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Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities[1]

This standard is issued under the fixed designation D6232; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers criteria which should be considered when selecting sampling equipment for collecting environmental and waste samples for waste management activities. This guide includes a list of equipment that is used and is readily available. Many specialized sampling devices are not specifically included in this guide. However, the factors that should be weighed when choosing any piece of equipment are covered and remain the same for the selection of any piece of equipment. Sampling equipment described in this guide includes automatic samplers, pumps, bailers, tubes, scoops, spoons, shovels, dredges, coring, augering, passive, and vapor sampling devices. The selection of sampling locations is outside the scope of this guide.

1.1.1 Table 1 lists selected equipment and its applicability to sampling matrices, including water (surface and ground), sediments, soils, liquids, multi-layered liquids, mixed solid-liquid phases, and consolidated and unconsolidated solids. The guide does not specifically address the collection of samples of any suspended materials from flowing rivers or streams. Refer to Guide D4411 for more information.

1.2 Table 2 presents the same list of equipment and its applicability for use based on compatibility of sample and equipment; volume of the sample required; physical requirements such as power, size, and weight; ease of operation and decontamination; and whether it is reusable or disposable.

1.3 Table 3 provides the basis for selection of suitable equipment by the use of an index.

1.4 Lists of advantages and disadvantages of selected sampling devices and line drawings and narratives describing the operation of sampling devices are also provided.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.6 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D1586 Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D4136 Practice for Sampling Phytoplankton with Water-Sampling Bottles (Withdrawn 2020)[3]
D4342 Practice for Collecting of Benthic Macroinvertebrates with Ponar Grab Sampler (Withdrawn 2003)[3]
D4343 Practice for Collecting Benthic Macroinvertebrates with Ekman Grab Sampler (Withdrawn 2003)[3]
D4348 Practice for Collecting Benthic Macroinvertebrates with Holme (Scoop) Grab Sampler (Withdrawn 2003)[3]
D4387 Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates (Withdrawn 2003)[3]
D4411 Guide for Sampling Fluvial Sediment in Motion
D4448 Guide for Sampling Ground-Water Monitoring Wells
D4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds
D4687 Guide for General Planning of Waste Sampling
D4696 Guide for Pore-Liquid Sampling from the Vadose Zone
D4700 Guide for Soil Sampling from the Vadose Zone
D4823 Guide for Core Sampling Submerged, Unconsolidated Sediments
D5013 Practices for Sampling Wastes from Pipes and Other Point Discharges
D5079 Practices for Preserving and Transporting Rock Core Samples (Withdrawn 2017)[3]
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5283 Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation
D5314 Guide for Soil Gas Monitoring in the Vadose Zone (Withdrawn 2015)[3]
D5358 Practice for Sampling With a Dipper or Pond Sampler
D5451 Practice for Sampling Using a Trier Sampler
D5495 Practice for Sampling with a Composite Liquid Waste Sampler (COLIWASA)
D5633 Practice for Sampling with a Scoop
D5679 Practice for Sampling Consolidated Solids in Drums or Similar Containers
D5680 Practice for Sampling Unconsolidated Solids in Drums or Similar Containers
D5681 Terminology for Waste and Waste Management
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]
D5743 Practice for Sampling Single or Multilayered Liquids, with or Without Solids, in Drums or Similar Containers
D5778 Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils

[3] The last approved version of this historical standard is referenced on www.astm.org.

D5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices
D6001 Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization
D6009 Guide for Sampling Waste Piles
D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
D6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities
D6063 Guide for Sampling of Drums and Similar Containers by Field Personnel
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6286 Guide for Selection of Drilling and Direct Push Methods for Geotechnical and Environmental Subsurface Site Characterization
D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
D6538 Guide for Sampling Wastewater With Automatic Samplers
D6634 Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
D6640 Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations
D6699 Practice for Sampling Liquids Using Bailers
D6759 Practice for Sampling Liquids Using Grab and Discrete Depth Samplers
D6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations
D6907 Practice for Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers
D6914 Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices
D7353 Practice for Sampling of Liquids in Waste Management Activities Using a Peristaltic Pump
D7758 Practice for Passive Soil Gas Sampling in the Vadose Zone for Source Identification, Spatial Variability Assessment, Monitoring, and Vapor Intrusion Evaluations
D7929 Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells
D8170 Guide for Using Disposable Handheld Soil Core Samplers for the Collection and Storage of Soil for Volatile Organic Analysis
E300 Practice for Sampling Industrial Chemicals
E1391 Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminologies D653 and D5681.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *environmental data, n*—defined for use in this document to mean data in support of environmental activities.

3.2.2 *matrix, n*—the principal constituent(s) or phase(s) of a material.

4. Summary of Guide

4.1 This guide discusses important criteria which should be considered when choosing sampling equipment.

4.1.1 Criteria discussed in this document include physical and chemical compatibility, sample matrix, sample volume, physical requirements, ease of operation, and decontamination. Costs are considered, where appropriate.

4.2 A limited list of sampling equipment is presented in two separate tables. The list attempts to include a variety of different types of equipment. However, this list is in no way all inclusive, as there are many excellent pieces of equipment not included. Table 1 lists matrices (surface and groundwater, stationary sediment, soil, and mixed-phase wastes) and indicates which sampling devices are appropriate for use with these matrices. It also includes ASTM method references (draft standards are not included). Table 2 indicates physical requirements (such as battery), electrical power, and weight; physical and chemical compatibility; effect on matrix; range of volume; ease of operation; decontamination; and reusability. Table 3 provides sampler type selection process based upon the sample type and matrix to be sampled.

5. Significance and Use

5.1 Although many technical papers address topics important to efficient and accurate sampling investigations (DQOs, study design, QA/QC, data assessment; see Guides D4687, D5730, D6009, D6051, and Practice D5283), the selection and use of appropriate sampling equipment is assumed or omitted.

5.2 The choice of sampling equipment can be crucial to the task of collecting a sample appropriate for the intended use.

5.3 When a sample is collected, all sources of potential bias should be considered, not only in the selection and use of the sampling device, but also in the interpretation and use of the data generated. Some major considerations in the selection of sampling equipment for the collection of a sample are listed below:

5.3.1 The ability to access and extract from every relevant location in the target population,

5.3.2 The ability to collect a sufficient mass of sample such that the distribution of particle sizes in the population are represented, and

5.3.3 The ability to collect a sample without the addition or loss of constituents of interest.

5.4 The characteristics discussed in 5.3 are particularly important in investigations when the target population is heterogeneous, such as when particle sizes vary, liquids are present in distinct phases, a gaseous phase exists, or materials from different sources are present in the population. The consideration of these characteristics during the equipment selection process will enable the data user to make appropriate statistical inferences about the target population based on the sampling results.

5.5 If samples are to be collected for the determination of per- and poly-fluorinated alkyl substances (PFAS), all sampling equipment should be made of fluorine-free materials. Other considerations for PFAS sampling may exist but are beyond the scope of this standard.

6. Selection Criteria

6.1 Refer to Tables 1 and 2 for a summary of matrix compatibility and selection criteria. Refer to Table 3 for an index of sampling equipment based upon sample type and matrix to be sampled.

6.2 *Compatibility*—It is important that sampling equipment, other equipment which may come in contact with samples (such as gloves, mixing pans, knives, spatulas, spoons, etc.), and sample containers be constructed of materials that are compatible with the matrices and analytes of interest. Incompatibility may result in the contamination of the sample and the degradation of the sampling equipment. Appropriate sampling equipment must be chemically and physically compatible.

6.2.1 *Chemical Compatibility*—The effects of a matrix on the sampling equipment is usually considered in the light of the analytes, or groups of analytes of interest. For example, poly-vinyl chloride (PVC) has been found to degrade in the presence of many separate phase organic compounds in water; therefore, it would be preferable to collect groundwater samples for organic analyses using fluoropolymer, stainless steel, or glass sampling equipment (**1, 2**).[4] Acids, bases, high-chloride groundwater in coastal areas, and wastes with high concentrations of solvents may also degrade many types of sampling equipment over time. The residence or contact time, the time the sample is in contact with the sampling equipment, may be significant in terms of chemical interaction between the sampled matrix and the equipment.

6.2.1.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what constituents may be present in the sampling environment because the constituents and materials may interact chemically or be incompatible. Consult available chemical compatibility charts.

6.2.1.2 If samples are to be collected for the determination of per- and poly-fluorinated alkyl substances (PFAS), all sampling equipment should be made of fluorine-free materials. Other considerations for PFAS sampling may exist but are beyond the scope of this standard.

6.2.2 *Physical Compatibility*—The sampling equipment should also be compatible with the physical characteristics of the matrices to be sampled. Equipment used to dig or core (shovels, augers, coring-type samplers) should be constructed of material that will not deform during use or be abraded by the

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

TABLE 1 Equipment Selection—Matrix Guide

Equipment (May be used for discrete sample collection)	Water and Wastewater			Sediment	Soil	Waste				
	Surface Water	Ground-water	Point Discharge			Liquid	Multi-Layer Liquid	Mixed Phase Solid/Liquid	Consolidated Solid	Unconsolidated Solid
Pumps and Siphons										
Automatic Sampler—Non Volatiles	√D6538[G]	-	-	-	-	N	N	-	-	-
Automatic Composite Sampler—Volatiles	√		√	-	-	-	-	-	-	-
Air/Gas Displacement Pump		√D4448[G]	√	-	-	-	√	-	-	-
Piston Displacement Pump		√D4448[G]	√	-	-		N	-	-	-
Bladder Pumps		√D4448[G]	√	-	-	N	N	-	-	-
		D6771[P]		-	-	-	-	-	-	-
Corrugated Bladder Pumps		√D6634[G]								
Peristaltic Pump	√D6759[P]	√D4448[G] √D7353[P]	√D6759[P]	-	-	√D6759[P]	√D6759[P]	N	-	-
Centrifugal Submersible Pump	√	√D4448[G] √D6771[P]	√	-	-	N	N	-	-	-
Gear Drive Pump	√	√D6634[G]	√	-	-	N	N	-	-	-
Progressing Cavity Pump	√	√D6634[G]	√	-	-	N	N	-	-	-
Inertia Lift Pump	-	√D4448[G]	-	-	-	-	-	-	-	-
Dredges										
Ekman Dredge	-	-	-	√D4387[G] D4343[P] √E1391[G]	-	-	-	-	-	-
Petersen Dredge	-	-	-	√D4387[G] √E1391[G]	-	-	-	-	-	-
Ponar Dredge	-	-	-	√D4387[G] D4342[P] √E1391[G]	-	-	-	-	-	-
Discrete Depth Samplers										
Bacon Bomb	√D6759[P]	-	-	-	-	√D6759[P]	N	-	-	-
Kemmerer Sampler	√D4136[P]	-	-	-	-	√D6759[P]	N	-	-	-
	D6759[P]	-	-	-	-		-	-	-	-
Syringe Sampler	√D5743[G]	-	N	-	-	√D6759[P]	√D6759[P]	√D6759[P]	-	-
	D6759[P]	-	-	-	-	-	-	-	-	-
Lidded Sludge/Water Sampler	-	-	-	-	-	N	N	√D6759[P]	-	N
Discrete Level Sampler	√D6759[P]	√	√D6759[P]	-	-	√D6759[P]	√D6759[P]	-	-	-
HYDRASleeve	N	√D7929[G]	-	-	-	N	N	-	-	-
Snap Sampler	-	√D7929[G]	-	-	-	N	N	-	-	-
Drive/Push/Drill Samplers										
Direct-Push Water Sampler	-	√	-	-√	-√	N	-	-	-	-
Split-Barrel Sampler	-	-	-	√	√D1586[T] √D6640[P]	-	-	N	-	N
Ring-Lined Barrel Sampler					√D3550[P] D6640[P]	-	-	√	-	N
Thin-Walled Soil Sampler	-	-	-	√D4823[G]	√D1587[P] √D6640[P]	-	-	-	-	√
Direct-Push Single-Tube Soil Sampler					√D6640[P] D6282[G]					
Direct-Push Dual-Tube Soil Sampler					√D6640[P] D6282[G]					
Sonic Drill Soil and Rock Sampler					√D6914[P]				√	
Soil Corers					√					
Coring-Type Sampler w/ Valve	-	-	-	√D4823[G]	N	-	-	√	-	√
Concentric Tube Thief	-	-	-	-	-	-	-	-	-	√
Trier	-	-	-	-	√	-	-	N	-	√D5451[P] √E300[P]
Handheld Soil Core Sampler	-	-	-	N	D4700[G] √D4547[G] √D8170[P]	-	-	-	-	N
Modified Syringe Sampler	-	-	-	N	√D4547[G]	-	-	-	-	N
Rotating Coring Devices										
Screw Auger	-	-	-	-	N	-	-	-	√	-
Rotating Corer	-	-	-	√D4823[G]	√D4700[G]	-	-	-	√	-
Captive Screw Auger	-	-	-	-	-	-	-	-	N	√
Augers										
Hand-Operated Bucket Auger	-	-	-	N	√D1452[P] D4700[G] √D6907[P]	-	-	-	-	√D1452[P] √D6907[P]
Solid-Stem Flighted Auger	-	-	-	-	√D1452[G] √D6286[G]	-	-	-	N	N

TABLE 1 *Continued*

Equipment (May be used for discrete sample collection)	Water and Wastewater			Sediment	Soil	Waste				
	Surface Water	Ground-water	Point Discharge			Liquid	Multi-Layer Liquid	Mixed Phase Solid/Liquid	Consolidated Solid	Unconsolidated Solid
Hollow-Stem Flighted Auger	-	√D5784^{G}	-	-	√D6169^{G} √D6151^{G}	-	-	-	N	N
Peat Borer	-	-	-	√	√	-	-	-	-	N
Liquid Profile Devices										
COLIWASA	-	-	-	-	-	√D5495^{P} √D5743^{G}	√D5495^{P} D5743^{G}	-	-	
Reusable Point Sampler	N	-	N	-	-	√D5743^{G}	√D5743^{G}	√	-	-
Drum Thief	-	-	-	-	-	√D5743^{G}	√D5743^{G}	√	-	-
Valved Sampler	-	-	-	-	-	√D5743^{G}	√D5743^{G}	√	-	-
Plunger-Type Sampler	N	-	N	-	-	√D5743^{G}	√D5743^{G}	√D5743^{G}	-	-
Liquid Profiler	N	-	N	-	-	√D6759^{P}	√D6759^{P}	√D6759^{P}	-	-
Surface Sampling Devices (Liquids)										
Bailer	N	√D4448^{G} √D6699^{P}	- -	- -	- -	N -	N -	- -	- -	- -
Point Sampling Bailer	N	√D4448^{G} √D6699^{P}	- -	- -	- -	N -	N -	- -	- -	- -
Differential Pressure Bailer	-	√D6699^{P}	-	-	-	N	N	-	-	-
Dipper	√D5358^{P} √D6759^{P}	-	√D5013^{P}	-	-	√D5358^{P} √D6759^{P}	-	√D5358^{P} √D6759^{P}	-	-
Liquid Grab Sampler	√D6759^{P}	-	N	-	-	√D6759^{P}		√D6759^{P}	-	-
Swing Jar Sampler	√D6759^{P}	-	N	N	-	√D6759^{P}		N	-	-
Passive Water Sampling Devices										
Passive Sampler, Bag Type	√	√D7929^{G}	-	-	-	-	-	-	-	-
Passive Sampler, Chamber Type	-	√D7929^{G}	-	-	-	-	-	-	-	-
Multi-Level Sampling Devices										
Dedicated Type 1	-	√	-	-	N	-	-	-	-	-
Dedicated Type 2	-	√	-	-	N	-	-	-	-	-
Portable	-	N	-	-	√	-	-	-	-	-
Surface Sampling Devices (Solids)										
Impact Devices	-	-	-	-	-	-	-	-	√D5679^{P}	-
Spoon	N	-	N	-	N	N	N	-	-	N
Scoops and Trowels	-	-	-	N	√D5633^{P}	N	-	N	-	√
Shovels	-	-	-	N	N	-	-	N	-	√
Vadose Zone Pore Sampling Devices										
Vacuum Lysimeter	-	N	-	N	√D4696^{G}	-	-	-	-	-
Vacuum/Pressure Lysimeter	-	N	-	N	√D4696^{G}	-	-	-	-	-
Passive Soil Gas Sampler	N	N	-	N	√D7758^{P}	-	-	-	-	-

√ = Equipment may be used with this matrix N = Not equipment of choice but use is possible - = Not recommended
^{G} = ASTM Guide ^{T} = ASTM Test Method ^{P} = ASTM Practice

material being sampled. Equipment abrasion may result in the contribution of contaminants to the sample being collected. For example, plastic or glass would not be appropriate for difficult-to-access matrices, and stainless steel equipment may contribute small amounts of metals if significantly abraded by the matrix.

NOTE 1—Information on sample containers and equipment used in sampling that is not used in the actual collection of the sample is not within the scope of this guide.

6.3 *Equipment Effects on the Matrix:*

6.3.1 *Equipment Design*—Samples collected using inappropriate sampling equipment may not provide representative samples (**1, 3**). An example of equipment design influencing sample results is a sampler which excludes certain sized particles from a soil matrix or waste pile sample. The shape of some scoops may influence the distribution of particle sizes collected from a sample (**1**). Dredges used to collect river or estuarine stationary sediments may also exclude certain sized particles, particularly the fines fraction which may contain a significant percentage of some contaminants such as polynuclear aromatic hydrocarbons (PAHs).

6.3.2 *Equipment Use*—Inappropriate use of sampling equipment can influence analytical results (**1, 3**). For example, if a pump is used to purge a well and the intake is placed below the well screen, sediment in the sump can be put into suspension and become part of the water sample (**4**). Excessive vacuum generated by sampling pumps can cause loss of volatile constituents or change valence states of some ions. The use of bailers for well purging and sample collection may also cause increased turbidity levels in groundwater samples and result in elevated organic and inorganic target analyte concentrations in the sample. When sampling containerized liquids, insertion of a COLIWASA sampler at too fast a rate may prevent it from collecting a representative, depth integrated sample.

6.4 *Sample Volume Capabilities*—Most sampling devices will provide adequate sample volume. However, the sampling equipment volumes should be compared to the volume necessary for all required analyses including the additional amount

TABLE 2 Sampling Equipment Selection Guide

Equipment	Chemical	Physical	Effect on Sample	Volume Range	Physical	Ease of Operation	Decon	Disposal or Reuse
Pumps and Siphons								
Automatic Sampler–Nonvolatiles	X	X	√	U	B/P	√	X	R
Automatic Composite Sampler–Volatiles	X	X	√	U	B/P	X	X	R
Air/Gas Displacement Pump	√	X	X	U	P/S/W	X	X	R
Piston Displacement Pump	√	X	X	U	P/S/W	X	X	R
Bladder Pumps	√	X	√	U	P	X	X	R
Corrugated Bladder Pump	√	X	√	U	P	√	X	R
Peristaltic Pump	X	X	√	U	B/P	X	√	R
Centrifugal Submersible Pump	X	X	X	U	P/S/W	√	X	R
Gear Drive Pump	X	X	X	U	B/P	√	X	D/R
Progressive Cavity Pump	X	X	X	U	P	√	X	R
Inertia Lift Pump	X	X	X	U	B/N	√	√	R
Dredges								
Ekman Dredge	√	√	X	0.5–3.0	N	X	X	R
Petersen Dredge	√	√	X	0.5–3.0	W	X	X	R
Ponar Dredge	√	√	X	0.5–3.0	W	X	X	R
Discrete Depth Samplers								
Bacon Bomb	X	X	√	0.1–0.94	N	√	X	R
Kemmerer Sampler	X	X	X	1.0–2.0	N	X	X	R
Syringe Sampler	√	√	√	0.2–0.5	N	√	X	R
Lidded Sludge/Water Sampler	√	X	X	1.0	S/W	X	X	R
Discrete Level Sampler	√	X	√	0.2–0.5	N	√	√	R
HYDRASleeve	√	√	√	0.6–3.1	N	√	√	D
Snap Sampler	√	√	√	0.04–0.35	N	√	X	R
Drive/Push/Drill Samplers								
Direct-Push Water Sampler	√	√	√	0.1–0.3	P/S/W	X	X	R
Split-Barrel Sampler	√	√	X	0.5–30.0	S/W	X	√	R
Ring-Lined Barrel Sampler	√	√	X	0.5–30.0	S/W	X	√	R
Thin-Walled Tube Sampler	√	√	X	0.5–5.0	S/W	√	√	R
Direct-Push Single-Tube Sampler	√	√	X	0.5–30.0	S/W	X	√	R
Direct-Push Dual-Tube Sampler	√	√	X	0.5–30.0	S/W	X	√	R
Sonic Drill Soil and Rock Sampler	√	√	X	0.5–100	S/W/P	X	√	R
Soil Corers	√	√	X	0.2–1	N	√	√	R
Coring-Type Sampler w/ Valve	√	√	√	0.2–1.5	N	√	√	R
Concentric Tube Thief	√	√	√	0.5–1.0	N	√	√	R
Trier	√	√	√	0.1–0.5	N	√	√	R
Handheld Core Sampler	√	√	√	0.01–0.05	N	√	√	D
Modified Syringe Sampler	√	√	√	0.01–0.05	N	√	X	D
Rotating Coring Devices								
Screw Auger	√	X	X	0.1–0.3	N	X	√	R
Rotating Corer	√	√	X	0.5–1.0	B/P	√	√	R
Captive Screw Auger	X	√	X	1–2	P	√	√	R
Augers								
Hand-Operated Bucket Auger	√	X	X	0.2–1.0	N	X	√	R
Solid-Stem Flighted Auger	X	√	X	U	P/S/W	X	√	R
Hollow-Stem Flighted Auger	X	√	X	U	P/S/W	X	√	R
Peat Borer	X	√	√	0.3	N	√	X	R
Liquid Profile Devices								
COLIWASA	√	X	√	0.5–3.0	N	√	X	D/R
Reusable Point Sampler	√	√	√	0.2–0.6	N	√	√	R
Drum Thief	√	X	√	0.1–0.5	N	√	X	D/R
Valved Sampler	√	√	√	0.3–1.6	N	√	√	D/R
Plunger-Type Sampler	√	X	√	0.2–U	N	√	√	D/R
Liquid Profiler	X	X	√	1.3–4.0	N	√	√	R
Surface Sampling Devices (Liquids)								
Bailer	X	√	X	0.5–2.0	N	√	√	D/R
Point Sampling Bailer	X	√	√	0.5–2.0	N	√	√	R
Differential Pressure Bailer	√	√	√	0.04–1.0	N	√	X	R
Dipper	√	X	√	0.5–1.0	N	√	√	R
Liquid Grab Sampler	√	√	√	0.5–1.0	N	√	√	R
Swing Jar Sampler	X	√	√	0.5–1.0	N	√	√	R
Passive Water Sampling Devices								
Passive Sampler, Bag Type	√	√	√	0.1–0.2	N	√	√	D/R
Passive Sampler, Chamber Type	√	√	√	1–4	W/S	X	X	D/R

TABLE 2 *Continued*

Equipment	Chemical	Physical	Effect on Sample	Volume Range	Physical	Ease of Operation	Decon	Disposal or Reuse
Multi-Level Sampling Devices								
Dedicated Type 1	√	√	√	U	W/S	X	X	D/R
Dedicated Type 2	√	√	√	U	W/S	X	X	D
Portable	√	√	√	0.01	N	X	X	DR
Surface Sampling Devices (Solids)								
Impact Devices	X	X	X	N/A	B/P	√	√	R
Spoon	√	√	X	N/A	N	√	√	R
Scoops and Trowels	√	√	X	0.1–0.6	N	√	√	R
Shovels	√	√	X	1.0–5.0	N	√	√	R
Vadose Zone Pore Sampling Devices								
Vacuum Lysimeter	√	√	√	0.1–0.5	N	√	√	D/R
Vacuum/Pressure Lysimeter	√	√	√	0.1–0.5	S/P	√	√	D
Passive Soil Gas Samplers	√	√	√	N/A	N	√	√	D

X = Significant operational consideration
√ = Not a significant operational consideration

Range of Volume (liters):
U = Unlimited
N/A = Not applicable

Physical Requirements:
B = Battery W = Weight
P = Power S = Size
N = No limitations

Disposal and Reuse:
R = Reusable
D = Single use

necessary for quality control (QC), split, and replicate samples (**4, 5**). Sampling devices which may not provide an adequate volume would be small-diameter glass tubes and triers. In this case, the investigator must consider the following options:

6.4.1 A similar device with an increased capacity,

6.4.2 An alternate device with an increased capacity, or

6.4.3 Modification of an existing device (often difficult or impractical).

6.4.4 If these alternatives are not acceptable or available, then the investigator must consider the collection of multiple aliquots to fulfill the sample volume requirement. The effect of multiple aliquots on the data quality objectives should be considered.

6.5 *Physical Requirements*—Sampling equipment selection should always consider factors such as the size and weight of the equipment, power requirements (battery/110V), and ancillary equipment required (for example, drill rig for direct-push technologies such as split-barrel samplers and augers). Most sampling equipment used in the collection of environmental samples is relatively easy to transport and use in the field. The use of equipment with significant physical requirements may impede the progress of a sampling investigation.

6.6 *Ease of Operation*—Much of the equipment used for environmental sampling is rather simple to employ. Samples may be collected easily as long as properly selected equipment is used with adequate consideration of the matrix of interest. Training requirements should focus on the proper use of equipment in varying environmental matrices.

6.7 *Decontamination and Reuse of Equipment:*

6.7.1 *Decontamination (see Practice D5088)*—Inadequate decontamination of sampling equipment can result in significant errors in analytical results. When choosing sampling equipment, ease of decontamination must be a consideration. Pumps, automatic samplers, Kemmerer samplers, and dredges require more effort to decontaminate than does a bailer or split-barrel sampler. The investigator should consider decontamination requirements prior to the study to avoid significant delays.

6.7.2 *Reuse*—Due to the expense of materials associated with modern sampling equipment (stainless steel, PTFE), most equipment is reusable following proper decontamination. Some equipment such as bailers may be disposed of after use or dedicated to a sampling point to save time during extensive field investigations. Drum thieves and COLIWASA samplers are typically not reused, particularly when waste samples have been collected.

6.8 *Cost*—Detailed information on the cost of sampling equipment is not contained within this guide. Cost is usually a major consideration in the process of sampling equipment selection. In general, the cost of PTFE and stainless steel equipment will be greater than equipment made of glass, PVC, or other plastics. However, the life expectancy for PTFE or stainless steel equipment is usually longer. In addition, labor costs for decontamination of reusable equipment versus the disposal costs of single-use equipment are also relevant considerations. Comments on costs are included in the "Advantages and Limitations" tables, where appropriate.

7. Sampling Equipment

7.1 Presented below are brief descriptions of some sampling equipment used in waste management and in the collection of environmental samples as they relate to waste management activities (**6**). This is by no means an inclusive list of the sampling equipment which is available to investigators. There are many pieces of equipment that have been designed for specific sampling needs. In addition, investigators may design their own pieces of equipment for a specific project. In all these instances, an investigator must keep in mind the criteria for sampling equipment selection which have been discussed previously in this guide.

7.2 *Pumps and Siphons (see Guide D4448)*—Pumps used for the collection of waste and environmental liquid samples for waste management include automatic samplers and displacement, bladder, peristaltic, and centrifugal pumps.

7.2.1 *Automatic Samplers (see Guide D6538)*—Automatic samplers may be used when samples are to be collected at

TABLE 3 Index of Sampling Equipment

Media Type	Sampler Type	Subsection	Sample Type
Consolidated Solid	Screw Auger	(7.6.1)	Surface, Disturbed
	Rotating Corer	(7.6.2)	Surface, Undisturbed
	Impact Devices	(7.11.1)	Surface, Disturbed
Unconsolidated Solid	Lidded Sludge/Water Sampler	(7.4.4)	Discrete, Composite
	Split-Barrel Sampler	(7.5.2)	Discrete, Undisturbed
	Ring-Lined Barrel Sampler	(7.5.3)	Surface, Undisturbed
	Thin-Walled Tube Sampler	(7.5.4)	Surface or Depth, Undisturbed
	Direct-Push Single-Tube Sampler	(7.5.5)	Surface or Depth, Representative
	Direct-Push Dual-Tube Sampler	(7.5.6)	Surface or Depth, Representative
	Sonic Drill Coring	(7.5.7)	Continuous, Representative/Disturbed
	Soil Corers	(7.5.8)	Surface, Undisturbed
	Coring-Type Sampler w/ Valve	(7.5.9)	Surface or Depth, Disturbed
	Concentric Tube Thief	(7.5.10)	Surface, Disturbed, Selective
	Trier	(7.5.10)	Surface, Relatively Undisturbed, Selective
	Handheld Core Sampler	(7.5.11)	Surface, Undisturbed
	Modified Syringe	(7.5.12)	Surface, Undisturbed
	Captive Screw Auger	(7.6.3)	Discrete, Disturbed
	Hand-Operated Bucket Auger	(7.7.1)	Surface or Depth, Disturbed
	Solid-Stem Flighted Auger	(7.7.2.1)	Surface or Depth, Disturbed
	Hollow-Stem Flighted Auger	(7.7.2.3)	Surface or Depth, Disturbed (if from flights)
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Spoon	(7.11.2)	Surface, Disturbed, Selective
	Scoops and Trowels	(7.11.3)	Surface, Disturbed, Selective
	Shovels	(7.11.4)	Surface, Disturbed
Soil	Split-Barrel Sampler	(7.5.2)	Discrete, Representative
	Ring-Lined Barrel Sampler	(7.5.3)	Discrete, Representative
	Thin-Walled Tube Sampler	(7.5.4)	Surface or Depth, Undisturbed
	Direct-Push Single-Tube Sampler	(7.5.5)	Surface or Depth, Representative
	Direct-Push Dual-Tube Sampler	(7.5.6)	Surface or Depth, Representative
	Sonic Drill Coring	(7.5.7)	Subsurface, Representative/Disturbed
	Soil Corers	(7.5.8)	Surface, Disturbed
	Coring-Type Sampler w/ Valve	(7.5.9)	Surface or Depth, Disturbed
	Trier	(7.5.10)	Surface, Relatively Undisturbed, Selective
	Solid-Stem Flighted Auger	(7.7.2.1)	Surface or Depth, Disturbed
	Hollow-Stem Flighted Auger	(7.7.2.3)	Surface or Depth, Disturbed (if from flights)
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Spoon	(7.11.2)	Surface, Disturbed, Selective
	Scoops and Trowels	(7.11.3)	Surface, Disturbed, Selective
	Shovels	(7.11.4)	Surface, Disturbed
	Vacuum Lysimeter	(7.12.1)	Surface to Depth, Pore Liquid
	Vacuum/Pressure Lysimeter	(7.12.2)	Depth, Pore Liquid
	Passive Soil Gas Samplers	(7.12.3)	Surface to Depth, Soil Gas
Mixed Solid/Liquid	Autosampler, Non-Volatiles	(7.2.1)	Shallow, Composite, Suspended solids only
	Peristaltic Pump	(7.2.5)	Shallow, Discrete or Composite, Suspended solids only
	Syringe Sampler	(7.4.3)	Shallow, Discrete, Disturbed
	Lidded Sludge/Water	(7.4.4)	Discrete, Composite
	Dipper	(7.4.9)	Shallow, Composite
	Liquid Grab Sampler	(7.4.10)	Shallow, Composite, Suspended solids only
	Swing Jar Sampler	(7.4.11)	Shallow, Composite
	Split-Barrel Sampler	(7.5.2)	Depth, Discrete, Undisturbed
	Ring-Lined Barrel Sampler	(7.5.3)	Depth, Discrete, Undisturbed
	Soil Corers	(7.5.8)	Depth, Discrete, Undisturbed
	Coring-Type Sampler w/ Valve	(7.5.9)	Depth, Disturbed
	Trier	(7.5.10)	Surface, Semi-solid only, Selective
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	COLIWASA	(7.8.1)	Shallow, Composite, Semi-liquid only
	Reusable Point Sampler	(7.8.1.3)	Shallow, Discrete
	Drum Thief	(7.8.2)	Shallow, Composite, Semi-liquid only
	Valved Sampler	(7.8.3)	Shallow, Composite, Semi-liquid only
	Plunger-Type Sampler	(7.8.4)	Shallow, Discrete
	Liquid Profiler	(7.8.5)	Depth, Composite, Suspended solids only
	Scoops and Trowels	(7.11.3)	Shallow, Composite, Semi-solid only
	Shovels	(7.11.4)	Shallow, Composite, Semi-solid only
Sediment	Ekman Dredge	(7.3.1)	Bottom, Surface, Soft only, Disturbed
	Petersen Dredge	(7.3.2)	Bottom, Surface, Rocky or Soft, Disturbed
	Ponar Dredge	(7.3.3)	Bottom, Surface, Rocky or Soft, Disturbed
	Split-Barrel Sampler	(7.5.2)	Discrete, Undisturbed
	Ring-Lined Barrel Sampler	(7.5.3)	Discrete, Undisturbed
	Thin-Walled Tube Sampler	(7.5.4)	Surface or Depth, Undisturbed
	Coring-Type Sampler w/ Valve	(7.5.9)	Surface or Depth, Disturbed
	Handheld Core Sampler	(7.5.11)	Exposed Surface only, Undisturbed
	Modified Syringe	(7.5.12)	Exposed Surface only, Undisturbed
	Rotating Corer	(7.6.2)	Bottom, Surface, Undisturbed if solid
	Hand-Operated Bucket Auger	(7.7.1)	Surface or Depth, Disturbed
	Solid-Stem Flighted Auger	(7.7.2.1)	Surface or Depth, Disturbed

TABLE 3 *Continued*

Media Type	Sampler Type	Subsection	Sample Type
	Hollow-Stem Flighted Auger	(7.7.2.3)	Surface or Depth, Disturbed (if from flights)
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Scoops and Trowels	(7.11.3)	Exposed Surface only, Disturbed, Selective
	Shovels	(7.11.4)	Exposed Surface only, Disturbed
Surface Water	Autosampler, Non-Volatiles	(7.2.1)	7.6 m (25 ft) Lift, Discrete or Composite
	Autosampler, Volatiles	(7.2.1)	7.6 m (25 ft) Lift, Discrete
	Peristaltic Pump	(7.2.5)	Shallow, up to 7.6 m (25 ft) Lift, Discrete
	Centrifugal Submersible Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Bacon Bomb	(7.4.1)	Depth, Discrete
	Kemmerer Sampler	(7.4.2)	Depth, Discrete
	Discrete Level Sampler	(7.4.5)	Depth, Discrete
	Dipper	(7.4.9)	Shallow, 3 m (10 ft), Composite
	Liquid Grab Sampler	(7.4.10)	Shallow, 1.8 m (6 ft), Composite
	Swing Jar Sampler	(7.4.11)	Shallow, 3 m (10 ft), Composite
	Plunger-Type Sampler	(7.8.4)	Shallow, 3.65 m (12 ft), Discrete
	Liquid Profiler	(7.8.5)	Shallow, Composite
	Spoon	(7.11.2)	Shallow, 2.5 cm (1 in.), Composite
Groundwater	Air/Gas Displacement Pump	(7.2.2.1)	Depth, Discrete
	Piston Displacement Pump	(7.2.2.2)	Depth, Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	7.6 m (25 ft) Lift, Discrete
	Centrifugal Submersible Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Inertia Lift Pump	(7.2.9)	Depth, Discrete
	Discrete Level Sampler	(7.4.5)	Depth, Discrete
	Bailer	(7.4.6)	Depth, Composite
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Differential Pressure Bailer	(7.4.8)	Depth, Discrete
	Direct-Push Water Sampler	(7.5.1)	Depth, Discrete
	Passive Sampler, Bag Type	(7.9.1)	Depth, Discrete
	Passive Sampler, Chamber Type	(7.9.2)	Multiple Depths, Discrete
	Dedicated Multi-Level Type 1	(7.10.1)	Multiple Depths, Discrete
	Dedicated Multi-Level Type 2	(7.10.1)	Multiple Depths, Discrete
	Portable Multi-Level	(7.10.2)	Multiple Depths, Discrete, Pore water
Liquid Effluent	Autosampler, Non-Volatiles	(7.2.1)	7.6 m (25 ft) Lift, Discrete or Composite
	Autosampler, Volatiles	(7.2.1)	7.6 m (25 ft) Lift, Discrete
	Peristaltic Pump	(7.2.5)	Shallow, up to 7.6 m (25 ft) Lift, Discrete
	Centrifugal Submersible Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Bacon Bomb	(7.4.1)	Depth, Discrete
	Kemmerer Sampler	(7.4.2)	Depth, Discrete
	Syringe Sampler	(7.4.3)	Shallow, 2.4 m (8 ft), Discrete
	Discrete Level Sampler	(7.4.5)	Depth, Discrete
	Dipper	(7.4.9)	Shallow, 3 m (10 ft), Composite
	Liquid Grab Sampler	(7.4.10)	Shallow, 1.8 m (6 ft), Composite
	Swing Jar Sampler	(7.4.11)	Shallow, 3 m (10 ft), Composite
	HYDRASleeve	(7.4.12)	Depth, Discrete
	Snap Sampler	(7.4.13)	Depth, Discrete
	Reusable Point Sampler	(7.8.1.3)	Shallow, 2.4 m (8 ft), Discrete
	Valved Sampler	(7.8.3)	Shallow, Discrete
	Plunger-Type Sampler	(7.8.4)	Shallow, 3.7 m (12 ft), Discrete
	Liquid Profiler	(7.8.5)	Shallow, Composite
	Spoon	(7.11.2)	Shallow, 2.5 cm (1 in.), Composite
Liquid	Air/Gas Displacement Pump	(7.2.2.1)	Depth, Discrete
	Piston Displacement Pump	(7.2.2.2)	Depth, Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	Shallow, 7.6 m (25 ft), Discrete
	Centrifugal Submersible Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Syringe Sampler	(7.4.3)	Shallow, 2.4 m (8 ft), Discrete
	Lidded Sludge/Water	(7.4.4)	Shallow, 2.4 m (8 ft), Discrete
	Discrete Level Sampler	(7.4.5)	Depth, Discrete
	Bailer	(7.4.6)	Depth, Discrete
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Differential Pressure Bailer	(7.4.8)	Depth, Discrete
	Dipper	(7.4.9)	Shallow, 3 m (10 ft), Composite
	Liquid Grab Sampler	(7.4.10)	Shallow, 1.8 m (6 ft), Composite
	Swing Jar Sampler	(7.4.11)	Shallow, 3 m (10 ft), Composite

TABLE 3 *Continued*

Media Type	Sampler Type	Subsection	Sample Type
	Direct-Push Water Sampler	(7.5.1)	Depth, Discrete
	COLIWASA	(7.8.1)	Shallow, 1.2 m (4 -ft), Composite
	Reusable Point Sampler	(7.8.1.3)	Shallow, 2.4 m (8- ft), Discrete
	Drum Thief	(7.8.2)	Shallow, 0.9 m (3 ft), Composite
	Valved Sampler	(7.8.3)	Shallow, 2.4 m (8 ft), Composite
	Plunger-Type Sampler	(7.8.4)	Shallow, 3.7 m (12 ft), Discrete
	Liquid Profiler	(7.8.5)	Shallow, Composite
	Spoon	(7.11.2)	Shallow, 2.5 cm (1 in.), Composite
	Scoops and Trowels	(7.11.3)	Shallow, 2.5 cm (1 in.), Composite
Multi-Layer Liquid	Air/Gas Displacement Pump	(7.2.2.1)	Depth, Discrete
	Piston Displacement Pump	(7.2.2.2)	Depth Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	Shallow, 7.6 m (25 ft), Discrete
	Centrifugal Submersible Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Syringe Sampler	(7.4.3)	Shallow, 2.4 m (8 ft), Discrete
	Discrete Level Sampler	(7.4.5)	Depth, Discrete
	Bailer	(7.4.6)	Depth, Discrete
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Differential Pressure Bailer	(7.4.8)	Depth, Discrete
	Dipper	(7.4.9)	Shallow, 3 m (10 ft), Composite
	Liquid Grab Sampler	(7.4.10)	Shallow, 1.8 m (6 ft), Composite
	Swing Jar Sampler	(7.4.11)	Shallow, 3 m (10 ft), Composite
	Direct-Push Water Sampler	(7.5.1)	Depth, Discrete
	COLIWASA	(7.8.1)	Shallow, 1.2 m (4 ft), Composite
	Reusable Point Sampler	(7.8.1.3)	Shallow, 2.4 m (8 ft), Discrete
	Drum Thief	(7.8.2)	Shallow, 0.9 m (3 ft), Composite
	Valved Sampler	(7.8.3)	Shallow, 2.4 m (8 ft), Composite
	Plunger-Type Sampler	(7.8.4)	Shallow, 3.7 m (12 ft), Discrete
	Liquid Profiler	(7.8.5)	Shallow, Composite

frequent intervals (see Figs. 1 and 2). They are frequently used in wastewater collection systems and treatment plants, but they can also be used during stream sampling investigations. They may be used to collect time composite or flow proportional samples. In the flow proportional sampling mode, the samplers are activated by a compatible flow meter. Peristaltic and vacuum pumps are commonly employed as the sampling mechanism. Automatic samplers designed specifically for the collection of samples for volatile organic analyses are available. See Table 4 for advantages and limitations.

NOTE 2—Flow proportional samples can also be collected using a discrete sampler and a flow recorder and manually compositing the individual aliquots in flow proportional amounts.

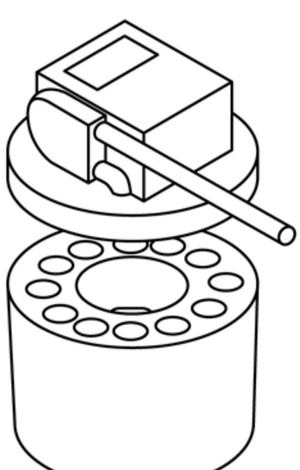

FIG. 1 Automatic Sampler—Non Volatiles

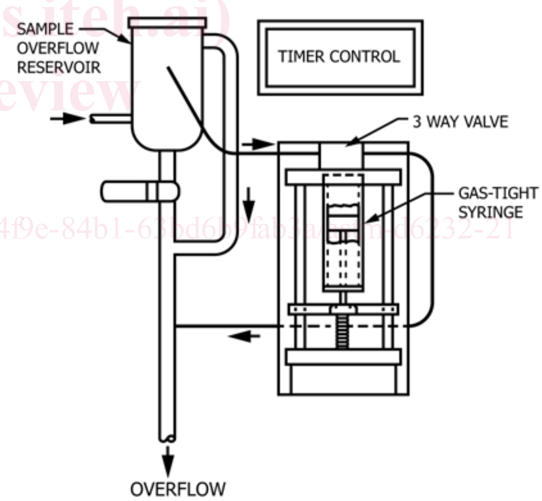

FIG. 2 Automatic Composite Sampler—Volatiles

7.2.2 *Displacement Pumps (see Guide D4448, Practice D6771)*—Displacement pumps are designed for groundwater sampling and mechanically force a discrete column of water to the surface. The air displacement pump uses compressed air. The piston displacement pump uses an actuating rod powered either from the surface or from a separate sealed air or electric actuator. See Table 5 for advantages and limitations.

7.2.2.1 The air displacement pump (see Fig. 3) operates by applying a positive pressure to the gas line causing the inlet check valve of the sampling device to close and the sample discharge line check valve to open, forcing the contents to the

TABLE 4 Automatic Samplers—Advantages and Limitations

Advantages	Limitations
Can collect either grab samples over time or a composite sample	May be unsuitable for samples requiring volatile organic analysis or samples containing dissolved gases
Will operate unattended	Need power source/battery
Versatile—can be programmed to sample proportional to flow	May be difficult to decontaminate due to design or construction materials, or both
	May be incompatible with liquid streams containing a high percentage of solids

TABLE 5 Displacement Pumps—Advantages and Limitations

Advantages	Limitations
Commonly constructed of PVC, or stainless steel, or both, but can be constructed of fluoropolymer to reduce risk of contamination when trace levels of organics are of interest	Potential loss of dissolved gases and VOCs from the pumped sample or contamination from the driving gas
Easy to decontaminate (air displacement)	Compressed gas or mechanical actuation required for operation
Flow rate is adjustable	May be difficult to decontaminate (piston displacement)

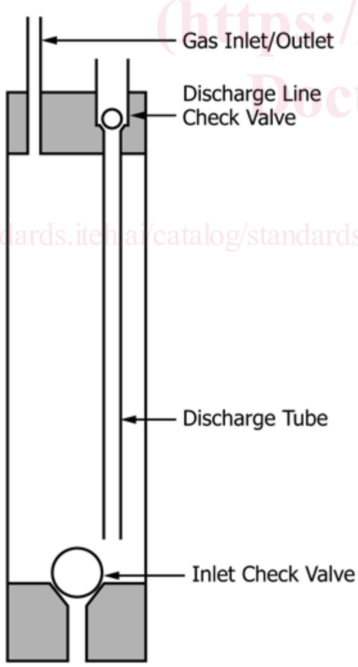

FIG. 3 Air/Gas Displacement Pump

surface. Cyclical removal of gas pressure will cause the flow to stop, the discharge line check valve to close and the inlet check valve of the sampling device to open, allowing the sampling device to fill.

7.2.2.2 The piston displacement pump (see Fig. 4) uses a mechanically operated plunger to deliver the sample to the surface at the same time as the chamber fills. It has a flexible flap valve on the piston and an inlet check valve.

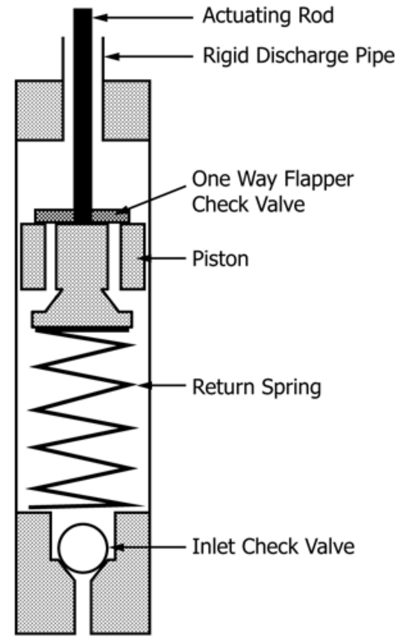

FIG. 4 Piston Displacement Pump

7.2.3 *Bladder Pumps (see Guide D4448, Practice D6771)*—Bladder pumps are used for sampling groundwater and are constructed with a flexible bladder inside a rigid sample container. There are two types. The squeeze type (see Fig. 5) has the bladder connected to the sample discharge line. The chamber between the bladder and the sampler body is connected to the gas line. The expanding type (see Fig. 6) has the bladder connected to the gas line with the sample discharge line connected to the chamber surrounding the bladder.

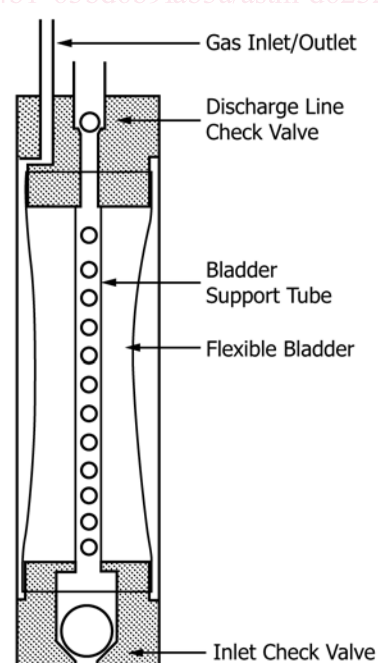

FIG. 5 Bladder Pump—Squeeze Type

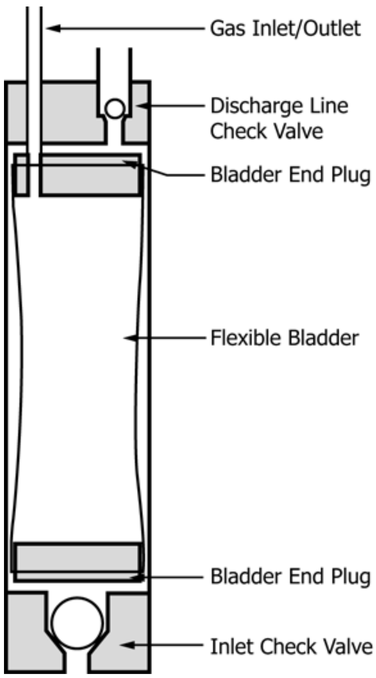

FIG. 6 Bladder Pump—Expanding Type

7.2.3.1 The pump operates by applying a positive pressure to the gas line causing either the bladder to expand or be compressed, dependent on the type. The sampler inlet valve closes and the sample discharge valve opens forcing the contents of the sampler up the discharge line. Cyclic removal of the gas pressure causes the flow to stop, the sample valve to close and the sampler inlet valve to open, allowing the sampler to refill. See Table 6 for advantages and limitations.

7.2.4 *Corrugated Bladder Pump (see Guide D6634)*—This variation on the bladder pumps covered in 7.2.3 uses a corrugated fluoropolymer bladder that is alternately compressed and expanded in a vertical axis by mechanical means to pump the sample to the surface (see Fig. 7). The inner concentric tube is attached to the corrugated bladder and is used to mechanically open and close the bladder, pumping water to the surface through the inner tube. This pump is available in only a 12 mm (0.47 in.) diameter and is used for sampling through small diameter direct push tools and wells. See Table 7 for advantages and limitations.

TABLE 6 Bladder Pumps—Advantages and Limitations

Advantages	Limitations
Suitable for sampling liquids containing volatile organic compounds as flow rate is adjustable	Requires compressed air or gas and a controller
Available in a variety of materials, such as fluoropolymer, stainless steel, PVC, etc. and diameters of 11.1 mm (7⁄16 in.) to 88.9 mm (3.5 in.)	
Have an operational pumping head of up to 305 m (1000 ft)	

7.2.5 *Peristaltic Pump* (**4**) *(see Guide D4448, Practice D6771)*—A peristaltic pump is a suction lift pump which is used at the ground surface (see Fig. 8(a)). A length of fluoropolymer or other suitable tubing is placed in the liquid and the other end is connected to the piece of flexible tubing which has been threaded around the rotor of the peristaltic pump. A second piece of fluoropolymer or other suitable tubing is connected to the discharge end of the flexible tubing to allow the water to be containerized (see Fig. 8(b)), sampled, etc. If the pump tubing is not compatible with the sample parameters of concern, a modification to the system is necessary.

7.2.5.1 The modification (see Fig. 8(c)) consists of a peristaltic pump using fluoropolymer tubing and a fluoropolymer insert to collect samples without the sample coming into contact with the pump tubing. This is accomplished by placing the fluoropolymer insert into the opening of a clean glass container. The fluoropolymer tubing connects the container to the pump and the sample source. The downhole tubing and tubing connecting to the sample container should be compatible with the matrix and analytes of interest.

7.2.5.2 The operation of the peristaltic pump results from the rotor compressing the flexible tubing causing a vacuum to be applied to the inlet tubing. The water is drawn up the inlet tubing and into the container, without coming into contact with the pump flexible tubing.

7.2.5.3 Samples for purgeable organic compounds analyses may be collected by attaching the fluoropolymer tubing to the intake side of the peristaltic pump, pumping the tubing full of the liquid, disconnecting the tubing, and allowing the fluoropolymer tube to drain into the sample vials. A peristaltic pump can also be used to mix and sample liquids from drums (see Guide D6063). See Table 8 for advantages and limitations.

7.2.6 *Centrifugal Submersible Pump (see Guide D4448, Practice D6771)*—Centrifugal submersible pumps (see Fig. 9) may be used for purging and sampling monitoring wells, wastewater impoundments, or point discharges. Water-contacting parts may be made of fluoropolymer and stainless steel. The motor cavity may be either filled with air, deionized, or distilled water that may be replaced as necessary. The pump may be controlled by either a 12V (DC) or a 110/220V (AC) converter. Flow rates range from 34 L (9 gal) per minute down to 100 mL per minute. The pump discharge hose may be made of fluoropolymer or other suitable material.

7.2.6.1 Operation of the pump relies upon the rotation of a set of impellers, powered by an electric motor. Water is drawn into the centrifugal pump by slight suction and then pressurized by the impellers working against fixed stator plates. The pressurized water is then driven to the surface through the discharge hose. The speed at which the impellers are driven controls the pressure applied, and hence, the flow rate. See Table 9 for advantages and limitations.

7.2.7 *Gear Drive Pump (see Guide D6634)*—Gear drive pumps may be used for purging and sampling monitoring wells, impoundments, or point discharges. Water-contacting parts are usually made from stainless steel and fluoropolymer (see Fig. 10). These electric pumps are usually driven by a

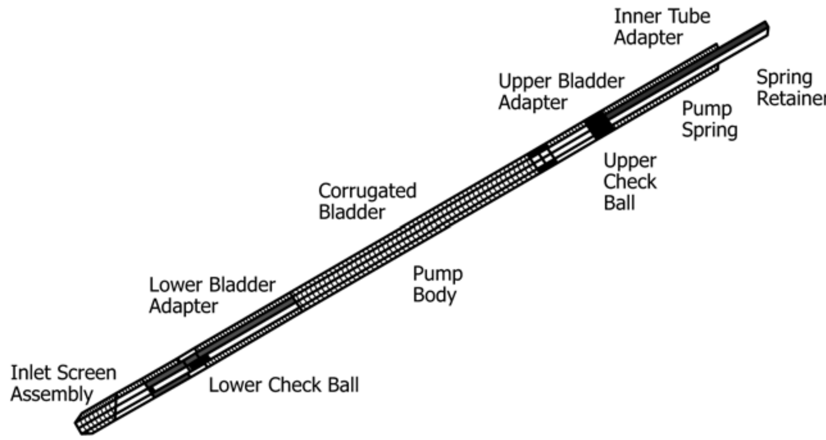

FIG. 7 Corrugated Bladder Pump

TABLE 7 Corrugated Bladder Pump—Advantages and Limitations

Advantages	Limitations
Suitable for sampling liquids containing volatile organic compounds as flow rate is adjustable	When depth to water is more than 23 m (75 ft) flow rate usually <200 mL/min
Available in fluoropolymer and stainless steel in a diameter of 12 mm (0.47 in.)	
Manually or 12 V actuator operated	
May be field decontaminated	

surface controller and have limited purging capability, but can be used to sample liquids containing VOCs and mobile colloids (**7, 8**).

7.2.7.1 The pump body contains a DC electric motor, usually 12 or 24V DC. This drives two gears within a pump cavity that draws water into the pump and delivers it to the surface through the discharge line. The pump speed controls the pressure, and hence, the flow. Heat may be generated, and cavitation may occur when these pumps are operated for extended periods at high speed. See Table 10 for advantages and limitations.

7.2.8 *Progressing Cavity Pump (see Guide D6634)*—Progressing cavity pumps (see Fig. 11) may be used to purge and sample monitoring wells as well as sample impoundments and point discharges. They are also known as helical rotor pumps. The pump design lends itself to use in sampling liquids containing VOCs (**8**), but care should be exercised to limit pump speed to minimize overheating. The output capacity of this pump design is limited.

7.2.8.1 They feature a helical rotor within a stator. In operation, a cavity is formed between the rotor and stator that moves upwards as shown in Fig. 11. This carries the trapped water to the discharge and then to the surface. See Table 11 for advantages and limitations.

7.2.9 *Inertia Lift Pump (see Guide D4448)*—Consists of a rigid or semi-rigid discharge tube with a check valve installed on the lower end (see Fig. 12). They may be used to purge and sample monitoring wells or other bodies of liquid. In use, the assembly is lowered into the liquid at the level desired for sampling. Rapid up/down motion applied to the upper end of the tube forces the liquid up the tube to the surface. They may be used to sample liquids containing VOCs (**9**) but may cause degassing through excessive mechanical disturbance to the water column.

7.2.9.1 Construction materials may be selected to satisfy the needs of the sampling plan. The tubing selected needs to have sufficient rigidity to allow the reciprocating motion to be applied to the check valve submerged in the liquid being sampled. The operation of the sampler may be facilitated with the use of a mechanical reciprocating device, either electrically or engine driven. Care needs to be taken to limit excessive movement to prevent excessive mixing of liquids, thereby increasing degassing and turbidity in collected samples. See Table 12 for advantages and limitations.

7.3 *Dredges (see Guides D4342, D4343, D4387, E1391 and Practice D4348)*—Dredges are used for the collection of submerged sediments and semi-consolidated sludge.

7.3.1 *Ekman*—The Ekman dredge (see Fig. 13) has only limited usefulness in environmental sampling. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms. It is also too light to use in streams with high flow velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

7.3.2 *Petersen*—The Petersen dredge (see Fig. 14) can be used for routine analyses when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches the bottom, because it can displace and miss lighter materials if allowed to drop freely. See Table 13 for advantages and limitations.

7.3.3 *Ponar*—The Ponar dredge (see Fig. 15) is a modification of the Petersen dredge and is generally similar in size and weight. Smaller, lighter versions are also available. It has been modified by the addition of side plates and a screen on top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily