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Selection and Use of Equipment for
the Sampling of Liquids

Michael Johnson

November 1995

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SELECTION AND USE OF EQUIPMENT FOR THE SAMPLING OF LIQUIDS

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November 1995

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ABSTRACT

The selection of sampling equipment for the collection of liquid waste is based on factors such as the viscosity of the sample matrix, matrix compatibility with the construction materials of the sampling device, and the physical location of the sampling point. This report provides information relating to sampling from such matrices as ground and surface waters, vadose zones, containerized liquids, lagoons, and seeps. It is intended to be a reference tool for personnel involved with the collection of liquid samples throughout the Department of Energy complex. This report provides a general overview of many liquid sampling devices used and for each device it provides a short narrative regarding applicability, an outline of the basic procedure for use, a list of advantages and disadvantages, and an illustration.

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I. Introduction

The collection of liquid waste samples requires the use of various types of sampling equipment. The selection of the specific sampling equipment is based on the situations most likely to be encountered in the field. Factors such as sample matrix, physical location of the sampling point and other site specific conditions must also be considered. Consideration must also be given to the compatibility of the liquid being sampled with the composition of the sampling device being used. Appendix A provides the definitions for terms used here, and Appendix B provides the abbreviations and acronyms.

Presented in this document are:

1. the selection criteria for a wide variety of liquid sampling equipment,
2. the application(s) of the liquid sampling equipment, and
3. a description of the proper use of various liquid sampling equipment.

For any given type of liquid sampling operation, not all of the equipment presented here will be applicable in all situations. The choice of a sampling device should be determined on a case-by-case basis.

This document is intended to be a reference tool to personnel involved in the collection of liquid samples. It provides a quick and easy source of information for a variety of liquid sampling devices.

Section II provides a general overview. Section III is a guide to the selection of liquid sampling equipment. Section IV presents summaries of devices used for liquid sample collection and the rationale for their use. It also contains guidance for the use of each device. The information, in this section is divided into four subsections, as stated below:

1. a short narrative on the sampling device,
2. an outline of the basic procedure for use of the sampling device,

3. a list of the advantages and disadvantages of the sampling device, and
4. an illustration of the device.

This document is strictly limited to the selection criteria, descriptions and applications for a variety of sampling equipment. This equipment will be used solely for the collection of liquid samples. The term liquid, for the purposes of this report, is defined as any aqueous fluid containing less than 5% dissolved solid material. When the concentration of solid material in a fluid rises above 5%, the material is termed "sludge".

II. Liquid Sampling Equipment

Obtaining representative samples from liquid matrices can be a difficult process. Density, solubility, local currents and other factors can cause changes in the composition of a liquid with respect to both time and distance. These factors may complicate attempts to take a representative sample of the matrix. The proper selection and use of sampling devices is therefore a critical part and the goal of collecting a representative sample.

This section consists of two parts: selection criteria and applicable matrices. Described selection criteria are the various factors that should be considered when selecting a sampling device. In applicable matrices, the various matrices are described that may be sampled and the appropriate sampling devices are summarized that may be used (see Table 1).

SELECTION CRITERIA

The factors related to the collection of a representative sample are discussed in the next five sections. These include chemical compatibility, equipment design, volume of the device, power requirements and ease of decontamination. Each factor is discussed below.

Chemical Compatibility

Choice of sampling equipment is dependent upon a knowledge of what compounds may be present in the material being sampled and how they may interact with the analytes of interest and the sampling device itself. It is critical that the materials used to construct the sampling device be chemically compatible (inert) with respect to the matrices and analytes of interest. Incompatibility may cause contamination of the sample and/or degradation of the equipment itself.

Equipment Design

Sampling equipment being used in a manner for which it was not designed may result in sample collections that are not representative of the matrix being sampled. Equipment can be biased because the device may include parts of the matrix that were not intended to be sampled or exclude parts of the sample which were intended to be sampled.

For example, when a sample is to be taken at a certain depth, the open sampling device is lowered into position. During this process it is exposed to portions of the liquid that were not intended to be sampled. This may result in non-representative material being included in the collected sample.

Volume of Sampling Device

The volume of a sampling device should be compared to the volume needed for all the required analytes and an additional amount for quality control (QC) samples (e.g., duplicates and matrix spikes). Often several insertions of the sampling device into the matrix will be required to meet the sample volume requirements. This type of repeated insertion into the matrix can alter the matrix and create a situation where the retrieved sample is no longer representative of the matrix from which it came.

Physical Requirements

Physical requirements such as the size, weight and power specifications must be considered when choosing sampling equipment. The distance that sampling equipment needs to be transported should also be considered when choosing equipment for any given sampling event.

Decontamination

Most equipment is reusable and therefore requires decontamination before it is re-used. When choosing equipment for a sampling event, the ease and consequences of repeated cleaning and decontamination should be considered. Incomplete or improper decontamination can cause significant errors in analytical results due to small amounts of material from the previous samples remaining in the device and contaminating the subsequent sample(s).

In some cases, where the matrix is extremely viscous or highly contaminated, the sampling device can not be decontaminated in the field. In these cases the device should be used only once and decontaminated later.

APPLICABLE MATRICES

Ground and Surface Water

Physical parameters such as depth and viscosity of the liquid to be sampled are of primary importance when selecting a sampling device. Even though groundwaters and surface waters can be quite different, sampling of both matrices can be accomplished through the use of the following sampling equipment:

Direct Immersion Bottle	Dipper
Pond Sampler	Weighted Bottle
Kemmerer	Van Dorn
Bacon Bomb Sampler	COLIWASA

Vadose Zones

Vadose zones (also called unsaturated zones) consist of a mixture of soil particles and water. They typically contain water from the humidity of the surrounding air, water trapped via capillary action of the soil and gravitational water (via water drainage through the soil). Vadose zones are sampled with lysimeters.

Water Sampling Using Monitoring and Potable Wells

Wells are not usually considered to be "sampling devices" but they do allow for the collecting of both groundwater and surface water samples from the environment.

Wells must be first purged free of all standing water before any sample is taken. When all the standing water has been removed, the water from the surrounding aquifer fills the well and a representative sample can then be taken. The accepted procedure for purging and subsequent sampling would call for removal of a volume of water equal to three-to-five times the volume of the initial standing water. This ensures that the water

sample is representative of the water present in the surrounding aquifer. Alternatively, the method may call for purging until measurements of pH and/or conductivity have stabilized.

For both monitoring wells or potable wells the sampling equipment includes:

Suction Lift Pumps	Submersible Pumps
Bladder Pumps	Packer Pumps
Air Lift Pumps	Bailers
Bomb Samplers	Kemmerer Samplers
Syringe Sampler	

Containerized Liquids

This term refers to liquid samples that are enclosed within drums, storage tanks (surface or underground), tanker trucks, transformers, etc.

Sampling can be accomplished through the use of the following sampling equipment:

COLIWASA
Open Tube Sampler
Stratified Sample Thief
PACS Grab Sampler

Seeps

A seep is part of the leachate collection system associated with every landfill. A seep is a conduit that allows the leachate to flow from the landfill to the lagoon, the final collection point for these liquids. A seep can be considered any depression, trough or trench that is used to transfer the landfills leachate to an associated lagoon. Sampling of leachate seeps is typically accomplished through the use of the following sampling

equipment:

Direct Immersion Bottle	Sampling Tube
Dipper	Sampling Thief
Wheaton Dip Sampler	PACS Grab Sampler
Bacon Bomb	

Table 1.
Summary of Sampling Devices and Applicable Matrices

	Ground & Surface Water	Vadose Zones	Wells	Containers	Lagoon	Seeps
Bailers			x			
Syringe Sampler			x			
Kemmerer Depth Sampler	x		x			
Bacon Bomb Sampler	x		x		x	x
PACS Grab Sampler				x	x	x
Coliwasa	x			x		
Open Tube Sampler	x			x	x	x
Stratified Sample Thief				x	x	x
Lysimeters		x				
Van Dorn Sampler	x					
Pumps						
Bladder Pump			x			
Suction Lift Pumps			x			
Packer Pump			x			
Submersible Pumps			x			
Airlift Pumps			x			
Direct Immersion Samplers						
Sampler Bottles	x					x
Weighted Bottles	x					
Wheaton Dip Sampler					x	x
Dipper/Pond Sampler	x				x	x

III. Equipment Descriptions for Liquid Sampling

BAILERS

One of the oldest and simplest methods of sampling liquid is the use of bailers. The use of bailers results in a minimum of sample disturbance when carefully handled. Their relatively low cost allows a bailer to be dedicated to a particular sampling site.

Bailers are the method of choice for the collection of samples susceptible to volatile stripping or degradation due to the aeration associated with most other recovery systems. Samples may be recovered with a minimum of aeration if care is taken to gradually lower the bailer until it contacts the water surface and is then allowed to sink as it fills.

Bailers are made of relatively inert material. PTFE (Teflon) is the preferred construction material. Stainless steel with a PTFE check valve is an acceptable alternative. A PTFE coated stainless steel leader and bailer line must be attached to the bailer and must be of sufficient length to enable collection of the sample.

Procedures for Use

- Unwrap the decontaminated bailer and connect to leader/cable for lowering.
- Lower the bailer slowly until it contacts the water surface.
- Allow the bailer to sink and fill with a minimum of surface disturbance.
- In cases of well sampling, do not allow the unit to scrape the sides of the well.
- Raise the bailer to the surface. Avoid contact of the bailer line to the well casing and/or ground.
- Tip the bailer to fill the sample containers. This will allow a slow discharge from the top gently down the side of the sample bottle to minimize turbulence. When applicable, always fill volatile organic sample vials first to zero headspace.

- Repeat the above steps until a sufficient sample volume is obtained.

Advantages

- No external power source is required.
- They are economical and convenient. A separate bailer may be dedicated to each sampling site to minimize cross contamination.
- They can be constructed from a variety of materials compatible with the many potential analytes of interest.
- Low surface area to volume ratio reduces outgassing of volatile organics.
- Simple to use.

Disadvantages

- A limited volume of sample can be collected (usually 200-500 mL maximum).
- They are unable to collect discrete samples from below the water surface.
- They should not be used to evacuate stagnant water.

A TYPICAL BAILER

SYRINGE SAMPLERS

The syringe sampler basically consists of a 15-1500 mL syringe. It has been developed for samples that need to be taken at great depths and/or for use in the sampling of water from wells. The device is not widely used.

Procedures for use

- Lower the unit to the desired sampling depth.
- Pull back the plunger by some remote means, either mechanical or pneumatic, thereby filling the syringe.
- Retrieve sampler.
- Transfer sample into precleaned sample bottles.

Advantages

- This is the best sampling device for sampling great depths (e.g., for depths up to 400 m).
- There is no direct gas-sample contact (for pneumatic units).

Disadvantages

- Not commercially available.
- Expensive.
- Collects small sample volumes.
- Cannot be adapted for well evacuation purposes.
- Particulates may clog the unit.

SYRINGE SAMPLER

KEMMERER DEPTH SAMPLER

The Kemmerer sampler is used to collect liquid waste samples in storage tanks, tank trailers, vacuum tanks, streams, lakes, lagoons, ponds or other situations where depth of collection prevents use of other sampling devices.

This sampling device consists of an open vertical tube with two sealing end pieces or stoppers. These end pieces can be withdrawn from the top and bottom of the tube and set in an open position. They remain in this position until the sampler is at the required sampling depth and then a weighted messenger is sent down the line or cable, releasing the end pieces and trapping the sample within the body.

Procedures for Use

- Mark the guide wire to the predetermined sampling depth.
- Set the sampling device so that the sealing end pieces are pulled away from the sampling tube, allowing the fluid to pass through the tube.
- Lower the open sampling device to the predetermined depth.
- Send down the messenger when the sample is at the required depth, closing the sampling device.
- Retrieve the sampler. Transfer the sample into laboratory precleaned sample bottles by holding the drain valve over the sample container.
- Allow the sample to flow slowly down the side of the sample bottle to minimize the disturbance.

Advantages

- Ability to sample at discrete depths.
- Ability to sample great depths (up to 400 m).

Disadvantages

- The sampling tube is exposed to material while traveling down to specified sampling depth.
- The transfer of the sample into the sample bottle must be done with care because of the possibility of sample aeration.

KEMMERER DEPTH SAMPLER

Bacon Bomb Sampler

The Bacon bomb sampler is a widely used, commercially available sampler, designed for sampling a variety of matrices and analytes. It is very useful for sampling large storage tanks because the internal collection chamber is not exposed to the matrix until the sampler is triggered. The Bacon bomb is also useful when collecting samples at discrete vertical locations.

The Bacon bomb sampler is constructed of brass or stainless steel and is available in several sizes ranging from 5-10 cm in diameter. The sampler ranges in volume from 100 mL up to 1 L. It is equipped with a trigger which is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into or out of the collection chamber.

Procedures for Use

- Lower the Bacon bomb sampler to the desired depth, allowing the line for the trigger to remain slack at all times.
- Pull the trigger line until taut when the desired depth is reached.
- Release the trigger line and pull the device back to the surface.
- Transfer the sample to the laboratory precleaned sample container by pulling on the trigger.

Advantage

- The sampler remains unopened until it reaches the desired sampling depth.

Disadvantages

1. Difficult to decontaminate
2. Due to the construction of the Bacon bomb it is difficult to transfer the sample from the Bacon bomb to a container without aerating the sample.

BACON BOMB

PACS GRAB SAMPLER

The PACS grab sampler can be used to collect water and liquid waste samples from lagoons, seeps, ponds, or containers with restricted access.

The sampler typically consists of a 1000-mL bottle that screws onto the end of a 6-m long handle. The control valve is operated from the top of the handle once the sampler is at the desired depth. For water and liquid waste sampling, the narrow necked model of the sampler is useful.

Procedures for Use

- Assemble this sampler in accordance with the manufacturer's instructions.
- Operate the sampler several times to ensure proper adjustment of the tightness of the cap, etc.
- Submerge the sampler into the liquid to be sampled.
- Open sampler bottle by turning the handle when the desired depth is reached.
- Retrieve the sampler.
- Transfer the sample into precleaned sample bottles.

Advantage

- Allows discrete samples to be taken at a respecified depth.

Disadvantages

- Depth of sampling is limited by the length of the pole.
- Difficult to decontaminate.

PACS GRAB SAMPLER

COLIWASA

COLIWASA is an acronym for Composite Liquid Waste Sampler. The basic device consists of three parts: a tube, a rod and a stopper. The external (sampling) tube encloses a center rod. This center rod has a T-handle at one end and a stopper at the other.

The tube section of a COLIWASA is typically constructed of either plastic or glass. The plastic type consists of a translucent plastic sampling tube. This type of device is used to sample most containerized liquids except liquids that contain ketones, nitrobenzene, dimethylforamide, mesityl oxide and tetrahydrofuran. The glass type of device uses a borosilicate glass plumbing pipe as the sampling tube. The glass type are used to sample all other containerized liquids that cannot be sampled with the plastic COLIWASA except strong alkali and hydrofluoric acid solutions. Both types of COLIWASAs employ PTFE for a stopper rod.

Procedures for Use

- Insert the sampler in the open position into the liquid to be sampled.
- Collect the sample at the desired depth by rotating the handle until one leg of the T is squarely perpendicular against the locking block.
- Withdraw the sampler and transfer the sample(s) into laboratory cleaned sample bottles.

Advantages

- Inexpensive.
- Simplicity of operation.
- Versatile.

Disadvantages

- Problems are encountered with fluids of very high viscosity.
- Many insertions into the liquid being sampled are often required due to limited internal volume.
- A COLIWASA can not sample the bottom of containers due to its design.

COLIWASA

OPEN TUBE SAMPLER (SAMPLING THIEF)

This sampler is basically a hollow glass or rigid plastic (PFTE) tube. It generally is 4 to 5 m in length and generally has an inside diameter of 1 to 3 cm, depending on the viscosity of the liquid to be sampled. The plastic open tube sampler (thief) is used to sample most containerized liquid wastes, except waste that contains ketones, nitrobenzene, dimethylformamide, mesityl oxide or tetrahydrofuran.

Procedures for Use

- Insert the sampler into the material to be sampled to the depth desired.
- Place gloved thumb securely over open end of tube.
- Carefully withdraw the thief.
- Transfer sample into laboratory precleaned sample bottles.

Advantages

- Least expensive sampling device.
- Simplicity of operation.
- Versatile.
- Disposable.

Disadvantage

- Possible contamination from thumb if proper procedure is not followed.

1.

Insert open tube (Thief) sampler
in containerized liquid.

2.

Cover top of sampler with gloved
thumb.

3.

Remove open tube (Thief) sampler
from containerized liquid.

4.

Place open tube sampler over
appropriate sample bottle and remove

OPEN TUBE SAMPLER

OPEN TUBE SAMPLER

STRATIFIED SAMPLE THIEF

The plastic stratified sample thief is used to sample most containerized liquid hazardous waste, except waste that contains ketones, nitrobenzene, dimethylformamide, mesityl oxide, and tetrahydrofuran. It is particularly useful for highly viscous, stratified liquids.

This sampler uses discs and wipers to hold stratified liquids in position while the tube is slipped past them. The wipers keep the inside of the tube from carrying portions of the upper fluid down into other layers.

Procedures for Use

- Insert the sampler into the material to be sampled with the outer sheath raised to the open positions. The attached example is for the sampling of a containerized liquid.
- Slide the outer sheath down over center section when the desired depth is reached.
- Withdraw the sampler and transfer the individual stratified samples into laboratory precleaned sample bottles.

Advantages

- Simplicity of operation.
- Representative sample obtained in viscous, stratified liquids.

Disadvantage

- Plastic is not compatible with certain substances (e.g., liquids that contain ketones, nitrobenzene, dimethyl-formamide, mesityl oxide and tetrahydrofuran)

← A. The sampler with extension rod is placed in the barrel through the pour spout.

B. The outer sheath is raised → to expose the center section.

← C. The outer sheath is slid down the center section, trapping the liquid.

D. The entire sampler is → withdrawn from the drum with a representative sample enclosed.

STRATIFIED SAMPLE THIEF

STRATIFIED SAMPLE THIEF-CLOSE-UP VIEW-

VAN DORN SAMPLER

The Van Dorn sampler is used to collect liquid waste samples in storage tanks, tank trailers, vacuum tanks, streams, lakes, ponds or other situations where site conditions or collection depths prevent the use of other sampling devices.

This sampling device consists of an horizontal tube with two sealing end pieces. These end pieces can be withdrawn from the ends of the tube and initially set in an open position. The end pieces remain in this position until the sampler is at the required sampling depth and then a weighted messenger is sent down the line or cable, releasing the end pieces and trapping the sample within the tube.

The sampler described above would normally be operated from a boat launched onto the lake, pond, lagoon or surface impoundment. The horizontal configuration of the unit makes it best suited for sampling at discrete depths.

Procedures for Use

- Set the sampling device so that the sealing end pieces are pulled away from the sampling tube, allowing the substance to pass through the tube.
- Lower the preset sampling device to the predetermined depth.
- When the sample is at the required depth, send down the messenger, closing the sampling device.
- Retrieve the sampler.
- Transfer the sample into laboratory precleaned sample bottles.

Advantages

- Ability to sample at discrete depths.
- Ability to sample great depths (up to 400 m).

Disadvantages

- Sampling tube is exposed to material while traveling down.
- Transfer of sample into sample bottle may be difficult.

VAN DORN SAMPLER

PUMPS

BLADDER

A bladder pump is typically used for sampling water from wells. It consists of a PTFE or stainless-steel housing that encloses a flexible membrane. Below the bladder, a screen is attached to filter any material that may clog the check valves that are located above and below the bladder.

The pump works as follows. Water enters through a membrane and through the lower check valve. Compressed gas is then injected into the cavity between the housing and the bladder. The water then moves through the upper check valve and into the discharge line. This check valve prevents back flow into the bladder. The bladder pump is utilized much like the portable submersible pump, except that no electrical lines are lowered down the body of water to be sampled. The source of gas for the bladder is either bottled gas or an on-site air compressor.

Procedures for Use

- Check all fittings for tightness.
- Lower the decontaminated pump and dedicated tubing into the liquid to be sampled until the entire unit is below the surface level.
- Connect the compressor to the power source.
- If a gas powered generator is being used, make sure the power source is downwind to prevent fumes from entering the sampling area. If a compressor is not used, connect the tubing to the external air source.
- Engage the air source (compressor or external). The full liquid flow will begin after 5 to 15 pumping cycles.
- Reduce the flow rate by adjusting the throttle control when sampling volatile and semi-volatile organics.
- Adjust the refill and discharge cycles to optimize pumping the efficiency. This can be performed by the following processes:

- Adjust the refill and discharge cycles to 10-15 sec for each.
- Measure the water volume discharged in a single cycle.
- Shorten the discharge cycle time until the end of the discharge cycle begins to coincide with the end of the water flow from the pump outlet.
- Shorten the refill cycle period until the water volume from the discharge cycle decreases 10-25% from the maximum value measured in the first step.

Advantages

- Simple design and operation.
- In-line filtration possible.
- Portable.

Disadvantages

- Large gas volumes needed.
- Potential for bladder rupture.
- Difficulty in cleaning the unit.
- Possible loss of volatiles due to pressure gradients.
- Low volume delivered (10-12 L min⁻¹).
- Noncontinuous sample flow.

BLADDER PUMP

SUCTION LIFT

Peristaltic

A peristaltic pump is a self-priming suction lift pump utilized at the surface. It consists of a rotor with ball bearing rollers. One end of PTFE tubing is inserted into the liquid to be sampled. The other end is attached to a flexible PTFE tube which has been threaded around the rotor, out of the pump, and connected to a discharge tube of PTFE. The liquid moves totally within the sample tube, and no part of the pump contacts the liquid.

If this type of pump is being used for well evacuation, the same length of PTFE tubing that was used for well evacuation may also be used for sample collection. If another approved material was used for well excavation, a new dedicated length of PTFE tubing may be required for sample collection. The tubing should be equipped with a foot valve to avoid having aerated water from the pump and the tubing falling back into the well.

Procedures for Use

- Make sure that the well has been properly evacuated and recharged before any sampling begins (if sampling from a well).
- Check tubing at rotor for cracks or leaks, replace if necessary.
- Insert dedicated length of PTFE tubing in the liquid to be sampled and attach it to a flexible length of PTFE tubing through the pumps rotor.
- Engage pump, commence evacuation (if sampling from a well) and then collect the sample.
- Transfer the sample into precleaned sample bottles.

Advantages

- Small diameter wells can be sampled.
- Sample does not contact the pump or any other sampling equipment prior to collection.
- Ease of operation.
- Speed of operation.
- Readily available.
- No decontamination of pump necessary.

Disadvantages

- Low pump rates.
- Sample depth limited to 10 m.
- Potential for loss of volatile fraction due to pressure gradient.
- Electric power required.

Centrifugal

A centrifugal pump is a nonself-priming suction lift pump that contains a rotating impeller mounted on a shaft turned by a power source. The rotation of the impeller increases the velocity of the liquid being sampled and discharges it into a surrounding casing. The shape of the casing converts the velocity into pressure. Each impeller/casing arrangement is called a stage. A multi-stage pump would be used when more pressure than a single stage pump can generate is needed.

Procedure for use

- Attach one end of PTFE tubing into the liquid being sampled.
- The tube is then routed around the rotor, out of the pump, and connected to a

discharge tube.

- Avoid having aerated liquid from the pump flowing back into the liquid being sampled by equipping the tubing with a foot valve.
- Engage the pump and collect the required sample into precleaned sample bottles.

Advantages

- Easy to clean.
- Fairly inexpensive.
- Allows for "in-line" filtration.

Disadvantages

- Sample depth is limited to 25 m.
- Possibility for the loss of volatile fraction due to pressure gradient.
- Electric power required.
- Pump needs to be primed.

PRESSURE PUMP

SUCTION LIFT PUMP

Packer

Packer pumps are used to isolate portions of a well for sampling or other purposes. These pumps consist of two expandable parts that isolate a sampling unit between them. They deflate for vertical movement within the well and inflate when the desired depth is reached. The packers are constructed of rubber and may be used with submersible, gas lift or suction pumps.

Procedure for Use

- Lower the deflated packer pump into the well to a predetermined depth.
- Inflate the "packer" (or bladder) section of the device according to manufacturer specifications using compressed air. At this point, the well has been segregated and is ready to be sampled.
- Collect the samples as given in the site's sampling and analysis plans (SAP).

Advantages

- Isolates portions of a well for sampling at discrete depths.
- Decreases the volume necessary for evacuation of well when more than one aquifer is encountered.

Disadvantages

- Must have knowledge about the contaminants and characteristics of the well to be sampled.
- The packers constructed of rubber may deteriorate with time and undesirable organics may enter the water sample or contaminate the well.

STRADDLE PACKER TYPE PUMP

SUBMERSIBLE

Some sampling events may require the collection of liquid samples from depths that exceed the limits of conventional sampling equipment. When these types of samples need to be taken, typically from monitoring or potable water wells, submersible pumps are routinely employed. Types of submersible pumps include bladder, piston, gear driven, squeeze, centrifugal, and helical rotor.

Helical Rotor

The helical rotor pumps employ an electric motor to turn a helical stainless steel rotor against a semi-flexible stator. The sample contacts only the stator and the stainless steel and Teflon surfaces of the pump.

Procedure for use

Due to the great variation from pump to pump no generic procedure can be given. Refer to the instruction manual for specific instructions.

Advantages

- Ability to take a continuous sample.
- Ease of use.
- High pump rates.
- Easy to clean.
- No priming needed.

Disadvantages

- External power required.
- Maximum depth of 50-150 m.
- Expensive.
- Liquids with high suspended solids or of high turbidity can cause operational problems for inexperienced operators.
- Turbulence may cause alteration of the sample.

SUBMERSIBLE PUMP

Adapted Centrifugal

The adapted centrifugal pump works the same as the suction-lift centrifugal pump except that both the pump and electric motor are lowered into the liquid to be sampled. As the impeller rotates, liquid is brought into the pump, displaced through the transfer line and out into the sample collection vessel (bottle).

Procedure for use

Due to the great variation from pump to pump, no generic procedure can be given. Refer to the instruction manual for specific instructions.

Advantage

- Large flow capability.

Disadvantages

- Materials of construction may be incompatible with liquid being sampled.
- Lubricants may be incompatible with liquid being sampled.

Piston

Piston pumps are typically considered "submersible" units. The three main types are: (1) mechanically driven-cable piston, (2) electrically driven-vibrating membrane, and (3) gas-driven piston pumps.

Of the three pump types listed, the gas-driven piston pump is by far the most widely used and will be the only one explained in detail. These pumps consist of a

submerged piston operated by a rod connected to the drive mechanism located at the surface. A check-valve is located just above (or below) the piston cylinder. As the piston is lowered in the cylinder, the check valve opens, and liquid fills the chamber. On the up-stroke, the check valve closes, and water is forced out of the cylinder and out through the transmission line. The transmission line also has a check valve that prevents liquid from re-entering the cylinder.

A special adaptation of the gas-driven piston pump uses compressed gas, rather than a rod connected to a driving mechanism. This system provides a more convenient and portable unit that can be made of materials compatible with most liquids that are sampled.

Procedure for use

Due to the great variation from pump to pump no generic procedure can be given. Refer to the instruction manual for specific instructions.

Advantages

- Easy to clean.
- Minimal sample alteration.
- Up to 175 m for maximum sampling depth.
- High pumping capacity.

Disadvantages

- Requires a portable compressor.
- Hard to use and move.
- Materials of construction may be incompatible with the liquid being sampled.
- Expensive.

Gear Driven

A gear driven submersible pump has a set of closely meshing Teflon gears. As the gears turn, driven by an electric motor, they form a type of paddle arrangement that pushes the water out the discharge tube. The close tolerance of the Teflon gears prevents possible backwash. The sample touches only the stainless steel pump body, the Teflon gears and the discharge tubing.

Procedure for use

Due to the great variation from pump to pump no generic procedure can be given. Refer to the instruction manual for specific instructions.

Advantages

- Minimal sample alteration.
- Easy to clean.

Disadvantage

- Limit of 50 m for maximum sampling depth.

Squeeze Pumps

Squeeze pumps consist of a collapsible membrane inside a long, rigid housing along with a compressed gas supply and appropriate control valves.

Procedure for Use

- Lower the unit into the liquid to be sampled. The lower check valve allows liquid to enter.
- Apply gas pressure, after the lower check valve is filled to the space between the housing and membrane, forcing the liquid upwards through the sampling tube.
- When the pressure is released, the top check valve prevents the liquid from flowing back down the discharge tube and more liquid enters the pump via the lower check valve.

Advantages

- Can be made in various sizes.
- Can be made of inert materials.
- Portable.
- Easy to use.

Disadvantages

- Large gas volumes required.
- Expensive.

THREE TYPES OF SUBMERSIBLE SQUEEZE PUMPS

GAS OPERATED SQUEEZE PUMP

Airlift

Airlift pumps are typically used to take samples from monitoring or potable water wells. They are not widely used because of their limitations. They should not be used with any type of squeeze pump and must be used at a depth less than the depth of any sensors (i.e., dissolved oxygen probe) that have been placed in the well.

Airlift pumps blow compressed air through a hose, or pipe, that may be open at the bottom or that is equipped with a special pump head. The pumps are then lowered into the water column formed by the well casing, or sampling tube. The injected air bubbles disperse into the water and this air-water mixture is less dense than the surrounding water thus causing it to rise in the well, or sampling tube, up to the surface where it can be sampled.

Procedure for use

Due to the great variation from pump to pump no generic procedure can be given. Refer to the instruction manual for specific instructions.

Advantages

- Good for removing stagnant water from wells.
- Portable.

Disadvantages

- Injection of any gas will greatly alter the sample.
- Not useable for the sampling of matrices that are going to be analyzed for volatile organic analytes (VOAs).
- Not useable for the sampling of matrices that are going to be analyzed for pH sensitive parameters.

AIR LIFT PUMPS

DIRECT IMMERSION SAMPLERS

Direct Immersion Sample Bottle

The most widely used method for collection of surface water samples is simple immersion of the laboratory cleaned sample bottle. Using the sample bottle for actual sampling eliminates the need for other equipment. This method also reduces the risk of introducing other variables into a sampling event.

Procedures for Use

- Make sure bottles have a good fitting lid.
- Proceed to immerse bottle into surface water and allow water to run slowly into bottle until full
- Collect samples for volatile organics analysis first to prevent loss of volatiles due to disturbance of the water and always fill vials to zero headspace.

Advantages

- Easy operation.
- No field cleaning necessary.
- No other equipment needed.
- Can be used to sample tap water.

Disadvantages

- Outside of bottle comes in contact with sample.
- Labeling may not be possible if the outside of the bottle is wet.

Weighted Bottle

The weighted bottle sampler can be used to sample liquids in storage tanks, wells, sumps, or other reservoirs that cannot be adequately sampled with another device.

This sampler consists of a bottle, usually glass, a weight sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. There are a few variations of this sampler. However, the sampler recommended in ASTM procedures, which uses a metallic bottle basket that also serves as the weight sinker, is preferred. The weighted bottle sampler can either be fabricated or purchased.

Procedures for Use

- Assemble the weighted bottle sampler.
- Lower the sampling device to the predetermined depth.
- Allow the bottle to fill completely. (This is usually evidenced by the cessation of air bubbles.)
- Retrieve sampler.
- Transfer sample into laboratory precleaned sample bottles.

Advantage

- Sampler remains unopened until at desired sampling depth.
- Sampling depth is limited only by the length of the line.

Disadvantages

- The laboratory supplied collection bottle may not fit into the weighted sinker part of the system.

DIRECT IMMERSION SAMPLE BOTTLE

WEIGHTED SAMPLE BOTTLE

1000 ml (1 quart)
weighted bottle sampler

Wheaton Dip Sampler

The Wheaton dip sampler is useful for sampling liquids in shallow areas, such as streams, lagoons or seeps.

The device consists of a glass bottle mounted on a metal pole. Attached to the bottle screw cap is a suction cup mounted on another metal pole. When the sampler is lowered to the desired sampling depth, the bottle cap is released by lifting this metal pole attached to the suction cup. When the bottle is full (usually evidenced by the cessation of air bubbles), the cap is screwed back on to seal the sampling container and retrieved.

Procedures for Use

- Assemble the sampler in accordance with the manufacturer's instructions.
- Operate the sampler several times to ensure proper adjustment, tightness of the cap, etc.
- Submerge the sampling unit into liquid to be sampled.
- When desired depth is reached, open sampling unit.
- Allow the sample bottle to fill.
- Retrieve sampling unit.
- Transfer sample into laboratory precleaned sample bottles.

Advantages

- Sample bottle is not opened until the specified sampling depth is obtained.
- Sampler can be closed after sample is taken ensuring sample integrity.
- Ease of operation.

Disadvantages

- Depth of sampling is limited by the length of the poles. Typically depths of 6-8 m can be reached.
- Exterior of sampling unit may come in contact with contamination.
- Apparatus may require additional equipment for sample transfers.
- Labeling may not be possible if the outside of the bottle is wet.

WHEATON DIP SAMPLER

Dipper/Pond Sampler

The pond sampler is used to collect liquid waste samples from disposal ponds, pits, lagoons, and similar reservoirs.

The pond sampler consists of an adjustable clamp attached to the end of a two or three piece telescoping aluminum tube that serves as the handle. The clamp is used to secure a sampling beaker. The sampler is commercially available or easily fabricated. The tubes can be readily purchased from most hardware or swimming pool supply stores. The adjustable clamp and sampling beaker can be obtained from most laboratory supply houses. The materials required to fabricate the sampler are shown in the example figure.

Procedures for Use

- Check that the beaker or sample bottle and the bolts and nuts that secure the clamp to the pole are tightened properly.
- Using proper protective garment and gear. Take grab samples by slowly submerging the beaker.
- Retrieve the pond sampler from the surface water with minimal disturbance.
- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/device edge.
- Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence. When applicable, always fill volatile organic analyte (VOA) vials first and fill to zero headspace.
- Repeat above steps until sufficient sample volume is acquired.

Advantage

- Can sample depths at distances up to 3.5 m.

Disadvantages

- Difficult to obtain representative samples in stratified liquids.
- Difficult to decontaminate when viscous liquids are encountered.

BASIC PARTS OF A DIPPER OR POND SAMPLER

Reference Materials¹

NJDEP:

Field Manual for Water Data Acquisition, third edition , 1987.

USEPA:

A Compendium of Superfund Field Operations Methods

EPA/540/P-87-001, 1987.

Emergency Response Team, Standard Operating Procedures,

EPA/540/P-91-006, 1991.

Emergency Response Team, Standard Operating Procedures

Number	Title
2001	General Field Sampling Guidelines
2005	QA/QC Samples
2006	Equipment Decontamination
2007	Groundwater Well Sampling
2013	Surface Water Sampling
2150	Monitor Well Installation

ASTM Standards:

D4448-85:

Guide for Sampling Groundwater Monitoring Wells

D4696-92:

Guide for Pore-Liquid Sampling in the Vadose Zone

D5088:

Practice for the Decontamination of Field Equipment at Non-Radioactive Waste Sites

¹Supporting information was obtained from these documents.

D5283-92:

Practice for the Generation of Environmental Data Related to Waste Management
Activities: QA/QC Planning and Implementation

D5358:

Practice for the Use of a Dipper or Pond Sampler

APPENDIX A

Definitions

Aquifers: Aquifers are subterranean bodies of water. They can be either: (1) confined or (2) unconfined. [Note: Unconfined aquifers are also referred to as the "water table".] When the groundwater is retained above impermeable bedrock and has an upper boundary that is permeable (i.e. soil), it is then called an unconfined aquifer. When the groundwater is retained above impermeable bedrock and has an overlying layer of impermeable material (i.e., rock) it can then be called a confined aquifer (see Groundwater).

Groundwater: Water that drains downward, through the soil, and is retained below the surface and above some type of impermeable bedrock formation is called ground water. Groundwater is always associated with some type of aquifer.

Potable Water: Water that is suitable for human consumption. It can be from either a groundwater source or a surface source.

Seeps: Any pit, depression, tank, and its associated troughs/trenches that are used as a collection point for waste liquids to be sampled, or transported to a waste storage, waste treatment or waste disposal facilities.

Surface Waters: Surface water is any water from lakes, ponds, swamps, marshes, streams, rivers, lagoons, surface impoundments, and leachate seeps.

Vadose Zones: Vandose zones (or zones of unsaturation) begin at the ground surface and extend downwards. Its total depth is variable and depends on the exact soil type and vegetation present. The vandose zone may contain: (1) water from the surrounding air, (2) water trapped via capillary action of the soil (water held by surface tension onto the soil particles), and (3) gravitational water (via water drainage through the soil).

Wells: The two basic types of wells can be defined as either: (1) artisan or (2) non-artisan. Artisan wells are those that penetrate aquifers in which groundwater is found under hydrostatic pressure. This condition occurs when the intake area of the artisan well is located above a confined aquifer. In these situations, the water level in the well stands above the water level in the aquifer.

Nonartisan wells are those that penetrate aquifers in which the groundwater is found under water table (nonpressurized) conditions. Pumping from a nonartisan well lowers the water table in the vicinity of the well and water moves toward the well under the pressure differences created.

APPENDIX B

ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Composition and Liability Act
COLIWASA	Composite Liquid Waste Sampler
DMF	Dimethylformamide
DQO's	Data Quality Objectives
ES&H	Environmental Safety and Health
GLP	Good Laboratory Practice
HF	Hydrofluoric Acid
H&S	Health and Safety
NIST	National Institute of Standards and Technology
PE	Performance Evaluation
PTFE	Polyfluorotrifluorotrifluorethylene
QA	Quality Assurance
QAPP	Quality Assurance Project Plans
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedures
SOW	Statement of Work
TDS	Total Dissolved Solids
THF	Tetrahydrofuran
UST	Underground Storage Tank
VOA	Volatile Organic Analyte

EML

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