slowest	04	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.7	1.9	2.2	2.5	1,000
15	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
15	fastest	05	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.9	2.2	2.5	2.8	930

APPENDIX A4-A–Table 1c. Isokinetic transit rates for a 1-liter bottle sampler with a 5/16-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Volume (mL)
		1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	
1	slowest	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	1,000
1	safe full volume	0.01	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	800
1	fastest	0.03	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.1	130
2	slowest	0.01	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	1,000
2	safe full volume	0.01	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.5	0.6	0.7	800
2	fastest	0.04	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.5	1.7	2.0	2.2	240
3	slowest	0.01	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.7	0.8	1,000
3	safe full volume	0.02	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	800
3	fastest	0.04	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.6	1.9	2.1	2.4	340
4	slowest	0.02	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1,000
4	safe full volume	0.02	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	800
4	fastest	0.04	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.7	2.0	2.3	2.6	420
5	slowest	0.02	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.2	1.3	1,000
5	safe full volume	0.03	0.4	0.5	0.6	0.7	0.8	0.9	0.9	1.1	1.3	1.5	1.7	800
5	fastest	0.05	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.8	2.1	2.4	2.7	500
6	slowest	0.03	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1,000
6	safe full volume	0.03	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.4	1.6	1.8	2.0	800
6	fastest	0.05	0.6	0.8	1.0	1.1	1.3	1.5	1.6	1.9	2.3	2.6	2.9	560
7	slowest	0.03	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	1,000
7	safe full volume	0.04	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.6	1.9	2.1	2.4	800
7	fastest	0.05	0.7	0.9	1.0	1.2	1.4	1.5	1.7	2.0	2.4	2.7	3.1	620
8	slowest	0.04	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.1	1,000
8	safe full volume	0.05	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.8	2.1	2.4	2.7	800
8	fastest	0.05	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.2	2.5	2.9	3.2	670
10	slowest	0.04	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.7	2.0	2.3	2.6	1,000
10	safe full volume	0.06	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.3	2.6	3.0	3.4	800
10	fastest	0.06	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.2	3.6	760
11	slowest	0.05	0.6	0.8	1.0	1.1	1.3	1.4	1.6	1.9	2.2	2.5	2.9	1,000
11	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
11	fastest	0.06	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.2	3.6	830
12	slowest	0.05	0.7	0.9	1.0	1.2	1.4	1.6	1.7	2.1	2.4	2.8	3.1	1,000
12	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
12	fastest	0.06	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.2	3.6	910
13	slowest	0.06	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2.6	3.0	3.4	1,000
13	safe full volume	--	--	--	--	--	--	--	--	--	--	--	--	--
13	fastest	0.06	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.4	2.8	3.2	3.6	980

APPENDIX A4-A–Table 2a. Isokinetic transit rates for a DH-2 sampler (1-liter bag) with a 3/16-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)										Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	
2	slowest	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	50
4	slowest	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	1,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	110
6	slowest	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	1,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	160
8	slowest	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	1,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	220
10	slowest	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	1,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	270
12	slowest	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	1,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	330
14	slowest	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1,000
14	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	380
16	slowest	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1,000
16	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	440
18	slowest	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1,000
18	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	490
20	slowest	0.4	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1,000
20	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	540
22	slowest	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1,000
22	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	600
24	slowest	0.5	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1,000
24	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	650
26	slowest	0.6	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7	1.8	1,000
26	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	710
28	slowest	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	1,000
28	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	760
30	slowest	0.7	0.8	1.0	1.1	1.3	1.5	1.6	1.8	2.0	2.1	1,000
30	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	820
32	slowest	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	1,000
32	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	870
34	slowest	0.7	0.9	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.4	1,000
34	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	920
36	slowest	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.2	2.3	2.5	1,000
36	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	980
37	slowest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	1,000
37	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	1,000

APPENDIX A4-A–Table 2b. Isokinetic transit rates for a DH-2 sampler (1-liter bag) with a 1/4-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)										Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	
2	slowest	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	1,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	100
4	slowest	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	1,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	190
6	slowest	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	1,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	290
8	slowest	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	390
10	slowest	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	480
12	slowest	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	580
14	slowest	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1,000
14	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	680
16	slowest	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.9	2.0	1,000
16	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	770
18	slowest	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	1,000
18	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	870
20	slowest	0.8	1.0	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.5	1,000
20	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	970

APPENDIX A4-A–Table 2c. Isokinetic transit rates for a DH-2 sampler (1-liter bag) with a 5/16-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)										Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	
2	slowest	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	1,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	150
4	slowest	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	1,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	300
6	slowest	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	450
8	slowest	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	600
10	slowest	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	1,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	750
12	slowest	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	1,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	900
13	slowest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5	1,000
13	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	980

APPENDIX A4-A–Table 3a. Isokinetic transit rates for a D-96 sampler (3-liter bag) with a 3/16-inch nozzle.
[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)																				Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	
2	slowest	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	50
4	slowest	0.03	0.04	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	3,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	110
6	slowest	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	3,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	160
8	slowest	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	3,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	220
10	slowest	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	3,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	270
12	slowest	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	3,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	330
14	slowest	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	3,000
14	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	380
16	slowest	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	3,000
16	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	440
18	slowest	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	3,000
18	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	490
20	slowest	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	3,000
20	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	540
24	slowest	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	3,000
24	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	650

APPENDIX A4-A–Table 3a. Isokinetic transit rates for a D-96 sampler (3-liter bag) with a 3/16-inch nozzle.—*continued*

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

26	slowest	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	3,000
26	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	710
28	slowest	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	3,000
28	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	760
30	slowest	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.4	3,000
30	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	820
35	slowest	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	3,000
35	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	950
40	slowest	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.7	1.8	3,000
40	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,090
50	slowest	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	3,000
50	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,360
60	slowest	0.4	0.5	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	3,000
60	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,630
70	slowest	0.5	0.6	0.8	0.9	1.0	1.1	1.4	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.2	3,000
70	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,900
80	slowest	0.6	0.7	0.9	1.0	1.2	1.3	1.6	1.7	1.9	2.0	2.2	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.5	3.6	3,000
80	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,200
90	slowest	0.7	0.8	1.0	1.1	1.3	1.5	1.8	2.0	2.1	2.3	2.4	2.6	2.8	2.9	3.1	3.3	3.4	3.6	3.7	3.9	4.1	3,000
90	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,400
100	slowest	0.7	0.9	1.1	1.3	1.4	1.6	2.0	2.2	2.4	2.5	2.7	2.9	3.1	3.3	3.4	3.6	3.8	4.0	4.2	4.3	4.5	3,000
100	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,700
110	slowest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	3,000
110	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	3,000

APPENDIX A4-A–Table 3b. Isokinetic transit rates for a D-96 sampler (3-liter bag) with a 1/4-inch nozzle.
[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)																					Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	
2	slowest	0.03	0.03	0.04	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	3,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	100
4	slowest	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	3,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	190
6	slowest	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	3,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	290
8	slowest	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	3,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	390
10	slowest	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	3,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	480
12	slowest	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	3,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	580
14	slowest	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	3,000
14	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	680
16	slowest	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	3,000
16	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	770
18	slowest	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.3	1.4	1.4	3,000
18	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	870
20	slowest	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	3,000
20	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	970
24	slowest	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9	1.9	3,000
24	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,160
26	slowest	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1	3,000
26	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,250
28	slowest	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	3,000
28	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,350
30	slowest	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	3,000
30	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,450
35	slowest	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.7	2.8	3,000
35	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,690
40	slowest	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3,000
40	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,930
50	slowest	0.6	0.8	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.7	2.9	3.1	3.2	3.4	3.5	3.7	3.9	4.0	3,000
50	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,410
60	slowest	0.8	1.0	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.2	4.4	4.6	4.8	3,000
60	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,900

APPENDIX A4-A–Table 3c. Isokinetic transit rates for a D-96 sampler (3-liter bag) with a 5/16-inch nozzle.

[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)																						Volume (mL)
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	
2	slowest	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	3,000
2	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	150
4	slowest	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	3,000
4	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	300
6	slowest	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	3,000
6	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	450
8	slowest	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	3,000
8	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	600
10	slowest	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	3,000
10	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	750
12	slowest	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.5	3,000
12	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	900
14	slowest	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.7	1.8	3,000
14	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,060
16	slowest	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	1.9	2.0	3,000
16	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,210
18	slowest	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	3,000
18	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,360
20	slowest	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	3,000
20	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,510
24	slowest	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3,000
24	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,810
26	slowest	0.5	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1.8	2.0	2.1	2.2	2.4	2.5	2.6	2.7	2.9	3.0	3.1	3.3	3,000
26	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	1,960
28	slowest	0.6	0.7	0.8	1.0	1.1	1.3	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.5	2.7	2.8	3.0	3.1	3.2	3.4	3.5	3,000
28	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,110
30	slowest	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.3	3.5	3.6	3.8	3,000
30	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,260
35	slowest	0.7	0.9	1.1	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.9	4.0	4.2	4.4	3,000
35	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,640
39	slowest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9	3,000
39	fastest	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	2,940

APPENDIX A4-A–Table 4a. Isokinetic transit rates for a D-99 sampler (6-liter bag) with a 1/4-inch nozzle.
[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)																								Volume (mL)
		3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	
2	slowest	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	6,000
2	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	100
4	slowest	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	6,000
4	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	200
6	slowest	0.06	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	6,000
6	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	300
8	slowest	0.08	0.09	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	6,000
8	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	400
10	slowest	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	6,000
10	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	500
12	slowest	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	6,000
12	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	600
14	slowest	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	6,000
14	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	700
16	slowest	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	6,000
16	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	800
18	slowest	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	6,000
18	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	900
20	slowest	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0	6,000
20	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,000
24	slowest	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.2	6,000
24	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,200
26	slowest	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3	6,000
26	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,300

APPENDIX A4-A–Table 4a. Isokinetic transit rates for a D-99 sampler (6-liter bag) with a 1/4-inch nozzle.—*continued*
[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

28	slowest	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	6,000
28	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,400
30	slowest	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	6,000
30	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,500
35	slowest	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	6,000
35	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,700
40	slowest	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.9	1.9	6,000
40	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,900
50	slowest	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.3	2.4	6,000
50	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,400
60	slowest	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	6,000
60	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,900
70	slowest	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.2	3.3	3.4	6,000
70	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	3,400
80	slowest	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.3	3.5	3.6	3.7	3.9	6,000
80	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	3,900
90	slowest	0.9	1.0	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.3	6,000
90	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	4,300
100	slowest	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.3	2.4	2.6	2.7	2.9	3.1	3.2	3.4	3.5	3.7	3.9	4.0	4.2	4.3	4.5	4.7	4.8	6,000
100	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	4,800
120	slowest	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6,000
120	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	5,800

APPENDIX A4-A–Table 4b. Isokinetic transit rates for a D-99 sampler (6-liter bag) with a 5/16-inch nozzle.
[Transit rates in feet per second; Depth is (water depth) – (unsampled zone); mL, milliliter]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)																								Volume (mL)
		3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	
2	slowest	0.03	0.04	0.04	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	6,000
2	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	150
4	slowest	0.06	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	6,000
4	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	300
6	slowest	0.09	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	6,000
6	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	450
8	slowest	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	6,000
8	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	600
10	slowest	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	6,000
10	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	750
12	slowest	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	6,000
12	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	900
14	slowest	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	6,000
14	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,100
16	slowest	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.2	6,000
16	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,200
18	slowest	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	6,000
18	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,400
20	slowest	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	6,000
20	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,500
24	slowest	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.8	6,000
24	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	1,800
26	slowest	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.8	1.8	1.9	2.0	6,000
26	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,000
28	slowest	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.1	6,000
28	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,100
30	slowest	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3	6,000
30	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,300
35	slowest	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.6	6,000
35	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	2,600
40	slowest	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	6,000
40	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	3,000
50	slowest	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4	2.5	2.6	2.8	2.9	3.0	3.1	3.3	3.4	3.5	3.6	3.8	6,000
50	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	3,800
60	slowest	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.4	4.5	6,000
60	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	4,500
70	slowest	1.1	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.9	4.0	4.2	4.4	4.6	4.8	4.9	5.1	5.3	6,000
70	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	5,300
78	slowest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.5	5.7	5.9	6,000
78	fastest	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	5,900

Appendix A4-A–Table 5. Filling times for isokinetic samplers. [To determine the transit rate, in feet per second, multiply the depth at the sampling vertical by 2 and divide by the sampling time.]

Appendix A4-A–Table 5a. Filling times for DH-81 sampler

DH-81 filling times, in seconds, to collect **800 milliliters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
1.8	4	6	
2.0	74	41	27
2.2	67	38	24
2.4	61	35	22
2.6	57	32	20
2.8	53	30	19
3.0	49	28	18
3.2	46	26	17
3.4	43	24	16
3.6	41	23	15
3.8	39	22	14
4.0	37	21	13
4.2	35	20	13
4.4	33	19	12
4.6	32	18	12
4.8	31	17	11
5.0	29	17	11
5.2	28	16	10
5.4	27	15	10
5.6	26	15	9
5.8	25	14	9
6.0	25	14	9
6.2	24	13	9
6.4	1	3	8
6.6	1	3	8
6.8	1	2	8
7.0	1	2	8
7.2	1	2	
7.4	1	1	
7.6	1	1	

Appendix A4-A–Table 5b. Filling times for DH-95 sampler

DH-95 filling times, in seconds, to collect **800 milliliters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
1.6	92	52	33
1.8	82	46	29
2.0	74	41	27
2.2	67	38	24
2.4	61	35	22
2.6	57	32	20
2.8	53	30	19
3.0	49	28	18
3.2	46	26	17
3.4	43	24	16
3.6	41	23	15
3.8	39	22	14
4.0	37	21	13
4.2	35	20	13
4.4	33	19	12
4.6	32	18	12
4.8	31	17	11
5.0	29	17	11
5.2	28	16	10
5.4	27	15	10
5.6	26	15	9
5.8	25	14	9
6.0	25	14	9
6.2	24	13	9
6.4	23	13	8
6.6	22	13	8
6.8	22	12	8
7.0	21	12	8
7.2	20	12	7
7.4	20	11	7
7.6	19	11	7

Appendix A4-A–Table 5c.
Filling times for D-95 sampler

D-95 filling times, in seconds, to collect **800 milliliters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
1.4	105	59	38
1.6	92	52	33
1.8	82	46	29
2.0	74	41	27
2.2	67	38	24
2.4	61	35	22
2.6	57	32	20
2.8	53	30	19
3.0	49	28	18
3.2	46	26	17
3.4	43	24	16
3.6	41	23	15
3.8	39	22	14
4.0	37	21	13
4.2	35	20	13
4.4	33	19	12
4.6	32	18	12
4.8	31	17	11
5.0	29	17	11
5.2	28	16	10
5.4	27	15	10
5.6	26	15	9
5.8	25	14	9
6.0	25	14	9
6.2	24	13	9
6.4	23	13	8
6.6	22	13	8
6.8	22	12	8
7.0	21	12	8
7.2	20	12	7
7.4	20	11	7
7.6	19	11	7

Appendix A4-A–Table 5d.
Filling times for DH-2 sampler

DH-2 filling times, in seconds, to collect **1 liter**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
2.0	92	52	33
2.5	74	41	27
3.0	61	35	22
3.5	53	30	19
4.0	46	26	17
4.5	41	23	15
5.0	37	21	13
5.5	33	19	12
6.0	31	17	11

Appendix A4-A–Table 5e.
Filling times for D-96 sampler

D-96 filling times, in seconds, to collect **3 liters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
2.0	276	155	99
2.5	221	124	80
3.0	184	104	66
3.5	158	89	57
4.0	138	78	50
4.5	123	69	44
5.0	110	62	40
5.5	100	57	36
6.0	92	52	33
6.5	85	48	31
7.0	79	44	28
7.5	74	41	27
8.0	69	39	25
8.5	65	37	23
9.0	61	35	22
9.5	58	33	21
10.0	55	31	20
10.5	53	30	19
11.0	50	28	18
11.5	48	27	17
12.0	46	26	17
12.5	44	25	16
13.0	42	24	15
13.5	41	23	15
14.0	39	22	14
14.5	38	21	14
15.0	37	21	13

Appendix A4-A–Table 5f.
Filling times for D-96 A-1 sampler

D96 A-1 filling times, in seconds, to collect **3 liters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
2.0	277	156	99
2.2	251	141	90
2.4	231	130	83
2.6	213	120	76
2.8	198	111	71
3.0	185	104	66
3.2	173	97	62
3.4	163	91	58
3.6	154	86	55
3.8	146	82	52
4.0	137	77	50
4.2	132	74	47
4.4	126	71	45
4.6	120	68	43
4.8	115	65	41
5.0	111	62	40
5.2	106	60	38
5.4	102	58	37
5.6	99	56	35
5.8	95	54	34
6.0	92	52	33

Appendix A4-A–Table 5g.
Filling times for D-99 sampler

D-99 filling times, in seconds, to collect **6 liters**			
stream velocity (ft/sec)	nozzle diameter (in.)		
	3/16	1/4	5/16
3.0	368	207	133
3.5	316	178	114
4.0	276	155	99
4.5	245	138	88
5.0	221	124	80
5.5	201	113	72
6.0	184	104	66
6.5	170	96	61
7.0	158	89	57
7.5	147	83	53
8.0	138	78	50
8.5	130	73	47
9.0	123	69	44
9.5	116	65	42
10.0	110	62	40
10.5	105	59	38
11.0	100	57	36
11.5	96	54	35
12.0	92	52	33
12.5	88	50	32
13.0	85	48	31
13.5	82	46	29
14.0	79	44	28
14.5	76	43	27
15.0	74	41	27

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APPENDIX A4-B
Instructions Related to Measuring Water Levels at Wells and a Sample USGS Ground-Water-Quality Field Form

All USGS personnel who sample or make water-level or water-quality measurements at wells must comply with requirements and be familiar with the guidelines provided by the USGS Office of Ground Water. Guidelines established by the Office of Ground Water related to measurement of well depth and water level have been adapted for water-quality work and are summarized in this appendix.

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A4-B-1. Establishing a permanent measuring point on wells at which water level will be measured APP.B3

A4-B-2. Well-depth measurement APP.B5
Figure B1. Example of a USGS field form for ground-water-level measurements **APP.B7**

A4-B-3. Water-level measurement by APP.B8
(a) Steel-tape procedure APP.B9
(b) Electric-tape procedure APP.B13

Figure B2. Example of a water-level measurement using a graduated steel tape **APP.B12**

A4-B-4. Water-level measurement by the air-line method APP.B17
Figure B3. Typical installation for measuring water level by the air-line method **APP.B20**

A4-B-5. Water-level measurement at flowing wells using low-pressure and high-pressure methods APP.B21

A4-B-6. Sample of the U.S. Geological Survey Ground-Water Quality Notes field form APP.B25

Appendix A4-B

Equipment and Supplies All sections of appendix A4-B – common supplies A4-B-1 – Establishing a permanent measuring point on wells A4-B-2 – Well-depth measurement.	
All sections	GWSI site schedule, Form 9-1904-A
	Ground-water-level measurement field form and/or other field forms and/or handheld or field computer for data entry
	Pens, ballpoint with non-erasable blue or black ink, for writing on field forms and in equipment log books
	Field folder and well file
	Two wrenches with adjustable jaws and other tools for removing the well cap
	Clean rag
	Key(s) for opening locks
	Equipment-cleaning supplies (NFM 3). Tape-cleaning supplies: refer to NFM 3.3.8 for soap-and-water wash guidance and disinfection. If disinfecting, use either (a) commercially available hypochlorite wipes; or (b) prepare a dilute chlorine solution adding 1 mL of common household bleach to 900 mL of water (0.005-percent solution)
A4-B-1	**Establishing a permanent measuring point (MP)**
	Steel tape, graduated in feet, tenths, and hundredths of feet; calibrated for making field measurements
	Reference steel tape, graduated in feet, tenths, and hundredths of feet; designated for calibration of field steel and electric tapes
	Calibration and maintenance log book for each steel tape
	Spray paint (bright color) or casing-notching tool
A4-B-2	**Well-depth measurement with steel tape**
	Steel tape, graduated in feet, tenths, and hundredths of feet; calibrated for making measurements. A black tape is better than a chromium-plated tape. If a chromium-plated tape has to be used, paint the back of the tape with a flat black paint to make it easier to read the wetted chalk mark
	Reference steel tape, graduated in feet, tenths, and hundredths of feet; designated for calibration of field steel and electric tapes
	Steel-tape calibration and maintenance log book (one for each steel tape)
	Weight (stainless steel, iron, or other noncontaminating material) – not lead
	Strong ring and wire, for attaching weight to end of tape. Wire should be strong enough to hold weight securely, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free
	Carpenters' chalk (blue)

Appendix A4-B-1
Establishing a permanent measuring point on wells at which water level will be measured[1]

A permanent measuring point (MP) from which all water levels for a given well are measured must be established for each well at which USGS data are collected. The MP should be established when a monitor well is installed or an existing well is inventoried. The accuracy with which the MP is established depends on the accuracy of the water-level measurement being made. **For water level measured in hundredths of a foot, the MP is to be established to an accuracy of 0.01 foot.** This guidance assumes that:

- All water-level measurements from a given well must be referenced to the same datum to ensure data comparability.
- Land-surface datum (LSD) at the well was established by the person who made the initial water-level measurement at the well. LSD is an arbitrary plane chosen to be approximately equivalent to the average altitude of the ground around thewell. Because LSD around a well may change over time, the distance between the MP and LSD should be checked every 3 to 5 years, or more frequently because of land development or other changes.
- Measuring points can change from time to time, especially on privately-owned wells. Such changes must be documented and dated in field notes and in the data base(s) into which the water-level data are entered.

To establish a permanent measuring point:

1. Establish the location of the MP at a specific point within the top of the casing. The MP is measured in reference to LSD. If possible, position the MP at a point on the casing where a leveling rod could be set on it directly over the well and the measuring tape can hang freely when it is in contact with the MP. Locate the MP at the most convenient place from which to measure the water level.

[1]From the USGS Office of Ground Water, Ground-Water Procedure Document 3.

2. Clearly mark the MP, either with an arrow sprayed with bright-colored paint or with a notch cut into the top of the casing. The MP must be as permanent as possible and be clearly visible and easily located. Location of the MP must be described in the well file.
3. Measure the height of the MP in feet above or below LSD. For USGS studies, record the following information into GWSI (figure B1):
   - Height and detailed description of the MP. Note that values for measuring point below land surface should be preceded by a minus sign (-).
   - Date the MP was established.
4. For most water-quality studies, the LSD and MP should be surveyed in.
5. Establish at least one clearly displayed reference mark (RM) in a location near the well; for example, a lag bolt set into a nearby telephone pole. The RM is an arbitrary datum established by permanent marks and is used to check the MP or to re-establish an MP should the original MP be destroyed or need to be changed.
6. Clearly locate the MP and RM on a detailed site sketch that goes into the well folder; the sketch commonly is made on the back of the paper GWSI form. If possible, photograph the site, including the RM and MP locations; draw an arrow to the RM and MP on the photograph(s) using an indelible marker, and place the photos in the well file.

Appendix A4-B-2
Well-depth measurement[2]

This method uses a graduated steel tape to measure the total depth of a well below land-surface datum. Select a graduated steel tape that is accurate to 0.01 foot. The steel tape should be calibrated against a reference steel tape. A reference steel tape is one that is maintained in the office and designated solely for tape calibration.

- If the well casing is angled, instead of vertical, the well depth will have to be corrected.
- When measuring wells of depth greater than 200 feet (deep wells), expansion and stretch of the steel tape must be considered and accounted for (see Garber and Koopman, 1968).
- Use of a steel tape is **not** recommended for measuring the depth of pumping wells.
- A weight usually is attached to the end of a steel tape to allow it to hang plumb. The weight should not be constructed of lead or other material that potentially could contaminate water in the well.
- Well obstructions could cause errors in the measurement if the steel tape cannot hang plumb.

To measure well depth:

1. Using a clean, calibrated steel tape, measure from the zero point on the tape to the bottom of the weight. Record this number as the length of the weight interval.
2. Lower the weight and tape into the well until the weight reaches the bottom of the well and the tape slackens.
3. Partially withdraw the tape from the well until the weight is standing in a vertical position, but still touching the bottom of the well. A slight jerking motion will be felt as the weight moves from the horizontal to the vertical position.
4. Repeat step 3 several times by lowering and withdrawing the tape to obtain a consistent reading.
5. Record the tape reading held at the measuring point (MP).

[2]From the USGS Office of Ground Water, Ground-Water Procedure Document 11.

6. Withdraw the tape from the well 1 to 2 feet, so that the weight will hang freely above the bottom of the well. Repeat steps 2-4 until two consistent depth readings are obtained.
7. Calculate total well depth below land-surface datum (LSD) as follows:

a. Tape reading held at the MP	84.3 feet
b. Length of the weight interval	+ 1.2 feet
c. Sum of a + b	85.5 feet
d. MP correction	- 3.5 feet
e. Total well depth below LSD	82.0 feet

8. After completing the well-depth measurement, clean the exposed portion of the tape using the procedures described in NFM 3.3.8. To prevent microbial cross-contamination of other wells, disinfect the tape using commercially available hypochlorite wipes or a dilute (0.005-percent) chlorine solution.
9. Record depth data to the nearest 0.01 foot. USGS well-depth data should be recorded in GWSI and on the Ground-Water Level Notes (fig. B1) and other field forms that are kept in the field folder.

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USGS science for a changing world

FIELD ID _____

GROUND-WATER LEVEL NOTES

Station No._____ Field ID _____

Station Name _____

Project No. _____ Proj Name_____

Measurement made by: _____

Signature _____ Date _____

WELL___ SPRING___ MONITOR___ SUPPLY___ OTHER_____

SUPPLY WELL PRIMARY USE: DOMESTIC__ PUBLIC SUPPLY__ IRRIGATION __ OTHER_____

Casing Material: _____ Altitiude (land surface) _____ ft abv MSL

Measuring Point: _____ ft abv blw LSD MSL MP Well Depth _____ ft abv blw LSD MSL MP

Sampling condition (72006) pumping (8) flowing (4) static (n/a)

[see QWDATA User Manual for additional fixed-value codes]

Water Level: _____ ft blw LSD (72019) ft blw MP (61055)

ft abv MSL (NGVD 29) (62610) ft abv MSL (NAVD 88) (62611)

Comments:

Depth to Water and Well Depth

	1ST	2ND	3RD (optional)
Time			
Hold (for DTW)			
- Cut			
= DTW from MP			
– Measuring point (MP)			
= DTW from LSD			
Hold (for well depth)			
+ Length of tape leader			
= Well depth below MP			
– MP			
= Well depth below LSD			

WATER-LEVEL DATA FOR GWSI

DATE WATER LEVEL MEASURED (C235) __ __-__ __-__ __ __ __ (Month Day Year)

TIME (C709) __ __ __ __

WATER LEVEL TYPE CODE (C243): L (below land surface) M (below meas. pt.) S (sea level)

WATER LEVEL (C237/241/242) __ __ __ __.__ __

MP SEQUENCE NO. (C248) __ __ __ (Mandatory if WL type=M)

WATER LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD 29 (National Geodetic Vertical Datum 0f 1929); NAVD 88 (North American Vertical Datum 0f 1988); Other (See GWSI manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measurement discontinued; O obstruction; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign substance; W well destroyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; E estimated; F transducer; G pressure gage; H calibrated pres. gage; L geophysical logs; M manometer; N non-rec. gage; O observed; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hundreth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geologist; L geophysical logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER-LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

RECORD READY FOR WEB (C858): Y checked; ready for web display; C not checked; no web display; P proprietary; no web display; L local use only; no web display

COMPILED BY :_____ DATE _____ ENTERED INTO GWSI BY: _____ DATE _____

CHECKED BY :_____ DATE _____ ENTERED INTO QWDATA BY: _____ DATE _____

GW Water Level Form ver. 1

Figure B1. Example of a USGS field form for ground-water-level measurements.

Appendixes A4-B-3(a) and (b) Water-level measurement by (a) steel tape, or (b) electric tape

A4-B-3: Equipment and Supplies A4-B-3(a) – Water-level measurement by graduated steel tape A4-B-3(b) – Water-level measurement by electric tape	
A4-B-3(a + b)[1]	Steel tape, graduated in feet, tenths, and hundredths of feet; calibrated for making water-level measurements
A4-B-3(a) [1]	Reference steel tape, graduated in feet, tenths, and hundredths of feet. A reference steel tape is one that is maintained in the office and designated solely for tape calibration
A4-B-3(a)	Steel-tape calibration and maintenance log book (one for each steel tape). Field forms, paper and/or electronic; ballpoint pens (blue or black, non-erasable) for recording information in the log book and on paper field forms
A4-B-3(a)	Weight (stainless steel, iron, or other noncontaminating material – do not use lead)
A4-B-3(a)	Strong ring and wire, for attaching weight to end of tape. Wire should be strong enough to hold weight securely, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free
A4-B-3(a)	Carpenters' chalk (blue)
A4-B-3(a + b)	Tape-cleaning supplies: refer to NFM 3.3.8 for soap-and-water wash guidance and disinfection. Disinfect using either commercially available hypochlorite wipes or a dilute (0.005-percent solution) chlorine solution
A4-B-3(b)[2]	An electric tape, double-wired and graduated in feet, tenths, and hundredths of feet, accurate to 0.01 ft. Electric tapes commonly are mounted on a hand-cranked and powered supply reel that contains space for the batteries and some device ("indicator") for signaling when the circuit is closed
A4-B-3(b)	Electric-tape calibration and maintenance log book; manufacturer's instructions. Field forms, paper and/or electronic; ballpoint pens (non-erasable blue or black ink) for recording information in the log book and on paper field forms
A4-B-3(b)	Replacement batteries, charged
A4-B-3(a + b)	Clean rag
A4-B-3(a + b)	Two wrenches with adjustable jaws or other tools for removing the well cap

[1]A black tape is better than a chromium-plated tape. If a chromium-plated tape has to be used, paint the back of the tape with a flat black paint to make it easier to read the wetted chalk mark.

[2]An older model electric tape, also known as an "M-scope", marked at 5-foot intervals with clamped-on metal bands has been replaced by newer, more accurate models.

A4-B-3(a) Steel tape[3]

The graduated steel-tape (wetted-tape) procedure is considered to be the most accurate method for measuring a depth to the water surface at nonflowing wells. A graduated steel tape is commonly accurate to 0.01 foot. When measuring deep water levels, however, tape expansion and stretch is a necessary consideration (Garber and Koopman, 1968). The method is most accurate for water levels less than 200 feet below land surface. This method is **not** recommended for measuring pumping levels in wells.

- May be impossible to get reliable results if water is dripping into the well or condensing on the well casing.
- If the well casing is angled, instead of vertical, the depth to water will have to be corrected.
- The steel tape should be calibrated against a reference steel tape. A reference steel tape is one that is maintained, in the office, for use only for calibrating steel tapes.
- Check that the well is free of obstructions that can affect the plumbness of the steel tape. An accurate measurement cannot be made if the tape does not hang plumb.

Before making a measurement:

1. Ensure that the steel tape for field use has been calibrated, using a reference steel tape (see the Equipment and Supplies table for Appendix A4-B-3, above). Check the equipment log book for the designated steel tape for calibration information.
2. Maintain the tape in good working condition by periodically checking the tape for rust, breaks, kinks, and possible stretch. Record all calibration and maintenance data associated with the steel tape in its calibration and maintenance log book.
3. If the steel tape is new, be sure that the black sheen on the tape has been dulled so that the tape will retain the chalk.
4. Attach a weight to the tape that is constructed of stainless steel or other noncontaminating material to protect ground-water quality in the event that the weight is lost in the well.
5. Place any previous measured water-level data for the well into the field folder.

[3]From the USGS Office of Ground Water, Ground-Water Procedure Document 1.

6. Check that the measuring point (MP) is clearly marked on the well and accurately described in the well file or field folder. If a new measuring point needs to be established, follow the procedures in Appendix A4-B-1 but do not use paint or create casing-material filings until after sampling has been completed for the day.
7. Prepare the Ground-Water Level Notes and Water-Level Data for GWSI field forms (fig. B1). The measurement process will be repeated at least twice and recorded in the respective column (refer to the unshaded portion of the box at the upper right of fig. B1). Record the time of measurement, using the column headed "1st" for the initial set of measurements. Water-level data are to be recorded to the appropriate accuracy for the depth being measured.
8. Spread clean plastic sheeting around the well to prevent the well tape from contacting the ground and introducing dirt into the well.

To measure water level using a steel tape:

1. Chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk (the wetted chalk mark identifies that part of the tape that was submerged).
2. If water level was measured previously at the well, use the previous measurement(s) to estimate the length of tape that should be lowered into the well.
3. Slowly lower the weight and tape into the well until the bottom end of the tape is submerged below the water. Work carefully to avoid splashing. Continue to lower the end of the tape into the well until the next graduation (a whole foot mark) is opposite the MP and record this number on the field form (fig. B1) next to "Hold (for DTW)" as illustrated on fig. B2.
4. Rapidly bring the tape to the surface before the wetted chalk mark dries and becomes difficult to read. Record the number as the "Cut."
5. Subtract the "Cut" from the "Hold" and record the difference as "DTW from MP" (Depth To Water from MP). The difference between these two readings is the depth to water below the MP.
6. Record the MP correction, subtract it from "DTW from MP," and record the result as "DTW from LSD" (depth to water from land-surface datum).

- To obtain the depth to water below land surface if the MP is above land surface: the distance between the MP and land surface datum is subtracted from the depth to water from the MP.
- To obtain the depth to water below land surface if the MP is below land surface: precede the MP correction value with a minus (-) sign and subtract the distance between the MP and land surface datum from the depth to water from the MP.
- If the water level is above LSD, record the depth to water in feet above land surface as a negative number.

7. Make a check measurement by repeating steps 2 through 6, recording check measurements in the second ("2nd") column (fig. B1).
   - The check measurement should be made using a different MP hold value than that used for the original measurement.
   - If the check measurement does not agree with the original measurement within 0.01 or 0.02 of a foot, make a third check measurement, recording this measurement in the third column. Make repeated check measurements until the reason for the lack of agreement is determined or until the results are shown to be reliable.
   - If more than two readings are taken, record the average of all readings.
8. In some pumped wells, a layer of oil may float on the water surface.
   - If the oil layer is a foot thick, read the tape at the top of the oil mark and use this data for the water-level measurement instead of the wetted chalk mark. The measurement will differ slightly from the water level that would be measured were the oil not present.
   - If several feet of oil are present in the well,or if it is necessary to know the thickness of the oil layer, a commercially available water-detector paste can be used that will detect the presence of water in the oil. Apply the paste to the lower end of the tape. The top of the oil shows as a wet line, and the top of the water shows as a distinct color change. Since oil density is about three-quarters that of water, the water level can be estimated by adding the thickness of the oil layer times its density to the oil-water interface elevation.
9. Record water-level data to the nearest 0.01 foot. Record USGS water-level data on field forms (kept in the field folder) and in GWSI, using the appropriate method code(s) (fig. B1).

10. After completing the water-level measurement, clean the exposed portion of the tape using the procedures described in NFM 3.3.8. To prevent microbial cross-contamination of other wells, disinfect the tape using commercially available hypochlorite wipes or a dilute chlorine solution (1 mL of bleach added to 900 mL water) (NFM 3.3.8). Rinse with DIW and dry the tape after each use. Do not store a steel tape while dirty or wet.

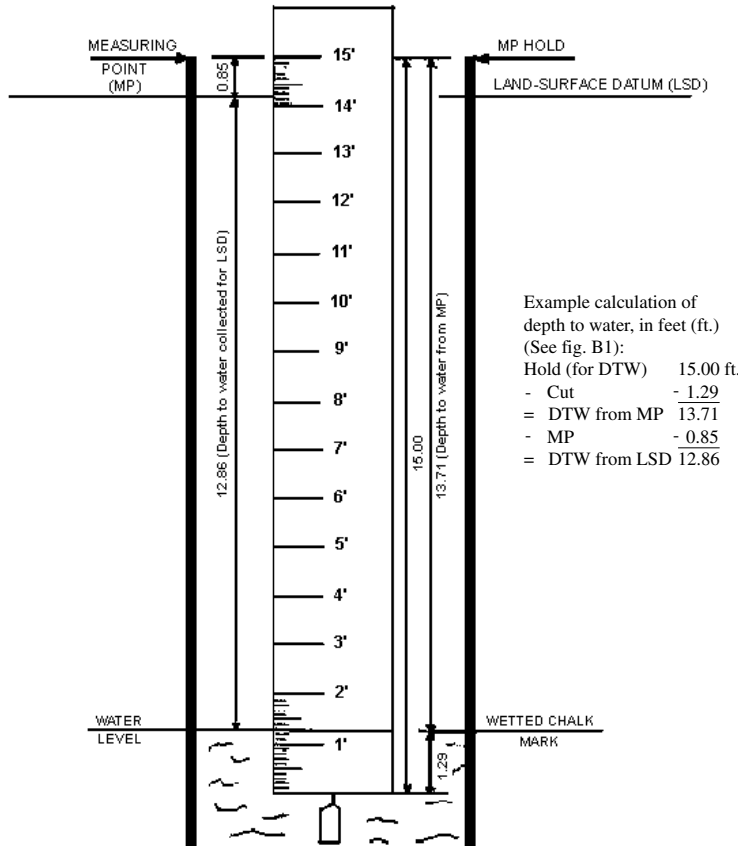

Figure B2. Example of a water-level measurement using a graduated steel tape.

A4-B-3(b) Electric tape[4]

The electric-tape procedure for measuring depth to the water surface in a nonflowing well is especially useful in wells that are being pumped with large-discharge pumps, when making a series of measurements in rapid succession (for example, during purging or aquifer tests), and in wells with condensation or dripping water. Use of an electric tape minimizes the danger of tape entanglement in the pump impellers because the probe signals when the water surface is reached.

The accuracy of electric-tape measurements depends on the type of tape used and whether or not the tape has been stretched out of calibration after use. Tapes that are marked the entire length with feet, tenths, and hundredths of a foot can be considered accurate to ± 0.01 ft and are most accurate for water levels less than 200 ft below land surface. Electric tapes are harder to keep calibrated than are steel tapes. When measuring deep water levels, tape expansion and stretch is an additional consideration (see Garber and Koopman, 1968). The electric tape should be calibrated against a reference steel tape (see the Equipment and Supplies table above for Appendix A4-B-3.

- If the water in the well has very low specific conductance, the tape may not give an accurate reading.
- Material on the water surface, such as oil, may interfere with obtaining consistent readings.
- If the well casing is angled, instead of vertical, the depth to water will have to be corrected.
- **The electric tape should be recalibrated annually or more frequently** if it is used often or if the tape has been subjected to abnormal stress that may have caused it to stretch.

Before measuring water level with the electric tape:

1. The electric steel tape requires an initial calibration before using it in the field. Calibrate the electric tape against a reference steel tape as follows:
   a. Check the distance from the probe's sensor to the nearest foot marker on the tape, to ensure that this distance puts the sensor at the zero foot point for the tape. If it does not, a correction must be applied to all depth-to-water measurements. Record this in the equipment log book and on the field form.

[4]From the USGS Office of Ground Water, Ground-Water Procedure Document 4, version 2007.1.

b. Compare length marks on the electric tape to those on the reference tape with the tapes laid out straight on the ground, or compare the electric tape against the known distance between fixed points on the ground.

c. Compare water-level measurements made with the electric tape to those made with the reference steel tape (or one that has recently been calibrated against it) in several wells that span the range of depths to water that are anticipated. For water levels of less than 500 ft below the MP, measurements should agree to within +/- 0.01 ft. For water levels greater than 500 ft below the MP, measurements should agree to within 1 part in 1000. If these accuracies are not met, then a correction factor based on a regression analysis should be developed.

d. Record all calibration and maintenance data in the calibration and maintenance log book for the electric tape.

2. Check the circuitry of the electric tape before lowering the probe into the well. To determine proper functioning of the tape mechanism, dip the probe into tap water and observe whether the indicator needle, light, and/or beeper (collectively termed the "indicator" in this document) indicate a closed circuit. For an electric tape with multiple indicators (sound and light, for instance), confirm that the indicators operate simultaneously. If they do not operate simultaneously, determine which is the most accurate and use that one.

3. Inspect the electric tape before using it in the field.

   a. Check the tape for wear, kinks, frayed electrical connections and possible stretch; the cable jacket tends to be subject to wear and tear.

   b. Test that the battery and replacement batteries are fully charged.

4. Place any previous measured water-level data for the well into the field folder.

5. After reaching the field site, check that the measuring point (MP) is clearly marked on the well and is accurately described in the well file or field folder. If a new measuring point needs to be established, follow the procedures in Appendix A4-B-1, but do not use paint or create casing-material filings until after sampling has been completed to avoid sample contamination.

6. Prepare the Gound-Water Level Notes and Water-Level Data for GWSI field forms (fig. B1). The measurement process will be repeated at least twice and recorded in the respective column (refer to the unshaded portion of the box at the upper right of fig. B1). Record the time of measurement, using the column headed "1st" for the initial set of measurements. Data are to be recorded to the appropriate accuracy for the depth being measured.
7. Prevent the well tape from contacting the ground and introducing dirt into the well by spreading a clean plastic sheet around the well.

To measure water level using an electric tape:

1. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made. Avoid letting the tape rub across the top of the well casing. Place the tip or nail of the index finger on the insulated wire at the MP and read the depth to water.
   - Record the depth to water measurement in the first data-entry column, as "DTW from MP."
   - Record the date and time of the measurement.
   - Make all readings using the same deflection point on the indicator scale, light intensity, or sound so that water levels will be consistent between measurements.
   - If the tape has been repaired and spliced go to the section on using a repaired/spliced tape (step 6).
2. Apply the MP correction to get the depth to water in feet below or above LSD. If the MP is below land surface, precede the MP correction value with a minus (-) sign to obtain the MP height. In all cases, subtract the MP height from the water level to obtain the depth to water (DTW from LSD). Referring to the non-shaded section of the Ground-Water Level Notes field form (fig. B1) in the "Depth to Water and Well Depth" table, record this value in the first (1st) data-entry column as "DTW from LSD." If the water level is above LSD, enter the water level as feet above land surface preceded by a minus sign (-).
3. Make a check measurement by repeating steps 1 and 2 and record the measurement in the second data column of fig. B1. If the check measurement does not agree with the original measurement within 0.01 or 0.02 of a foot, make a third check measurement, recording this measurement in the third (3rd) column. Make repeated check measurements until the reason for the lack of agreement is determined or until the results are shown to be reliable. If more than two readings are taken, record the average of all readings.

4. Water-level data are recorded to the nearest 0.01 foot. Record USGS water-level data on field forms and in GWSI, using the appropriate method code(s) (fig. B1).
5. After completing the well measurement, wipe down the section of the tape that was submerged in the well water, using the cleaning and/or disinfection method of choice (NFM 3.3.8). If disinfecting the tape, rinse the tape thoroughly with deionized or tap water after disinfection Dry the tape and rewind it onto the tape reel. Do not rewind or otherwise store a dirty or wet tape.
6. **Using a repaired/spliced tape:** If the tape has been repaired by cutting off a section of tape that was defective and splicing the sensor to the remaining section of the tape, then the depth to water reading at the MP will not be correct. To obtain the correct depth to water, apply the following steps, which is similar to the procedure for using a steel tape and chalk.
    a. Ensure that the splice is completely insulated from any moisture and that the electrical connection is complete.
    b. Measure the distance from the sensing point on the probe to the nearest foot marker above the spliced section of tape. Subtract that distance from the nearest foot marker above the spliced section of tape. That point then becomes the "tape correction." For example, if the nearest foot marker above the splice is 20 feet, and the distance to the probe sensor is 0.85 ft, then the tape correction will be 19.15 feet. Record the tape correction on a field form. Periodically recheck the tape-correction factor by measuring the spliced electric tape with a reference steel tape.
    c. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made. Place the tip or nail of the index finger on the insulated wire at the MP and read the depth to water. Record the depth-to-water measurement and the date and time of the measurement on the field form.
    d. Subtract the "Tape Correction" value from the "Hold" value and record the result as DTW from LSD (fig. B1).
    e. Return to Step 2.

Appendix A4-B-4
Water-level measurement by the air-line method[5]

The submerged air-line method for measuring a depth to the water surface in a nonflowing well requires installation of the air line and associated equipment. This method is especially useful in pumped wells where water turbulence may preclude using a more precise (steel-tape or electric-tape) method and can be used while the well is being pumped.

The air-line method is less accurate than the graduated steel-tape or the electric-tape method. Bends or spirals in the air line do not influence the accuracy of this method as long as the position of the tubing is not appreciably changed.

- Water-level measurements using an altitude gage should be accurate to 0.1 foot.
- Water-level measurements using a pressure gage are approximate and should notbe considered accurate to more than the nearest one foot.
- When measuring deep water levels, corrections for fluid temperatures and vertical differences in air density are additional considerations (see Garber and Koopman, 1968).

Equipment and Supplies Appendix A4-B-4 – Air-line method for water-level measurement	
	1/8 or 1/4-inch diameter, seamless copper tubing, brass tubing, or galvanized pipe with a suitable pipe tee for connecting an altitude or pressure gage. (Flexible plastic tubing can be used but is less desirable).
	Altitude or pressure gage, and spare gages
	Tire valve stem and tire pump
	Small open-end wrench
	Wire or electrician's tape
	Steel tape (see Appendix A4-B-3)
	Carpenters' chalk
	Equipment calibration and maintenance log books, for each altitude or pressure gage and steel tape.
	Tape-cleaning supplies (refer to the list for well depth and steel- and electric-tape water-level measurement)

[5]From the USGS Office of Ground Water, Ground-Water Procedure Document 13

To measure water level using the air-line method:

1. Install an air-line pipe or tube in the well. Figure B3 shows a typical installation for measuring water levels by the air-line method.
   - The air line can be installed by either lowering it into the annular space between the pump column and casing after the pump has been installed in the well, or by securing it to sections of the pump and pump column with wire or tape as it is lowered into the well.
   - The air line must extend far enough below the water level that the lower end remains submerged during pumping of the well.
2. Attach a pipe tee to the top end of the air line. On the opposite end of the pipe tee, attach a tire valve stem.
3. Using a wrench, connect to the fitting on top of the pipe tee either (a) an altitude gage that reads in feet, or (b) a pressure gage, that reads pressure in pounds per square inch (lb/in^2 or psi).
4. Connect a tire pump to the tire valve stem fitting on the pipe tee.
   - As the water level in the well changes, **h** and **d** (fig. B3) must change in a manner such that their sum remains the same.
   - Their sum is a constant (**k**), which is determined at the same time as a simultaneous wetted-steel tape and air gage measurement is made.
5. To calibrate the air line and gage, make an initial depth to water level (**d**) measurement with a wetted-steel tape, and an initial air gage reading (**h**). Add **d** and **h** to determine the constant value for **k**. Use a tire pump to pump compressed air into the air line until all the water is expelled from the line. Once all water is displaced from the air line, record the maximum gage reading.
   - *Example (a)* – using an altitude gage: given an initial measured depth to the water level, **d,** of 25.86 ft, the initial altitude gage reading, **h**, is 75.5 ft. Then the constant **k** = 25.9 ft + 75.5 ft = 101.4 ft).
   - *Example (b)* – using a pressure gage: given an initial measured depth to the water level, **d,** of 85.85 ft, the initial pressure gage reading, **h**, is 28 psi. Then the constant **k** = 86 ft + (2.3 ft/psi x 28 psi) = 86 ft + 64 ft = 150 ft.
6. Calibrate the air line and gage as described in step 5 above.

7. To measure the water level depth in a well with an air line, subsequent air line readings are subtracted from the constant **k** to determine the depth to the water level below the MP. Use a tire pump to pump compressed air into the air line until all the water is expelled from the line, and record the maximum gage reading.
   - *Example (a)* – depth to the water level in a well using an altitude gage with a constant **k** of 101.4 ft. During a later pumping period, the maximum altitude gage **h** reads 50.0 ft; therefore, the water level, **d** = 101.4 ft - 50.0 ft = 51.4 ft.
   - *Example (b)* – depth to the water level in a well using a pressure gage with a constant **k** of 150 ft. During a later pumping period, the maximum pressure gage **h** reads 18 psi; therefore, the water level, **d** = 150 ft - (2.3 ft/psi x 18 psi) = 150 ft - 41 ft = 109 ft.
8. Measure the water-level depth as described above in step 7.
9. Apply the MP correction to get the depth to water below or above land-surface datum.
10. Record USGS water-level data on a field form and in GWSI, using the appropriate method code(s).

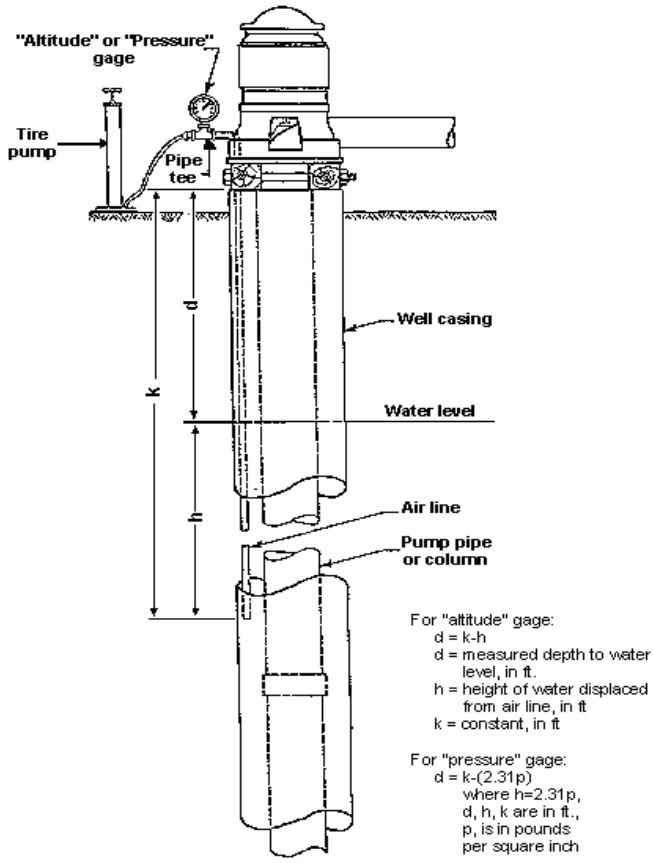

Figure B3. Typical installation for measuring water level by the air-line method. Modified from Driscoll, 1986.

Appendix A4-B-5
Water-level measurement at flowing wells using low-pressure and high-pressure methods[6]

Head can be measured at flowing wells under low-pressure and high-pressure conditions, but require training and experience to be executed correctly. The low-pressure head-measurement method is more accurate, simpler, faster, and safer than the high-pressure head-measurement method.

- Use the low-pressure head-measurement method at wells with heads lower than 5 to 6 feet above land surface (the low-pressure method is impractical at wells with heads greater than 5 to 6 feet above land surface).
- Use the high-pressure method at wells with heads greater than 5 to 6 feet above land surface. Be aware that implementing the high-pressure method is more complex, takes more time, and can be dangerous.
- The accuracy of the head measurement depends on the method and equipment used, and on the experience and care of the field person:
  - Low-pressure head measurements can be measured to an accuracy of 0.1 foot.
  - High-pressure head measurements using a pressure-gage probably are not accurate to within less than 0.1 foot, although they may be read to 0.01 foot.

[6]From the USGS Office of Ground Water, Ground-Water Procedure Document 12.

Equipment and Supplies Appendix A4-B-5 – Flowing-well water-level measurements	
Low pressure	Short length of transparent plastic tubing
	Hose clamps
	Measuring scale
High pressure	Flexible hose with a 3-way valve
	Hose clamps
	Altitude or pressure gage, and spare gages
	Small open end wrench
	Altitude or pressure gage calibration and maintenance log book(s)
	Soil-pipe test plug ("sanitary seal") to fit 2 to 10-inch diameter pipes (available at plumbing supply stores).[1]

[1] Soil-pipe test plugs consist of a length of small-diameter pipe, generally 0.75 inch, surrounded by a rubber packer. The packer can be expanded by an attached wingnut to fit tightly against the inside of the well casing or discharge pipe. The small-diameter pipe is threaded so that it can be attached to a valve, hose, or altitude/pressure gage.

When preparing for measuring the head at a flowing well:

1. **If using the high-pressure method, handle the pressure gage appropriately and with care**. Altitude/pressure gages are delicate, easily broken and subject to erroneous readings if dropped or mistreated.
   - The middle third of the range of the pressure gage provides the most accurate reading.
   - **Never let the well pressure exceed the altitude/pressure gage limits.**
   - Never connect a gage to a well that uses a booster pump in the system – the pump could start automatically and the resulting pressure surge may ruin the gage.
   - Altitude/pressure gages must be calibrated with a dead-weight tester. Record the calibration in the instrument log book for the gage that is being used.
2. When a flowing well is closed or opened by a valve or test plug, it should be done gradually. If pressure is applied or released suddenly, the well could be permanently damaged by the "water-hammer effect" by caving of the aquifer material, breakage of the well casing, or damage to the distribution lines or gages. To reduce the possibility of a "water-hammer effect", install a "pressure-snubber" ahead of the altitude/pressure gage.

3. If possible, shut down all flow from the well so that a static water-level measurement can be made; however, shut down may not be possible because of well owner objections or system leaks. Wells without a shut-down valve, can be shut-in by installing a soil-pipe test plug on the well or discharge line.
4. If a well has to be shut down, the time required to reach static pressure after shut-in may range from hours to days. Since it may be impractical or impossible to reach true static conditions, record the shut-in time for each gage reading. During return visits to a particular well, it is desirable to duplicate the previously used shut-in time before making an altitude/pressure gage reading.
5. Check that the measuring point (MP) is clearly marked on the well and accurately described in the well file or field folder. If a new measuring point needs to be established, follow the procedures in Appendix A4-B-1 but do not use paint or create casing-material filings until after sampling has been completed for the day.

To measure water level at a flowing well:

Low-pressure head-measurement (direct measurement) method:

1. Connect a short length of transparent plastic tubing tightly to the well with hose clamps.
2. Raise the free end of the tubing until the flow stops.
3. Rest the measuring scale on the measuring point (MP).
4. Read the water level directly, by placing the hose against the measuring scale.
5. Apply the MP correction to get the depth to water above land-surface datum.
6. Repeat steps 2 through 5 for a second check reading.

High-pressure head-measurement (indirect measurement) method:

1. Make sure that all well valves are closed except the one to the altitude/pressure gage. This will prevent use of the well during the measurement period and ensure an accurate water-level reading. Record the original position of each valve that is closed (full open, half open, closed, etc.), so that the well can be restored to its original operating condition.

2. Connect a flexible hose with a 3-way valve to the well with hose clamps.
3. Select a gage where the water pressure in the well will fall in the middle third of the gage range. If in doubt, use a pressure gage having a 100-pound per square inch (psi) range to make an initial measurement, then select the gage with the proper range for more accurate measurements.
4. Attach the altitude/pressure gage to one of the two "open" valve positions using a wrench. Never tighten or loosen the gage by twisting the case because the strain will disturb the calibration and give erroneous readings.
5. Bleed air from the hose, using the other "open" valve position.
6. Open the altitude/pressure gage valve slowly to reduce the risk of damage by the "water-hammer effect" to the well, distribution lines and gages. Once the needle stops moving, tap the glass face of the gage lightly with a finger to make sure that the needle is not stuck.
7. Make sure that the well is not being used by checking to see that there are no fluctuations in pressure.
8. Hold the altitude/pressure gage in a vertical position, with the center of the gage at the exact height of the MP. If using an altitude gage, read the gage to the nearest 0.1 foot. For pressure gages with psi units, read the gage to the nearest psi or 0.1 psi and multiply by 2.31 to convert to feet of water.
9. Apply the MP correction to get the depth to water above land-surface datum.
10. Shut off the well pressure and repeat steps e-i for a second check reading.
11. Record the identification number of the altitude/pressure gage with each water-level measurement so that the reading can be back referenced to the calibration record, if necessary.
12. Record USGS water-level data on field forms and in GWSI, using the appropriate method code(s).

Appendix A4-B-6
Sample of the U.S. Geological Survey Ground-Water Quality Notes field form[7]

[7]This form was developed for U.S. Geological Survey personnel and is included for informational use only.

February 2006

USGS science for a changing world

U. S. GEOLOGICAL SURVEY GROUND-WATER QUALITY NOTES

FIELD ID _____

NWIS RECORD NO _____

Station No._____ Station Name _____ Field ID _____

Sample Date _____ Mean Sample Time (watch) _____ Time Datum _____ (eg. EST, EDT, UTC)

Sample Medium _____ Sample Type _____ Sample Purpose (71999) _____ Purpose of Site Visit (50280) _____ QC Samples Collected? Y N

Project No. _____ Proj Name_____ Project No. _____ Proj Name_____

Sampling Team _____ Team Lead Signature _____ Date _____

Comments:

Sample Set ID _____

LABORATORY INFORMATION

Samples Collected: NUTRIENTS ____ MAJOR IONS ____ TRACE ELEMENTS: filtered ____ unfiltered ____ MERCURY: filtered ____ unfiltered ____ MICROBIOLOGY ____

ORGANICS: filtered ____ unfiltered ____ PEST ____ VOC ____ RADIOCHEMICALS: filtered ____ unfiltered ____ RADON ____ (Radon samp coll time:_____)

ISOTOPES ____ DOC ____ TPC ___ (vol filtered ____mL) PIC ___ (vol filtered ____mL) TPC (QC) ___ (vol filtered ____ mL) OTHER _____ _____

Lab Schedule: _____ _____ _____ _____ _____ _____ _____ _____ _____

Lab Codes: _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE

COMMENTS _____ Date Shipped _____

****Notify the NWQL in advance of shipment of potentially hazardous samples—phone 1-866-ASK-NWQL or email LabLogin@usgs.gov**

FIELD MEASUREMENTS

Water Level _____

ft blw lsd (72019) ft blw mp (61055)

ft abv msl (NGVD 1929) (62610)

ft abv msl (NAVD 1988) (62611)

Flow Rate (00059) _____ gal/min

Sampling Depth (78890) _____ ft blw msl

Sampling Depth (TBD) _____ ft blw lsd

Depth to top of sampling interval (72015) _____ ft blw lsd

Depth to bottom of sampling interval (72016) _____ ft blw lsd

Temp, Air (00020) _____ °C

Temp, Water (00010) _____ °C

pH (00400) _____ units

Sp. Cond (00095) _____ µS/cm@25 °C

Dis. Oxygen (00300) _____mg/L

DO sat. (00301) _____ %

Barometric pres. (00025) _____ mm Hg

Eh (00090) _____ mvolts

Turbidity ( ) _____ Method code ___

Units: FNU NTU FNMU FBU

ANC ( ) _____ mg/L

Alkalinity ( ) _____ mg/L

Bicarbonate ( ) _____ mg/L

Carbonate ( ) _____ mg/L

Hydroxide ( ) _____ mg/L

Hydrogen sulfide odor detected? (71875) yes no

Sample acidified beforehand? yes no

[see p. 7 for NWIS coding info]

Hyd. sulfide, unfltd, measured (99119) _____mg/L

Method: Hach Chemetrics Electrode

Other: _____ _____

SAMPLING INFORMATION

Sampler Type (84164) _____ Sampler/Pump Type (make/model) _____ Pump/Sampler ID _____

Sampling Method (82398) _____ Sampling Condition (72006) _____ Filter Type(s): Capsule Disc 142mm 47mm 25mm GFF Membrane

Sampler Material: STAINLESS STEEL PVC TEFLON OTHER _____ Tubing Material: TEFLON PLASTIC TYGON COPPER OTHER _____

Aquifer name _____ Depth pump set at: _____ft blw LSD MSL

Sampling point description _____

GW Color _____ GW Clarity _____ GW Odor _____ Sample in contact with: ATMOSPHERE OXYGEN NITROGEN OTHER _____

Weather : ***SKY-*** CLEAR PARTLY CLOUDY CLOUDY ***PRECIPITATION-*** NONE LIGHT MEDIUM HEAVY SNOW SLEET RAIN MIST _____

WIND- CALM LIGHT BREEZE GUSTY WINDY EST. WIND SPEED _____ MPH ***TEMPERATURE-*** VERY COLD COOL WARM HOT

OBSERVATIONS:

COMPILED BY :_____ **DATE** _____ **CHECKED BY :**_____ **DATE** _____ **LOGGED INTO NWIS BY:** _____ **DATE** _____

Calibrated by:_____ STN NO_____
Date:_____ Time:_____ Location: _____

METER CALIBRATIONS/FIELD MEASUREMENTS

TEMPERATURE Meter make/model _____ S/N _____ Thermister S/N _____ Thermometer ID _____

Calibration criteria: ± 1 percent or ± 0.5 ℃ for liquid-filled thermometers ± 0.2 ℃ for thermisters

Lab Tested against NIST Thermometer/Thermister? Y N Date: _____ ±_____ °C

Measurement Location : FLOW-THRU CHAMBER SINGLE POINT AT _____ ft blw LSD VERTICAL AVG. OF ____ POINTS

Field Readings # 1 _____ # 2 _____ # 3 _____ # 4 _____ # 5 _____ **MEDIAN**:_____ **ºC** Remark ___ ___ Qualifier __ __

pH Meter make/model _____ S/N _____ Electrode No. _____ Type: GEL LIQUID OTHER _____

Sample: FILTERED UNFILTERED FLOW-THRU CHAMBER SINGLE POINT AT _____ ft blw LSD VERTICAL AVG. OF ____ POINTS

pH Buffer	Buffer Temp	Theoretical pH from table	pH Before Adj.	pH After Adj.	Slope	Millivolts
pH 7						
pH 7						
pH 7						
pH ___						
pH ___						
pH ___						
CHECK pH ___						

Temperature correction factors for buffers applied? Y N

BUFFER LOT NUMBERS : pH 7: _____
pH ____: _____
CHECK pH ____: _____

BUFFER EXP. DATES: pH 7: _____
pH ____ : _____
CHECK pH ____: _____

Calibration Criteria: ± 0.2 pH units

Field Readings # 1 _____ # 2 _____ # 3 _____ # 4_____ # 5 _____ **MEDIAN: _____ units** Remark __ __ Qualifier __ __

SPECIFIC CONDUCTANCE Meter make/model _____ S/N _____ Sensor Type: Dip Flow-thru Other _____

Sample: Flow-thru chamber Single point at _____ ft blw lsd Vertical avg. of _____ points

Std Value µS/cm	Std Temp	SC Before Adj.	SC After Adj.	Std Lot No.	Std type (KCl; NaCl)	Std Exp. Date

Calibration Criteria: the greater of 5 µS/cm or 3% of measured value

AUTO TEMP COMPENSATED METER ___
MANUAL TEMP COMPENSATED METER ___
CORRECTION FACTOR APPLIED? Y N
CORRECTION FACTOR= _____

Field Readings # 1 _____ # 2 _____ # 3 _____ # 4 _____ # 5 _____ **MEDIAN:**_____ **µs/cm** Remark ___ ___ Qualifier ___ ___

DISSOLVED OXYGEN Meter make/model _____ S/N _____
Sensor Type: Polarographic Luminescent Probe No. _____
Sample: Flow-thru chamber Single point at _____ ft blw lsd Vertical avg. of _____ points BOD bottle Stirrer Used? Y N
Water-Saturated Air Air-Saturated Water Air Calibration Chamber in Water Air Calibration Chamber in Air Winkler Titration Other _____

Calibration Temp ºC	Barometric Pressure mm Hg	DO Table Reading mg/L	Salinity Correc-tion Factor	DO Before Adjust-ment	DO After Adjust-ment

Calibration Criteria: ± 0.3 mg/L

Zero DO Check _____mg/lL Adj. to _____ mg/L Date: _____
Zero DO Solution Date_____ Thermister Check? Y N Date_____
Membrane Changed? N Y N/A Date: _____ Time: _____
Barometer Calibrated? N Y Date: _____ Time: _____
Battery Check: REDLINE _____ RANGE _____

Field Readings # 1 _____ # 2 _____ # 3 _____ # 4 _____ # 5 _____ **MEDIAN:** _____ **mg/L** Remark___ ___ Qualifier___ ___

STN NO_____

TURBIDITY Meter make/model _____ S/N _____ Type: turbidimeter submersible spectrophotometer

Sample: pump discharge line flow-thru chamber single point at _____ ft blw LSD MSL MP Sensor ID _____

Sample: Collection Time: _____ Measurement Time: _____ Measurement: In-situ/On-site Vehicle Office lab NWQL Other _____

Sample diluted? Y N Vol. of dilution water _____ mL Sample volume _____ mL

Calibration Criteria: ± 0.5 TU or ± 5%	Lot Number or Date Prepared	Expiration Date	Concentration _____ (units)	Calibration Temperature °C	Initial instrument reading	Reading after adjustment
Stock Turbidity Standard						
Zero Standard *(DIW)*						
Standard 1						
Standard 2						
Standard 3						

TURBIDITY VALUE = ***A*** x (***B***+***C***) / ***C***

where:
A= TURBIDITY VALUE IN DILUTED SAMPLE
B= VOLUME OF DILUTION WATER, mL
C= SAMPLE VOLUME, mL

Comments/Calculations:

Field Readings #1 _____ #2 _____ #3 _____ #4 _____ #5 _____

MEDIAN _____ **Parameter Code** _____ FNU NTRU FNMU FBU **METHOD CODE** ___ **Remark Codes(s)** ___ ___ **Qualifier(s)** ___ ___

WELL and WATER-LEVEL INFORMATION

WELL___ SPRING___ MONITOR___ SUPPLY___ OTHER_____

SUPPLY WELL PRIMARY USE: DOMESTIC__ PUBLIC SUPPLY__ IRRIGATION __ OTHER_____

Casing Material: _____ Altitude (land surface) _____ ft abv MSL

Measuring Point: _____ ft abv blw LSD MSL MP

Well Depth _____ ft abv blw LSD MSL MP

Sampling condition (72006) pumping (8) flowing (4) static (n/a)
[see reference list for additional fixed-value codes]

Water Level: _____ ft blw LSD (72019) ft blw MP (61055)
ft abv MSL (NGVD 29) (62610) ft abv MSL (NAVD 88) (62611)

Comments:

Depth to Water and Well Depth

	1ST	2ND	3RD (optional)
Time			
Hold (for DTW)			
- Cut			
= DTW from MP			
– Measuring point (MP)			
= DTW from LSD			
Hold (for well depth)			
+ Length of tape leader			
= Well depth below MP			
– MP			
= Well depth below LSD			

WATER-LEVEL DATA FOR GWSI

DATE WATER LEVEL MEASURED (C235) __ __ - __ __ - __ __ __ __ (Month - Day - Year) TIME (C709) __ __ __ __ WATER LEVEL TYPE CODE (C243) **L** (below land surface) **M** (below meas. pt.) **S** (sea level)

WATER LEVEL (C237/241/242) ___ ___ ___ ___.___ ___ MP SEQUENCE NO. (C248) (Mandatory if WL type=M) ___ ___ ___

WATER LEVEL DATUM (C245) (Mandatory if WL type=S) **NGVD 29** (National Geodetic Vertical Datum 0f 1929) **NAVD 88** (North American Vertical Datum 0f 1988) Other (See GWSI manual for codes)

SITE STATUS FOR WATER LEVEL (C238)

A	B	C	D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z
atmos. pressure	tide stage	ice	dry	recently flowing	flowing	nearby flowing	nearby recently flowing	injector site	injector site monitor	plugged	measure-ment discontinued	obstruct-tion	pumping	recently pumped	nearby pumping	nearby recently pumped	foreign sub-stance	well des-troyed	affected by surface water	other

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	F	G	H	L	M	N	O	R	S	T	V	Z
airline	analog	calibrated airline	esti-mated	trans-ducer	pressure gage	calibrated pres. gage	geophysi-cal logs	manometer	non-rec. gage	observed	reported	steel tape	electric tape	calibrated elec. tape	other

WATER LEVEL ACCURACY (C276) **0** (foot) **1** (tenth) **2** (hun-dreth) **9** (not to nearest foot)

SOURCE OF WATER-LEVEL DATA (C244)

A	D	G	L	M	O	R	S	Z
other gov't	driller's log	geol-ist	geophysi-cal logs	memory	owner	other reported	reporting agency	other

PERSON MAKING MEASUREMENT (C246) (WATER-LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

RECORD READY FOR WEB (C858)

Y	C	P	L
checked; ready for web display	not checked; no web display	proprietary; no web display	local use only; no web display

WELL PURGE LOG STN NO_____

Allowable Drawdown: _____ *ft* **Purge method:** STANDARD LOW-FLOW OTHER _____

Time	Water Level blw MP LSD	Draw-down ft	Well Yield gpm	Pumping Rate gpm	Water Temp ºC	Conduc-tivity µs/cm	pH units	Dis-solved oxygen	Turbidity _____ _____	Comments [clarity, etc.]
										MEDIAN VALUES
										QUIESCENT PH
										FINAL FIELD MEASUREMENTS

Well Volume (gal) = *V* = 0.0408 *HD*² or **Well Volume = *H* x *F***

where:
V is volume of water in the well, in gallons
H is height of water column, in feet
D is inside Diameter of well, in inches
F is casing Volume Factor (see table)

H = Well depth - Static water level = _____ feet

Diameter, inside (***D***) = _____ inches

1 well volume (***V***) = _____ gallons

Parameter	Stability Criteria*
pH	± 0.1 units (± 0.05 units if instrument display 2 or more digits to the right of the decimal)
Temperature (T)	± 0.2° C (thermistor)
Specific Conductivity (SC)	± 5%, of SC < 100 µS/cm ± 3%, for SC > 100 µS/cm
Dissolved Oxygen (DO)	± 0.3 mg/L
Turbidity (TU)	± 10%, for TU< 100: ambient TU is < 5 or most ground-water systems (visible TU > 5)

*allowable variation between 5 or more sequential field-measurement values

Purge Volume = (*n*)(*V*) = _____ gallons [Actual =_____ gal]

where:
n is number of well volumes to be removed during purging
V is volume of water in the well, in gallons
Q = estimated pumping rate = _____ gallons per minute
Approximate purge time = (purge volume)/***Q*** = _____ minutes

	VOLUME FACTORS												
DIAMETER (in.)	1.0	1.5	2.0	3.0	4.0	4.5	5.0	6.0	8.0	10.0	12.0	24.0	36.0
CASING VOL.	0.04	0.09	0.16	0.37	0.65	0.83	1.02	1.47	2.61	4.08	5.88	23.5	52.9

Screened/Open Interval: TOP _____.____ ft blw LSD MSL

Bottom _____.____ ft blw LSD MSL

Depth to Top of Sampling Interval _____.____ft blw LSD MSL

Depth to Bottom of Sampling Interval _____.____ ft blw LSD MSL

Depth to set pump from MP (all units in feet) **:**

Distance to top of screen from LSD	
+ MP	
– (7 to 10 x diameter (ft) of the well)	
= Depth to pump intake from MP	

Depth to pump from LSD (all units in feet) **:**

– MP	
= Depth pump set from LSD MSL	

Notes/Calculations:

STN NO_____

ALKALINITY/ANC CALCULATIONS

BEGINNING H_2O TEMP. _____ °C

pH	ΔpH	VOL ACID DC OR mL	ΔVOL ACID DC OR mL	ΔpH / ΔVOL ACID

END H_2O TEMP. _____ °C

BEGINNING H_2O TEMP. _____ °C

pH	ΔpH	VOL ACID DC OR mL	ΔVOL ACID DC OR mL	ΔpH / ΔVOL ACID

END H_2O TEMP. _____ °C

FIRST TITRATION RESULTS

DATE _____

BEGIN TIME _____ END TIME_____

ALKALINITY/ANC _____ meq/L

ALKALINITY/ANC _____ mg/L AS $CaCO_3$

BICARBONATE_____mg/L _____meq/L AS HCO_3^-

CARBONATE_____mg/L _____ meq /L AS CO_3^{2-}

ACID: 1.6N 0.16N 0.01639N

OTHER:_____

ACID LOT NO. _____

ACID EXPIRATION DATE _____

SAMPLE VOLUME: _____mL

FILTERED UNFILTERED

METHOD: INFLECTION POINT GRAN

FIXED ENDPOINT

STIRRING METHOD: MAGNETIC MANUAL

SECOND TITRATION RESULTS

DATE _____

BEGIN TIME _____ END TIME_____

ALKALINITY/ANC _____ meq/L

ALKALINITY/ANC _____ mg/L AS $CaCO_3$

BICARBONATE _____mg/L _____meq/L AS HCO_3^-

CARBONATE _____mg/L _____ meq /L AS CO_3^{2-}

ACID: 1.6N 0.16N 0.01639N

OTHER:_____

ACID LOT NO. _____

ACID EXPIRATION DATE _____

SAMPLE VOLUME: _____mL

FILTERED UNFILTERED

METHOD: INFLECTION POINT GRAN

FIXED ENDPOINT

STIRRING METHOD: MAGNETIC MANUAL

CALCULATIONS

ALKALINITY OR ANC (meq/L) = 1000 (B) (C_a) (CF) / V_s

ALKALINITY (mg/L AS $CaCO_3$) = 50044 (B) (C_a) (CF) / V_s

where:

B = volume of acid titrant added from the initial pH to the bicarbonate equivalence point (near pH 4.5), in milliliters. To convert from digital counts to milliliters, divide by 800 (1.00 mL = 800 counts)

C_a = concentration of acid titrant, in milliequivalents per milliliter (same as equivalents per liter, or *N*)

CF = correction factor (obtain from OWQRL for Hach acid cartridges of certain lot numbers — default value is 1.00)

V_s = volume of sample, in milliliters

For samples with pH ≤ 9.2:

BICARBONATE (meq/L) = 1000 (B-2A) (C_a) (CF) / V_s

BICARBONATE (mg/L) = 61017 (B-2A) (C_a) (CF) / V_s

CARBONATE (meq/L) = 2000 (A) (C_a) (CF) / V_s

CARBONATE (mg/L) = 60009 (A) (C_a) (CF) / V_s

where:

A = volume of acid titrant added from the initial pH to the carbonate equivalence point (near pH 8.3), in milliliters. To convert from digital counts to milliliters, divide by 800 (1.00 mL = 800 counts)

NOTE: For samples with pH > 9.2, these equations for bicarbonate and carbonate will fail to give accurate results. Use the Alkalinity Calculator at http://oregon.usgs.gov/alk or PCFF.

HACH CARTRIDGE CORRECTION FACTOR _____

[See OWQ WaQI Note 2005.02 for info]

pH meter calibration	Meter make/model:		S/N	
Electrode No.		Type: gel liquid other	Slope	Milli-volts
pH buffer	**Buffer temp**	**Theoretical pH from table**	**pH before adj.**	**pH After adj.**
pH 7				
pH __				
Check pH ___				

Comments/Calculations:

STN NO_____

QUALITY-CONTROL INFORMATION

PRESERVATIVE LOT NUMBERS

7.5N HNO_3 _____ (METALS&CATIONS) 6N HCl _____ (Hg) 4.5N H_2SO_4 _____ (NUTRIENTS&DOC) Conc. H_2SO_4 _____ (COD, PHENOL, O&G) NaOH _____ (CYANIDE)

OTHER _____ 1:1 HCl _____ (VOC) Number of drops of HCL added to lower pH to ≤ 2 _____ (**NOTE:** Maximum number of drops = 5)

BLANK WATER LOT NUMBERS

Inorganic (99200) _____ 2nd Inorganic (99201) _____

Pesticide (99202) _____ 2nd Pesticide (99203) _____ Spike vials (99104) _____

VOC/Pesticide (99204) _____ 2nd VOC/Pesticide (99205) _____ Surrogate vials _____

FILTER LOT NUMBERS

capsule_____ pore size _____ type _____

disc_____ pore size _____ type _____

142mm GFF _____ (organics) pore size _____ type _____

47mm GFF _____ (organics) pore size _____ type _____

25mm GFF _____ (organic carbon) pore size _____ type _____

142mm membrane _____ (inorganics) pore size _____ type _____

other _____ pore size _____ type _____

QC SAMPLES

Starting date for set of samples (99109) (YMMDD) _____ **Ending date for set of samples** (99110) (YMMDD) _____

Sample Type	NWIS Record No.	Sample Type	NWIS Record No.	Sample Type	NWIS Record No.
Equip Blank _____	_____	Sequential _____	_____	Trip Blank _____	_____
Field Blank _____	_____	Spike _____	_____	Other _____	_____
Split _____	_____	Concurrent _____	_____	Other _____	_____

NWQL Schedules/lab codes (QC Samples) _____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____ _____ _____ _____

COMMENTS_____

(Circle appropriate selections)

99100 Blank-solution type
10 Inorganic grade (distilled/deionized)
40 Pesticide grade (OK for organic carbon)
50 Volatile-organic grade (OK for inorganic, organic, and organic carbon)
80 Universal blank water
200 Other

99101 Source of blank water
10 NWQL
40 NIST
55 Wisconsin District Mercury Lab
200 Other

99105 Replicate-sample type
10 Concurrent
20 Sequential
30 Split
40 Split-Concurrent
50 Split-Sequential
200 Other

99102 Blank-sample type
1 Source Solution
30 Trip
60 Filter
70 Preservation
80 Equipment (done in non-field environment)
90 Ambient
100 Field
200 Other

99111 QC sample associated with this environmental sample
1 No associated QA data
10 Blank
30 Replicate Sample
40 Spike sample
100 More than one type of QA sample
200 Other

99108 Spike-solution volume, mL _____

99106 Spike-sample type
10 Field

99107 Spike-solution source
10 NWQL

99112 Purpose, Topical QC data
1 Routine QC (non-topical)
10 Topical for high bias (contamination)
20 Topical for low bias (recovery)
100 Topical for variability (field equip)
110 Topical for variability (field collection)
120 Topical for variability (field personnel)
130 Topical for variability (field processing)
140 Topical for variability (shipping&handling)
200 Topical for variability (lab)
900 Other topical QC purpose

REFERENCE LIST FOR CODES USED ON THIS FORM

Sample Medium Codes
6 Regular Ground water
S Quality-control sample (associated environmental sample –6 (GW))
For replicates and spikes
Q Artificial

71999 Sample purpose
10 Routine
15 NAWQA
50 GW Network
110 Seepage Study
120 Irrigation Effects
130 Recharge
140 Injection

A complete set of fixed-value codes can be found online at:
http://wwwnwis.er.usgs.gov/currentdocs/index.html

Time Datum Codes

Time Zone	Std Time Code	UTC Offset (hours)	Daylight Time Code	UTC Offset (hours)
Hawaii-Aleutian	HST	-10	HDT	-9
Alaska	AKST	-9	AKDT	-8
Pacific	PST	-8	PDT	-7
Mountain	MST	-7	MDT	-6
Central	CST	-6	CDT	-5
Eastern	EST	-5	EDT	-4
Atlantic	AST	-4	ADT	-3

Value Qualifiers
e see field comment
f sample field preparation problem
k counts outside the acceptable range

Sample Type Code
9 Regular
7 Replicate
2 Blank
1 Spike

00003 Sampling depth, ft blw LSD
00059 Sampling flow rate, GPM
72004 Pump or flow period prior to sampling, minutes
72019 Water level, ft blw LSD

Null-value Qualifiers
e required equipment not functional or available
f sample discarded; improper filter used
o insufficient amount of water

82398 Sampling method
4010 Thief sampler
4020 Open-top bailer
4025 Double-valve bailer
4030 Suction pump
4040 Submersible pump
4045 Submersible multiple impeller (turbine) pump
4050 Squeeze pump
4060 Gas reciprocating pump
4070 Gas lift
4080 Peristaltic pump
4090 Jet pump
4100 Flowing well
4110 Resin trap collector
8010 Other

84164 Sampler type
4010 Thief Sampler
4020 Open-top Bailer
4025 Double-valve Bailer
4030 Suction Pump
4035 Submersible Centrifugal Pump
4040 Submersible Positive-pressure Pump
4041 Submersible Helical Rotor Pump
4045 Submersible Gear Pump
4050 Bladder Pump
4060 Gas Reciprocating Pump
4070 Gas Lift
4075 Submersible Piston Pump
4080 Peristaltic Pump
4090 Jet pump
4095 Line-Shaft Turbine Pump
4100 Flowing Well
8010 Other

50280 Purpose of site visit
2001 Primary (primary samples should not exist for a site for more than one date per HIP, and the primary sampling date generally has the highest number of NAWQA analytes)
2002 Supplemental (to fill in missing schedules not sampled or lost)
2003 Temporal characterization (for previously sampled schedules; includes LIP and seasonal samples)
2004 Resample (to verify questionable concentrations in primary sample)
2098 Ground-water quality control
2099 Other (ground-water related samples with medium code other than "6", such as soil samples or core material)

72006 Sampling Condition
0.01 The site was dry (no water level is recorded)
0.02 The site had been flowing recently
0.03 The site was flowing, head could not be measured
0.04 A nearby site that taps the Aquifer was flowing
0.05 Nearby site tapping same Aquifer had been flowing recently
0.06 Injector site
0.07 Injector site monitor
0.08 Measurement discontinued
0.09 Obstruction encountered in well above water surface
0.10 The site was being pumped
0.11 The site had been pumped recently
0.12 Nearby site tapping the same Aquifer was being pumped
0.13 Nearby site tapping the Same Aquifer was pumped recently
0.14 Foreign substance present on the surface of the water
0.16 Water level affected by stage in nearby site
0.17 Other conditions affecting the measured water level
2 Undesignated
4 Flowing
6 Flowing on gas lift
8 Pumping
10 Open hole
18 Producing
19 Circulating
22 Lifting
23 Flowing to Pit
24 Water Flooding
25 Jetting
30 Seeping
31 Nearby well pumping
32 Nearby well taking water
33 Well taking water

Alkalinity/ANC Parameter Codes
39086 Alkalinity, water, filtered, incremental titration, mg/L
00418 Alkalinity, water, filtered, fixed endpoint, mg/L
29802 Alkalinity, water, filtered, Gran titration, mg/L
00419 ANC, water, unfiltered, incremental titration
00410 ANC, water, unfiltered, fixed endpoint, mg/L
29813 ANC, water, unfiltered, Gran titration, mg/L
29804 Bicarbonate, water, filtered, fixed endpoint, mg/L
63786 Bicarbonate, water, filtered, Gran, mg/L
00453 Bicarbonate, water, filtered, incremental, mg/L
00440 Bicarbonate, water, unfiltered, fixed endpoint, mg/L
00450 Bicarbonate, water, unfiltered, incremental, mg/L
29807 Carbonate, water, filtered, fixed endpoint, mg/L
63788 Carbonate, water, filtered, Gran, mg/L
00452 Carbonate, water, filtered, incremental, mg/L
00445 Carbonate, water, unfiltered, fixed endpoint, mg/L
00447 Carbonate, water, unfiltered, incremental, mg/L
29810 Hydroxide, water, filtered, fixed endpoint, mg/L
71834 Hydroxide, water, filtered, incremental, mg/L
71830 Hydroxide, water, unfiltered, fixed endpoint, mg/L
71832Hydroxide, water, unfiltered, incremental, mg/L

71825 Hydrogen Sulfide Odor
Value
none entered (null)

Remark Code	Method Code
M detect	U un-acidified sample
U non-detect	V acidified sample

APPENDIX A4-C
Quality-control samples collected by field personnel for water-quality studies

Page

Blank samples APP.C2

Replicate samples.....APP.C5

Reference, spike, and blind samples.....APP.C6

APPENDIX A4-C—Quality-control samples collected by field personnel for water-quality studies.

[Common types of quality-control (QC) samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for QC samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Koterba and others (1995), Mueller and others (1997), unpublished notes from the USGS course "Quality-Control Sample Design and Interpretation," and the following USGS Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations[1]: PBW, pesticide-grade (not nitrogen-gas purged) blank water; VPBW, volatile-organic-compound and pesticide-grade, nitrogen-gas-purged blank water; IBW, inorganic-grade blank water]

BLANK SAMPLES[2]		
Sample type	**General description[3]**	**Purpose[3]**
Field blank	Blank water that is passed through the entire sampling equipment system **onsite** and subjected to identical collection, processing, preservation, transportation, and storage procedures and laboratory handling as for environmental samples. • The field blank is processed onsite through clean equipment on the same day as, and along with, the environmental samples, either, (*a*) directly after the equipment has been field cleaned and before leaving for the next site (NFM 3), ***or***, (*b*) at the next site, just before environmental samples for that site are processed. • A set of blanks can be processed and associated with the field blank (fig. 4-14).	Determine the concentrations of target analyte(s) present in the environmental sample that could be attributed to field procedures for equipment cleaning and sample handling. Results include effects from laboratory handling. Examples related to (*a*) and (*b*) (see "General description"): (*a*) Check the adequacy of field-cleaning procedures (demonstrate that equipment was adequately decontaminated after previous use); (*b*) Identify contamination of sampling equipment while in transport from office to field site or between field sites, and ambient field conditions at the field site.
Equipment blank	Blank water that is passed sequentially through each component of the equipment system to be used for collecting and processing environmental samples and resulting in a single final blank sample. • Differs from a field blank in that the equipment blank is processed under controlled conditions in an office laboratory and before equipment will be used for field work. Standard USGS procedure is to collect an annual equipment blank if the equipment is not in active use. • Can result in collecting a series of blank samples sequentially, each sample of which represents a different component or components of the equipment system; for example, sampler-equipment blank, splitter-equipment blank, filter-equipment blank.	• Identify effects of the equipment system used to collect and process samples on analyte concentrations. • Verify adequacy of equipment-cleaning procedures (NFM 3). • Relating to components of the equipment system, assess potential of sample contamination and adequacy of equipment-cleaning procedures associated with each component of the equipment system to be used for field work. • Can be used to help identify or eliminate source(s) of contamination.

APPENDIX A4-C—Quality-control samples collected by field personnel for water-quality studies.—*continued*

[Common types of quality-control (QC) samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for QC samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Koterba and others (1995), Mueller and others (1997), unpublished notes from the USGS course "Quality-Control Sample Design and Interpretation," and the following USGS Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations[1]: PBW, pesticide-grade (not nitrogen-gas purged) blank water; VPBW, volatile-organic-compound and pesticide-grade, nitrogen-gas-purged blank water; IBW, inorganic-grade blank water]

BLANK SAMPLES[2]		
Sample type	**General description[3]**	**Purpose[3]**
Ambient blank	Blank water that is exposed to the identical collection and processing areas and time period as environmental samples. The blank water is transferred from the stock-solution container to the same type of bottle used for an environmental sample. The specific mode of exposure to the atmosphere is determined by the QC objective. **Examples:** (*a*) The blank water is transferred to a sample bottle while in the sample-processing chamber used for environmental samples. (*b*) Container such as a sample bottle is prefilled with blank water, opened while in the processing chamber, and exposed to the chamber atmosphere throughout the processing of environmental samples.	Determine analyte concentrations present in the environmental sample that could be attributed to exposure of sample to the ambient atmosphere in which samples are collected, processed, and analyzed. Referring to the general description: • Example (*a*) is used to assess concentrations after processing the blank in a manner that mimics collection of the environmental sample. • Example (*b*) is used to indicate the maximum analyte concentration that would result from prolonged sample exposure to ambient conditions.
Source-solution blank	Stock solution of PBW, VPBW, or IBW that is transferred to a sample bottle in an area of the office laboratory within a controlled atmosphere that is relatively clean and protected with respect to target analytes.	Determine the source of water used for blanks and the degree to which the composition of blank solution could have changed (with respect to target analytes) from time of laboratory certification to time of use.
Sampler blank	Blank water processed through the same sampler used for environmental samples after the sampler has been cleaned. (Blanks processed through pump samplers usually are designated pump blanks).	• Identify effects of sampler components on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).
Splitter blank	Blank water processed through the same sample-splitting device used to collect or to process environmental samples (such as a churn splitter, cone splitter, or manifold system), after the splitter has been cleaned.	• Identify effects of splitter components on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).

APPENDIX A4-C—Quality-control samples collected by field personnel for water-quality studies.—*continued*

[Common types of quality-control (QC) samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for QC control samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Koterba and others (1995), Mueller and others (1997), unpublished notes from the USGS course "Quality-Control Sample Design and Interpretation," and the following USGS Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations[1]: PBW, pesticide-grade (not nitrogen-gas purged) blank water; VPBW, volatile-organic-compound and pesticide-grade, nitrogen-gas-purged blank water; IBW, inorganic-grade blank water]

BLANK SAMPLES[2]		
Sample type	**General description[3]**	**Purpose[3]**
Pump blank	Blank water processed through the pump-and-tubing system used for environmental samples, after pump and tubing have been cleaned.	• Identify effects of pump components and tubing on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).
Filter blank	Blank water processed through the filter assembly used for environmental samples, after the filter unit or assembly has been cleaned.	• Identify effects of filtration assembly on analyte concentrations. • Verify adequacy of cleaning procedures, if a plate or cartridge assembly is used—see NFM 3. • If the filter blank is to represent the same filter media, the blank is processed prior to the environmental samples.
Preservation blank	Blank water that is transferred to a sample bottle and chemically treated with a preservative in an area protected from atmospheric contamination (usually under a clean hood environment in the office laboratory). The preservative used is from the same lot number used for the other QC and environmental samples.	Determine the potential for, and magnitude of, sample contamination from the chemical treatment to be used to preserve the environmental sample.
Shelf blank ("Hold" blank)	Blank water that is transferred into the same type of bottle used for an environmental sample (usually in a protected environment in the office laboratory) and stored adjacent to stored environmental samples for the same length of time.	Determine the potential for and magnitude of sample contamination from sample storage in a designated area for a designated length of time.
Refrigerator blank	Blank water that is transferred to a sample bottle (usually in a protected environment in the office laboratory) and stored adjacent to environmental samples in a refrigerated area for the same length of time.	Determine the potential for, and magnitude of, sample contamination from refrigeration of the sample for a designated length of time.

APPENDIX A4-C—Quality-control samples collected by field personnel for water-quality studies.—*continued*

[Common types of quality-control (QC) samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for QC samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Koterba and others (1995), Mueller and others (1997), unpublished notes from the USGS course "Quality-Control Sample Design and Interpretation," and the following USGS Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations[1]: PBW, pesticide-grade (not nitrogen-gas purged) blank water; VPBW, volatile-organic-compound and pesticide-grade, nitrogen-gas-purged blank water; IBW, inorganic-grade blank water]

	REPLICATE SAMPLES	
Sample type	**General description[3]**	**Purpose[3]**
Replicates (duplicates, triplicates, etc. of sequential, split, concurrent, or other type of replicate sample)	A set of samples that is collected close in time and space and in a manner so that the samples are thought to represent virtually the same physical, chemical, and biological properties.	Depending upon its type, a replicate is used to determine variability in some part of the sample collection, processing, and analysis system.
Concurrent replicates	Samples obtained simultaneously using two or more samplers or by using one sampler and alternating collection of samples into two or more compositing containers (Horowitz and others, 1994).	Identify and (or) quantify the variability in the system being sampled.
Sequential replicates	Samples that are collected one after the other and considered virtually identical in composition.	• Identify and (or) quantify the variability introduced from collection, processing, shipping, and laboratory handling and analysis. • Can be designed to indicate temporal variability resulting from consecutive collection of samples.
Split replicates	Samples obtained by dividing one sample into two or more subsamples either before or after sample processing and preservation. **Each of the subsamples is to be analyzed for concentrations of the same constituents or compounds**. Examples: (*a*) A processed and treated sample in a sample bottle is split into two or more aliquots and subjected to identical handling and analysis. (*b*) Environmental water is passed through a splitting device (such as a cone splitter or T-valve) from which subsamples are collected simultaneously and subjected to identical handling and analysis. (*c*) Environmental water is collected into a compositing device from which subsamples are collected sequentially and subjected to identical handling and analysis.	• Assess variability for a given sample matrix. • Compare differences in analyses obtained from the same or separate laboratories.

APPENDIX A4-C—Quality-control samples collected by field personnel for water-quality studies.—*continued*

[Common types of quality-control (QC) samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for QC samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Koterba and others (1995), Mueller and others (1997), unpublished notes from the USGS course "Quality-Control Sample Design and Interpretation," and the following USGS Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations[1]: PBW, pesticide-grade (not nitrogen-gas purged) blank water; VPBW, volatile-organic-compound and pesticide-grade, nitrogen-gas-purged blank water; IBW, inorganic-grade blank water]

	REFERENCE, SPIKE, AND BLIND SAMPLES	
Sample type	**General description[3]**	**Purpose[3]**
Reference sample	A laboratory-prepared solution or material whose composition is certified for one or more properties so that it can be used to assess a measurement method or for assigning concentration values of specific analytes.	Tests for bias and variability of the laboratory measurement process.
Spike sample	Environmental ("field-matrix spikes") or reference-material sample to which a spike solution has been added in known concentrations and in a manner that does not substantially change the original sample matrix. **Spike solution** is a solution having laboratory-certified concentrations of selected analytes and that are added in known quantities to a sample.[4]	Assess the recovery of target analytes relative to the actual conditions to which samples have been exposed; quantify effects of sample-matrix interferences and analyte degradation on analyte recovery.
Blind sample	A sample (typically, reference material) submitted for laboratory analysis with composition known to the submitter but unknown (blind) to the analyst. Every blind sample analyzed should have an associated reference to the source and preparation procedure.	Test for bias and variability of the laboratory measurement process.

[1]Blank water is a solution that is free of analyte(s) of interest at a specified detection limit and that is used to develop specific types of QC samples.USGS personnel are required to use blank water that has been analyzed and certified to be of a specific grade.

[2]Blank samples (blanks) for trace-element analysis have a unique NWQL schedule of analysis, different from that of the environmental sample.

[3]The description of a QC sample depends to some extent on the purpose for which it is collected. The purpose for the QC sample can govern the mode of its collection, processing, and treatment, and the equipment to which it is exposed. Purposes for a specific type of QC sample are varied. Analysis of all QC samples includes the bias and variability introduced from shipping and laboratory handling and analysis of the sample.

[4]For USGS studies, obtain spike solutions in spike kits for pesticide and volatile organic compound analyses from the USGS National Field Supplies Service (NFSS) through One-Stop Shopping.

APPENDIX A4-D
Examples from the National Water-Quality Assessment Program Related to Protocols for Collecting Blank Samples at Ground-Water Sampling Sites

Modified from Koterba and others, 1995

Table 1. Example of procedure to estimate and collect field volumes of blank solutions.

Table 2. Example of procedure to collect blank samples with a submersible water-quality pump.

APPENDIX A4-D—Table 1. Example of procedure to estimate and collect field volumes of blank solutions.

[Modified from Koterba and others, 1995, and based on protocols of the National Water-Quality Assessment Program. DIW, District deionized water with specific electrical conductance less than 1.0 microsiemens per liter; VPBW, volatile-organic-compound and pesticide-grade blank water; PBW, pesticide-grade blank water; IBW, inorganic-grade blank water; DOC, dissolved (filtered) organic carbon; gal, gallons; L, liters; ~, approximately; NWQL, National Water Quality Laboratory]

Assumptions: Submersible pump was used to collect the ground-water samples. Equipment just used to collect ground-water samples has been decontaminated, and, except for the pump intake being in a standpipe, is set up on site in the same manner as it was for the collection of ground-water samples.

Blank-Solution Types and Estimate of Volumes Required[1]

Field blank(s) desired	Required blank-solution type	Minimum volume in gal (L)	Comments
Major ions and nutrients	IBW	1.0 (~4)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of the IBW needed through the system.
Trace elements	IBW	1.0 (~4)	
Major ions and nutrients and trace elements	IBW	1.5 (~6)	Waste 0.5 gal, then collect field blanks; if necessary, use DIW to force last of the IBW needed through the system.
VOCs and DOC[1]	VPBW	1.5 (~6)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW (or PBW) through the system.
Pesticides and DOC	PBW[1]	1.5 (~6)	
VOCs, DOC[1] and pesticides	VPBW	2.0 (~8)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW or PBW through the system.

[1]Use VPBW for VOC field blanks. PBW can not be used. Select VPBW or PBW for DOC field blanks only after reviewing certification forms of the lot numbers available. A solution-blank sample of water from the same lot of NWQL water is poured directly into the DOC 125-mL amber sample bottle and is required for every DOC field blank. Record the lot number of the water used for the solution blank on the ASR form.

APPENDIX A4-D—Table 2. Example of procedure to collect blank samples with a submersible water-quality pump.

[Modified from Koterba and others (1995). DIW, deionized water; VPBW, volatile-organic-compound and pesticide-grade blank water; PBW, pesticide-grade blank water; IBW, inorganic-grade blank water; VOC, volatile organic compound; QC, quality control]

General Field-Blank Collection Procedure[1]

1. Divide field team duties—Three-person team recommended—Two people collect samples in a manner similar to that used to collect ground-water samples; the third person adds blank water to standpipe and controls flow through system, as needed, to facilitate field blank collection.

2. Check flow set-up—From standpipe to sample collection/processing chamber, ensure that adequate volumes of DIW and the required blank water are within easy reach of person stationed at standpipe andarranged in order of cdlection: IBW first, and PBW or VPBW last.[2]

3. Set low flow rate—Once pumping is initiated, set flow (on basis of measurement at chamber outflow) to about 0.1 gal. (500 mL) per minute orless to avoid wasting excessive amounts of blank water (to avoid air bubbles, 150 mL/min or less is recommended for filling VOC vials).

4. Collect blank solutions in prescribed sequence, collecting the IBW before the equipment is exposed to methanol and PBW or VPBW—As solutions are changed, pump operator should change to clean gloves, empty residual solution from standpipe, rinse pump intake and standpipe, individually, at least three times each, with the next solution.

   • Use an air segment to mark the end of one solution and the beginning of the next; alternatively, determine the change in solutions on the basis of the storage volume in the line divided by the pumping rate to estimate the time it takes for the solution to travel from the standpipe to the collection/processing chamber.

   • Pass about 0.5 gallons (approximately 2 L) of blank solution to waste before collecting the QC sample, regardless of whether air segments or timed flow or both are used to assess when the solution arrives at the collection chamber.

   • Use one type of water toforce the last of another type from the sample tubingafter all samples that require that blank-water type have been collected, in order to limit the amount of blank water left in the sample tubing.

[1]**Assumptions:** Submersible pump w as used to collect the ground-w ater samples. Organic and inorganic field blanks will be collected. Equipment just used to collect ground-water samples has been cleaned, and, except for the pump intake being in a standpipe instead of a we ll, is set up on site in the same manner as it was for the collection of ground-water samples. Standpipe has just been cleaned and subsequently rinsed with VPBW. If only inor ganic field bla nks will be collected, rinse cle aned standpipe with IBW and modify steps 2 to 4 accordingly.

[2]Referring to NFM 3, follow the cleaning sequence shown on fig. 3-1 for the inorganic and organic cleaning procedure.

Techniques of Water-Resources Investigations

Book 9
Handbooks for Water-Resources Investigations

National Field Manual for the Collection of Water-Quality Data

Chapter A5. PROCESSING OF WATER SAMPLES

Franceska D. Wilde
Managing Editor

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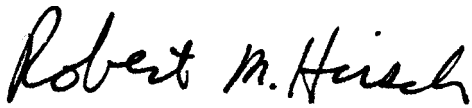
Foreword

The mission of the Water Resources Division of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems. These data are used for environmental and resource assessments by the USGS, other government and scientific agencies, and the general public. Reliable and objective data are essential to the credibility and impartiality of the water-resources appraisals carried out by the USGS.

The development and use of a *National Field Manual* is necessary to achieve consistency in the scientific methods and procedures used, to document those methods and procedures, and to maintain technical expertise. USGS field personnel use this manual to ensure that data collected are of the quality required to fulfill our mission.



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Chief Hydrologist

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PROCESSING OF WATER SAMPLES

A5.

National Field Manual for the Collection of Water-Quality Data

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Chapter A5. PROCESSING OF WATER SAMPLES

Edited by **Franceska D. Wilde, Dean B. Radtke, Jacob Gibs, and Rick T. Iwatsubo**

ABSTRACT

The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols and provides guidelines for U.S. Geological Survey (USGS) personnel who collect data used to assess the quality of the Nation's surface-water and ground-water resources. This chapter addresses methods to be used in processing water samples to be analyzed for inorganic and organic chemical substances, including the bottling of composite, pumped, and bailed samples and subsamples; sample filtration; solid-phase extraction for pesticide analyses; sample preservation; and sample handling and shipping.

Each chapter of the *National Field Manual* is published separately and revised periodically. Newly published and revised chapters will be announced on the USGS Home Page on the World Wide Web under "New Publications of the U.S. Geological Survey." The URL for this page is <http://water.usgs.gov/lookup/get?newpubs>.

INTRODUCTION

As part of its mission, the U.S. Geological Survey (USGS) collects the data needed to assess the quality of our Nation's water resources. The *National Field Manual for the Collection of Water-Quality Data (National Field Manual)* describes protocols (required and recommended procedures) and provides guidelines for USGS personnel who collect those data on surface-water and ground-water resources. Chapter A5 describes methods to be used in processing water samples to be analyzed for inorganic and organic chemical substances, including the bottling of composite, pumped, and

bailed samples and subsamples; sample filtration; solid-phase extraction; sample preservation; and sample handling and shipping. **Formal training and field apprenticeship are necessary in order to implement correctly the procedures described in this manual.**

The *National Field Manual* is Section A of Book 9 of the USGS publication series "Techniques of Water-Resources Investigations" (TWRI) and consists of individually published chapters designed to be used in conjunction with each other. A list of TWRI publications is included at the end of this report. Chapter numbers are preceded by an "A" to indicate that the report is part of the *National Field Manual*. Other chapters of the *National Field Manual* are referred to in the text by the abbreviation "NFM" and the specific chapter number (or chapter and section number). For example, NFM 6 refers to chapter A6 on "Field Measurements" and NFM 6.4 refers to the section in Chapter A6 on field measurement of pH.

The procedures described in this chapter represent protocols that are applicable to most USGS studies involving the collection of water-quality data. Modification of required and recommended procedures to fulfill study objectives or to enhance data quality must be documented and published along with the data and data interpretation.

PURPOSE AND SCOPE

The *National Field Manual* is targeted specifically toward field personnel in order to (1) establish and communicate scientifically sound methods and procedures, (2) encourage consistency in the use of field methods for the purpose of producing nationally comparable data, (3) provide methods that minimize data bias and, when properly applied, result in data that are reproducible within acceptable limits of variability, and (4) provide citable documentation for USGS water-quality data-collection protocols.

The purpose of this chapter on processing water samples is to provide field personnel and other interested parties with a description of the required and recommended procedures routinely used in USGS studies to composite, subsample, filter, preserve, and ship surface-water and ground-water samples to the USGS National Water Quality Laboratory (NWQL) for analysis. The sample processing procedures presented can be applied to the majority of samples that are analyzed routinely by NWQL for inorganic constituents and organic compounds. Samples that require special analysis or samples that are to be sent to other laboratories for analysis might require different processing procedures, the protocols for which are beyond the scope of this chapter.

REQUIREMENTS AND RECOMMENDATIONS

As used in the *National Field Manual*, the terms **required** and **recommended** have USGS-specific meanings.

Required (require, required, or requirements) pertains to USGS protocols and indicates that USGS Office of Water Quality policy has been established on the basis of research and (or) consensus of the technical staff and have been reviewed by water-quality specialists and selected District[1] or other professional personnel, as appropriate. Technical memorandums or other internal documents that define the policy pertinent to such requirements are referenced in this chapter. Personnel are instructed to use required equipment or procedures as described herein. Departure from or modifications to the stipulated requirements that might be necessary to accomplishing specific data-quality requirements[2] or study objectives must be based on referenced research and good field judgment, and be quality assured and documented.

[1]District refers to an office of the USGS, Water Resources Division, located in any of the States or territories of the United States.

[2]As used in this report, data-quality requirements are that subset of data-quality objectives pertaining to the analytical detection level for concentrations of target analytes and the allowable variability that fulfill study objectives.

Recommended (recommend, recommended, recommendation) pertains to USGS protocols and indicates that USGS Office of Water Quality policy recognizes that one or several alternatives to a given equipment selection or procedure are acceptable on the basis of research and (or) consensus. Specific data-quality requirements, study objectives, or other constraints might affect the choice of recommended equipment or procedures. Selection from among the recommended alternatives must be based on referenced research and good field judgment. Reasons for the selection should be documented. Departure from or modifications to recommended procedures must be quality assured and documented.

FIELD MANUAL REVIEW AND REVISION

Chapters of the *National Field Manual* will be reviewed, revised, and reissued periodically to correct any errors, incorporate technical advances, and address additional topics. Comments or corrections can be sent to NFM-QW, USGS, 412 National Center, Reston, VA 20192 (or direct electronic mail to nfm-owq@usgs.gov). Information regarding the status and any errata of this or other chapters can be found at the beginning of the electronic version of each chapter, located in the Publications section of the following Web site: http://water.usgs.gov/lookup/get?owq.

Newly published and revised chapters will be announced on the USGS Home Page on the World Wide Web under "New Publications of the U.S. Geological Survey," at http://water.usgs.gov/lookup/get?newpubs.

ACKNOWLEDGMENTS

The information included in this chapter of the *National Field Manual* is based on existing manuals, various reference documents, and a broad spectrum of colleague expertise. In addition to the references provided, important source materials include USGS handbooks, manuals, and technical memorandums. The editors and authors wish to acknowledge the following individuals in the USGS who developed the field and training manuals that provided the foundation for information on the collection and processing of water samples: M.E. Dorsey, T.K. Edwards, W.B. Garrett, W.J. Gibbons, R.T. Kirkland, L.R. Kister, J.R. Knapton, C.E. Lamb, R.F. Middelburg, J. Rawson, L.R. Shelton, M.A. Sylvester, and F.C. Wells.

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PROCESSING OF WATER SAMPLES A5.

Edited by **Franceska D. Wilde, Dean B. Radtke, Jacob Gibs, and Rick T. Iwatsubo**

Sample processing forms a continuum with sample collection (NFM 4) and involves the compositing, subsampling (splitting), filtration, solid-phase extraction, preservation, and shipment of samples. Samples are most vulnerable to sampling artifacts, contamination, incorrect chemical treatment, and mislabeling during sample processing. Samples must be processed as soon as possible after collection.[3]

Sample processing: the measures taken to prepare and preserve a water sample as or after it is collected and shipped for laboratory analysis.

GENERAL INFORMATION 5.0

By **D.B. Radtke and F.D. Wilde**

How samples are processed depends on the targeted analytes and the intended use of the data. Processing procedures for some analytes might require modification of standard processing procedures, as described in section 5.6. **Equipment components must be made of materials that (1) will not contribute or sorb target analytes to or from the water sample, and (2) can withstand cleaning solutions**.

[3]Consult NFM 4 for collection of water samples, and in addition, NFM 1 for field preparations, NFM 2 for equipment selection, NFM 3 for equipment cleaning, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material samples, and NFM 9 for field safety.

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PREPARATORY PROCEDURES 5.0.1

Use of the procedures described in this section will help to avoid mistakes and preserve sample integrity. Protocols that are applicable to most sampling efforts for surface water are described in detail in Horowitz and others (1994). Koterba and others (1995) describe the protocols for ground-water sampling that were designed for the National Water-Quality Assessment (NAWQA) Program; these protocols are generally applicable to the routine collection of ground-water samples. Field personnel are responsible for being familiar with any specific sampling protocols that might be required for their studies and programs, especially those that differ from the routine procedures covered by this field manual. For example, field procedures, bottle type, and sample preservation requirements differ for samples collected as part of the USEPA Drinking Water Program (National Water Quality Laboratory Technical Memorandum 97.05[4]).

- To minimize delays in sample processing, calibrate field instruments (NFM 6), and set up processing equipment and supplies in the work area before collecting the sample.
- Clean-sampling procedures are recommended as a general practice when processing raw samples, particularly those for analysis of trace levels of inorganic and organic analytes.
- **Clean-sampling procedures such as Clean Hands/ Dirty Hands techniques (NFM 4) are required when collecting samples to be filtered for analysis of trace elements** (Office of Water Quality Technical Memorandum 94.09; Horowitz and others, 1994; Koterba and others, 1995).

[4]The technical memorandums referenced in this manual are available on the World Wide Web; see "Selected References and Internal Documents" for memorandum titles, dates, and the Web Site address.

- **When using Clean Hands/Dirty Hands techniques:**
  - Designate the Clean Hands (CH) person and the Dirty Hands (DH) person before field work begins (table 4-2 in NFM 4).
  - **CH duties**: Has the only contact with the sample bottle; transfers sample from sampler to splitter; filters, extracts, and preserves sample.
  - **DH duties**: Operates sampling equipment and manages any contact with potential sources of contamination (for example, the churn carrier and pumps).
  - **CH and DH**: Both must wear appropriate disposable, powderless gloves (vinyl, latex, or nitrile for inorganic work; latex or nitrile for organic work).
- **Check sample-designation codes and processing requirements for each sample.** Requirements depend on program and laboratory protocols, study objectives, and data-quality requirements. Laboratory codes and processing requirements are summarized in Appendixes A5-A, B, and C.
  - **Organic analytes**. Identify the bottle requirement by checking the sample designation code (see in-text table below and Appendix A5-A). Use only containers that arrive clean, baked, and capped. **Discard any bottles that arrive uncapped**.
  - **Inorganic and radiochemical analytes**. Identify the bottle requirement by checking the sample designation code (see in-text table below and Appendixes A5-B and A5-C). For example, samples to be acidified must be collected in bottles that arrive from the laboratory acid rinsed and capped; **discard any acid-rinsed bottles that arrive uncapped**. Prerinse all bottles used for nutrients, major-ion, and trace-element samples with deionized water (DIW) before sampling. Field rinse bottles with the water to be sampled, if a field rinse is specified (section 5.0.3 and Appendixes A5-B and A5-C).

Common organic-compound sample-designation codes for the National Water Quality Laboratory of the U.S. Geological Survey

[Refer also to Appendix A5-A. ml, milliliters; °C, degrees Celsius]

Sample designation code	Bottle description and sample preservation
VOC	40-mL amber glass vials, laboratory cleaned and baked, for analysis of volatile organic compound sample (VOC or VOA); sample chilled to or below 4°C without freezing. Some programs require chemical treatment.
GCC	1-L amber, glass bottle, laboratory cleaned and baked, for various types of pesticides and organic-compound samples other than VOCs; sample chilled to or below 4°C without freezing.
TOC, DOC	125-mL amber glass bottle, laboratory cleaned and baked, for total (TOC) or dissolved (DOC) organic carbon; sample chilled to 4°C or below without freezing.

Common inorganic-constituent sample-designation codes of the National Water Quality Laboratory of the U.S. Geological Survey

[Refer also to Appendix A5-B and A5-C. mL, milliliter; <, less than; °C, degrees Celsius; L, liter]

Sample designation code	Bottle description and sample preservation
RA, FA	250-, 500-, or 1,000-mL polyethylene bottles, acid-rinsed, capped, to be filled with raw (RA) or filtered (FA) samples and acidified with nitric acid to pH <2.
RU, FU	250-, 500-, or 1,000-mL polyethylene bottles, uncapped, to be filled with untreated raw (RU) and filtered (FU) samples.
FCC	125-mL polyethylene bottles, uncapped, to be filled with filtered (FCC, brown bottle) sample for nutrient analysis and chilled to or below 4°C without freezing.
WCA, FCA	125-mL polyethylene bottles, uncapped; to be filled with raw (WCA, uncolored bottle) or filtered (FCA, brown bottle) sample for nutrient analysis, treated with sulfuric acid, and chilled to or below 4°C without freezing.
RAM, FAM	250-mL glass bottles, acid-rinsed, capped, to be filled with raw (RAM) or filtered (FAM) sample for mercury analysis, and treated with 6 N hydrochloric acid, ultrapure.
FAR	1-L polyethylene bottles, acid rinsed, capped, to be filled with filtered (FAR) samples for radiochemical analysis and treated with nitric acid to pH <2.

- **Clean equipment and supplies as directed in NFM 3.**
  - **Organic analytes.** All containers arrive precleaned and baked from the laboratory. **Do not prerinse or field rinse these glass bottles or vials.** Samples to be analyzed for organic compounds are hereafter referred to as organic-compound samples.
  - **Inorganic analytes.** Prerinse bottles with DIW and store half filled with DIW. This procedure is required for all FA samples with target analytes at parts-per-billion (ppb) concentrations, and is recommended for all samples to be analyzed for inorganic constituents (hereafter referred to as inorganic-constituent samples) that also require field-rinsed bottles.
- **Set up a clean work area** at the field site for sample processing. (An appropriate area includes, for example, a mobile laboratory, a water-quality field vehicle (NFM 2), or clean space in a building near the sampling site.)
  - Protect the area from airborne sources of contamination such as dust, vehicle emissions, and vapors from inorganic chemicals and organic solvents.
  - Spread sheeting over the area where samples are to be processed. For inorganic-constituent samples, use plastic sheeting. For organic-compound samples, use aluminum foil.
- **Prevent direct contact with potential source(s) of contamination.**
  - Exclude airborne particulates by processing samples onsite in processing and preservation chambers.
  - Handle anoxic samples rapidly and under an inert gas atmosphere (NFM 4.0.3).
  - Keep hands gloved and away from potential sources of contamination while processing samples. While filling the sample bottle, the sample must not come in contact with gloved hands.
- **Keep sample-processing equipment covered** with a clean, noncontaminating material when not in use; keep sample bottles capped and covered or bagged.

SEQUENCE FOR PROCESSING SAMPLES 5.0.2

The order of sample collection, processing, and preservation for specific analytes should be determined before beginning field work and adhered to consistently. The recommended sequence for sample collection and processing is based on logistics for maintaining sample integrity and differs for ground-water and surface-water sampling. The recommended sequence can be modified, depending on the types of samples to be collected and on data objectives. In general, process samples in the order indicated on table 5-1.

- For ground-water sampling, the amount of well purging might affect concentrations of VOCs measured in the ground-water samples (Gibs and Imbrigiotta, 1990). Therefore, VOC samples are collected first.
- When sampling either surface water or ground water for inorganic analyses,
  - Filter trace-element samples first, as prescribed and explained in section 5.2 and in Horowitz and others (1994).
  - Next, filter nutrient, major ion, and other inorganic-constituent samples having concentrations that will not be appreciably affected as nominal pore size of the filter media decreases.
  - Filter the alkalinity sample (NFM 6) with the other anions.
- When composite samples of surface water are processed, samples for analysis of organic compounds usually are processed first and are taken from a noncontaminating compositing device separate from that for inorganic-constituent samples, unless a cone splitter is used (section 5.1).

Table 5-1. Recommended sequence for processing samples

1. Organic compounds—Raw (wholewater or unfiltered) samples first, followed by filtered samples. **Do not field rinse bottles.** Chill. a. Volatile organic compounds (VOCs). b. Pesticides, herbicides, polychlorinated biphenyls (PCBs) and other agricultural and industrial organic compounds.
2. Organic carbon[1]. Chill. See step 4 for capsule-filtered dissolved organic carbon (DOC).
3. Inorganic constituents, nutrients, radiochemicals, isotopes: **For ground water,** filtered samples first, followed by raw samples. **For surface water,** raw samples first, followed by filtered samples. (Field rinse each bottle, as required.) a. Trace and major element cations. b. Separate-treatment constituents (such as mercury, arsenic, selenium). c. Nutrients, major anions, and alkalinity. Chill nutrients. d. Radiochemicals and isotopes. (Bottle-rinse, filtration, and preservation requirements depend on analysis to be performed (section 5.6 and Appendix A5-C.)[2])
4. Capsule-filtered DOC (5.2.2.C), followed by radon and chlorofluorocarbons.[2] (Do not rinse bottles.)
5. Microorganisms (NFM 7).

1(Footnote deleted.)

[2]Radon and chlorofluorocarbon and most isotope samples are collected outside of the processing chamber.

5.0.3 FIELD RINSING OF BOTTLES USED TO CONTAIN SAMPLES FOR ANALYSIS OF INORGANIC CONSTITUENTS

Most polyethylene sample bottles and only those glass sample bottles that are designated for analysis of inorganic constituents (inorganics bottles) are field rinsed as described in table 5-2. Check Horowitz and others (1994) and the laboratory requirements (summarized in Appendixes A5-B and A5-C) for more detailed discussions of field rinsing. **The field-rinse water normally is the same as the water that will fill the sample bottle: use wholewater sample for raw (unfiltered) samples and filtrate for filtered samples.**

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- If the volume of sample obtained for processing is limited, DIW of the appropriate quality may be substituted as the rinse solution for the first two of the three required rinses.
- Wear disposable, powderless gloves while processing samples.

Check analyte requirements before field rinsing bottles. For example, DO NOT field rinse glass bottles that are designated for analysis of organic compounds.

Table 5-2. Directions for field rinse of bottles used to contain samples for inorganic-constituent analysis

[DIW, deionized water; mL, milliliters]

Bottle Preparation
• If bottles were previously rinsed and half-filled with DIW[1], discard DIW and rinse once only with the water to be sampled. Use filtrate for filtered samples and wholewater for raw samples.
• If bottles were not prerinsed with DIW, rinse twice with DIW onsite, followed by one field rinse with the water to be sampled (use only 25-mL filtrate for bottle rinse for the filtered sample[1,2]).
Field-Rinse Technique
1. Put on disposable, powderless gloves.
2. Fill sample bottle about 1/10 full of rinse water. Cap bottle.
3. Shake the bottle vigorously to rinse all interior surfaces.
4. Discard rinse water by swirling the solution out of the bottle.
5. Shake off adhering droplets.

[1]Required for filtered trace-element samples (Horowitz and others, 1994).
[2]Refer to section 5.2.1.A for detailed guidance relating to surface-water and ground-water samples.

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RAW SAMPLES 5.1

By **D.B. Radtke, A.J. Horowitz, Jacob Gibs, and F.D. Wilde**

Raw samples, commonly referred to as wholewater or unfiltered samples, are collected directly into the appropriate type of sample bottle from the sampling device (such as a submersible pump, sample-compositing device, peristaltic pump, or cone splitter). It is recommended that this sample collection take place within a processing chamber, especially if analyte concentrations are expected to be near the detection limit, to prevent contamination from airborne sources.

- Equipment must be clean before samples are collected and processed.
- Disposable, powderless gloves must be worn throughout sample collection and processing. In order to withstand the solvents or chemicals that could be contacted, vinyl gloves are adequate for inorganic work, but use of organic solvents for organic work requires latex or nitrile gloves.

COMPOSITES AND SUBSAMPLES 5.1.1

Surface-water samples normally are composited and processed through sample splitting (subsampling) devices (NFM 2). Ground-water samples are not composited but are pumped either directly through a splitter or through a filtration assembly (filter assembly) into sample bottles, unless a bailer or other thief-type sampler is used to collect the sample. Inorganic-constituent samples usually are composited in the plastic or fluoropolymer churn splitter; organic-compound samples commonly are composited in a fluoropolymer churn splitter or metal container, or are processed through a fluorocarbon polymer cone splitter.

Only the Clean Hands person fills sample bottles with water withdrawn from the churn or cone splitter (NFM 4).

Two types of water-sample splitters commonly used by the USGS are the polypropylene churn splitter (churn) and the fluorocarbon polymer cone splitter (cone).[5] Each splitter has specific advantages and disadvantages (NFM 2.2.1). By convention, the churn usually is used only for inorganic-constituent (and possibly for suspended organic carbon) samples. The churn is constructed of plastic materials that can potentially affect concentrations of other organic compounds. The cone is constructed of fluorocarbon polymer material and can be used for either inorganic-constituent or organic-compound samples. **Program or study protocols might dictate which equipment to use.**

- Either the churn or cone splitter can be used for splitting raw samples with suspended-sediment concentrations up to 1,000 mg/L.
- Only the cone splitter can be used for splitting raw samples with suspended-sediment concentrations up to 10,000 mg/L (Office of Water Quality Technical Memorandum 97.06).
- The splitting accuracy of the cone splitter is unknown for suspended-sediment concentrations between 10,000 to 100,000 mg/L (Office of Water Quality Technical Memorandum 97.06), but data are available that indicate the splitting accuracy of the cone is unacceptable at concentrations of 100,000 mg/L or more.

5.1.1.A Churn-Splitter Procedure

Subsamples collected from the composite sample in a churn splitter must be processed according to the specific procedures described below, using Clean Hands/Dirty Hands (CH/DH) techniques as applicable.

1. Assemble sample-processing equipment and supplies on a clean work surface.
   - Put on appropriate, disposable, powderless gloves (gloves). (Wearing multiple pairs of gloves at one time provides an efficient means of changing gloves quickly.)

[5]Consult the following references for more detailed information about the churn and cone splitters: Office of Water Quality Technical Memorandums 76.24-T, 80.17, 94.13, and 97.06; Capel and others (1995); and Capel and Larson (1996).

- If hand contact is made with a potential contaminant, remove the outer (contaminated) gloves before continuing with sample processing.
- For CH/DH techniques: Remove churn splitter and inner bag from churn carrier. Leave the churn carrier and outer bag outside the processing area (vehicle or building).

2. Place all prelabeled wholewater or suspended-material bottles within easy reach of the churn spigot.
3. Churn the composite sample at a uniform rate by raising and lowering the disk inside the churn splitter with smooth, even strokes.
   - When churning, the disk should touch bottom on every stroke, and the stroke length should be as long as possible without breaking water surface. **Do not break the surface of the water**.
   - **The churning rate should be about 9 inches per second (in/s).** If the churning rate is significantly greater than 9 in/s, or if the disk breaks the surface of the water, excessive air is introduced into the sample and could affect dissolved gases, bicarbonate, pH, and other characteristics of the sample.
   - Inadequate churning can result in withdrawal of nonrepresentative wholewater or suspended-material samples.
4. Pre-mix the composite sample by churning for about 10 strokes to uniformly disperse suspended material before subsampling.
5. **Raw subsample.** Withdraw the raw subsamples for wholewater or suspended-materials analyses first.
   - Withdraw an adequate volume of sample water for the field rinse while continuing to churn.
   - **Withdraw the first subsample.** The first subsample withdrawn from the churn should be the largest volume required (usually a 1-L sample).
   - Do not interrupt the churning/subsampling process, if possible. If an interruption occurs, reestablish the churning rate and remix the sample by churning ten strokes before resuming subsampling.
   - As the volume of composite sample in the churn decreases, adjust the stroke length to maintain a churning rate of about 9 in/s and avoid breaking the surface of the water being sampled.

6. Check requirements for sample preservation. **For raw samples that require chemical treatment ⇨ Go to section 5.4.**
   - For raw samples that require chilling without chemical treatment(s)—Pack samples in ice or refrigerate as quickly as possible. Maintain at or below 4°C without freezing (section 5.4).
   - For raw samples that do not require chilling or chemical treatment—Set samples aside in a clean area for shipping to the laboratory (section 5.5).
7. **Filtered samples ⇨ Go to section 5.2.** After wholewater or suspended-material subsampling is complete, use the remainder of the composite sample in the churn for filtered samples.
8. Empty the churn after the required number of samples has been processed.
   - If the churn will be reused during the field trip, disassemble and field clean onsite while still wet, as described in NFM 3.
   - If the churn will not be reused during that trip, rinse with DIW before it dries out, place it in a plastic bag and in the churn carrier to be transported back to the office laboratory for cleaning.
9. Document on field forms and in field notes the types of samples collected and the splitting procedures used.

A field blank might be required after all sampling and processing equipment has been field cleaned (NFM 4.3).

TECHNICAL NOTES: Subsamples totaling 10 L and 5 L can be withdrawn from the 14-L and 8-L churn, respectively, for samples for wholewater analysis. The sample volume remaining in either churn may be used for filtered samples.

The churn splitter is used to split samples with particle sizes ≤ 250 µm and suspended-sediment concentrations ≤1,000 mg/L. Splitting accuracy becomes unacceptable at particle sizes > 250 µm and concentrations > 1,000 mg/L.

Cone-Splitter Procedure 5.1.1.B

Inorganic-constituent and organic-compound samples can be split using a fluorocarbon polymer (Teflon™) cone splitter. Although the cone splitter is used primarily for simultaneous distribution of surface-water samples into bottles, the cone also can be used similarly for a bailed or composited ground-water sample. The sample is poured into the splitter from the sampling device or transferred from a noncontaminating compositing container. If used for splitting pumped ground-water samples, the sample is pumped directly into the cone splitter.

1. Put on appropriate, disposable, powderless gloves (gloves). Remove cone splitter from protective covering.
2. Prepare a processing area that is protected from dust and fumes. Preferably, the cone splitter is installed in a processing chamber or covered with a large plastic bag.
3. Install cone splitter (see NFM 2, fig. 2-10, for a labeled diagram). **The cone splitter is built to close tolerances to achieve accurate and reliable operation and requires the following:**
   - **Use a bull's-eye level to level the cone splitter: this is critical for accurate performance.**
   - All tubes exiting the cone splitter must be the same length, as short as possible, and precleaned. Organic-compound samples require fluorocarbon polymer tubing. Carry a separate set of tubes for each site, and clean all sets on return to the office laboratory. If extra tubes are not available, do not reuse tubes for multiple sites without first cleaning them.
   - Push tubes as far as possible into the fittings on the splitter.

Minimize atmospheric contamination—Cover the cone splitter and sample bottles during the sample splitting process and when not in use.

4. Field rinse cone splitter and the appropriate sample bottles with the water to be sampled. **Do not field rinse laboratory-cleaned and baked glass bottles.**
   a. Open cover to access cone-splitter reservoir. (Flap or access slots for hands can be cut into the plastic bag covering the splitter.)
   b. Transfer 2 to 4 L of the sample into the cone-splitter reservoir. Some splitter reservoirs may be retrofitted with a funnel to ease pouring.
   c. Close cover and lightly tap splitting system to dislodge adhering water drops. Discard rinse water.
   d. Field rinse bottles for raw samples (RA, RU, and so on) with wholewater sample. Do not use the water sample previously processed through the cone splitter; follow directions in table 5-2.
5. Place bottles for raw samples under outlet tubes. Complete splitting procedure first with bottles for organic-compound samples, next with bottles for inorganic-constituent samples.
   - Place outlet tubes into sample bottles to prevent spilling. **Outlet tubes should not extend beyond the neck of the sample bottle. Do not submerge the ends of outlet tubes in the sample.**
   - Outlet tubes can be combined to collect various combinations of volumes of the original sample. Make sure no back pressure results from restrictions of water and air flow if combining outlet tubes into a single bottle.
   - Direct sample discharge from unused outlet tubes to waste.
6. Pour (or pump) sample into cone splitter. If hand contact is made with a potential contaminant while using CH/DH techniques, remove outer contaminated glove(s) or put on a new pair of gloves before transferring sample to cone splitter.
   a. Gently shake or agitate sample for at least 10–15 seconds to resuspend any particulate matter present in sampler bottle or discrete sampler (such as a bailer).

b. Transfer sample to cone-splitter reservoir (some splitter reservoirs may be retrofitted with a funnel to ease filling).

- Open cone-splitter cover and invert sampler or compositor containing sample over splitter reservoir. (If using a bailer, empty through bottom-emptying device. If using a pump, hold sample line over the cone-splitter reservoir and pump sample directly into the cone splitter.)
- First, collect organic-compound samples into clean, baked glass bottles (Appendix A5-A).
- Next, collect inorganic-constituent samples into cleaned and field-rinsed polyethylene bottles or as designated (Appendix A5-B or A5-C).

c. Maintain a head of water above the splitter standpipe to prevent air from entering the splitting block while rapidly transferring the sample. **Do not spill any of the sample when pouring or pumping it into the cone splitter.**

d. For proper operation, the splitter standpipe must be discharging at full-flowing capacity.

- **Never overfill sample bottle.**
- **Always transfer the entire composite sample into cone splitter** for thorough distribution into the sample bottles.

7. **When splitting the samples, avoid exposing samples to direct sunlight or freezing conditions.** During sample splitting, the temperature of samples from the cone splitter should remain constant.
8. Close cone-splitter cover.
9. After flow has stopped, lightly tap the cone splitter to dislodge adhering drops.
10. Remove sample bottles and cap them immediately.
11. **To obtain smaller subsample volumes**, position bottles at cone outlet ports and pour a sample from the preceding set of split samples into the cone splitter. **For inorganics only, remember to rinse each new set of polyethylene sample bottles with DIW and sample as previously directed** (sections 5.0.1 and 5.0.3).

12. If multiple passes through the cone are required, randomize the ports selected. This minimizes bias from differences in ports caused by manufacturing processes.
13. Check requirements for sample preservation. **For samples that require chemical treatment ⇨ Go to section 5.4.**
    - For raw samples that require chilling without chemical treatment(s)—Pack samples in ice or refrigerate as quickly as possible. Maintain samples at or below 4°C without freezing (section 5.4).
    - For raw samples that do not require chilling or chemical treatment—Set samples aside in a clean area for shipping to the laboratory (section 5.5).
14. **Filtered samples ⇨ Go to section 5.2.** Remember to use only sample filtrate for the bottle field rinse.
15. Clean cone splitter, following instructions in NFM 3.
    - Disassemble and clean in the field before reusing. Field cleaning between sites must be done onsite while the cone splitter is still wet.
    - If the cone splitter will not be reused immediately, rinse with DIW and place in a plastic bag for transporting back to the office laboratory for cleaning.
16. Document on field forms and in field notes the types of samples collected and the splitting procedures used.

A field blank might be required after sampling and processing equipment has been field cleaned (NFM 4.3).

GROUND WATER: PUMPED AND BAILED SAMPLES 5.1.2

Steps for filling bottles with raw sample pumped from water-supply wells and monitoring wells are described in this section (refer also to section 5.6 and Appendixes A5-A, A5-B, and A5-C). The equipment needed and the procedures required to purge a well and withdraw the sample are described in NFM 2 and NFM 4, respectively, and are only briefly described below.

The recommended method for withdrawing ground-water samples from conventional supply or monitoring wells is to use a submersible or peristaltic pump and to pump the sample directly to a processing chamber (or to a glove box filled with inert gas).[6] Ground-water samples collected using a bailer or other discrete sampling device can be processed either as described under 5.1.1 (composites and subsamples) or within a processing chamber (or glove box), as described later in this section.

Only the Clean Hands person fills the sample bottle inside of the sample-processing chamber (NFM 4).

Collect/process equipment blanks, field blanks, replicates, and other types of quality-control (QC) samples periodically (NFM 4.3 and Appendix A4-B of NFM 4). The frequency, number, types, and distribution of QC samples are determined ahead of time according to the study workplan. Nevertheless, in the event of unforeseeable field conditions (for example, dust storms, new point source(s) of contamination, or application of agricultural or other chemicals), **field personnel must judge whether to process additional QC samples**.

- Replicates of environmental samples—Fill bottles one after the other (NFM 4.3).
- Field blanks—Process according to the study quality-assurance plan or as needed (NFM 4.3).

[6]Wells or devices constructed to obtain samples under natural flow gradient (passive) conditions are not addressed in this report.

Processing of samples

The steps listed below for processing raw ground-water samples are based on the assumption that both organic-compound and inorganic-constituent samples will be collected. Before proceeding, check section 5.6 for analyte requirements.

- Prelabel bottles with site identification, sample designation, date, and time (section 5.5 and NFM 1).
- Process samples in the order recommended for sample collection listed on table 5-1. This helps to limit overpurging of volatile compounds, reduce airborne contamination and cross contamination among samples and sites, and minimize discrepancies in the ionic mass balance.
- When pumping the sample, do not stop the pump or interrupt flow to the processing chamber during sampling. The rate of flow during sampling should remain constant throughout processing and be the same as the rate of flow while making final field measurements at the end of purging (NFM 4, NFM 6).

To process ground-water samples for organic-compound analyses:

1. Put on appropriate (latex or nitrile), disposable, powderless gloves (gloves). Cover bench or table with a sheet of aluminum foil to make a clean work surface.
2. Assemble necessary equipment and supplies on the clean work surface, and remove aluminum foil wrapping from precleaned equipment. Attach processing chamber cover. (Processing of organic-compound samples within a chamber is not mandatory but is recommended.)
3. Check requirements for treatment of the sample(s) collected.
   - If collecting a VOC sample that will be acidified—Test for the number of drops of HCl needed to lower sample pH to ≤ 2 using 40 mL of the final purge water. Dispense the HCl from a dropper bottle.
   - All samples processed for organic-compound analysis are to be chilled to 4°C or below without freezing.
4. Place bottles and other equipment needed for processing raw samples into processing chamber. If collecting samples for VOCs, place only VOC vials and VOC equipment in the chamber.

5. Withdraw samples from the well.

If using a pump—

a. Purge wells first, preferably with the same pump to be used for withdrawing the samples. Consult NFM 4.2 for purging procedures.

b. Check that the discharge end of sample line from the pump or manifold is secured in the processing chamber.

c. Direct sample flow through the sample line into the processing chamber (NFM 4.2).

- Waste initial sample through chamber drain for the sample-line rinse; do not let sample spray onto chamber cover—change chamber cover if this happens.
- Check for air bubbles in the sample line; tap the line or make adjustments to remove any air from the line.
- Flow should appear smooth and uniform (with no splashing) and should not exceed 150 mL/min when filling 40-mL VOC vials or 500 mL/min for larger bottles.

If using a bailer—

a. Purge wells first, using a pump (NFM 4.2). Do not purge wells with a bailer unless absolutely necessary.

b. Set up holding stand, as appropriate.

c. Lower the sampler (after field rinse) smoothly into the well; cause as little disturbance to the water column as possible. Follow analogous directions as those for sampler field rinsing (NFM 4.0.2.A).

d. After reaching the sampling depth within the screened or open interval, collect sample by raising the sampler smoothly (minimizing disturbance to water column). Keep the deployment line clean and untangled as sampler is lowered and raised.

e. Place sampler into holding stand and insert sample-delivery tube/device.

> TECHNICAL NOTE: Sampling from wells with a bailer or other discrete sampling device is not recommended if target analytes (such as trace elements and hydrophobic organic compounds) are those that typically associate or partition to particulates because deployment of bailers or other point-source samplers usually stirs up or otherwise mobilizes particulates. Fine-grained and colloidal-sized particulates can persist in the water column, causing a potential for bias.

6. Collect all raw organic-compound samples into designated bottles.
   a. Fill VOC vial from bottom of vial to overflowing without entraining air bubbles. Leave a convex meniscus. If sample will not be acidified, cap vial securely, invert, and check for air bubbles. **Follow directions in section 5.6.1.A.**
   b. If acidification of the sample is required,
      - The preservative can be added to VOC samples while samples are inside the processing chamber as long as the chemical treatment will not affect any subsequent samples to be collected for analysis of organic compounds. Otherwise, acidify VOC samples in a preservation chamber.
      - Add 1 to 5 drops of HCl to the sample (sections 5.4 and 5.6). Usually two drops of HCl are sufficient to lower the pH of the VOC sample to ≤ 2. Cap vial securely, invert, and check for air bubbles. If air bubbles are present, discard the vial and start again.
      - Change cover of processing chamber and change gloves.
   c. Place remaining raw organic-compound sample bottles into processing chamber. Fill bottles directly from the sample line to the shoulder of each bottle (section 5.6.1.B).
7. For filtered organic-compound samples:
   a. Place aluminum plate-filter assembly into chamber for pesticides and other filtered organic-compound samples. Change gloves.
   b. Load the filter, connect the plate-filter assembly, and field rinse the filter as directed in section 5.2.2.A.
   c. After following filtration directions in section 5.2.2.A, pass bottles out of chamber for DH handling.
8. After processing raw and filtered organic-compound samples:
   a. Fill sample bottle with DIW and label "temperature-check sample" to accompany chilled organic-compound samples.
   b. Remove the equipment used to process the samples and pass to DH.
   c. Discard chamber cover.
   d. Remove aluminum foil covering from work bench.
9. **Sample preservation ⇨ Go to section 5.4.**

Process ground-water samples for inorganic-constituent and remaining analyses:

1. Direct flow of pumped sample away from the processing chamber. Change to vinyl or latex, disposable, powderless gloves (gloves).
2. Cover bench or table with a plastic sheet to make a clean work surface. Change processing chamber cover. Assemble equipment and supplies needed on the clean work surface. Remove plastic wrapping from pre-cleaned equipment. Change gloves.
3. **For filtered inorganic-constituent, nutrient, radiochemical, and isotope samples**:
   a. Place filtration equipment, sample bottles (prelabeled), and other supplies and equipment for filtered inorganic-constituent samples into processing chamber. Change gloves.
   b. Connect filtration equipment as directed in section 5.2.1.
   c. Resume sample flow to the chamber.
      - Check for air bubbles in the sample line; tap line or make adjustments to remove air from the line.
      - Flow should be smooth and uniform—about 500 mL/min to fill sample bottles without splashing.
   d. Collect all filtered inorganic-constituent samples first, as directed in section 5.2.1.
4. Disconnect the filter assembly. Change gloves.
5. **Raw inorganic-constituent, nutrient, radiochemical, and isotope samples:**
   a. Place prelabeled bottles for raw samples into the processing chamber. Change gloves.
   b. Field rinse bottles with raw sample (section 5.1, table 5-1).
   c. Collect samples into designated bottles.
   d. Place bottles outside of chamber. Change gloves.
6. Remove equipment, discarding chamber cover appropriately.
7. **Sample preservation ⇨ Go to section 5.4.**
8. **Radon and CFC samples ⇨ Go to section 5.6.**

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FILTERED SAMPLES 5.2

By **D.B. Radtke, A.J. Horowitz, and M.W. Sandstrom**

Filtration is the physical process used to separate the particulate and aqueous fractions of a water sample. Samples are filtered for several purposes; for example, to remove microorganisms in order to help preserve ambient analyte concentrations, to remove suspended materials that interfere with specified analytical procedures, and to determine chemical speciation and fractionation of trace elements for geochemical studies.

Study objectives and the analytes targeted for study dictate the filtration method and equipment to be used. Ambient concentrations of filtered analytes typically can be near the limit of detection; therefore, field personnel must pay strict attention to possible sources of contamination from sampling and processing equipment, construction material of the chamber frame and of the filtration equipment, and the way the equipment is handled. (Equipment and supplies used to filter water samples are described in detail in NFM 2.)

- Check the composition and pore size of the filter medium and the effective filtration area of the filter; these can affect the quality and accuracy of the data and can compromise data-quality requirements.
- To minimize airborne contamination,
  - Filter samples within a processing chamber.
  - Add chemical treatments to samples within a separate preservation chamber.

Filter samples during or immediately after sample collection.

5.2.1 INORGANIC CONSTITUENTS

Most filtration systems currently used by the USGS are appropriate for filtering wholewater samples, if the limitations of each system are taken into account. **Standard USGS procedure is to filter inorganic-constituent wholewater samples through a 0.45-micrometer (µm) pore-size disposable capsule filter.** Filtration through media with pore sizes other than 0.45 µm or with other equipment (such as tangential-flow devices) depends on the use and interpretation of the data and can yield substantially different results for trace-element concentrations.

Data-quality requirements for interpretive studies of ground-water and surface-water chemistry can dictate filtering the sample through a nominal pore size of ≤ 0.2 µm. The quality-assurance procedures used for samples filtered through the 0.45-µm nominal-pore-size capsule, plate, or other filtration equipment also are required for the ≤ 0.2-µm filters. If concentrations of target analytes are analyzed at sub-parts-per-billion levels, more stringent QA/QC measures are needed. Such samples can be filtered through a plate filter or other filtration equipment (for example, a 47-mm-diameter vacuum-filter unit) as long as the equipment used is approved by the study or program, data-quality requirements are met, and additional quality-control samples are collected. For additional information on filtration artifacts, procedures, and equipment, see Kennedy and others (1976), Salonen (1979), McCarthy (1988), McCarthy and Zachara (1989), Puls and Barcelona (1989), Ward and Harr (1990), Horowitz and others (1992, 1994), Williams and others (1993), Robards and others (1994), and Koterba and others (1995).

Cleaning and conditioning of various filter media used for inorganic constituents are summarized in table 5-3. Contamination during sample filtration can be reduced by following the instructions given for cleaning, conditioning, and handling of the filter media.

Table 5-3. Field cleaning and conditioning procedures for media used to filter samples for inorganic-constituent analysis

[µm, micrometer; mL, milliliter; sample, the water to be sampled; µg/L, microgram per liter; mm, millimeter; HNO_3, 1 molar solution of ultrapure-grade nitric acid; HCl, 1 molar solution of ultrapure-grade hydrochloric acid; nutrients, nitrogen and phosphorus species; DIW, District- or laboratory-produced deionized water of known quality, ASTM Type-1 grade or better; IBW, laboratory-produced inorganic-grade blank water; *N*, normal; >, greater than]

Description	Filter media	Field cleaning/ conditioning	Application
Disposable capsule filter[1] (Polypropylene)	Polysulfone, pleated membrane, 0.45-µm or 0.2-µm pore size	Clean with 1,000 mL DIW and remove residual DIW[2] Condition with 25 mL sample	Major ions and nutrients; trace elements with concentrations > 1 µg/L; radio-chemicals and isotopes
Plate filter — 142 mm (Polycarbonate or acrylic)	Cellulose nitrate, tortuous path (0.45 and 0.1 µm are most commonly used pore sizes)	Clean with 500 mL DIW and extract residual DIW Condition with 100 mL sample	Major ions and nutrients; trace elements if concentrations > about 100 µg/L
Cartridge or hand-pressure filter assembly—47 mm (Polypropylene or fluorocarbon polymer)	Cellulose nitrate, tortuous path (0.45, 0.2, and 0.1 µm are most commonly used pore sizes)	Clean with 100 mL DIW and remove residual DIW Condition with 20 mL IBW or 10 mL sample	Major ions and nutrients; trace elements with concentrations at about 1 µg/L or greater
Cartridge or hand-pressure filter assembly—47 mm (Fluorocarbon polymer)	Polycarbonate (such as Nuclepore), direct path (0.40 and 0.1 µm are most commonly used pore sizes)	Soak in HNO_3 rinse with IBW.[3] Remove residual IBW Condition with 20 mL IBW or 10 mL sample	Major ions and nutrients; trace elements with concentrations at about 1 µg/L or greater

[1]Example: Gelman Sciences 12175 (0.45 µm); 600 square-centimeter filtration area. Other disposable capsule filters are available that have different effective filtration area, media type, and media pore size.

[2]For trace-metal analyses at nanogram-per-liter concentration levels, first acid rinse with 500 mL of 1-*N* HCl (polysulfone membranes cannot withstand HNO_3).

[3]Substitute HCI for HNO_3 if sampling includes nutrients.

- Before filtering, designate one member of the processing team as Clean Hands (CH) and another member as Dirty Hands (DH) if using the CH/DH method (NFM 4).
- Wear appropriate, disposable, powderless gloves throughout the process. Vinyl gloves are adequate for inorganic-constituent sampling.
- Filter the samples within a processing chamber to minimize the possibility of contamination.

5.2.1.A Capsule-Filter Procedure

The capsule filter is a disposable, self-contained unit composed of a pleated filter medium encased in a plastic housing that can be connected in-line to a sample-delivery system (such as a submersible or peristaltic pump) that generates sufficient pressure (positive or negative) to force water through the filter. Filter media are available in several other pore sizes, but 0.45 µm is the pore size used routinely for most studies at this time. The capsule filter is required for most studies when filtering samples for trace-element analysis and is recommended when filtering samples for major-ion or other inorganic-constituent analyses.

The following instructions implement Clean Hands/Dirty Hands (CH/DH) techniques and the other QA procedures that are required for trace-element samples with analyte concentrations at the parts-per-billion (ppb) level and that are recommended as good field practice for all samples.

- The DH team member performs operations that are outside of the processing chamber and the CH team member performs operations inside the chamber. DH and CH must wear appropriate disposable, powderless gloves (gloves).
- Preclean capsule filters (step 5 below) before leaving for the field to save field time.

Fill bottles for filtered samples in this sequence: FA (trace elements) ➜ FAM (mercury) ➜ FA and FU (major ions) ➜ FCC or FCA (nutrients) ➜ FAR and all other samples.

Revise the above sequence to: FA (trace elements and cations) -> FAM (mercury) -> FCC or FCA (nutrients) -> FU (anions) -> FAR -> DOC and all other samples.

To prepare the work space, sample bottles, and capsule filter:

1. CH/DH: Put on one or several layers of gloves.
2. *CH*: Assemble processing chamber, attach chamber cover, and change gloves. Place capsule filter and sample bottles into chamber, and run discharge end of peristaltic pump tubing into the chamber. Open DIW[7] container and cover it with a plastic bag to prevent contamination from airborne particulates.
3. *CH*/*DH*: (*CH*) Insert intake end of peristaltic pump tubing through the plastic covering and into a l-L container of DIW.
   a. (*DH*): Attach tubing to peristaltic pump head and pump DIW to fill tubing.
   b. Discharge waste rinse water through a sink funnel or a toss (waste) bottle.
4. Discard DIW stored in DIW-prerinsed sample bottles. If sample bottles were not DIW-prerinsed by field personnel:
   a. Wearing gloves, rinse off exterior of each bottle.
   b. Pour DIW into bottle until about one-tenth full.
   c. Cap bottle and shake vigorously about five times.
   d. Uncap and empty bottle.
   e. Repeat b–d of step 4 twice (for a total of three times).
   f. Recap bottles until ready to field rinse.

[7]Office of Water Quality Technical Memorandum 92.01 describes the quality required of the deionized water.

5. **Clean the capsule filter.** If the capsule filter was precleaned, go to the sections that follow on “To filter a composite sample” or “To filter a pumped sample,” as appropriate. The steps below comprise sufficient precleaning of the filter for inorganic analytes at the parts-per-billion (ppb) concentration level. More rigorous precleaning procedures that include rinsing with trace-metal-grade hydrochloric acid are required for samples containing ppb concentrations of target analytes (table 5-3). **Only CH touches those portions of tubing that will be in direct contact with the DIW or capsule filter.**

   a. *CH*: In the processing chamber, remove capsule filter from protective bags.

      - Attach pump tubing to inlet connector of capsule filter, keeping tubing as short as possible. **Make sure direction of flow through capsule filter matches the direction-of-flow arrow on the side of the capsule.**
      - To help minimize aeration of the sample (usually for ground-water samples), secure a short length of clean fluorocarbon polymer tubing onto capsule filter outlet to extend into the sample bottle so the bottle can be filled from the bottom up.

   b. *CH/DH*: Pump 1 L of DIW through capsule filter; discharge waste rinse water through a sink funnel or to a toss bottle.

      - *DH* operates the pump at a low speed.
      - *CH* inverts the capsule filter so the arrow on the housing is pointing up. (This expels trapped air from the capsule during initial filling; do not allow water to spray onto the chamber walls.)

   c. *DH*: Remove tubing from DIW reservoir and continue to operate pump in forward mid-range speed position to drain as much of the DIW that remains in the capsule filter as possible. While pump is operating, shake capsule filter to help remove any entrained DIW.

   d. *CH*: Detach capsule filter from peristaltic pump tubing, put it into a clean, sealable plastic bag, and place in a corner of the processing chamber until ready for use.

Filtration procedures differ somewhat, depending on how the sample is collected. If the sample is collected using discrete collection equipment, such as the surface-water bag or bottle sampler or ground-water bailer, use the procedures described below in "To filter a composite sample." If the sample is collected by pumping it directly from the source, use the procedures described below in "To filter a pumped sample." Ground-water samples usually are not collected as a composite. If samples are to be withdrawn from

a well using a bailer, consider using a bailer to which the capsule filter or other filtration device can be connected inline to the bailer bottom-emptying device. Pouring a sample from the top of the bailer into another receptacle aerates the sample and therefore is not a generally recommended procedure for processing ground-water samples.

To filter a composite sample (generally for surface water):

1. Field rinse peristaltic pump tubing with the water to be sampled.
   a. *CH:* Rinse the outside of each end of the peristaltic pump tubing.
   b. *CH*: Transfer intake end of peristaltic pump tubing into composite sample. If a churn splitter is used, transfer intake end of peristaltic pump tubing through churn funnel and reseal plastic bag around the tubing.
   c. *DH*: Start peristaltic pump to slowly pump sufficient sample to completely fill pump tubing.
   d. *CH*: Discard rinse water through the sink funnel or into a toss bottle or other receptacle and dispose of appropriately. Prevent water from ponding in the processing chamber.
   e. *DH*: Stop peristaltic pump after tubing is field rinsed.
2. Field rinse capsule filter:
   a. *CH*: Remove cleaned capsule filter from plastic bag and attach discharge end of the peristaltic pump tubing to the inlet connector on the capsule filter.
      - A clean, small plastic hose clamp may be used to secure the discharge end of the tubing to the capsule filter inlet connector.
      - Check that the direction of sample flow through the capsule filter matches the direction of the arrow on the capsule.
   b. *DH:* Operating the pump at low speed, pump sample through the tubing to the capsule filter.
   c. *CH:* Turn capsule filter so that the outlet is pointing up (arrow on capsule housing is pointing up) and flow of the sample forces trapped air out of the capsule filter while it is filling. **Do not let sample spray onto chamber cover.**
      - The chamber cover must be changed if sample has sprayed onto it.
      - If some water that sprayed onto the chamber cover has dripped into the sample bottle, discard the bottle, change the cover, and collect a new sample.

d. *DH:* Stop the peristaltic pump as soon as the capsule filter is full of sample and all air in the capsule filter has been expelled.

TECHNICAL NOTE: The goal is to minimize clogging the filter medium with suspended materials by minimizing the volume of sample that will be used to field-rinse the filter.

1. Collect sample filtrate.
   a. *CH*: Check that there is a tight connection between the pump tubing and the capsule filter.

      DH: Check that the intake tube is properly inserted in the sample and start the pump.

      CH: Collect a maximum of 25 mL of the water to be sampled as it discharges through the filter. **Do not exceed 25 mL**.

      CH: Field rinse a precleaned 250-mL FA bottle for trace-element sample only with sample filtrate.

      DH: Stop the pump in time to prevent losing filtrate to waste.

      CH: Cap bottle, shake vigorously, and then discard rinse water into appropriate receptacle.

   b. *DH:* Start pump and resume flow from pump to the filter.

      CH: **Filter only the next 200 mL of the sample** into the trace-element FA bottle (fill to top of upper lip of standard 250-mL polyethylene bottle). Cap bottle securely and set aside for chemical treatment.

   c. *DH:* Stop the pump after the trace-element/major ion FA bottle is filled.

   d. If a filtered mercury sample is required, restart pump and repeat steps 3a–c, substituting a FAM bottle for the FA bottle.

   e. *CH:* Field rinse any remaining sample bottles for inorganic analyses. **Use no more than a total of 100 mL of filtrate per capsule filter to field rinse any remaining bottles for filtered sample. Do not rinse the DOC bottle.**

   f. Fill remaining bottles in the following order: (1) nutrients and major anions (including alkalinity), (2) radiochemicals (Appendix A5-A), and (3) stable isotopes. Cap each bottle immediately after filling. Collect capsule-filtered dissolved organic carbon (DOC) last.

Note: Page revised 2/27/2009.

To filter a pumped sample (usually ground water):

Ground-water samples usually are withdrawn from a well by means of a submersible pump. Note that this method might be appropriate for some surface-water samples. The capsule filter or other filter assembly is connected inline with the sample tubing in order to collect samples directly from the well.

- When sampling ground water, DH should check that the turbidity values recorded at the end of purging have remained stable. Equipment changes or adjustments that disrupt sample flow can affect sample turbidity and should be avoided. If sample flow is disrupted, pump for several minutes until ambient turbidity values are reestablished.
- **Maintain a smooth, uniform flow.** Do not stop pump or divert flow from capsule filter or other filter assembly during bottle field rinse or filtration, if possible.

  TECHNICAL NOTE: If using a three-way valve, changing the setting to divert the flow of sample being pumped to the filter with a submersible pump can cause air bubbles to form, can air-block the filtration equipment, and can cause changes in pumping rate that could result in increased turbidity. These effects should be avoided to preserve sample integrity; therefore, flow to the filter should not be stopped until all filtration is complete.

1. Field rinse the capsule filter with sample water:
   a. *CH:* Ensure that the sample line is full of sample and free of bubbles; then attach the discharge end of the sample line to the inlet connector on the capsule filter.
      - Practice your technique for attaching the capsule filter to the tubing carrying flowing water so that water does not spray onto chamber walls.
      - Check that the direction of flow matches the direction of the arrow on the capsule.

   b. *DH:* Adjust the sample flow through the sample line to the capsule filter, keeping a slow rate of flow.

   c. *CH*: Turn the capsule filter so the outlet is pointing up (arrow on capsule housing is pointing up) and the flow of sample forces trapped air out while the capsule filter is filling.
      - Do not allow water to spray onto chamber walls.
      - The capsule filter should be full of sample. No air should be left in the capsule filter.

d. Field rinse bottles for inorganic-constituent filtered samples with sample filtrate (section 5.0.3). Use bottles that were already rinsed three times with DIW. Determine whether the potential clogging of pores in the filter medium is of concern for your samples (see TECHNICAL NOTE below).

CH: Fill a 250-mL FA bottle for trace elements with 25 mL of sample filtrate; cap, shake vigorously, and discard rinse water into appropriate receptacle.

CH: Fill a FA bottle for trace elements with about 200 mL of sample filtrate (to top of upper lip of 250 mL bottle). Cap bottle and set aside for chemical treatment.

CH: If a mercury sample is required, field rinse and fill a FAM bottle using the same procedure as for the 250-mL FA bottle.

CH: Field rinse remaining bottles, trying to use no more than an additional 100 mL of sample filtrate. Do not rinse the DOC bottle.

> TECHNICAL NOTE: Depending on sample turbidity and composition, the nominal pore size of filter media tends to decrease as the volume of sample passed through the filter increases because pores are clogged by sediment loading or mineral precipitation on the filter (Horowitz and others, 1994). Ground water with turbidity ≤5 NTU should not affect filter pore size appreciably. To minimize the chance of filter clogging, limit the volume of sample passed through the filter by eliminating the field rinse—be sure that you use clean bottles and fill them one after the other. For ground-water sampling, do not stop the pump during the field-rinse and sampling process.

e. *CH:* Collect sample filtrate immediately into any remaining bottles in the following sequence (flow rate should be slow enough to avoid splashing sample out of the bottle): (1) nutrients and major anions (including alkalinity sample for field titration), (2) radiochemicals (check Appendix A5-A for bottle-rinse and filtration requirements, (3) stable isotopes, (4) capsule-filtered dissolved organic carbon (DOC).

f. *CH*: Cap each bottle immediately.

Rinse FA, FU, FAM, FCA, and FCC bottles with filtered sample—not with raw sample.

Note: Page revised 2/27/2009.

After collecting filtered samples:

1. *CH*: If samples require chemical treatment, place FA bottles in the preservation chamber and go to section 5.4.
2. For filtered samples that do not require chemical treatment:
   a. *CH*: Set samples outside processing chamber.
   b. *DH*: Check that information on the bottle label is correct and complete.
   c. *DH:* Pack samples that require chilling in ice or refrigerate immediately.
   d. *DH:* Pack remaining samples for shipping (section 5.5).
3. Rinse all reusable equipment with DIW immediately—before equipment dries.
   - *CH*: If equipment will be reused at another site before returning to the office, rinse immediately with DIW and field clean tubing and other sample-wetted parts of the equipment using the prescribed cleaning procedures (NFM 3).
   - *CH*: If equipment or tubing will not be reused before returning to the office, rinse immediately with DIW and store rinsed tubing and equipment in plastic bags for office or laboratory cleaning.
4. **Discard the capsule filter after filtering each sample—do not reuse.**
5. Document the filtration procedures used on field forms and in field notes.

Use of the 0.45-µm disposable capsule filter for trace-element samples is required for many USGS programs.

5.2.1.B Plate-Filter Procedure

The filtering procedure using a 142-mm-diameter plastic plate-filter assembly is described below. The procedure remains basically the same for plate-filter assemblies of different diameters.

Prepare and precondition plate-filter assembly:

The following instructions pertain to either a 142-mm-diameter or a 47-mm-diameter plastic plate-filter assembly and require that the assembly components have been rigorously cleaned (NFM 3). To avoid recleaning in the field, prepare a set of filtration equipment for each well or surface-water sampling station. (Ignore Step 3 below if plate-filter assembly has been rinsed in the office.)

1. *CH*: Put on gloves. In a processing chamber, open a clean plate-filter assembly and load with the filter.
   a. Using nonmetallic forceps, place the bottom retaining screen on the base of the filter assembly. **Do not interchange bottom and top retaining screens.**
   b. Place the filter on top of bottom retaining screen using clean, blunt plastic or ceramic forceps. Do not touch the filter with hands (gloved or ungloved).
      - Be sure that only one filter is transferred from its original container directly to the plate of the filter assembly. Take care not to transfer the paper liner that separates each filter.
      - The filter should never be removed from the original container until each is transferred to the plate-filter assembly for use. (Exception: polycarbonate (Nuclepore) filter medium is precleaned with acid solution. If transferring one of these, hold the filter with forceps and rinse off acid with inorganic blank water (IBW) dispensed from wash bottle.)
   c. Using forceps, place the top retaining screen on top of the filter.

      TECHNICAL NOTE: If filtering sediment-laden water, a prefilter can be placed between the filter and the top retaining screen.

   d. Dispense 10 to 20 mL of DIW from a wash bottle onto the filter.

e. Close the plate-filter assembly by aligning the top and bottom plates and lightly tightening the plastic bolts, followed by finger tightening opposite pairs of bolts. **Overtightening can cause the plate-filter assembly to warp and leak.** Check that O-rings are in place before closing the assembly. Change gloves.

2. *DH/CH*: Pass the discharge end of the pump tubing through the hole in the side or top of the processing chamber. **Only the CH team member touches sections of tubing that will be in direct contact with the plate-filter assembly.**
   - Keep tubing as short as practical.
   - Attach a short piece of clean tubing to outlet connector of plate-filter assembly.
3. *DH/CH*: Rinse the plate-filter assembly with DIW, using a peristaltic pump, as follows **(rinsing must be repeated each time a clogged filter is replaced with a new filter)**:
   a. *CH*/*DH*: Place intake end of peristaltic pump tubing into a 500-mL container of DIW. Turn pump on low speed.
   b. *CH*: Open the air-vent valve on top of the plate-filter assembly. Tilt the filter assembly slightly to the side and squeeze the outlet tube closed to force trapped air out through the vent. Release the outlet tube. (Venting trapped air is necessary because air bubbles will reduce the effective filtering area by preventing sample from passing through the filter.)
   c. *CH*: Close valve when top is filled with sample.
   d. *CH*: Pump sample through the plate-filter assembly and discard this field-rinse water through the sink funnel or into the toss bottle to prevent the water from ponding in the bottom of the processing chamber.
   e. *CH*/*DH*: Remove intake end of the pump tubing from the DIW container and continue to pump, draining as much of the remaining DIW from the plate-filter assembly as possible.
4. If using a peristaltic pump to transfer the sample to the processing chamber (go to step 5 if sample delivery is with a submersible ground-water pump):
   a. *CH*: Rinse intake end of the peristaltic pump tubing with the water to be sampled.
   b. *CH*: Transfer intake end of the peristaltic pump tubing into the container of sample. If a churn splitter is used, transfer the intake end through the churn funnel and reseal the plastic bag around the tubing.

c. *CH*: Remove peristaltic pump tubing from the inlet connector of the plate-filter assembly and hold the end of the tubing over the sink funnel or toss bottle.

d. *DH/CH*: Start the peristaltic pump in the forward position at slow speed and pump sufficient sample to fill and rinse all pump tubing. Stop the pump after the tubing is rinsed.

5. *CH*: Attach the discharge end of the peristaltic-pump or submersible pump tubing to the inlet connector of the plate-filter assembly.
   - Keep tubing as short as practical.
   - A clean, small, plastic hose clamp can be used to secure the discharge tubing to the inlet connector.
6. *DH*: Start sample flow to the plate-filter assembly.
7. *CH*: Vent trapped air and rinse plate-filter assembly as instructed in steps 3 b–d above.
   - If using a peristaltic pump, turn pump on low speed.
   - If using a submersible pump, maintain a slow and steady flow rate.
8. *CH*: Rinse appropriate sample bottles once with filtrate. Filter no more than 100 mL of sample for the final rinse of all sample bottles that require rinsing.
9. Filter samples, filling bottles in the following order, as applicable to study objectives and sample designation:
   a. Trace elements/major cations

      TECHNICAL NOTE: Study objectives and data-quality requirements govern procedures to be used if the filtered trace-element sample is to reflect concentrations of analytes in true solution (the dissolved fraction). Such interpretive studies of ground-water or surface-water chemistry commonly use ≤0.1-µm filter media and plate-filter assembly or a tangential flow method of phase separation. Note that any deviation from the standard procedure for collecting filtered trace-element samples through the 0.45-µm capsule filter must be documented and reported with the analytical results.

   b. Nutrients, major anions, and alkalinity sample
   c. Radiochemicals
   d. Isotopes

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Note: Page revised 2/27/2009.

10. *CH*: If the filter medium clogs before the needed volume of water is filtered, carefully remove the filter and replace with a new filter. Repeat steps 1 through 7. Cap each bottle immediately after filling.
11. **If samples require chemical treatment ⇨Go to section 5.4.**
12. *DH*: After filtration,
    a. Check that information on the bottle label is complete and set the samples aside for shipping (section 5.5). Samples that must be chilled need to be refrigerated or packed in ice as quickly as possible and maintained at 4°C without freezing.
    b. Disconnect and disassemble the plate-filter assembly. **Discard the used filter.**
    c. Rinse all equipment with DIW immediately after use and before it dries. Equipment that has dried after sampling without being rinsed or cleaned needs to be cleaned vigorously with a detergent and rinsed with DIW before the next use. Nonmetallic equipment must also be acid rinsed.
    d. Put rinsed tubing in a plastic bag for cleaning at the office laboratory.
    e. If equipment is to be used at the next site, field clean all the equipment using the procedures described in NFM 3. Field cleaning between sampling sites is carried out while still at the sampling site.
13. Document on field forms and in field notes any modifications to the filtration procedures used.

ORGANIC COMPOUNDS 5.2.2

Standard procedure for phase separation of general trace-organic compounds involves the use of a stainless steel or aluminum 142- (or 293-) mm-diameter plate-filter assembly with glass-fiber filter media and a valveless piston or fluorocarbon polymer diaphragm-head metering pump (section 5.2.2.A). Equipment and procedures differ when filtering samples for dissolved and suspended organic carbon (section 5.2.2.C) and optionally for organonitrogen herbicide analyses (section 5.2.2.B). Required conditioning for filter media is discussed below and summarized in table 5-4.

Table 5-4. Field conditioning requirements for media used to filter samples for organic-compound analysis

[mm, millimeter; mL, milliliter; PBW, pesticide-grade blank water; sample, the water to be sampled; methanol, pesticide-grade methanol; DIW, deionized water]

Filtration equipment *Application*	Construction materials	Filter media	Filter cleaning and conditioning[1]
Plate-filter assemblies: 142 or 293 mm *General trace organic compounds*	Stainless steel or aluminum	Glass-fiber filter[2]	Wet with PBW: 10-20 mL (142 mm) or 50-75 mL (293 mm) Condition with 100-125 mL sample
Disposable capsule filter: 25 mm *Organonitrogen herbicides*	Polypropylene	Nylon	Rinse with 10 mL of methanol No conditioning
Pressure filter apparatus: 47 mm *Dissolved and suspended organic carbon*	Stainless steel or fluorocarbon polymer	Silver metal	Rinse with 100 mL PBW or District-prepared organic-grade DIW Condition with 10-15 mL sample

[1]Do not reuse filters.

[2]Use only glass-fiber filters that have been adequately baked.

The procedures for filtering samples for analysis of trace-organic compounds, including volatile organic compounds, pesticides, and base-neutral compounds, are summarized from Sandstrom (1995). CH/DH techniques and associated QA procedures for inorganic analytes with parts-per-billion concentrations are not required for organic analytes but are recommended as good field practices to maintain the integrity of sample chemistry. Field personnel must wear disposable, powderless gloves (gloves). These gloves must be able to withstand any solvents or other chemicals that will be used during sample processing and equipment cleaning. Equipment and supplies used to filter different types of organic compounds are described in NFM 2. Additional information about organic-compound filtration can be found in Ward and Harr (1990), Manning and others (1994), Shelton (1994), and Koterba and others (1995).

For revised procedures for dissolved organic carbon (DOC) refer to section 5.2.2.C.

Plate-Filter Procedure 5.2.2.A

Read through the procedures described in Sandstrom (1995) and presented in tables 5-4 and 5-5 and in figure 5-1. Obtain the equipment needed (table 5-5), test equipment operation, and collect an equipment blank if needed. Filtering samples for organic-compound analysis inside a processing chamber and using Clean Hands (CH)/Dirty Hands (DH) techniques is not mandatory but is recommended.

Table 5-5. Equipment for filtration of water-sediment samples for determination of organic compounds

[Modified from Sandstrom (1995); FEP, fluorinated ethylene-propylene; mm, millimeter; mL/min, milliliter per minute; L, liter; µm, micrometer; °C, degree Celsius]

Item	Description of equipment
	Container for unfiltered sample. Clean, laboratory-grade glass bottles with fluorocarbon polymer-FEP-lined lids.
	Fluorocarbon polymer-FEP tubing, 6.35-mm outside diameter.
	Union, 6.35-mm tube (Swagelok Company, Solon, Ohio, No. SS-400-6 or equivalent).
	Fluorocarbon polymer-FEP convoluted tubing, 6.35-mm outside diameter (Cole-Parmer Instrument Company, Chicago, Ill., No. L-06486-02 or equivalent).
	Tube fitting, 6.35-mm diameter tube to 6.35-mm diameter pipe thread (Swagelok Company, Solon, Ohio, No. SS-400-1-4 or equivalent).
	Pump, ceramic-piston, valveless, with 12-volt direct current motor, capable of pumping from 0 to 500 mL/min (Fluid Metering, Inc., Oyster Bay, N.Y., Model QB-1 CSC or equivalent).
	Battery, 12-volt direct current.
	Tube fitting, 6.35-mm diameter tube to 9.53-mm diameter pipe thread (Swagelok Company, Solon, Ohio, No. SS-400-1-6 or equivalent).
	In-line plate-filter assembly, aluminum (or stainless steel), 142-mm diameter (Geotech Environmental Equipment Inc., Denver, Colo., No. 0860 or equivalent).
	Glass-microfiber filter media, binder-free, 142-mm diameter, 0.7-µm nominal pore size (Whatman Inc., Clifton, N.J., GF/F grade, No. 1825C142 or equivalent). Note: The filters must be baked at 400°C for at least 2 hours and kept wrapped in aluminum foil before use.
	Bottle for filtered samples, amber borosilicate glass, 1 L with fluorocarbon polymer-FEP-lined cap.
	Fluorocarbon polymer-FEP squeeze (wash) bottle for organic-grade blank water.
	Stainless-steel forceps for handling the filters.

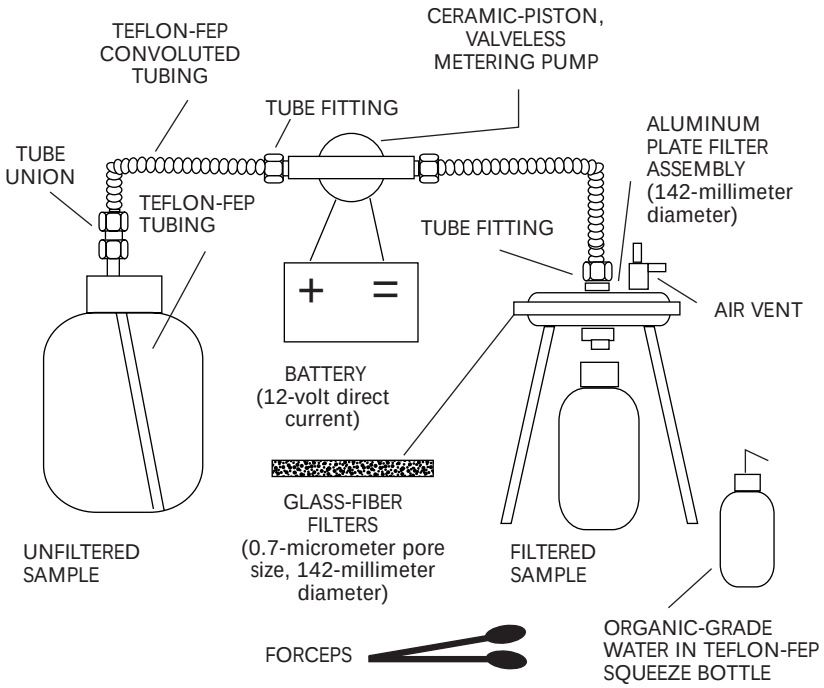

Figure 5–1. An equipment system suitable for filtering samples for analysis of organic compounds (from Sandstrom, 1995).

To filter sample for analysis of general trace-organic compounds in solution:

1. *CH/DH*: Wear appropriate (latex or nitrile) gloves throughout sample processing. Change gloves after setting up equipment. (Wearing several layers of gloves can save time.)
2. *CH*: Load the filter onto the plate-filter assembly within the processing chamber.
   a. Open precleaned plate-filter assembly.
   b. Place one stainless steel support screen on the base of the plate-filter assembly—Use stainless steel forceps.
   c. Place one clean 0.7-µm pore-size glass microfiber filter on top of the screen. **Do not touch the filter with fingers; use stainless steel forceps.**
   d. Wet the filter with a few drops of pesticide-grade blank water (PBW) from a fluorocarbon polymer wash bottle to help keep the filter in place as the unit is assembled.

e. Close plate-filter assembly—Align top and bottom plates. **Lightly tighten** the locking bolts or locking ring. Attach a short length of fluorocarbon polymer tubing to the outlet of the plate-filter assembly to channel filtrate to a toss bottle, sink funnel, or drain.

f. Add 10 to 20 mL of PBW rinse water through the inlet in the upper plate to wet the filter completely before tightening the clamps. (This rinse also helps prevent damage to the filter: a dry filter might rupture when the plate-filter assembly is tightened.)

g. Tighten the locking bolts or ring by hand. **Overtightening can cause the plate-filter assembly to warp and leak and the filter to rupture.**

3. *CH/DH*: Rinse the pump tubing (from a metering pump) or the sample tubing (from a submersible ground-water pump) with the water to be sampled. Discard rinse water into a sink funnel or toss bottle.

4. Set up the pump for filtration.

- *CH*: If using a metering pump, place intake end of tubing into the container holding the sample. Attach discharge end of pump tubing to the inlet connector of the plate-filter assembly. Use a stainless steel compression fitting of the appropriate size to secure the discharge hose to the inlet connector.
- *CH*: If using a submersible pump, attach discharge end of the sample tubing from the pump to the plate-filter assembly, keeping tubing as short as practical. Use a stainless steel compression fitting of the appropriate size to secure the discharge hose to the inlet connector.

5. *CH*: Rinse and condition the filter. The total volume of sample passed through the filter, including rinse water, needs to be accurately determined to ±1 mL and recorded in the field notes.

a. Turn on the metering pump at low speed or open the sample tubing from the submersible pump and operate at a low flow rate.

b. Open the air-vent valve located on top of the plate-filter assembly. Tilt the assembly slightly to the side to allow all trapped air to escape (vent).

c. Close the air-vent valve when water discharges through the valve.

d. Pass 100 mL of sample through the filter to remove any residual liquids from the cleaning or prewetting procedures. If concentration of organic compounds in suspended-material phase is to be determined:

   i. Capture the rinse water in a dry, clean, graduated cylinder.

   ii. Measure and record the actual volume of sample passed through the filter.

e. Discard rinse water to a sink funnel or toss bottle.

6. *DH*: Tare the weight of a clean, baked, glass sample bottle. (First check to see if this is required for the analytical procedures to be used.)
   a. Set up, level, zero, and check the accuracy of the balance with a reference weight. Record accuracy in field notes.
   b. Tare the weight of a dry, clean, capped 1-L amber bottle, and record the weight. Remove the bottle cap.
7. Filter and weigh each sample. (Do not field rinse baked, glass sample bottles.)
   a. *CH*: Resume the flow of sample through the plate-filter assembly.
   b. *CH*: Place the appropriate sample bottle under the outlet of the plate-filter assembly.
   c. *CH*: Collect approximately 1 L of filtered sample for each analytical schedule, but leave headspace in each bottle. If the filter medium becomes too clogged to proceed, go to step 13 below.
   d. *DH*: Cap the bottle(s) and pass sample(s) out of chamber. Wipe the bottle dry with a lint-free laboratory tissue, such as Kimwipe™, to remove any condensation from the outside of the sample bottle.
   e. *DH*: Weigh and record the amount of sample filtered (total weight minus tare weight of bottle).
   f. Chill samples immediately and maintain at or below 4°C without freezing for shipment to the laboratory (section 5.5).

8. *CH*: Remove as much water as possible from the inside of the plate-filter assembly by using the metering pump to pump air through the sample tubing, or by pulling water out through the outlet nozzle with a peristaltic pump, or by using a syringe to apply positive air pressure to the inlet connector. This removes any residual sample and prevents spilling the water-sediment slurry when the plate-filter assembly is disassembled.
9. *CH*: If sediment collected on the filter is to be analyzed for organic compounds:
   a. Carefully disassemble the top of the plate-filter assembly.
   b. Using metal forceps, carefully fold the filter in half and then in half again (quarters).
   c. Transfer the filter to a baked, wide-mouth glass jar with a fluorocarbon-polymer-lined cap.
   d. Record on the jar label and on field forms the total volume of sample that passed through the filter.
   e. Chill and maintain the sediment sample at or below 4°C for shipment to the laboratory (section 5.5)
10. *DH/CH*: If sediment on the filter will not be analyzed, disassemble the top of the plate-filter assembly and remove the filter with forceps. Discard the filter appropriately. Rinse the plate-filter assembly components and tubing immediately after the filter has been removed.
11. *DH/CH*: **If the equipment is to be used at a subsequent site, field clean all equipment while equipment is still wet and before going to the next site.** Clean with detergent solution, rinse with DIW, and final rinse with methanol—do not use methanol on equipment used for TOC, DOC, or SOC samples (NFM 3). If the plate-filter assembly will not be reused before returning to the office, rinse all components with DIW. Put rinsed components and tubing in a resealable bag for cleaning at the office laboratory.
12. Document on field forms and in field notes the filtration procedures used.

13. **If the filter medium becomes clogged before the required volume of sample has been collected,** stop the metering pump or divert the sample flow from the submersible pump (see TECHNICAL NOTE below) and replace the filter with a new filter as indicated in steps a through f below.

> TECHNICAL NOTE: Diverting the flow of sample being pumped with a submersible pump by use of a three-way valve can result in a temporary increase in turbidity (NFM 4). Allow turbidity to clear after reestablishing flow through the sample tubing and to the plate-filter assembly.

a. Remove as much water as possible from inside the plate-filter assembly. The stainless-steel or aluminum plate-filter assembly does not have an upper support screen, so the filter cannot be backflushed. Remove the inlet tubing to the metering pump from the sample and either attach tubing from a peristaltic pump to the outlet and pull residual water out, or use a syringe to apply positive air pressure to the inlet connector.

b. Remove the clogged filter with forceps. **If sediment collected on a filter is to be analyzed for organic compounds, follow directions in step 9**.

c. Load the plate-filter assembly with a new filter and reassemble the unit as described in step 2.

d. Prepare the filter as described in steps 2f and 5a–d, allowing the first 125 mL of sample to remove any sediment particles that may have moved below the filter during the replacement procedure. Use a graduated cylinder to measure volume.

e. Record the volume of sample rinsed through the plate-filter assembly if sediment collected on the filter is to be analyzed for organic compounds. Volume accuracy should be ± 1 mL.

f. Place a tared sample bottle under the plate-filter assembly outlet, resume the flow of sample through the filter, and continue to collect the sample filtrate.

Capsule-Filter Procedure for Processing Samples for Analysis of Organonitrogen Herbicides (Optional) 5.2.2.B

The capsule-filter procedure for filtering samples for organonitrogen-herbicide analysis described below is provided if the option to process these samples onsite is selected. The steps that follow are taken from Sandstrom (1995), which includes more detailed instructions and description of the equipment, including the 25-mm-diameter disposable nylon-media filter capsule (nylon filter):

1. Before leaving for the field site, clean the nylon filter.
   a. Put on appropriate, disposable, powderless gloves (gloves).
   b. Place intake end of the metering pump tubing into the methanol.
   c. Pump about 10 mL through the nylon filter to a used-methanol disposal container.

CAUTION: Do the following if using methanol or other organic solvent:

- **Work under a fume hood or in a well-ventilated area, NOT in the field vehicle.**
- **Wear protection against skin and eye contact and do not inhale fumes.**
- **Collect methanol rinse waste into proper disposal containers and dispose of according to local regulations.**

2. At the field site, cover the field bench or table with a sheet of aluminum foil or Teflon™ to prepare a clean work surface.
3. Place equipment and supplies on the clean work surface. Remove foil or other wrapping from precleaned equipment. Change gloves.
4. Remove the nylon filter from the plastic bag. Rinse the discharge end of the pump tubing with methanol. Discard used methanol to a proper waste container. Attach the metering-pump tubing to the capsule inlet; keep tubing as short as possible.
5. If filtering with a metering pump, transfer the intake end of the pump tubing to the sample. If using a submersible pump to collect the ground-water sample, redirect the sample flow to and from the nylon filter as needed, using a manifold flow-valve system.
6. Purge air from the sample tubing. Before connecting the nylon filter, allow ground-water sample to flow through the tubing at a very low rate. This will require just a few milliliters of sample if a metering pump is used. With sample flowing, connect tubing to the nylon filter. (Use a Luer™ connector of appropriate size to secure the discharge hose to the inlet connector.)
7. Collect at least 100 mL of filtrate in a 125-mL baked amber glass sample bottle. Do not completely fill the bottle. Allow 2–3 cm of headspace. The headspace leaves space for matrix spike standards to be added (if required) and prevents sample loss if the sample freezes.
8. If the nylon filter medium becomes clogged before a sufficient amount of sample has been filtered, replace it with a new nylon filter and repeat steps 6 and 7 until at least 100 mL have been collected.
9. When filtering is complete, cap the bottle firmly. Chill and maintain the sample at or below 4°C without freezing during storage and shipment to the laboratory (section 5.5).
10. Discard the nylon filter. Field clean the pump and tubing as described in NFM 3 before using the equipment at the next site.
11. Document on field forms and in field notes the filtration procedures used.

Procedures for Processing Samples for Carbon Analysis 5.2.2.C

Standard methods are described in this section for processing a sample for analysis of (1) total particulate carbon (TPC), particulate inorganic carbon (PIC), and particulate organic carbon (POC)[1]; and (2) dissolved organic carbon (DOC). The specific method to be used depends on the target analyte and the choice of filter type and filtration equipment, which are to be documented on field forms and in field notes.

- **TPC (Total Particulate Carbon), PIC (Particulate Inorganic Carbon), and POC (Particulate Organic Carbon).** Filtration of the sample requires a 25-mm glass-microfiber filter (see *UPDATE* below). Particulate organic carbon is determined by subtracting the laboratory-analyzed concentrations of particulate inorganic carbon from total particulate carbon; that is, POC = TPC - PIC.
- **DOC (Dissolved Organic Carbon).** Filtration of the sample requires either a quality-controlled disposable disc filter (i.e., Pall Aquaprep filter) or a 25-mm glass-microfiber filter (GF/F) (see *UPDATES* below).

For Aquaprep, One Stop item Q460FLD; For GF/F, Q441FLD

UPDATE: The NFM-5/99 version of this section (5.2.2.C) entitled "Gas-Pressurized Filter Procedures for Processing Samples for Analysis of Dissolved and Suspended Organic Carbon," which was based on a field method using silver filters, has been moved to Appendix A5-D. That method is no longer used in USGS studies as a standard procedure because of the decreasing availability of the silver filters (Office of Water Quality Technical Memorandum 2000.08).

UPDATE: Use of the Whatman large-capacity Supor capsule filter, beginning with lot # T873, was discontinued for filtration of samples for DOC analysis as of August 6, 2008, because of systematic failure in quality-control testing.

[1]POC, determined by a calculation, is distinguished from the suspended organic carbon (SOC) analysis, which is determined by direct analysis of organic carbon residue on a silver filter. USEPA method 440.0 is used for laboratory analysis of the TPC and PIC samples and also provides direct determination of total particulate nitrogen (TPN) concentration.

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Equipment and equipment-cleaning procedures

The equipment needed to process samples for analysis of TPC and PIC depends on whether the pressure-filtration method (table 5-6a) or the vacuum-filtration method (table 5-6b) will be used. The equipment options for processing samples for analysis of DOC are given in table 5-6c. (Refer to Appendix A5-D if the silver-filter method will be used to process samples for analysis of TOC, SOC (suspended organic carbon), or DOC.)

Equipment should be cleaned while still wet from sampling, preferably before leaving the field site. Immediately after each use, rinse the carbon-processing equipment at least three times with DIW and store it in a plastic bag until sampling is complete and there is time to clean the equipment using USGS standard procedures.

- Clean the carbon-collection and carbon-processing equipment according to the standard procedures described in NFM 3.3.4.C. **Do not use methanol or any other organic solvent to clean this equipment** (see TECHNICAL NOTE).
- If it is necessary to return to the office before cleaning the equipment, be sure to field rinse the equipment onsite immediately after use and then place it in a clean plastic bag for transport.
- After the equipment has been cleaned, double-wrap all apertures and the filter apparatus with aluminum foil and store them inside a sealable plastic bag for transport to the next site or storage in the office.

> TECHNICAL NOTE: Periodically check the NFM Comments and Errata page (http://water.usgs.gov/owq/FieldManual/mastererrata.html)under Chapters A3 and A5 for an update or any changes in equipment-cleaning procedures. If a circumstance arises in which methanol-cleaned equipment must be used to collect samples for DOC analysis, it is necessary to (1) record and report the total volume of water that has passed through the equipment before the DOC sample is collected, (2) collect a field blank sample for laboratory analysis by passing organic-grade blank water through the equipment, (3) collect a source-water blank for laboratory analysis, and (4) compare the laboratory results of carbon concentrations for the environmental and quality-control samples and document the results in field notes and in any report in which the DOC data are presented.

Table 5-6a. Equipment and supplies used to process samples for analysis of total particulate carbon and particulate inorganic carbon using the pressure-filtration method

[FEP, fluorinated ethylene-propylene; DOC, dissolved organic carbon; mm, millimeter; µm, micrometer; °C, degrees Celsius; mL, milliliter; in, inch; oz, ounce; lbs/in^2, pounds per square inch; mg/L, milligrams per liter; VOC, volatile organic compound]

Item	Description/Comments	Supplier or USGS One Stop Shopping Item Number[1]
FEP pressure-filtration apparatus (DOC-25)	Holds a 25-mm filter	Q444FLD
Ring stand and clamp	Holds the DOC-25 filtration unit	Open market
Filter, in-line vent, 50 mm	0.2-µm pore size; pre-filter to remove airborne particulates	Q445FLD
Peristaltic pump	Adjustable flow rate	Open market
C-Flex tubing	For use with pump	Open market
Precombusted (baked) glass-microfiber filters (GF/F)	25 mm, 0.7-µm pore size, laboratory-baked at 400°C (3 filters are required)	Q441FLD
Metal forceps, two pair	Standard metal forceps for handling filter media.	Open market
Glass cylinder	100-mL graduated cylinder, cleaned	Open market
Aluminum foil squares	6 in x 6 in	Q443FLD
Whirl-Pak bags	6 oz	Open market
Whirl-Pak bags	18 oz	Open market
Aluminum foil	Heavy duty	Open market
Cooler and ice	Standard; check with shipper for size and weight restrictions	Open market
Replacement filter-support screen	25 mm, either stainless steel or polysulfone	Pall Gelman Laboratory Part nos. 79791 or 87265
Pressure gage (optional)	Glycerin-filled, 0-30 lb/in^2, to be inverted into side of a plastic tee that is positioned in-line between the peristaltic pump and the DOC-25 filtration unit.	Cole Parmer catalog no. P-07370-70 or equivalent
Organic grade water (if using this method for DOC processing)	Laboratory analysis of the water must certify a concentration of organic carbon that is less than the long-term laboratory reporting limit for DOC (currently <0.16 mg/L). Check the laboratory analysis for the lot number to confirm that it can be used.	N1600 (Pesticide-grade blank water) or N1570 (VOC/Pesticide grade blank water)

[1]The equipment designated by the letters Q or N preceding a unique number is supplied exclusively for USGS studies through the USGS internal One Stop Shopping. The USGS performs quality-control checks for such equipment. Such equipment can be obtained for non-USGS studies on the open market or other source specified by the user. "Open market" designates equipment to be obtained from a retail or other vendor.

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Table 5-6b. Equipment and supplies used to process samples for analysis of total particulate carbon and particulate inorganic carbon using the vacuum-filtration method

[mL, milliliter; mm, millimeter; µm, micrometer; °C, degrees Celsius; in, inch; oz, ounce; FEP, florinated ethylene-propylene]

Item	Description/Comments	Supplier or USGS One Stop Shopping Item Number[1]
Filtration flask	Polypropylene, 500 or 1,000 mL	Open market
Filter funnel	Polysulfone, 25 mm with 200-mL reservoir[2]	Open market
Peristaltic pump or hand pump	Adjustable flow rate	Open market
C-Flex tubing	For use with pump	Open market
Baked glass-microfiber filters (GF/F)	25 mm, 0.7-µm pore size, laboratory-baked at 400°C (3 filters are required)	Q441FLD
Metal forceps, 2 pair	Standard metal forceps for handling filter media	Open market
Glass cylinder	100-mL graduated cylinder	Open market
Aluminum foil squares	6 in x 6 in	Q433FLD
Whirl-Pak bags	6 oz	Open market
Whirl-Pak bags	18 oz	Open market
Aluminum foil	Heavy duty	Open market
Cooler and ice	Standard: check with shipper for size and weight restrictions	Open market

[1]The equipment designated by the letters Q or N preceding a unique number is supplied exclusively for USGS studies through the USGS internal One Stop Shopping. The USGS performs quality-control checks for such equipment. Such equipment can be obtained for non-USGS studies on the open market or other source specified by the user. "Open market" designates equipment to be obtained from a retail or other vendor.

[2]The filter-support screen can be replaced with a stainless-steel screen like the one used in the FEP pressure-filtration apparatus. Contact Pall Gelman Laboratory, 600 Wagner Road, Ann Arbor, MI, 48103-9019; phone (734) 665-0651.

Do not use methanol or any other solvent to clean TPC or DOC equipment (NFM 3).

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Table 5-6c. Equipment and supplies used to process samples for analysis of dissolved organic carbon

[µm, micrometer; GF/F, glass microfiber filter; mm, millimeter; °C, degrees Celsius; FEP, fluorinated ethylene-propylene; oz, ounce; mL, milliliter; DOC, dissolved organic carbon; <, less than; mg/L, milligrams per liter; *N*, normal; VOC, volatile organic compound]

Item	Description and Comments	Supplier or USGS One Stop Shopping Item Number[1]
Disposable disc filter	Pall Apuaprep disc filter, in disposable polypropylene casing, 0.45-µm pore size; for sample size < 1 liter	Q460FLD
----------or----------	----------or----------	----------or----------
Precombusted (baked) glass microfiber filters (GF/F)	25-mm diameter, 0.7-µm nominal pore size, laboratory baked at 400°C FEP pressure-filtration apparatus or filtration flask with funnel and associated equipment is required, as indicated in table 5-6a and table 5-6b, respectively	Q441FLD
4-oz amber glass bottle, baked	Bottles (125 mL) supplied for DOC samples have been pre-cleaned and baked at 400°C and quality-controlled to meet a detection limit criterion for organic carbon of <0.1 mg/L	Q28FLD
Sulfuric acid (H_2SO_4) preservative	4.5*N*-H_2SO_4, supplied in 1-mL vials	Q438FLD
Organic-grade water	Laboratory analysis of the water must certify a concentration of organic carbon that is less than the long-term laboratory reporting limit for DOC (currently <0.16 mg/L). Check the laboratory analysis for the lot number to confirm that it can be used.	N1600 (Pesticide-grade blank water) or N1570 (VOC/Pesticide grade blank water)
Aluminum foil	Heavy duty	Open market
Cooler and ice	Standard; check with shipper for size and weight restrictions	Open market
Foam bottle sleeve	Individual bottles are slipped into foam sleeves to protect from breakage.	Q137FLD

[1]The equipment designated by the letters Q or N preceding a unique number is supplied exclusively for USGS studies through the USGS internal One Stop Shopping. The USGS performs quality-control checks for such equipment. Such equipment can be obtained for non-USGS studies on the open market or other source specified by the user. "Open market" designates equipment to be obtained from a retail or other vendor.

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TPC, PIC, and POC sample processing

The sample-processing options described below involve use of either the pressure-filtration or vacuum-filtration method. The equipment and supplies needed are listed in tables 5-6a and 5-6b, respectively. Particulate analytes (TPC, PIC, POC, SOC) are reported in units of mass per volume (milligrams per liter), and therefore **the volume of sample passed through each filter must be measured accurately and recorded on the field form and the Analytical Services Request (ASR) form**.

- The amount of water to be filtered to obtain a sufficient quantity of material for the analysis depends on the suspended-sediment concentration and/or on the concentration of humic and other substances (such as organic and inorganic colloids).
- A graph of the historical stream stage plotted against suspended-materials concentration can aid in estimating concentrations of suspended materials. Suspended-material concentrations can be used to help select the volume of sample to be filtered for a POC determination (table 5-6d).
- Record the filtrate volume passed through each filter used for particulate analysis. **This is critical for calculation of POC concentrations.**

Table 5-6d. Guidelines for selecting the volume needed for filtration of samples for analysis of suspended and particulate organic carbon
[Guidelines are based on sand-sized materials; other physical property factors and chemical composition were not taken into account; mg/L, milligrams per liter; mL, milliliters; >, greater than]

Approximate concentration of suspended materials (mg/L)	Volume of sample to be filtered (mL)
1 - 30	250
30 - 300	100
300 - 1,000	30
> 1,000	10

For TPC and PIC samples, be sure to record the total volume of water that passed through each GF/F filter.

To process samples for analysis of TPC and PIC:

1. **Sampling location and collection:** Study objectives and site characteristics determine where the sample will be collected. Follow guidelines for (1) preventing sample contamination as described in NFM 4.0, (2) using the appropriate isokinetic or nonisokinetic method as described in NFM 4.1, and (3) preparing composites and subsamples or discrete samples as described in NFM 5.0 through 5.1.1.[2] Avoid the use of methanol-rinsed equipment.

2. Select one of the following three options. (Note that the actual volume of sample needed is determined by the concentration of particulates for the specific site and not by the bottle volume.)

   - **Collect a discrete sample with a weighted bottle sampler at centroid of flow** (see NFM 4, section 4.1.1.A, VCF method)—Load the sampler with baked 125-mL DOC bottles or a 1-L baked pesticide bottle, depending on the type of sampler being used. Cap all bottles securely after they are filled with sample.

   - **Collect, composite, and process the sample through a cone splitter**—Using procedures described in 5.1.1.B, collect the TPC/PIC subsample from the methanol-free cone splitter into a baked, 1-L pesticide bottle or into three to four baked 125-mL DOC bottles. Cap all bottles securely.

   - **Collect, composite, and process the sample through a churn splitter**—Using procedures described in 5.1.1.A, collect the TPC/PIC subsample from the churn splitter into a baked, 1-L pesticide bottle or into three to four baked 125-mL DOC bottles. Cap all bottles securely.

     TECHNICAL NOTE: An experiment to test the effect of sand in the polyethylene churn splitter on particulate carbon concentrations showed that, under most sampling conditions, the abrasion of material from the churn by sand particles will result in negligible bias in the analytical results. Caution is recommended in situations where very large concentrations of sand particles coincide with carbon concentrations that are close to the analytical minimum reporting limit (MRL).

[2]The guidelines described were designed for stream sampling. These procedures can be adapted for the collection of TPC, PIC, and TPN in ground-water samples, if necessary.

ALERT! Do not field rinse the baked DOC or pesticide bottles.

3. Cover the bench or table with a sheet of aluminum foil to make a clean work surface. Put on disposable, powderless gloves. Assemble necessary equipment and supplies on the clean work surface.

   a. Fold into thirds the aluminum foil square(s) into which the filters will be placed.

   b. To remove airborne particulates, attach an in-line, 0.2-µm pore-size filter to the inlet side of a dry pump hose between the filtration apparatus and the peristaltic or hand pump.

   c. Attach pump tubing to pump.

   d. Remove the aluminum foil wrapping from the equipment.

   e. Change gloves.

4. Prepare the filtration apparatus.

   • **Pressure-filtration method:**

      a. Open the bottom of the DOC-25 filtration unit.

      b. Using metal forceps, place a 25-mm, 0.7-µm pore size, GF/F onto the support screen in the base of the DOC-25 apparatus.

      c. Push the bottom white ring that holds the filter base up against the filter unit and screw it onto the base of the filtration-apparatus barrel by screwing the blue top ring down onto the bottom white ring.

         – Finger-tighten only. Turning the bottom white ring will cause the outer edge of the filter to be cut off, making removal of the filter difficult.
         – Take care not to wrinkle or tear the GF/F.

      d. Place the DOC-25 apparatus into the ring-stand clamp. Place a bottle or beaker under the DOC-25 filtration unit.

      e. Shake the sample vigorously to suspend all particulate matter and immediately pour an aliquot of the sample into the barrel of the DOC-25 apparatus. While pouring, ensure that the particulates remain suspended.

      f. Screw the top part of the DOC-25 apparatus onto the barrel and attach the peristaltic pump tubing.

- **Vacuum-filtration method:**

  a. Place the filter funnel on the filter flask.

  b. Lift the top part of the filter funnel.

  c. Using metal forceps, place the GF/F onto the base of the filter funnel. **Make sure the filter is not wrinkled or torn.**

  d. Place the top part of the filter funnel back on the base.

  e. Shake the sample vigorously to suspend all particulate matter and immediately pour an aliquot of the sample into the filter funnel. While pouring, swirl sample to ensure that the particulates remain suspended (top of filter flask can be covered with aluminum foil while swirling sample).

  f. Attach the pump tubing from the peristaltic pump or hand pump to the vacuum flask.

5. Apply pressure (pressure filtration) or suction (vacuum filtration) to start the flow of sample water through the filtration apparatus.

   - If using a peristaltic pump to pressurize the DOC-25, install a pressure gage in the line.

     a. Do not exceed about 15 lbs. of pressure.

     b. During pumping, a drop in pressure will signal when the last of the sample water has passed through the filter.

6. After an aliquot of sample has been filtered, tap the bottom of the filter apparatus and increase the pressure slightly to dislodge the remaining drops of sample water. When no more filtrate comes out:

   a. Depressurize the filtration apparatus carefully.

      – **Pressure-filtration method**: Remove the tubing to release the pressure and then remove the top of the DOC-25 apparatus. Check that there is no water on the filter and that the filter is covered with particulates. The particulate cake should not be extremely thick.

      – **Vacuum-filtration method**: Remove the foil cover and look into the top of the filter funnel. Check that there is water on the filter and that the filter is covered with particulates.

   b. If the filter is dry but not covered with particulates, add another aliquot of sample by repeating steps 4e-f, 5, and 6a until the filter is loaded to capacity. **It is important that all the water in the barrel be passed through the GF/F, leaving the filter "dry."**

   c. After the filter is dry and covered with particulates, go to step 7.

7. Pour the filtrate into a graduated cylinder and measure and record the volume on the field form and on the "Comments to NWQL" line of the ASR form.

8. Using organic-grade water, rinse any remaining particles from the sides of the DOC-25 barrel or the sides of the filtration funnel. **Do not include the rinse water in the measured volume.**

9. Discard filtrate. **Do not send this filtrate to the laboratory for analysis of DOC.**

10. After all the organic-grade water filtrate has passed through the DOC-25 filtration unit:

    a. Remove the DOC-25 apparatus from the ring stand.

    b. Continue pumping, rotating the DOC-25 apparatus at a slight angle while tapping the side of the filtration unit to evacuate any remaining water droplets that are clinging to the sides of the filtration unit. This procedure moves droplets toward the center of the filter surface for final passage through the filter.

    c. The procedure is complete when filtrate droplets are entirely evacuated and have passed through the filter-holder funnel.

11. After completing the rinse, depressurize the filtration apparatus. Change gloves.

12. Lift the top off the filter funnel to check that the filter is dry before proceeding to carefully remove the bottom of the DOC-25 apparatus.

    a. Open the previously folded aluminum foil square and place it on the clean work surface.

    b. Gently remove the filter from the filter holder with metal forceps. Do not touch the filter with your fingers. Using two metal forceps:

        i. Place the filter so that it is centered on one of the creases in the aluminum foil square; start the fold with the forceps, then press the foil down on top of the filter to complete the fold.

        ii. Fold it in half with suspended material on the inside. Do not lose any suspended material.

Wear safety glasses when pressurizing or depressurizing a filter apparatus.

13. Repeat steps 4-12 two more times until a total of three filters (two for TPC and one for PIC) have been processed.

    - **If the same volume of sample water was filtered through all three filters,** place them all, side by side, into one aluminum-foil envelope.
    - **If different volumes have been filtered,** use either three separate, properly labeled aluminum foil envelopes or use a single packet and write the volume for each filter on the outside of the foil in which each of the filters is located.

14. Close the other flap of the aluminum foil, turning the ends up carefully.

    i. Label the aluminum foil envelope(s) with site identification, date and time, total filtered volume of sample, laboratory sample-designation code, and the laboratory schedule requested.

    ii. Do not use tape and, if a preprinted label is used, do not let it wrap around the ends of the envelope. (The envelope will be opened and used at the laboratory when drying the filters.)

15. Place labeled aluminum foil envelope(s) into small (6 oz) Whirl-Pak bag(s) and seal the bag(s).

16. Place the 6-oz Whirl-Pak bag(s) inside a large (18 oz) Whirl-Pak bag and seal the large bag.

17. Place the 18-oz Whirl-Pak package into an ice-filled cooler and maintain the samples at or below 4°C during storage and shipment to the laboratory.

For TPC and PIC analyses, record the TOTAL volume of sample that passed through each filter.

DOC sample processing

The sample-processing options described below involve filtering the sample either through a GF/F and pressure-filtration apparatus (the pressure-filtration method), or through a disposable disc filter (the disc-filter method). The pressure-filtration and disc-filter methods are described below and the equipment needed for each method is listed in tables 5-6a and 5-6c, respectively. The silver-filter method and equipment are described in Appendix A5-D.

- Use organic-grade water when collecting an equipment blank or field blank for quality control. Organic-grade water is deionized water that has been certified by laboratory analysis of the lot to have an organic-carbon concentration that is less than the laboratory reporting limit (currently at 0.16 mg/L for DOC).
- Each equipment or field blank designated for carbon analysis should be accompanied by a source blank collected from the same lot of organic-grade water as is used for the equipment and field blanks.

  The small-capacity disc filter that is in current use and quality controlled at the NWQL (One Stop item Q460FLD) has a 19.6 cm_2 effective filter area and should be rinsed with ~~100~~ 50 mL of VPBW followed by 10 mL of sample water before use. Because of its small capacity, clogging of pores in the filter media may occur rapidly and the disc filter may need to be replaced repeatedly.

- USGS designations and preservation treatment for various filtered samples are listed below. The general order of preservation is to acidify all samples requiring HCl treatment first, followed by those for H_2SO_4 treatment if nutrient samples are to be acidified, and then those for HNO_3 treatment. Wholewater samples are preserved along with their filtered counterparts. The chamber cover is changed with each change in the acid treatment.

  - FAM: filtered, acidified with HCl, for mercury analysis.
  - FCC: filtered and chilled to ≤ 4 ˚C for nitrogen and phosphorus nutrient analysis.
  - FCA: filtered, acidified with H_2SO_4, and chilled to ≤ 4 ˚C for nitrogen and phosphorus nutrient analysis.
  - DOC: filtered, acidified with H_2SO_4, for dissolved organic carbon analysis.
  - FA: filtered, acidified with HNO_3, for trace-element and major-cation analysis.
  - FAR: filtered, acidified with HNO_3, for radiochemical analysis.

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Disc-filter method:

1. Collect samples within a protective chamber that has been set up with a clean disc filter and laboratory-cleaned DOC sample bottle(s).

   a. **Surface Water:** Follow guidelines for (1) preventing sample contamination as described in NFM 4.0, (2) using the appropriate isokinetic or nonisokinetic method as described in NFM 4.1, (3) preparing composites and (or) subsamples or discrete samples as described in NFM 5.0 through 5.1.1, and (4) equipment selection and quality control as described in the TECHNICAL NOTE below.

   b. **Ground Water:** Follow standard guidelines for (1) well purging (NFM 4.2), (2) sampling (NFM 4.0, 4.2, 5.0, and 5.1.2), and (3) equipment selection and quality control as described in the TECHNICAL NOTE below. Use a clean bailer that has not contacted methanol if other sampling equipment has been methanol-rinsed. Sample collection and filtration can be conducted in the same protective chamber.

   TECHNICAL NOTE: Process the DOC sample after other filtered samples have been processed. To prevent methanol contamination of the sample, do not use methanol-rinsed collection and processing equipment, and use a fresh disc filter. Collection and analysis of field-blank and source-blank samples is recommended. If methanol-rinsed equipment must be used, collection of these blanks to correlate with each DOC sample is required, regardless of the volume of water passed through the system before DOC sample collection. Taking these quality-control measures does not remove the possibility of methanol contamination of the sample, however.

2. Change gloves. Place a 125-mL baked glass amber bottle under the disc filter outlet.

   - Do not field rinse the DOC bottle.
   - Do not splash sample water.
   - Pass ~~100~~ 50 mL of **organic-grade water** (VPBW or certified for organic-carbon concentration of less than the laboratory reporting limit) through the disc filter. If collecting a quality-control sample, go to step 3.
   - Pass at least 10 mL of **sample water** through the disc filter before collecting the DOC sample. If the filter shows signs of clogging, replace with a new disc unit.

3. Fill the bottle to its shoulder.

4. Cap the bottle and transfer it to the preservation chamber.

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5. Change gloves. Open the DOC bottle in the preservation chamber. Add the contents of a 1-mL H_2SO_4 vial to the DOC sample.
6. Cap the DOC bottle securely. Shake the sample bottle vigorously to mix the sample and H_2SO_4.
7. Remove the DOC bottle from the preservation chamber.
8. Check that the bottle is labeled correctly and completely. Place the bottle in a foam sleeve and then into an ice-filled shipping container.
9. Maintain the sample at or below 4°C without freezing (NFM 5.5).

Pressure-filtration method:

1. Collect sample(s).
   a. **Surface Water:** Follow guidelines for (1) preventing sample contamination as described in NFM 4.0, (2) using the appropriate isokinetic or nonisokinetic method as described in NFM 4.1, (3) preparing composites and (or) subsamples or discrete samples as described in NFM 5.0 through 5.1.1, and (4) equipment selection and quality control as described in the TECHNICAL NOTE below.
   b. **Ground Water:** Follow standard guidelines for (1) well purging (NFM 4.2), (2) sampling (NFM 4.0, 5.0, and 5.1.2), and (3) equipment selection and quality control as described in the TECHNICAL NOTE below.

TECHNICAL NOTE: To prevent methanol contamination of the sample, avoid using methanol-rinsed collection and processing equipment. If methanol residue is a concern, process the DOC sample either before introduction of any methanol-rinsed equipment or well after the work area has been cleared of methanol-rinsed equipment and methanol fumes. Collection and analysis of field-blank and source-blank samples is recommended. If methanol-rinsed equipment must be used, collection of these blanks to correlate with each DOC sample is required, recording the volume of water passed through the system before DOC sample collection. Taking these quality-control measures does not remove the possibility of methanol contamination of the sample, however.

2. Cover the bench or table with a sheet of aluminum foil to make a clean work surface. Assemble the necessary equipment on the clean work surface, wearing disposable powderless gloves.

   a. When using the DOC-25 filtration apparatus, remove airborne particulates as follows: attach an in-line, 0.2-µm pore-size filter (table 5-6a) to the inlet side of a dry pump hose or to the outlet between the peristaltic pump and the DOC-25 unit. If attaching the DOC-25 on the inlet side, be sure to dedicate a piece of tubing for the sole purpose of channeling air flow.

   b. Remove the aluminum foil wrapping from the precleaned equipment.

   c. Change gloves.

3. Prepare the filtration apparatus:

   a. Remove the bottom barrel of the filtration apparatus.

   b. With metal forceps, place a clean GF/F filter onto the support screen in the base of the filtration apparatus. **Make sure that the filter medium is not wrinkled or torn.**

   c. Push the bottom white ring that holds the filter base up against the filter unit and screw it onto the base of the filtration-apparatus barrel by screwing the blue top ring down onto the bottom white ring.

      – Finger-tighten only. Turning the bottom white ring will cause the outer edge of the filter to be cut off, making removal of the filter difficult.
      – Take care not to wrinkle or tear the GF/F.

   d. Open the top of the filtration-apparatus barrel and fill with approximately 100 mL of wholewater sample.

      – **For water with high concentrations of suspended materials** (usually in surface water), collect the sample into a clean baked glass bottle, cap it securely, place it on ice, and allow the suspended materials to settle; then, pour 100 mL of the clear supernatant into the filter barrel.
      – **For surface water,** the 100-mL wholewater sample can be either a subsample collected from the churn or cone splitter or the supernatant from the bottle(s) used in the weighted-bottle sampler.
      – **For ground water,** the 100-mL wholewater sample is collected directly from the pump discharge unless turbidity is high. For turbid samples, follow the procedure described above for water with high concentrations of suspended materials.
      – **For a quality-control sample,** use organic-grade blank water.

e. Screw the top part of the filter apparatus onto the barrel and attach the pump tubing.

f. Apply pressure, regulated to less than 15 lb/in^2, to start the flow of sample water through the filter apparatus.

g. Place a 125-mL clean, baked glass bottle under the discharge tube of the filtration apparatus. **Do not field rinse the DOC bottle.**

h. Fill the DOC bottle to the shoulder with sample filtrate.

- If the filter clogs before 100 mL of sample for DOC analysis can be filtered, depressurize the filtration unit, empty the remaining volume of wholewater sample from the barrel, and remove the clogged GF/F filter.
- Using clean metal forceps, replace the old filter with a new GF/F filter, following the directions from steps 3b-g above for a pressure-filtered DOC sample.

4. After the DOC sample bottle has been filled to the shoulder, cap the bottle and transfer it to the preservation chamber.

5. Depressurize and dismantle the filtration apparatus, discarding the used GF/F filter(s). Clean the apparatus immediately (while still wet), following the USGS procedures prescribed in NFM 3.3.4.C. If the apparatus cannot be field-cleaned immediately, it must be cleaned the same day it is used and before being reused—rinse it copiously with DIW and place it into a plastic bag so that it will not dry before being cleaned.

6. Change gloves before working in the preservation chamber.

7. In the preservation chamber, open the DOC bottle. Add the contents of a 1-mL vial containing 4.5*N* H_2SO_4 preservative.

8. Cap the DOC bottle securely and shake vigorously to mix the sample. Remove the DOC sample bottle from the preservation chamber.

9. Check that the bottle is labeled correctly and completely. Place the bottle into a foam sleeve and into an ice-filled shipping container (see NFM 5.5 for correct shipping procedures).

10. Maintain the sample at or below 4°C without freezing (NFM 5.5).

Wear safety glasses when pressurizing or depressurizing the filter apparatus.

11. To collect a QC sample:

    a. Use the same carbon-processing equipment after it has been cleaned (see step 5, above).

    b. Label bottles.

    c. Change gloves.

    d. Working in a clean processing chamber, process a sample of organic-grade water through the cleaned carbon-sampling and carbon-processing equipment, following the steps prescribed in steps 2-4 above. Cap securely and pass the bottle to the preservation chamber.

    e. Follow steps 6-10 above for sample preservation, handling, and shipping.

    f. Depressurize and dismantle the filtration apparatus, discarding the used filter(s). Allow the apparatus components to air dry in a clean chamber. Cover the apertures of the dry apparatus with aluminum foil and place in a clean, sealable plastic bag for storage.

Never increase the pressure in a filter apparatus to greater than 15 lb/in^2 in order to increase the rate of filtration.

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SOLID-PHASE EXTRACTION OF PESTICIDES 5.3

By **M.W. Sandstrom**

Samples collected for analysis of dissolved pesticides can be processed at the laboratory or onsite through a column containing pesticide-specific sorbents. Onsite solid-phase extraction (SPE) is useful, especially at remote sites, because pesticides isolated on the sorbent are less susceptible to degradation than when in water. Also, the SPE cartridges are less expensive to ship than water samples. However, onsite SPE is not required, and in some situations, laboratory SPE might be preferred.

All SPE methods require that the water sample be filtered (section 5.2.2.A) as soon as possible after collection. General equipment and supply needs for SPE for a broad-spectrum analysis of pesticides are listed in table 5-7 and general instructions are given in sections 5.3.1 and 5.3.2. More detailed information on SPE methods and procedures can be found in Sandstrom and others (1992), Sandstrom (1995), Zaugg and others (1995), Lindley and others (1996), and Werner and others (1996).

- Filter the environmental sample (section 5.2.2.A): this is necessary to prevent blockage of the SPE column by particulate material.
- Process the pesticide sample through an SPE column within 4 days of collection.
- Determine the reagents needed for the SPE method to be used (for example, conditioning solution, surrogate solution, and field-matrix spike solution).

Table 5-7. Checklist of general equipment and supplies required for broad-spectrum pesticide analysis by onsite solid-phase extraction

[SPE, solid-phase extraction; mm, millimeter; µL, microliter; µm, micrometer; mL, milliliter; NWQL, National Water Quality Laboratory]

✓	General equipment and supplies[1]	Description	Number required
	Aluminum foil	Heavy duty	1 box
	Blank water[2]	Pesticide grade (One-Stop Shopping)	4 L
	Filter media	Glass microfiber, 147-mm diameter, 0.7-µm pore diameter, precleaned[3]	1 per sample
	Detergent, nonphosphate laboratory	0.2-percent solution	4 L
	Glass bores	Disposable, for 100-µL micropipet	ample
	Gloves, disposable	Powderless, latex or nitrile, assorted sizes	supply ample
	Graduated cylinder or beaker	50 mL, glass	supply 2
	Luer™ connector, Tefzel™ male	P-625	1 or more
	Metering pump, valveless, piston-type	FMI Model RHB OCKC	1
	Methanol	Pesticide grade (One-Stop Shopping)	4 L
	Micropipet	Fixed volume (100 µL)	1 or more
	Nut and union, Tefzel™	P-623	1 or more
	Plastic beaker	1 L, for collecting extracted water	1 or more
	Plate-filter assembly	147-mm diameter, aluminum or stainless steel	1
	Portable balance	(Check method for weight requirements.)	1
	Sample bottles and vials (40 mL)[2]	Amber glass, precleaned	1 per sample
	SPE column adapter	(Check method requirements)	1 or more
	SPE columns, precleaned[2]	C-18: Analyticum™ C-18, 500 mg; Carbopak-B™, 500 mg; Other: as required	1 or more of each, as required
	SPE solutions[2]	(Check method requirements for conditioning, surrogate, and spike solutions)	as required by method
	Stopwatch	Standard	1
	Wash bottle, fluorocarbon polymer	250 mL, for methanol	1
	Wash bottle, fluorocarbon polymer	250 mL, for pesticide-grade water	1

[1]Filtration equipment and supplies are described in section 5.2.2.A, table 5-5, and figure 5-1.

[2]Supplies are ordered by USGS personnel from USGS One-Stop Shopping.

Replacement page 11/24/2004

SOLID-PHASE EXTRACTION BY C-18 COLUMN 5.3.1

The C-18 SPE column is used for samples that will be analyzed by capillary column gas chromatography/mass spectrophotometry with selected ion monitoring using NWQL schedule 2010 for a broad spectrum of pesticides.[8] Detailed descriptions of the method and laboratory and field extraction procedures are found in Zaugg and others (1995). For C-18 SPE processing, obtain a precleaned Analytichem™ SPE column (500 mg) and the other supplies and equipment described in the spike kit available from the NWQL (table 5-7).

Quality-control samples are required as an integral part of the sampling program.

- Process an initial field blank and then after about every 10 to 20 samples.
  - Use pesticide-grade blank water (PBW, obtained from the laboratory).
  - Process the blank in the same manner as you process the environmental water sample.
- Process a field matrix spike about every 20 samples. When processing a field matrix spike:
  - Collect duplicate samples.
  - Use a 100-µL micropipet to add the spike solution (mixture) to one of the duplicate samples. The concentration of spike solution can vary, depending on availability and the needs of the study (1 ng/µL concentration is commonly used at this time). Follow the instructions provided with the spike kit.
  - Add the surrogate to every spiked sample and an associated unspiked sample.
  - Record lot number and concentration of spike mixture on the NWQL Schedule 2010 Reporting Form (worksheet) (fig. 5-2).

[8]C-18 solid-phase extraction method is used for isolation and concentration of 41 pesticides and pesticide metabolites with concentrations of 4 mg/L or less in natural water samples (atrazine, alachlor, cyanazine, and metolachlor have upper concentration limits of 20 mg/L) (Zaugg and others, 1995).

Schedule 2010 Field Extraction Checklist and Reporting Form
U.S. Geological Survey/National Water Quality Laboratory
Solid-Phase Extraction and GC/MS Analysis Filtered Water

Station ID or Unique Number:_____ Station Name_____
Date: _____ Time:_____ Collector: _____
Telephone Number of Collector: _____
Comments: _____

NWQL INFORMATION

❑ SPE Column Brand or Type: _____
Lot #: _____
Dry weight (wt.): _____ grams (g)

ON-SITE INFORMATION

❑ Filter Sample (0.7-µm glass fiber filter)
Prior to filtration record bottle tare wt.:_____g
❑ SPE column Conditioning
Methanol (2 mL):_____milliliters (mL)
Pesticide-grade water (2 mL):_____mL

(DO NOT LET COLUMN GO DRY ONCE CONDITIONING STARTED)

❑ Sample Sample + bottle wt: _____ g
– Bottle tare wt: _____ g
= Sample wt:_____ g
Add methanol conditioner (1% of sample wt.): _____ mL
Sample + bottle + methanol: _____ g
❑ Surrogate Solution ID:_____
Volume added (100 µL): _____ µL
❑ QA Samples – Spike Mixture
Solution ID:_____
Volume added (100 µL): _____ µL
❑ Sample through column _____g
Sample + plastic beaker_____ g
Plastic beaker_____ g
❑ Flow Rate (= Sample wt. extracted/Time) _____ g
Start time _____ hr:min
Finish time_____ hr:min
❑ Remove excess water. Write station ID,date,time, on column. Store in 40-mL vial @ 4°C.

NWQL INFORMATION

Lab ID:_____ Set#:_____ Date Received_____
❑ Dry Column with N_2 or CO_2: Date:
Pressure: _____ lb/in^2
Time: _____ min
Dry SPE column wt.:_____ g
❑ SPE Elution_____ Date: _____
Add 1.8 mL elution solvent _____ mL
❑ Internal Standard (PAH-dn mixture in toluene keeper)
Solution ID:_____
Volume added (100mL): _____ mL
❑ Evaporate solvent - nitrogen
Pressure: _____ lb/in^2
Time: _____ min

Analysis: Instrument ID:_____ Date:_____
Comments:

Figure 5-2. Worksheet for C-18 solid-phase extraction of pesticides.

Prepare to process samples onsite using the C-18 SPE column:

1. Cover a bench or table with a sheet of aluminum foil to make a clean work surface. Put on appropriate disposable, powderless gloves.
2. Collect and split samples using the appropriate procedures (NFM 4; NFM 5.1; Sandstrom and others, 1995). Filter the samples as instructed in section 5.2.2. Wear gloves (usually latex or nitrile) during sample collection and processing.
3. Set up the necessary equipment and supplies and assemble them on the clean work surface. Remove the aluminum foil wrapping from the precleaned equipment.
4. Record the sampling site information, the lot number and dry weight of the C-18 SPE column, and the surrogate solution identification number on the Schedule 2010 worksheet (fig. 5-2).
5. Change gloves.
6. Tare the weight of a clean amber glass 1-L sample bottle and a 1-L plastic beaker to the nearest gram using an analytical balance and record the weights on the Schedule 2010 worksheet.

Extract the sample:

Use the appropriate surrogate solution mixture supplied by the NWQL for the C-18 SPE method with each environmental sample.

SAMPLE EXTRACTION SHOULD BE COMPLETED ONSITE, IF POSSIBLE. If onsite extraction is not possible, extract the sample within 4 calendar days of collecting the sample.

1. Condition the SPE column:
   a. Pipet 2 mL of pesticide-grade methanol into the C-18 SPE column and allow it to flow through the column by gravity. Collect the methanol rinse in a proper container for disposal.
   b. Remove any excess methanol by rinsing approximately 2 mL of PBW, by gravity, through the column. The rinse water/ methanol mixture must be disposed of according to local, State, or Federal regulations.

c. **Do not allow the SPE column to go dry once the conditioning has started.**

- If the column goes dry, repeat the conditioning process.
- To keep the column from drying out once the conditioning has started, maintain water in the C-18 SPE column by replacing water that drained through the column. Alternatively, attach an on/off valve-to-column outlet to prevent complete draining before the sample is extracted.

2. Following the filtration instructions for general organic compounds (5.2.2.A or Sandstrom, 1995), pass about 1 L of sample through the a glass microfiber filter into the tared bottle, leaving about 2 cm of headspace.
3. Weigh the filled bottle and record the weight on the worksheet (fig. 5-2).
4. Add about 10 mL of methanol to the filtered sample using the bottle-top dispenser or a volumetric pipet. Weigh and record the sample-plus-methanol weight on the worksheet.
5. Add the surrogate solution contained in the 2-mL amber screw-cap vial to the filtered sample as follows (refer to Spike Kit Instruction Manual for detailed information and instructions on use of a micropipet):
   a. Withdraw the surrogate solution from the 2-mL amber screw-cap vial using a clean 100-µL micropipet and a clean glass bore.
   b. Insert the tip of the glass bore into the sample bottle below the surface of the sample, and depress the plunger to deliver the surrogate to the sample. (Tip the bottle on its side, if necessary, to reach below the surface of the sample with the glass bore.)
   c. Keeping the plunger depressed, swirl pipetor in water several times and then withdraw the micropipet from the bottle. Release the plunger, then remove the used glass bore from the micropipet and discard properly.
   d. Rinse the fluorocarbon polymer tip of the micropipet with methanol.
   e. Add the field-matrix spike as dictated by the study's quality-assurance plan, as required.
   f. Cap and swirl the sample to mix the sample + surrogate. (For spiked samples, mix sample + surrogate + spike solution.)
   g. If a duplicate will be submitted for analysis, repeat steps 5a–f on the duplicate sample.

6. Extract the sample through the SPE column using a metering pump fitted with 3.18 mm (1/8 in.) fluorocarbon polymer tubing with appropriate connectors (Sandstrom, 1995; NFM 2).
   a. Insert clean tubing from the inlet side of the pump into the sample bottle.
   b. Turn on the pump, flush air from the tubing (be careful to minimize any sample discharge from the end of the tubing), and then attach the outlet side of the tubing to the small end of the SPE column.
   c. Invert the SPE column to drain any remaining conditioning water left in the SPE column reservoir.
   d. Begin extraction by pumping the sample through the column at a rate of 20 to 25 mL/min and collect the extracted water into the tared 1-L plastic beaker.
7. After the sample has been pumped through the SPE column, turn the pump off and disconnect the column.
8. Remove excess sample from the SPE column using a syringe with 10 to 20 mL of air to push excess sample into a plastic beaker.
9. Weigh the beaker containing the volume of sample extracted through the SPE column. Subtract the tare weight of the beaker from the weight of the beaker plus the extracted sample and record this weight on the worksheet.
10. Write the sample identification number and the sampling date and time on the side of the SPE column. Place the SPE column into a 40-mL glass or plastic shipping ampoule and wrap it in aluminum foil.
11. Finish filling out the worksheet (fig. 5-2). Wrap the completed worksheet around the shipping ampoule and secure it with a rubber band or tape. Place in a sealable plastic bag.
12. Chill the SPE column immediately and maintain between 4°C and 25°C during storage and shipping.
13. Keep a copy of the worksheet for the field folder.

14. Field clean all equipment, including the pump and tubing, immediately after use and before going to the next site (NFM 3).
    a. Rinse thoroughly with about 50 mL of a 0.2-percent solution of a phosphate-free laboratory detergent, followed by about 50 mL of tap water (or DIW) to remove the detergent.
    b. Final rinse with about 30 to 50 mL of methanol. Collect used methanol into an appropriate container for disposal.
15. After cleaning, wrap all the equipment apertures with aluminum foil.

Ship the SPE column to the laboratory immediately. Elution from the SPE column must be completed within 7 days of extraction.

5.3.2 INSTRUCTIONS FOR FIELD USE OF SPIKE SOLUTIONS FOR ORGANIC-ANALYTE SAMPLES

-This section replaces Solid-Phase Extraction by Carbopak-B™ Column (no longer in use by the USGS NWQL).

.To view the Instructions for Field Use of Spike Solutions for Organic-Analyte .Samples, see Section 5.3.2 in the Chapter 5 html page.

. (Page revised 8/10/2009.)

SAMPLE PRESERVATION 5.4

By **D.B. Radtke**

Sample preservation is the measure or measures taken to prevent reduction or loss of target analytes. Analyte loss can occur between sample collection and laboratory analysis because of physical, chemical, and biological processes that result in chemical precipitation, adsorption, oxidation, reduction, ion exchange, degassing, or degradation. Preservation stabilizes analyte concentrations for a limited period of time. Some samples have a very short holding time. **Verify that time-dependent samples were received in proper condition, at the correct temperature, and that holding times were not exceeded by contacting the laboratory.**

Some samples must be preserved by filtration (section 5.3) and (or) chilling and (or) chemical treatment (Appendixes A5-A through A5-C). The preservation required for a given sample is described by the analyzing laboratory; for the NWQL, consult the laboratory for sample-preservation instructions.

- Before going to the field site and again at the field site:
  - Check the sample-designation code required for each sample.
  - Check sample requirements for chilling and chemical treatment.
  - Check with the laboratory and make note of holding time restrictions.

CHILLING 5.4.1

Immediately following sample collection and processing, samples that require chilling must be packed in ice or placed in a refrigerator and maintained at 4°C or less, without freezing, until analyzed.

- Check that there is sufficient headspace in the sample bottle to allow for sample expansion.
- Put foam sleeves around samples in glass bottles before packing them in ice.

- **Include a temperature check sample in the shipping container.**
  - Fill a polyethylene bottle with tap water, cap it securely, and label it "Temperature Check Sample," along with the site identification and the date(s) and time(s) of sampling and shipping.
  - Prepare a self-addressed, stamped postcard that is labeled "Temperature Check Sample report." The postcard should include the site information, date(s) and time(s) of sampling and shipping, and a space for the laboratory to record the arrival temperature of the check sample.
  - Put the postcard into the sealable plastic bag with the ASR form. The laboratory will record the temperature of the check sample upon arrival and will complete the card and return it to the sender.
  - Use this information to document that samples were maintained at 4°C or less.

Pack a temperature-check sample with other chilled samples.

Chilled Samples

[This list of samples that require chilling is not comprehensive—check with the analyzing laboratory. These samples must be refrigerated or placed on ice immediately and maintained at or below 4 degrees Celsius without freezing.]

Chemical classification	USGS sample-designation codes[1]
Organic compounds	VOC, GCC, TOC, DOC, SOC, RCB, LC0052, SH 2010, SH 2051, SH 2001, SH 2050
Nutrients	WCA, FCA, FCC
Chemical Oxygen Demand (COD)	LC 2144
Cyanide	LC 0880, LC 0023
$^{15}N/^{14}N$	RUS; LC 1717, LC 1718
^{14}C	RUR/RUS; LC 1199

[1]These sample-designation codes are unique to the USGS and are subject to change.

CHEMICAL TREATMENT 5.4.2

Chemicals used for sample preservation depend on the target analyte (Appendixes A5-A, A5-B, and A5-C). The most frequently used chemical preservatives by the USGS are provided in individual ampoules and contain one of the following: ultrapure nitric acid (HNO_3), hydrochloric acid (HCl), sulfuric acid (H_2SO_4), sodium hydroxide (NaOH), or phosphoric acid/copper sulfate ($H_3PO_4/CuSO_4$). The National Water Quality Laboratory can provide a complete list of sample treatments, along with sample designations and container requirements. The preservatives are procured from One-Stop and come with a quality-control certificate of analysis for selected constituents. Keep the certificate of analysis in the study data file to help with future interpretation of quality-control and environmental data.

Take steps to minimize sample contamination and maximize safety during the preservation process (Horowitz and others, 1994; Shelton, 1994; Koterba and others, 1995; Timme, 1995). Note that a chemical preservative for one sample may be a source of contamination for another. To help reduce contamination during the preservation process and ensure proper handling of chemicals:

- Work inside a preservation chamber (only the Clean Hands person works inside the chamber). **Change gloves and the cover of the portable preservation chamber each time a different type of chemical treatment is used**. Clean Hands/Dirty Hands techniques must be used for parts-per-billion levels of trace elements and are recommended for use in general and as appropriate for the study.
- Use preservatives packaged in individual ampoules for routine preservation. Be aware that preservatives dispersed from dropper-type bottles or automatic pipets could become contaminated and could result in the contamination of subsequent samples.
- Use the grade of preservative appropriate to meet data-quality requirements. (Check the certificate of analysis for the method detection limit and the concentration of the target analytes of interest.)

Replacement page 11/23/2004. (In the first paragraph, the preservatives are procured from the USGS One-Stop Shopping in place of QWSU.

- Always store preservatives in separate, sealed containers, preferably away from each other, and away from environmental and quality-control samples.
- Store spent preservative ampoules, containers, and supplies separately in closed and labeled containers (such as screw-cap bottles) until they can be disposed of properly.
  - Use a separate ampoule-waste container for each type of chemical preservative.
  - Store used gloves and chamber covers in a closed container, such as a pail with a lid, until proper disposal can be arranged.
- Follow a prescribed order in which samples are to be preserved (the recommended order is described in the steps below).

CAUTION: Before handling any chemical, refer to the Material Safety Data Sheet (MSDS) for safety precautions. Wear appropriate gloves, safety glasses, and apron when working with corrosive or oxidizing solutions.

For chemical treatment and handling of samples, follow the recommended sequence and procedure described in the steps that follow:

1. Put on appropriate disposable, powderless gloves.
2. Set up preservation chambers and assemble equipment and solutions in the order in which they will be used. If nitric acid is the only chemical preservative being used, the processing chamber can be used as a preservation chamber after all the filtered samples have been removed from the chamber.
3. Rinse the outside of each preservative ampoule with DIW and dry with a laboratory-grade, lint-free paper towel (for example, Kimwipe™).
4. For organic-compound samples:
   a. Change gloves.

Note: This section is being revised. Change the order of preservation described on pages 93-94 to the following:
1. Nutrients (4.5-N H2SO4)
2. Organic carbon (4.5-N H2SO4)
3. Trace elements and major cations (HNO3)
4. Mercury (6-N HCL) followed by other samples that require HCL
5. Remaining samples that require chemical treatment.

b. Place inside the preservation chamber the required organic-compound samples, chemical preservatives (treatments), and ampoule-waste containers. Common treatments include hydrochloric acid, sulfuric acid, or phosphoric acid/copper sulfate. **(VOC samples that are to be chemically treated can have the acid preservative added to the sample within the processing chamber as long as subsequent samples are not contaminated (section 5.1.2 and Appendix A5-A).**

c. Change gloves.

d. Uncap the sample bottle and dispense the appropriate chemical treatment into the sample. Place any spent ampoule into the appropriate ampoule-waste container.

e. Immediately recap the sample bottle and invert the bottle about five times to mix. **Vials with septum-lined caps for VOC must have no headspace.**

f. Repeat steps b, c, and d for each type of chemical treatment, if necessary, changing gloves and chamber cover each time. Make sure there is headspace in all glass bottles except for the vials for volatile organic compounds (VOC).

g. Chill all organic samples (treated and untreated) immediately and maintain them at 4°C during storage and shipment to the laboratory (section 5.5).

5. For inorganic-constituent samples:

a. Change gloves.

b. Change the chamber cover. Set up additional preservation chambers, if practical. (For example, one chamber for nitric acid treatments and a separate one for potassium dichromate treatment.)

- Transfer samples requiring chemical treatment to the preservation chamber.
- Place the first preservative and its waste container inside the chamber.
- Change gloves.

c. Add chemical treatments to samples as follows:

i. Major, minor, and trace cation samples: Add contents of the vial containing 1-mL HN03 to the samples designated RA or FA (Appendix A5-B). Place the spent vial into the HNO3-vial waste container.

ii. Mercury sample(s): Add contents of the vial containing 2 mL of 6N ultrapure HCl to the sample(s) designated RAM or FAM (Appendix A5-B). Place spent vial into the HCl-vial waste container.

The correct (9/2004) order of sample treatment: (1) nutrients, (2) organic carbon, (3) trace elements, (4) major ions, (5) mercury, (6) other acid-preserved samples, HCL first, (7) other.

iii. Change chamber cover and change gloves.

iv. Nutrient samples designated WCA or FCA (Water Quality Technical Memorandum 99.04):

- Place sample bottles into chamber.
- Add contents of the 1-mL 4.5-normal H_2SO_4 ampoule to 125-mL samples designated as WCA or FCA (Appendix A5-B). Place the spent ampoule into the H_2SO_4 ampoule waste container.
- Chill samples to 4°C or below without freezing immediately after adding the sulfuric acid.

v. Change chamber cover and gloves. Place bottles requiring other acid treatments into the chamber, along with the necessary chemicals and chemical-waste containers. Add the hydrochloric or other acid treatments to the samples. Place spent ampoules in appropriate waste containers.

vi. Remaining samples (Appendixes A5-B and A5-C): Change the chamber cover and change gloves for each type of treatment (for example, zinc acetate, sodium hydroxide, copper sulfate).

d. Tighten the cap on the bottle immediately after adding the chemical treatment and invert about five times to mix.

- Chilled samples must be put on ice and shipped to the laboratory immediately.
- Emptied ampoules must be stored in designated waste or recycle containers.

6. Disassemble and clean the chamber frame.
   a. Remove the disposable cover from the chamber and the work area.
      - Collapse the plastic cover while outside of the field vehicle.
      - Tie a knot in the cover to close it.
      - Dispose of the cover as regulations require.
   b. Clean the chamber frame, if necessary.
7. Document in field notes the preservation procedures and chemical treatments used.
8. Spent ampoules should be collected and, at the end of each field trip, disposed of according to Federal, State, and local regulations. (The District safety officer and water-quality specialists can be consulted for proper ampoule-disposal methods.)

HANDLING AND SHIPPING OF SAMPLES 5.5

By **D.B. Radtke**

Samples should be packaged and shipped to the laboratory for analysis as soon as possible. Generally, the shorter the time between sample collection/processing and sample analysis, the more reliable the analytical results will be. Before shipping samples to the laboratory:

- Check that sample bottles are labeled correctly.
- Complete an Analytical Services Request (ASR) form.
- Pack samples carefully in the shipping container to prevent bottle breakage, shipping container leakage, and sample degradation. Check that the bottle caps are securely fastened.

Protocols for labeling, documenting, and packaging samples established by the receiving laboratory must be followed. **Obtain authorization from the laboratory before shipping highly contaminated or potentially hazardous samples for analysis.** A summary of procedures for shipping samples to the NWQL is outlined below. Office of Water Quality Technical Memorandum 92.06 and National Water Quality Laboratory Technical Memorandum 95.04 give detailed instructions on shipping procedures.

LABELING SAMPLE BOTTLES 5.5.1

Each sample bottle must be correctly labeled with the station identification number, date, time, and sample designation. Sample designation is established by the laboratory. Laboratory codes that are added or deleted from the analytical schedule requested should be recorded on the ASR forms that accompany the samples—**not on the sample bottles.**

1. Label each bottle with a permanent, waterproof marker, or use preprinted labels that will remain securely attached to the bottles, even if they become wet.

2. Write legibly and include as a minimum the following information:
   - Station identification number.
   - Date and time of sample collection.
   - Sample designation code (Appendixes A5-A through A5-C).

A bottle with an unreadable label or no label is a wasted sample.

5.5.2 FILLING OUT AN ANALYTICAL SERVICES REQUEST FORM

Each set of samples must include an Analytical Services Request (ASR) form. To ensure correct processing of samples, the information recorded on the ASR form must correspond to each sample in the shipment.

- **Never send a sample to the NWQL without an ASR form** (forms are available through DENSUPPL).
- **Information recorded on ASR forms must be legible** and completed in permanent ink or by computer.

Fill out the ASR form as follows, including as much information about the sample(s) as possible:

1. Record mandatory information:
   - Station identification number and (or) unique number
   - Telephone number at which field personnel who collected the samples can be reached
   - Name of study chief and (or) field personnel
   - State and District user codes
   - Project account number
   - Date and time at beginning of field trip
   - Schedules and laboratory codes of the analytical work requested for submitted samples

2. Record the Sample Medium, Analysis Status, Analysis Source, Hydrologic Condition, Sample Type, and Hydrologic Event information. This information is mandatory if the analytical results are to be stored in the USGS National Water Information System (NWIS) data base.
3. Record the field-measurement values of specific electrical conductance (conductivity), pH, and field alkalinity (or acid neutralizing capacity).
4. In the comments section of the form, add information that needs to be brought to the laboratory's attention. **Be sure to note if the samples are potentially hazardous or highly contaminated so that proper precautions can be taken by laboratory personnel.**
5. At the bottom of the ASR form, list the total number of sample bottles for each sample-designation code.
6. To prevent water damage to paperwork accompanying samples to the laboratory (such as the ASR form and the temperature-check postcard), place all paperwork inside two sealable plastic bags. In coolers, tape the bags containing the paperwork to the underside of the lid.
7. Keep a copy of the completed ASR forms in the study files.

Add a bold cautionary note to the ASR form if samples could contain hazardous concentrations of contaminants.

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5.5.3 PACKAGING SAMPLES

When packaging samples for shipment to the laboratory, remember that all bottles must be protected from breaking (especially glass bottles) and (or) leaking. The laboratory usually will return with the cooler reusable packing materials such as mesh bags, foam sleeves, and bubble wrap. Plastic bags and cardboard boxes will not be returned. **Do not use foam peanuts or vermiculite.**

When packaging samples:

1. Make sure bottle labels are waterproof and that information is legible.
2. Tighten all bottle caps to prevent leakage.
3. Line all shipping containers, including those without ice, with doubled heavy-duty plastic bags.
4. Use adequate packing material to prevent bottle breakage.
   - Ship all glass bottles in foam sleeves or wrap them with bubble wrap.
   - Enclose each sleeved FAM and RAM bottle in two sealable plastic bags.
   - Pack bottles so that they do not touch each other.

Sample integrity must be maintained. Ship samples with enough ice to keep chilled at 4°C or below without freezing until the sample is logged in at the laboratory.

5. Pack samples designated for chilling in coolers.
   a. Use insulated ice chests (coolers) (1- to 5-gallon sizes are recommended). Larger volumes of chilled samples can be sent in coolers as long as the carrier's maximum weight and size restrictions are not exceeded. **Do not use broken or leaky coolers.**
   b. Pack samples designated for chilling with ice.
      - The volume of ice should be equal to or greater than the volume occupied by samples (twice the volume of ice to samples is recommended during warm temperatures).
      - The amount of ice necessary will vary depending on the length of time in transit and ambient air temperature. Chilling the cooler and samples prior to shipment is recommended in hot weather.
      - **Do not use blue ice or other types of commercial refreezing containers that have freezing points below 0°C.** This can cause bottles to freeze and result in ruined samples or broken bottles.
      - Enclose ice and samples in doubled plastic bags. **Do not mix ice with water-absorbent packing materials.**
   c. Seal cooler spouts or drains, preferably with silicone or epoxy.
6. Samples not requiring chilling can be shipped in heavy-duty cardboard boxes but may also be shipped in coolers.

DO NOT USE

— foam peanuts or vermiculite as packing material.

— dry ice to keep samples chilled.

7. When shipping multiple sets of samples in the same container, label each set of sample bottles with a different letter of the alphabet (A, B, C) so that bottles of each sample set will have the same letter.
   - Print the letter in the upper right-hand corner of the ASR form for that particular sample set.
   - Place all bottles from a sample set into a separate bag (such as plastic or mesh) or bind with a rubber band to keep them together.

8. All bottles for a particular schedule should be sent in the same shipping container, with some exceptions. Samples that do not need to be chilled can be packed and shipped in the cooler with chilled samples, provided the following exceptions do not apply. The ASR form must list only those samples that are being shipped with that form. On the ASR form, delete laboratory codes of any sample bottles not included in the same shipping container.
   - **Exception: Do not ship nutrient samples with samples that were treated with HNO_3.**
   - **Exception:** Do not ship FAM and RAM samples in the same container as FA or RA samples when requesting sample analysis for potassium and (or) chromium concentrations.
9. After samples and ice (if required) are placed in doubled plastic bags, close each bag separately with a knot.
10. Inside coolers:
   - Include a return address shipping label with the ASR form. This label must include a street address (not a post office box number), an account number, and the USGS District User Code (to bill return-shipping charges).
   - Label the inside of each cooler and cooler lid with a current return address and telephone number, using a permanent waterproof marker.
11. Include the ASR form for each sample set shipped in each cooler or box.
   - Remember to place the ASR form and temperature-check postcard into two sealable plastic bags to prevent water damage.
   - Tape the plastic bag containing the ASR form(s) and temperature-check card to the underside of the cooler lid, or place the sealed paperwork on top of samples packed in a cardboard box.

SHIPPING SAMPLES 5.5.4

Whenever possible, ship samples to the laboratory on the day of collection. Check laboratory hours of operation—keep in mind that the laboratory might not receive samples on Saturdays, Sundays, or holidays. The integrity of chilled samples sent late on a Thursday or on a Friday could be compromised if not received by the laboratory in time to be unpacked and refrigerated. Check planned arrival time before selecting the carrier service.

- No carrier service will accept or deliver leaky boxes or coolers. Securely tape the outside of shipping containers to prevent leaking and to maintain container integrity.
- Do not exceed maximum weight and size restrictions set by the carrier service.
- When shipping a single set of samples in multiple containers, mark the outside shipping label with the number of containers being shipped (such as 1 of 2, 2 of 2).
- Comply with the carrier service's requirements for meeting U.S. Department of Transportation regulations for transporting hazardous substances.
- **Identify samples that require special shipping procedures:**
  - Send chilled samples to the laboratory by the fastest means possible.
  - Some samples require special handling and shipping (such as radon and CFC samples). Contact the laboratory for specific instructions.
  - Obtain authorization from the laboratory before sending any highly contaminated or potentially hazardous samples to the laboratory for analysis.

Document date of sample shipment on the copy of each ASR form. Keep a copy in study files.

5.6 SUMMARY OF SAMPLE-COLLECTION AND SAMPLE-PROCESSING PROCEDURES FOR SPECIFIC ANALYTES

By **F.D. Wilde and Jacob Gibs**

Collection methods, equipment needs, and preservation requirements for specific analytes can change over time, owing to advancements in knowledge and technology. Any major changes to sample collection and processing procedures will be announced on the USGS Office of Water Quality Web site (http://water.usgs.gov/lookup/get?owq/) or as a technical memorandum (http://water.usgs.gov/lookup/get?techmemo/). Consult NWQL or the District water-quality specialist for instructions related to the collection, processing, or analysis of solid materials, gases, biota, and any other analytes not described in this manual. Chemical formulas used in this section are spelled out in "Conversion Factors, Selected Terms, Abbreviations, and Chemical Formulas."

5.6.1 COMMON ORGANIC COMPOUNDS

Sample bottles for organic-compound analyses are precleaned and baked at the laboratory and should be received capped. Collect and process samples within processing and preservation chambers, as appropriate, and while wearing disposable, powderless latex or nitrile gloves. In general, change gloves between each collection and processing step and with each new sample type. After collection and processing, check that the information is correct on the bottle label. Place the filled glass sample bottle in a foam sleeve and chill sample to 4◦C or below without freezing.

- Most samples for organic-compound analysis are collected in 1-L amber glass bottles, leaving headspace in case of sample expansion (Appendix A5-A).

Note: Section 5.6.1.F, "Wastewater, Pharmaceuticals, and Antibiotic Compounds" must be accessed as a separate file (see Contents page for Chapter A5).

- Samples for glyphosphate analysis are collected in 40-mL vials, leaving headspace in case of sample expansion.
- Volatile organic compounds are collected in 40 mL baked glass vials without headspace.

Do not field rinse bottles prepared for organic-compound samples.

5.6.1.A Volatile Organic Compounds (VOCs)

Label baked 40-mL amber glass vials as "VOC." Collect three vials per sample for ground water and four vials per sample for surface water.

- **Do not use tape on the vials.** Tape causes the autosampler to jam.
- **Do not aerate the sample.** Samples with air bubbles must be discarded.

TECHNICAL NOTE: **Some programs, such as NPDES and NAWQA, require treatment of VOC samples by adding HCl.** To determine the number of HCl drops needed to lower sample pH to ≤2 before collecting the sample, collect a test sample toward the end of purging and pour 40 mL of the sample into a beaker or spare VOC vial. Check the pH (use narrow-range pH indicator strips such as pHydrion™) after each addition of 2, 3, and 4 drops. Do not use pH indicator strips that are old or expired.

To collect VOC samples:

1. Insert the fluorocarbon polymer discharge line from the pump or the bailer emptying device to the bottom of the vial; flow should be smooth and uniform (between 100 and 150 mL/min).
   - If the vial was supplied with chemical treatment, do not fill vial to overflowing.
   - If no chemical treatment will be added or if the treatment will be added after the vial is filled, allow sample to overflow the vial in order to help purge air from the sample.
2. Slowly withdraw the discharge line from the bottle; slide the discharge line to the side of the vial as the line is about to clear the vial so as to avoid breaking the water surface. Leave a convex meniscus.

3. Add chemical treatment (HCl) to sample if required by the program and if the HCl is not already in the vial. Add 2 to 5 drops (see TECHNICAL NOTE above) of 1:1 HCl:H_2O, drop by drop, to the filled vial to lower the pH to ≤2. Dispense the HCl from a fluorocarbon polymer dropper bottle. **Do not add more than 5 drops of HCl**.
4. If residual chlorine is present, add 25 mg of ascorbic acid to the vial in addition to the HCl.
5. Replace the vial cap immediately. Do not allow the samples to degas. The fluorocarbon polymer (white) side of the septum in the cap should contact the sample.
6. Invert the vial and tap the vial to release any bubbles. Check carefully for gas bubbles in the sample. If gas bubbles are present, discard the sample vial and resample. If degassing of the samples makes excluding bubbles impossible, record this on the field forms and the laboratory ASR form and report an estimate of the relative volume of bubble(s) in the sample.
7. Protect the sample from sunlight. Chill and maintain at 4°C or below without freezing.

Semivolatile Organic Compounds (Base-Neutral Acids), Pesticides, Organonitrogen Herbicides, Polychlorinated Biphenyls (PCBs) 5.6.1.B

Label 1-L baked glass bottles as "GCC." Add the laboratory code, if required. Certain analytical schedules require a filtered sample (check with the laboratory for processing and bottle requirements).

1. Fill to the shoulder of the bottle directly from the sampling, splitting, or filtering device.
2. Be sure to leave headspace in the bottle.
3. Chill and maintain at 4°C or below without freezing.

Instructions for field solid-phase extraction (SPE) of pesticides are provided in section 5.3. Field SPE is an alternative method for processing samples for pesticide analysis and should be considered in situations where transporting glass bottles, shipping weight, or holding/shipping times pose a problem. Field SPE samples usually are extracted after most other onsite activities are completed or by a third team member because equipment setup, sample extraction, and equipment cleaning can be quite time consuming.

REPLACEMENT PAGE

5.6.1.C Phenols (Modified 4/2004)

Label two 500-L baked amber glass phenol bottles as "LC2322" -NWQL TechMemo 99.03

1. Fill two 500-mL baked amber glass bottles with raw sample directly from the sampling or splitting device.
2. Leave a small headspace in the bottle.
3. Add 1 mL H_2SO_4 to the sample to achieve pH <2. If chlorine is suspected in the sample water, add 0.5 mL of a 100 g/L (or 1 mL of a 50 g/L) $FeSO_4$ solution.
4. Chill and maintain at or below 4°C without freezing.

5.6.1.D Carbon

Particulate organic and inorganic carbon[10]***:***

1. Label the samples for Total Particulate Carbon (TPC) as "LC2606" and for Particulate Inorganic Carbon (PIC) as "LC2608." Note that the concentration of Particulate Organic Carbon (POC, LC2611) is calculated as the difference between TPC and PIC.
2. Refer to the detailed instructions given in section 5.2.2.C for processing the TPC and PIC samples.

Raw (TOC) sample:

1. Use 125-mL baked glass bottles. Label the sample for total organic carbon "LC114."
2. Pour, discharge, or pump the raw sample directly into the sample bottle, up to the shoulder of the bottle (leave headspace).

[10]The analysis for total particulate nitrogen (TPN), LC2607, is performed on the TPC sample upon request.

Filtered (DOC) and suspended (SOC) samples:

1. Label the DOC sample as follows: (a) "LC2612" if processed through a disposable disc filter; (b) "LC2613" if processed through a GF/F; and (c) "LC113" if processed through a silver filter.
2. Refer to the detailed instructions given in section 5.2.2.C for processing DOC using either the disc or GF/F filtration procedures. Fill the 125-mL baked glass bottle to the shoulder—allow enough heasdspace for the addition of 4.5*N* H_2SO_4 and the expansion of the chilled sample. Refer to the instructions given in Appendix A5-D if using the silver-filter procedure.
3. Label the SOC sample as "LC305." Refer to the detailed instructions given in Appendix A5-D for the silver-filter procedure. LC305 is available only as a custom analysis.

Methylene Blue Active Substances (MBAS) and Oil and Grease 5.6.1.E

MBAS:

1. Label a 250-mL polyethylene bottle as "RCB."
2. Field rinse the bottle and fill with raw sample.
3. Chill and maintain at 4°C or below without freezing.

Oil and grease:

1. Label a 1-L baked amber glass bottle as "LC0127."
2. Do not field rinse; fill with raw sample, leaving a small headspace.
3. Add approximately 2 mL of sulfuric acid to reach a pH <2.
4. Chill and maintain at 4°C or below, without freezing.

MAJOR IONS AND TRACE ELEMENTS 5.6.2

Bottles (including acid-rinsed polyethylene and glass bottles) used to collect samples for analysis of major ions and trace elements should be rinsed and partially filled with DIW before they are used at the field site, as instructed in NFM 3. Exceptions apply when collecting samples for analysis of isotopes or radiochemicals—consult the isotope laboratory. Collect and process samples within processing and preservation chambers, as appropriate, and while wearing appropriate (for example, vinyl) disposable, powderless gloves. In general, change gloves between each collection and processing step. After collection and processing, check the bottle label for correct information and place glass bottles into foam sleeves.

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- Use acid-rinsed bottles (for cations) only if they arrive capped with colorless translucent caps. Do not use any acid-rinsed bottles that are received uncapped.
- Before going to the field, first rinse and then half fill each bottle with DIW as described in NFM 3.
- Discard DIW from bottles at the field site before field rinsing and (or) sampling.
- **Field rinse the inside of sample bottles and bottle caps with sample** (table 5-2; Appendix A5-B). Use filtrate to rinse the bottles that will contain filtered sample.

5.6.2.A Major and Minor Cations and Trace Elements

Use of Clean Hands/Dirty Hands techniques and good field practices are required for samples with parts-per-billion concentrations of trace elements and are recommended for all samples.

Raw samples:

1. Label acid-rinsed polyethylene bottles as "RA" for major and minor cations and most trace-element samples. Label bottles with the laboratory schedule, as appropriate.
   - Arsenic, antimony, and selenium analyses—Label bottles as "RAH." (Some samples are designated "USEPA"—check with the laboratory.)
   - Mercury samples—Label glass bottles as "RAM."
   - USEPA drinking water samples—Label bottles as described in NWQL Technical Memorandum 97.05 or as directed.
2. Field rinse and fill sample bottles directly from the sample-collection or processing device.
3. Add chemical treatment, as specified by the analyzing laboratory.
   - Major and minor cations and trace elements: Add HNO_3 to lower sample pH to <2.
   - Mercury: Add contents of vial containing 2 mL of 6*N* ultrapure HCl.

Filtered samples:

1. Label acid-rinsed polyethylene bottles as "FA" for most trace-element samples, including arsenic, antimony, and selenium. Check NWQL Technical Memorandum 97.05 for requirements for USEPA drinking water samples.
   Exception: Mercury—Label the acid-rinsed 250-mL glass bottles as "FAM."
2. Field rinse and fill sample bottles directly from the filter assembly. Refer to section 5.2 for filtration instructions.

3. Add chemical treatment, if specified by the analyzing laboratory.
   - Major and minor cations and trace elements: Add HNO_3 to lower sample pH to <2.
   - Mercury: Add contents of vial containing 2 mL of 6*N* ultrapure HCl.

Nutrients (Nitrogen and Phosphorus) 5.6.2.B

Refer to Office of Water Quality Technical Memorandums 94.16, 99.04 and 2000.08 for the most recent changes to collecting and processing nutrient samples. See 5.6.1.D and 5.2.2.C for processing of a Total Particulate Nitrogen (TPN) sample, LC2607.

Raw samples:

1. Label bottles as follows:
   - "WCA" for raw samples to be treated with H_2SO_4 (125-mL translucent bottles are preferable).
   - "ERC" for raw samples collected for the USEPA Drinking Water Program (refer to National Water Quality Laboratory Technical Memorandum 97.05 or contact the laboratory for instructions).

   A clean, graduated cylinder may be used when the volume of sample to be filtered is less than 64 mL.
2. Field rinse and fill the sample bottles directly from the sampler or sample splitting device.
3. Add a chemical treatment to WCA and ERC samples, as appropriate.
4. Chill WCA and ERC samples immediately and maintain at 4°C or below without freezing.

Filtered samples:

1. Label bottles as follows:
   - FCC" for filtered samples (125-mL brown bottles).
   - FCA" for filtered samples to be treated with H_2SO_4 (125-mL brown bottles).
2. Field rinse and fill sample bottles directly from the capsule filter or other filter assembly.

- **Use of 0.45-µm pore-size filter media is the standard to date for State or Federal programs that regulate drinking water and for routine water-quality studies for which consistency with historical nutrient data is necessary.**
- Use of 0.2-µm pore-size filter media is recommended for studies for which exclusion of bacteria from the sample is desirable, and inconsistency with historical data is not an issue. Prefilter sediment-laden samples through 0.45-µm filter media. Record the filter pore size used, if other than 0.45 µm, under the comments section on the field form and ASR forms.

3. Add chemical treatment to FCA samples. (FCC samples do not require chemical treatment.)
4. Chill FCC and FCA samples immediately and maintain at 4°C or below without freezing.

5.6.2.C Anions

Label polyethylene bottles as "FU" (filtered untreated). Process alkalinity samples for field titration using the same steps as for other anions (with the exception of ANC samples) (NFM 6).

1. Refer to section 5.2 for filtration instructions.
2. Field rinse and fill sample bottles directly from the capsule filter (or filter assembly).
3. Do not add chemical treatment.

Exceptions:

- **Cyanide**—Label the 250-mL polyethylene bottle as "LC0880" for filtered sample and as "LC0023" for raw sample. **Cyanide requires addition of NaOH to raise the pH to >12.**
- **ANC** (acid neutralizing capacity)—Do not filter the ANC sample. Label sample bottle as "RU" (NFM 6).

TABLE ISOTOPES AND RADIOCHEMICALS 5.6.3

Isotopes and radiochemicals generally are not processed in a processing or preservation chamber, unless samples are being handled in a glove box. Wear appropriate, disposable, powderless gloves when collecting and processing samples.

Leave enough air space (at least 2 cubic centimeters) if glass bottles are used and the sample will be chilled to allow for the expansion of water samples unless instructed otherwise (Appendix A5-C). Close the polyseal cap tightly and seal with wax or plastic tape, or as directed below for the specific isotope or radiochemical.

Carbon ($^{13}C/^{12}C$ and ^{14}C) 5.6.3.A

Do not let the sample contact air. Filter the sample along with other inorganic-constituent samples if particulates are visible. **Samples without particulates do not require filtration or chemical treatment** (NWQL Technical Memorandum 96.05). If ^{13}C will be collected by direct precipitation in the field using ammoniacal $SrCl_2$, then the precipitates must be submitted as washed, dried, homogenized powders. **The laboratory will not accept bottles with ammoniacal $SrCl_2$ in solution.**

Samples for $^{13}C/^{12}C$ analysis:

1. Label a 1-L glass bottle as "$^{13}C/^{12}C$, RUS," and the laboratory code or schedule number (as requested by the laboratory).
2. Filter the sample if particulates are visible. Establish a closed path from the sample source through the filter and to the bottle to exclude air from the collection system.
3. When filling the bottle, fill from the bottom of the bottle and allow an overflow of two to three bottle volumes. Cap the sample immediately.

Samples for ^{14}C analysis:

The sample must provide a minimum of 5 mg dissolved inorganic carbon (DIC) per sample container.

1. Label bottles as "^{14}C, RUS/RUR," and the appropriate laboratory schedule number. Check with the laboratory and refer to NWQL Technical Memorandum 96.05 for bottling and other field requirements for samples to be analyzed for ^{14}C.
2. Collect sample in duplicate. Filter the sample if particulates are visible. Establish a closed path from the sample source, through the filter, to the bottle to ensure that air is excluded from the collection system.
3. Fill sample container.
   - For samples with ^{14}C content greater than or equal to 5-percent modern carbon, fill the bottle from the bottom of the bottle, allowing an overflow of 2 to 3 bottle volumes. This helps to purge air from the sample. Cap the bottle immediately. For potentially low ^{14}C concentrations, (<10 percent modern carbon) or if relatively long filtration time is required, flush the headspace above the water sample with nitrogen while filling the bottle.
   - For samples with ^{14}C content less than 5-percent modern carbon, use a stainless steel collection vessel, such as a Whitey™ Sample cylinder No. 304L-HDF4, with stainless steel valves on each end. Flush with several liters of filtrate from the bottom of the cylinder up and close the cylinder, leaving no headspace.
4. Archive a duplicate sample and store in the dark, chilled to 4°C or below without freezing.
   - Secure container caps with electrical tape.
   - Record the sample pH and alkalinity on the sample bottle.

Hydrogen ($^{2}H/^{1}H$) and Oxygen ($^{18}O/^{16}O$) 5.6.3.B

Hydrogen and oxygen isotope samples can be collected together in one bottle. Use either a 60-mL clean glass bottle or a 250-mL polyethylene bottle. Label the bottles as "RUS, SH 1142." Use caps with polyseal conical inserts. **To request bottles with appropriate caps, send E-mail to isotopes@usgs.gov.**

- Do not field rinse bottles.
- Do not add chemical treatment.
- Samples may be either raw or filtered.

1. Fill bottle to overflowing directly from the sampler or sample splitting device (raw sample) or from the capsule filter or other filter assembly (filtered sample).
2. If filling a glass bottle, fill to overflowing and then decant the sample until the water level is at the bottle shoulder. Cap the bottle immediately
3. If filling a polyethylene bottle, fill to overflowing and cap the bottle immediately, leaving no headspace. Do not use polyethylene bottles if the sample will be held or archived.

5.6.3.C Nitrogen ($^{15}N/^{14}N$)

Collect filtered, untreated sample **(do not use mercuric chloride)** in a 1-L amber or foil-wrapped glass or high-density polyethylene bottle. Use a polyseal bottle cap. Refer to National Water Quality Technical Memorandum 95.05.

1. Label the bottles as "RUS" and with the appropriate laboratory code (LC 1717, for $^{15}N/^{14}N$ as ammonia; LC 1718, for $^{15}N/^{14}N$ as nitrate; or LC 1921, for $^{15}N/^{14}N$ as nitrate plus ammonia).
2. Fill the bottle to the shoulder directly from the capsule filter or other filter assembly.
3. Put the glass sample bottle into a foam sleeve and keep it chilled at or below 4°C without freezing. Ship overnight, per shipping instructions in NWQL Technical Memorandum 95.04.

5.6.3.D Sulfur ($^{34}S/^{32}S$)

Dissolved sulfide and sulfate are collected and processed separately, according to the directions given in Carmody and others (1998).

1. Label the bottles as "RUS" and with the appropriate laboratory code or schedule number.
2. Send questions to the following E-mail address: <isotopes@usgs.gov>. Special equipment, chemical reagents, and training are needed in order to collect these samples properly.
   Sulfate: Procedures and equipment differ for processing the sulfate sample, depending on whether sulfate concentrations are less than 20 mg/L or equal to or greater than 20 mg/L. Onsite estimation of sulfate concentration is described in Carmody and others (1998).
   - When a water sample from which dissolved sulfate will be collected for isotopic analysis also contains dissolved sulfide (greater than 0.01 mg/L), the sulfide should be removed by nitrogen stripping to avoid contamination of the sulfate sulfur by oxidized sulfide sulfur with very different isotopic composition.

- Sulfate in water with concentrations of greater than 20 mg/L sulfate is collected by precipitating $BaSO_4$ from an acidified sample (up to 2-L volume). $BaSO_4$ can be precipitated and filtered in the laboratory or in the field.
- Anion exchange resin can be used to collect sulfate from samples in which sulfate concentrations are less than 20 mg/L.

Sulfide: Determine if dissolved sulfide (H_2S) is present by its distinctive rotten-egg odor. Measure H_2S concentration with a field spectrophotometer.

- Measurement of dissolved sulfide concentrations greater than 0.6 mg/L with a field spectrophotometer has been problematic.
- An alternative method for samples with dissolved sulfide concentration greater than about 0.5 mg/L is to collect the dissolved sulfide by direct precipitation of Ag_2S by adding $AgNO_3$ to the sample. Care must be taken to add sufficient $AgNO_3$ to precipitate all the sulfide present, or the sulfide sample will be fractionated.
- A method for collection of dissolved sulfide by nitrogen stripping and precipitation of Ag_2S in an $AgNO_3$ trap has been tested and found to cause a small fractionation of the isotopic composition of the sulfide. Two approaches are recommended to minimize this fractionation: (1) collect sulfide by nitrogen stripping for 3 hours or more to minimize the amount of sulfide left in the carboy and, thus, the fractionation produced; and (2) determine the kinetic fractionation factor (α) for the collection apparatus and use this α to calculate the original sulfur isotopic composition of the dissolved sulfide in the ground water from Ag_2S collected for a short time (about 30 minutes).

5.6.3.E Radium 226 and Radium 228

Label acid-rinsed polyethylene bottle(s) as "FAR" and add the appropriate laboratory code ("LC 794" for radium-226 and "LC 1364" for radium-228). Bottle-size requirements depend on analytical method or schedule.

1. Filter the sample using the procedures for inorganic-constituent samples, and fill the sample bottle to the shoulder directly from the capsule filter or other filter assembly.
2. Add reagent-grade HNO_3 to preserve sample to pH <2. **Do not substitute HCl for HNO_3.**

5.6.3.F Uranium (U-234, U-235, U-238)

Label 1-L acid-rinsed polyethylene bottle(s) as "FAR, SH 1130." Check with the laboratory for bottle requirements for the analysis requested.

1. Filter the sample and fill the sample bottle to the shoulder directly from the capsule filter or other filter assembly.
2. Add reagent-grade HNO_3 to preserve the sample to pH <2. **Do not substitute HCl for HNO_3.**

5.6.3.G Gross Radioactivity

Label 1-L acid-rinsed polyethylene bottle(s) as "FAR" (filtered sample) for the gross alpha and the gross beta analyses and with the appropriate laboratory schedule number. The laboratory schedule requested depends on the concentration of total dissolved solids in the sample.

1. Filter the sample.
2. Fill the sample bottle to the shoulder directly from the capsule filter or other filter assembly.
3. Add reagent-grade HNO_3 to preserve the sample to pH <2. **Do not substitute HCl for HNO_3.**

Tritium 5.6.3.H

Label a 1-L bottle as "RUR" and add the appropriate laboratory code. (High density polyethylene bottles are preferred; a glass bottle with a polyseal cap may be used. Refer to National Water Quality Technical Memorandum 92.04.)

- Do not place tritium samples near watches or other devices with luminescent dials. Do not store sample near tritium sources (for example, glowing clocks, watches, signs).
- **Do not field rinse sample bottles.**

1. Fill bottle with raw, untreated sample. The bottle should be dry before being filled. It might be desirable to flush the bottle with a filtered, inert gas such as argon or nitrogen before leaving for the field—consult with the laboratory.
2. Do not allow the bottle to overflow when filling with sample.
3. Leave a slight headspace in the bottle to allow for expansion of the sample.
4. Cap the bottle securely and tape the cap to prevent it from working loose during shipping.
5. Record the date and time of sampling on the bottle label and ASR form.

For tritium samples—Keep luminescent devices far from sample collection, handling, or storage areas.

5.6.3.I Radon-222

Modify the sample collection setup to collect raw samples for radon analysis. Sample is collected in a glass vial containing liquid-scintillation solution (obtain radon kit from NWQL). Label radon-222 samples as "RURCV" and add the laboratory code.

Do not write on or put any labels on the side of the radon vial.

Precautions are needed when collecting samples for radon analyses to prevent introducing gas bubbles into the sample and to prevent the sample from degassing.

- Use insulated sample tubing to prevent warming of the sample.
- Inspect sample tubing to determine whether gas bubbles are forming inside the tubing or whether any air is being drawn into the sample at any connection.
- Dislodge bubbles in sample tubing by striking the tubing firmly with a blunt object.
- Tighten connections to help prevent entrainment of air.
- To reduce degassing during sample collection, create back pressure by partially closing the valve on the radon-collection unit.

1. Collect the radon sample into a syringe directly from the pump discharge or other sampling device.
2. Rinse the syringe as follows: Insert the glass syringe needle through the septum port with the collection-unit valve partially closed. Close the valve further until there is sufficient back pressure to create an almost effortless withdrawal of sample into the syringe. Fill the syringe partially, withdraw it from the septum and invert (needle up). Eject the water to waste. Repeat at least once.
3. With the syringe plunger completely depressed (no air or water in the syringe barrel) and after the final rinse, reinsert the needle through the septum. Withdraw about 15 mL of sample into the syringe barrel slowly; avoid suction and degassing.

4. Withdraw the needle, invert the syringe (needle up), and eject the sample slowly until 10 mL remain in the syringe.
5. Tip the syringe needle downward, and insert the needle tip into the mineral oil and down to the bottom of the radon sample vial.
6. Inject the entire sample slowly. Remove the syringe and cap the vial firmly. Record the date and the exact time of sample collection on the top of the cap (do not write on or put a label on the vial).
7. Shake the vial for 30 seconds after injecting the sample. Repack it in the shipping tube and cap the tube. Complete the ASR form, wrap it around the tube, secure with a rubber band, and place the tube into a sealable plastic bag. **Ship to the NWQL immediately by overnight delivery. Do not ship samples on a Friday. Do not ship radon-222 samples in coolers.**

Do not allow air to contact samples for radon analysis.

Tritium/Helium-3 ($^3H/^3He$) 5.6.3.J

This section has been updated and now includes Chlorofluorocarbons (formerly section 5.6.3.K). See the next page for the updated section.

5.6.3.J Chlorofluorocarbons (CFCs), Sulfur Hexafluoride (SF_6), Dissolved Gases, and Tritium/Helium-3 ($^3H/^3He$)

The Reston Chlorofluorocarbon Laboratory provides analytical services for CFCs, sulfur hexafluoride, and dissolved gases, and administers the USGS contract for tritium/helium-3 dating. The data generated by the Reston Chlorofluorocarbon Laboratory are being used in hydrologic studies to trace the flow of young water and to determine the time elapsed since recharge.

Guidance and detailed directions in collecting and processing samples for these analyses, is provided at to the USGS Chlorofluorocarbon Laboratory website: http://water.usgs.gov/lab/, at which is located also a sample submission form. The links shown below allow access to information specific to the analyte shown:

CFCs: http://water.usgs.gov/lab/chlorofluorocarbons/

Dissolved Gas: http://water.usgs.gov/lab/dissolved-gas/

SF_6: http://water.usgs.gov/lab/sf6/

SF_5CF_3 and CFC-13: http://water.usgs.gov/lab/sf5cf3/

$^3H/^3He$: http://water.usgs.gov/lab/3h3he/

Section 5.6.4 - CONSTITUENT SPECIES

5.6.4.A - Arsenic Speciation
(Access as a separate file)

5.6.4.B - Low-level Mercury
(Access as a separate file)

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CONVERSION FACTORS, SELECTED TERMS, ABBREVIATIONS, AND CHEMICAL FORMULAS

CONVERSION FACTORS

Multiply	By	To obtain
micrometer (µm)	0.00003937	inch
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
microliter (µL)	0.0000338	ounce, fluid
milliliter (mL)	0.0338	ounce, fluid
	0.000264	gallon
liter (L)	0.2642	gallon
nanogram (ng)	3.53×10^{-11}	ounce
microgram (µg)	3.53×10^{-8}	ounce
milligram (mg)	0.0000353	ounce
gram (g)	0.03527	ounce, avoirdupois
kilopascal	0.1450	pound per square inch
picocurie (pCi)	0.037	Becquerle (Bq)

Temperature: Water and air temperature are given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

Selected Terms

Editors and authors of the *National Field Manual* have attempted to use terms common in the water-quality community. Some of the terms used have restricted meanings within the context of this report. The following terms either are used in a context familiar primarily to USGS personnel, or in a format that is more succinct, or that is considered to be more specific than a common usage:

Accuracy: The degree of agreement of a measured value with the true or expected value (from Taylor, 1987).

Analyte (target analyte): "Substances being determined in an analysis" (from Bennett, 1986). The term target analyte is used in this report to refer to any chemical or biological substance for which concentrations in a sample will be determined. The definition for target analyte does not include field-measured parameters such as temperature, specific electrical conductance, pH, dissolved oxygen, Eh, alkalinity, color, or turbidity.

Bias: Systematic error inherent in a method or caused by some artifact or idiosyncrasy of the sample measurement, collection, or processing system. The error can be positive (indicating contamination) or negative (indicating loss of analyte concentration) (from Taylor, 1987).

Contaminant: Biological or chemical substances added to the medium of concern, commonly through human activity.

Contamination (of water): Change of ambient water composition by the addition of biological or chemical substances as a result of human activity or natural processes. Addition of such substances can be detrimental to the quality of the water resource.

Data-quality requirements: The subset of data-quality objectives pertaining specifically to the analytical detection level for concentrations of target analytes and the variability allowable to fulfill the scientific objectives of the study.

Quality Assurance (QA): The systematic management of data-collection systems by using prescribed guidelines and criteria for implementing technically approved methods and policies. Quality assurance incorporates a comprehensive plan that outlines the overall process for providing a product or service that will satisfy the given requirements for quality.

Quality Control (QC): The specific operational techniques and activities used to obtain the required quality of data. Quality control consists of the application of technical procedures to achieve prescribed standards of performance and to document the quality of collected data. Quality-control data are used to identify and evaluate any corrective actions necessary to improve performance or data interpretation to acceptable levels.

Trace element(s): For the purpose of this report and to maintain consistency with common usage, the term trace element(s) is used to refer to metal and nonmetal inorganic elements such as arsenic, antimony, selenium, and tellurium that usually are present in natural surface-water and ground-water systems in concentrations less than 1 mg/L (modified from Hem, 1985). Common usage of this term, as defined above, is inexact and not rigorous with respect to aqueous chemistry.

Abbreviations

cc	cubic centimeter
lb/in^2	pounds per square inch
min	minute
mg/L	milligram per liter

µg/L	microgram per liter (equivalent to parts per billion (ppb))
mL/min	milliliters per minute
+ ng/L	nanogram per liter
ng/µL	nanogram per microliter
pCi	picocuries
ppb	parts per billion (see µg/L)
ANC	acid neutralizing capacity
ASR	Analytical Services Request
BNA	base-neutral acids
CFC	chlorofluorocarbon
CH	Clean Hands
DH	Dirty Hands
DIC	dissolved inorganic carbon
DIW	distilled/deionized water
DOC	dissolved organic carbon
FA	filtered, acidified sample
FAM	filtered, acidified sample for analysis of mercury
FAR	filtered, acidified sample for analyses of selected radiochemicals
FCA	filtered, chilled, acidified sample
+ FCC	filtered, chilled sample
FEP	fluorinated ethylene-propylene
FU	filtered, untreated sample
GCC	glass, chilled sample for analysis of nonvolatile organic compounds
GC/MS	gas chromatograph/mass spectrophotometer
IBW	inorganic-grade blank water (water with certified analysis of trace elements and other inorganic constituents and used for blank QC samples for analysis of inorganic constituents)
MBAS	methylene blue active substances
NAWQA	National Water-Quality Assessment Program
NFM	*National Field Manual for the Collection of Water-Quality Data*
NPDES	National Pollutant Discharge Elimination System
NWQL	National Water Quality Laboratory of the U.S. Geological Survey (Denver, Colo.)
OWQ	Office of Water Quality of the U.S. Geological Survey (Reston, Va.)
PBW	pesticide-grade blank water (water certified free of pesticide compounds)
PCB	polychlorinated biphenyl
+ QA	quality assurance
QC	quality control

QW	quality of water
QWSU	Quality of Water Service Unit of the U.S. Geological Survey (Ocala, Fla.)
RA	raw, acidified sample
RAH	raw, acidified sample for analysis of antimony, arsenic, and (or) selenium
RAM	raw, acidified sample for analysis of mercury
RCB	raw, chilled sample
RU	raw, untreated sample
RUR	raw, untreated sample for analysis of selected radiochemicals
RUS	raw, untreated sample for analysis of stable isotopes
SOC	suspended organic carbon
SPE	solid-phase extraction
TOC	total organic carbon
URL	Uniform Resource Locator
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VBW	volatile-organic-compounds-grade blank water (water certified free of VOCs)
VOC	volatile organic compounds
WCA	raw, chilled, acidified nutrient sample

Chemical Formulas

Ag_2S	silver sulfide
$AgNO_3$	silver nitrate
$BaSO_4$	barium sulfate
$^{13}C/^{12}C$	carbon-13/carbon-12 isotope ratio
^{14}C	carbon-14
$CuSO_4$	copper sulfate
$^{2}H/^{1}H$	deuterium/protium isotope ratio
$^{3}H/^{3}He$	tritium/helium-3 isotope ratio
HCl	hydrochloric acid

H_2O	water
H_2S	hydrogen sulfide
H_2SO_4	sulfuric acid
H_3PO_4	phosphoric acid
HNO_3	nitric acid
$HNO_3/K_2Cr_2O_7$	nitric acid/potassium dichromate
NaCl	sodium chloride
NaOH	sodium hydroxide
$^{15}N/^{14}N$	nitrogen-15/nitrogen-14 isotope ratio
$^{18}O/^{16}O$	oxygen-18/oxygen-16 isotope ratio
$^{34}S/^{32}S$	sulfur-34/sulfur-32 isotope ratio
$SrCl_2$	strontium chloride

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Internal Documents

Office of Water Quality and National Water Quality Laboratory technical memorandums are available through the USGS Home Page on the World Wide Web. The site address (URL) is http://water.usgs.gov/lookup/get?techmemo.

Memo No.	Title	Date
	Water Quality	

qw92.01	Distilled/Deionized Water for District Operations	December 20, 1991
qw92.02	FIELD TECHNIQUES--Field Preparation of Containers for Aqueous Samples	December 20, 1991
qw92.06	Report of Committee on Sample Shipping Integrity and Cost	March 20, 1992
qw92.11	Deleted - out of date.	
qw94.09	Revision of New Division Protocol for Collecting and Processing Surface-Water Samples for Low-Level Inorganic Analyses	January 28, 1994
qw94.16	New Preservation Techniques for Nutrient Samples	August 5, 1994
qw95.02*	Establishment of U.S. Geological Survey (USGS) Laboratory for Determination of Chlorofluorocarbons (CFCs) in Air and Water Samples	December 29, 1994
qw97.03	Protocols for Cleaning a Teflon Cone Splitter to Produce Contaminant-Free Subsamples for Subsequent Determinations of Trace Elements	February 7, 1997
qw97.06	Comparison of the Suspended-Sediment Splitting Capabilities of the Churn and Cone Splitters	May 5, 1997
qw99.04	Changes in Field Treatment Protocols and Bottle Types for Whole-Water Samples Collected for Total Ammonium Plus Organic Nitrogen and Total Phosphorus Determinations	November 25, 1998

*95.02 was prepared jointly by the Office of Water Quality and the Office of Ground Water.

Memo No.	Title	Date
	National Water Quality Laboratory	
92.01	Technology Transfer. Availability of Equipment Blank Water for Inorganic & Organic Analyses	March 25, 1992
92.04	Bottles for Tritium Analyses	August 12, 1992
93.01	Identification of Low Levels of Sodium Contamination in Nitric Acid Samples	October 5, 1992
93.09	Radon—Discontinuance of Duplicate Samples for Radon-In-Water	August 24, 1993
95.04	Shipping Samples to the National Water Quality Laboratory	December 2, 1994
95.05	Nitrogen Isotope Sample Preservation for Water Samples	March 8, 1995
96.05	Collection, Processing, and Analysis of Carbon Isotope Samples	April 5, 1996
97.01 97.01S	Use of Syringes to Add Volatile Organic Compounds to Water Samples for Use as Matrix Spike Samples (97.01S is supplementary)	November 5, 1996
97.04S	Collection, Processing, and Analysis of Ground-Water Samples for Tritium/Helium-3 Dating	April 7, 1997
97.05	Using the National Water Quality Laboratory for the Analysis of Drinking Water Samples	February 28, 1997

PUBLICATIONS ON TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

The U.S. Geological Survey publishes a series of manuals describing procedures for planning and conducting specialized work in water-resources investigations. The material is grouped under major subject headings called books and is further divided into sections and chapters. For example, Section A of Book 9 (Handbooks for Water-Resources Investigations) pertains to collection of water-quality data. The chapter, which is the unit of publication, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises.

The Techniques of Water-Resources Investigations (TWRI) reports listed below are for sale by the U.S. Geological Survey, Branch of Information Services, Box 25286, Federal Center, Denver, CO 80225 (authorized agent of the Superintendent of Documents, Government Printing Office). Prepayment is required. Remittance should be sent by check or money order payable to the U.S. Geological Survey. Prices are not included because they are subject to change. Current prices can be obtained by writing to the above address. When ordering or inquiring about prices for any of these publications, please give the title, book number, chapter number, and "U.S. Geological Survey Techniques of Water-Resources Investigations." An updated list of TWRI reports can be found by accessing the World Wide Web url: http://water.usgs.gov/lookup/get?TWRI.

Book 1. Collection of Water Data by Direct Measurement

Section D. Water Quality

1–D1.Water temperature—influential factors, field measurement, and data presentation, by H.H.þStevens, Jr., J.F. Ficke, and G.F. Smoot: USGS—TWRI Book 1, Chapter D1. 1975. 65þpages.

1–D2.Guidelines for collection and field analysis of ground-water samples for selected unstable constituents, by W.W. Wood: USGS—TWRI Book 1, Chapter D2. 1976. 24 pages.

Book 2. Collection of Environmental Data

Section D. Surface Geophysical Methods

2–D1.Application of surface geophysics to ground-water investigations, by A.A.R. Zohdy, G.P. Eaton, and D.R. Mabey: USGS—TWRI Book 2, Chapter D1. 1974. 116 pages.

2–D2.Application of seismic-refraction techniques to hydrologic studies, by F.P. Haeni: USGS—TWRI Book 2, Chapter D2. 1988. 86 pages.

Section E. Subsurface Geophysical Methods

2–E1.Application of borehole geophysics to water-resources investigations, by W.S. Keys and L.M.þMacCary: USGS—TWRI Book 2, Chapter E1. 1971. 126 pages.

2–E2.Borehole geophysics applied to ground-water investigations, by W.S. Keys: USGS—TWRI Book 2, Chapter E2. 1990. 150 pages.

Section F. Drilling and Sampling Methods

2–F1.Application of drilling, coring, and sampling techniques to test holes and wells, by Eugene Shuter and W.E. Teasdale: USGS—TWRI Book 2, Chapter F1. 1989. 97 pages.

Book 3. Applications of Hydraulics

Section A. Surface-Water Techniques

3–A1.General field and office procedures for indirect discharge measurements, by M.A. Benson and Tate Dalrymple: USGS—TWRI Book 3, Chapter A1. 1967. 30 pages.

3–A2.Measurement of peak discharge by the slope-area method, by Tate Dalrymple and M.A. Benson: USGS—TWRI Book 3, Chapter A2. 1967. 12 pages.

3–A3.Measurement of peak discharge at culverts by indirect methods, by G.L. Bodhaine: USGS—TWRI Book 3, Chapter A3. 1968. 60 pages.

3–A4.Measurement of peak discharge at width contractions by indirect methods, by H.F. Matthai: USGS—TWRI Book 3, Chapter A4. 1967. 44 pages.

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3–A7.Stage measurement at gaging stations, by T.J. Buchanan and W.P. Somers: USGS—TWRI Book 3, Chapter A7. 1968. 28 pages.

3–A8.Discharge measurements at gaging stations, by T.J. Buchanan and W.P. Somers: USGS—TWRI Book 3, Chapter A8. 1969. 65 pages.

3–A9.Measurement of time of travel in streams by dye tracing, by F.A. Kilpatrick and J.F. Wilson, Jr.: USGS—TWRI Book 3, Chapter A9. 1989. 27 pages.

3–Al0.Discharge ratings at gaging stations, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A10. 1984. 59 pages.

3–A11.Measurement of discharge by the moving-boat method, by G.F. Smoot and C.E. Novak: USGS—TWRI Book 3, Chapter A11. 1969. 22 pages.

3–A12.Fluorometric procedures for dye tracing, Revised, by J.F. Wilson, Jr., E.D. Cobb, and F.A. Kilpatrick: USGS—TWRI Book 3, Chapter A12. 1986. 34 pages.

3–A13.Computation of continuous records of streamflow, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A13. 1983. 53 pages.

3–A14.Use of flumes in measuring discharge, by F.A. Kilpatrick and V.R. Schneider: USGS—TWRI Book 3, Chapter A14. 1983. 46 pages.

3–A15.Computation of water-surface profiles in open channels, by Jacob Davidian: USGS—TWRI Book 3, Chapter A15. 1984. 48 pages.

3–A16.Measurement of discharge using tracers, by F.A. Kilpatrick and E.D. Cobb: USGS—TWRI Book 3, Chapter A16. 1985. 52 pages.

3–A17.Acoustic velocity meter systems, by Antonius Laenen: USGS—TWRI Book 3, Chapter A17. 1985. 38 pages.

3–A18.Determination of stream reaeration coefficients by use of tracers, by F.A. Kilpatrick, R.E.þRathbun, Nobuhiro Yotsukura, G.W.þParker, and L.L. DeLong: USGS—TWRI Book 3, Chapter A18. 1989. 52 pages.

3–A19.Levels at streamflow gaging stations, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A19. 1990. 31 pages.

3–A20.Simulation of soluble waste transport and buildup in surface waters using tracers, by F.A. Kilpatrick: USGS—TWRI Book 3, Chapter A20. 1993. 38 pages.

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Appendix A5-A. Sample-designation codes and a summary of field-processing requirements for analyses of organic compounds in water

[NWQL, National Water Quality Laboratory of the U.S. Geological Survey; mL, milliliters; °C, degrees Celsius; HCl, hydrochloric acid; mg, milligram; L, liter; LC, laboratory code; %, percent; H_3PO_4, phosphoric acid; $CuSO_4$, copper sulfate; g/L, grams per liter; µm, micrometer; GF/F, baked glass fiber filter media; SH, schedule number; mm, millimeter; SPE, solid-phase extraction; <, less than; oz, ounce; in, inch]

Organic compound[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation[3]
Volatile or purgeable organic compounds (VOCs or POCs)	40-mL baked glass septum vial. Replicates are required and numbered in the order filled. Fill 3 vials for ground water, 4 vials for surface water. **No field rinse.**	VOC	Raw sample. Do not let sample degas. Chill/maintain at 4°C. • For treated sample[4]: Add two drops of 1:1 HCl from Teflon™ dropper bottle • If residual chlorine is present, add 25 mL ascorbic acid to vial before filling.
Methylene-chloride-extractable compounds (BNAs)	500-mL baked glass bottle. **No field rinse.**	GCC	Fill bottle to shoulder. Add 1 mL concentrated sulfuric acid to adjust to pH <2. If chlorine is suspected in the sample, add 100 mg ferrous sulfate. Mix, chill, and maintain at 4°C.
Phenols	1-L baked amber glass bottle. **No field rinse.**	LC0052	Raw sample. Add 2 mL of 8.5% H_3PO_4 to 1 L sample to pH 4. Add 10 mL $CuSO_4$ (100 g/L). Fill to shoulder. Chill/maintain at 4°C.
Polychlorinated biphenyls (PCBs)	1-L baked glass bottle. **No field rinse.**	GCC	Raw, untreated sample. Chill/maintain at 4°C.
Pesticides (raw)	1-L baked amber glass bottle. **No field rinse.**	GCC	Raw, untreated sample. Chill/maintain at 4°C.
• Organo-nitrogen herbicides	1-L baked amber glass bottle. **No field rinse**.	GCC	Raw sample, untreated. Chill/maintain at 4°C.
Pesticides (filtered)	1-L baked amber glass bottle. **No field rinse.**	GCC	Filtered sample (0.7-µm GF/F). Chill/maintain at 4°C.
• Organo-nitrogen herbicides	125-mL baked amber glass bottle. **No field rinse**.	GCC (SH1379)	Filtered sample, untreated. Optional: use 25-mm nylon filter capsule. Chill/maintain at 4°C.

Appendix A5-A. Sample-designation codes and a summary of field-processing requirements for analyses of organic compounds in water—*Continued*

Organic compound[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation[3]
• Broad spectrum pesticides by C-18 SPE	C-18 SPE column.	SH2010	Filtered sample (0.7-µm GF/F), pass through SPE column and treat as described in text. Chill/maintain at 4°C.
• Broad spectrum pesticides by Carbopak-B™ SPE	Carbopak-B™ SPE column.	SH2051	Filtered sample (0.7-µm GF/F), pass through SPE column and treat as described in text. Chill/maintain at 4°C
Total particulate carbon (TPC)[5]	6-oz and 18-oz Whirl-Pak bags	TPC (LC2606)	Retain particulate material on 25-mm baked glass microfiber filters (GF/F). Fold filters into 6-in x 6-in aluminum foil squares, as described in the text, label, and place into 6-oz bag and then into 18-oz bag. Chill/maintain at 4°C.
Total organic carbon (TOC)	125-mL baked glass bottle. **No field rinse.**	TOC (LC0114)	Raw sample, untreated. Fill to shoulder. Chill/maintain at 4°C.
Dissolved (filtered) organic carbon (DOC)	125-mL baked glass bottle. **No field rinse.**	DOC (LC0113)	Filtered sample (silver filter media) , untreated. Fill to shoulder. Chill/ maintain at 4°C.
Suspended organic carbon (SOC)	Petri dish, plastic. No field rinse.	SOC (LC0305)	Retain suspended materials on silver filter, untreated. Chill/maintain at 4°C.
Methylene blue active substances (MBAS)	250-mL polyethylene bottle. **Field rinse.**	RCB	Raw sample, untreated. Fill to shoulder. Chill/maintain at 4°C.
Oil and grease	1-L baked glass bottle. **No field rinse.**	GCC (LC2125)	Raw sample. Leave small headspace. Add about 2 mL H_2SO_4 to lower pH to <2. Chill/maintain at 4°C.

Appendix A5-A. Sample-designation codes and a summary of field-processing requirements for analyses of organic compounds in water—*Continued*

Explosives	1-L baked amber glass bottle. **No field rinse.**	GCC (SH 1377)	Filtered sample (0.7 µm GF/F), untreated. Chill/maintain at 4°C.
Total petroleum hydrocarbons	1-L baked glass bottle. **No field rinse.**	GCC (LC2126)	Raw sample. Leave small headspace. Add about 2 mL H_2SO_4 to lower pH to <2. Chill/maintain at 4°C.
Ultraviolet-absorbing substances			

[1]This table is not complete or comprehensive. Check with NWQL for the most current information on analytical schedules, laboratory codes, parameter codes, sample requirements, prices, and associated information.

[2]Container size is subject to sample-volume and analytical-method requirements. Glass bottles must be received from the laboratory baked, capped, and ready for use. **Do not use glass bottles that arrive uncapped.**

[3]Procedures for sample treatment and preservation are also described in Shelton and others (1994), Koterba and others (1995), Timme (l995), Sandstrom (1995), Zaugg and others (1995), and Werner and others (1996).

[4]Acidification of VOC samples is mandatory for NPDES and NAWQA programs, but normally is optional (unless study objectives dictate acidified samples).

[5]The summary for particulate inorganic carbon (PIC), sample designation code LC2608, is identical for that of TPC.

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Appendix A5-B. Sample-designation codes and a summary of field-processing requirements for analyses of inorganic constituents in water

[NWQL, National Water Quality Laboratory of the U.S. Geological Survey; mL, milliliters; °C, degrees Celsius; H_2SO_4, sulfuric acid; HNO_3, nitric acid; <, less than; $K_2Cr_2O_7$, potassium dichromate; NaOH, sodium hydroxide; >, greater than]

Inorganic constituent[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation
Nutrients: Nitrogen and phosphorus (raw)	125-mL translucent polyethylene bottle. **Field rinse**.	WCA	Raw sample, treated: Add 1 mL of H_2SO_4. Chill/maintain at 4°C.
Nitrogen and phosphorus (filtered)	125-mL brown polyethylene bottle. **Field rinse.**	FCC FCA	Filtered sample, untreated. Chill/maintain at 4°C. Filtered sample: Add 1 mL of H_2SO_4. Chill/maintain at 4°C.
Anions	250-mL polyethylene bottle. **Field rinse.**	RU FU	Raw sample, untreated. Filtered sample, untreated.
Cations (major cations, trace elements)	250-mL polyethylene bottle, acid rinsed. **Field rinse.**	RA FA	Raw sample. Acidify with HNO_3 to pH<2. Filtered sample. Acidify with HNO_3 to pH<2
Mercury	250-mL glass bottle, (clear), acid rinsed. **Field rinse.**	RAM FAM	Raw sample. Acidify with HCl, 6N, 2 mL, ultrapure Filtered sample. Acidify with HCl, 6N, 2 mL, ultrapure
Antimony Arsenic Selenium	250-mL polyethylene bottle, acid rinsed. **Field rinse.**	RAH	Raw sample. Acidify with HNO_3 to pH<2.
Cyanide	250-mL polyethylene bottle. **Field rinse.**	LC0023 LC0880	Raw sample. Add NaOH to pH >12. Chill/maintain at 4°C. Filtered sample. Add NaOH to pH >12. Chill/maintain at 4°C.

[1]List of constituents and sample-designation codes is not complete or comprehensive. Some notable omissions include chemical oxygen demand and sulfide. Check with NWQL for a comprehensive list of analyses and sample designations and instructions. Check National Water Quality Technical Memorandum 97.05 for requirements of the USEPA Drinking Water Program.

[2]Container size is subject to sample-volume and analytical-method requirements. Acid-rinsed bottles must be received from the laboratory capped. Do not use acid-rinsed bottles that arrive uncapped.

Appendix A5-C. Sample-designation codes and a summary of field-processing requirements for analyses of stable isotopes and radiochemicals in water

[NWQL, National Water Quality Laboratory of the U.S. Geological Survey; L, liter; LC, laboratory code; DIC, dissolved inorganic carbon; mL, milliliters; $HgCl_2$, mercuric chloride; °C, degrees Celsius; HNO_3, nitric acid; <, less than; TDS, total dissolved solids]

Stable isotopes and radiochemicals[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation[3]
$^{13}C/^{12}C$	1-L glass bottle, narrow neck, with Teflon™/silicon septum. **Field rinse**.	RUS LC440	Raw sample, untreated. Contact laboratory for $^{13}C/^{12}C$ and $^{18}O/^{16}O$ combined sample (LC1243). Fill bottle to overflowing.
^{14}C	Safety-coated or glass bottles with Teflon™/silicon septum. **Field rinse**. Secure cap with electrical tape. Bottle size depends on sample pH and concentration of DIC per volume of sample.	RUS/RUR	Raw or filtered sample—Filter samples with visible particulates; untreated. Fill bottle to overflowing. Exclude air and (or) flush headspace with nitrogen gas. Store chilled and in the dark. Contact NWQL.
$^{2}H/^{1}H$	60 mL clear glass bottle. Leave small headspace. Option: 250 mL polyethylene, no headspace. Use caps with polyseal conical inserts. Do not use plastic bottles if sample will be held or archived. **No field rinse.**	RUS, LC1574 or SH1142 if analyzing together with $^{18}O/^{16}O$.	Raw or filtered sample, untreated. Fill bottle to overflowing; then decant to leave a slight headspace. (Can be collected with $^{18}O/^{16}O$.)
$^{18}O/^{16}O$	Same as $^{2}H/^{1}H$ (LC1574) No field rinse.	RUS, LC0489 or SH1142 if analyzing together with $^{2}H/^{1}H$.	Filtered or unfiltered sample, untreated. Fill bottle to overflowing.

Appendix A5-C. Sample-designation codes and a summary of field-processing requirements for analyses of stable isotopes and radiochemicals in water —*Continued*

Stable isotopes and radio-chemicals[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation[3]
$^{15}N/^{14}N$	1-L amber glass bottle or high-density polyethylene (HDP) bottle. Use caps with polyseal conical inserts. **No field rinse.**	RUS, LC1717 (ammonia), LC1718 (as nitrate), or LC1921 (as nitrate plus ammonia)	Filtered sample, untreated. Fill bottle to shoulder. Wrap HDP bottle in aluminum foil. (Do not add $HgCl_2$.) Chill/maintain at 4 °C. **Send overnight to NWQL.**
$^{34}S/^{32}S$	[Refer to Carmody and others (1998) or E-mail **isotopes@usgs.gov**.]	RUS, Add appropriate laboratory code.	[Refer to Carmody and others (1998) or E-mail isotopes@usgs.gov.]
Radium 226	2-L polyethylene bottle, acid rinsed. (Check with laboratory.) **No field rinse.**	FAR, LC794	Filtered sample. Fill bottle to shoulder. Add HNO_3 to pH <2.
Radium 228	2-L or 7-L polyethylene bottle (check laboratory requirements), acid rinsed. **No field rinse.**	FAR, LC1364	Filtered sample. Fill bottle to shoulder. Add HNO_3 to pH <2.
Uranium U-234 U-235 U-238	Two 1-L polyethylene bottles, acid rinsed. **No field rinse.**	FAR, SH1130	Filtered sample. Fill bottle to shoulder. Add HNO_3 to pH <2.
Gross radio-activity (Gross alpha and gross beta)	1-L polyethylene bottle(s), acid rinsed. **No field rinse.**	FAR, SH456 or SH458, depending on TDS	Filtered sample. Fill bottle to shoulder. Add HNO_3 to pH <2.

Appendix A5-C. Sample-designation codes and a summary of field-processing requirements for analyses of stable isotopes and radiochemicals in water —*Continued*

Stable isotopes and radio-chemicals[1]	Size and type of sample container[2]	Sample-designation codes of NWQL[1]	Treatment and preservation[3]
Tritium[1]	High-density, nonbreakable, poly-ethylene (HDPE) or 1-L glass GCC bottle. **No field rinse.**	RUR	Raw sample, untreated. Leave slight headspace. Do not store sample near radium (for example, glowing clocks, watches, signs)
Radon-222	Glass vial containing liquid-scintil-lation solution. **No field rinse.**	RURCV	Raw sample. Inject 10 mL of sample below liquid-scintilla-tion solution.

[1]This table is not complete or comprehensive. Check with NWQL for the most current information on analytical schedules, laboratory codes, parameter codes, sample requirements, prices, and associated information. "G" indicates glass container; "CC" indicates chilled sample; "LC", laboratory code; "SH," laboratory schedule; "R" designates a raw or wholewater sample. For tritium/helium-3 and chlorofluorocarbon sampling requirements, see sections 5.6.3.J and 5.6.3.K, respectively.

[2]If glass bottles are used, leave enough air space in bottles to accommodate expansion of chilled samples unless instructed otherwise. Seal cap with wax or plastic tape, or as directed by laboratory. Send electronic mail requests to isotopes@usgs.gov. Container size is subject to sample-volume and analytical-method requirements. Acid-rinsed bottles must be received from the laboratory capped. Do not use acid-rinsed bottles that arrive uncapped.

[3]Procedures for collection and processing of isotope and radiochemical samples are also described in Shelton and others (1994), Koterba and others (1995), and Timme (l995).

Appendix A5-D. Procedures for Processing Samples for Analysis of Dissolved and Suspended Organic Carbon Using a Silver Filter and Gas-Pressurized Filtration Apparatus.

This appendix describes the original procedure ("Gas-Pressurized Filter Procedures for Processing Samples for Analysis of Dissolved and Suspended Organic Carbon," NFM 5.2.2.C, Version 5/99) for processing samples for analysis of dissolved organic carbon (DOC) and suspended organic carbon (SOC).[1] This procedure may be used as an alternative to those described in section 5.2.2.C. The laboratory analysis of SOC samples requires a different method from that of POC or TPC samples. The field team needs to ensure that the correct method code has been entered onto the laboratory analytical request form.

SOC and DOC can be processed through a 47-mm-diameter, 0.45-µm pore-size, silver-metal filter medium. A gas-pressurized filter assembly (SOC/DOC filter apparatus) constructed of either stainless steel or fluorocarbon polymer is required for this procedure (fig. A5-D.1). In addition, either a peristaltic pump, a manual air pump, or compressed gas (usually organic-free nitrogen gas) is used to pressurize the filtration apparatus and force the sample through the silver filter. Filtration procedures are identical for ground-water and surface-water samples.

A. Stainless steel filter assembly

B. Fluorocarbon polymer filter assembly

Figure A5-D.1 . Apparatus for filtering samples for analysis of dissolved/ suspended organic carbon: (A) stainless steel pressure-filter assembly and (B) fluorocarbon polymer pressure-filter assembly. (Published with permission: A, Gelman Sciences; B, Savillex Corporation.)

[1]Refer to Office of Water Quality Technical Memorandums 2000.05, 2000.07, and 2000.08 for an explanation of changes to the field procedures for collecting and processing samples for organic carbon analysis.

A different set of procedures and separate silver filters are used to process the SOC and the DOC samples, unless suspended-material concentrations are low (up to about 30 mg/L). This section describes methods for (1) filtration of SOC samples only, (2) combined SOC and DOC sample filtration, and (3) filtration of DOC samples only.

- **If sample contains a large amount of suspended materials, at least two filtrations must be performed: one for SOC and one for DOC.**
- If sample contains low concentrations of suspended materials, filtration procedures can be combined using the same silver filter.
- Unless the study plan dictates an additional sample for quality control, only one silver filter should be needed for the SOC filtration.
  - The SOC filtration requires a minimum of 0.5 mg of suspended material in the 125-mL sample.
  - If filter clogging is a problem, or if it is difficult to obtain the 125-mL volume of sample needed for the SOC analysis, 64 mL of sample or multiple 64-mL samples can be substituted.
- Immediately after each use, rinse the filter apparatus several times with organic-grade DIW.
  - Field clean the filter apparatus while still wet if it is to be used at the next site. Otherwise, rinse, bag, and return the apparatus to the office laboratory for cleaning.
  - Thoroughly rinse the white (fluorocarbon polymer) O-ring and any other fluorocarbon polymer parts.
  - After cleaning, double-wrap all apertures and the filter apparatus with aluminum foil and place filter apparatus inside a sealable plastic bag.
- Blank water (VBW or PBW) from a freshly opened bottle should be used for quality-control samples for the DOC analysis. This blank water can also be used for prerinsing the filter media, if necessary. Once the bottle has been opened, the VBW or PBW must not be used for collection of future quality-control samples.
- Document on field forms and in field notes the filtration procedures used.

Do not use methanol or any other solvent to clean SOC, DOC, or TOC equipment (NFM 3).

TECHNICAL NOTE: Use of 64 mL or 125 mL baked glass bottles (available from OWQRL) is recommended instead of a graduated cylinder to measure sample volume for the DOC or combined SOC/DOC analysis. The advantage of using the baked glass bottles to measure volume is that they are certified as clean, whereas graduated cylinders can be difficult to clean adequately, especially under field conditions (Burkhardt and others, 1997), and cannot be baked because calibration will be lost.

- Bottles for DOC samples must have been baked at 400°C and meet a detection limit criterion for organic carbon of <0.1 mg/L.
- Volumetric accuracy of the 125-mL and 64-mL baked glass bottles is about ±1 mL.

SOC sample processing:

SOC analysis of the suspended material left on the silver filter requires that the volume of sample passed through the silver filter be measured and recorded. Determination of the volume of sample to be filtered for SOC analysis can depend on the concentrations of suspended materials; however, the concentration of humic and other substances that cause colored water, such as organic and inorganic colloids, will affect the volume that can pass through the silver filter. The sample volume that can pass through the silver filter decreases as the concentration of suspended materials increases. A graph of the historical stream stage compared to a graph of the suspended-material concentration will aid in estimating suspended-material concentrations at a given surface-water site. Guidelines for selecting the volume of sample to be filtered for SOC analysis, based on suspended-material concentrations, are shown in table 5-6d.

1. Collect the SOC sample(s) in a baked glass bottle, either at the centroid of the streamflow (NFM 4) or as a subsample from the churn or cone splitter. The data-quality requirements of the study and site characteristics determine where to withdraw the sample. If collecting sample at the centroid of flow with a weighted-bottle sampler, fill the bottle to the top; this is not necessary if subsampling from the churn or cone splitter. Cap the bottle securely.

    - Use a 125-mL baked glass bottle for water with relatively small concentrations of suspended materials (concentrations approximately less than 250 to 300 mg/L) (table 5-6d).
    - 64-mL baked glass bottles are recommended for samples that are colored or particulate laden.
    - A clean, graduated cylinder may be used when the volume of sample to be filtered is less than 64 mL.

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Table 5-6d. Guidelines for selecting the volume needed for filtration of samples for analysis of suspended and particulate organic carbon
[Guidelines are based on sand-sized materials; other physical property factors and chemical composition were not taken into account; mg/L, milligrams per liter; mL, milliliters; >, greater than]

Approximate concentration of suspended materials (mg/L)	Volume of sample to be filtered (mL)
1 - 30	250
> 30 - 300	100
> 300 - 1,000	30
> 1,000	10

2. Cover the bench or table with a sheet of aluminum foil to make a clean work surface. Put on appropriate disposable, powderless gloves. Assemble necessary equipment on the clean work surface.

   a. To remove airborne particulates, attach an in-line, 0.2-µm pore-size filter (Acrodisc 50™) to the inlet side of a dry pump hose that goes to the filter apparatus when using peristaltic or hand pumps to pressurize the apparatus.

   b. Change gloves.

   c. Remove the aluminum foil wrapping from equipment.

3. Disassemble the clean filter apparatus.

4. Using metal forceps, place a silver filter on the base of the filter apparatus between the support screen and the fluorocarbon polymer gasket, and screw the barrel onto the filter base. (There is no gasket in the fluorocarbon polymer apparatus.)

5. Pour a minimum of 100 mL of ASTM Type II reagent water (Burkhardt and others, 1997) or VBW or PBW into the barrel. Analysis of the water used must indicate less than 0.1 mg/L of organic carbon.

6. Screw the top part of the filter apparatus onto the barrel and attach a clean, dry hose, either from a peristaltic pump, hand pump, or compressed gas cylinder (use a clean metal hose clamp to secure the discharge hose to the inlet connector). Set the filter apparatus into a stand.

7. Apply pressure to start the flow of rinse water through the filter apparatus, using either a peristaltic pump or hand pump, or by regulating the flow of compressed gas (usually nitrogen).

   a. The pump pressure must be regulated to less than 15 lb/in^2.

   b. If compressed gas (for example, organic-free nitrogen) is used, ensure that the gas is clean by way of gas-purveyor certification or by attaching an in-line 0.2-mm Gelman Acro™ 50 hydrophobic membrane filter disk. **Do not use any other type of filter**. Proceed as follows:

      i. **Make sure that the pressure regulator valve is closed.** Turn the handle on the pressure regulator counterclockwise for several turns until the pressure-regulator valve is closed.

      ii. Open the valve to the nitrogen cylinder.

      iii. Open the pressure-regulator valve by turning the handle clockwise until up to 15 lb/in^2 registers on the pressure gage. Do not exceed 15 lb/in^2 of pressure.

   c. Discard rinse water.

8. Depressurize the filter apparatus. **Always point the apparatus away from your body, face, and other people.** When using compressed gas,

   a. Close the valve to the pressure regulator after the pressure gage shows no pressure.

   b. Close the valve to the gas cylinder.

   c. Change gloves.

Wear safety glasses when pressurizing or depressurizing the filter apparatus.

9. Remove the top of the filter apparatus carefully.

10. Shake the sample vigorously (swirl if using a graduated cylinder) to suspend all particulate matter. (This is possible even if the bottle is filled to the top.)

11. Pour an aliquot of the sample immediately into the barrel of the filter apparatus, keeping particulates suspended.

12. Screw the top part of the filter apparatus onto the barrel and pressurize to filter the sample. Follow the instructions in step 7 (above) for pressurizing the filter apparatus.

13. After an aliquot of sample has been filtered or filtrate is being collected at less than one drop per minute:

    a. Depressurize apparatus (step 8).

    b. Remove the top of the filter apparatus.

    c. Check if there is water on the silver filter and if it is covered with particulates.

    - If the silver filter is dry but not covered with particulates, add another aliquot of sample by repeating steps 10–12.
    - After the silver filter is dry and covered with particulates, continue to step 14.

TECHNICAL NOTES:

It is important that all the water in the barrel be passed through the silver filter, leaving the filter "dry." To accomplish this, it might be necessary to filter the sample as separate aliquots, repeating steps 10–13 until the filter is loaded to capacity.

Shake the sample to resuspend particulates before pouring each aliquot into the barrel.

If using a 125-mL or 64-mL bottle, it is not necessary to empty the entire sample volume. Use of a clean, graduated cylinder also is acceptable.

It is recommended (but not required) that the sides of the barrel of the filter apparatus be rinsed with organic-grade DIW.

14. Collect the filtrate in a 50-mL or other appropriately sized graduated cylinder.

    - If additional aliquots will be filtered through the same silver filter, collect all the filtrate in the graduated cylinder.
    - When the entire filtration is complete, record the total volume of filtrate on field forms and on the Analytical Services Request (ASR) form.
    - Discard filtrate in the graduated cylinder—**Do not send to laboratory for analysis.**

15. Depressurize (step 8) and disassemble the bottom of the filter apparatus.

    a. Use a pair of metal forceps to remove the silver filter.

    b. Fold the silver filter in half with suspended material on the inside, taking care not to lose any suspended material. **Do not wrap the silver filter in aluminum foil.**

    c. Place the folded silver filter into a petri dish for SOC analysis.

    d. Close the petri dish and label it with site identification, date and time, total filtered volume of sample, and laboratory sample designation code. (The total volume of filtered sample includes the volume used to precondition the silver filter(s).)

    e. Maintain SOC sample at or below 4°C during storage and shipment to the laboratory.

Combined SOC/DOC sample processing:

Procedures for a combined filtering of samples for SOC and DOC analysis are listed below. Additional information can be found in Burkhardt and others (1997).

1. Collect the sample for SOC/DOC analysis as instructed in NFM 4.

2. Cover the bench or table with a sheet of aluminum foil to make a clean work surface. Put on appropriate disposable, powderless gloves. Assemble necessary equipment on the clean work surface.

    a. To remove airborne particulates, attach an in-line, 0.2-µm pore-size filter (Acrodisc 50™) to the inlet side of a dry pump hose that goes to the filter apparatus when using peristaltic or hand pumps to pressurize the apparatus.

    b. Change gloves.

    c. Remove the aluminum foil wrapping from equipment.

3. Disassemble the clean filter apparatus.

4. Using metal forceps, place a silver filter on the base of the filter apparatus between the support screen and the fluorocarbon polymer gasket, and screw the barrel onto the filter base. (There is no gasket in the fluorocarbon polymer pressure-filter apparatus.)

5. Pour a minimum of 100 mL of ASTM Type II reagent water (Burkhardt and others, 1997) or VBW or PBW into the barrel. Analysis of the water used must indicate less than 0.1 mg/L of organic carbon.

6. Screw the top part of the filter apparatus onto the barrel and attach a clean, dry hose, either from a peristaltic pump, hand pump, or compressed gas cylinder (use a clean metal hose clamp to secure the discharge hose to the inlet connector). Set the filter apparatus into a stand.

7. Apply pressure to start the flow of rinse water through the filter apparatus, using either a peristaltic pump or hand pump, or by regulating the flow of compressed gas (usually nitrogen).

Wear safety glasses when pressurizing or depressurizing the filter apparatus.

   a. The pump pressure must be regulated to less than 15 lb/in^2.
   b. If compressed gas (for example, organic-free nitrogen) is used, proceed as follows:
      i. **Make sure that the pressure regulator valve is closed.** Turn the handle on the pressure regulator counterclockwise for several turns until the pressure-regulator valve is closed.
      ii. Open the valve to the nitrogen cylinder.
      iii. To pressurize the filter apparatus, open the pressure-regulator valve by turning the handle clockwise until up to 15 lb/in^2 registers on the pressure gage.
   c. Discard rinse water.

Do not exceed 15 lb/in^2 of pressure.

8. Depressurize the filter apparatus. **Always point the apparatus away from your body, face, and other people.** When using compressed gas,
   a. Close the valve to the pressure regulator after the pressure gage shows no pressure.
   b. Close the valve to the gas cylinder.
   c. Change gloves.
9. Remove the top of the filter apparatus carefully.
10. Condition the silver filter for the SOC/DOC sample:
    a. Select the volume of wholewater (either 64 mL or 125 mL) to be filtered based on the estimated suspended-materials concentration of the sample, and record the volume on the ASR and the field forms. The volume to be filtered can be based on the table 5-6 guidelines and on previous experience of filtering samples from the site.

b. Shake the sample vigorously to resuspend settled particles and measure the sample volume using a clean, baked 64-mL or 125-mL bottle filled to the very top. **Do not field rinse baked glass bottles.** Immediately transfer the entire volume of the sample container to the barrel of the filter apparatus.

c. Screw the top part of the filter apparatus onto the barrel and pressurize to filter the sample. Follow the instructions in step 7 (above) for pressurizing the filter apparatus.

d. Condition the silver filter by passing 15 to 25 mL of sample water through the filter to waste. (Pass 15 mL of sample water through the silver filter if using a 64-mL volume of sample; 15 mL is the minimum volume of sample that should be used.) Record the total volume of water that was passed through the silver filter.

Do not field rinse DOC bottle.

11. Place a 125-mL baked glass bottle under the discharge tube of the filter apparatus and collect the sample filtrate for the DOC analysis (100 mL is recommended; a minimum of 50 mL is required). If the silver filter clogs before sufficient volume for the SOC analysis can be filtered, start the process over and filter a smaller volume of water; the 64-mL bottles are useful for such conditions. **If the silver filter clogs before the entire volume of the 64-mL bottle can be filtered, this combined SOC/DOC method cannot be used. Start over and filter SOC and DOC samples separately.**

    - If the volume needed for the SOC analysis is insufficient for a DOC analysis (less than 50 mL), two or more filtrations through separate silver filters can be combined into one DOC bottle. (Retain two of the filters if a duplicate SOC analysis is planned and record the total volume of sample that passed through each of the retained filters.)
    - Each time a new silver filter is used, repeat steps 3–10, rinsing and conditioning the silver filter as described. Discard the first 15 or 25 mL of sample filtrate to waste. Reposition the DOC bottle under the discharge tube and collect the sample filtrate. Record the total volume of sample that was passed through each silver filter.
    - If the volume needed for SOC analysis is greater than the 100 mL of sample to be used for DOC analysis, remove DOC bottle after filling with 100 mL of filtrate, but continue filtering until the entire volume needed for SOC analysis has been filtered. (Record total volume filtered and discard extra filtrate.)

12. After the DOC sample has been collected and the volume for SOC analysis has been filtered, cap the DOC bottle securely and check that the bottle is labeled correctly and completely. Place the bottle in a foam sleeve before placing in an ice-filled shipping container.

13. Depressurize the filter apparatus (step 8), then disconnect the hose from the filter apparatus cylinder and remove the top. When depressurizing the compressed-gas-operated apparatus:

    a. Close the valve to the pressure regulator only after the gage indicates no pressure.

    b. Close the valve to the nitrogen cylinder.

14. Using no more than a total of 20 mL of organic grade DIW:

    - Rinse residual suspended matter from the bottle that was used to measure sample volume and pour into the filter barrel.
    - Rinse any residual suspended matter from the sides of the filter barrel.

15. Reconnect the top of the filter apparatus. Attach the pressure hose and pressurize (step 7), passing the organic-grade DIW rinse water through the silver filter. Discard rinse water to waste. Depressurize the filter apparatus (step 8).

16. Disassemble the bottom of the filter apparatus and remove the silver filter.

    a. Use a pair of metal forceps when removing the silver filter.

    b. Fold the filter in half with suspended material on the inside, taking care not to lose any suspended material. **Do not wrap the silver filter in aluminum foil.**

    c. Place the folded filter in a petri dish for SOC analysis.

    d. Close the petri dish and label dish with site identification, date and time, total filtered volume of sample, and the laboratory sample designation code. (Include the volume used to precondition the silver filter(s) in the total volume of filtrate.)

    e. Place the labeled petri dish in a sealable plastic bag.

    f. Chill DOC and SOC samples and maintain at or below 4°C without freezing (section 5.5). For SOC samples submitted to NWQL, record the total volume of filtrate on the comment line of the ASR form.

g. If more than one silver filter was needed for the SOC sample, place each silver filter into a separate petri dish that is labeled as described in step 16d. Place all the petri dishes for a single sample into one sealable plastic bag labeled with the site identification and the date and time of sample collection. This is submitted as a single sample.

- Package the silver filter(s) for duplicate SOC analysis separately.
- Ship samples for SOC analysis to the laboratory with a note on the ASR form stating the number of silver filters used.

For SOC analysis, record TOTAL VOLUME of sample that passed through each silver filter.

DOC sample processing:

Procedures for filtering a DOC-only sample are listed below. Additional information can be found in Burkhardt and others (1997).

1. Collect the sample for DOC analysis (NFM 4).
2. Cover a bench or table with a sheet of aluminum foil to make a clean work surface. Put on appropriate disposable, powderless gloves. Assemble necessary equipment on the clean work surface.
   a. To remove airborne particles, attach an in-line filter, 0.2-µm pore size, (Acrodisc 50™) to a dry pump hose in front of the filter apparatus when using peristaltic or hand pumps to pressurize the apparatus.
   b. Change gloves.
   c. Remove the aluminum foil wrapping from equipment.
3. Disassemble the clean filter apparatus.
4. Using metal forceps, place a silver filter on the base of the filter apparatus between the support screen and the fluorocarbon polymer gasket, and screw the barrel onto the filter base. (There is no gasket in the fluorocarbon polymer pressure-filter apparatus.)
5. Pour a minimum of 100 mL of ASTM Type II reagent water (Burkhardt and others, 1997) or VBW or PBW into the barrel. Analysis of the water used must indicate less than 0.1 mg/L of organic carbon.
6. Screw the top part of the filter apparatus onto the barrel and attach a clean, dry hose, either from a peristaltic pump, hand pump, or compressed gas cylinder (use a clean metal hose clamp to secure the discharge hose to the inlet connector). Set the filter apparatus into a stand.

7. Apply pressure to start the flow of rinse water through the filter apparatus, using either a peristaltic pump or hand pump, or by + regulating the flow of compressed gas (usually nitrogen).

Wear safety glasses when pressurizing or depressurizing the filter apparatus.

   a. The pump pressure must be regulated to less than 15 lb/in^2.
   b. If compressed gas (for example, organic-free nitrogen) is used, proceed as follows:
      i. **Make sure that the pressure regulator valve is closed.** Turn the handle on the pressure regulator counterclockwise for several turns until the pressure-regulator valve is closed.
      ii. Open the valve to the nitrogen cylinder.
      iii. Open the pressure-regulator valve by turning the handle clockwise until up to 15 lb/in^2 registers on the pressure gage. Do not exceed 15 lb/in^2 of pressure.
   c. Discard rinse water.

8. + Depressurize the filter apparatus. **Always point the apparatus away from your body, face, and other people.** When using compressed gas,
   a. Close the valve to the pressure regulator after the pressure gage shows no pressure.
   b. Close the valve to the gas cylinder.
   c. Change gloves.
9. Remove the top of the filter apparatus carefully.
10. Condition the prerinsed silver filter:
   a. Open the barrel of the filter apparatus and pour about 125 mL of wholewater sample into the barrel (or about 64 mL if silver filter media is expected to clog). For water with large concentrations of suspended materials, collect the sample first into a baked glass bottle, allow suspended materials to settle, and pour 125 mL of the clear supernatant into the filter barrel.
   b. Screw the top part of the filter apparatus onto the barrel.
11. Apply pressure to start the flow of sample through the filter apparatus (step 7).
   + • **Do not exceed 15 lbs/in^2.**
   • If using compressed gas, open the pressure-regulator valve first, then the valve to release gas from the cylinder (tank).

12. Condition the silver filter media by passing about 25 mL of sample through the silver filter to waste.

13. Filter the sample:

    a. Place a 125-mL organic-free amber glass bottle under the discharge tube of the filter apparatus. **Do not prerinse the DOC bottle.**

    b. If the silver filter media clogs, depressurize the filter apparatus and replace the silver filter.

        i. Rinse the new filter with blank water as described in steps 5–9.

        ii. Fill a clean DOC bottle with the water to be sampled and let the suspended materials settle before decanting the sample into the barrel of the filter apparatus.

        iii. Condition the new silver filter by passing about 25 mL of sample through the filter to waste.

        iv. Reposition the DOC bottle under the discharge tube and continue to collect the filtrate.

    c. Fill the bottle until sufficient volume for DOC analysis has been collected (50 mL is the minimum requirement; 100 mL is recommended). Cap the bottle securely and check that the bottle is labeled correctly. Place the bottle in a foam sleeve before placing in an ice-filled shipping container.

14. Depressurize the filter apparatus (step 8).

15. Chill and maintain the DOC sample at or below 4°C without freezing (section 5.5).

16. Disassemble the bottom of the filter apparatus. Remove the silver filter with metal forceps and place the filter in a plastic bag for disposal or recycling. **Do not reuse silver filters.**

Never increase the pressure in a filter apparatus to greater than 15 lb/in^2 in order to increase the rate of filtration.

Isco Product Data

Isco 6712 Full-size Portable Sampler

Isco's 6700 Series Portable Samplers have set the industry standard, providing the most comprehensive and durable performance available. With the introduction of our new 6712, Isco takes another step toward the ultimate by including SDI-12 interface capabilities.

This full-size portable lets you take full advantage of the advanced 6712 Controller, with its powerful pump, versatile programming, and optional plug-in modules for integrated flow measurement. Setup is fast and simple, with online help just a key stroke away.

The environmentally-sealed 6712 controller delivers maximum accuracy and easily handles all of your sampling applications, including:

- Flow-paced sampling with or without wastewater effluent
- stormwater monitoring
- CSO monitoring
- permit compliance
- pretreatment compliance

In the Standard Programming Mode, the controller walks you through the sampling sequence step-by-step, allowing you to choose all parameters specific to your application. Selecting the Extended Programming Mode lets you enter more complex programs.

Optional land-line and GSM and CDMA cellular telephone modems allow programming changes and data collection to be performed remotely, from a touch-tone phone. They also provide dial-out alarm.

Bottle options are available for practically any sequential or composite application.

Versatile and Convenient

With eleven bottle choices, Isco's 6712 Sampler lets you quickly adapt for simple or intricate sampling routines. Up to 30 pounds (13.5 kg) of ice fits in the insulated base, preserving samples for extended periods, even in extreme conditions. The 6712 with the “Jumbo Base” option holds bottles up to 5.5 gallon (21 liter).

Tough and Reliable

The 6712 Portable Sampler features a vacuum-formed ABS plastic shell to withstand exposure and abuse. Its tapered design and trim 20-inch (50.8 cm) diameter result in easy manhole installation and removal. Large, comfortable handles make transporting safe and convenient—even when wearing gloves.

Isco's 6712 Portable Sampler carries a NEMA 4X, 6 (IP67) enclosure rating.

Superior capability, rugged construction, and unmatched reliability make the 6712 the ideal choice for portable sampling in just about any application.

Specifications

Isco 6712 Full-size Portable Sampler	
Size (Height x Diameter):	27 x 20 inches (50.7 x 68.6 cm)
Weight:	Dry, less battery - 32 lbs (15 kg)
Bottle configurations:	24 - 1 Liter PP or 350 ml Glass 24 - 1 Liter ProPak Disposable Sample Bags 12 - 1 Liter PE or 950 ml Glass 8 - 2 Liter PE or 1.8 Liter Glass 4 - 3,8 Liter PE or Glass 1 - 9,5 Liter PE or Glass 1 - 5.5 gallon (21 Liter)PE or 5 gallon (19 Liter) Glass, (with optional Jumbo Base)
Power Requirements:	12 V DC (Supplied by battery or AC power converter.)
Pump	
Intake suction tubing:	
Length	3 to 99 feet (1 to 30 m)
Material	Vinyl or Teflon
Inside dimension	3/8 inch (1 cm)
Pump tubing life:	Typically 1,000,000 pump counts
Maximum lift:	28 feet (8.5 m)
Typical Repeatability	±5 ml or ±5% of the average volume in a set
Typical line velocity at Head height: of	
3 ft. (0.9 m)	3.0 ft./s (0.91 m/s)
10 ft. (3.1 m)	2.9 ft./s (0.87 m/s)
15 ft. (4.6 m)	2.7 ft./s (0.83 m/s)
Liquid presence detector:	Non-wetted, non-conductive sensor detects when liquid sample reaches the pump to automatically compensate for changes in head heights.

Controller	
Weight:	13 lbs. (5.9 kg)
Size (HxWxD)	10.3 x 12.5 x 10 inches (26 x 31.7 x 25.4 cm)
Operational temperature:	32° to 120°F (0° to 49°C)
Enclosure rating:	NEMA 4X, 6 (IP67)
Program memory:	Non-volatile ROM
Flow meter signal input:	5 to 15 volt DC pulse or 25 millisecond isolated contact closure.
Number of composite samples:	Programmable from 1 to 999 samples.
Clock Accuracy:	1 minute per month, typical, for real time clock
Software	
Sample frequency:	1 minute to 99 hours 59 minutes, in 1 minute increments. Non-uniform times in minutes or clock times 1 to 9,999 flow pulses
Sampling modes:	Uniform time, non-uniform time, flow, event. (Flow mode is controlled by external flow meter pulses.)
Programmable sample volumes:	10 to 9,990 ml in 1 ml increments
Sample retries:	If no sample is detected, up to 3 attempts; user selectable
Rinse cycles:	Automatic rinsing of suction line up to 3 rinses for each sample collection
Program storage:	5 sampling programs
Sampling Stop/Resume:	Up to 24 real time/date sample stop/resume commands
Controller diagnostics:	Tests for RAM, ROM, pump, display, and distributor

Ordering Information

***Note**: Power source, bottle configuration, suction line, and strainer must be ordered separately. Many options and accessories are available for 6712 Samplers; see separate literature for 700 Series Modules and other components to expand your monitoring capabilities. Contact Isco, or your Isco representative for pricing and additional information.*

Description	Part Number
6712 Portable Sampler, Full-size Includes controller with 512kB RAM, top cover, center section, base, distributor arm, instruction manual, pocket guide.	68-6710-070
6712 Portable Sampler, with Jumbo Base As described above	68-6710-082

The 6712 Controller is also an SDI-12 data logger, and has many optional capabilities. Please contact Isco or your Isco distributor for more information.

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Water is life. Protect it.

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US SS-1 Fluoropolymer Sample Splitter, "14-Liter Teflon® Churn Splitter"

part number: SS-1

This inert, non-contaminating, fluoropolymer "Churn Splitter" consists of a thick walled cylindrical polytetrafluoroethylene (PTFE) vessel and agitator. A PTFE "push-pull" type spigot is supplied to draw off sub-samples from the splitter. The splitter has a volume of 14 liters. The splitter's dimensions are approximately 12 inches diameter by 13 inches tall and it weighs approximately 22 lbs.

Figure 1. US SS-1, 14-Liter Teflon Churn Splitter

Figure 2 is an exploded view listing all the parts of the US SS-1 Churn Splitter. The information in parenthesis is the part number for each part. The following parts are interchangeable with the US SS-4, 8-liter Teflon Churn Splitter: Cap (SS-4-03), Carry Handle O-Ring (SS-4-04C), Valve Body (SS-4-06A), Valve Insert (SS-4-06B), Valve Body O-Ring (SS-4-06C), Valve Insert O-Ring (SS-4-06D), and Valve Body Screw (SS-4-06E).

Teflon® is a registered trademark of the DuPont Corporation.

God Bless Our Troops

US SS-1 Fluoropolymer Sample Splitter, "14-Liter Teflon® Churn Splitter"

part number: SS-1

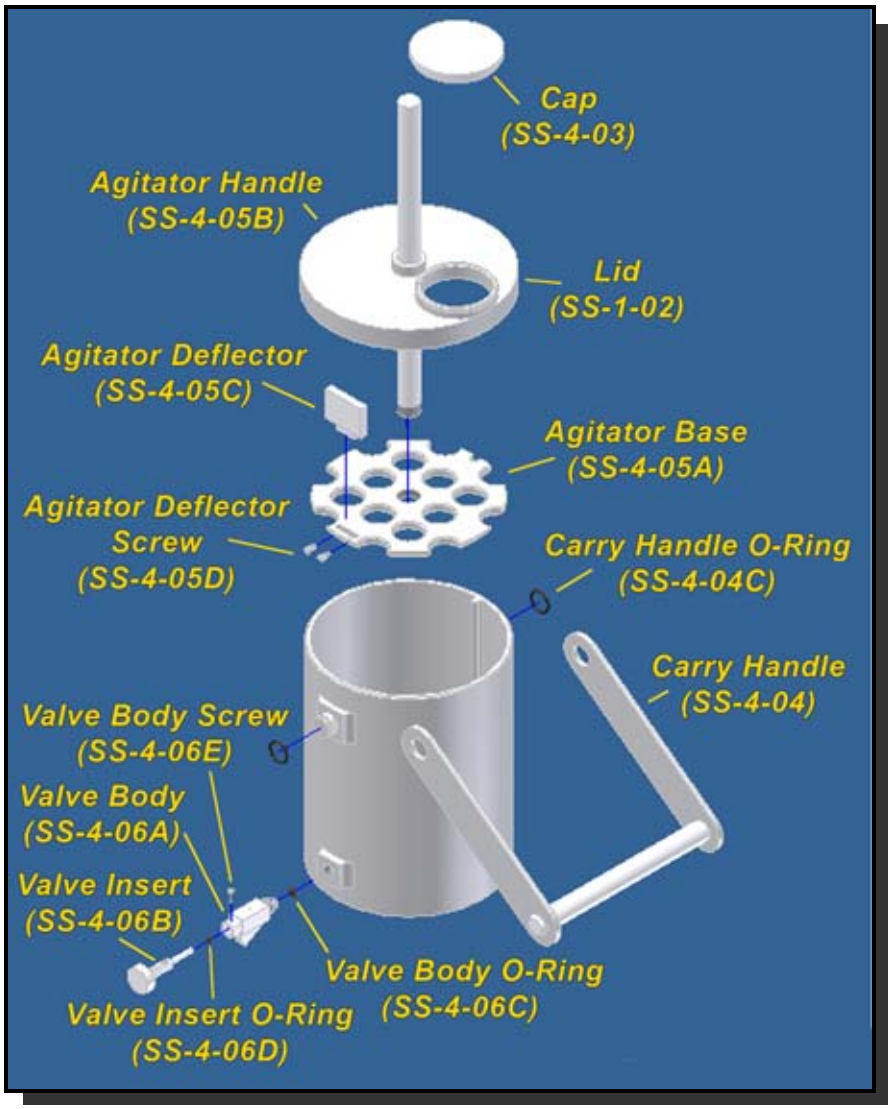

Figure 2. US SS-1, 14-Liter Teflon Churn Splitter Exploded Parts Illustration

STANDARD OPERATING PROCEDURE (SOP) AP-01

SAMPLE PACKAGING AND SHIPPING

SCOPE AND APPLICATION

This SOP describes specific requirements for sample packaging and shipping to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein. This SOP also presents the method to be used when packing samples that will either be hand delivered or shipped by commercial carrier to the laboratory.

EQUIPMENT AND SUPPLIES REQUIRED

Make sure that you have the equipment and supplies necessary to properly pack and ship environmental samples, including the following:

- Project-specific sampling and analysis plan (SAP)
- Project-specific field logbook
- Sealable airtight bags in assorted sizes (e.g., Ziploc®)
- Wet ice in doubled, sealed bags; frozen Blue Ice®; or dry ice
- Cooler(s)
- Bubble wrap
- Fiber-reinforced packing tape, clear plastic packing tape, and duct tape
- Scissors or knife
- Chain-of-custody (COC) forms
- COC seals
- Large plastic garbage bags (preferably 3 mil [0.003 in.] thick)
- Paper towels
- "Fragile," "This End Up," or "Handle With Care" labels
- Mailing labels
- Air bills for overnight shipment

PROCEDURE

Customize the logistics for sample packaging and shipping to each study. If necessary, transfer samples from the field to a local storage facility where they can be frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory or use a commercial courier or shipping service. In the latter case, Integral field personnel must be aware of any potentially limiting factors to timely shipping, such as availability of overnight service and weekend deliveries to specific areas, and shipping regulations regarding "restricted articles" (e.g., dry ice, formalin) prior to shipping the samples.

SAMPLE PREPARATION

Take the following steps to ensure the proper transfer of samples from the field to the laboratories:

At the sample collection site:

1. Document all samples using the proper logbooks or field forms (see SOP AP-02), required sample container identification (i.e., sample labels with tag numbers), and COC form (example provided in SOP AP-03). Fill out the COC form as described in SOP AP-03, and use the sample labeling techniques provided in SOP AP-04.
2. Make all applicable laboratory quality control sample designations on the COC forms. Clearly identify samples that will be archived for future possible analysis. Label these samples as follows: "Do Not Analyze: Hold and archive for possible future analysis." Some laboratories interpret "archive" to mean that they should continue holding the residual sample after analysis.
3. Notify the laboratory contact and the Integral project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Send copies of all COC forms to Integral's project QA/QC coordinator or project manager, as appropriate.
4. Keep the samples in the possession of the sampling personnel at all times. Lock and secure any temporary onsite sample storage areas to maintain sample integrity and COC requirements.
5. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.
6. Complete the COC form as described in SOP AP-03, and retain the back (pink) copy for project records prior to sealing the cooler. Check sample containers against the COC form to ensure all the samples that were collected are in the cooler.

7. Store each sample container in a sealed plastic bag that allows the sample label (example provided in SOP AP-03) to be read. Before sealing the bags, ensure that volatile organic analyte (VOA) vials are encased in a foam sleeve or in bubble wrap.
8. If the samples require storage at a specific temperature, place enough ice in the sample cooler to maintain the temperature (e.g., 4°C) throughout the sampling day.

At the sample processing area (immediately after sample collection) take the following steps:

1. If the samples require a specific storage temperature, then cool the samples and maintain the temperature prior to shipping. For example, place enough ice in each sample cooler to maintain the temperature at 4°C until processing begins at the testing laboratory.
2. Be aware of holding time requirements for project-specific analytes and arrange the sample shipping schedule accordingly.
3. Place samples in secure storage (i.e., locked room or vehicle) or keep them in the possession of Integral sampling personnel before shipment. Lock and secure any sample storage areas to maintain sample integrity and COC requirements.
4. Store samples in the dark (e.g., keep coolers shut).

At the sample processing area (just prior to shipping), do the following:

1. Check sample containers against the COC form to account for all samples intended for shipment.
2. Choose cooler(s) of appropriate size and make sure they are clean of gross contamination inside and out. If the cooler has a drain, close the drain and secure it with duct tape.
3. Line the cooler with bubble wrap and place a large plastic bag (preferably with a thickness of 3 mil), open, inside the cooler.
4. Individually wrap each glass container (which was sealed in a plastic bag at the collection site) in bubble wrap and secure with tape or a rubber band. Place the wrapped samples in the large plastic bag in the cooler, leaving room for ice to keep the samples cold (i.e., 4°C).
5. If temperature blanks have been provided by the testing laboratory, place one temperature blank in each sample cooler.
6. If the samples require a specific storage temperature, add enough wet ice or Blue Ice® to maintain that temperature during overnight shipping (i.e., 4°C). Always overestimate the amount of ice that will be required. Keep ice in a sealed plastic bag, which is placed in a second sealed plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it may insulate the samples from the ice. After adding all samples and ice to the cooler, use bubble wrap (or other

available clean packing material) to fill any empty space and prevent the samples from shifting during transport.

7. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the project-specific QA project plan calls for them.
8. Sign, date, and include any tracking numbers provided by the shipper on the COC form. Remove the back (pink) copy of the original COC form and retain this copy for the project records.
9. Seal the rest of the signed COC form in a bag and tape the bag to the inside of the cooler lid. Each cooler should contain an individual COC form for the samples contained inside it. If time is short and it becomes necessary to combine all the samples onto a single set of COC forms and ship multiple coolers together, then indicate on the outside of the appropriate cooler, "Chain-of-Custody Inside."
10. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it with fiber-reinforced packing tape. Tape the cooler around the opening, joining the lid to the bottom, and around the circumference of the cooler at both hinges.
11. As security against unauthorized handling of the samples, apply two COC seals across the opening of the cooler lid (provided with example field forms). Place one seal on the front right portion of the cooler and one on the back left. Be sure the seals are properly affixed to the cooler to prevent removal during shipment. Additional tape across the seal may be necessary if the outside of the cooler is wet.

SAMPLE SHIPPING

Hand Delivery to the Testing Laboratory

1. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be delivered to the laboratory and the estimated arrival time.
2. When hand-delivering environmental samples, make sure the testing laboratory receives them on the same day that they were packed in the coolers.
3. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after it has been faxed. Never leave the original COC form in the custody of non-Integral staff.

Shipped by Commercial Carrier to the Laboratory

1. Apply a mailing label to the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the cooler and to protect it from the weather. This is a secondary label in case the air bill is lost during shipment.
2. Fill out the air bill and fasten it to the handle tags provided by the shipper (or the top of the cooler if handle tags are not available).
3. If samples must be frozen (–20°C) during shipping, make sure that dry ice has been placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require.
4. Make sure that benthic infauna samples have been preserved with formalin in the field prior to shipping. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require for these samples.
5. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be shipped and the estimated arrival date and time. If environmental samples must be shipped at 4°C or –20°C, choose overnight shipping for delivery next morning. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after faxing. Never leave the original COC form in the custody of non-Integral staff.

STANDARD OPERATING PROCEDURE (SOP) AP-02

FIELD DOCUMENTATION

SCOPE AND APPLICATION

This SOP describes the Integral procedure for accurate record-keeping in the field for the purposes of ensuring that samples can be traced from collection to final disposition.

Document all information relevant to field operations properly to ensure that activities are accounted for in written records to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. Several types of field documents are used for this purpose and should be consistently used by field personnel. Field documentation should include only a factual description of site-related activities and observations. Field personnel should not include superfluous comments or speculation regarding the field activities or observations.

FIELD LOGBOOKS

During field sampling events, field logbooks must be used to record all daily activities. The purpose of the field logbook is to document events and record data measured in the field to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. The project manager (or designee) should issue a field logbook to the appropriate site personnel for the direction of onsite activities (e.g., reconnaissance survey team leader, sampling team leader). It is this designee's responsibility to maintain the site logbook while it is in his or her possession and return it to the project manager or turn it over to another field team.

Make entries in the field logbook as follows:

1. Document all daily field activities in indelible ink in the logbook and make no erasures. Make corrections with a single line-out deletion, followed by the author's initials and the date. The author must initial and date each page of the field logbook. The author must sign and date the last page at the end of each day, and draw a line through any blank space remaining on the page below the last entry.

2. Write the project name, dates of the field work, site name and location (city and state), and Integral job number on the cover of the field logbook. If more than one logbook is used during a single sampling event, then annotate the upper right-hand corner of the logbook (e.g., Volume 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event. Secure all field logbooks when not in use in the field. The following is a list of the types of information that is appropriate for entry in the field notebook:
   - Project start date and end date
   - Date and time of entry (24-hour clock)
   - Time and duration of daily sampling activities
   - Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, rain, thunder, wave action, current, tide, vessel traffic, air and water temperature, thickness of ice if present)
   - Name and affiliation of person making entries and other field personnel and their duties, including what times they are present
   - The location and description of the work area, including sketches, map references, and photograph log, if appropriate
   - Level of personal protection being used
   - Onsite visitors (names and affiliations), if any, including what times they are present
   - The name, agency, and telephone number of any field contacts
   - Notation of the coordinate system used to determine the station location
   - The sample identifier and analysis code for each sample to be submitted for laboratory analysis, if not included on separate field data sheets
   - All field measurements made (or reference to specific field data sheets used for this purpose), including the time of collection and the date of calibration, if appropriate
   - The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates, if not included on separate field data sheets
   - For aquatic sampling, the type of vessel used (e.g., size, power, type of engine)
   - Specific information on each type of sampling activity
   - The sample type (e.g., groundwater, soil, surface sediment), sample number, sample tag number, and any preservatives used, if not included on separate field data sheets
   - Sample storage methods

- Cross-references of numbers for duplicate samples
- A description of the sample (source and appearance, such as soil or sediment type, color, texture, consistency, presence of biota or debris, presence of oily sheen, changes in sample characteristics with depth, presence/location/thickness of the redox potential discontinuity [RPD] layer, and odor) and penetration depth, if not included on separate field data sheets
- Estimate of length and appearance of recovered cores, if not included on separate field data sheets
- Photographs (uniquely identified) taken at the sampling location, if any
- Details of the work performed
- Variations, if any, from the project-specific sampling and analysis plan (SAP) or standard operating protocols and reasons for deviation
- Details pertaining to unusual events that might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity, control of vertical descent of the sampling equipment)
- References to other logbooks or field forms used to record information (e.g., field data sheets, health and safety log)
- Any field results not appearing on the field data sheets (if used), including station identification and location, date, and time of measurement
- Sample shipment information (e.g., shipping manifests, chain-of-custody (COC) form numbers, carrier, air bill numbers, time addresses)
- A record of quantity of investigation-derived wastes (if any) and storage and handling procedures.

3. During the field day, as listed above, record in the logbook a summary of all site activities. Provide a date and time for each entry. The information need not duplicate anything recorded in other field logbooks or field forms (e.g., site health and safety officer's logbook, calibration logbook, field data sheets), but should summarize the contents of the other logbooks and refer to the pages in these logbooks for detailed information.
4. If measurements are made at any location, record the measurements and equipment used, or refer to the logbook and page number(s) or field forms on which they are recorded. All maintenance and calibration records for equipment should be traceable through field records to the person using the instrument and to the specific piece of instrumentation itself.

5. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

FIELD DATA FORMS

Occasionally, additional field data forms are generated during a field sampling event (e.g., groundwater monitoring form, sediment core profile form, water quality measurement form) to record the relevant sample information collected. For instructions regarding the proper identification of field data forms, sampling personnel should consult the project-specific SAP.

Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

PHOTOGRAPHS

In certain cases, photographs (print or digital) of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Ensure that photographs include a measured scale in the image, when practical. If you take photographs of sample characteristics and routine sampling activities, avoid using telephoto or wide-angle shots, because they cannot be used in enforcement proceedings. Record the following items in the field logbook for each photograph taken:

1. The photographer's name or initials, the date, the time of the photograph, and the general direction faced (orientation)
2. A brief description of the subject and the field work shown in the picture
3. For print photographs, the sequential number of the photograph and the roll number on which it is contained
4. For digital photographs, the sequential number of the photograph, the file name, the file location, and back-up disk number (if applicable).

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all photographic materials to be developed (prints) or copied (disks). Place the prints or disks and associated negatives in the project files (at the Integral project manager's location). Make photocopies of photo logs and any supporting documentation from the field logbooks, and place them in the project files with the prints or disks.

EQUIPMENT CALIBRATION RECORDS

Record in the field logbook all equipment calibration records, including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration. Calibrate all equipment used during the investigation daily, at a minimum, in accordance with the manufacturers' recommendations.

DISTRIBUTION OF COPIES

At Integral offices, make two copies of all field logbooks and additional field data forms. Stamp the first copy with a "COPY" stamp, and place it in the project file to be available for general staff use. Stamp the second copy with a "FILE" stamp, and place it in the data management file with the laboratory data packages, to be used by the data management and quality assurance staff only. Place the original field logbooks and forms in a locked file cabinet.

SET-UP OF LOCKING FILE CABINET

Place each project in its own file folder in a locking file cabinet. On the folder label, include the project name and contract number. Each project folder will include up to six kinds of files:

- Field logbook(s)
- Additional field data forms
- Photographs
- COC forms
- Acknowledgment of Sample Receipt forms
- Archive Record form (to be completed only if samples are archived at an Integral field storage facility or Integral laboratory).

STANDARD OPERATING PROCEDURE (SOP) AP-03

SAMPLE CUSTODY

SCOPE AND APPLICATION

This SOP describes Integral procedures for custody management of environmental samples.

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP AP-01, which covers sample packaging and shipping; SOP AP-02, which covers the use of field logbooks and other types of field documentation; and SOP AP-04, which covers sample labeling. Chain-of-custody (COC) forms ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in his or her possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside of Integral personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then an Integral field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

CHAIN-OF-CUSTODY FORMS

The COC form is critical because it documents sample possession from the time of collection through final disposition. The form also provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

Complete the COC form after each field collection activity and before shipping the samples to the laboratory. Sampling personnel are responsible for the care and custody of the samples until they are shipped. The individuals relinquishing and receiving the samples must sign the

COC form(s), indicating the time and date of the transfer, when transferring possession of the samples.

A COC form consists of three-part carbonless paper with white, yellow, and pink copies. The sampling team leader keeps the pink copy. The white and yellow sheets are placed in a sealed plastic bag and secured inside the top of each transfer container (e.g., cooler). Field staff retain the pink sheet for filing at the Integral project manager's location. Each COC form has a unique four-digit number. This number and the samples on the form must be recorded in the field logbook. Integral also uses computer-generated COC forms. If computer-generated forms are used, then the forms must be printed in triplicate and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file. Alternatively, if sufficient time is available, the computer-generated forms will be printed on three-part carbonless paper.

Record on the COC form the project-assigned sample number and the unique tag number at the bottom of each sample label. The COC form also identifies the sample collection date and time, type of sample, project name, and sampling personnel. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form is sent to the laboratory along with the sample(s).

PROCEDURES

Use the following guidelines to ensure the integrity of the samples:

1. Sign and date each COC form. Have the person who relinquishes custody of the samples also sign this form.
2. At the end of each sampling day and prior to shipping or storage, make COC entries for all samples. Check the information on the labels and tags against field logbook entries.
3. Do not sign the COC form until the team leader has checked the information for inaccuracies. Make corrections by drawing a single line through any incorrect entry, and then initial and date it. Make revised entries in the space below the entries. After making corrections, mark out any blank lines remaining on the COC form, using single lines that are initialed and dated. This procedure will prevent any unauthorized additions.

   At the bottom of each COC form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date of the transfer. The time the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.

4. If samples are sent by a commercial carrier not affiliated with the laboratory, such as FedEx or United Parcel Service (UPS), record the name of the carrier on the COC form. Also enter on the COC form any tracking numbers supplied by the carrier. The time of transfer should be as close to the actual drop-off time as possible. After signing the COC forms and removing the pink copy, seal them inside the transfer container.
5. If errors are found after the shipment has left the custody of sampling personnel, make a corrected version of the forms and send it to all relevant parties. Fix minor errors by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.
6. Provide a COC form and an Archive Record form for any samples that are archived internally at Integral.

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all COC forms to be copied. A discussion of copy distribution is provided in SOP AP-02.

CUSTODY SEAL

As security against unauthorized handling of the samples during shipping, affix two custody seals to each sample cooler. Place the custody seals across the opening of the cooler (front right and back left) prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

SHIPPING AIR BILLS

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., FedEx, UPS), the shipper provides an air bill or receipt. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting the sender's copy of all shipping air bills to be copied at an Integral office. A discussion of copy distribution is provided in SOP AP-02. Note the air bill number (or tracking number) on the applicable COC forms or, alternatively, note the applicable COC form number on the air bill to enable the tracking of samples if a cooler becomes lost.

ACKNOWLEDGMENT OF SAMPLE RECEIPT FORMS

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. The person receiving this form is responsible for reviewing it, making sure that the laboratory has received all the samples that were sent, and verifying that the correct analyses were requested. If an error is found, call the laboratory immediately, and document

any decisions made during the telephone conversation, in writing, on the Acknowledgment of Sample Receipt form. In addition, correct the COC form and fax the corrected version to the laboratory.

Submit the Acknowledgment of Sample Receipt form (and any modified COC forms) to be copied. A discussion of copy distribution is provided in SOP AP-02.

ARCHIVE RECORD FORMS

On the rare occasion that samples are archived at an Integral office, it is the responsibility of the project manager to complete an Archive Record form. This form is to be accompanied by a copy of the COC form for the samples, and will be placed in a locked file cabinet. The original COC form remains with the samples in a sealed Ziploc® bag.

STANDARD OPERATING PROCEDURE (SOP) AP-04

SAMPLE LABELING

SCOPE AND APPLICATION

This SOP describes the general Integral procedures for labeling samples, and the three kinds of labels that can be used on a project (i.e., sample labels, sample tags, and internal sample labels). Consult the project-specific sampling and analysis plan (SAP) to determine the exact sample identifiers and sample labels that are required for a given project. If they are not specified in the SAP, then follow the designations below.

SAMPLE IDENTIFIERS

Before field sampling begins, establish sample identifiers to be assigned to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes: 1) to identify related samples (i.e., replicates) to ensure proper data analysis and interpretation, 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples, and 3) to track individual sample containers to ensure that the laboratory receives all material associated with a single sample. To accomplish these purposes, each container may have three different codes associated with it: the sample identifier, the sample number, and the sample tag number. These codes and their use are described as follows:

- **Sample Identification Code**—The sample identification code (Sample ID) is a unique designation that identifies where and how the sample was collected. The sample identifier is recorded in the field logbook *only* and is not provided on the sample label or chain-of-custody (COC) form. The sample identifier is a multiple-part code. The first component begins with the letter abbreviation; for example, "SWNS" or "SWNB" to designate the surface water sample was collected from the near-surface or near-bottom of the water column. The second part could identify the sampling event; for example, "1" to designate Round 1 sampling. The third part could contain an abbreviation for whether the station is a single point (SP), a transect (TR), a composite (CO), or a vertically integrated station (VI). The station number would be the final component of the sample identifier. Use leading zeros for stations with numbers below 100 for ease of data management and correct data sorting.

  If appropriate, add a supplemental component to the sample identifier to code field

duplicate samples and splits. Use a single letter (i.e., a suffix of "A" and "B") to indicate field duplicates or splits in the final component of the sample identifiers. For equipment decontamination blanks, assign sequential numbers starting at 900 instead of station numbers. Use a sample type code that corresponds to the sample type for which the decontamination blank was collected. Additional codes may be adopted, if necessary, to reflect sampling equipment requirements (see project-specific SAP).

Examples of sample IDs are as follows:

- SWNS-1-SP-002: Surface water sample collected from the near-surface at a single point during Round 1 from Station 2.
- SWNB-1-TR-010-A: Duplicate surface water sample from the near-bottom transect during Round 1 from Station 10.

- **Sample Number**—The sample number is an arbitrary number assigned to each distinct sample or split that is shipped to the laboratory for separate analysis. The sample number appears on the sample containers and the COC forms. Each sample will be assigned a unique sample number. All aliquots of a composited field sample will have the same sample number. In cases where samples consist of multiple bottles from the same location, assign each bottle the same sample number and time. However, assign replicates from the same location different sample numbers and times. Sample numbers of related field replicates will not necessarily have any shared content.

  Each field split of a single sample will also have a different sample number and time. The sample number is generally a unique six-digit number that includes a two-digit media code and a four-digit number. The media code may be site-specific, but the Integral default codes are as follows:

  - SS—Surface soil
  - BH—Subsurface soil or rock (typically from borehole)
  - GW—Groundwater
  - SW—Surface water
  - PW—Pore water
  - SD—Sediment
  - BT—Biota or biological tissue

    The exact sample numbering scheme may vary from project to project. Variances in the sample numbering scheme will be described in the project-specific SAP for the field event. Example sample numbers are PW0001, PW0002, PW0003, etc.

- **Tag Number—**Attach a different tag number to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, assign each container the same sample number and a different sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted).

  The sample tag number is a unique five- or six-digit number assigned to each sample label (or "tag") for multiple bottles per sample. Integral sample labels come with a preprinted sample tag number. The tag number provides a unique tracking number to a specific sample bottle. This allows for greater flexibility in tracking sample bottles and assists in field quality control when filling out documentation and shipping. Sample tags are not used by many other consultants, and there may be resistance from such firms during teaming situations. However, experience has shown that tags can be very valuable, both in the field and while processing data from field efforts.

  Record tag numbers on the COC form. Laboratories use tag numbers only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Assign sample numbers sequentially in the field; sample labels are preprinted with sequential tag numbers.

SAMPLE LABELS

Integral sample labels are designed to uniquely identify each individual sample container that is collected during a sampling event. Field sampling teams are provided with preprinted sample labels, which must be affixed to each sample container used. Fill out the labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- A unique number (commonly referred to as the "Tag Number") that is preprinted on the label consisting of five or six digits; used to identify individual containers.

SAMPLE TAGS

Integral sample tags are designed to be affixed to each container that is used for a sample. Sample tags are required only for environmental samples collected in certain U.S.

Environmental Protection Agency (EPA) regions (e.g., EPA Region 5). Field crews are provided with preprinted sample tags. Attach sample tags to each individual sample container with a rubber band or wire through a reinforced hole in the tag. Mark all sample tag entries with indelible ink. Fill out the tags at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- Type of analysis.

A space for the laboratory sample number (provided by the laboratory at log-in) will also be provided on the sample tag.

INTERNAL SAMPLE LABELS

For benthic infaunal samples, wash away the sediment from the sample and collect the remaining benthic infauna into a sample container. Affix sample label (as discussed above) to the outside of the sample container. In addition, place an internal sample label inside the sample container. This internal sample label is made of waterproof paper; be sure to make all internal sample label entries with pencil. Fill out the internal sample labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservative used (e.g., formalin).

STANDARD OPERATING PROCEDURE (SOP) AP-05

INVESTIGATION-DERIVED WASTE HANDLING

SCOPE AND APPLICATION

This SOP presents the method to be used for handling wastes generated during field sampling activities that could be hazardous. These wastes are referred to as investigation-derived waste and are subject to specific regulations.

All disposable materials used for sample collection and processing, such as paper towels and gloves, are not considered investigation-derived wastes and will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal at a solid waste landfill.

EQUIPMENT AND REAGENTS REQUIRED

- 55-gallon drums (or appropriately sized waste container)
- Paint markers
- Tools (to open and close drum)
- Ziploc® bags
- Drum labels.

PROCEDURES

1. Place solid wastes that need to be containerized in properly labeled, DOT- approved, 55-gallon drums.
2. Properly close, seal, label, and stage all filled or partially filled drums before demobilization. Properly profile full drums and have them shipped off site to a RCRA Subtitle C facility.

3. Sampling activities generate personal protective equipment and miscellaneous debris that require disposal. Remove gross contamination from these items, and place the items in plastic bags. It is acceptable to store these items in plastic bags as an interim measure. At the end of each day, dispose of the bags at an appropriate solid waste facility dumpster.

STANDARD OPERATING PROCEDURE (SOP) AP-06

NAVIGATION AND STATION POSITIONING

SCOPE AND APPLICATION

This SOP describes procedures for accurate station positioning required to ensure quality and consistency in collecting samples and in data interpretation and analysis. Station positioning must be both absolutely accurate in that it correctly defines a position by latitude and longitude, and relatively accurate in that the position must be repeatable, allowing field crew to reoccupy a station location in the future (e.g., for long-term monitoring programs).

This SOP describes the most commonly used station positioning method, differential global positioning system (DGPS). Integral uses a Trimble Pathfinder™ Pro XRS DGPS for station positioning for many field efforts. The Pro XRS offers the submeter accuracy often required for documenting sampling station locations and for re-locating previously sampled stations. A comprehensive discussion of the Trimble Pathfinder™ Pro XRS DGPS is provided in Attachments 1, 2, and 3 of this SOP.

SUMMARY OF METHOD

Global positioning system (GPS) navigation is used to position the sampler at the desired location. GPS is a satellite-based system that receives positioning data at 1-second intervals from multiple satellites at known positions in space. Standard GPS is calculated to an accuracy of about 10 m.

One can obtain a higher accuracy of approximately 2 m by applying differential corrections to the standard GPS positioning data using DGPS. These differential corrections are applied by sending GPS differential corrections to the GPS receiver via radio transmission. If the sampling location is near the coastal U.S, the U.S. Coast Guard generates differential corrections that are transmitted via radio link to the GPS receiver. If a Coast Guard station is out of range of the sampling area, then a receiver may be set up at a known (i.e., surveyed) reference point on land, or real-time satellite differential signals can be purchased from a private company (e.g., OmniSTAR).

With the Pro XRS, GPS data can be gathered to submeter accuracy using a choice of differential correction sources (i.e., free beacon differential signals such as Coast Guard beacons or OmniSTAR) without establishing a reference station. Data must be corrected to gain submeter accuracy. Free beacon or base station signals allow differential corrections to be

performed after data collection by using a nearby beacon or base station logging data files. (Note: The station must be within 300 miles of the data collection location.) For satellite-based signals, a built-in virtual base station allows for real-time data correction, eliminating the need for post-processing data in some cases. However, postprocessing data corrections can obtain accuracies in the range of 30–50 cm. These accuracies are for the horizontal (northing and easting) component only. The vertical component (elevation) accuracy ranges from submeter to 3 times larger than the horizontal accuracy.

The GPS receiver displays and transmits differentially corrected positioning data to the computer using an integrated navigation software package (e.g., HYPACK, Terrasync). The computer data are typically displayed and recorded in World Geodetic System of 1984 (WGS-1984) geographic coordinates (latitude/longitude). However, the integrated navigation system can display and record information in other datums (e.g., UTM, NAD83). The integrated navigation system, acting as a data manager, displays the sampler's position relative to a target station location in plan view on a video screen. The resulting pictorial screen presentation, as well as numeric navigation data (e.g., range and bearing to the target sampling location) assists the vessel operator (when sampling on-water) in approaching and maintaining the station position while sampling.

SUPPLIES AND EQUIPMENT

- Cable
- GPS antenna
- Telemetry antenna (for differential corrections)
- GPS receiver
- Differential corrections receiver
- Computer and monitor
- Navigation software (e.g., Terrasync)
- Logbook or log sheets.

PROCEDURES

Obtain latitude and longitude coordinates at the locations where samples are collected. An average positioning objective is to accurately determine and record the positions of all sampling locations to within 2 m. Positioning accuracies on the order of 1–3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS provides the operator with a listing of the time intervals during the

day when accuracies are decreased. Avoiding these times allows for better positioning accuracy.

On-Land Sampling Event

A backpack DGPS unit may be used to direct the sampling team to the proposed sampling location. To expedite field activities, enter the target station coordinates into the navigation system database prior to beginning sampling. Place the DGPS antenna as close as possible to where the sampling will occur. Once the sample(s) have been collected at the appropriate location, record the horizontal coordinates of the station in the field logbook.

On-Water Sampling Event

Mount the GPS antenna vertically at the outboard end of the vessel's boom, with the GPS antenna cable extended along the boom into the cabin. Mount the telemetry antenna for receiving differential corrections on a convenient fixture outside the cabin. Locate the GPS receiver, the differential corrections receiver, and the computer in the cabin. Orient the video screen for the computer to allow the vessel operator to observe on-screen positioning data from the helm.

Alternatively, use a backpack DGPS unit to position the sampling vessel (e.g., barge) over a proposed sampling location. Place the DGPS beacon as close as possible to where the drilling will occur (i.e., moon pool). Using the DGPS unit, direct the sampling vessel operator to the sample station location.

Once the sampling vessel is anchored at the appropriate location, record the horizontal coordinates of the station in the field logbook. To expedite field activities, enter the target station coordinates in the navigation system database prior to beginning sampling.

Positioning System Verification

GPS requires no calibration, as all signal propagation is controlled by the U.S. government (the Department of Defense for satellite signals and the U.S. Coast Guard for differential corrections). Verifying the accuracy of the GPS requires coordinates to be known for one (or more) horizontal control point within the study area. The GPS position reading at any given station can then be compared to the known control point. Verify the GPS accuracy at the beginning and end of each sampling day.

Station Positioning Activities

Use a consistent routine for each day's positioning activities. After confirming successful reception of differential signals, turn on the computer on, and the boot the software. Verify the accuracy of the system at a horizontal control point, as described in the previous section.

The sampling team proceeds to a target station location selected by the team leader. That station location is then selected from a number of preselected station locations that have been entered into the integrated navigation system database. Once the station has been selected, the positioning data are displayed on the computer screen or hand-held unit to assist in proceeding to the station and in maintaining the station position during sampling. A confirmed position is recorded electronically each time a sample collection is attempted. (This means that during sediment grab sampling and coring, the locations of both accepted and rejected grabs or cores are recorded.) Upon recovery of the sampling device, read the station position northing (y) and easting (x) coordinates from the archived computer file and record them in the field logbook or on log sheets as a backup to the computer record. Also record time and water depth, if applicable. Ancillary information recorded in the field logbook may include personnel operating the GPS, tidal phase, type of sampling activity, and time when coordinates were collected.

REFERENCES

Trimble Navigation Limited. 2001. TSC1 Asset Surveyor operation manual. Version 5.20. http://trl.trimble.com/dscgi/ds.py/Get/File-8145/Oper.pdf.

Trimble Navigation Limited. 2007. GPS tutorial. Accessed on January 12, 2007. http://www.trimble.com/gps/index.shtml.

ATTACHMENT 1
PRO XRS DESCRIPTION

The Pro XRS combines a high-performance GPS receiver and antenna, beacon differential receiver, and satellite differential receiver in one compact unit. It also includes Trimble's advanced Everest™ technology, which allows users to collect accurate position data near walls, water, vehicles, or other surfaces that reflect satellite signals. Reflected signals, also called multipath signals, make it difficult for GPS receivers to accurately determine position. Everest™ uses a patented technique to remove multipath signals before measurements are used to calculate position.

Equipment Required

The GPS Pathfinder™ Pro XRS consists of the following:

- GPS receiver in backpack casing (with system batteries and cables)
- Hand-held data logger (TSC1) and cable, *or* laptop computer with Terrasync software installed and cable. (Note: Terrasync procedures are described under separate cover.)
- Pro XRS antenna, range poles, and cable
- Compass and tape measure
- Spare 12-volt camcorder and 9-volt batteries (minimum of two each) (use only Kodak, Duracell, or Energizer 9-volt batteries)
- Battery charger and power cord.

Pro XRS Setup

Follow these procedures for the proper setup of the Pro XRS:

1. Ensure that connections between batteries, receiver, and data logger are correct and secure. The coaxial antenna cable connects from the GPS receiver port "ANT" to the base of the antenna. The TSC1 cable (a "pig-tail"-type cable) connects from the bottom or top of the TSC1 to the receiver port "B," where a 9-pin serial port dongle is attached. The dual Y-clip cables should be connected from the receiver to the batteries. Alternatively, if AC power is available (e.g., aboard a vessel), then the power cable for the battery charger can be attached directly to the receiver on some models.
2. Screw the three long antenna poles together (the shorter pole may be added if necessary for taller users). Screw on the antenna and connect its cable.
3. Put backpack and/or shoulder strap on. The pouch for the data logger should be in place around the waist strap or in the backpack.

4. Screw antenna to the attachments on the top of the backpack. Wind cord around pole, and ensure the antenna is secure. Please be aware of overhead hazards, especially if working near low-hanging power lines. Severe injury or death can result.

Basic Operation of the Pro XRS

Recording a Feature

Before beginning field use, ensure that all GPS configurations and settings are set correctly for the particular use of the Pro XRS and that an appropriate data dictionary is loaded onto the TSC1 (see Attachments 2 and 3 for typical settings). These steps outline the basic use of the GPS to document a sample position or any other defined "feature." Note that the TSC1 has both hard and soft keys that allow for its operation. The hard keys comprise all of the keys (e.g., letters and numbers) on its surface. The soft keys are the F1 through F5 hard keys. The function of these changes depending upon the context. These keys will be referred to with brackets around them (<soft-key>).

1. Turn data logger on outside in an open area. Wait for antenna to receive satellite signals. The display will read Recording Almanac, Too Few SVs, and PDOP Too High. Continue to wait until enough satellites (four) are acquired and the PDOP is below 5.0.
2. Ensure that the real-time settings are correct according to the parameters listed in Attachment 2.
3. Select **Data Collection**, and create a new rover file or open an existing file. This file should be named according to the format specified by the project GIS analyst. Note: If opening an existing file, press **<NEW>** to access the *Antenna Options* menu and *Start Feature* menu.
4. Enter the height of the antenna from the ground to the *Measurement Method* reference point shown in the *Antenna Options* menu and then press **ENTER** to bring up the *Start Feature* menu.
5. Pick the appropriate data dictionary to use with the rover file. Only one dictionary can be used with a rover file. Consult with the project GIS analyst to formulate the most appropriate data dictionary for the type of sampling you wish to perform. The data dictionary titled *Generic* contains only a comment field and is appropriate for simple navigation tasks. If using a data dictionary, make sure to become familiar with its attributes before recording information in the field.

6. Move to the location of the first feature for which you want to record the GPS position. Select the appropriate feature and press **ENTER** to begin logging. Log data points in accordance with the feature type. Point features should have at least 10 points collected at a stationary location. Line features should be collected while moving. If movement is stopped, press the **<PAUSE>** key. When movement starts again, press the **<RESUME>** key. Area features should be collected with enough points to define the outline of the area (e.g., a square building would have four single points, collected on each corner, and the **<PAUSE>** key would be used between each of the points).
7. Depending on the setup of the data dictionary, each feature may have one or more feature attributes. An attribute is used to record additional data associated with the feature. For example, the attributes assigned to a sediment sampling station could be the sample number, station ID, sampling gear, sediment color, odor, etc.
8. Use the **<PAUSE>** key while recording feature attributes to avoid too many data points being collected at one point feature. (Body movements while logging attributes for an extended time can decrease the accuracy of collection.) The **<PAUSE>** key must be used when recording attributes of a line or area feature because only one data point should be collected in a single location.
9. Once all attributes are entered and the feature data points are logged, press **ENTER** to complete and save the feature and move on to a new feature. Pressing **ESC** instead of **ENTER** will allow the user to abandon the logged feature without saving.
10. When all features in a given area have been recorded, from the *Data Collection* menu, press **ESC** to exit data capture and then press **<YES>** to close the file. Features are appended and saved to the file after each collection, so there is no need to "save" the file. When the Pro XRS is not in use, it should be turned off. If you need to come back to the same rover file later in the day, the rover file may be reopened at that time. Rover files may not be edited after 7 days from the first feature was created. Please consult the project GIS analyst for the best way to handle multi-week sampling projects.
11. At the end of each day, download the rover file to a PC using Pathfinder Office software.

Feature Collection Options

Offsets—The Pro XRS can collect a point or line feature while standing at a set distance away from the feature. This option may be necessary because of obstructions such as tree cover, buildings, or car traffic. For a point feature, measure the distance between the object you want recorded and the Pro XRS antenna. Use the compass to determine the bearing (e.g., west is 270°). The bearing is the direction the point should be moved for it to be located in the correct place (e.g., if you are due north of the feature, the bearing is south, or 180°; i.e., the position you want recorded is south of where you are standing). Estimate the inclination from the

feature to the GPS antenna (if altitude determination is critical, a clinometer should be used). The inclination is the degree angle up from the feature to the antenna (e.g., if the feature is 5° below the antenna position, enter −5°). During data capture, from within the feature, press the **<OFFSET>** button, and enter the distance, bearing, and inclination. Press **OK** to complete the feature. Note: This procedure describes an offset of a single feature. A constant offset may be applied to all features collected as well.

Nesting—While recording a line feature or an area feature, a point feature may be collected to avoid backtracking. While recording the line or area feature, press **<PAUSE>** and then **<NEST>**. The Pro XRS will prompt for collection of a new feature. Move to the feature, and collect data as for any other point feature. When the feature is complete, press **OK**. The Pro XRS is ready to resume collecting data as part of the line/area feature: press **<RESUME>**. (Remember to continue moving before pressing resume to avoid having multiple positions recorded in the same place in the line or area feature.)

Segmenting—While moving along a line feature, changing the attributes of that line may be necessary (e.g., because of a change in surface type from paved to dirt road). This change may be done without having to begin a new feature by pressing **<PAUSE>** and then ****. Change the appropriate attributes and then press **<RESUME>** to continue recording.

Repeat—This function allows the collection of a new feature with the same feature attributes as the previous feature. If features are not exactly the same, it also allows editing of the attributes.

Quickmark—Allows collection of point features while moving (e.g., from a car or a boat) by estimating the exact location. The use of this feature will not result in positionally accurate locations and is not recommended for most sampling operations.

Reviewing and Editing Features

It is possible to review or edit features collected in the field while still in the data capture mode. For example, it may be necessary to document the GPS location in the field logbook or to edit one of the feature's attributes. Without exiting data capture, press **<REVIEW>**. (If data capture is already complete, just press **<REVIEW>** and then select the appropriate rover file.) This step will display a list of data points including each feature collected. Scroll to the appropriate feature, and follow the steps below depending on the required action:

- To view the GPS location (e.g., lat/lon), press **<POS>.**
- To edit the attributes, press **ENTER**. Make any necessary edits to the attributes by scrolling through.
- To change or add an offset, press **<POS>** and then **<OFFSET>**. Make any necessary changes.
- To delete a feature collected in error, press **<DEL>**.

Navigating to an Existing Location

Waypoints

To use the Pro XRS to navigate to a previously established position, this position must be loaded into the data logger as a waypoint, present as a feature position in the data files, or generated in the field using the GPS unit. Waypoints may be entered into the TSC1 by:

- Entering coordinates manually
- Choosing previously recorded locations and importing them into the TSC1 by using Pathfinder Office
- Defining a location stored in a rover file saved to the TSC1 as a waypoint (see *Reviewing/Editing Features*, above)
- Creating a way point from the current position being shown by the operating GPS unit in the field.

Navigating

Usually you will use the *Navigation* module (accessed by pressing **MENU** followed by **Navigation**) to guide yourself to a target (waypoint or feature). You can also use the *Map* module (accessed by pressing **MENU** followed by **Map**) to:

1. Orient yourself in the area where you are working.
2. Get a general indication of the location of a feature or waypoint that you want to find.
3. Find or select features or waypoints to which you wish to navigate toward.
4. Plot a course from one place to another.
    a. While in the Map screen, the GPS cursor x shows the current position reported by the receiver and is always shown on the Map screen (Note: it may not always be within the visible part of the screen when panning or scrolling). The **<OPTIONS>** key can be used to hide or display the GPS trail (line of dots showing up to 60 previous positions), the heading showing the direction of travel, and other options on the map display.
    b. Select a feature by pressing **MENU**, Data Collection to reach the *Start Feature* screen, and then **<REVIEW>** to access all features contained in the data file. Highlight and select the desired feature by pressing the **<Target>** key, which adds a crossed flag to the feature. Reaccess the *Map* screen by selecting **MENU**, then **Map**, which will now show the highlighted feature with a crossed flag symbol on the Map screen. You can then start moving toward the feature, and the current position (shown by the x) will move closer to the target position as the user approaches.

c. There are two graphical modes of navigation with the Pro XRS in the TSC1 *Navigation* module. On both modes, text information appears on the right of the screen in the *Info* panels, which can be configured by the user. The graphical modes available are the *Directional Dial* screen or the *Road* screen, which can be toggled between using the **<Mode>** key.

d. To navigate, select a target and then a start position. Each of these positions can be features from an open data file or a waypoint. Access a list of available features or waypoints by pressing **<TARGET>** or **<START>**. Once the item has been chosen as a target, it will show the crossed flags symbol in the list. Once a target has been selected, *Distance to Go* appears at the bottom of the *Navigation* screen, which indicates the distance from the current GPS position to the target. Select a start position (not required but useful for calculating crosstrack error and other navigation information) by pressing **<START>**. A waypoint of the current GPS position can be created for use as the Start point by selecting **<CREATE>**. Once the Start position is selected, a flag symbol will appear next to the item in the list.

e. In the *Directional Dial* mode, an arrow will appear that will always point at the target. This is the bearing to go. (Note: You need to be moving for this to be accurate, as it will lock if you are moving too slowly or have stopped.) The triangle at the top represents the direction that you are going or heading. This triangle never moves, but by changing directions, you can line up the arrow with the triangle. When the two are aligned, you are heading in the direction of the target. When you are close to the target, a bull's-eye (two concentric circles) will appear at the edge of the screen. This is warning you that the unit will be switching to the close up screen. A proximity alarm will sound and the directional arrow will be replaced by the bull's-eye on the close up screen. Your current position will be shown by an x and the target by the bull's-eye. Move so that the x is in the same location as the bull's-eye.

f. In the *Road* mode, navigate by walking down a road. Your position is shown by a stick figure and is always positioned in the center of the screen. The target (crossed flags) shows the point to which you are navigating toward. Your heading is shown by the top center of the screen and the bearing to go is shown by the direction of the road, which will rotate as you change your heading. Change your heading until the road is pointing at the top of the screen (*Target* is also at the top of the screen) and the edges are parallel to the sides of the screen. As you move toward the target the screen zooms in, so the road appears to get wider.

Downloading Rover Files

Upon returning to the office, download all rover files from the TSC1 to a PC for post-processing. You will need the Trimble Pathfinder software installed on your computer. If you

are not using a field laptop that already has the program installed, contact your project GIS analyst for instructions on how to install the software.

Connect the TSC1 to your computer using the appropriate cables. In addition to the "pigtail" cable, you will also need a null modem (a 9-pin female-to-female cable) to plug into a PC serial port. Once connected, power up the TSC1 unit and navigate to *MENU>File Manager>File Transfer*. Then, open the Pathfinder software and navigate to the *Utilities>Data Transfer…* window from the menu bar. Select **GIS Datalogger** on COM1 (for most computer systems), and press the green **Connect** button. Download files from the TSC1 by selecting the **Receive** tab and choosing the data file type from the *Add* pulldown menu (Figure 1).

After downloading, remove all rover files and waypoints from the TSC1 to conserve memory. Rover files may be deleted from the *File Manager* menu as follows:

1. Select **MENU>File Manager>Delete File(s)**
2. Select the rover file to be deleted, and press **<ENTER>**
3. Confirm the deletion of this file by pressing **<YES>**.

Delete data dictionaries in the same manner by selecting **Data Dictionaries** from the *File Manager* menu. Delete waypoints by selecting **Utilities** from the *Main* menu and then by selecting **Waypoints,** followed by **<DEL>**.

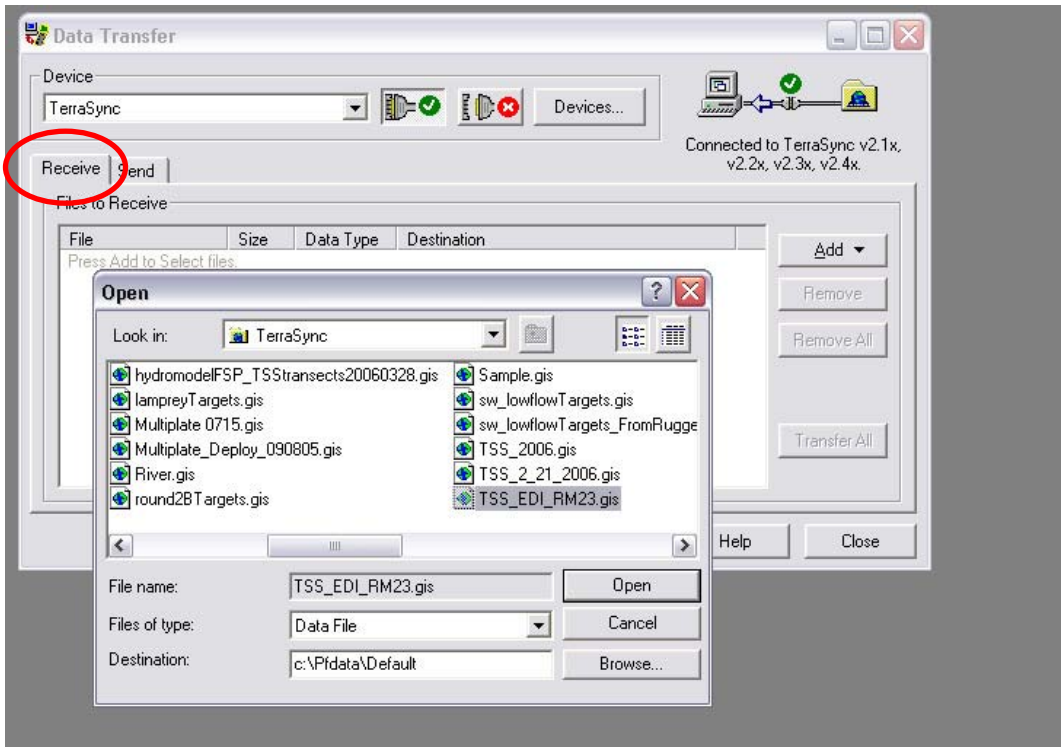

Figure 1. Transferring File from Terrasync

ATTACHMENT 2
TSC1 SETTINGS

The following are lists of menus that can be accessed through the TSC1 keypad. Please ensure that settings are correct before proceeding. Do not make changes to the settings unless necessary. Each menu will list all available subheadings, the correct setting, and the available **<soft-keys>** to access additional menus. Comments are included only where necessary.

GPS Rover Options

To access this menu, select **Configuration** from the main menu and then select **GPS Rover Options**. The table below lists logging options and settings.

Logging Options	Setting	Comment
Logging intervals		
Point feature	1s	
Line/area feature	2s–5s	depending upon speed of movement
Not in feature	None	
Velocity	None	
Confirm end feature	No	
Minimum pos	10	
Carrier Mode	Off	
Carrier phase min. time	10 minutes	
Dynamics code	Land	May be changed to sea or air, as appropriate
Audible click	Yes	
Log DOP data	Yes	
Log PPRT data	Yes	
Log QA/QC data	Yes	
Allow GPS update	Warn First	
Warning Distance	Any	
Position Mode Manual	3D	
Elevation Mask	15°	Should not go below 13° (accuracy decreases)
SNR Mask	6.0	Can raise to 7 if multi-path filtering is poor
PDOP Mask	5.0	Can be raised up to 8; reduces accuracy
PDOP Switch	6.0	

Real-Time Input Options

Access this menu from the GPS Rover *Options* menu by selecting **Real-Time Input**. The table below shows options and settings for real-time input.

Options	Setting	Comment
Preferred Correction Source		
	Choice 1	Integrated Beacon
	Choice 2	Integrated WAAS
	Choice 3	Use uncorrected GPS
Correction Age Limit	20s	

Antenna Options

Access this menu from the GPS rover *Options* menu by selecting **Antenna Options**. The table below shows antenna options and settings.

Option	Setting	Comment
Height	6 ft	Enter correct user antenna height using measurement method indicated below
Measure	Uncorrected	
Type	Integrated GPS/Beacon/Satellite	
Confirm	Per file	Can be changed to “Per feature” if antenna height varies and elevation is critical
Part Number	33580-50	Auto selected based on TYPE selected
Measurement	Bottom of Antenna	
Method	Mount	

ATTACHMENT 3
ADDITIONAL SETTINGS FOR THE TSC1

Additional TSC1 settings can be found in the *Configuration* menu. Items of particular importance are indicated in italics.

Configuration

This menu can be accessed by selecting **Configuration** from the main menu. The table below lists options and descriptions for the *Configuration* menu.

Options	Description
GPS base station options	For using a land base station or beacon for real time corrections
NMEA/TSIP output	Consult manual
Coordinate system	Changes coordinate system among latitude/longitude, UTM, and other coordinate systems. System can be converted, if necessary, after data capture by using Pathfinder Office software.
Map Display options	Change layers, scale, background files and items shown on the TSC1 screen during data collection
Navigation options	Changes Navigation parameters
Units and display	Changes various units, for example: length (e.g., feet, meters), altitude reference (e.g., MSL), *North reference* (i.e., true or magnetic). Units can be converted, if necessary, after data capture by using Pathfinder Office software.
Time and date	Changes to *local time*, 24-hour clock, date format, and other options
Quickmarks	Set-up parameters for use with Quickmarks.
Constant offset	Set-up parameters for use with a constant offset.
External sensors	Connections with external sensors.
Hardware (TSC1)	TSC1 settings such as beep volume, contrast, *internal and external battery status*, software version, free space.

Contrast and Backlighting

The TSC1 display can be viewed in various light settings. Press **FUNC,** then **L** to turn on the display backlight for viewing in dim lighting. Adjust the contrast by pressing **FUNC**, then **E** or **F**.

ATTACHMENT 4
PRE-SAMPLING ACTIVITIES BEFORE USE OF THE PRO XRS

Determination of Optimal Satellite-Use Time

Positioning accuracies on the order of ±1 to 3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS unit provides the operator with a listing of the time intervals during the day when accuracies are decreased. Avoiding these time intervals permits the operator to maintain better positioning accuracy.

ATTACHMENT 5
MANAGING GPS DATA FROM TERRASYNC—A TUTORIAL

Currently, positional data collected in the field is most often done with a Trimble GPS unit (usually rented) interfaced with a laptop via Trimble's Terrasync software. The Terrasync software sometimes exhibits quirks that interfere with the smooth operation of data collection in otherwise stressful field conditions. This tutorial is meant to supplement the Terrasync software documentation and serve as a guide to field personnel to help them retrieve and collect geographic data as efficiently as possible with existing software.

Scope

This document is intended to be a reference for procedures involving the following:

- Fixing files that are more than 7 days old so that they can be updated
- Adding features in GPS Pathfinder software (companion to Terrasync) and then importing them as base files in Terrasync..

This document is not intended to be a comprehensive manual for using Terrasync or Pathfinder software. It is assumed that the reader has received at least some training on how to use the basic features of Terrasync and is competent at using MS Windows.

The Basics

GPS data collection currently relies on two pieces of complementary software:

- Terrasync—the interface for GPS navigation and data collection.
- Pathfinder Office—a multiuse piece of software that acts as a conduit between GIS data files (shape files) and Terrasync GPS files. Pathfinder can also be used as a simple map editor.

Installing the Correct Versions of Terrasync and Pathfinder

Important Note: This tutorial uses Pathfinder Office v. 3.00 and Terrasync v. 2.50. It is very important to use the proper versions of this software to avoid compatibility issues. These software versions should be included in the same folder as this tutorial, or can be obtained from GIS staff.

http://www.trimble.com/terrasync_ts.asp?Nav=Collection-4576

Key code for TerraSync
499043-00110-05273-EDD049BC

Pathfinder v.3.00
001533-00300-04152-0ee4d11f

Initial Setup of Terrasync/Pathfinder

Certain settings and configuration setups are needed before Pathfinder can talk to Terrasync. Whether you are installing this software for the first time or have an existing installation, check to make sure that these settings are in place.

1. Open Pathfinder Office and go to the *Utilities>Data Transfer...* menu. A dialog box should appear. This is the interface for communicating with Terrasync.
2. Click the **Devices** button, and then **New…** (Figure 1).
3. Click on **GIS Folder**.
4. Browse to the Terrasync data folder on your computer, which in most cases will be *C:\My Documents\TerraSync*.
5. In the next box, *Type* will be **Terrasync**, and *Version* will be **v. 2.1x, v.2.2x, v.2.3x,** and **v2.4x**.
6. At the prompt for a name that will display in the device list, enter **Terrasync**.
7. Go back to the Data Transfer dialog box, select **Terrasync** from the dropdown menu, press the **Connect** icon, and look for a green check mark indicating success.

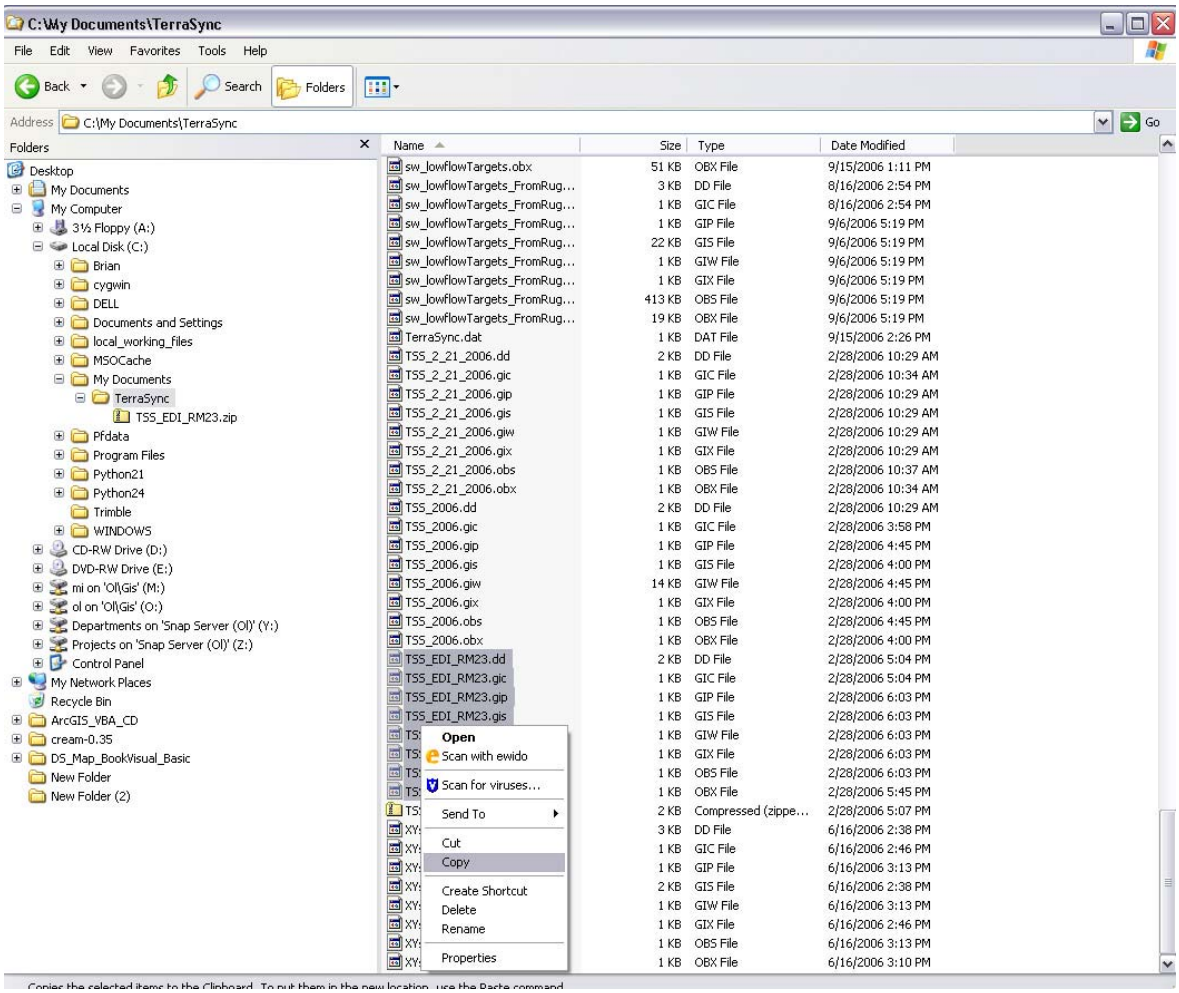

Figure 2. Selecting Files To Copy to a Different Directory

If this procedure does not work for you, you may have the wrong version of Pathfinder. For some unknown reason, with each version upgrade of Pathfinder, connectivity to older versions of Terrasync is lost. You can check what version of Pathfinder you have installed by going to the *Help>About GPS Pathfinder Office...* menu. To find out what version of Terrasync you have, go to *C:\Program Files\TerraSync*, right-click on **Terrasync.exe**, and choose the **Version** tab.

Handling Expired Files in Terrasync

One of the most common problems that field personnel will have to deal with is the 1-week expiration date when trying to collect data with Terrasync. This is a built-in function of Terrasync, and there is no simple way to work around it. The following instructions will guide you through the process to make the files usable. See Figure 3.

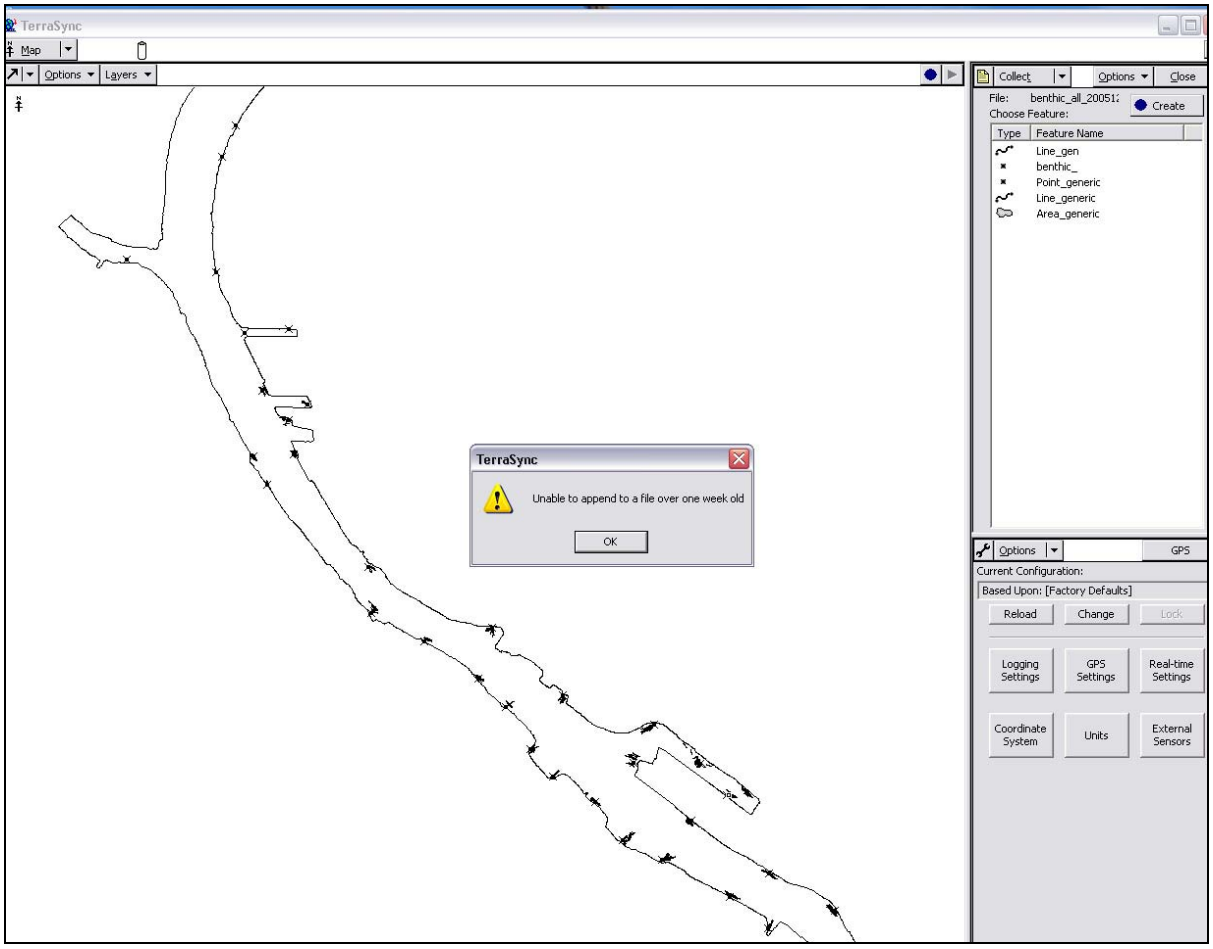

Figure 3. Notice That Terrasync File Older Than 1 Week Will Not Allow User To Collect Features (time begins to elapse when first feature is collected in the field, not when file is created)

Two options are available, depending on your needs. If you do not need to see the previously logged locations and need only to see the targets, use the original files provided by GIS staff (Option 1). If you need to see previously occupied locations in order to make decisions about where to go next, then transfer the file to Pathfinder and back again (Option 2).

Option 1: Move and replace logged files with original targets.

At the beginning of the field effort, you should receive a set of files with the target locations, most likely in a zip archive (.zip file extension). There will be six to eight files with the same name but with different extensions (Figure 4). These files will have to go into the *C:\My Documents\TerraSync* folder in order to be available to Terrasync.

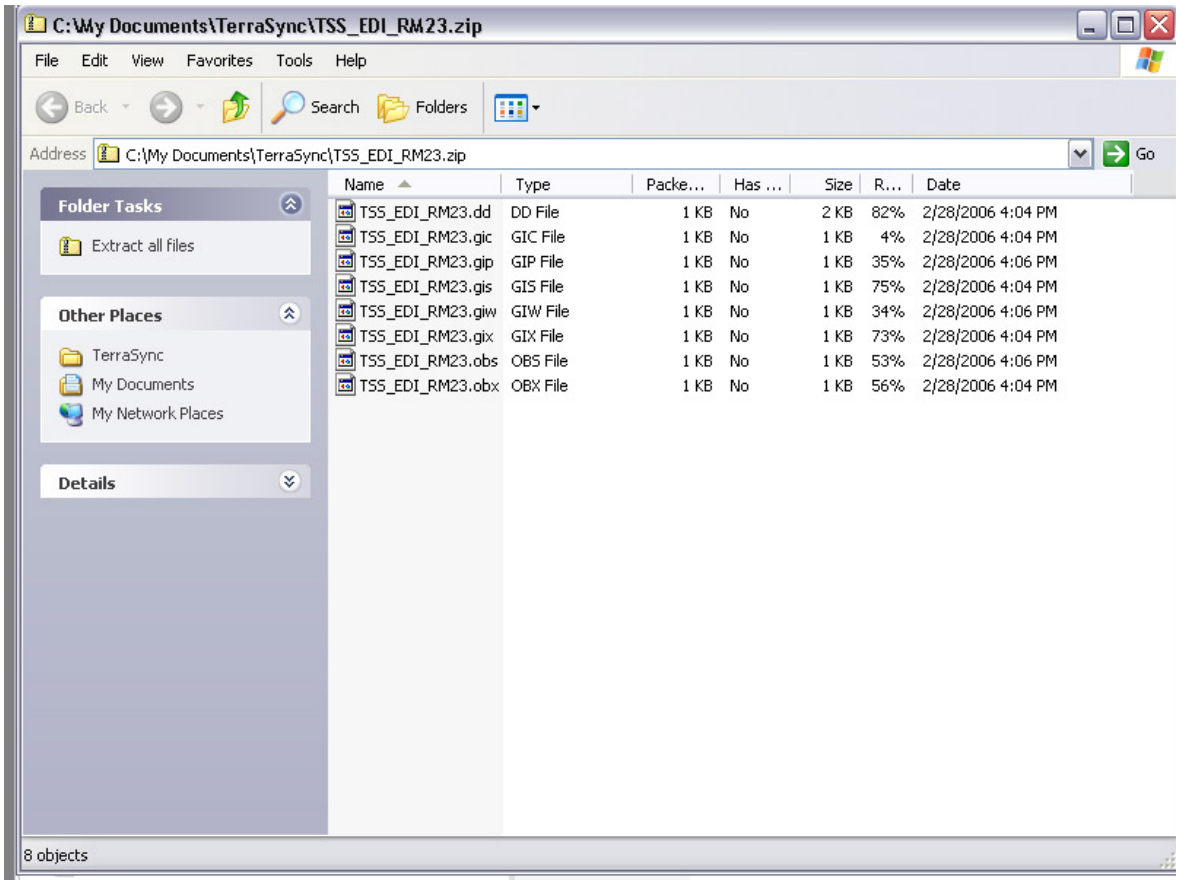

Figure 4. Example of File Set To Be Unzipped into the Terrasync Folder

After you unzip these files to Terrasync, keep this zip archive around in an easy-to-find place, such as your computer desktop, because the 1-week clock does not start until you begin collecting your first point in the field. You can use this unadulterated file again, as long as you make a copy of the work you did the previous week. The detailed steps are as follows:

1. Make sure you have the original files with the target locations available in a handy place. This will probably be the original zip archive. Also, be sure to close Terrasync while performing this process.
2. Navigate to C:\My Documents\TerraSync\ in Windows Explorer. Locate the files that you have been using the previous week. Note: It is crucial to get all of the small files associated with the data set. While it is useful to sort the files by date modified, you can miss some of the small files—it is highly recommended that you sort the files alphabetically.

3. Copy all of these files to a different directory, preferably one that is named appropriately to reflect the data and time period that you were collecting. For example: C:\Documents and Settings\bpointer\Desktop\lampreyTargets_20060925. These files contain the data you have collected the previous week and should be backed up and/or emailed to the appropriate project manager or GIS staff.
4. You can now safely replace the files you just copied with the ones from the original zip file. Right-click the zip archive, and click Extract All. When prompted to Select a folder to extract files to, browse to C:\My Documents\TerraSync. (Figure 5). If prompted about replacing existing files, select Yes to All. Note: It is crucial to make copies of the files first (see Step 3 above)—otherwise, you may lose the data.
5. You should now be able to open the file in Terrasync and begin logging as normal.

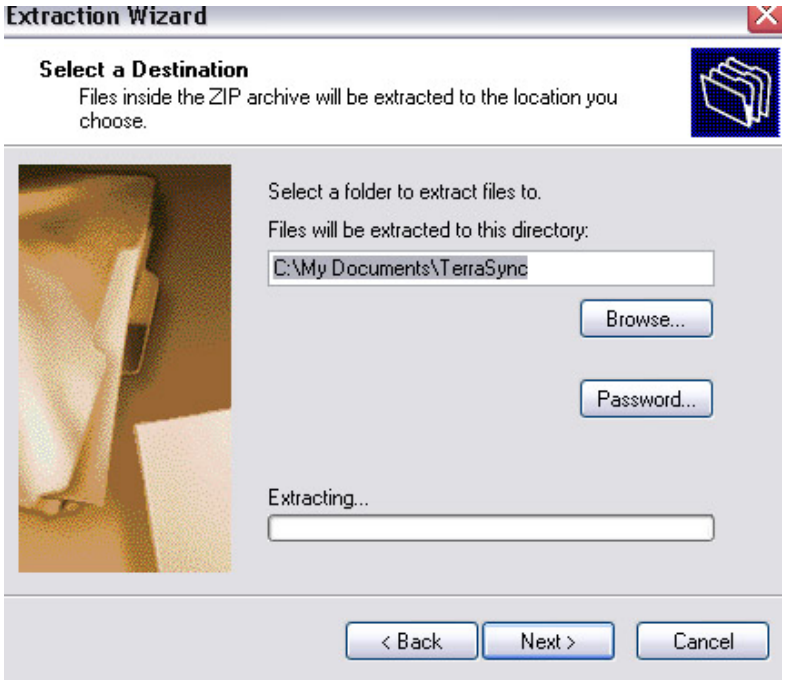

Figure 5. Extract (or copy) Original Target Files into the Terrasync Directory

Option 2: Transfer files back and forth from Terrasync.

If you need to be able to see the previously occupied positions from last week while positioning this week, you need to use Pathfinder to reset the file. This process will essentially combine the targets and actuals from last week into one file. However, this method has its drawbacks; once converted, the actuals from last week will not be able to be corrected, so a backup procedure similar to the one in the previous option should be carried out to maintain data integrity.

The steps for file transfer are as follows:

1. For good data management, back up the data files from the previous week using the procedure laid out in steps 1 through 3 in Option 1 above.
2. Close Terrasync and open up Pathfinder Office.
3. Go to the Utilities>Data Transfer menu or just click the icon on the left (Figure 6).
4. Ensure that the device listed is Terrasync. If not, follow the initial setup instructions at the beginning of this document. Most of the computers used for GPS logging are already setup for this.
5. There are two tabs, Receive and Send. Make sure that Receive is selected and then go to Add>Data File. Select the file(s) that you are using and select Open. The file should now be in the Files to Receive box. Click Transfer All and wait for the transfer to take place. If you have made the recommended backups, it is fine to replace any files.
6. Now select the Send tab (Figure 7), and go to Add>Data File. Select the file you just transferred (it will have the same name as the Terrasync file) and click Open. Now click Transfer All to move the file back to Terrasync.

   By transferring the file back and forth from Terrasync to Pathfinder, you have "reset the clock" and can now update the file for an additional 7 days. This file will have your targets and actual positions from the last week, so it is important to be aware of the features you are selecting for navigation.

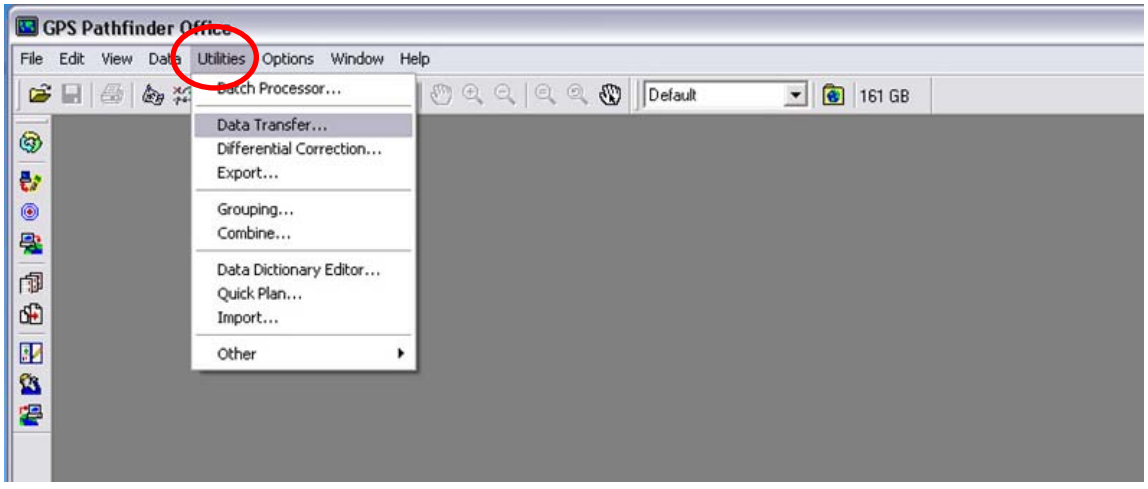

Figure 6. Data Transfer Menu

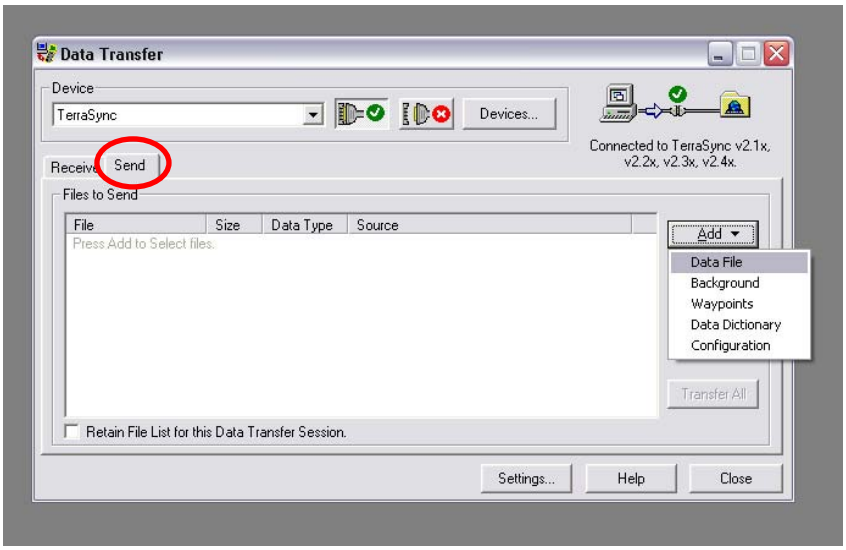

Figure 7. Sending Data File

ATTACHMENT 2
FIELD FORMS

	FIELD CHANGE REQUEST	Project Number:

Field Change No.
Page _____ to

Project Number:
Project Name:

CHANGE REQUEST
Applicable Reference:
Description of Change:

Reason for Change:

Impact on Present and Completed Work:

Requested by:
Date: ____/____/

(Field Scientist)

Acknowledged by:
Date: ____/____/

(Field Task Leader)

FIELD OPERATIONS MANAGER RECOMMENDATION

Recommended Disposition:

Recommendation by:
Date: ____/____/

(Sampling and Analysis Coordinator)

PROJECT MANAGER APPROVAL

Final Deposition:

Approved/Disapproved by:
Date: ____/____/

(CERCLA Coordinator)

CORRECTIVE ACTION RECORD

Page ___ of

Audit Report No. :_____ Date:

Report Originator:

Person Responsible for Response:

DESCRIPTION OF PROBLEM:

Date and Time Problem Recognized: _____ By:

Date of Actual Occurrence: _____ By:

Analyte: _____ Analytical Method:

Cause of Problem:

CORRECTIVE ACTION PLANNED:

Person Responsible for Corrective Action:

Date of Corrective Action:

Corrective Action Plan Approval: _____ Date:

DESCRIPTION OF FOLLOW-UP ACTIVITIES:

Person Responsible for Follow-up Activities:

Date of Follow-up Activity:

Final Corrective Action Approval: _____ Date:

STORMWATER SAMPLING CHECKLIST
ISCO AUTOMATED SAMPLER
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Date:			**Sampling Site:**	
Weather:			**Sampling Team Leader:**	
Prepare Field Equipment Prior to Sampling				
Wash and Rinse Cooler	□		Fill Cooler with Ice	□
Nitrile Gloves	□		Ziploc Bags	□
Plastic Bags	□		Plastic Sheet	□
Replacement Sample Bottles	□		Trash Bags	□
Procedures at Field Sampling Site				
Inspect Outside of Sampler and Note Any Damage:				□
Prepare Sampling Site				□
Remove Sampler Cover				□
Record Displayed Flow Information	**Depth:**	**Flow:**	**Volume:**	□
Record Error Messages (if any, if none write "none"):				□
Cap Sample Bottles				□
Remove Sample Bottle				□
Label Sample Bottle				□
Bag Sample Bottle				□
Place Sample Bottle in Cooler for Transport to Laboratory				□
Seal Cooler When All Samples Have Been Collected				□
Fill Out Chain of Custody Form (note time on form)				□
Plug in Rapid Download Module and Capture Data from Sampler				□
Check Battery Voltage and Record	**Volts:**			□
Notify O&M Team to Replace Battery if Below 12 Volts				□
Reset Sampler and Confirm Self Check (If self check fails notify O&M Team and Program Manager)				□
Install New Sample Bottles				□
Reinstall Sampler Cover				□
Redeploy Sampler				□
Call Sampler and Disable				□
Police Site and Put All Used Gloves, Bags, and Other Materials in Trash Bag				□
Procedures at Laboratory				
Deliver Samples to the Laboratory				□
With the Lab Technician Unpack the Samples Verifying that They are Properly Labeled and Not Damaged.				□
Relinquish Custody of the Samples to the Laboratory Technician				□
Sign Chain-of-Custody Form				□
Have Laboratory Technician Sign Chain-of-Custody Form (note time on form)				□
Retain Carbon Copy with this Sampling Checklist				□
Notify Program Manager and O&M Team if Necessary				□

DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

FIELD SAMPLING DATA SHEET

ANCHOR QEA

10707 Corporate Drive, Suite 230
Stafford, TX 77477
Tel: 281-565-1133

PROJECT NAME: **LOCATION ID:**

SITE ADDRESS: **BLIND ID:**

DUP ID: **NA**

WIND FROM:	N	NE	E	SE	S	SW	W	NW	LIGHT	MEDIUM	HEAVY
WEATHER:	SUNNY		CLOUDY		RAIN		?		**TEMPERATURE:**	° F .	° C

[Circle appropriate units]

HYDROLOGY/LEVEL MEASUREMENTS (Nearest 0.01 ft)

					[Product Thickness]	[Water Column]		[Water Column x Gal/ft]
Date	Time	DT-Bottom	DT-Product	DT-Water	DTP-DTW	DTB-DTW		Volume (gal)
/ /	:	.	.	.	.	.	X 1	.
/ /	:	.	.	.	.		X 3	.

Gal/ft = (dia./2)^2 x 0.163	1" =	0.041	2" =	0.163	3" =	0.367	4" =	0.653	6" =	1.469	10" = 4.080	12" = 5.875

§ METHODS: (A) Submersible Pump (B) Peristaltic Pump (C) Disposable Bailer (D) PVC/Teflon Bailer (E) Dedicated Bailer (F) Dedicated Pump (G) Other =

WATER SAMPLING DATA (if product is detected, do NOT sample) Sample Depth: [√ if used]

Bottle Type	Date	Time	Method §	Amount & Volume mL	Preservative [circle]	Ice	Filter	pH	√
VOA Glass	/ /	:		3	40 ml	HCl	YES	NO		
Amber Glass	/ /	:			250, 500, 1L	(None) (HCl) (H_2SO_4)	YES	NO		
White Poly	/ /	:			250, 500, 1L	None	YES	NO	NA	
Yellow Poly	/ /	:			250, 500, 1L	H_2SO_4	YES	NO		
Green Poly	/ /	:			250, 500, 1L	NaOH	YES	NO		
Red Total Poly	/ /	:			250, 500, 1L	HNO_3	YES	NO		
Red Diss. Poly	/ /	:			250, 500, 1L	HNO_3	YES	YES		
	/ /	:			250, 500, 1L		YES			

Total Bottles (include duplicate count):

Analysis Allowed per Bottle Type

BOTTLE TYPE	TYPICAL ANALYSIS ALLOWED PER BOTTLE TYPE (Circle applicable or write non-standard analysis below)
VOA - Glass	(8021) (8260B) (BTEX) (NWTPH-Gx)
AMBER - Glass	(PAH) (TPH-HCID) (NWTPH-Dx) (TPH-418.1) (Oil &Grease) (8081A)
WHITE - Poly	(pH) (Conductivity) (TDS) (TSS) (BOD) (Turbidity) (Alkalinity) (HCO_3/CO_3) (Cl) (SO_4) (NO_3) (NO_2) (F)
YELLOW - Poly	(COD) (TOC) (Total PO_4) (Total Keldahl Nitrogen) (NH_3) (NO_3/NO_2)
GREEN - Poly	(Cyanide)
RED TOTAL - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na)
RED DISSOLVED - Poly	(As) (Sb) (Ba) (Be) (Ca) (Cd) (Co) (Cr) (Cu) (Fe) (Pb) (Mg) (Mn) (Ni) (Ag) (Se) (Tl) (V) (Zn) (Hg) (K) (Na) (Hardness) (Silica)

WATER QUALITY DATA Purge Start Time: : Pump/Bailer Inlet Depth:

Meas.	Method §	Purged (gal)	pH	E Cond (µS)	°F Temp °C	Other	Diss O_2 (mg/l)	Water Quality
4		.	.		.		.	
3		.	.		.		.	
2		.	.		.		.	
1		.	.		.		.	
0		**0.00**	.		.		.	

[Casing] [Select A-G] [Cumulative Totals] [Circle units] [Clarity, Color]

SAMPLER:

(PRINTED NAME) (SIGNATURE)

Any Lab
Address:

Chain of Custody Record

Client Information	Sampler:	Lab PM:	Carrier Tracking No(s):	COC No:
Client Contact:	Phone:	E-Mail:		Page: Page 1

Company: Anchor QEA LLC	Analysis Requested	Job #:
Address: 1423 3rd Avenue, Ste 300	Due Date Requested:	
City: Seattle	TAT Requested (days):	
State, Zip: WA, 98101		
Phone: 206-287-9130(Tel)	PO #:	
Email: dpeterson@anchorqea.com	WO #:	
Project Name:	Project #:	
Site:	SSOW#:	

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2SO3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - ph 4-5
L - EDA	Z - other (specify)

Other:

Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	Total Number of containers	Special Instructions/Note:
			Preservation Code:					
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			
			G		N			

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For _____ Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by:	Date:	Time:	Method of Shipment:

Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company

Custody Seals Intact: Δ Yes Δ No	Custody Seal No.:	Cooler Temperature(s) °C and Other Remarks: