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A Guide to the Proper Selection and Use of Federally Approved Sediment and Water-Quality Samplers

Open-File Report 2005-1087

U.S. Department of the Interior
U.S. Geological Survey

A Guide to the Proper Selection and Use of Federally Approved Sediment and Water-Quality Samplers

By Broderick E. Davis and the Federal Interagency Sedimentation Project

Sponsored by: U.S.D.A. Agricultural Research Service, U.S. Army Corps of Engineers, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Environmental Protection Agency, U.S.D.A. Forest Service, U.S. Geological Survey

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U.S. Department of the Interior
U.S. Geological Survey

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U.S. Geological Survey, Reston, Virginia: 2005

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Suggested citation:
Davis, B.E., 2005, A Guide to the Proper Selection and Use of Federally Approved Sediment and Water-Quality Samplers: Vicksburg, MS, U.S. Geological Survey, Open File Report 2005-1087, 20 p.

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ABBREVIATIONS

in ..... inch
ft ..... feet
lbs ..... pounds
ft/sec ..... feet per second
in^2 ..... square inches
in^3 ..... cubic inches
mm ..... millimeter
cm ..... centimeter
cm^3 ..... cubic centimeters
ml ..... milliliter
TFE ..... tetrafluoroethylene
PFA ..... perfluoroalkoxy
FEP ..... fluorinated ethylenee propylene

FACTORS FOR CONVERTING INCH/POUND UNITS TO SI METRIC UNITS

Multiply	By	To Obtain
Inch (in)	2.54	centimeter (cm)
pint, liquid (pt)	0.4732	Liter (L)
quart, liquid (qt)	0.9464	Liter (L)
gallon (gal)	3.785	Liter (L)
pound, avoirdupois	0.4545	kilogram (kg)
feet per second (ft/sec)	0.3048	meter per second (m/sec)
ºF	5/9(ºF - 32)	ºC

The use of brand names in this report is for identification purposes only and does not imply endorsement by the United States Government.

Superscripted number refer to references listed at the end of the report.

Introduction

The Federal Interagency Sedimentation Project (FISP) was created in 1939 to unify and standardize the research and development activities of Federal agencies involved in fluvial sediment studies[1,2]. Research and development conducted by the FISP originally focused on hydraulic and mechanical aspects of sediment sampling. The mission of the FISP has expanded to provide, identify, and evaluate tools and techniques for accurate, standardized, calibrated, cost-efficient, and safe measurement and analysis of sediment properties and transport. FISP activities focus on measurement and analysis of suspended sediment, bedload sediment, bed material, bed topography, adsorbed constituents, sediment characteristics, and water quality. Sponsoring agencies and the public gain a distinct advantage from the cooperative action that leads to common standards, methods, equipment, and procedures for the measurement and characterization of sediment.

As interest in the health of rivers and streams increases[3], and new water-quality regulations[4] are promulgated, interest in sediment and water-quality sampling equipment and technologies has increased. While much information on the subject exists, a comprehensive summary document of sediment sampling equipment and technology is lacking. This report seeks to provide such a summary.

Purpose

The purpose of this report is to provide (1) a general understanding of sediment sampling equipment and technology, (2) guidance for the selection of the appropriate equipment, and (3) an introduction to new FISP approved sampling equipment.

Explanation of Terms

Sediment that may be sampled using FISP approved equipment is divided into three categories depending on its location in the stream.

1. Suspended sediment is sediment that is carried in suspension in the flow of a stream for appreciable lengths of time, being kept in this state by the upward components of flow turbulence or by Brownian motion[5].
2. Bedload is defined as that part of the sedimentary load of the stream which is moving in almost continuous contact with the stream bed, being rolled or pushed along the bottom by the tractive force of the moving water[6]. The mechanisms by which it moves can be varied and complex.
3. Bed material is sediment in the streambed that is at rest, but may re-suspend and move as coarse suspended sediment or move as bedload.

FISP nomenclature for sediment sampling equipment denotes the series, type, and year development started. The following explains FISP nomenclature:

- US: United States series
- D: Depth integrating
- P: Point integrating
- H: Hand held or hand line
- 00 (numeric): Year development started
- BL: Bedload
- BM: Bed material
- SA: Sediment analyzer

For example, the US DH-48 is a hand-held depth-integrating suspended-sediment sampler in which development started in 1948. The US BL-84 is a bedload sampler that was developed starting in 1984. The US DH-2 is a hand-held depth-integrating suspended-sediment/water-quality sampler that was developed starting in 2002. If there is no “H” in the sampler designation, it is deployed with a suspension system.

FISP suspended-sediment sampling equipment is designed and calibrated to sample isokinetically. An isokinetic sampler collects a water-sediment sample from the stream at a rate such that the velocity in the intake nozzle is equal to the incident stream velocity at the nozzle entrance. The water-sediment sample collected is proportional to the instantaneous stream velocity at the locus of the intake nozzle and, therefore, is representative of the sediment load at that point. Most FISP approved suspended-sediment samplers collect an isokinetic sample at minimum stream velocities of 1.5 to 2.0 ft/sec stream velocity. At velocities less than 1.5 ft/sec, samplers that use rigid containers have a slight static head between the air exhaust and the nozzle so that the sampler will still collect a sample. The user must understand that the sample collected under these conditions is not an isokinetic sample. All depth-integrating samplers designed after 1980 can serve the dual purpose of suspended-sediment and water-quality sampling.

Isokinetic suspended-sediment samplers are divided into two categories according to how they sample: depth-integrating and point-integrating. A depth-integrating

sampler fills as it is lowered and raised through the water column. Depth-integrating samplers are further divided into two general categories, those that use a rigid bottle for sample collection and those that use a collapsible bag. A sampler using a rigid bottle container is limited to stream depths of 15 ft or less. A collapsible bag sampler is limited in depth according to the volume of the bag and the size of the nozzle.

A point-integrating suspended-sediment sampler has a remotely operated valve for starting and stopping the collection of a sample. The sampler is lowered to the desired depth in the water column, the sample is collected by remotely opening and closing the valve, and then the sampler is raised to the surface for removal of the sample container. To eliminate sudden inrush at the selected sampling point, the diving bell principle is used to balance the air pressure in the bottle with the hydrostatic pressure at the nozzle. The "diving bell" in the sampler is the body cavity behind and surrounding the sample container. It is connected by ports through the valve system to the surrounding stream and to the sample bottle.

Water-quality samplers are suspended-sediment samplers that are specially coated and use non-contaminating material in parts that come in contact with the sample. All FISP approved water-quality samplers can be used as suspended-sediment samplers, but not all FISP approved suspended-sediment samplers can be used for water-quality sampling. FISP approved water-quality samplers meet protocol for water-quality sampling as outlined the USGS's National Field Manual for the Collection of Water-Quality Data[7]. Samplers that serve the dual purpose of suspended-sediment and water-quality sampling are italicized in the table on page 8.

Selecting a Sampler

Four flow-charts (figures1-4) are provided to guide the user through the selection process for determining the applicable piece of equipment based on the type of sampling to be done. The categories for type of sampling are: "Suspended-Sediment Sampling", "Water-Quality Sampling, "Bed Material Sampling", and "Bedload Sampling." The flow-charts guide the user to appropriate FISP approved sampling equipment. The rest of this publication provides a detailed description of each sampler along with references for further information.

The flow-chart decision process is primarily based on stream depth and whether a piece of equipment can be deployed by hand or requires a cable and reel system. The table provides a general description of the suspended-sediment/water-quality samplers with minimum and maximum operating velocities. For each piece of equipment in the flow-chart, a reference is provided to a page in the report that contains a detailed description, operating parameters, and limitations of the equipment.

The selection of a sampler should be based upon the most extreme conditions (depth and velocity) under which the samples are likely to be collected. As an example, suppose a user needs to take a depth-integrated suspended-sediment sample in a stream 10 ft deep at bank-full that is not accessible with a cable and reel system. To select the appropriate sampler, the user would choose the flow chart "Suspended-Sediment Sampling" (figure 1). From this chart the user would choose "Depth Integrating" and then the appropriate depth, in this case, "Depths to 15 ft". Under "Depths to 15 ft" the user would have two choices, "Hand Line" or "Reel". Because the site is not accessible with a cable and reel, the user would choose "Hand Line". Under "Hand Line" the user would have the choice of three samplers, the US DH-59, US DH-76, or US DH-95. The user would refer to the table and the description of the samplers to determine which of the three best fit the maximum expected stream velocity.

FISP equipment is available to any Federal agency directly from USGS's Hydrologic Instrumentation Facility (HIF). FISP equipment is also available to others through five authorized commercial distributors. For pricing and ordering information visit the FISP web site at *http://fisp.wes.army.mil* or contact HIF directly at (800) 382-0634. Reports and operating instructions for FISP equipment are available either on the FISP web site or from the FISP.

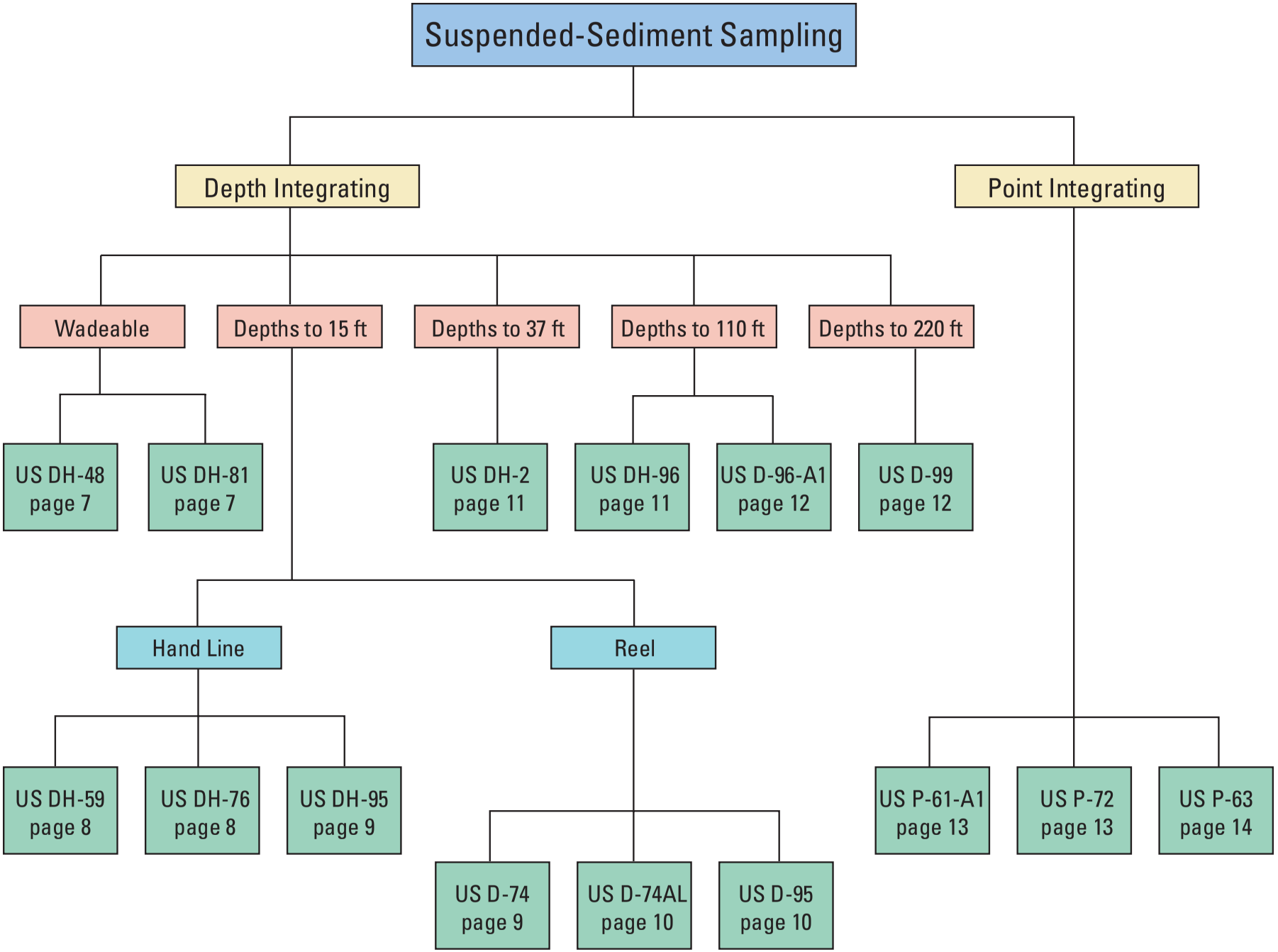


Figure 1. Flow chart for the selection of suspended-sediment sampling equipment.

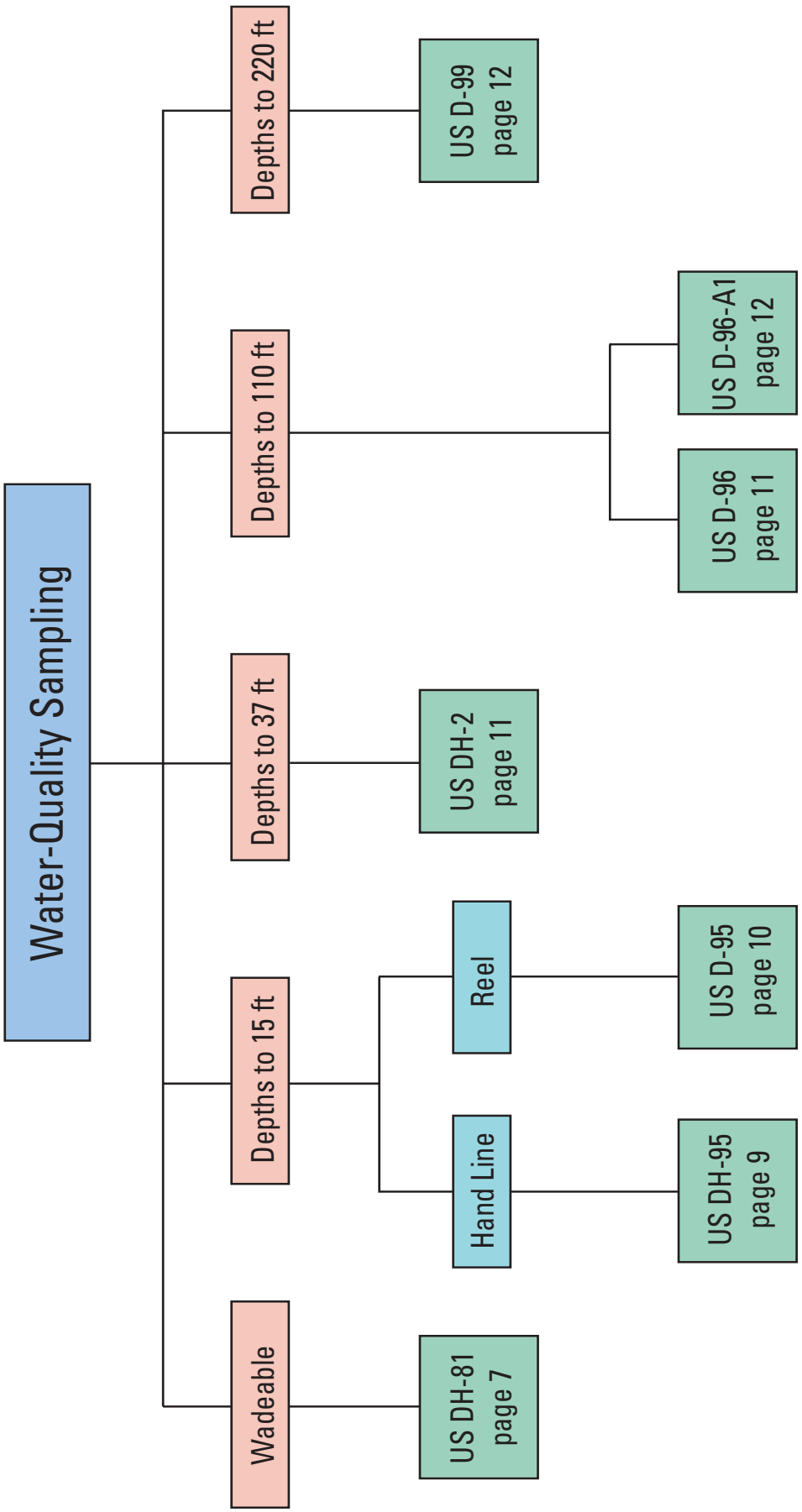


Figure 2. Flow chart for the selection of water-quality sampling equipment.

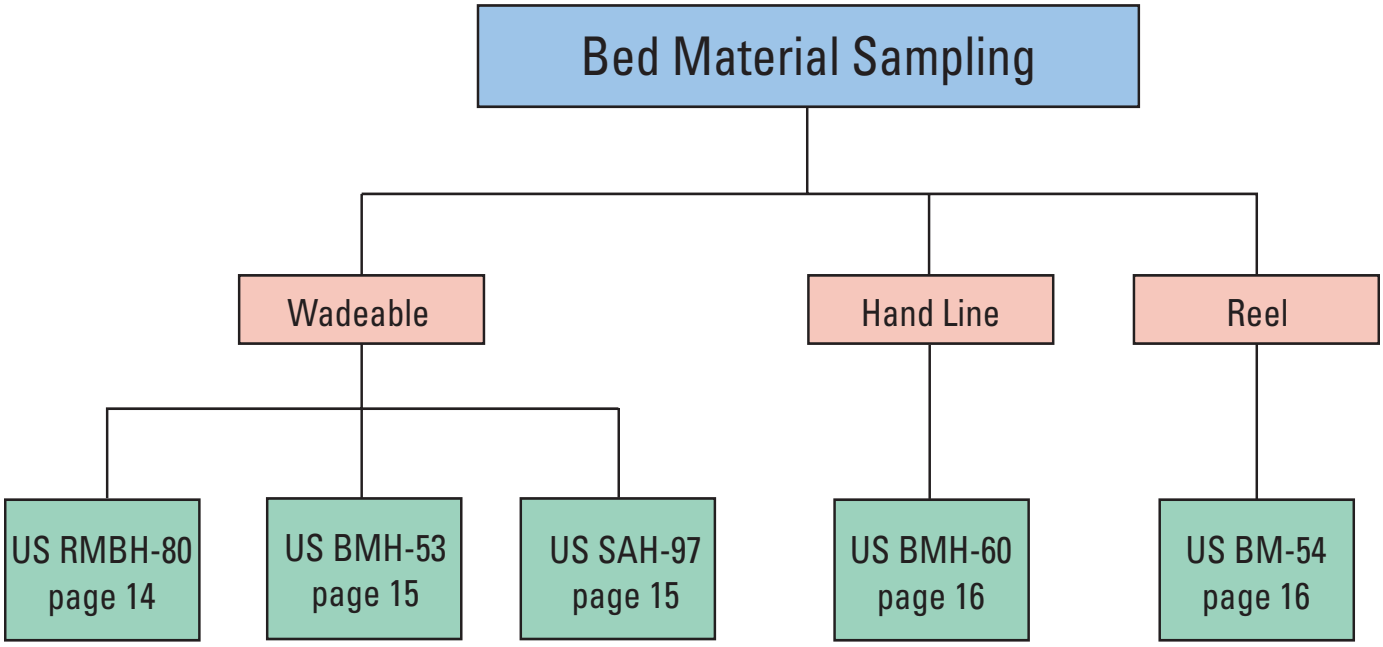


Figure 3. Flow chart for the selection of bed material sampling equipment.

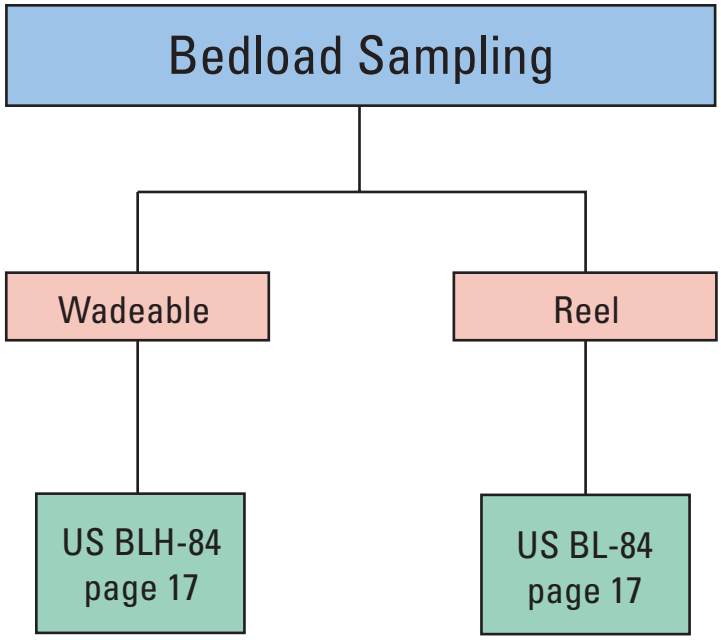


Figure 4. Flow chart for the selection of bedload sampling equipment.

Table—Suspended-sediment sampler characteristics and operating parameters.

Sampler Designation	Nozzle ID (in)	Container Size	Maximum Depth (ft)	Minimum Velocity (ft/sec)	Maximum Velocity (ft/sec)	Unsampled Zone (in)	Weight (lbs)
US DH-48	1/4	pint	9	1.5	8.9	3.5	4
US DH-59	3/16	pint	15	1.5	5.0	4.5	22
US DH-59	1/4	pint	9	1.5	5.0	4.5	22
US DH-76	3/16, 1/4	quart	15	1.5	6.6	3.2	25
US DH-81	3/16	liter	9	2.0	6.2	4.0	1
US DH-81	1/4	liter	9	1.5	7.6	4.0	1
US DH-81	5/16	liter	9	2.0	7.0	4.0	1
US DH-95	3/16	liter	15	2.1	6.2	4.8	29
US DH-95	1/4	liter	15	1.7	7.0	4.8	29
US DH-95	5/16	liter	15	2.1	7.4	4.8	29
US DH-2	3/16	liter	35	2.0	6.0	3.5	30
US DH-2	1/4	liter	20	2.0	6.0	3.5	30
US DH-2	5/16	liter	13	2.0	6.0	3.5	30
US D-74	3/16	pint/quart	15	1.5	6.6	4.1	62
US D-74	1/4	pint/quart	9(pt) 15(qt)	1.5	6.6	4.1	62
US D-74AL	3/16	pint/quart	15	1.5	5.9	4.1	42
US D-74AL	1/4	pint/quart	9(pt) 15(qt)	1.5	5.9	4.1	42
US D-95	3/16	liter	15	1.7	6.2	4.8	64
US D-95	1/4	liter	15	2.0	6.7	4.8	64
US D-95	5/16	liter	15	2.0	6.7	4.8	64
US D-96	3/16	3 liters	110	2.0	12.5	4.0	132
US D-96	1/4	3 liters	60	2.0	12.5	4.0	132
US D-96	5/16	3 liters	39	2.0	12.5	4.0	132
US D-96A1	3/16	3 liters	110	2.0	6.0	4.0	80
US D-96A1	1/4	3 liters	60	2.0	6.0	4.0	80
US D-96A1	5/16	3 liters	39	2.0	6.0	4.0	80
US D-99	3/16	6 liters	220	3.5	15.0	9.5	275
US D-99	1/4	6 liters	120	3.0	15.0	9.5	275
US D-99	5/16	6 liters	78	3.0	15.0	9.5	275
US P-61A1	3/16	pint/quart	180(pt) 120(qt)	1.5	10.0	4.3	105
US P-63	3/16	pint/quart	180(pt) 120(qt)	1.5	15.0	5.9	200
US P-72	3/16	pint/quart	72(pt) 51(qt)	1.5	5.3	4.3	41

Note: Italicized samplers serve the dual purpose of suspended-sediment and water-quality sampling and meet the protocols for water-quality sampling as outlined in the USGS National Field Manual for the Collection of Water-Quality Data[7]

US DH-48

The US DH-48[8] is a lightweight hand-held depth-integrating sampler used for the collection of suspended-sediment samples in wadeable streams. The US DH-48 was one of the first samplers designed by FISP. Like all FISP suspended-sediment samplers, it is designed to sample isokinetically, meaning that water and sediment enters the nozzle at the same velocity as the stream being sampled in order to collect a representative sample.

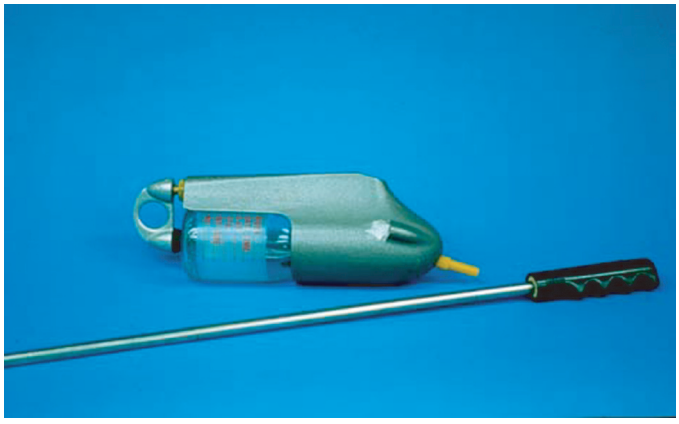
The sampler is made of aluminum, weighs 3.5 lbs. and is approximately 10 in long. A pint milk bottle is used as the sample container. The pint milk bottle container is held in place and sealed against a rubber gasket by a hand operated, spring tensioned clamp at the rear of the sampler. A brass 1/4-in internal diameter intake nozzle extends horizontally from the nose of the sampler body. A streamlined projection on the side of the sampler that points toward the rear of the sampler accommodates the air exhaust port that allows air to escape from the sample bottle as it fills with sample.

A standard 1/2-in diameter wading rod is threaded into the top of the sampler body for suspending the sampler. To sample to depths greater than can be waded, wading rod extensions in 1- and 3-ft lengths can be added to the sampler. With the extensions, the sampler can be deployed from a low bridge or boat. The unsampled zone using the US DH-48 is 3.5 in. The sampler can be used in velocities that range from 1.5 to 8.9 ft/sec.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-48 Depth-Integrating Suspended-Sediment Sampler[9], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.



US DH-81

The US DH-81 is depth-integrating suspended-sediment and water-quality sampler fabricated using parts from other FISP approved suspended-sediment samplers. It meets the protocols for water-quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7]. The US DH-81A is a plastic adapter with a threaded insert that accepts a 1/2-in diameter wading rod and is used with a variety of caps, nozzles, and containers to assemble a hand-held sediment sampler designated as the US DH-81. The US DH-81A will accept a plastic US D-77 cap or a US D-95 tetrafluoroethylene (TFE) cap. The US D-77 cap is threaded to accept a container with Mason jar threads. The US D-95 cap is threaded to accept a 1-liter fluorinated ethylene propylene (FEP) bottle. US D-77 plastic and TFE nozzles with internal diameters of 3/16, 1/4, and 5/16 in can be used with the US D-77 and US D-95 caps. The metal wading rod used with the US DH-81A is covered with plastic heat-shrink tubing to help prevent contamination of samples for trace metal analysis in water-quality sampling.

The US DH-81 sampler will collect samples at an acceptable inflow efficiency in stream velocities ranging from 2.0 to 6.2 ft/sec with a 3/16-in nozzle, 1.5 to 7.6 ft/sec with a 1/4-in nozzle, and 2.0 to 7.0 ft/sec with a 5/16-in nozzle. Based on the recommended maximum volume of 800 ml the US DH-81 sampler will collect samples to a maximum recommended depth of 12 ft. The sampler can be used to a depth of 15 ft by collecting up to 1 liter of sample. To sample depths greater than can be waded, wading rod extensions in 1- and 3-ft lengths can be added to the sampler. With the extensions, the sampler can be deployed from a low bridge or boat. The unsampled zone using the US DH-81 is 4 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-81 Depth-Integrating Suspended-Sediment Sampler[11], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

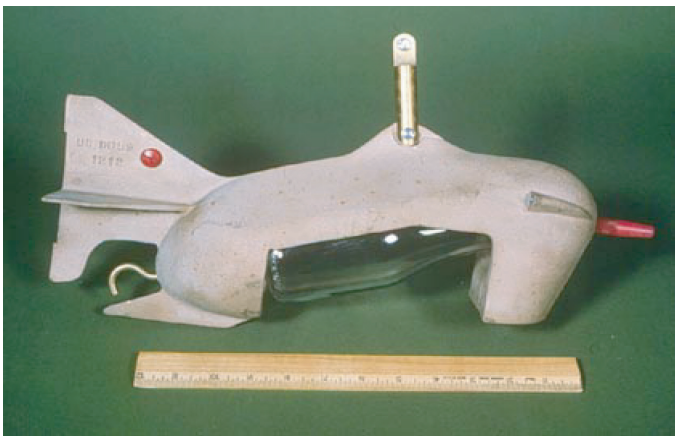
US DH-59

The US DH-59[12] is a medium-weight hand-line suspended-sediment sampler. The sampler can be lowered and raised, hand over hand, with a flexible suspension line. It can be used in stream depths up to 15 ft and in steam velocities ranging from 1.5 to 5.0 ft/sec.

The sampler is a streamlined bronze casting that is 15 in long and weighs 22 lbs. The sampler uses a pint glass milk bottle. The bottle container is sealed against a gasket in the head cavity of the casting by pressure applied to the base of the bottle by a hand operated, spring tensioned, pull rod assembly at the rear of the sampler. The sampler uses a 3/16- or 1/4-in internal diameter intake nozzle that projects horizontally upstream from the head of the casting. As a sample is collected, the displaced air in the bottle is ejected downstream through the air exhaust tube integrally cast into the body and protected by a streamlined projection on the side of the head of the sampler. The unsampled zone using the US DH-59 is 4.5 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-59, and US DH-76 Depth-Integrating Suspended-Sediment Samplers[13], available at the FISP website: *http://fisp.wes.army.mil*.



Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.10, available at *http://water.usgs.gov/pubs/twri/*.

US DH-76

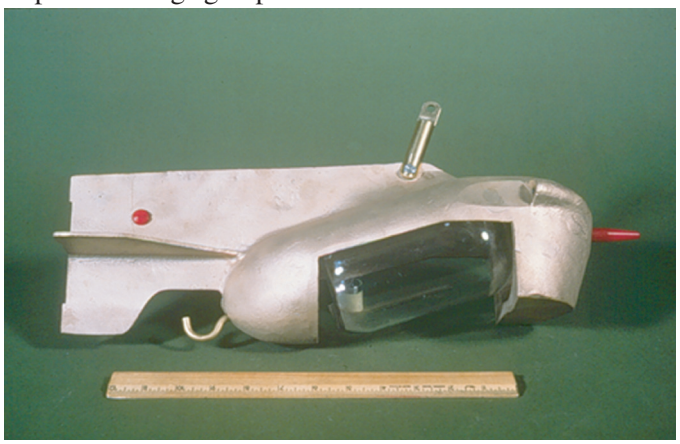
The US DH-76 is a medium-weight hand-line suspended-sediment sampler. The sampler can be lowered and raised, hand over hand, with a flexible suspension line. It can be used in streams with depths up to 15 ft and in stream velocities ranging from 1.5 to 6.6 ft/sec. The US DH-76 is similar in design to the US DH-59, but uses a quart glass bottle for additional sample volume, as opposed to the pint bottle used in the US DH-59.

This sampler is a streamlined bronze casting that is 17 in long and weighs 25 lbs. The quart glass bottle sample container is sealed against a gasket in the head cavity of the casting by pressure applied to the base of the bottle by a hand operated, spring tensioned, pull rod assembly at the tail of the sampler. As the sampler collects a suspended-sediment sample, the displaced air in the bottle is ejected downstream through an air exhaust tube cast integrally in the body of the sampler and is protected by a streamlined projection alongside the head of the sampler. The sampler uses 3/16- and 1/4-in internal diameter nozzles. The unsampled zone using the US DH-76 is 4 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-59, and US DH-76 Depth-Integrating Suspended-Sediment Samplers[13], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at http://water.usgs.gov/pubs/twri/.



US DH-95™

The US DH-95™[14] is a hand-line suspended-sediment/water-quality sampler. The sampler can be lowered and raised, hand over hand, with a flexible suspension line. The US DH-95 meets the protocols for water-quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data7. The sampler can be used in stream depths up to 15 ft and in stream velocities ranging from 1.7 to 7.4 ft/sec.

The US DH-95™ weighs approximately 29 lbs and is 22 in long with the bottle, cap, and nozzle in place. The bottle cavity is machined from a low-lead bronze casting that is coated with plastic. The tail section is made of high-density polyethylene plastic. The sampler is designed to use a 1-liter FEP or plastic bottle mated to the US D-95 Cap™ or US D-77 sampler cap and nozzle. Plastic and TFE nozzles with 3/16-, 1/4-, and 5/16- in internal diameter are available. The recommended sample volume to be collected with the US DH-95™ sampler is 800 ml. The unsampled zone using the US DH-95™ is 4.8 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-95™ Depth-Integrating Suspended-Sediment Sampler[15], available at the FISP website: h*ttp://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

US D-74

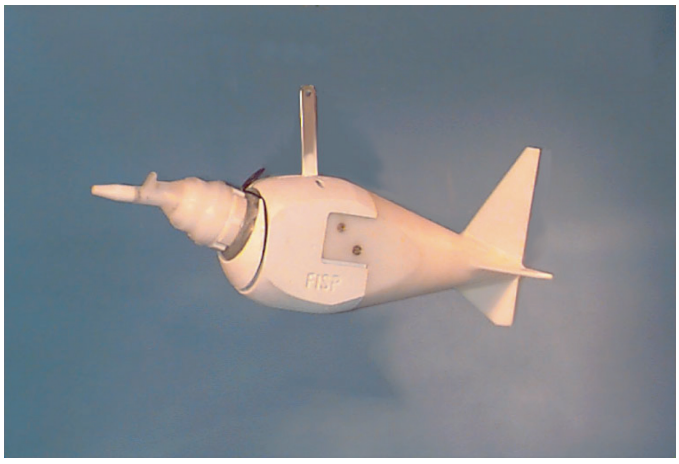
The US D-74 is a cable-suspended suspended-sediment sampler. The sampler is lowered and raised by means of a suspension system such as a reel and crane or bridge board. It could also be used with a cableway. The sampler can be used in stream depths up to 15 ft and in stream velocities ranging from 1.5 to 6.6 ft/sec.

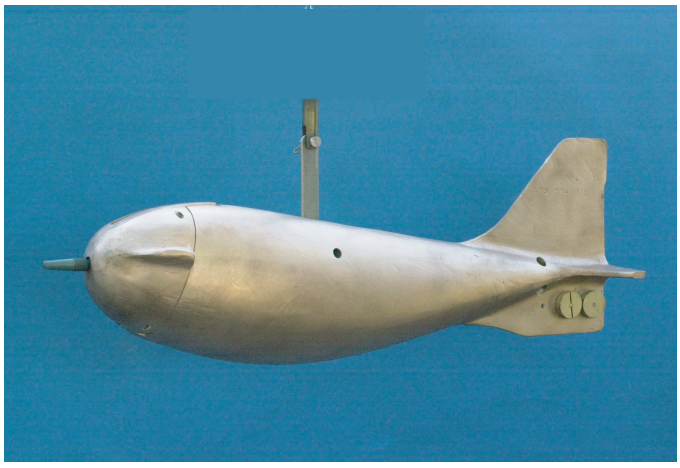
The sampler has a cast bronze, streamlined body that is 24 in long and weighs 62 lbs. A pint or quart glass bottle sample container is used with the sampler. The head of the sampler is hinged to permit access to the sample container. Tail vanes are provided to orient the instrument into the stream flow. The US D-74 uses 3/16- and 1/4- in internal diameter intake nozzles that project into the stream current for collecting a sample. A port, which points downstream, is located on the side of the sampler head from which air escapes as it is displaced by the sample filling the container. The unsampled zone using the US D-74 is 4.1 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-74, and US D-74AL Depth-Integrating Suspended-Sediment Samplers[16], available from FISP.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.





US D-74AL

The US D-74AL is a cable-suspended suspended-sediment sampler. The sampler is lowered and raised by means of a suspension system such as a reel and crane or bridge board. It could also be used with a cableway. The sampler can be used in stream depths up to 15 ft and in stream velocities ranging from 1.5 to 5.9 ft/sec.

The sampler has a cast aluminum, streamlined body that is 24 in long and weighs 42 lbs. A pint or quart glass bottle sample container is used with the sampler. The head of the sampler is hinged to permit access to the sample container. Tail vanes are provided to orient the instrument into the stream flow. The US D-74AL uses 3/16- and 1/4- in internal diameter intake nozzles that project into the current for collecting a sample. A port, which points downstream, is located on the side of the sampler head from which air escapes as it is displaced by the sample being collected in the container. The unsampled zone using the US D-74AL is 4.1 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-74, and US D-74AL Depth-Integrating Suspended-Sediment Samplers[16], available from FISP.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

US D-95™

The US D-95™[17] suspended-sediment and water-quality sampler is a depth-integrating sampler designed for use in streams not exceeding 15 ft in depth. It meets the protocols for water quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7]. The sampler is lowered and raised by means of a suspension system such as a reel and crane or bridge board. The sampler is designed to sample at an acceptable inflow efficiency in stream velocities ranging from 1.5 to 7.5 ft/sec.

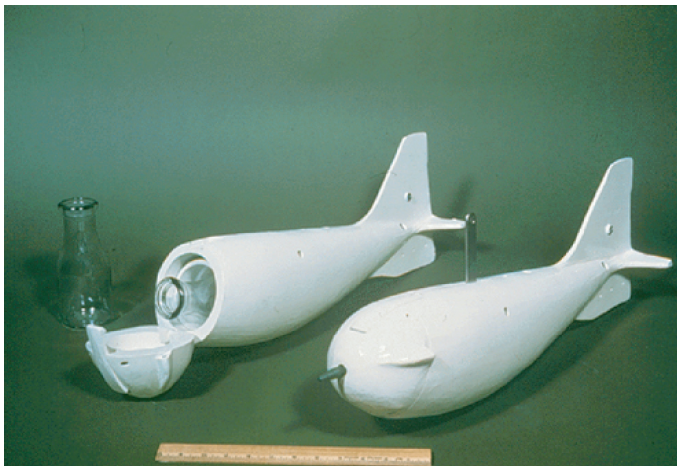
The sampler weighs 64 pounds and is 26 in long with the bottle, cap, and nozzle in place. The bronze body casting is coated with plastic and the tail section is constructed from plastic to help avoid metal contamination during water quality sampling. The sampler is designed to use a 1-liter Teflon or plastic bottle mated to the US D-95 Cap™ or US D-77 sampler cap and nozzle. Plastic and TFE nozzles with 3/16-, 1/4-, and 5/16-in internal diameter are available. The unsampled zone using the US D-95™ is 4.8 inches. The recommended sample volume to be collected with the US D-95™ sampler is 800 ml.

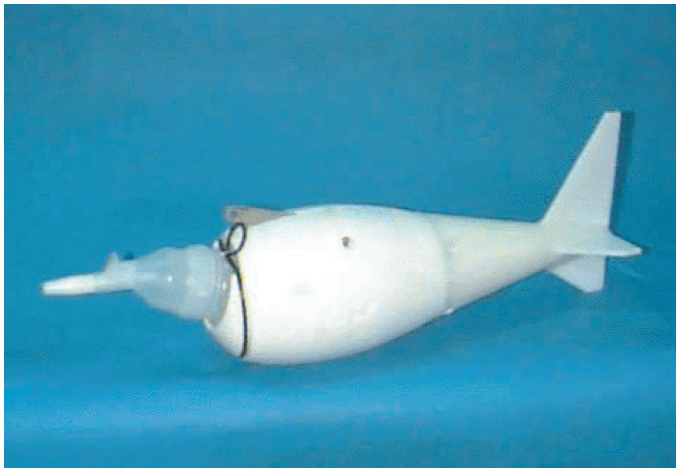
Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-95™ Depth-Integrating Suspended-Sediment Sampler[18], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Selection of Equip-





ment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

US DH-2

The US DH-2 is a hand-line suspended-sediment/water-quality collapsible-bag sampler capable of collecting a 1-liter sample. The sampler can be lowered and raised, hand over hand, with a flexible suspension line. The US DH-2 meets the protocols for water quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7]. The sampler can be used in stream depths up to 37 ft using a 3/16-in internal diameter nozzle, 20 ft using a 1/4-in internal diameter nozzle, and 13 ft using a 5/16-in internal diameter nozzle. The sampler can be used in stream velocities ranging from 2.0 to 6.0 ft/sec.

The US DH-2 is fabricated from cast bronze and high-density polyethylene and is plastic coated. It is 19 in long and weighs 29 lbs. The sampler uses plastic or TFE nozzles and plastic or PFA bags. The unsampled zone using the US DH-2 is 4 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US DH-2 Depth-Integrating Collapsible-Bag Suspended-Sediment Sampler[19], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

US D-96

The US D-96[20,21] is a collapsible-bag suspended-sediment/water-quality sampler capable of collecting a 3-liter sample. It is 35 in long, weighs 132 lbs, and has a hollow cavity inside the sampler body. It is fabricated from bronze and aluminum castings with a high-density polyethylene tail. All metal parts are plastic coated. The sampler employs a sliding tray that supports the bag and holds the nozzle holder with nozzle in place. The bag is attached to the nozzle holder with a hook-and-loop strap. The sampler uses a plastic or TFE nozzle and a plastic or PFA bag as the sample container. The US D-96 meets the protocol for water-quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7]. The sampler is protected by US Patent No. 6,216,549 B1.

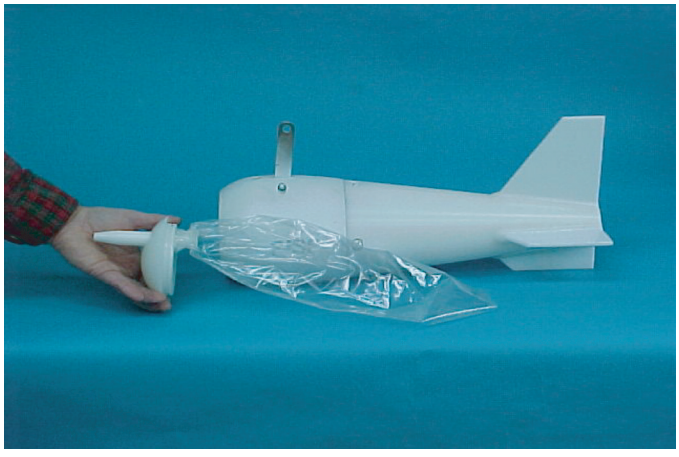
The US D-96 sampler will collect acceptable flow-weighted samples in streams velocities ranging from 2.0 to 12.5 ft/sec. Extreme care should be practiced when deploying the sampler at stream velocities above 10 ft/sec. The US D-96 sampler is capable of sampling to a depth of 39 ft with a 5/16-in internal diameter nozzle, 60 ft with a 1/4 in internal diameter nozzle, and 110 ft with a 3/16-in internal diameter nozzle. The unsampled zone using the US D-96 sampler 4 in.

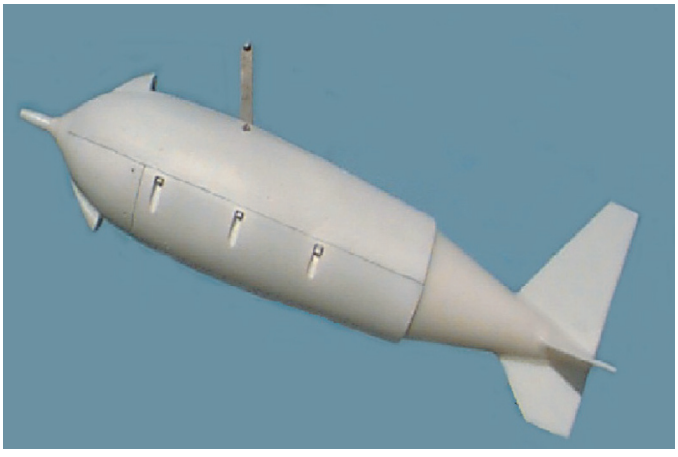
Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-96 Depth-Integrating Collapsible-Bag Suspended-Sediment Sampler[22], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques





of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

US D-96-A1

The US D-96-A123 is a collapsible-bag suspended-sediment/water-quality sampler capable of collecting a 3-liter sample. It is 35 in long, weighs 82 lbs, and has a hollow cavity inside the sampler body. It is fabricated from aluminum and bronze castings with a high-density polyethylene tail. All metal parts are plastic coated. The sampler employs a sliding tray that supports the bag and holds the nozzle holder with nozzle in place. The bag is attached to the nozzle holder with a hook-and-loop strap. The sampler uses a plastic or TFE nozzle and a plastic or PFA bag as the sample container. The US D-96-A1 meets the protocol for water-quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7]. The sampler is protected by US Patent No. 6,216,549 B1.

The US D-96-A1 sampler will collect acceptable flow-weighted samples in stream velocities ranging from 2 to 6 ft/sec. The US D-96-A1 sampler is theoretically capable of sampling to a depth of 39 ft with a 5/16-in internal diameter nozzle, 60 ft with a 1/4-in internal diameter nozzle, and 110 ft with a 3/16-in internal diameter nozzle. However, in field use in streams with high velocities, obtainable sampling depths will likely be less than theoretical due to the large drift angle created by the sampler in high stream velocities. The unsampled zone using the US D-96-A1 sampler is 4 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-96-A1 Depth-Integrating Collapsible-Bag Suspended-Sediment Sampler[24], available at the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

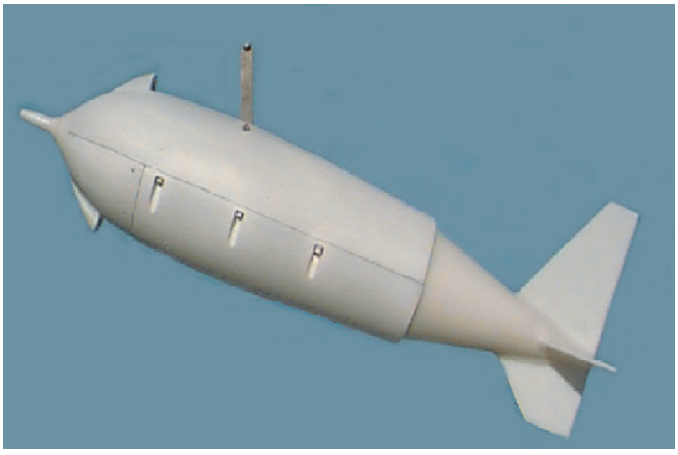
Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/*.

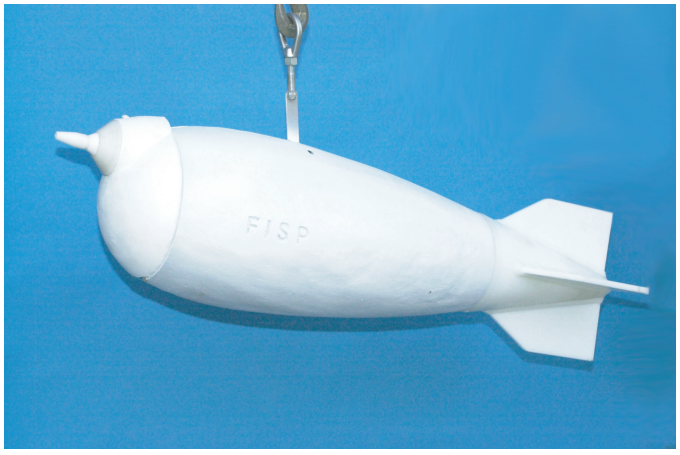
US D-99

The US D-99 is a collapsible-bag suspended-sediment/water-quality sampler capable of collecting a 6-liter sample. It is 39 in long, weighs 275 lbs, and has a hollow cavity inside the sampler body. It is fabricated from a bronze casting with a high-density polyethylene tail. It has a hinged head that closes horizontally and holds the nozzle holder and nozzle in place. All metal parts are plastic coated. The bag is attached to the nozzle holder with a hook-and-loop strap. The sampler uses a plastic or TFE nozzle and a plastic or PFA bag as the sample container. The US D-99 meets the protocol for water quality sampling as outlined in the USGS's National Field Manual for the Collection of Water-Quality Data[7].

The US D-99 sampler will collect acceptable flow-weighted samples in stream velocities ranging from 3.0 to 15 ft/sec. Extreme care should be practiced when deploying the sampler at stream velocities above 10 ft/sec. The US D-99 sampler is capable of sampling to a depth of 78 ft with a 5/16-in internal diameter nozzle, 120 ft with a 1/4-in internal diameter nozzle, and 220 ft with a 3/16-in internal diameter nozzle. The unsampled zone using the US D-99 is 9.5 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler.





Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US D-99 Depth-Integrating Collapsible-Bag Suspended-Sediment Sampler[25], available at the FISP website: *http://fisp.wes.army.mil.*

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/.*

Wilde, F.D., Radtke, D.B., Gibs, J., and Iwatsubo, R.T., 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey hniques of Water-Resources Investigations, Selection of Equipment for Water Sampling, book 9, chap. A2[7], available at: *http://water.usgs.gov/pubs/twri/.*

US P-61-A1

The US P-61-A1 is a point-integrating suspended-sediment sampler that has an electrically operated valve for starting and stopping the collection of a sample. The sampler is lowered to the desired depth in the water column, the sample collected by remotely opening and closing the valve, and then the sampler is raised to the surface for removal of the sample container.

The sampler has a streamlined cast bronze body 28 in long that weighs 105 lbs. It has tail fins to orient the sampler so that the intake nozzle in the head points directly into the approaching flow. The sampler head is hinged to provide access to the pint or quart bottle sample container located in a cavity in the sampler body. An exhaust port pointing downstream on the side of the sampler head permits escape of air from the sample container as it is displaced by the sample being collected. The sampler uses a 3/16-in internal diameter nozzle and can be used in stream velocities ranging from 1.5 to 10 ft/sec. It can be used to a depth of 180 ft with a pint container and 120 ft with a quart container.

To eliminate a sudden inrush of sample due to hydrostatic pressure, the diving bell principle is used to balance the air pressure in the bottle with the hydrostatic pressure at the nozzle prior to opening the valve at the start of sampling. The "diving bell" in the sampler is the body cavity behind and surrounding the sample container. It is connected by ports through the valve system to the surrounding stream and to the sample bottle.

The operating current may be supplied by the US RBP-95 rechargeable battery pack, which is sold separately.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

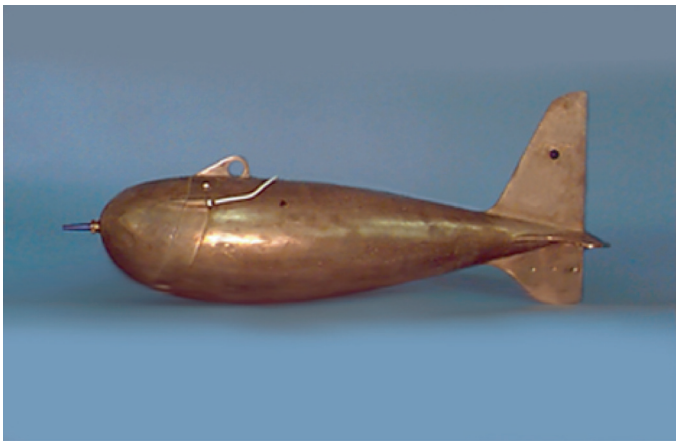
Operator's Manual for the US P-61-A1 Point-Integrating Suspended-Sediment Sampler[26] is available at the FISP website: *http://fisp.wes.army.mil*.

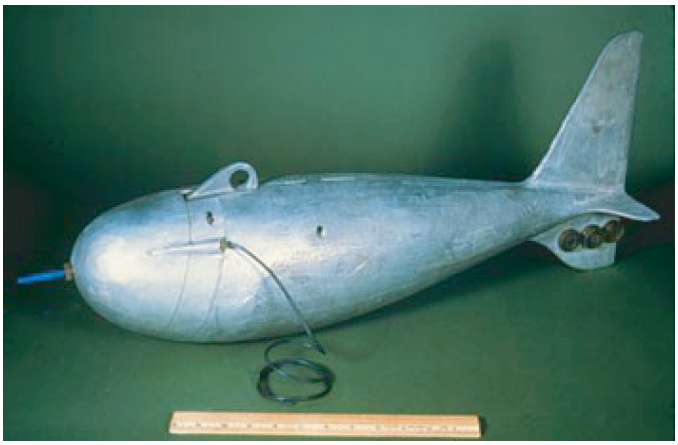
Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/.*

US P-72

The US P-72 is a point-integrating suspended-sediment sampler that has an electrically operated valve for starting and stopping the collection of a sample. The sampler is lowered to the desired depth in the water column, the sample collected by remotely opening and closing the valve, and then the sampler raised is to the surface for removal of the sample container.

The sampler has a streamlined cast aluminum body 28 in long that weighs 41 lbs. It has tail fins to orient the sampler so that the intake nozzle in the head points directly into the approaching flow. The sampler head is hinged to provide access to the pint or quart bottle sample container located in a cavity in the sampler body. An exhaust port pointing downstream on the side of the





sampler head permits escape of air from the sampler container as it is displaced by the sample being collected. The sampler uses a 3/16-in internal diameter nozzle and can be used in stream velocities ranging from 1.5 to 5.3 ft/sec. It can be used to a depth of 72 ft with a pint container and 51 ft with a quart container.

To eliminate sudden inrush at a selected sampling point below the water surface, the diving bell principle is used to balance the air pressure in the bottle with the hydrostatic pressure at the nozzle prior to opening the valve at the start of sampling. The "diving bell" in the sampler is the body cavity behind and surrounding the sample container. It is connected by ports through the valve system to the surrounding stream and to the sample bottle.

The operating current may be supplied by the US RBP-95 rechargeable battery pack, which is sold separately.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following reference:

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

US P-63

The US P-63 is a point-integrating suspended-sediment sampler that has an electrically operated valve for starting and stopping the collection of a sample. The sampler is lowered to the desired depth in the water column, the sample collected by remotely opening and closing the valve, and then the sampler is raised to the surface for removal of the sample container.

The sampler has a streamlined cast bronze body 37 in long that weighs 200 lbs. It has tail fins to orient the sampler so that the intake nozzle in the head points directly into the approaching flow. The sampler head is hinged to provide access to the pint or quart bottle sample container located in a cavity in the sampler body. An exhaust port pointing downstream on the side of the sampler head permits escape of air from the sample container as it is displaced by the sample being collected. The sampler uses a 3/16-in internal diameter nozzle and can be used in stream velocities ranging from 1.5 to 15 ft/sec, and to a depth of 180 ft with a pint container and 120 ft with a quart container.

To eliminate a sudden inrush of sample due to hydrostatic pressure, the diving bell principle is used to balance the air pressure in the bottle with the hydrostatic pressure at the nozzle prior to opening the valve at the start of sampling. The "diving bell" in the sampler is the body cavity behind and surrounding the sample container. It is connected by ports through the valve system to the surrounding stream and to the sample bottle.

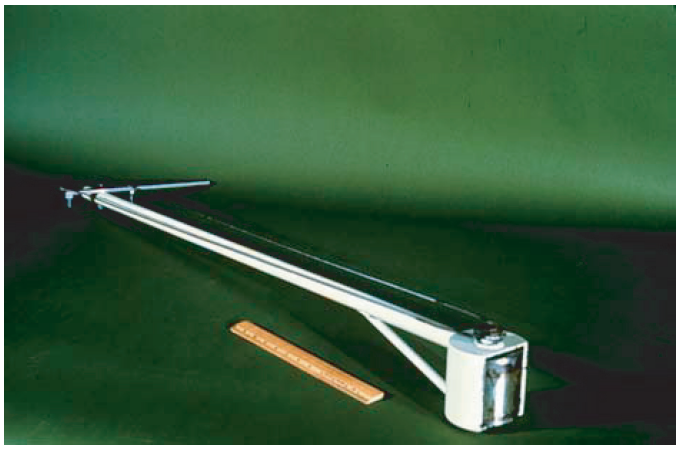
The operating current may be supplied by the US RBP-95 rechargeable battery pack, which is sold separately.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following reference:

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

US RBMH-80

The US RBMH-80 is a hand-held rotary-scoop bed-material sampler with a semi-cylindrical bucket for collecting the sample. Operation is simple: the sampler is placed on the streambed and the lever on the handle closes the bucket, collecting the sample. The sampled material is protected from washing out while rising



through the water column. The sampler is approximately 56 in long and weighs 8 lbs.

The sampler can be used in sand-bed and gravel-bed streams up to approximately 3 ft deep. It will collect a sample volume of approximately 15 in^3 (250 cm^3) of material and will sample to a maximum bed material depth of 1.75 in.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following reference:

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

US BMH-53

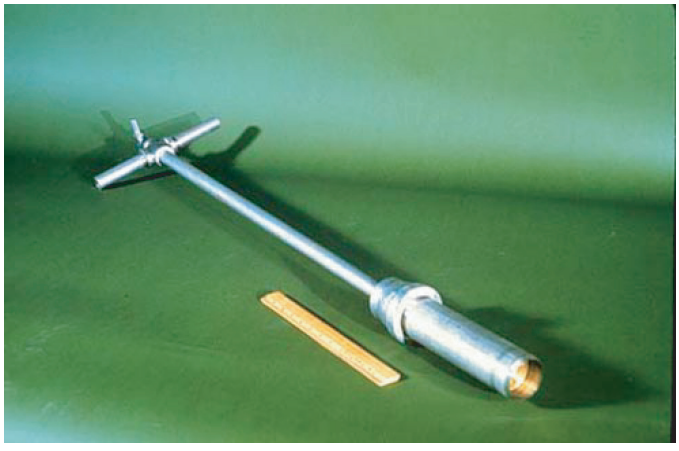
The US BMH-53 is a hand-held piston-type bed-material sampler. The sampler is used to collect a sample of material from the bed of a shallow stream. The overall length of the tubular sampler is 46 in and it weighs 7.5 lbs.

The lower end of the sampler contains a 2-in diameter, 8 in long cylinder that is pressed into the stream bed to collect the sample. A handle for pressing the cylinder into the bed is on the upper end, and passes through the sampler frame to the piston inside. The suction created by the piston holds the sample in the cylinder. The sample is pushed out of the cylinder by the piston.

The US BMH-53 sampler will not work for some bed materials, such as coarse sands and gravels.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following reference:

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3 chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.



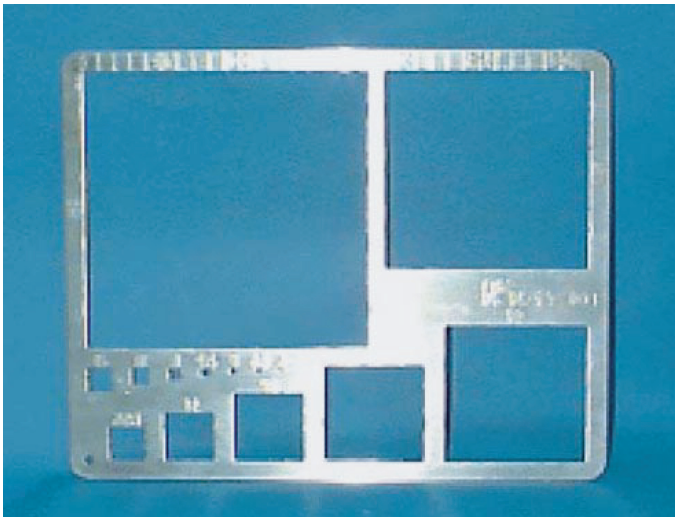
US SAH-97™

The US SAH-97™ is a hand-held size analyzer used to grade or measure gravel and small cobble-size bed sediments in the field. Generic names are gravelometers, gravel templates, and pebblemeters.

The unit is 11 in by 13 in and constructed from 1/8 in thick 6061 aluminum. The US SAH-97™ has 14 square holes of common sieve sizes (1/2-phi unit classes) ranging from 2 mm to 180 mm. There is also a scale along one side that can be used to measure up to 310 mm. The scale is in 10-mm increments. A particle is sized by passing it through the smallest hole possible, along the particle's smallest axis.

Instructions for use of the SAH-97 can be found in the Operator's Manual for the US SAH-97 Hand-Held Size Analyzer "Gravelometer"[27] available at the FISP website: *http://fisp.wes.army.mil*.

Additional sampling information is available in USDA Forest Service General Technical Report RMRS-GTR-74: Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-Bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring, 2001, by Kristin Bunte and Steven Abt.[28]



US BMH-60

The US BMH-60 is a hand-line bed-material sampler. It is used to collect samples from the bed of a stream, lake, or a reservoir. Penetration into the bed material is approximately 1.7 in. The sampler can be suspended from a flexible line and lowered and raised by hand. The weight of the sampler limits its use to tranquil streams and moderate or slightly compacted sand and pebble bed materials.

The US BMH-60 is 22 in long and weighs 32 lbs. The body of the sampler is made of aluminum. Ballast makes the sampler nose heavy by about four pounds to assist the sampling bucket mechanism in penetrating the bed material of the stream. The sampling bucket accommodates approximately 11 in^3 (175 cm^3) of material and is spring loaded by cross-curved, constant-torque, motor-type springs. Tension on the hand suspension line or use of a specially made safety yoke allows the bucket to be cocked in the open position by means of a wrench. Once the bucket is fully retracted within the body shell of the sampler, it is ready to take a sample. As long as the safety yoke is in place, the bucket mechanism cannot be released. For sampling, the safety yoke is removed and the sampler lowered by the hand line until the sampler rests on the bottom of the stream. Once the tension on the suspension line is reduced to a specified amount, the spring-loaded cocking device will release the bucket mechanism. The rapidly closing bucket penetrates the streambed and completely encloses a sample of the bed material. Gaskets prevent loss or contamination of the trapped sample. Once the sampler is raised to the surface, the bed material sample can be transferred to a container.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US BM-54 and US BMH-60 Bed-Material Samplers[29], available from FISP.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p. [10], available at *http://water.usgs.gov/pubs/twri/.*

US BM-54

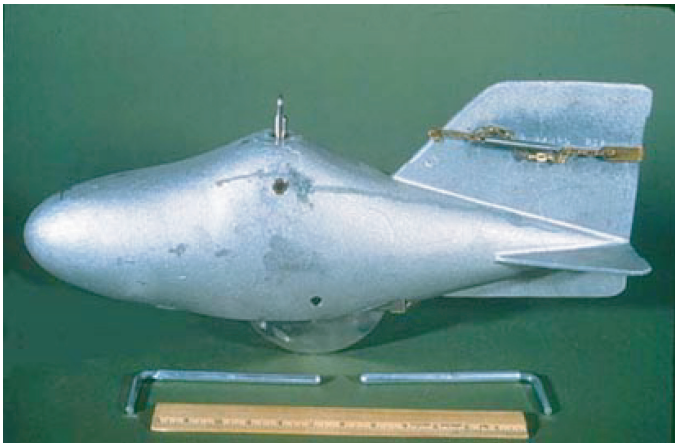
The US BM-54[30] is a cable-suspended bed-material sampler. It is used to collect sand and gravel samples from the bed of a stream, lake, or a reservoir. Penetration into the bed material is approximately 2 in.

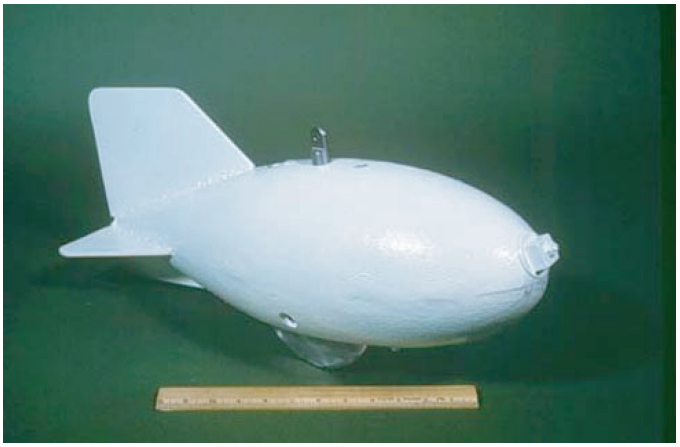
The US BM-54 is 22 in long and weighs 100 lbs. The body of the sampler is made of cast iron. The spring-loaded sampling bucket accommodates approximately 18 in^3 (300 cm^3) of material. Tension on the cable suspension line allows the bucket to be cocked in the open position by means of a wrench. Once the bucket is fully retracted within the bodshell of the sampler, it is ready to take a sample. To collect a bed-material sample, the sampler is lowered by reel until it rests on the bottom of the stream. Once the tension on the cable is reduced to a specified amount, the spring-loaded cocking device will release the bucket mechanism. The rapidly closing bucket penetrates the streambed and completely encloses a sample of the bed material. Gaskets prevent loss or contaminatiof the trapped sample. Once the sampler is raised to the surface, the bed material samplcan be transferred to a container.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Operator's Manual for the US BM-54 and US BMH-60 Bed-Material Samplers[29], available from FSIP.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], *available at http://water.usgs.gov/pubs/twri/.*





US BLH-84

The US BLH-84 is a wading-type hand-held bedload sampler. The sampler consists of an expanding nozzle, a sample bag, and a wading rod assembly. The sampler design enables collection of particle siznozzle and an area expansion ratio (ratio of nozzle exit area to entrance area) of 1.4. A polyester mesh bag with mesh openings of 0.25 mm is attached to the rear of the nozzle assembly with a rubber "O" ring.

The sampler is constructed of aluminum, weighs 10 lbs and is 28 in long.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Sampling with the US BL-84 Bedload Sampler[31], available on the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

Additional information about pressure-differential bedload samplers is listed in the uncited references section of this report.

US BL-84

The US BL-84 is a cable-suspended bedload sampler used to collect samples from streams that cannot be waded. The sampler consists of an expanding nozzle mounteda frame, and a sampler bag. The sampler design enables collection of particle sizes larger than the bag mesh opening and smaller than 1.5 in (38 mm) at stream velocities up to 9ft/sec. The sampler has a 3 by 3 in entrance nozzle and an area expansion ratio (ratio of nozzle exit area to entrance area) of 1.4. A 295 in^2 polyester mesh sample bag 18 in long with mesh openings of 0.25 mm is attached to the rear of the nozzle assembly with a rubber "O" ring.

The US BL-84 is constructed of stainless steel and aluminum, weighs 32 lbs and is 36 in long. It is equipped with tail fins that orient it into the stream-flow. The sampler must be supported by a steel cable and reel to be lowered into a river or stream for taking a bed load sample. At high stream velocities, a tether line may be required.

Where and how the sampler is deployed in the field is as important as the fundamental design of the sampler. Additional information about how to properly use this sampler can be found in the following references:

Sampling with the US BL-84 Bedload Sampler[32], available on the FISP website: *http://fisp.wes.army.mil*.

Edwards, T.K., and Glysson, G.D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water Resources Investigations, book 3, chapter C2, 89 p.[10], available at *http://water.usgs.gov/pubs/twri/*.

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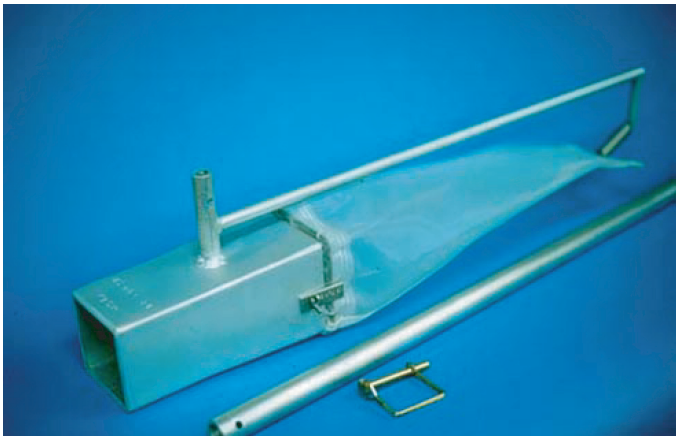

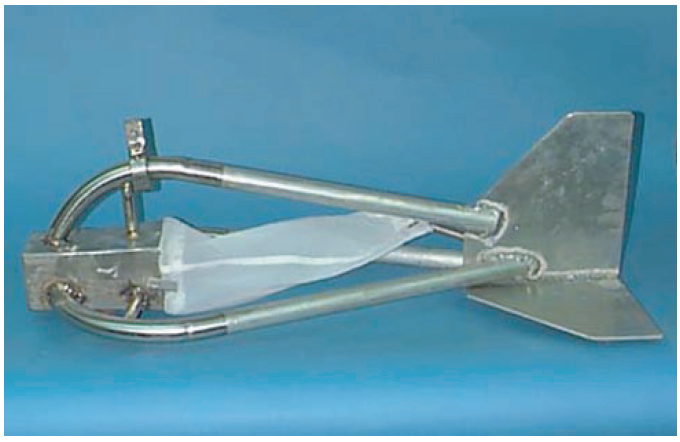

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