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14. ABSTRACT

The purpose of this report is to summarize briefly the history of the Surface Water Research project since its inception in 1952, the work accomplished, and the problems encountered. In general, each topic is discussed under two periods of time: 1952-1963, when projects were confined to the Helmand River Valley and was entitled "Helmand Surface Water Investigations (306-12-021, 306-M-12-AD and 306-AC-12-AD5)," and 1963-1969 when activities were expanded to cover most of Afghanistan and title was changed to "Surface Water Research (306-11-190-002)".

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Appendix (16)

HYDROLOGY TRAINING MANUAL

NUMBER 3

COLLECTION

OF BASIC SEDIMENT DATA

MINISTRY OF AGRICULTURE

HYDROLOGY TRAINING MANUAL

Number 3

Collection

of Basic Sediment Data

by Dallas Childers, Jr.

Prepared by the

United States Agency for International Development

Mission to Afghanistan

in cooperation with the

Water and Soils Survey Department

of the

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CONTENTS

ILLUSTRATIONS

TABLES

Table

GLOSSARY

EOLIAN SEDIMENT -- Sediment that is transported by, or suspended, in air, or that has been deposited by air currents.

BED LAYER -- A thin layer along the streambed through which the bedload is discharged; commonly assumed to be only a few grain diamters thick (grain diameters of the sediment of which the bed is composed).

BEDLOAD -- Sediment that is transported within the bed layer by rolling, sliding or bouncing along the bed or very close to it.

BEDLOAD DISCHARGE -- The amount of bedload material moving past a point or through a cross section of a stream in a unit of time; usually measured as tons per day.

BED MATERIAL -- The sediment of which the streambed is composed.

CENTROID SAMPLING METHOD -- A method of sampling the suspended sediment transported by a stream through a cross section whereby individual samples are taken at the midpoints of several parts of equal discharge.

CLAY -- Sediment particles smaller than 0.004 mm (4 microns) in size.

COMPOSITE SAMPLE -- A single sample formed by combining the sediment from all the individual bottles making up a set of samples. A set of samples taken by the equal-transit-rate method can be composited in the laboratory. A set taken by the centroid method cannot be composited.

CONFLUENCE -- A place where two or more streams come together to form one stream.

DEPTH-INTEGRATED SAMPLE -- A water-sediment mixture that is accumulated continuously in a suspended-sediment sampler which moves vertically at an approximately constant transit rate between the surface of a stream and a point a few centimeters above the streambed. The sampler allows the mixture to enter the sampler nozzle at a velocity about equal to the velocity of flow.

EQUAL-TRANSIT RATE SAMPLING METHOD -- Also called ETR method. A method for sampling the suspended-sediment transported by a stream through a cross section. Between 10 and 20 sampling verticals are used, and the same transit rate is used at all verticals. A method for sampling the suspended sediment that is discharge-weighted (more water-sediment mixture is obtained in the parts of a stream with greater discharge than in other parts with less discharge). The ETR sampling method is the most accurate method for sampling suspended sediment for concentration and is the only method used for sampling the suspended-sediment size distribution.

FLUVIAL SEDIMENT -- Sediment that is transported by, suspended in, or deposited by water.

GRAIN SIZE -- Sediment particle size or the size of an individual piece of sediment. Grain size is usually measured in microns or millimeters. 1 micron = 0.001 millimeter.

LOESS -- Fine-grained sand, silt and clay that has been deposited by wind. The soil around Balkh and Shibargan is an excellent example of loess.

SAMPLED ZONE -- That part of a sampling vertical that is sampled by a suspended-sediment sampler; the part above the unsampled zone.

SAMPLING VERTICAL, or VERTICAL -- An approximately vertical path from the water surface to the streambed along which a sample is accumulated to define suspended-sediment concentration or grain size distribution.

SAND -- Sediment particles between 0.062 and 2.000 mm (62 to 2000 microns) in size.

SILT -- Sediment particles between clay and sand in size (0.004 to 0.062 mm or 4 to 62 microns).

SIZE SAMPLES -- Samples of the suspended sediment transported by a stream that are used to determine the distribution of the grain size. The equal-transit-rate (ETR) sampling method is used always.

STREAM -- A general term for any body of water moving along a water course. Any river, creek, brook or wash can be called a stream. The Helmand River and Shahjoi Wash are streams but are never called the Helmand Stream or Shahjoi Stream.

STREAMBED, RIVERBED, or BED -- The bottom of a water course.

STREAM DISCHARGE -- The volume of water passing through a cross section in a unit of time, as in cubic feet per second (cfs) or cubic meters per second (cms).

SUSPENDED-SEDIMENT DISCHARGE -- The weight of suspended sediment passing through a cross section in a unit of time, as in tons per day.

SUSPENDED-SEDIMENT SAMPLER -- A mechanical device that collects a sample of the water-sediment mixture moving in a stream.

SUSPENDED SEDIMENT -- Sediment that is held in suspension for appreciable lengths of time in a stream.

TOTAL SEDIMENT DISCHARGE -- The sum of the suspended-sediment discharge plus the bedload discharge.

TRANSIT RATE -- The rate (feet per second or meters per second) at which a suspended-sediment sampler is lowered or raised in a sampling vertical.

TRAP EFFICIENCY -- The ability of a lake or reservoir formed by a dam to capture sediment carried into it by contributing streams. If all, or most, of the sediment is deposited in the reservoir, and comparatively clean, clear, sediment-free water is released at the dam outlet or spillway, the reservoir has a high trap efficiency. If most of the sediment passes through the reservoir, and sediment-laden water is released at the dam outlet or spillway, the reservoir has a low trap efficiency.

TURBULENCE -- The turbulence of flow in a stream means the roughness of the flow. Turbulent flow is the opposite of smooth (laminar) flow. Most of the flow in the Salang River is turbulent flow; most of the flow in the Canal-i-Zahir Shah near Kandahar is smooth (laminar) flow.

UNSAMPLED ZONE -- The bottom part of a sampling vertical which cannot be sampled by a suspended-sediment sampler. The nozzle on samplers is located 9 to 10 centimeters above the bottom of the sampler. When the sampler has been lowered to the streambed, this height of the nozzle leaves an unsampled zone between the nozzle and the streambed.

VISCOSITY -- The internal (molecular) resistance of a liquid which makes it resist the tendency to flow (makes it flow more slowly). Gasoline can be poured more easily than motor oil; therefore, motor oil has a higher viscosity than gasoline. The viscosity of water changes slightly as minerals (salts) are dissolved in it and also as its temperature changes.

WEATHERING -- The action of the weather (wind rain, freezing and melting of water in cracks in rocks) on the surface of the earth that reduces the size of rock fragments forming smaller rocks, gravel, sand, silt and clay.

Collection of Basic Sediment Data

by

Dallas Childers, Jr.

U. S. Geological Survey

INTRODUCTION

In the development of the water resources of Afghanistan, reliable information is needed regarding the amount and nature of sediment transported by its streams. Sediment data should be collected in all parts of the country to define general basin characteristics and also at sites where future water projects are planned.

Many problems are caused by sediment. Two of the most common are: (1) the economic and physical life of a reservoir is shortened by the reduction in storage capacity which results from the accumulation of sediment; and (2) sediment deposits in irrigation canals may result in less efficient operation and maintenance. These and other problems may be reduced or eliminated through careful design providing adequate sediment data are available.

This manual is designed to be used in the training of engineers and technicians of the Water and Soils Survey Department (WSSD), Ministry of Agriculture and Irrigation. It includes a brief introduction to sediment origin, transport, and deposition, as well as a detailed explanation of the sediment program, field procedures, and techniques. Organization and responsibilities of the sediment section of WSSD are presented. By careful study of this manual, hydrographers of WSSD will arrive at a better understanding of the sediment program and their part in it.

For those who wish to become more familiar with the field of sedimentation, a list of publications is included in the back of this manual. Copies of these can be found in the reference library maintained by the sediment section of WSSD.

SEDIMENT

Origin

Most sediment originates from the weathering of rocks on the earth's surface. Weathering reduces the size of rock fragments forming smaller rocks, gravel, sand, silt and clay. When rain falls on a land surface, some of the water runs off as sheet flow carrying with it some of the material produced by weathering. This sheet flow comes together in small channels which join with others further downhill to form larger channels, eventually either forming a stream or joining a stream already formed. These channels carry the products of weathering away from their point of origin by a process called erosion. In this manner, the products of weathering are carried into streams and become fluvial sediment. Water flowing in a channel often causes erosion of streambeds and banks, another source of fluvial sediment.

Sediment carried by or deposited by the wind is called eolian sediment.

Movement

Based on the way it is transported by a stream, fluvial sediment can be classed into two categories:

(1) Sediment that rolls or slides along a streambed and that is in contact with the bed almost all of the time is called bedload sediment.

(2) Sediment that stays in suspension for appreciable lengths of time is called suspended-sediment. These grains of sediment

shift up and down within the flow and may move out of and back into the bed layer.

Fine material in suspension is usually fairly evenly distributed both vertically and horizontally within a cross section (figures 1 and 2). The bed of a stream, however, very often consists of coarser material and, while most of it may not rise above the bed layer, some grains of this coarser sediment may go into suspension by bouncing upward from the bed toward the surface (figure 3). The amount of bed material in suspension in any part of a stream cross section depends on many factors, but mainly on the velocity of the stream at that location and the grain sizes and densities of the bed material. In general, the suspended-sediment concentration may vary considerably within a cross section because of the behavior of the bed material. In a sampling vertical, more coarse bed material will be found near the streambed than near the surface. In a given cross section, more bed material may go into suspension in those parts of the stream flow with higher velocities than in those with lower velocities (figure 4). Also, more bed material may be transported as bedload in those parts with higher velocities.

Variations in suspended-sediment load and bedload within a cross section also are caused by other conditions. If the sediment load of a stream is different from that of a tributary, the distribution of sediment across their combined flows will remain separate and distinct for a long distance below the confluence. Also, the distribution of sediment within a cross section is often abnormal where streambeds or banks are being eroded by the stream.

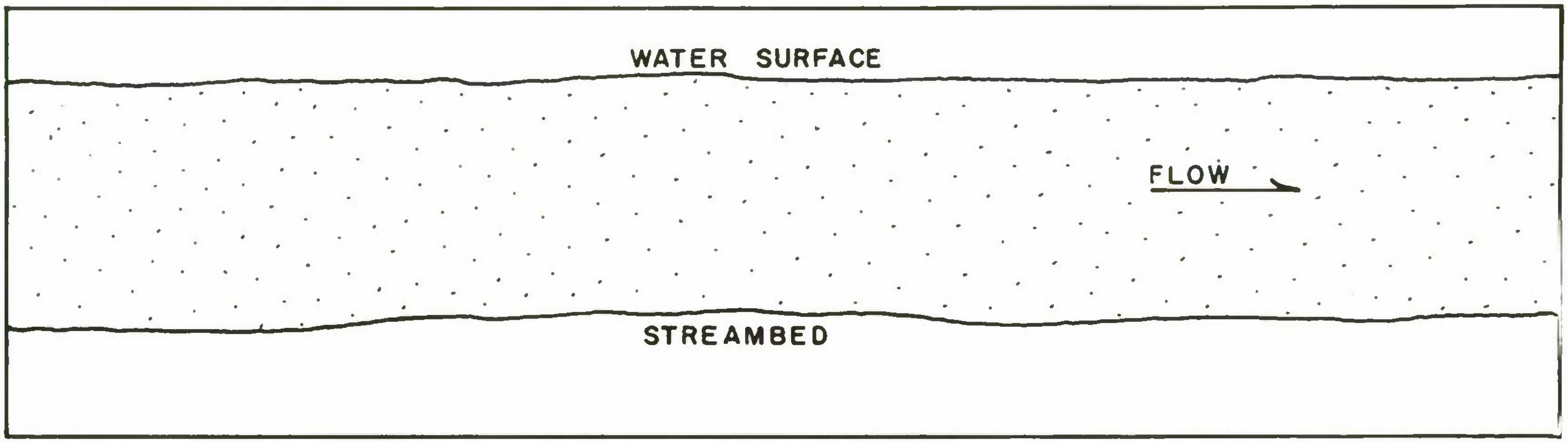


Figure 1.-- Diagram showing typical even distribution of fine suspended-sediment in a longitudinal view of a sampling cross section.

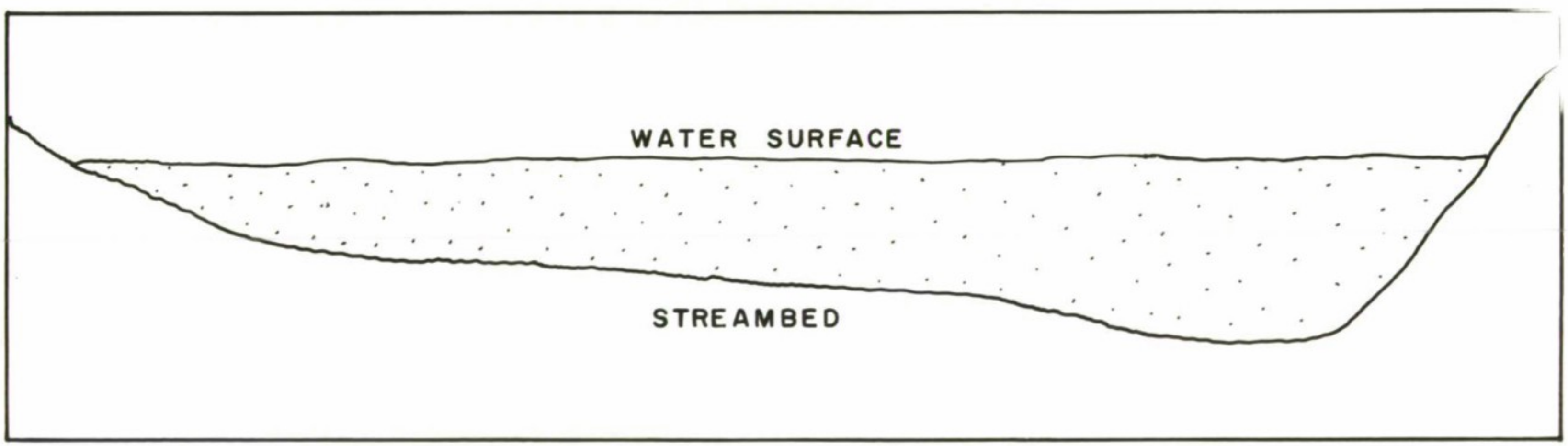


Figure 2.-- Diagram showing typical even distribution of fine suspended-sediment in a cross section of a stream.

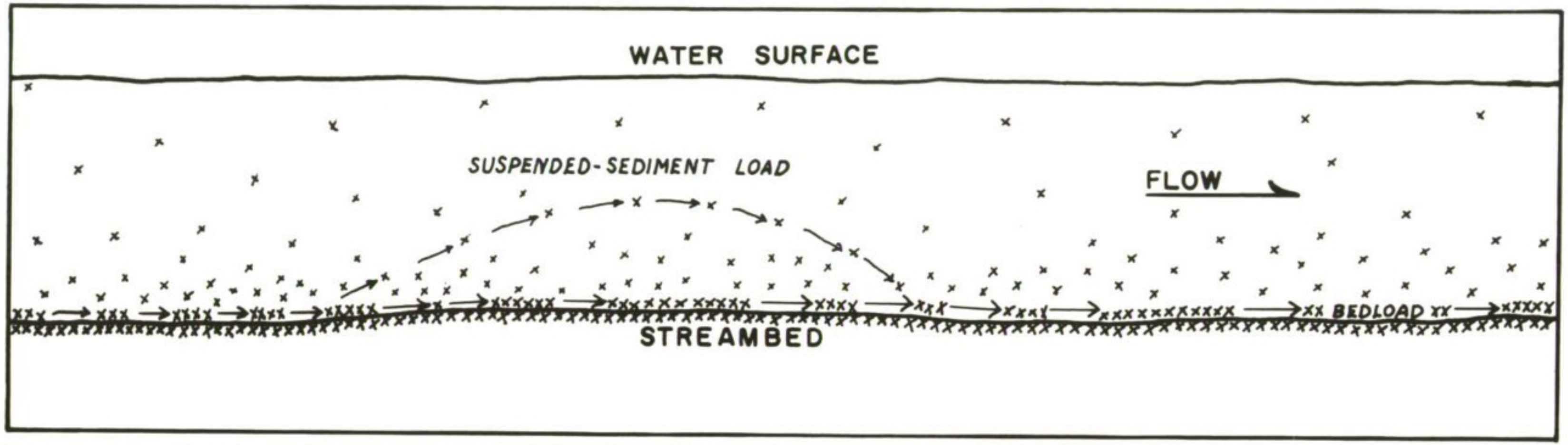


Figure 3.-- Diagram showing typical uneven distribution of coarse sediment in a longitudinal view of a sampling cross section.

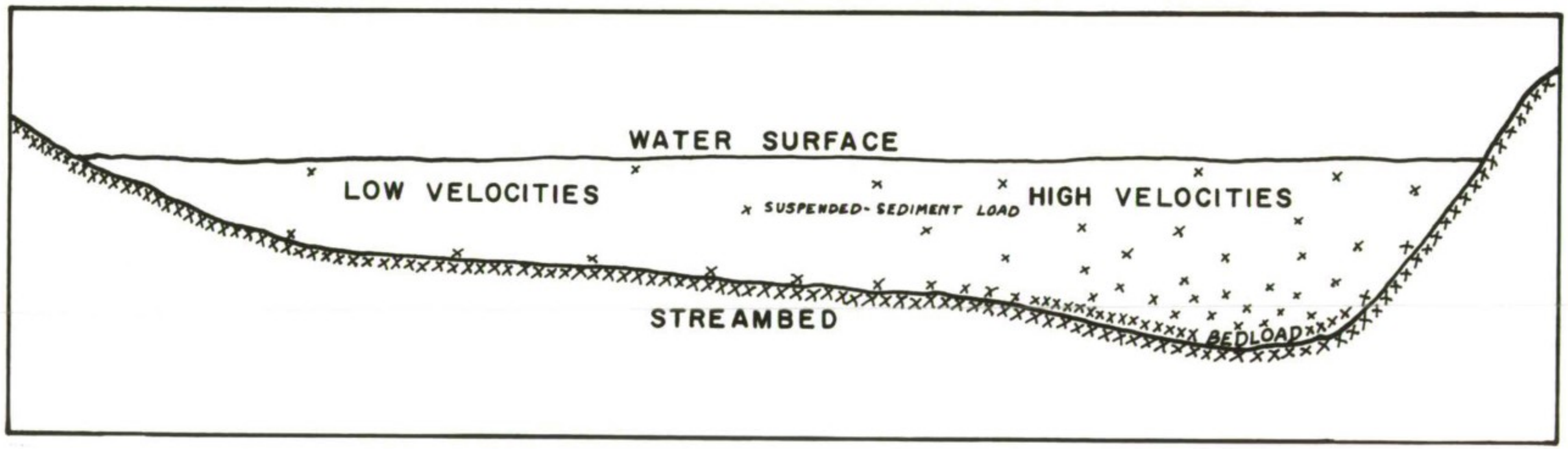


Figure 4.-- Diagram showing typical uneven distribution of a coarse sediment in a cross section of a stream.

Deposition

The sediment discharge of a stream through any particular cross section depends on two things: (1) the stream's capacity for transporting sediment and (2) the availability of sediment for transport. For example, a stream may have the capacity to transport 20 tons per day of sediment but may transport only 5 tons per day because not enough sediment is available.

A stream's capacity for transporting sediment is affected by many factors that are interrelated, such as the discharge, slope, velocity and turbulence of the stream, the roughness of the streambed, and the viscosity and temperature of the water. When one or more of these factors change, the transport capacity also changes.

When a stream does not carry a capacity load, sufficient sediment is not available. The Zarduch River in Badakshan does not usually carry its full capacity load of sediment because it flows through hard-rock terrain, and its channel is lined with large boulders and occasional outcroppings of bedrock. At the other extreme, the Sar-i-Pul River often may carry its capacity load because the channel is cut through a thick loess deposit of sand, silt, and clay.

When a stream's capacity to transport sediment changes, either scour or deposition may occur. During a flood, the increase in velocity and turbulence, as well as the increase in discharge may cause a scouring of the streambed and banks if the material is of such a nature that it can be moved by the action of water. If a flood causes the stream to overflow its banks, deposition probably will occur in the overflow section providing the velocity decreases sufficiently. As a flood recedes, sediment may be deposited in the stream channel as the velocity decreases.

A stream carrying a capacity load, as it approaches a reservoir, will deposit the coarsest material where the velocity of the stream is first affected by the reservoir, thus forming a delta. Some fine sediment may be deposited along with the coarse sediment, although most of the fine sediment may be carried further into the reservoir. If the reservoir is of sufficient size, such as Kajakai, essentially all fine sediment is deposited at the bottom of the reservoir before the water moves as far as the outlet at the dam or spillway, and the reservoir is said to have essentially 100 percent trap efficiency. If the reservoir is small, such as Kargha, and sediment-bearing water is released at the outlet of the dam or spillway, the reservoir is said to have less than 100 percent trap efficiency.

THE SEDIMENT PROGRAM

Information Needed

Two basic types of sediment information are needed at a site -- the amount and grain size distribution of the suspended sediment transported and the amount and grain size of the bedload. When a stream deposits sediment in a reservoir, the volume of the sediment deposit depends on the distribution of grain sizes transported into the reservoir. For example, a ton of coarse sand or gravel occupies a volume different than a ton of fine clay, and different combinations of these materials occupy volumes different from either. When a reservoir is planned at a particular site, the storage volume that will be lost to sediment deposits in a given number of years may be calculated with reasonable accuracy if enough accurate sediment data of both types are available.

The suspended-sediment discharge and grain-size distribution at a particular site usually can be determined fairly easily by analyzing enough suspended-sediment samples. Bedload discharge cannot be measured directly by any sampling procedure yet devised and must be calculated by indirect methods, such as the modified Einstein formula. Therefore, the sediment program in Afghanistan consists of obtaining suspended-sediment samples at many carefully selected sites, processing them in the sediment laboratory, computing suspended-sediment discharge for the most important sites and tabulating and filing all data in such a manner that they can be obtained and used easily. Bedload samples will be taken under the direction of specialists at the time that bedload discharges are needed in connection with specific projects.

Operation

Daily suspended sediment samples are taken by station gagement throughout the year at the most important sediment stations. Daily samples are taken only during the flood season at a few other less important sites. At the least important sediment stations, suspended sediment samples are taken only monthly by hydrographers. During monthly visits, hydrographers take check samples at stations that are sampled daily, and take size samples at all sediment stations about six times a year. In general, hydrographers always use the equal-transit rate method. Field observers always use the centroid sampling method.

Clean bottles are carried to the observers by hydrographers who also return the samples taken by observers to the laboratory.

Personnel of the sediment section are responsible for the instruction of new employees of WSSD in sediment operations as well as the training of observers when time allows them to do so. At times, a hydrographer may be called on to train a new observer. The sediment section processes the samples, tabulates the data, and computes suspended sediment discharge.

Sediment Station Classification

It would be desirable to collect sediment data at every gaging station in Afghanistan; but because this is not feasible, a small number of stations has been selected to be included in the sediment data-collection network. Stations have been selected in most parts of the country, however, priority has been given to the larger rivers with the greatest potential for development. To obtain the necessary detailed information at the most important sites and less detailed information at a maximum number of less important sites, sediment stations have been classified into three categories:

Daily Record Station -- a station where sufficient sediment samples are taken to define accurately the sediment concentration at all times during the entire year.

Partial Record Station -- a station where sufficient sediment samples are taken during the high-runoff (flood) season to accurately define the sediment concentration during that period only. Periodic samples are taken during the remainder of the year.

Periodic Sampling Station -- a station where sediment samples are taken only periodically throughout the year. In general, these samples should cover the complete range of sediment concentrations for the entire year.

Additional sediment samples may be taken at other gaging stations not included in the sediment data collection network. Sediment data gathered during abnormally large floods at any gaging station will be of great value.

Selection of Sediment Stations

A map of Afghanistan (figure 5) can be found in the pocket in the rear of this manual. The gaging stations included in the sediment data collection network are plotted as well as the complete network of operational gaging stations in the hydrologic network of the WSSD.

At least one daily or partial record station has been selected in each major river basin. Additional daily or partial record stations are located where detailed information is needed in relation to a particular project, either already in existence or planned for the future. Periodic stations are much more numerous and are located generally where no project is planned for the near future, but where general information is desirable. If a project is conceived for a site near a periodic station, it should be reclassified as a daily or partial record station. In such a case, the data gathered in previous years under the periodic classification will be of great value, even though it is not as detailed as the data gathered afterward. The list of gaging stations included in the sediment data-collection network is subject to change at any time and will be reviewed constantly to be sure that the needs for sediment data are being met.

The following is a list of stream-gaging stations that at present are included in the sediment data-collection network:

	Station	River Basin	Classification
1.	Helmand River at Ghizab	Helmand	Periodic
2.	Kaj River nr Kajiron	Helmand	Partial
3.	Helmand River nr Deh Rawud	Helmand	Daily
4.	Tirin River at Anarjoi	Helmand	Daily
5.	Arghandab River at Maisan	Helmand	Periodic
6.	Arghandab River above Arghandab Reservoir	Helmand	Daily
7.	Tarnak River nr Shahjoi	Helmand	Periodic
8.	Khoram River at Chamkani	Khoram	Periodic
9.	Khal River below Khost	Khal	Periodic
10.	Khojagon Wash above Seraj Reservoir	Ghazni	Periodic
11.	Barriq Ab Wash above Seraj Reservoir	Ghazni	Periodic
12.	Jilga River above Sardi Reservoir	Ghazni	Periodic
13.	Paltu River above Sardi Reservoir	Ghazni	Periodic
14.	Ghazni River above Ab-I-Istada	Ghazni	Periodic
15.	Park (Nahar) River nr Yusuf Khel	Ghazni	Periodic
16.	Arghistan River nr Kandahar	Helmand	Periodic
17.	Helmand River nr Chaharburjak	Helmand	Daily
18.	Khash River at Dileram	Khash	Periodic
19.	Malman River nr Shawalat	Farah	Periodic
20.	Farah River at Petch-I-Tangi	Farah	Periodic
21.	Adraskand River at Adraskand	Adraskand	Periodic
22.	Hari River at Tagab Gaza	Hari	Daily
23.	Kowgon River at Langar	Hari	Periodic

	Station	River Basin	Classification
24.	Hari River at Marwa	Hari	Daily
25.	Murghab River at Bala Murghab	Murghab	Daily
26.	Shirin Tagab River nr Maimana	Shirin Tagab	Partial
27.	Shirin Tagab at Patababa	Shirin Tagab	Periodic
28.	Balkh River at Naiak	Balkh	Periodic
29.	Balkh River at Chisma Shefa	Balkh	Daily
30.	Khulm River nr Sayad	Khulm	Periodic
31.	Kokcha River nr Baharak	Kokcha	Daily
32.	Warduch River at Baharak	Kokcha	Periodic
33.	Warduch River below Baharak	Kokcha	Partial
34.	Kokcha River nr Kishm	Kokcha	Daily
35.	Kishm River nr Kishm	Kokcha	Periodic
36.	Bangi River at Pul-i-Bangi	Kunduz	Periodic
37.	Khanabad River at Pul-i-Alcin	Kunduz	Periodic
38.	Khanabad River at Pul-i-Chuga	Kunduz	Periodic
39.	Kunduz River at Char Darra	Kunduz	Periodic
40.	Logar River nr Kabul	Kabul	Periodic
41.	Kabul River at Tangi Garu	Kabul	Daily
42.	Panjshir River at Omers	Kabul	Periodic
43.	Panjshir River at Gulbahar	Kabul	Daily
44.	Shatol River nr Gulbahar	Kabul	Periodic
45.	Ghorband River at Pul-i-Asawa	Kabul	Periodic
46.	Laghman River at Pul-i-Qarghai	Kabul	Periodic
47.	Kunar River at Pul-i-Kama	Kabul	Periodic

The Sediment Section

The sediment section consists of two or more technicians under the administrative supervision of an engineer.

It is the responsibility of the supervising engineer to be sure that the sediment program is being carried out as planned. He re-evaluates the program at frequent intervals so that changes can be made to meet new needs for sediment data as they arise. Only with his approval are sediment stations reclassified, or other stations added to or removed from the sediment network. It is his responsibility to be sure that the technicians of the sediment section carry out their work as scheduled, and that all engineers and technicians of the WSSD carry out their field work as scheduled by the sediment section.

At least two technicians are assigned to the sediment section at all times because of the heavy workload when the sediment program is in full operation. Considerable training is necessary before a technician is able to do his work properly. All technicians assigned to the section must have a complete understanding of the entire sediment program and be able to function efficiently in both the field and laboratory. It is the responsibility of these technicians to carry out the routine operations of the sediment program. In addition to the work assigned them by the supervising engineer, their responsibilities include the following:

(1) Advise the supervising engineer when special problems arise that require his personal attention.

(2) Advise the supervising engineer well in advance when laboratory supplies are to be re-ordered.

(3) Draw up sampling schedules for all sediment stations, and

coordinate with hydrographers going on field trips so that these schedules will be followed.

(4) Arrange for hydrographers to deliver clean sample bottles to observers at sediment stations and pick up the samples taken by the observer and deliver them to the sediment laboratory.

(5) Maintain an adequate supply of clean sample bottles at all times to meet the requirements of both observers and hydrographers.

(6) Process all sediment samples as soon as possible after they are brought in from the field.

(7) Obtain from the hydrology section all necessary data from discharge measurements made at sediment stations and daily discharges computed for those stations. Obtain all data from the labels on sample bottles. These data will be kept up to date and filed at the sediment laboratory.

(8) Compute daily suspended-sediment discharges for the required sediment stations.

(9) Make field trips as required to check on the techniques and procedures followed by both hydrographers and observers in obtaining sediment samples.

(10) Instruct all new employees of the WSSD in the techniques used in taking sediment samples as well as all other aspects of field operations connected with the sediment program.

(11) Train observers for sediment stations in the techniques they must use when taking daily sediment samples.

At least one engineer or technician remains in the laboratory at all times so that laboratory work will not fall behind. Samples are processed as soon as possible so that sample bottles can be washed and returned to the field for use without delay. The other engineers or technicians can be in the field keeping a close check on the sediment program and assisting hydrographers in taking sediment samples. All members of the sediment section should take turns doing field and laboratory work so that they will be thoroughly familiar with all phases of the program.

FIELD OPERATIONS

Sampling Methods

Two methods for taking suspended-sediment samples are used in Afghanistan. The centroid method is used by observers at daily record stations and partial record stations where daily sediment samples are collected. The equal-transit rate, or ETR, method is used by hydrographers as a check against the observer's samples. Also, a minimum of six times a year, size samples are obtained by taking duplicate ETR samples when check samples are taken.

It is important for the hydrographer to understand the reasons that the different sampling methods are used. The centroid method is used for taking daily samples because fewer sample bottles are required than with the ETR method. About 93 to 124 bottles are needed each month per station for the centroid method whereas the ETR method would require about 120 to 310. Also, while hydrographers of WSSD have the educational background and streamgaging experience required to take accurate ETR samples, it is difficult to find similarly qualified observers in the farming communities of the countryside.

The ETR method is used when check samples are taken because it is the most accurate method for sampling sediment concentrations. The concentrations obtained from daily centroid samples can be adjusted by calculating a ratio between them and the concentrations obtained from the check samples if there is very much difference between the results of the two different methods.

The ETR method must be used when taking size samples because it is the only practical method for obtaining a representative sample of the suspended sediment passing a given cross section of the flow.

Sampling Equipment

Three different kinds of samplers are used: DH-48 wading sampler, DH-59 hand-line sampler, and D-49 reel-mounted sampler. All are designed to take accurate depth-integrated suspended-sediment samples. Identical glass sample bottles are used in all three samplers. A brass nozzle is hand-screwed into the front of each sampler and provides the intake passage for the sample into the bottle. The nozzles should be used only with the type of sampler for which they are designed. D-49 samplers are supplied with nozzles in three sizes: 1/4-inch, 3/16-inch and 1/8-inch inside diameters. These can be used in any D-49 sampler but must not be used in DH-59 or DH-48 samplers. DH-59 samplers are also supplied with nozzles in three sizes: 1/4-inch, 3/16-inch and 1/8-inch inside diameters. These can be used in any DH-59 sampler but must not be used in any other type sampler. DH-48 samplers are supplied with 1/4-inch nozzles only and are designed to be used with only those nozzles. The following table should help the hydrographer avoid the mistake of using the wrong nozzle:

Sampler	Length	Exhaust end of nozzle tapered 1/4-inch per foot about 1-inch deep	Flat place on knurled collar of nozzle
DH-48 (wading)			
1/4-inch nozzle only	4-1/8-inches	No	No
DH-59 (hand line)			
1/4-inch	4-1/8 inches	Yes	No
3/16-inch	4-1/8 inches	Yes	No
1/8-inch	4-1/8 inches	Yes	No
D-49 (reel mounted)			
1/4-inch	3-7/8 inches	Yes	Yes
3/16-inch	3-7/8 inches	Yes	Yes
1/8-inch	3-7/8 inches	Yes	Yes

Each sampler has an exhaust hole on one side to allow air to escape from the bottle. All three samplers function in the same manner. As long as the sampler is submerged in the river with the nozzle pointing upstream, a continuous stream of river-water is taken into the sample bottle at about the same velocity as the velocity of the stream at that point. As the water-sediment mixture enters the bottle, air is allowed to escape out the exhaust hole.

The DH-48 wading sampler consists of a streamlined aluminum casting and weighs about 3-1/2 pounds (figures 6 and 7). It is designed to be attached to the standard round wading rod, and is used for obtaining samples while wading shallow streams.

The DH-59 hand-line sampler is made of cast bronze and weighs about 22 pounds (figures 8 and 9). It is designed to be attached to a hand line or length of strong rope, and is raised and lowered by hand from a

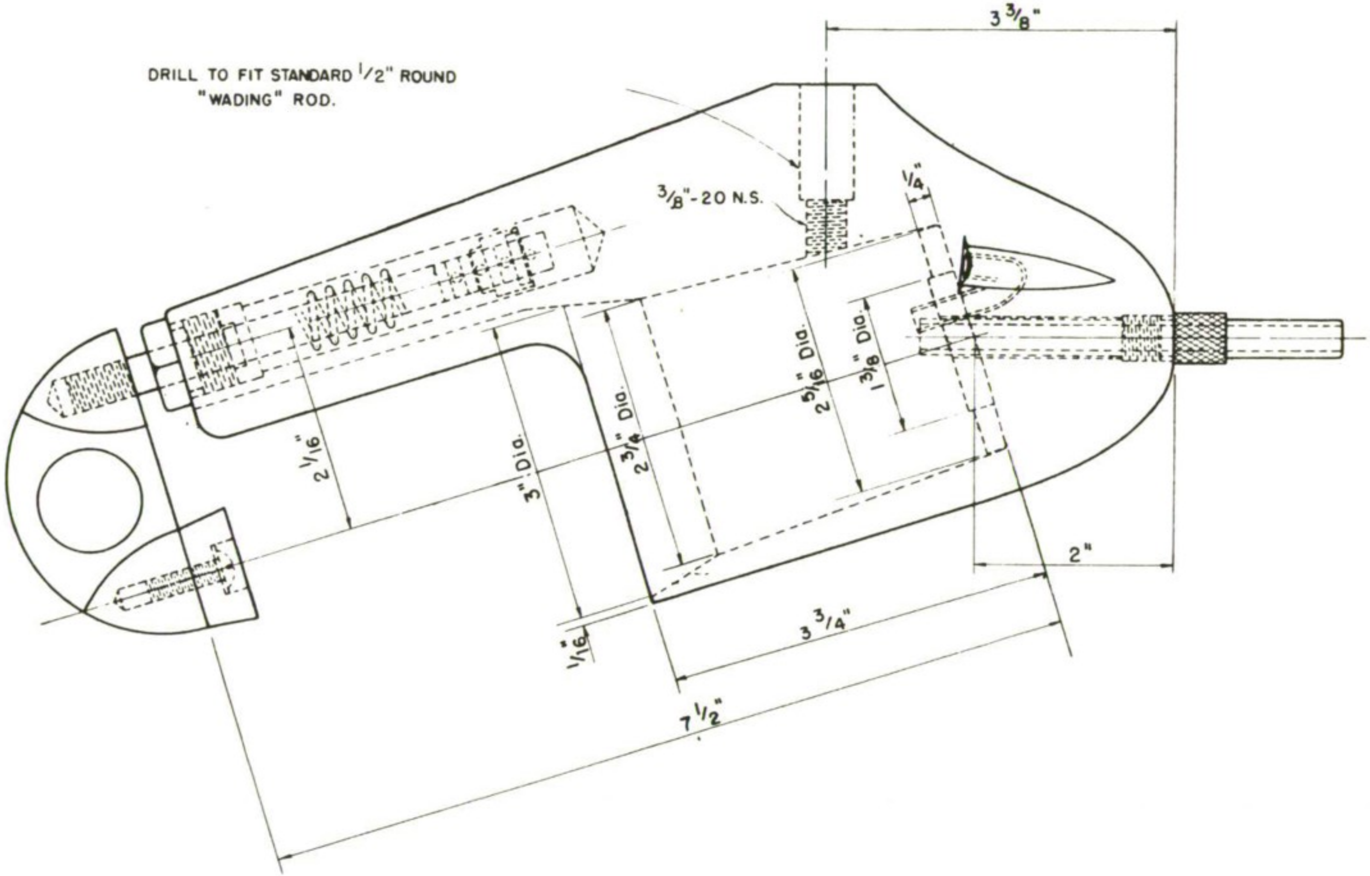


Figure 6. --Diagram of Depth-Integrating Suspended-Sediment DH-48 or Wading Sampler.

Figure 7.-- Photograph showing DH-48 wading sampler in use.

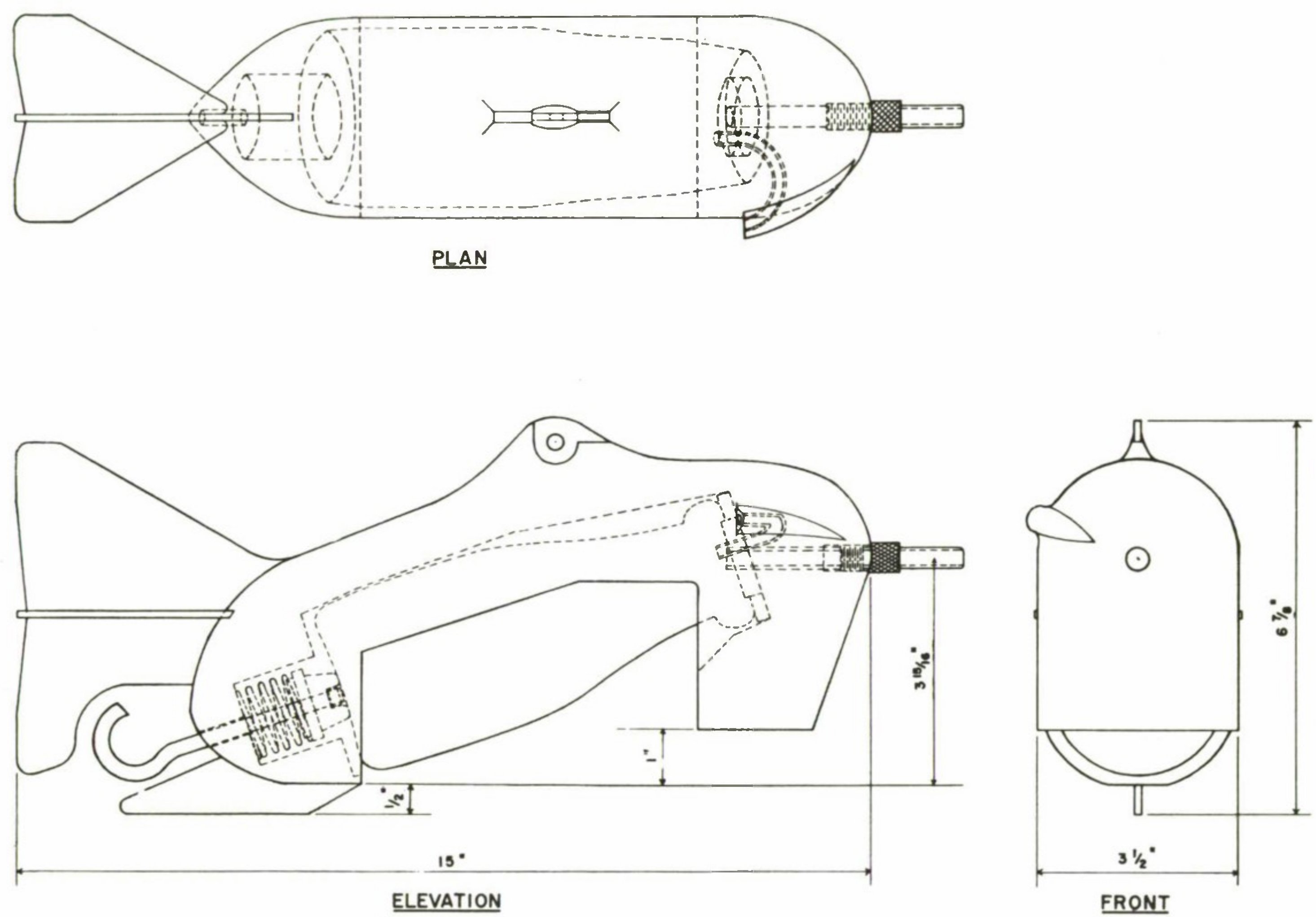


Figure 8.-- Diagram of depth-integrating suspended-sediment DH-59 hand-line sampler.

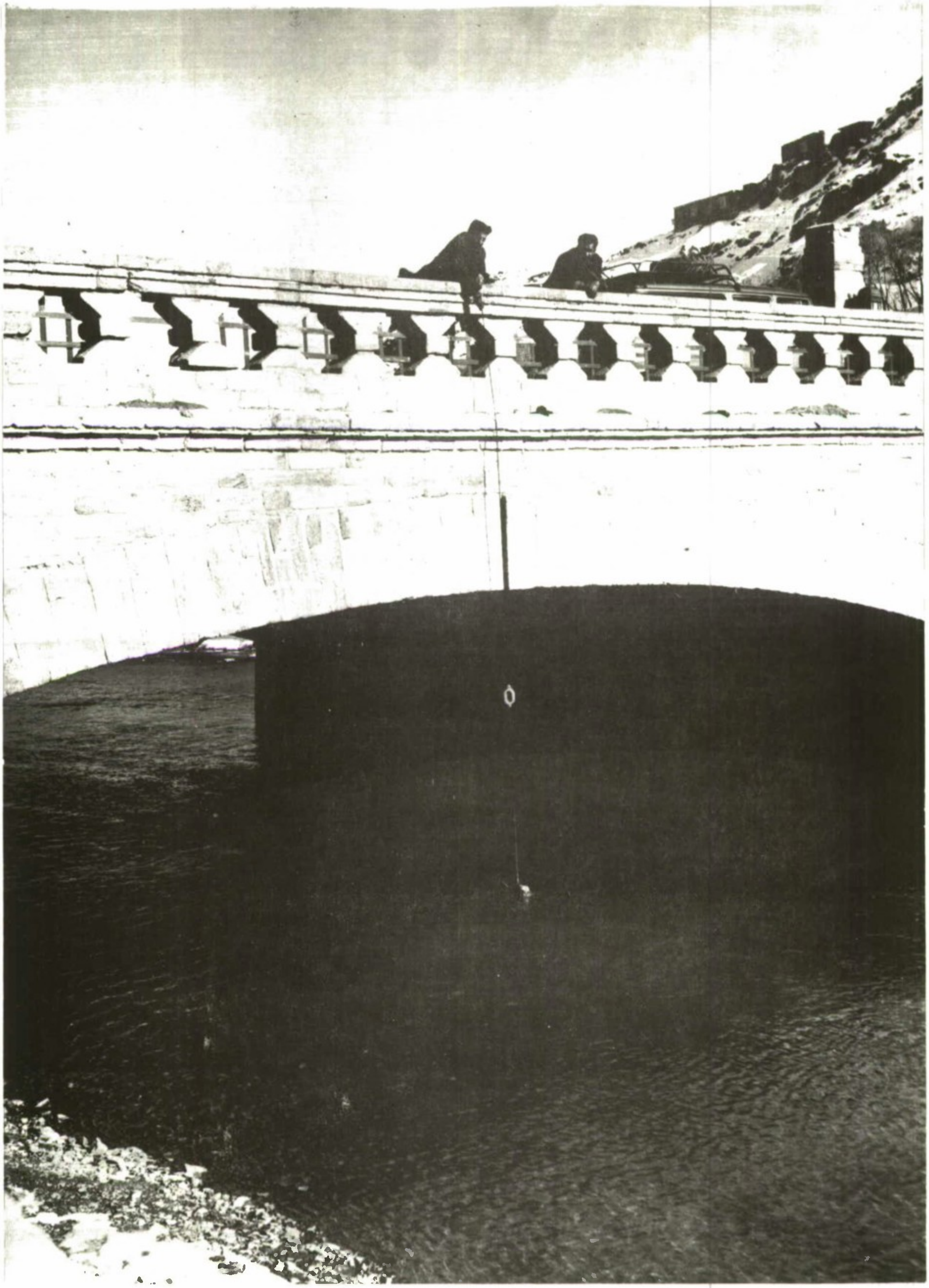


Figure 9.-- Photograph showing DH-59 hand-line sampler in use.

cable car or bridge. Since it is lightweight and requires no reel or other costly equipment for operation, it is ideally suited for use by observers at sediment stations. It can be used to sample rivers up to 15 feet deep providing the velocities are not too high.

The D-49 sampler (figures 10 and 11) is made of cast bronze, weighs about 62 pounds, and is more streamlined than the hand-line sampler. It is designed to be suspended from a reel that is mounted on a cable car or bridge crane. It also can be used to sample rivers up to 15 feet deep, and because it is heavier and more streamlined than the hand-line sampler, it can be used to obtain accurate samples in higher velocities. Thus, it is well suited for use by hydrographers in the field.

The glass sample bottle used in the samplers has a capacity of about 470 ml (figure 12). Because of the locations of the intake nozzle and exhaust hole on all samplers, and because the bottle is at an angle from the vertical, any sample containing more than about 440 ml may be in error due to circulation of the sample out the exhaust hole. Any bottle filled to a level between 300 and 400 ml is preferable. At least 250 ml is usually required for accurate analysis of the sample in the laboratory.

Sample bottle carrying cases are of three types (figure 13). The American type is made of hardwood, sheet metal and wire, and will hold 20 bottles. The other two types are designed especially for use in Afghanistan; each of these will hold 24 bottles and each has a cover. Although one is made of wood and the other from sheet metal, both types have wood partitions that separate the bottles to protect them from breaking when in transit. Although samples always should be protected

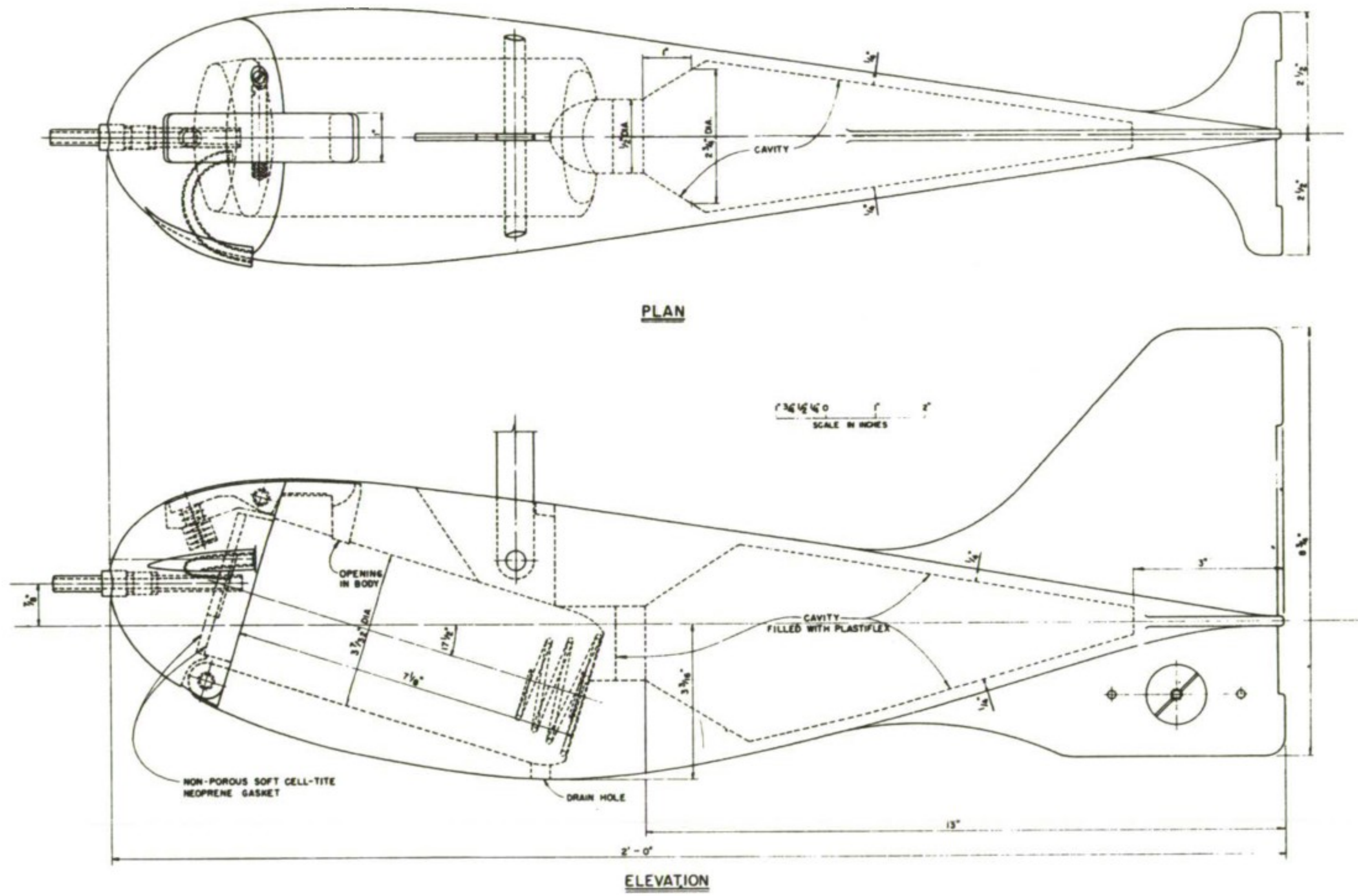


Figure 10.-- Diagram of depth-integrating suspended-sediment D-49 reel-mounted sampler.

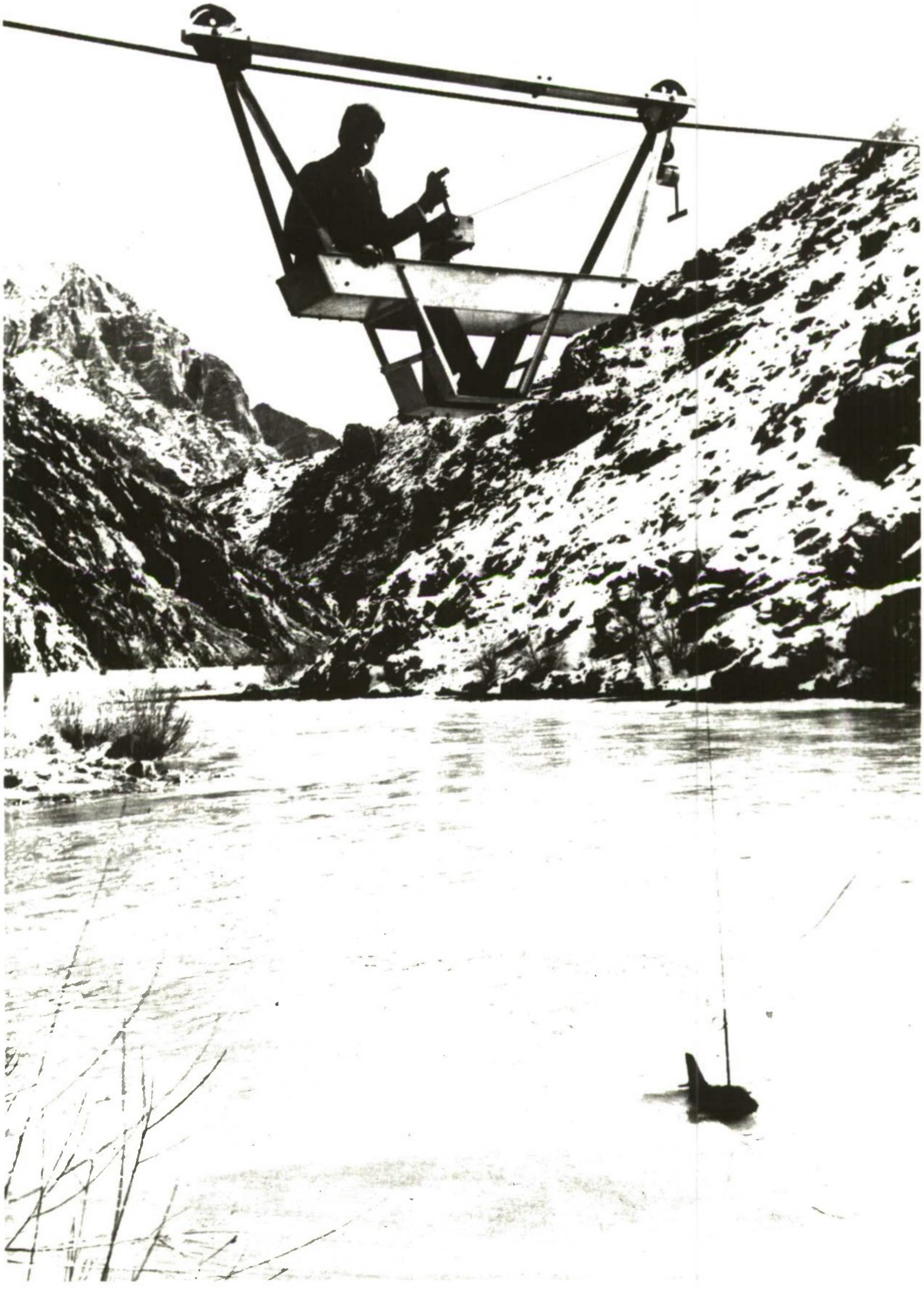


Figure 11.-- Photograph showing D-49 reel-mounted sampler in use.

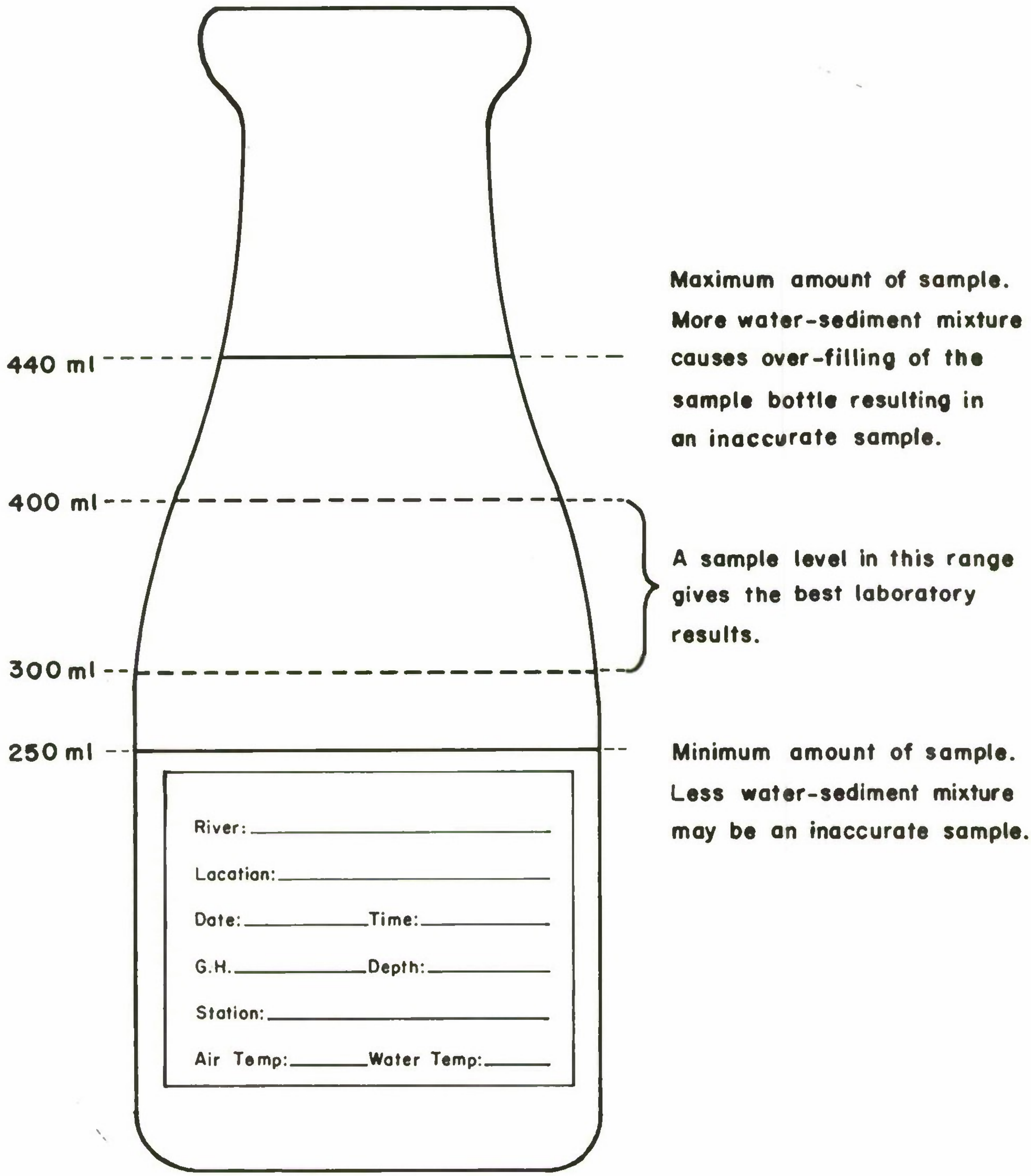


Figure 12.-- Diagram of glass sample bottle used in the DH-48, DH-59 and D-49 samplers.

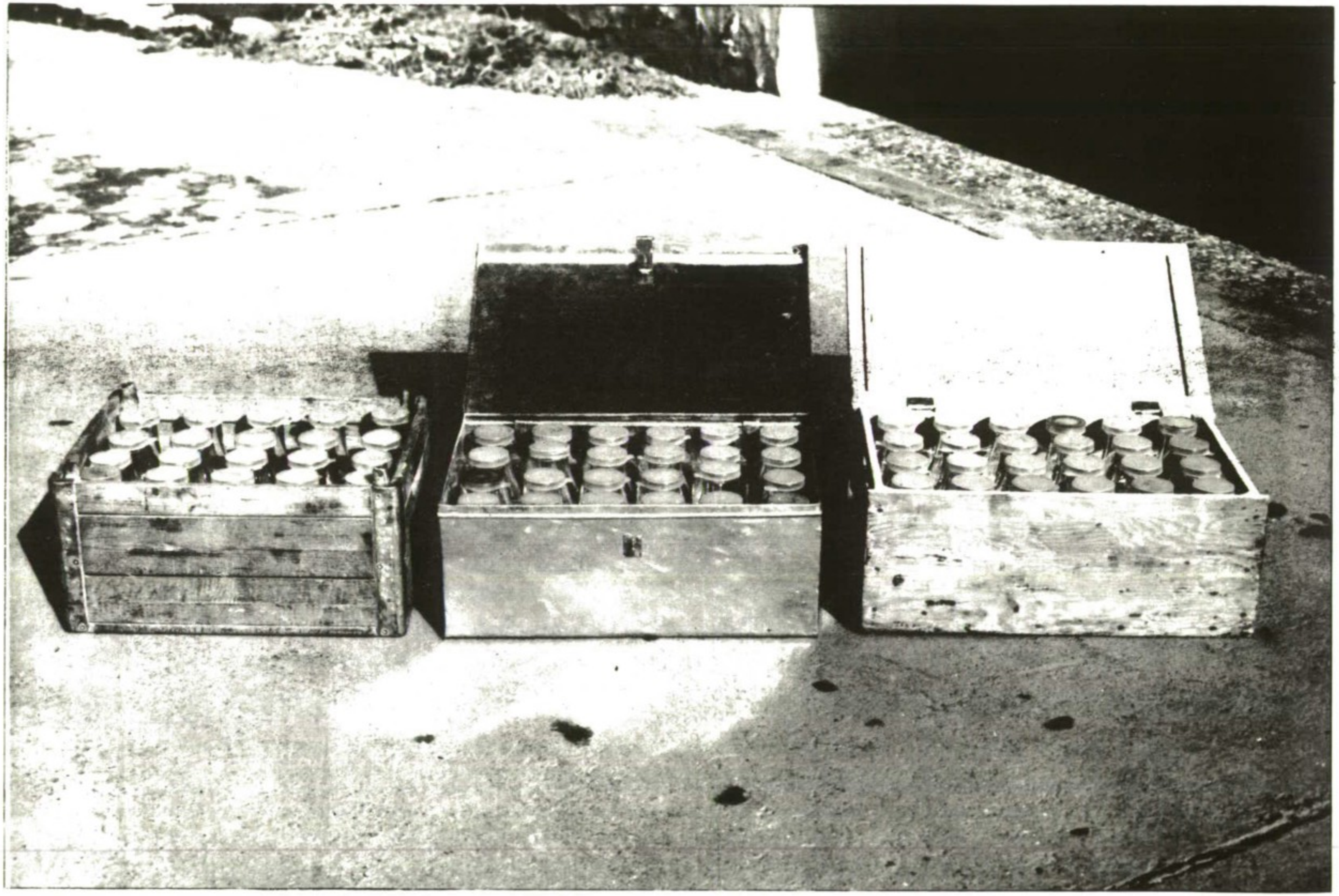


Figure 13.-- Photograph showing three types of suspended-sediment sample bottle carrying cases used in Afghanistan.

from freezing by storing indoors in a heated room, they can receive additional protection by filling the case with sawdust after the samples are placed inside the case.

Sampling Techniques

The centroid method is used by observers at all daily and partial record stations following the sampling schedules established for those stations. When hydrographers make discharge measurements at those stations. it is their responsibility to compute the locations of the centroids at which the observers will take samples during the following month.

When the flow in the measuring section is confined to a single channel, three centroids should be selected using the following procedure:

(1) Make a discharge measurement and compute it immediately (figure 14).

(2) Find the mid-points (stationing on the tag-line, cable or bridge railing) of three parts of equal discharge. Using the example in figure 14 as a guide, use the following procedure:

(a) Divide the total discharge into three equal parts

$380 \div 3 = 127$ (all numbers rounded)

(b) Beginning with the first sub-section discharges in the last column on the right of the discharge measurement, total the sub-discharges until the total is closest to the number 127.

0 + 1.3 + 2.8 Z 4.8 + 6.3 + 7.6 + 8.4 + 9.3 + 10.4 + 11.1 + 11.8 + 11.8 + 13.0 + 12.8 + 12.3 = 123.7

angle coeff.	dist. from initial point	width	depth	obs. depth	rev-olu-tions	time in sec-onds	VELOCITY at point	VELOCITY mean in vertical	adjusted for hor. angle or	area	discharge
		LEW	@1445								
	25	1.0	0							0	0
	27	2.5	1.0	.5	10	46	0.51			2.5	1.3
	30	4.0	1.2	.6	10	40	0.58			4.8	2.8
	35	5.0	1.4	.6	20	67	0.69			7.0	4.8
	40	5.0	1.6	.6	20	58	0.79			8.0	6.3
	45	5.0	1.8	.6	20	54	0.85			9.0	7.6
	50	5.0	1.9	.6	20	52	0.88			9.5	8.4
(56)	55	5.0	2.0	.6	20	49	0.93			10.0	9.3
	60	5.0	2.2	.6	20	48	0.95			11.0	10.4
1500	65	5.0	2.2	.6	20	45	1.01			11.0	11.1
	70	4.5	2.3	.6	20	40	1.13			10.4	11.8
	74	4.0	2.4	.6	30	55	1.23			9.6	11.8
	78	4.0	2.4	.6	30	50	1.35			9.6	13.0
	82	35	2.5	.8	30	52	1.29	1.46		8.8	12.8
				.2	30	41	1.64				
	85	30	2.6	.8	30	49	1.38	1.58		7.8	12.3 (123.7)
				.2	40	50	1.79				
	88	3.0	2.7	.8	30	46	1.47	1.69		8.1	13.7
				.2	40	47	1.91				
	91	3.0	2.9	.8	30	43	1.56	1.82		8.7	15.8
1515				.2	40	43	2.08				
	94	3.0	3.0	.8	30	40	1.68	1.96		9.0	17.6
				.2	40	40	2.23				
(97)	97	3.0	3.1	.8	40	50	1.79	2.08		9.3	19.3
				.2	50	47	2.38				
	100	2.5	3.2	.8	40	48	1.87	2.20		8.0	17.6
				.2	50	44	2.53				
	102	2.0	3.2	.8	40	47	1.91	2.28		6.4	14.6
				.2	50	42	2.65				
	104	2.0	3.2	.8	40	46	1.95	2.36		6.4	15.1
1530				.2	50	40	2.78				

	106	2.0	3.2	.8	40	45	1.99	2.44		6.4	15.6
				.2	60	46	2.90				(129.3)
	108	2.0	3.2	.8	40	44	2.03	2.54		6.4	16.3
				.2	60	44	3.04				
	110	2.0	3.3	.8	40	44	2.03	2.60		6.6	17.2
				.2	60	42	3.18				
	112	2.0	3.3	.8	40	44	2.03	2.60		6.6	17.2
				.2	60	42	3.18				
	114	2.0	3.2	.8	40	44	2.03	2.57		6.4	16.4
1545				.2	60	43	3.11				
	116	2.0	3.0	.8	40	45	1.99	2.48		6.0	14.9
				.2	60	45	2.97				
(118)	118	2.0	2.7	.8	40	46	1.95	2.36		5.4	12.7
				.2	50	40	2.78				
	120	2.0	2.5	.8	40	48	1.87	2.20		5.0	11.0
				.2	50	44	2.53				
	122	2.0	2.3	.6	40	45	1.99			4.6	9.2
	124	2.0	1.9	.6	40	52	1.72			3.8	6.5
	126	2.0	1.5	.6	30	49	1.38			3.0	4.1
	128	1.5	1.2	.6	20	47	0.97			1.8	1.7
	129	.5	0							0	0 (127.2)
	REW @ 1600										
										236.9	380.2
							ROUNDED			237	380
										÷3 =	(127)
	THREE CENTROIDS										
	LOCATED AT										
	STATIONS:		56								
			97							CHECK	127.2
			118								129.3
											123.7
											380.3

Figure 14.-- Example of a typical discharge measurement showing the selection of three centroids.

By adding one more sub-discharge, the total would become 137.4, so we find that 127 cfs is flowing in the stream between stations 25 (left edge of water) and about station 86 (since the number 127 is closer to 123.7). The midpoint of this 127 cfs is at station 56

$$\frac{86 + 25}{2} = \frac{111}{2} = 55.5 = 56 \text{ (rounded to nearest foot)}$$

therefore, station 56 is the mid-point of the first 1/3 of the total discharge, also called the first centroid.

(c) Resume totaling the sub-discharges, beginning with the next number:

13.7 + 15.8 + 17.6 + 19.3 + 17.6 + 19.3 + 17.6 + 14.6 + 15.1 + 15.6 = 129.3

This shows that 127 cfs is flowing between stations 86 and about station 107. The mid-point of this 127 cfs is station 96:

$$\frac{86 + 107}{2} = \frac{193}{2} = 96.5 = 96 \text{ (rounded to nearest foot)}$$

therefore, station 96 is the second centroid.

(d) The total of the remaining numbers is found to be 127.3, therefore 127 cfs is flowing between stations 107 and 129 (right edge of water) and its mid-point is at station 118:

$$\frac{107 + 129}{2} = \frac{236}{2} = 118$$

therefore, station 118 is the third centroid.

(e) As a check against addition, the three parts of nearly equal discharge should total 380.3, which was the original discharge already computed

$123.7 + 129.3 + 127.3 = 380.3$

thus the addition is proved correct.

Therefore, the three centroids at which the observer will take samples for the following month are located at stations 56, 96, and 118 on the bridge-railing, cable or tag line (figure 15).

(3) Mark the three stations on the cable or bridge railing with flagging or by any other effective method. When samples are to be obtained by wading, the discharge measurement should be made directly underneath the cableway or bridge if possible. When the centroids are computed from the tag-line stationing, they can be marked on the cableway or bridge directly above the tag line. Then no good measuring section can be found under a cableway or bridge, and the discharge measurement is made at another location, the hydrographer may measure the locations of the centroids by the number of steps into the stream from one bank.

(4) Check the technique used by the observer as he takes samples.

(5) Pick up the samples collected by the observer during the previous month and leave enough clean bottles to last until the next visit by a hydrographer. Be sure that the observer has recorded all necessary information on the labels of all sample bottles.

Occasionally it will be necessary to compute the locations of centroids for a cross section at which the flow has divided into two or more channels. Several different conditions may be encountered and the following procedures should be used:

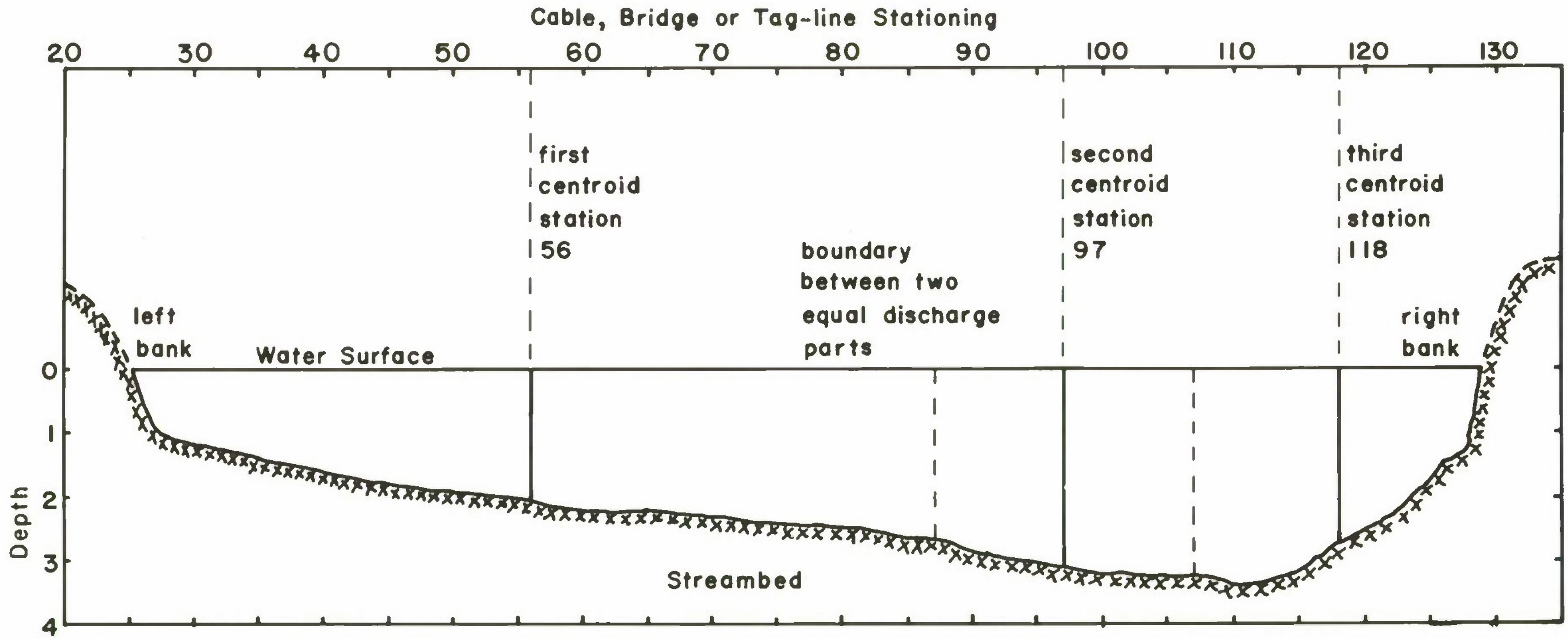


Figure 15.-- Illustration showing cross section of a stream (from figure 14) with locations of three centroids and boundaries between parts of equal discharge.

(1) Two channels:

(a) If the smaller channel has less than 15 percent of the total flow, it can be ignored, and only three centroids will be computed for the main channel as previously described.

)) If the smaller channel has between 15 and 40 percent of the total flow, three centroids will be selected, with one in the smaller channels and two in the main channel.

(c) If the two channels are about the same size, four centroids should be selected, two in each channel.

(2) Three channels:

(a) If each of the two smaller channels has less than 15 percent of the total flow, they can be ignored, and only three centroids will be selected in the main channel.

(b) If the smallest channel has less than 15 percent and the other small channel has between 15 and 40 percent of the total flow, three centroids should be selected, two in the main channel and one in the middle-sized channel.

(c) If each of two small channels has more than 15 percent of the total flow, and the main channel has about 50 percent four centroids should be selected, one for each small channel and two for the main channel.

(d) If the three channels are approximately equal in flow, three centroids should be selected, one for each channel.

(3) If more than three channels are found at a measuring section, the hydrographer must exercise his own judgment in locating the centroids, fllowing, in general, the procedures explained for

centroids for three channels.

Reasonably accurate concentrations of suspended sediment can be obtained from samples taken by the centroid method when three or more centroids are selected for a cross section. When several channels of flow exist in a cross section and samples are taken at only one point in these smaller side channels, the overall accuracy of the set of sample declines. The only answer to this problem is to rely more heavily on the check samples, and to adjust the daily concentrations by the resulting ratios.

When the hydrographer checks the technique used by the observer, it is his responsibility to be sure that accurate samples are being obtained. At times, the hydrographer will find it necessary to change the size of the nozzle on the sampler used by the observer. He also must be sure the felt washer is in place in the head of the sampler and that no water is leaking out of the sampler as it is being raised from the water surface to the bridge railing or cable car. He must observe the transit rate to be sure it is constant. He must check the rope on the DH-59 sampler for frayed or worn places, which may cause the rope to break and result in the loss of the sampler.

When a stream is very shallow and the hand-line sampler cannot be used effectively, a DH-48 wading sampler is used by the observer. The same procedure is followed as with the hand-line sampler except that the observer must wade the stream in order to take the samples. The DH-48 sampler is attached to a standard round wading rod, and is lowered into the water at a constant transit rate with the nozzle pointed upstream in the same manner as described for the hand-line sampler. The observer takes daily samples by placing himself in the river directly beneath the three flags, or marks, that were placed by the hydrographer on the bridge railing or cableway, or at whatever other locations the hydrographer selects.

These instructions should be passed on orally by the hydrographer when training observers.

When an observer takes samples from a bridge or cableway, he will use the hand-line sampler with the following technique:

(1) Place a clean bottle in the sampler. Be sure that the felt washer is in place in the head of the sampler.

(2) At the station for the first centroid, lower the sampler to a point where the bottom barely touches the water surface. The flowing water will press on the tailfin of the sampler causing it to swing downstream pointing the nozzle upstream into the flow. Do not allow the nozzle to become submerged until the sampler is in this position and the nozzle is pointed directly into the flow.

(3) As soon as the sampler is in the proper position, slowly lower it into the river, using a constant transit rate until it touches the streambed. The sampler should not be allowed to remain on the streambed. Immediately raise the sampler toward the surface of the stream, once again using a constant transmit rate.

(4) When the sampler rises out of the water, immediately raise it to the bridge or cable car and carefully remove the bottle from the sampler.

(5) Place a cap firmly on the top of the bottle and record all of the required information on the bottle label (figure 16).

(6) Repeat this procedure at the remaining centroids. The transit rates may be different at each centroid.

(7) After gaining experience, the gageman should be able to select a transit rate most of the time that will cause the bottle to fill to the proper level on the first attempt at each centroid. He will be sampling his station every day and will come to know it very well. It is, of course, very important that he be instructed properly when he is first hired and carefully checked frequently to be sure he develops no bad habits. The following are a few suggestions to help the gageman and the hydrographer to obtain good samples.

(a) If a transit rate has been selected that is too fast, and the bottle is not filled to the proper level (minimum 250 ml, see page 26), the same bottle can be placed back in the sampler, being careful not to spill any sample, and once again lowered to the water surface. Another sample then may be added at that same centroid, by using a transit rate that will fill the bottle to the proper level. If in doubt as to the accuracy of the sample, a clean bottle should be used, and another sample taken at a slower transit rate.

(b) Whenever debris is found on the nozzle, the sample should be thrown out, the dirty bottle set aside, a clean bottle placed in the sampler and another sample taken. If debris is found inside a nozzle, it usually can be cleared by

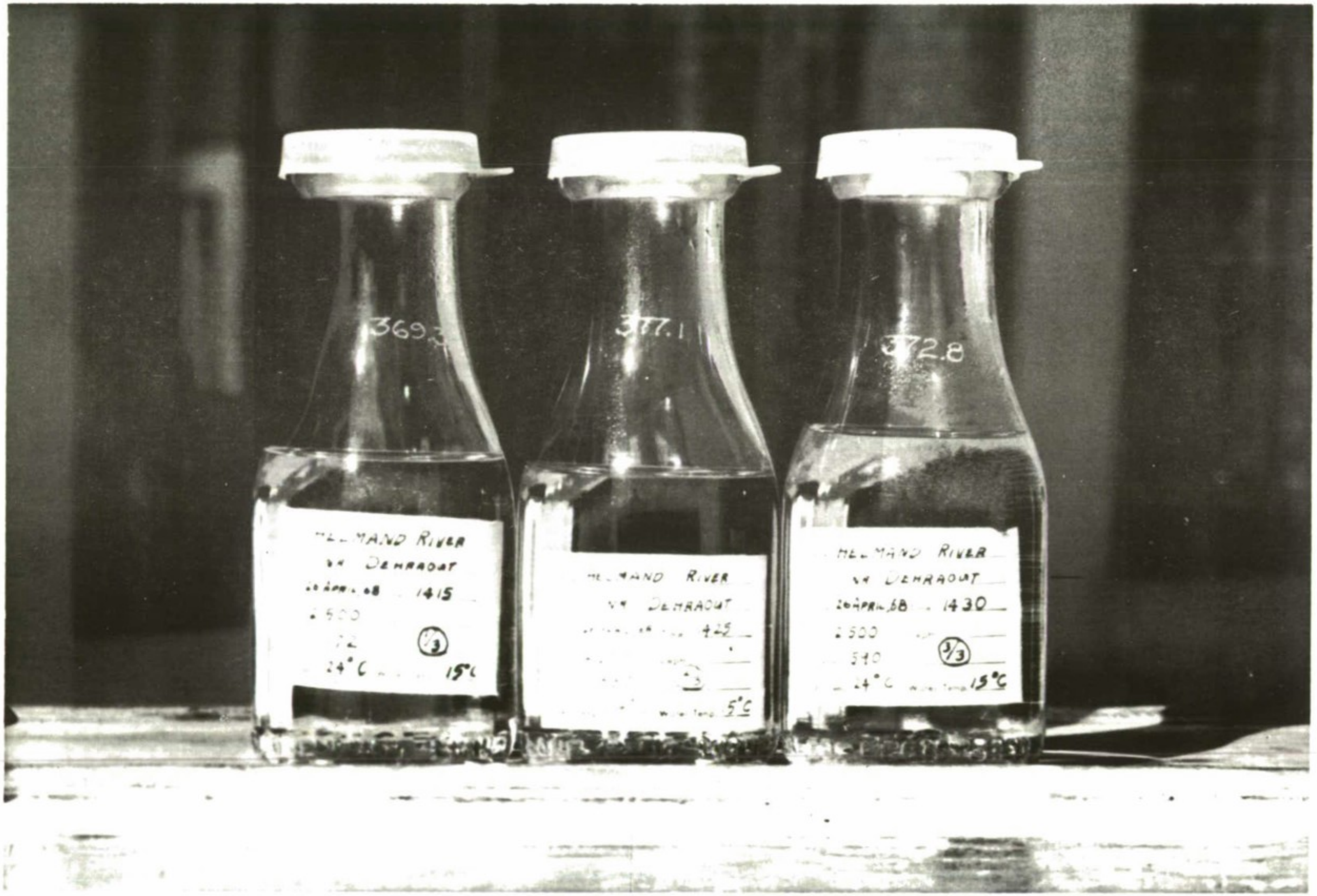


Figure 16.-- Information required on labels of suspended-sediment sample bottles when the centroid method is used.

blowing through it.

(c) If a bottle does not obtain as much water at a centroid as experience indicates that it should for that depth and velocity, the sample should be thrown out, and another sample taken in a clean bottle. It may be that a piece of debris has been caught on the nozzle for only part of the time that the sampler was submerged, and was washed off before it was raised out of the water.

(d) If the gageman sees water draining out from the nozzle, when he is raising the sampler from the water surface, it means the bottle is over-filled, and the sample should be thrown out and another sample taken in a clean bottle at a faster transit rate.

(e) If he sees more water than usual draining from the sampler, when he raises the sampler from the water surface, it may mean that the bottle was placed improperly in the sampler and that some of the sample has leaked out around the gasket. In this case, he should discard the sample and take another sample in a clean bottle.

The <u>Equal-Transit-Rate method</u> is used by hydrographers in taking check samples and size samples. The procedures differ considerably from those for the centroid method. In the centroid method, a different transit rate often is used at each of the three sampling points, in each case a transit rate should be used that will cause that single bottle to be filled to the proper level. In contrast, in the ETR method a single uniform transit rate is used at <u>all</u> sampling verticals. The transit rate must be one that causes the bottle used in the deepest, fastest sampling vertical to be filled to the proper level. Usually, in the ETR method, between four and ten bottles are used to obtain the complete sample. It is best to take a discharge measurement before sampling, because useful information is gained about the depths and velocities.

The following procedure should be used for ETR sampling:

(1) Select 10 to 20 equally-spaced points in the cross section for sampling verticals (figure 17).

(2) By selecting the values of velocity and depth from the discharge measurement for the <u>deepest</u> and <u>fastest</u> sampling vertical, and by studying tables 1 and 2 and following the instructions on pages 43-47, select a transit rate that will fill a single bottle to the proper level in that vertical.

(3) Place a bottle in the sampler. When wading, use the DH-48 wading sampler; when sampling from a bridge or cable car, use the D-49 sampler suspended from a reel. Be sure that the felt washer is in place in the front of the sampler.

(4) Using the transit rate selected, take a sample in the first vertical. If it is possible to do so without overfilling, use the same bottle and take a sample at the second vertical.

(5) Continue sampling across the river at the preselected sampling verticals, changing bottles only when necessary in order to prevent overfilling. It is generally possible to use a single bottle at two or three sections in the slower, shallower parts of the river while in the deeper, faster parts only one bottle will be used per vertical.

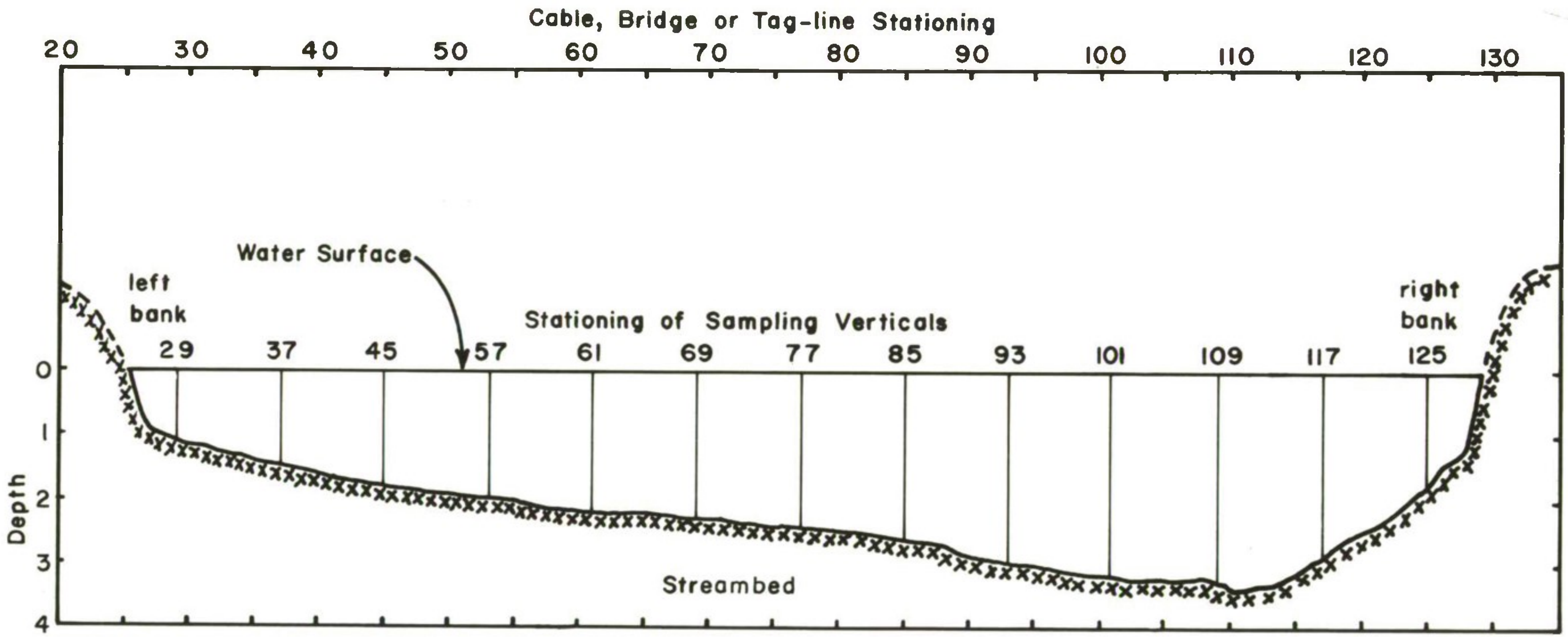


Figure 17.-- Illustration showing cross section of a stream (from figure 14) with locations of 13 sampling verticals selected for using the equal-transit-rate (ETR) sampling method.

Table 1. Total filling time for suspended-sediment sample bottles for about 395 ml of water-sediment mixture (stream velocity in FEET PER SECOND).

AVERAGE STREAM VELOCITY (FEET PER SECOND)	FILLING TIME, IN SECONDS		
	SIZE OF NOZZLE		
	1/4-INCH	3/16-INCH	1/8-INCH
1.0	42	72	165
1.5	28	50	110
2.0	21	37	85
2.5	17	29	65
3.0	14	25	55
3.5	12	21	48
4.0	11	19	42
4.5	9	17	36
5.0	8	15	33
5.5	8	14	30
6.0	7	12	27
6.5	6	11	25
7.0	6	11	23
7.5	6	10	21
8.0	5	9	20
8.5	5	8	19
9.0	5	8	18
9.5	4	8	17
10.0	4	7	17

Table 2. Total filling time for suspended-sediment sample bottles for about 395 ml of water-sediment mixture (stream velocity in METERS PER SECOND).

AVERAGE STREAM VELOCITY (METERS PER SECOND)	FILLING TIME, IN SECONDS SIZE OF NOZZLE 1/4-INCH	3/16-INCH	1/8-INCH
0.25	47	80	118
0.50	24	42	94
0.75	18	30	63
1.00	13	23	51
1.25	11	19	41
1.50	8	15	33
1.75	7	13	29
2.00	6	11	24
2.25	6	10	21
2.50	5	9	20
2.75	5	8	18
3.00	4	7	17

(6) Enter the required information on the labels of all bottles (figures 18 and 19). These should all be marked "ETR" and numbered in the following manner: if there are six bottles used for the total set of samples, they should be marked 1/6, 2/6, 3/6, 4/6, 5/6 and 6/6, meaning that the bottle marked 3/6 is bottle number 3 in a set of 6 bottles.

The following example illustrates the procedure to be used for selection of a proper transit rate when using the ETR method. Assume that a discharge measurement has been made, and the deepest, fastest vertical in the cross section is 3.3 feet deep with a velocity of 2.9 feet per second. The dept of 3.3 feet indicates that the sampler must travel a total vertical distance of 6.6 feet (3.3 feet down and 3.3 feet up). Table 1 shows that 26 seconds are required to fill a sample bottle to the proper level in water flowing at 2.9 feet per second if the 3/16-inch nozzle is used, and 14 seconds if the 1/4-inch nozzle is used. Based on this information, the transit rate can be calculated by the formula:

$$\text{transit rate} = \frac{\text{depth in deepest section x 2}}{\text{filling time for sample bottle}}$$

if the 3/16-inch nozzle is used:

$$\text{transit rate} = \frac{\text{3.3 feet x 2}}{\text{26 seconds}} = \frac{\text{6.6 feet}}{\text{26 seconds}} = \text{0.25 feet per second}$$

and if the 1/4-inch nozzle is used:

$$\text{transit rate} = \frac{\text{3.3 feet x 2}}{\text{14 seconds}} = \frac{\text{6.6 feet}}{\text{14 seconds}} = \text{0.47 feet per second}$$

Because the hydrographer cannot move the sampler at a transit rate of exactly 0.25 or 0.47 feet per second with the equipment he uses, it is

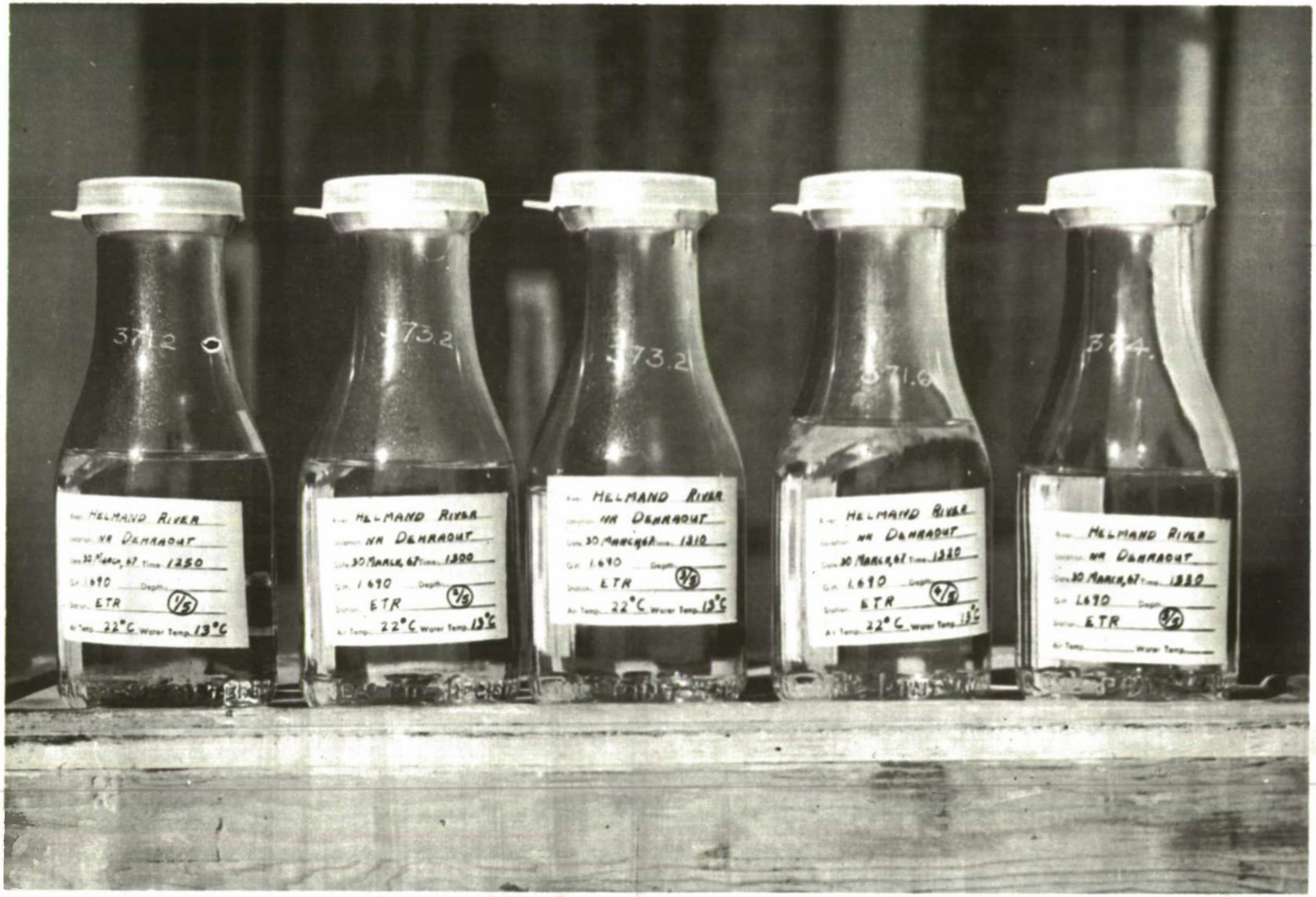


Figure 18.-- Information required on the labels of sample bottles when the equal-transit-rate method has been used. In this case, five bottles make up the set of ETR samples.

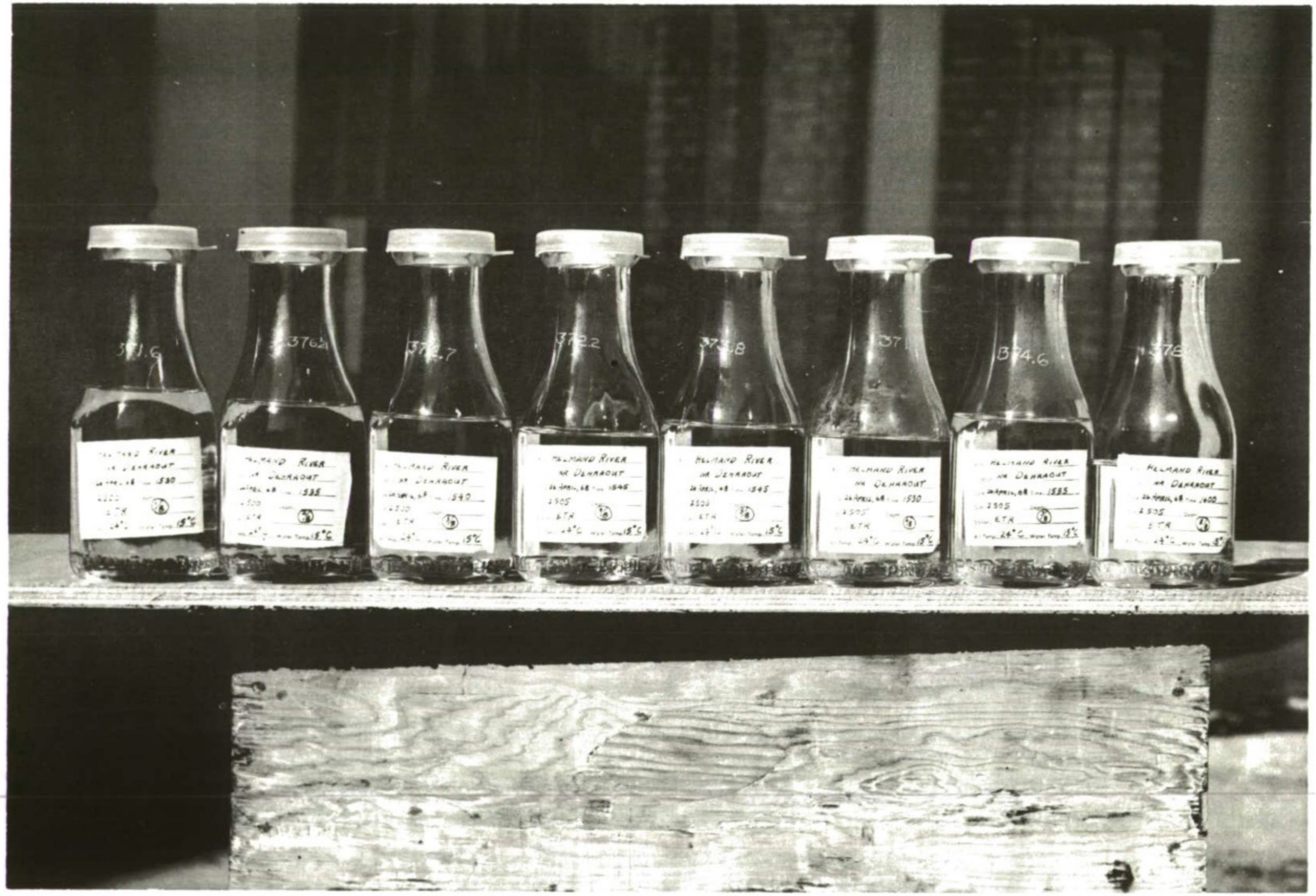


Figure 19.-- Information required on the labels of sample bottles when the equal-transit-rate method has been used. In this case, eight bottles make up the set of ETR samples.

much simpler to round these figures to 1/4 and 1/2 foot per second, respectively.

The above example shows the proper method for calculating the transit rate for different size nozzles. Three things should be considered in selecting which size nozzle to use. First, the 1/4-inch nozzle should be used whenever possible because it obtains more accurate samples than do the smaller nozzles. The 1/8-inch nozzle should be used only when a correct sample cannot be obtained with the larger nozzles because coarse sand in suspension may not enter the 1/8-inch nozzle in the proper proportions. Second, a transit rate must be selected that the hydrographer can manage and still obtain an accurate sample. The transit rate that can be managed varies with different hydrographers according to the experience they have had in taking samples. The beginner may not be able to manage a transit rate in excess of about one foot per second while the more experienced hydrographer may be able to manage up to two feet per second. Third, a transit rate should be selected that is less than 4/10 of the velocity of the stream in the slowest sampling vertical. In other words, if the slowest velocity is 1.0 foot per second, the transit rate should be less than 4/10 feet per second. If the slowest velocity is 2.5 feet per second, the transit rate should be less than 1.0 feet per second. If a small part of the flow, for instance near the banks, is very slow but the majority of the flow is much faster, the slow portion can be ignored when using this 4/10 rule.

In the example already given, the proper transit rate is 1/2 foot per second using the 1/4-inch nozzle.

The following example illustrates a sampling problem. If the deepest, fastest section in the cross section is 7.0 feet deep with a velocity of 7.0 feet per second, the transit rate for the 1/4-inch nozzle is about 2.3 feet per second and for the 3/16-inch nozzle, about 1.3 feet per second. In this case, the beginner should use the 3/16-inch nozzle at a transit rate of a little more than 1-1/4 feet per second; the more experienced hydrographer might use the 1/4-inch nozzle if he decides he can handle the faster transit rate and still obtain an accurate sample.

The hydrographer must use his judgment based generally on his own experience plus the instructions and suggestions presented in this manual in selecting proper transit rates and nozzles. The most important consideration is that the samples be as accurate as possible.

Sediment Station Operation

Daily Record Stations -- Suspended-sediment samples will be taken daily throughout the year by the observer using the centroid method with the following exceptions:

(1) If the color of the river changes noticeably, or the gage height changes by a half meter or more within a 24-hour period, the sampling frequency should be increased to twice daily. After the stage or color of the river has held constant for three days, the observer should return to sampling only once daily.

(2) During periods of low and relatively clear flow, the sampling frequency can be reduced to twice weekly; however, the observer should reduce his sampling frequency only when instructed to do so by a hydrographer from WSSD.

When a daily record station is visited by a hydrographer from WSSD, the following procedure should be followed:

(1) Visit the recorder and follow the procedures presented in the "Hydrology Training Manual for Basic Streamgaging."

(2) Make a discharge measurement.

(3) Compute the locations of three or more centroids using the procedure outlined on pages 28-35.

(4) Check the technique used by the observer as he uses the centroid method as outlined on pages 35-38.

(5) Take a set of check samples by the ETR method as described on pages 38-47.

(6) If size samples are required, take a duplicate set of ETR samples.

(7) Pick up the samples taken by the observer during the previous month and leave him enough clean sample bottles to last at least five weeks, the number of bottles depending on the number of centroids being sampled. Always leave full cases of bottles. This provides the observer with extra bottles in case he needs to take twice-daily samples for part of the month.

Partial Record Stations -- Suspended-sediment samples will be taken daily by the observer using the centroid method during the flood or high-runoff season only. During the flood season, the instructions for the operation of a daily record station will be followed as outlined above. For the remainder of the year, samples will be taken periodically by a hydrographer when monthly visits are made to the station, and instructions for the operation of a periodic sampling station will be followed as outlined below.

Periodic Sampling Station -- Suspended-sediment samples will be taken only by a hydrographer when monthly visits are made to the station. The gageman will have no responsibilities in the sampling program. When the station is visited by a hydrographer, the following procedure should be followed:

(1) Visit the recorder and follow the procedures outlined in the "Hydrology Training Manual for Basic Streamgaging".

(2) Make a discharge measurement.

(3) Take a set of samples by the ETR method as described on pages 38-47.

(4) If size samples are required, take a duplicate set of ETR samples.

Size Samples -- Size samples will be taken at all gaging stations in the sediment data-collection network. The ETR method will be used, and samples will be taken according to the following schedule:

(1) Once shortly before the flood season.

(2) At least three times during the flood season: shortly after it has begun, on the first big peak of the flood season, and late in the season. Additional size samples should be taken on any abnormally large flood.

(3) Once shortly after the flood season.

(4) Once during the middle of the low flow period.

The exact dates for taking size samples after the flood season, during the low flow period, and before the next flood season will be decided by the sediment section. The exact dates for taking size samples during the flood season must be decided by the hydrographers responsible for that particular station during the flood season.

Miscellaneous Suspended-sediment Samples -- A first priority has been assigned to sampling at daily and partial record stations and a second priority assigned to periodic sampling stations. However, valuable sediment data can be obtained from all other gaging stations in Afghanistan. Hydrographers should make every effort to obtain suspended-sediment samples at any gaging station that has a flood of abnormal size. An abnormally large flood can be defined as one that overflows its banks or is larger than any previous known flood at that site.

When it is known in advance that such a flood is approaching a gaging station, it may be possible to assemble all equipment in advance and be prepared for its arrival. Ideally, one set of samples should be taken on the rising stage, one on the peak and several on the recession of the flood. Either the ETR or centroid method may be used by the hydrographer although the ETR method is preferred because it is more accurate.

In general, the following procedure should be followed:

(1) Visit the recorder following the procedures given in the "Hydrology Training Manual for Basic Streamgaging". Check the recorder frequently during the flood to be sure it is operating properly.

(2) Arrange all streamgaging and sampling equipment for handy use.

(3) Make a discharge measurement prior to the flood if possible.

(4) Without taking time to compute the measurement, take two sets of ETR samples, one for concentration and one for size analysis.

(5) Repeat steps 3 and 4 when the flood arrives on the rising stage.

(6) Repeat steps 3 and 4 on the flood peak.

(7) Repeat steps 3 and 4 on the recession when the discharge has receded about 25 percent.

(8) When it is possible, a fully-equipped hydrographer should remain at the station until the flood recedes to nearly normal flow. Additional discharge measurements and single sets of ETR samples should be obtained. If time does not permit, duplicate ETR samples for size analysis may not be taken, and only single sets for concentration analysis need be obtained. The discharge measurements are of first priority, and all suspended-sediment samples should be taken only after the discharge measurement has been made. Suspended-sediment samples for concentration analysis are of second priority and size samples are third.

APPENDIX A

PUBLICATIONS AVAILABLE AT THE SEDIMENT SECTION REFERENCE LIBRARY

Field methods for fluvial sediment measurements, by Harold P. Guy and Vernon W. Norman, U.S. Geological Survey, Techniques of Water Resources Investigations, Book 3, Chapter C2, now in press.

Laboratory theory and methods for sediment analysis, by Harold P. Guy, U.S. Geological Survey, Techniques of Water Resources Investigations, Book 5, Chapter C1, now in press.

Fluvial sediments--a summary of source, transportation, deposition, and measurement of sediment discharge, by Bruce R. Colby, U.S. Geological Survey Bulletin 1181-A, 1963.

The sediment problem, flood control series number 5. United Nations Economic Commission for Asia and the Far East, 1953.

Removal of water and rearrangement of particles during the compaction of clayey sediments--review, by Robert H. Meade. U.S. Geological Survey Professional Paper 497-B, 1964.

Fluvial sediment concepts, by Harold P. Guy, U.S. Geological Survey Techniques of Water Resources Investigations, Book 3, Chapter C1, now in press.

Effect on sediment characteristics on erosion and deposition in ephemeral-stream channels, by S. A. Schumm. U.S. Geological Survey Professional Paper 352-C, 1961

Sedimentation--Section 3, Soil Conservation Service National Engineering Handbook, U.S. Department of Agriculture, 1968.

Conference Proceedings--Federal Inter-Agency Sedimentation Conference of 1963, many authors. Prepared by Agriculture Research Service, U.S. Department of Agriculture, issued June, 1965.

Initial unit weight of deposited sediments, by Lara and Pemberton, Office of the Assistant Commissioner and Chief Engineer, U.S. Bureau of Reclamation, Denver, Colorado -- A paper prepared for presentation at the Federal Inter-Agency Sedimentation Conference in Jackson, Mississippi, January, 1963.

A Series of Reports by the Subcommittee on Sedimentation of the Inter-Agency Committee on Water Resources, United States of America:

Report Number 1: Field practice and equipment used in sampling suspended-sediment, August, 1940.

Report Number 3: Analytical study of methods of sampling suspended-sediment, November, 1941.

Report Number 4: Methods of analyzing sediment samples, November, 1951.

Report Number 5: Laboratory investigation of suspended-sediment samplers, December, 1951.

Report Number 6: The design of improved types of suspended-sediment samplers, May, 1952.

Report Number 7: A study of new methods of size analysis of suspended-sediment samples, June, 1943.

Report Number 9: Density of sediment deposited in reservoirs, November, 1943.

Report Number 10: Accuracy of sediment size analyses made by the bottom withdrawal tube method, April, 1953.

Report Number 11: The development and calibration of the visual-accumulation tube, 1957.

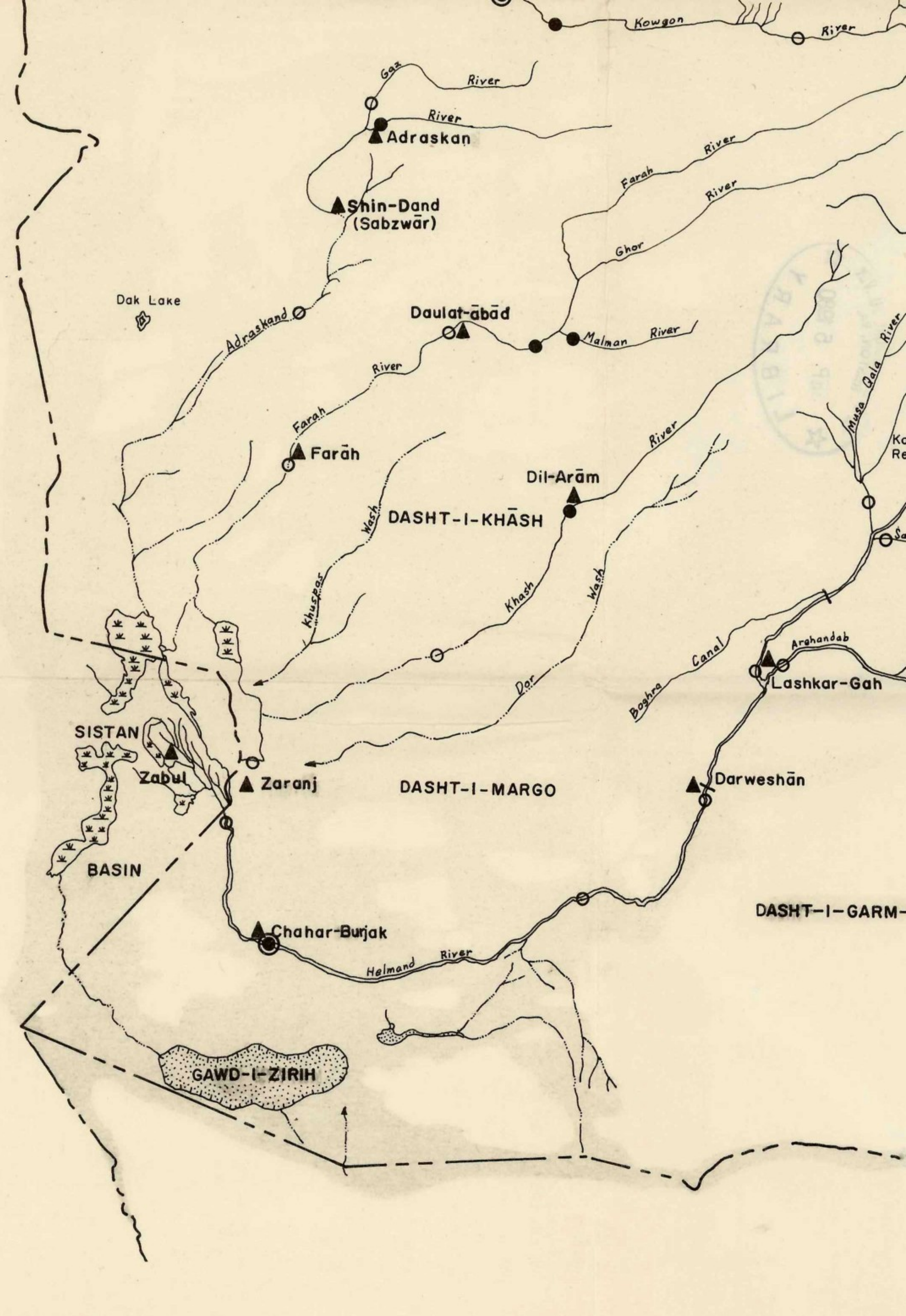
Report Number 13: The single-stage sampler for suspended-sediment, 1961.

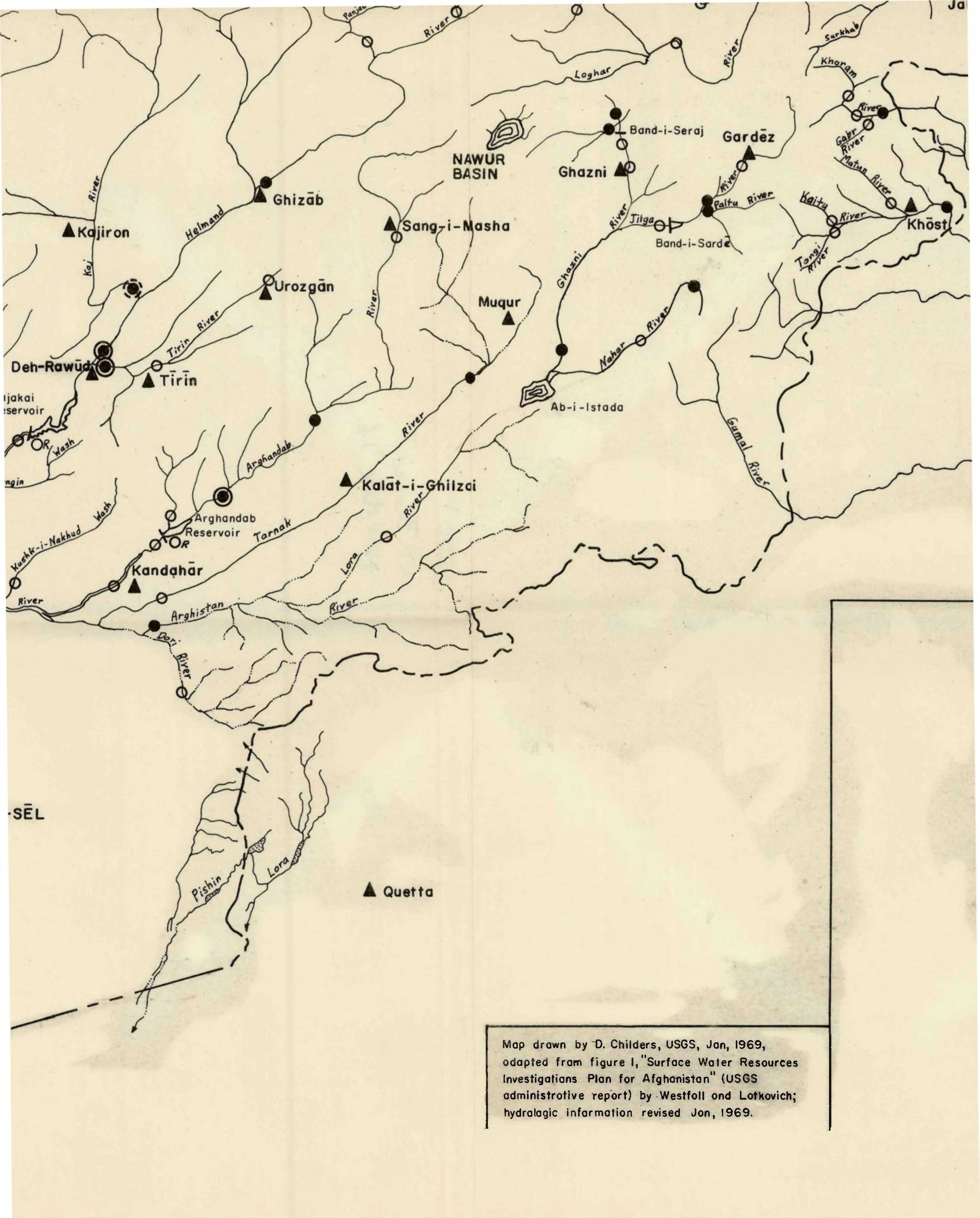
Report Number 14: Determination of fluvial sediment discharge, 1963.

(200)
WR3wsw
appendix 16

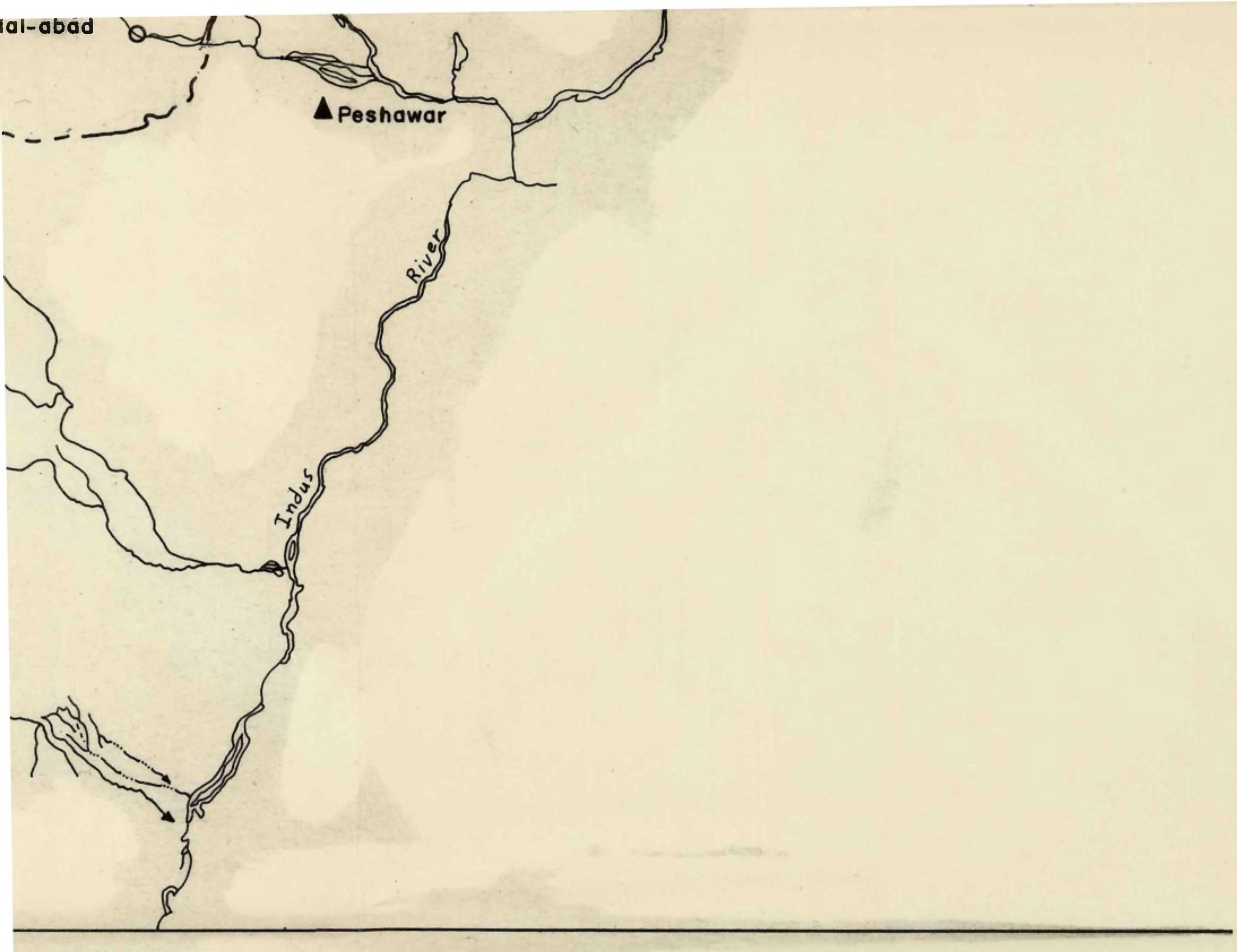

N
Doshanbi
(Oxus)
River
Amu (Oxus)
River
Termez
Panj
River
Kokcha
River
Andkhōy
Āqcha
Mazār-i-Sharif
Tashkurghān
Kunduz
Kundus
Khanabad
River
Taliqān
Kishm
Kishm River
Khan-ābād
Bangi
River
Shibarghān
DASHT-I-LELI
Daulatabad
Sar-i-pul
Sar-i-Pul
Sorab
River
River
Shirin Tagab
Maimana
Balkh
River
Darra Suf
River
Kholem
River
River
Baghlān
Pul-i-Khumri
Dōshi
KU
Jaosar
River
River
River
HINDU
Shatol
River
Panshir
River
Balkh (Band-i-Amir)
River
Band-i-Amir
Lakes
Bamiān
Kundus (Bamian)
River
Chārikār
S
Chakcharān
River
Ghorband
KŌH - I - BĀBĀ
Siasang
River
Band-i-Kargha
Band-i-Naghlu
Band-i-Sarobi
Band-i-
Mahipur
KABUL
Kabul
Panj-āb
River
Markhana
River
River
Lashman

Shiwa River
Shiwa Lake
Faiz-ābād
Panj River
Zarduch River
Warduch
Kokcha River
River
Pamir River
Wākhān
Wakhan River
S H
Pesh River
River
Kunar
Band-i-Durunta
River


Kowgon
River
Gaz
River
River
Adraskan
Farah
River
River
Shin-Dand
(Sabzwār)
Ghor
Dak Lake
Adraskand
Daulat-ābād
Malman
River
River
Farah
Farāh
Musa Qala
River
Dil-Arām
River
DASHT-I-KHĀSH
Wash
Khuspas
Khash
Wash
Dar
Canal
Boghra
Arghandab
Lashkar-Gah
SISTAN
Zabul
Zaranj
DASHT-I-MARGO
Darweshān
BASIN
DASHT-I-GARM-
Chahar-Burjak
Helmand
River
GAWD-I-ZIRIH



Map drawn by D. Childers, USGS, Jan, 1969, adapted from figure I, "Surface Water Resources Investigations Plan for Afghanistan" (USGS administrative report) by Westfall and Latkovich; hydrologic information revised Jan, 1969.



O Recording Gaging Station

OS Staff Gage

OR Reservoir Station

Daily Record Sediment Station

Partial Record Sediment Station

Periodic Sampling Sediment Station

City or Town

Capitol

Natural Lake

Reservoir

Natural Depression

Dam

Shallow Lake or Swamp

FIGURE

MAP OF AFGHANISTAN
SEDIMENT DATA COLLECTION NETWORK

SCALE: 1:2,000,000

25 0 25 50 75 100 125 KILOMETERS

25 0 25 50 75 100 125 MILES