HYDROLOGICAL PROCEDURE NO. 19

THE DETERMINATION OF SUSPENDED SEDIMENT DISCHARGE

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JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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CONTENTS

THE DETERMINATION OF SUSPENDED SEDIMENT DISCHARGE

1. INTRODUCTION

In the design of engineering works, many problems are encountered where the nature of the works demands storage or diversion of sediment laden water. Unforeseen difficulties in operating and maintaining these engineering works have developed due to the presence of sediment, and the economic life for many of them has been much shorter than anticipated. Some of the more serious sediment problems encountered are the silting up of river beds thereby increasing flood heights and flooded areas; reservoirs sedimentation, thereby reducing their capacity and function; the silting up of irrigation canals and navigation channels, thereby making them inefficient and costly to maintain.

From the above, it can be seen that sediment problems are often severe and the cause of much desilting expenses. In many cases, good remedies for these problems have not been found, but by careful planning and intelligent handling, the difficulties may be avoided or minimised. For working out the best solution of any case involving sediment, an accurate knowledge of both the quantity and particle size of the sediment is necessary. The quantity of sediment to be expected at any particular structure determines the necessity for, and the dimensions of, sediment removal devices, and since sediments composed of different size particles, act very differently, it is necessary to know the sizes as well. Therefore, samples are taken in rivers as often as possible, and under all conditions, in order that the sediment transporting potentialities of the river under all conditions may be known and the total suspended sediment load of the river can be calculated.

2. THEORY OF SEDIMENT TRANSPORT

Sediment moved by flowing water may be divided into three classes according to the physical process by which it is moved; namely, contact load, suspended load and saltation load. The physical processes involving the movement of sediment are related to the water flow and to the force exerted by the water on the sediment particles. The motion of stream water is turbulent, the degree of turbulence depending on the degree of roughness of the banks and bed and velocity with which the water moves. Therefore, particles of water and sediment do not move in straight or parallel lines, but move in various directions which, in general, approximate the direction of flow in the channel.

Contact load is the material rolled or slid along the bed in substantially continuous contact with the bed. Due to the turbulence of the water, the velocity of the current impinging on a particle of sediment is not constant; therefore, whenever this velocity is of a magnitude for a sufficient period to exert a force on the particle overcoming its inertia, motion is produced. Thus the sediment will roll or slide along the stream bed propelled by the required velocity.

Suspended load is the material which is moving in suspension, and which is maintained in this position by components of upward currents of turbulent water, tending to force the particles upward, opposed to the force of gravity tending to pull the particles downward. The particles are sustained in suspension for a time interval depending on the settling rate of the particles.

Saltation load is the material bounding along the bed, or moved, directly or indirectly, by the impact of the bouncing particles. A small amount of material in the form of particles travelling near the stream bed may intermittently strike the bed and bounce upward or, as a result of the impact, may force the other particles upward into the flowing water for a temporary period.

Except in very high velocities, or very turbulent water, material of gravel and larger sizes travels almost entirely as contact load, and except in very low velocities or water of very low turbulance, material of silt and clay sizes move almost entirely in suspension. Under many conditions, most of the sand sizes travel both as contact load, and as suspended load. When sand is carried as suspended load, the greater portion of the sand usually moves near the stream bottom.

The materials moving as the contact load, the saltation load and the coarse part of the suspended load which cannot be sampled by a suspended load sampler, are ordinarily combined into what is termed "Bed-Load", which may be defined as "coarse material moving on or near the bed".

3. THE MEASUREMENT OF SUSPENDED SEDIMENT

3.1 General

The same criteria used for the selection of flow measuring stations should be used in selecting a site for sediment discharge measurements. However, measurements are normally taken at existing river gauging stations, as river velocity and discharge values are necessary for the computation of sediment discharge. It is not essential that velocity measurements be taken at the same time as sediment sampling, provided the samples are taken at verticals where velocity measurements have been made and there is no change in cross-section. This procedure is adopted in order that the depths of the river at the preselected verticals can be determined without having to carry out soundings of the river bed with the sampler. In such cases, the depths at the preselected verticals are obtained either from the cross-section survey plan of the gauging station or from the depth observations taken during velocity measurements.
Suspended sediment sampling is usually carried out by the use of a standard sampler in conjunction with one of the following:— cableway, or bridge using a A-Frame gauging crane and winch, or boat and winch or by wading. The general procedure for positioning the sampler at the preselected verticals and for lowering it into the river to the required depth is the same as for river gauging. Instructions on the

correct use of a cableway, A-Frame gauging crane, and winches are described in Hydrological Procedure No. 15.

Whenever possible, sediment sampling from a boat should be preferred over sampling from a cableway or a bridge. This is because, sampling from a boat, will reduce greatly the amount of winding in and out of the sampler each time a sample is taken, thus saving a lot of time; also better control can be exercised over the sampling procedure and the accuracy of the measurements. If sampling from a cableway or bridge cannot be avoided, then it is always advisable to station an officer in a boat over the sampling point, to check, remove, and replace the bottle in the sampler at the water surface. This again, will reduce greatly the very tedious work of winding the sampler from the water surface to the operator, and back again to the water surface, each time a sample is taken. However caution should be exercised during the occurrence of serious floods when the safety of personnel and equipment should be considered. In such instances, it would be advisable not to operate from a boat.

The accuracy of the measurement of suspended sediment depends upon:— the equipment used, methods employed, the care taken and the ability of the personnel engaged in the measurement.

3.2 Method of sampling

The general procedure for taking sediment samples consists of firstly dividing up the cross section to be sampled into sub-sections by selecting a number of vertical sampling sections, called verticals, across the cross section. The ideal subdivision is to so locate the verticals that their boundaries divide the cross section into sub-sections of equal discharge. Each vertical is then sampled, either by integration throughout its depth, or by integration over a short period of time at one or more representative points in the vertical. The ideal sample required is one which fills the sample bottle to about 2/3rds of its volume. The bottle must not be filled under any circumstances. All information pertinent to the sampling is then recorded on the appropriate form, J.P.T. 11C, and the samples adequately identified before forwarding to the Laboratory for analysis. It is imperative that the sample should be sent for analysis within 14 days from the time samples are taken. Also ensure that three (3) drops of Formaldehyde solution are added to the sample immediately after it is taken. This is to prevent the growth of algae in the sample.

3.3 Location of verticals

The sediment-distribution in any river generally shows only slight variation in the transverse direction whereas considerable variation may be encountered in the vertical direction. Therefore, there will be little loss of accuracy if verticals in which samples are taken are widely spaced across the river and it has been found that three will suffice. The location of verticals so that they represent sections of equal discharge is usually only approximated in the field. A large number of gaugings are required to enable the operator to draw up a chart showing graphically how sections of equal discharge can be located and these charts should be brought along to the sites concerned during the sampling operation.

When the cross section to be sampled is fairly uniform, two methods may be used to select verticals so that they represent sections of approximately equal discharge. If the cross section is wide, shallow and uniform, verticals selected at 1/6th, 1/2 and 5/6ths of the stream width will divide the cross section into three sub-sections of equal discharge. If the cross section is more or less U-shaped, V-shaped or nearly parabolic, a closer approximation to three areas of equal discharge can be made by selecting verticals at 1/4, 1/2 and 3/4ths of the stream width.

3.4 Location of sampling points in the verticals

When taking samples by the point integration method, the points selected for sampling are at 0.2 of the vertical depth and 0.8 of the vertical depth, referred to as 0.2 d. and 0.8 d. Then, 3/8ths of the concentration at 0.8 d. is added to 5/8ths of the concentration of 0.2 d. to obtain the mean concentration in the vertical. This method of obtaining the mean concentration in the vertical was mathematically derived by Dr. Lorenz G. Straub, and the method bears his name. The basis of the derivation is an assumption that the sediment distribution in the vertical is approximately linear in the great majority of cases. Only in the case of large particles does the vertical distribution curve depart from the approximate straight line and this occurs near the bed of the stream.

If precise measurements are required for special investigation, a large number of points in the vertical are selected for sampling, but the work involved in analysis and computation is far too laborious for routine sampling.

When taking samples by depth integration, the question of selecting sampling points in the vertical does not arise because, theoretically and practically, every point in the vertical is sampled for an infinitesimal period, when the sampler is moving downwards and again when moving upwards. This is the meaning of integration; that is, the total concentration is obtained by adding together the concentration at an infinite number of points which are at infinitely small distances apart.

3.5 Sampling frequency

A change in stage is the first direct indication of surface run-off from a watershed, and it is generally accompanied by a change in sediment concentration, but it is important to note that the variations in concentration during a rising stage are rapid and erratic, while the variations during a falling stage are gradual and fairly consistent. Sampling frequency is determined with these considerations in view. Accurate measurements can be obtained by sampling at 1/2 hour intervals on a rising stage, and at 4–hour intervals on the falling stage but, if the early part of the rise has been missed, frequent sampling is relatively unimportant, as the error introduced by missing the rise cannot be compensated for by more frequent sampling on the falling stage.

3.6 Sampling by depth integration method

The method of depth integration is based on the assumption that, in traversing the depth of a stream at a uniform speed, the sampler receives at every point in the vertical, a small instantaneous sample whose volume is proportional to the stream velocity, since the sampler is designed to fill at a rate proportional to the velocity of the approaching flow.

One sample only is required from each vertical, and it is representative of the mean concentration and practicle size distribution in the vertical.

Instructions which follow refer to the use of the D–49 and DH–59 samplers but depth integrated samples can be taken with the P–61 sampler by traversing the desired depth with the valve in the sampling position. (i.e. the nozzle inlet is kept open throughout the traversing operation).

When taking a depth integrated sample, the operation must continue uninterrupted while the sampler is being lowered and raised at a uniform speed for the full range of depth, and the vertical traverse of the sampler should be reversed as quickly and smoothly as possible immediately it touches bottom. If the bottom is reached sooner than expected, the raising rate may be slower than the rate at which it was lowered, to give the correct total sampling time. Similarly, if the lowering rate was too slow, the total time can be corrected by raising the sampler at a higher, though still uniform speed

The procedure for taking a depth integrated sample in a vertical with a D–49 or DH–59 sampler is as follows:–

(i) Insert a clean sample bottle into the sampler.

(ii) Estimate the length of time required to obtain a sample of the desired volume by reference to the filling time curve for the size of nozzle being used. (Curves for the various nozzle sizes are provided with the sampler by the manufacturer).

(iii) Obtain rate of sampler movement by dividing twice the depth by the estimated sampling time.

Note: With practice, the rate of sampler movement can be estimated quite accurately without having to calculate it.

(iv) Lower the sampler from just above the water surface, after zeroing depth counter, to the bed of the stream at the predetermined rate, making sure that before commencing to lower, the sampler is directed upstream; this can be done by allowing the vertical tail fin to just enter the water and to remain there until the sampler head is directed upstream.

(v) Reverse the direction of travel, (as stated earlier) as soon as the sampler touches the bottom and raise the sampler at the same rate as it was lowered. Do not allow the sampler to rest on or disturb the bed before commencing to raise it. This can be achieved if the stage is known and depth obtained from the master cross-section.

During actual operation it is good practice to reverse the tranverse 15cm short of the depth as obtained from the master cross section.

(vi) When the sampler has cleared the water surface, it can be raised for removal of sample.

(vii) Remove the sample bottle, being careful not to spill or contaminate the sample. It is always advisable to hold the nozzle vertical while removing the glass bottle from the sampler. Decant contents of sample bottle into a plastic bottle provided.

(viii) Cap plastic bottle and record all necessary information onto the standard form J.P.T. 11C, and also label and indentify the plastic bottle properly.

The depth integration method is also used to take samples with the hand sampler, DH–48, in conjunction with a tag line for the location of verticals. The procedure is much the same as with the larger sampler, each vertical being sampled by traversing the depth of the vertical in both directions at a uniform speed, rapidly reversing the direction of travel as soon as the sampler touches the bottom. All precautions should be taken to prevent contamination, spillage and evaporation of the sample, and all necessary information should be recorded. As there is no tail fin to orientate the nozzle parallel to the flow, care must be taken to ensure that this conditions is fulfilled.

The tag line is stretched between stakes driven into each bank. Once it is located, never walk upstream of the tag line, and keep downstream disturbance of the stream bed to a minimum. When taking each sample, stand about eighteen inches downstream of the tag line while positioning the sampler alongside the tag line at an angle 45° to your position. Ensure that there are no people bathing upstream or any other such temporary disturbances to the normal regime of the river.
In the case of wading sampling, a simplified method called the "Equal Transit Rate Method" is also used to obtain samples representing the mean concentration in the cross section. With a bottle in the sampler, start at the first vertical and take a

small sample, being careful to note the rate of traverse used. Move on to succeeding verticals, which should be at one foot intervals for narrow rivers, 2 ft. intervals for moderately wide rivers and 4 ft. intervals for wide rivers. Samples are taken in succeeding verticals at exactly the same "transit" or traverse rate as was used in the first vertical, regardless of the varying depths in each vertical.

When the bottle is 2/3rds full, the sample is decanted into a plastic bottle, the empty bottle is fitted back into the sampler, and sampling continued across the remaining portion of the cross section still maintaining the same rate of transit. Each time the bottle is 2/3rds full, the sample is removed and sampling continued as above. On completion of sampling of the whole cross section, whatever little amount of sample that is finally collected in the bottle for the last remaining section of the cross-section is also removed and sent for analysis with the earlier samples. The composite samples obtained in this way are representative of the whole cross section and only the total discharge at the time of sampling need be known. In the event that insufficient amount of samples is collected in the bottle (less than ½ full) after all the verticals in the cross section have been sampled once, sampling of the full cross section should be repeated until sufficient sample is obtained. (i.e. 2/3 to ¾ volume of the full capacity of the glass bottle).

3.7 Sampling by point integration method

Samples taken with a point integrating sampler are integrated or "added up" over a period of time with the sampler stationary at the required point in the vertical. This method allows an average sample to be taken which represents the mean concentration at the point, taking into account the fluctuations in concentration over the sampling period, that is, it is a time integrated sample.

The following procedure should be carried out when taking point samples with a P–61 sampler:–

(i) Make and break the electrical switch once, this should be accompanied by a clicking sound in the sampler, indicating that the valve can be opened and closed by operation of the switch. This is a check to ensure that the P–61 is functioning.

(ii) Insert a clean sample bottle and close the sampler head.

(iii) Lower the sampler to the point in the stream where the sample is to be taken.

(iv) Make one contact of the switch and open again. The sampler is filling.

(v) When the desired sampling time has elapsed make and break the switch again, and sampling ceases.

(vi) Raise the sampler.

(vii) Depress the catch and raise the sampler head while ensuring that the sampler is held vertical so as not to spill the sample.

(viii) Remove the sample bottle, taking care not to spill or contaminate the sample. Decant contents of sample bottle into a plastic bottle provided.

(ix) Cap the plastic bottle and record all necessary information as stated earlier.

Subsequent point samples:—

- Insert a clean sample bottle and close the sampler head.
- Make a break the switch once, checking whether the valve is in proper working condition.
- Follow items (iii) — (ix) detailed above.

Samples in the vertical should be taken at 0.2, 0.6 and 0.8 of the depth for routine sampling, but in deep streams or during high runoff, 4 or more samples should be taken in each vertical. For small streams, two samples in the vertical are sufficient, one at 0.2 d. and one at 0.8 d. For very shallow depths, one sample at 0.6 d. is sufficient.

3.8 Choice of Method and Equipment

The choice of method and equipment for carrying out suspended sediment sampling is interrelated to each other and depends mainly on site conditions, such as velocity of flow, depth of flow and the type of winches used. Briefly, the various methods and equipment suitable for different site conditions could be summarised as follows:—

	Method	**Equipment**	**Site conditions**
(i)	Wading:— Equal transit-Depth integrating method	DH—48	When depth $<$ 1 meter and $d \times V \leqslant 1$ where:— d = max. depth in meter, V = max. velocity in m/s
(ii)	Hand-line:— Equal transit-Depth integrating method	DH—59	As above, but when wading is not advisable. Sampling could then be carried out from a boat or bridge without using a winch.

(iii)	Bridge or Boat using small portable winches: 3 Verticals-Depth integrating method	DH–59	When Depth < 3 meters, and velocity < 0.6 m/s. Sufficient Columbus weight may be attached above the sampler in order to reduce the drag angle < 5°
(iv)	Cableway:– 3 Verticals-Depth integrating method	D–49	When Depth < 5 meters and Velocity > 0.6 m/s. Sufficient Columbus weight may be attached above the sampler in order to reduce the drag angle < 5°.
(v)	Cableway:– 3 Verticals-Depth integrating method	P–61	When Depth > 5 meter. Traversing the depth one way with the valve in the sampling position.
(vi)	Cableway:– 3 Verticals-Point integrating method	P–61	When Depth > 5 meter. Sampling at any desired point in verticals.

The above summary serves only as a guide and values given for depths of flow and velocities are not absolute. In all cases, the officer should ensure that the sampler bottle should not be more than 3/4rs. full. The appropriate filling time and choice of nozzle should be selected from the graph provided in Appendix 2 and the detailed operating instructions strictly followed.

3.9 Descriptions and Operating Instructions of Samplers

Detailed descriptions and operating instructions of the DH–48, DH–59 and D–49, and P–61 are included in Appendix 1, Appendix 2 and Appendix 3 respectively.

4. PRECAUTIONS IN SUSPENDED SEDIMENT MEASUREMENT

To ensure that the best possible sampling results are achieved, the following precautions in procedure should be observed:–

(i) The sampler nozzle, sample bottles and plastic bottles should be thoroughly cleaned before each and every individual sampling operation.

(ii) The sampler must be steady and correctly oriented so that the intake nozzle faces directly into the approaching flow, before sampling commences. This is achieved in the case of the sampler suspended from a cable, by lowering the sampler to the surface of the water until the vertical stabilising fin touches the water, and the nozzle is still above the surface. Wait until the sampler is quite stable or as stable as conditions will permit before commencing traversing of sampler.

(iii) The operation of traversing the sampler should be smooth and uninterrupted. Immediately the sampler reaches the predetermined depth, the direction of traverse is reversed.

(iv) When sampling in rivers with soft silty or muddy beds, the sampler should not be allowed to touch the bed at all as this will cause the sampler to sink into the mud thus choking up the nozzle. In such cases, the direction of traverse is reversed when the sampler is estimated to be 15cm above the river bed. (Vertical soundings from preceding gauging operation or from the master cross-section can be used if gauging section is stable).

(v) The rate of traversing should not exceed 0.36 times the maximum velocity in a vertical. With this rate of traverse the flow approaches the nozzle at an angle of 20° and the loss of sediment intake is of the order of 2%. With a greater rate of traverse the sediment intake falls off rapidly.

(vi) The sampler bottle should not be more than 3/4rs. full. If water is seen pouring from the intake nozzle when the sampler is removed from the river then the sample should be discarded, the bottle throughly flushed and another taken, slightly increasing the uniform speed of traverse, so as to enable a correct amount of sample to be taken.

(vii) When sampling by wading, the operator should never walk upstream of the cross-section being sampled and should keep downstream disturbance of the stream bed to a minimum. Also ensure that there are no unnatural disturbance upstream of sampling section (e.g. people bathing, boats plying, removal of sand for commerce, and any other such activities which are inconsistent and erratic).

(viii) In hand sampling, the operator must hold the suspension rod vertical in which case the intake nozzle is horizontal and he should stand eighteen inches downstream of the cross-section and at an angle of 45° to the sampler which is positioned at the cross-section.

(ix) When carrying out sampling of shallow rivers by wading the Equal Transit Rate Method should be preferred.

(x) When a satisfactory sample is taken it should be poured into the plastic container in such a manner as to ensure that no sediment is left in the bottle. This can be achieved by pouring 2/3 of the same into the plastic-container first, then slosh the remaining 1/3 sample around within the bottle such that any sediment residue sticking to the walls of the bottle are washed and absorbed by the residue sample. Then pour the remaining sample at a fast rate into the container. Throughout this operation ensure that you do not spill any part of the sample. Should this occur then the operation will have to be repeated.

(xi) All sample container bottles (plastic bottles) should be tightly capped to prevent spillage and evaporation. Formaldehyde solution should be added as stated earlier to all samples taken.

(xii) In addition to recording information on the standard tabloid, all the field data required for computing sediment load should be entered onto the Suspended Sediment Discharge Data card. (J.P.T. 11c).

5. RECORDING OF INFORMATION

5.1 Information on tabloid pasted onto plastic bottles

Complete records must be made so that there is the least possible chance of the information being lost or of the bottle being mixed up. The standard tabloid as set out below should always be filled up and glued securely to the outside of the plastic bottles.

Name of State	....
Name of river	....
Name of station	....
Station No.	....
Location in X-section	....
Gauge height	....
Recorder reading (if any)	....
Date & Time	....
Sample No.	....
*Plastic container No.	....

* (To be etched on the container with a sharp hot object by Depot Perkhidmatan Alatan, Ampang).

5.2 Suspended Sediment Discharge Data Card (J.P.T. 11C)

All relevant data must be recorded on the standard suspended sediment discharge data card (J.P.T. 11C), which accompanies every set of samples.

The following is an explanation of the information to be supplied on Suspended Sediment Discharge Data Card, J.P.T. 11C, example of which is included in Appendix 4. Entries that must be completed during the actual sampling are shown with an asterisk. The remainder are for office calculation purposes.

ENTRY	EXPLANATION
FORM JPT 11C (Front Page)	
1. No Sukatan	Each suspended sediment measurement should have its own number, e.g. PHG. 40/75 to mean Pahang, sampling No. 40 in 1975. The numbers must be listed in a separate register so that sampling can be easily traced.
2.* Sungai	Accepted name of river.
3.* Nama Stesyen	Accepted station name of sampling site. Every site must have one and only one name.
4. No. Stesyen	Every site must have a unique station number according to Hydrological Procedure No. 6.
5.* Tarikh	The date on which the measurement was made.
6.* (a) Waktu sukatan dimulakan	Time sampling began. (Use the 24 hour international system for recording time. e.g. 3.15 p.m. in the afternoon is 1515 hrs; for 6.20 a.m. in the morning, 0620 hrs.)
(b) Siap	Time sampling ended.
7.* Kumpulan Kerjaluar	Initials of field party leader.
8. Sukatan berkaitan dengan kadaralir sungai-No. Sukatan	Measurement related to river discharge measurement number. This is the gauging number of the discharge measurement carried out in conjunction with the sampling.
9.* Pencontoh	Type of sampler used. e.g. D49, P61, DH48, DH59 etc.
10.* Waktu	Time of actual sampling at a vertical.
11.* Bacaan tolok	Stick gauge reading at the time of sampling at a vertical.
12.* Jàuh dari tanda permulaan	Distance from initial point (common zero) to the sampling vertical; i.e. the reading from the tape, tagline or counter of traversing winch measured from a common zero.

	ENTRY	EXPLANATION
13.*	Ukor dalam	Depth of river at the sampling vertical.
14.*	Cara Cerapan	Method of observation e.g. D.I.M. – Depth Integrating Method P.I.M. – Point Integrating Method E.T.R. – Equal Transit Rate Method
15.	Botol Berat-Gram	Plastic Bottle weight in grams.
	(a) No.	Plastic bottle number
	(b) Dengan contoh	Weight with sample
	(c) Kosong	Weight empty
	(d) Berseh	Nett weight of sample
16.	Penapis Berat-Gram	Filter weight in grams.
	(a) No.	Filter Number
	(b) Dengan Contoh kering	Weight with dry sediment
	(c) Berseh	Nett weight of dry sediment
17.	Himpunan Enapan B.S.J. (Bahagian Sejuta)	Sediment concentration P.P.M. (parts per million)
	(a) Contoh S_c	Sediment concentration of sample, S_c
	(b) Pugak purata S_v	Mean sediment concentration in vertical, S_v
	(c) Muka kerat purata S_s	Mean sediment concentration in section, S_s
18.	Kadaralir Mukakerat – q m^3/s	Discharge in section in cu. meters per sec. – q m^3/s
19.	Hasil darab $S_s.q$	Product $S_s.q$
20.	Kadaralir Enapan Ampaian Tonne Sehari	Suspended Sediment Discharge in Tonnes per Day
	(a) G_s .... t/h	G_s .... t/day
	(b) Bacaan tolok purata .... m	Mean stick gauge height .... m
21.	Himpunan purata enapan bagi muka keratan (S) $\frac{\Sigma s_s q}{\Sigma q}$ B.S.J.	Mean sediment concentration for cross section (S) $\frac{\Sigma s_s q}{\Sigma q}$ P.P.M.
22.	Cerakinan makmal oleh	Laboratory analysis by .... (initials)
23.	Dihitong oleh	Computed by .... (initials)

ENTRY		EXPLANATION
24.	No. Lembaran .... dari .... helai	Sheet number .... of .... sheets

J.P.T. 11C (Back Page)

25.	Ketumpatan enapan (P_s) dalam t/m^3 (P_s biasanya dianggap 2.65 t/m^3)	Density of sediment (P_s) in t/m^3 (P_s is generally assumed to be 2.65 t/m^3)
26.	Ketumpatan campuran air enapan (iaitu contoh – P_m) dalam t/m^3 Dimana: $P_m = \frac{P_s}{ds - (S \times 10^{-6})(ds - d_w)}$ t/m^3	Density of the water sediment mixture (i.e. sample – P_m) in t/m^3, where $P_m = \frac{P_s}{ds - (S \times 10^{-6})(ds - d_w)}$ t/m^3
27.	Kadaralir enapan ampaian (G_s) dalam t/hari. Di mana: $G_s = P_m \times S \times q \times 86{,}400 \times 10^{-6}$ t/hari	Suspended Sediment Discharge (G_s) in t/day. Where: $G_s = P_m \times S \times q \times 86{,}400 \times 10^{-6}$ t/day
28.	Catitan-Kiraan Tambahan	Remarks-Additional Calculations

29. **Peringatan:** / **Note:**

G_s = Kadaralir enapan dalam tonne sehari (t/hari).	G_s =	Sediment discharge in tonnes per day (t/day).
S = Purata berat himpunan enapan dalam muka kerat dalam biji sejuta (b.s.j.)	S =	Weighted mean sediment concentration in cross section in parts per million (p.p.m.).

ENTRY				EXPLANATION
q =	Kadaralir sungai dalam meter padu sesaat (m^3/s).		q =	River discharge in cubic meters per second (m^3/s).
p_m =	Ketumpatan campuran air enapan dalam tonne semeter padu (t/m^3).		P_m =	Density of the water-sediment mixture in tonnes per cubic meter (t/m^3).
P_s =	Ketumpatan tanah/enapan (t/m^3).		P_s =	The density of the soil/sediment (t/m^3).
dw =	Ketumpatan bandingan air = 1.0 (biasanya).		dw =	The specific gravity of water = 1.0 (normally).
ds =	Ketumpatan bandingan tanah.		ds =	Specific gravity of the soil.
86,400 =	Sa'at dalam sehari.		86,400 =	Seconds in one day.

6. LABORATORY ANALYSIS

On completion of field work, the samples are forwarded together with the relevant data card, JPT 11C, to the Pusat Penyelidekan, Jabatan Parit dan Taliair, Ampang. or the Chemistry Department, whichever is applicable.

In carrying out the analysis, the samples are first weighed on a laboratory balance, to give the total weight of sample plus bottle. The sample is then poured into a filter crusible or filter holder, taking care to rinse and flush off all sediment adhering to the bottle. The empty bottle is dried and weighed and the weight of the sample obtained by subtraction from the weight of the bottle plus sample.

Filtration of the sample is carried out with the aid of a vacuum pump. The vacuum pump should be carefully regulated to ensure correct filtration. When filtration is completed, the filter, complete with wet sediment is then placed into an oven controlled at approximately 105°C. On attaining constant weight, the sample is placed in a desicator to cool, after which it is weighed to the nearest 0.0001 gram. By subtracting the weight of the filter from this value, the nett weight of dry sediment is found.

The sediment concentration is calculated by dividing the weight of sediment by the weight of the water-sediment mixture (sample), and expressing the result in parts per million (p.p.m.). The sediment concentration of each sample is then entered by the analyst in the appropriate column in the data card, which is then forwarded to the Hydrology Branch, Jabatan Parit dan Taliair Headquarters, for computation of sediment discharge.

7. COMPUTATION OF SEDIMENT DISCHARGE

On completion of analysis, the data card is forwarded to the Hydrology Branch, Jabatan Parit dan Taliair, Ibu Pejabat for computation of daily suspended load. The information contained on this card is the water discharge on the day of sampling and concentration of sediment in the water in parts per million. The data which is required is the rate at which sediment was being carried down by the river, and is expressed in tonnes per day.

It is now necessary to determine the mean sediment concentration in the vertical and/ or the mean sediment concentration for the cross section. Depth integration sampling gives an automatically velocity weighted mean sediment concentration in vertical. For point sampling, the mean sediment concentration in the vertical is that developed by Dr. Straub based on the assumption that the sediment distribution in the vertical is approximately linear. Where samples are taken at 0.2 and 0.8 of the total depth, the mean sediment concentration in the vertical is 3/8 of the concentration at 0.8D added to 5/8 of the concentration at 0.2D. Where samples are taken at 0.1, 0.4, 0.6, and 0.9 D, the mean concentration is:–

$$0.29 \times 0.1D + 0.36 \times 0.4D + 0.22 \times 0.6D + 0.13 \times 0.9D$$

Where sampling is carried out at multi-verticals in a cross-section, the mean sectional concentration is the average of the mean concentrations in the two adjoining verticals. The mean sediment concentration for sections adjoining the banks of the river is assumed to be that of the respective adjoining vertical. For sampling by the three verticals method, the mean sectional concentration for each of the three sections is that of the respective verticals themselves.

The weighted mean sediment concentration, S, for the entire section is computed as:–

$$S = \frac{\Sigma S_s \times q}{\Sigma q}$$

where q = sectional discharge

S_s = mean sectional sediment concentration

The total sediment discharge for the cross-section in tonnes per day (t/d) is calculated using the following formula:

$$G_s = P_m \times S \times q \times 86{,}400 \times 10^{-6}$$

where G_s = sediment discharge in tonnes per day (t/d)

S = wieghted mean sediment concentration in cross section in p.p.m.

q = river discharge in cubic meters per second $(\frac{m^3}{s})$

P_m = density of the water sediment mixture is tonnes per cubic meter $(\frac{t}{m^3})$

The density of sediment in the water-sediment mixture is generally assumed to be 2.65. However, density measurements show that it may vary from 2.0 to 3.5. As this variation will alter the density value, P_m obtained for a water-sediment mixture, it is adviseable to determine the density of sediment for areas where there is a suspected difference. The density can be determined using standard laboratory procedure for density determination of solids:—

$$P_m = \frac{P_s}{d_s - (S - 10^{-6})(d_s - d_w)}$$

where P_s = the density of the sediment (t/m^3)

d_w = the specific gravity of water = 1.0

d_s = specific gravity of sediment

S = weighted mean sediment concentration in cross section in p.p.m.

The density of the water sediment mixture P_m is not only affected by variation in the value of the density of the sediment, but is also affected by the concentration of suspended sediment. An increase in concentration increases the density of the mixture. Based on the assumption that the specific gravity of water is 1.00 and the specific gravity of sediment is 2.65, the density of clean fresh water (suspended sediment concentration $<$ 10,000 p.p.m.) is 1.00 tonnes per cubic meter. For increasing concentration, the value of P_m increases and the values are shown for various concentration range in the table below:—

Concentration range (ppm)	**P_m (mg/l)**	**Concentration range (ppm)**	**P_m (mg/l)**
0 – 15,900	1.00	322,000 – 341,000	1.26
16,000 – 46,800	1.02	342,000 – 361,000	1.28
46,900 – 76,500	1.04	362,000 – 380,000	1.30
76,600 – 105,000	1.06	381,000 – 399,000	1.32
106,000 – 133,000	1.08	400,000 – 416,000	1.34
134,000 – 159,000	1.10	417,000 – 434,000	1.36
160,000 – 185,000	1.12	435,000 – 451,000	1.38
186,000 – 210,000	1.14	452,000 – 467,000	1.40
211,000 – 233,000	1.16	468,000 – 483,000	1.42
234,000 – 256,000	1.18	484,000 – 498,000	1.44
257,000 – 279,000	1.20	499,000 – 514,000	1.46
280,000 – 300,000	1.22	515,000 – 528,000	1.48
301,000 – 321,000	1.24	529,000 – 542,000	1.50

The values of P_m are based on a water density of 1.00 g/cm^3 and a sediment density of 2.65 g/cm^3. They are calculated to three significant figures in 2 per cent steps. Computation errors from use of these factors will be less than 1 percent and will average zero.

8. SEDIMENT RATING CURVE

The Sediment Rating Curve is plotted on standard size log-log paper provided by the Department. Sediment load in tonnes per day is plotted as abscissa and corresponding discharge in cubic metres per second as ordinate. A straight line can generally be drawn through the points. Variation in the curve will be found with storms of varying rainfall intensity and with rising or falling stages (the peak of the sediment discharge usually precedes the peak of the water discharge); but, in general, fairly stable curves can be produced.

The Sediment Rating Curve is a critical factor in determining the accuracy of the final estimate of the sediment yield. If this curve is accurately defined, an accurate forecast of the long term average annual sediment yield can be made. For this reason it is important that sufficient sediment data be collected in order to define the rating curve, especially in the region of high discharges.

A typical Sediment Rating Curve as plotted on standard department log-log paper is shown in Appendix 5.

9.0 REFERENCES

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DEPTH-INTEGRATING SUSPENDED-SEDIMENT WADING-TYPE HAND SAMPLER, DH–48

1. DESCRIPTION

This is a light-weight sampler for collection of suspended-sediment samples where wading rod sampler suspension is used.

The sampler consists of a streamlined aluminium casting, 13 inches long, which partially encloses a round pint bottle sample container (not furnished). The sampler weighs 4 1/2 pounds including sample container. A brass intake nozzle extends horizontally from the nose of the sampler body. A streamlined projection, pointing toward the rear on the side of the sampler head, accommodates the air exhaust port from which air may escape from the bottle as the sample is being collected. A standard 1/2 inch wading rod (not furnished) is threaded into the top of the sampler body for suspending the sampler. The sample container is held in place and sealed against a rubber gasket in the sampler head, by a hand-operated spring tensioned clamp at the rear of the sampler. The instrument can sample to within 3 1/2 inches of the stream bed. The sampler is calibrated with a 1/4 inch inside diameter nozzle. A nozzle having a 3/16 inch bore may also be used.

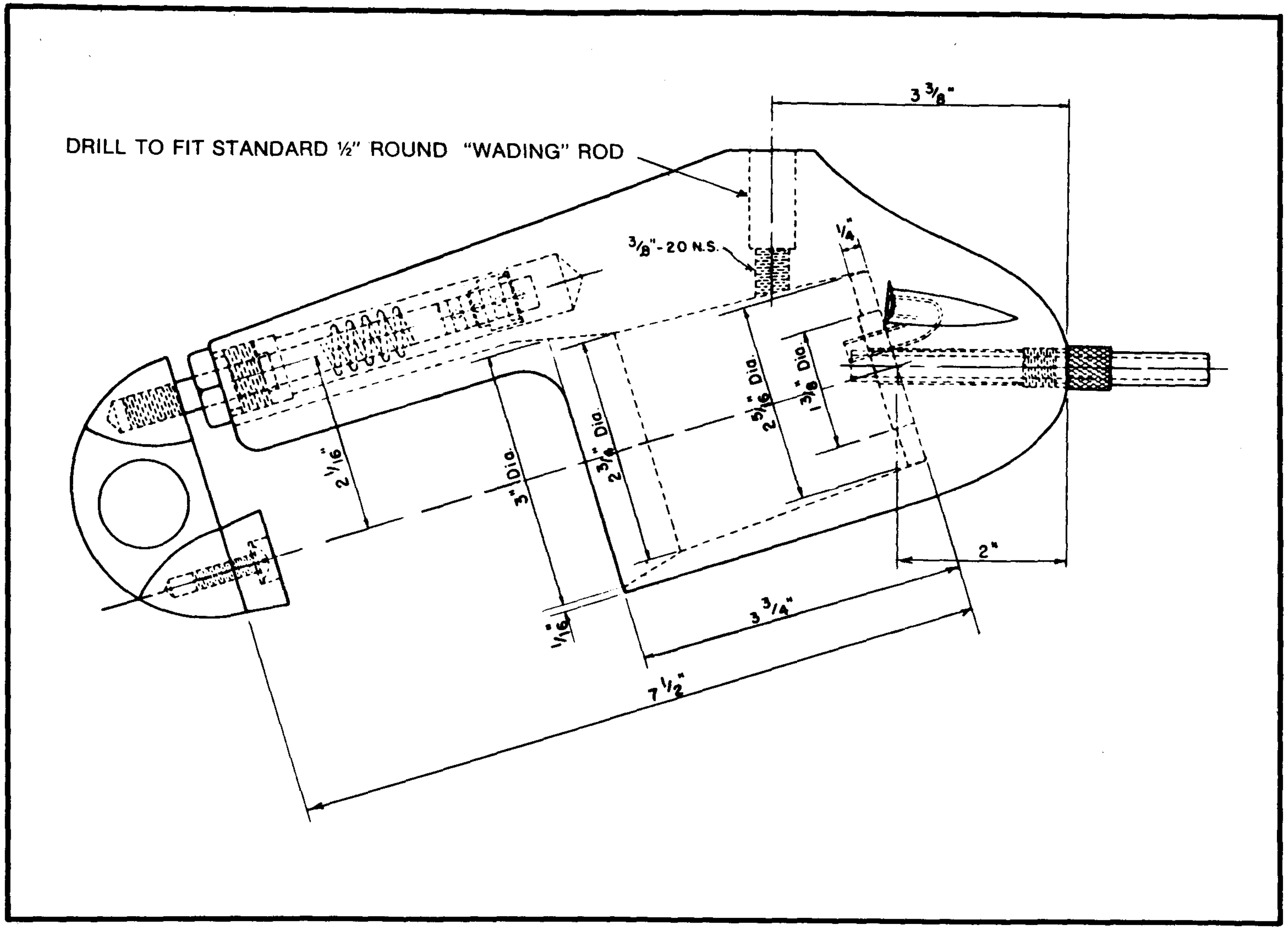
In the sampling operation, the intake nozzle is oriented into the current and held in a horizontal position while the sampler is lowered into the stream. The sampler is lowered at a uniform rate from the water surface to the bottom of the stream, instantly reversed, and then raised again to the water surface at a uniform rate. The sampler continues to take its sample throughout the time of submergence. At least one suspended-sediment sample should be taken at each vertical selected in the stream cross section. A clean bottle is used for each sample.

Diagram of Depth-Integrating Suspended-Sediment Wading-Type Hand Sampler, DH–48 appears on next page.

2. OPERATING INSTRUCTIONS

The hand sampler, DH–48, was designed for depth – integration of suspended-sediment samples in shallow streams. With this instrument the operator takes the sediment samples while wading in the stream or, if more convenient, by operating from a low bridge. The sampler consists essentially of a streamlined aluminium casting, 13 inches long and weighing approximately 3½ pounds, which encloses the sample container. The sampler is supported on ½ inch round wading rod, in sections which are threaded for assembly to any desired length. A brass nozzle, threaded to permit hand assembly to the streamlined head, projects upstream and provides the intake passage for the sample.

Round pint milk bottles are used for a sample containers. Pressure from a spring-tensioned operating rod, which is rotated by hand to bear upon the base of the sample bottle, holds and seals the bottle against a rubber gasket within the sample head.



DEPTH-INTEGRATING SUSPENDED-SEDIMENT WADING-TYPE HAND SAMPLER, DH–48

The axis of the sample container is inclined at an angle of 72½% to the vertical which permits sampling to within 3½ inches of stream bed. With the instrument oriented into the direction of flow (nozzle horizontal and pointed upstream) a continuous stream filament is discharged into the sample bottle during the period of submergence. The air displaced by the sample is ejected through the air escape vent projecting from the instrument alongside the head and oriented to discharge downstream.

A clean bottle should be used for each separate sediment sample. At least one suspended-sediment sample is taken at each stream vertical selected in the cross section. In sampling operation, the intake nozzle is oriented upstream, directly into the current, and held in a horizontal position while the sediment sample is lowered into the stream. Submerged obstructions directly upstream or adjacent to the sampler should be avoided to preclude interference with the stream filament approaching the intake nozzle. The sampler should be lowered at a uniform rate form the water surface to the bottom of the stream, instantly reversed, and then raised again to the water surface at a uniform but not necessarily on equal rate. Each field sample bottle when removed from the instrument should be capped immediately and appropriately marked.

A hand sampler continues to take its sample in flowing water throughout the time of submergence, even after the bottle is completely filled. If the bottle becomes entirely full, the sample may not be representative and it should be discarded. Although the capacity of the sample container is about 470 c.c., the tilt of the bottle is such that any sample containing more than 440 c.c. may be in error. In order to provide sufficient sample for a laboratory analysis, the length of time of the instrument remains submerged should be adequate to produce a sample volume greater than 375 c.c. but not to exceed 440 c.c. as marked on bottle.

The volume of sample collected throughout any stream vertical is dependent primarily upon mean stream velocity in that vertical, the size of the intake nozzle, and the time of submergence of the instrument. Thus, the volume of the sample may be increased or decreased by varying correspondingly the sampling time.

DEPTH-INTEGRATING HAND-LINE SUSPENDED SEDIMENT SAMPLER, DH–59 AND D–49

1. DESCRIPTION OF SUSPENDED SEDIMENT SAMPLER DH–59

This is a medium-weight suspended-sediment sampler for attachment to a hand-line type of suspension. The sampler can be lowered and raised by hand power with a flexible suspension line and hand over hand operation.

This sampler comprises a stream-lined bronze casting, 15 inches long, which partially encloses a round pint-size glass milk bottle. This sampler weighs approximately 22–pounds and is equipped with a tail vane assembly to orient the intake nozzle of the sampler into the approaching flow as the sampler enters the water. The glass-bottle sampler 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. Suspended-sediment samples, collected by the intake nozzle projecting horizontally upstream from the head of the casting, are discharged into the milk bottle container. The air in the milk bottle which is being displaced by the accumulated sample is ejected downstream through an air exhaust tube cast integrally with the body casting and protected by a streamlined projection alongside the head of the sampler. The sampler is calibrated and supplied with nozzles having 1/4 inch, 3/16 inch and 1/8 inch bore. Sample container bottles and the suspension are not furnished with the handline suspended-sediment sampler.

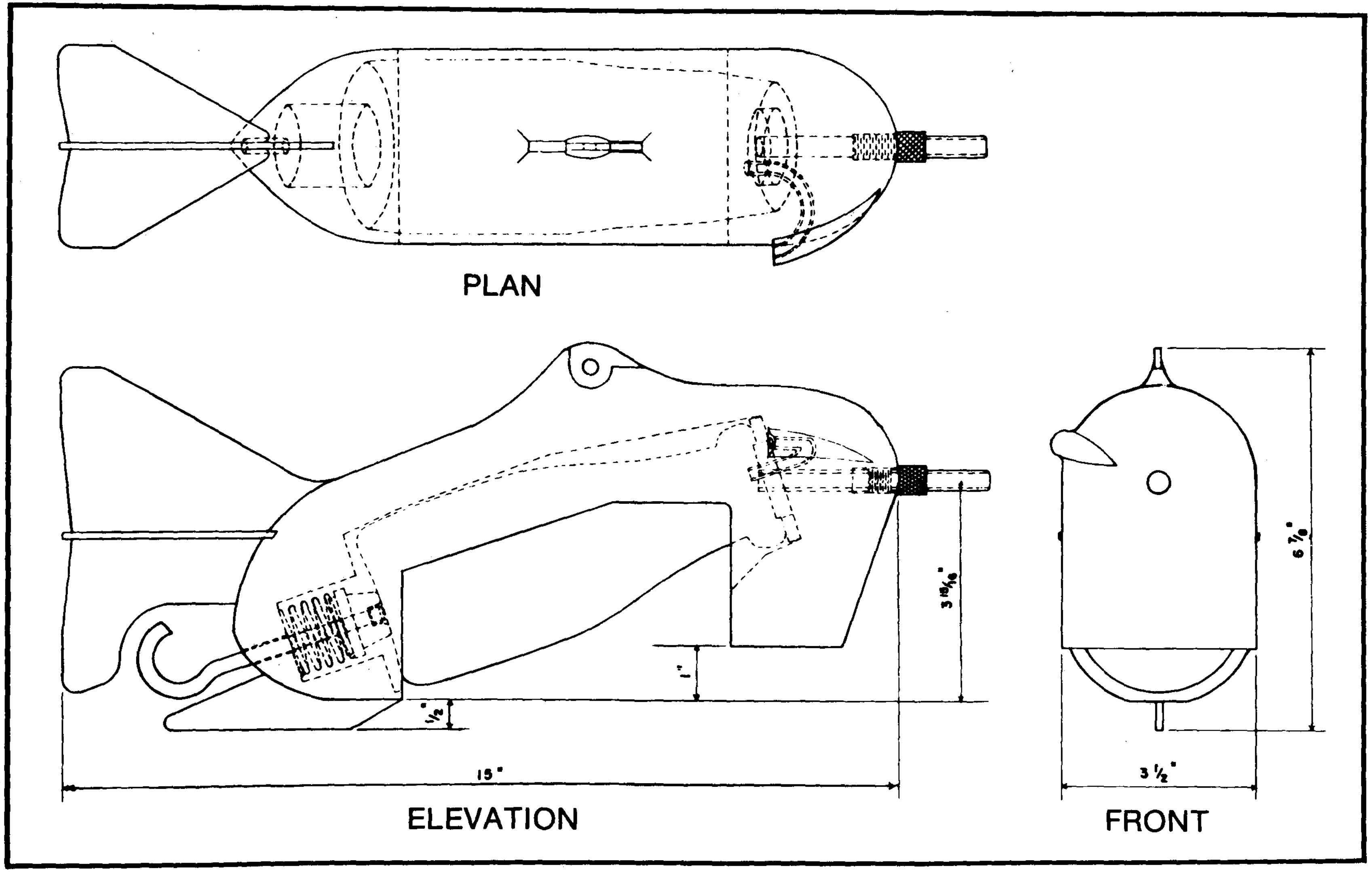
In operation, a clean bottle for each sample is securely sealed within the body of the sampler. The appropriate nozzle is selected and seated in the threaded recess of the sampler head, and the sampler lowered and raised at a uniform rate between the water surface and the bottom of the stream. On contacting the stream bed the direction of travel is reversed instantly and the sampler raised at the same or some other uniform rate. This sampler continues to take its sample throughout the period of submergence and must be removed from the stream before the bottle has completely filled. Bottled samples are carefully removed from the sampler, properly capped and marked, and shipped to the laboratory for analysis.

Diagram of Suspended-Sediment Sampler, DH–59 Hand Line Suspension appears on next page.

2. DESCRIPTION OF SUSPENDED SEDIMENT SAMPLER D–49

This is a 62 pound sampler for suspension by cable, reel, and crane to take suspended-sediment samples in streams not greater than 18 feet in depth.

The sampler has a cast bronze streamlined body–24 inches long, in which a round pint bottle sample container (not-furnished) is enclosed. The head of the sampler is hinged to permit access to the sample container. Tail vanes are provided to orient



SUSPENDED-SEDIMENT SAMPLER, DH–59
HAND LINE SUSPENSION

the instrument into the stream flow. The head, of the sampler is drilled and tapped to receive the 1/4 inch, 3/16 inch, or 1/8 inch intake nozzle which projects into the current for collecting the sample. A port which points downstream is provided on the side of the sampler head from which air escapes as it is displaced by the sample being collected in the container.

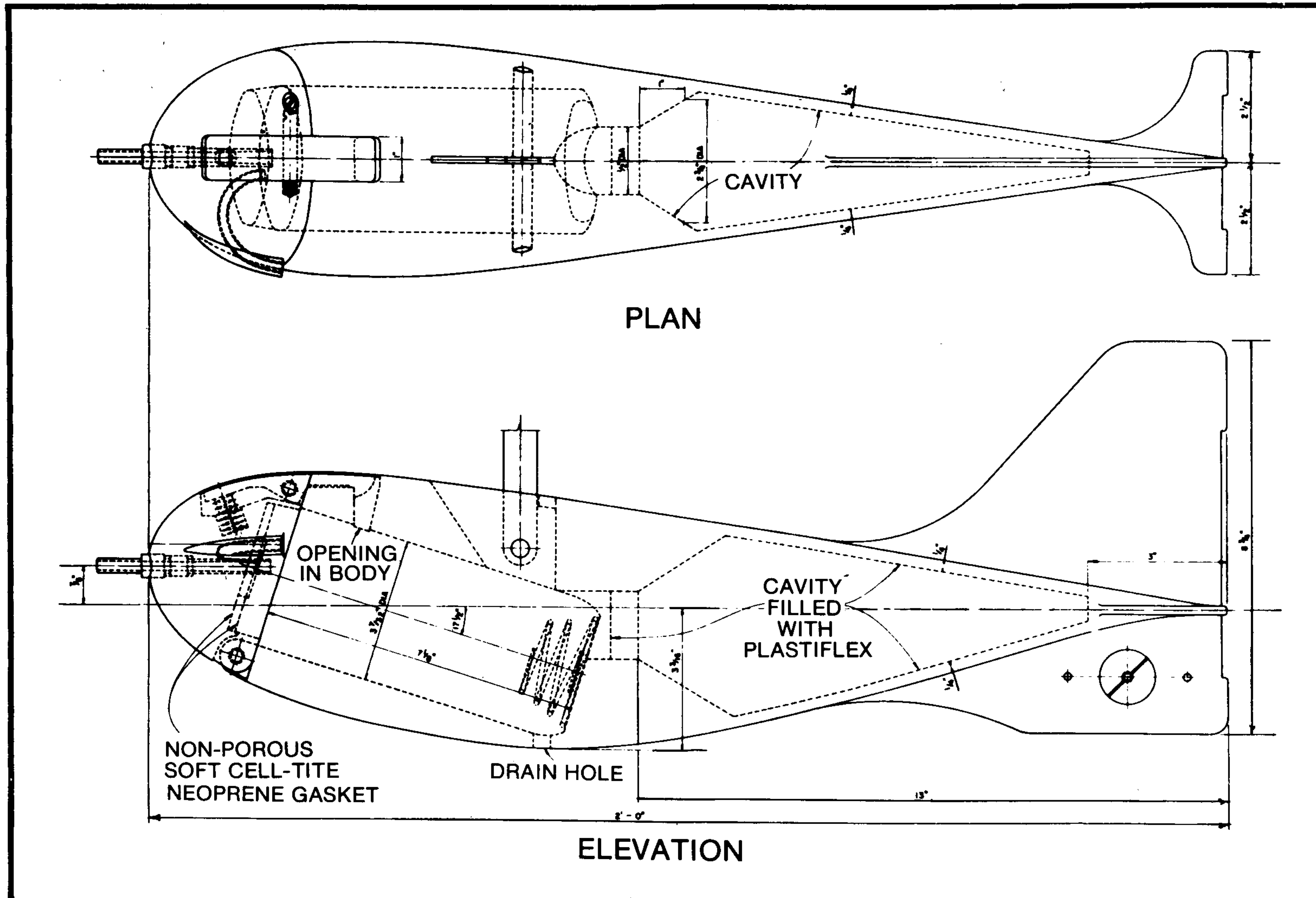
The instrument is suspended on a hanger bar attached to a 1/8 inch steel cable and is lowered and raised by means of a reel mounted on a crane. None of the equipment for suspension of the sampler is furnished. This instrument is generally operated from a bridge or cableway.

To obtain a sample, a bottle is inserted in the sampler and the instrument is lowered at a uniform rate from the water surface to the bottom of the stream, instantly reversed, and then raised again to the water surface at a uniform rate. The sampler continues to take its sample throughout the time of submergence. At least one sample should be taken at each vertical selected in the stream cross section. A clean bottle is used for each sample.

Diagram of Depth-Integrating Suspended-Sediment Sampler, D–49 appears on next page.

3. OPERATING INSTRUCTIONS

The D–49 and DH–59 suspended-sediment samplers are depth-integrating instruments designed for use in streams not more than about 15 feet in depth. The samplers have streamlined bodies weighing about 62 and 24 pounds, respectively, which are recessed to accommodate round one-pint bottle sample containers. Tail vanes to orient the instruments into the direction of flow and air escape passages are cast integrally. The heads of the samplers are drilled and tapped to receive the intake nozzles. The D–49 head is hinged, permitting access to the sample bottle cavity by releasing the catch and swinging the head downward, away from the hangar bar support. Nine Brass nozzles, three each with 1/4–inch, 3/16–inch, and 1/8–inch diameter bore, threaded for hand assembly to the head, are supplied with each D–49 instrument. Five Brass nozzles, two each with 1/4–inch and 3/16–inch diameter bore, and one 1/8–inch diameter bore, threaded for hand assembly to the head, are supplied with each DH–59 instrument. In the sampling operation, the head is oriented upstream with the nozzle pointing directly into the current, and the sampler is lowered from the water surface to the stream bed and then raised to a position above the water surface. During the period of submergence, a continuous filament of stream flow is collected in the sample bottle. Air displaced from the bottle while the sample accumulates is discharged through the air escape passage which points downstream. A fixed static head differential of 1/2–inch between the intake and exhaust facilitates sampling in low stream velocities and slack waters.
Selection of sampling locations requires evaluation of local conditions, a procedure which will not be discussed here. After the sediment sampling station or cross section has been selected sediment samples are usually taken at verticals that represent



DEPTH-INTEGRATING SUSPENDED-SEDIMENT SAMPLER, D–49 equal fractions of stream discharge. One or more samples may be taken at each sampling vertical.

Depth-integrating suspended-sediment samplers accumulate a sample of the water-sediment mixture throughout the period of submergence. However, if the container becomes completely filled during a sampling operation, the sample will not be representative and must be discarded. Clean bottles must be used and after sampling they should be covered with suitable caps to prevent contamination or loss of the sample. The capacity of the sample bottle is about 470 c.c. However, because the axis of the bottle is inclined to the vertical, any sample containing more than 440 c.c. may be in error due to circulation of the water-sediment mixture. The period of submergence should be sufficient to produce a sample volume less than 440 c.c., but greater than 375 c.c. in order to obtain a sample large enough for laboratory analysis. It is generally preferable to retain an initial sample of less than 375 c.c., but greater than 300 c.c., rather than to discard the sample and resample into the same bottle. If the initial sample volume is considerably less than 300 c.c., the stream vertical may be integrated a second time, or even a third time, each being additive to the same sample bottle. A minimum sample of 350 c.c. is suggested but sufficient latitude in minimum sample volume should be permitted to avoid re-taking a large number of samples.

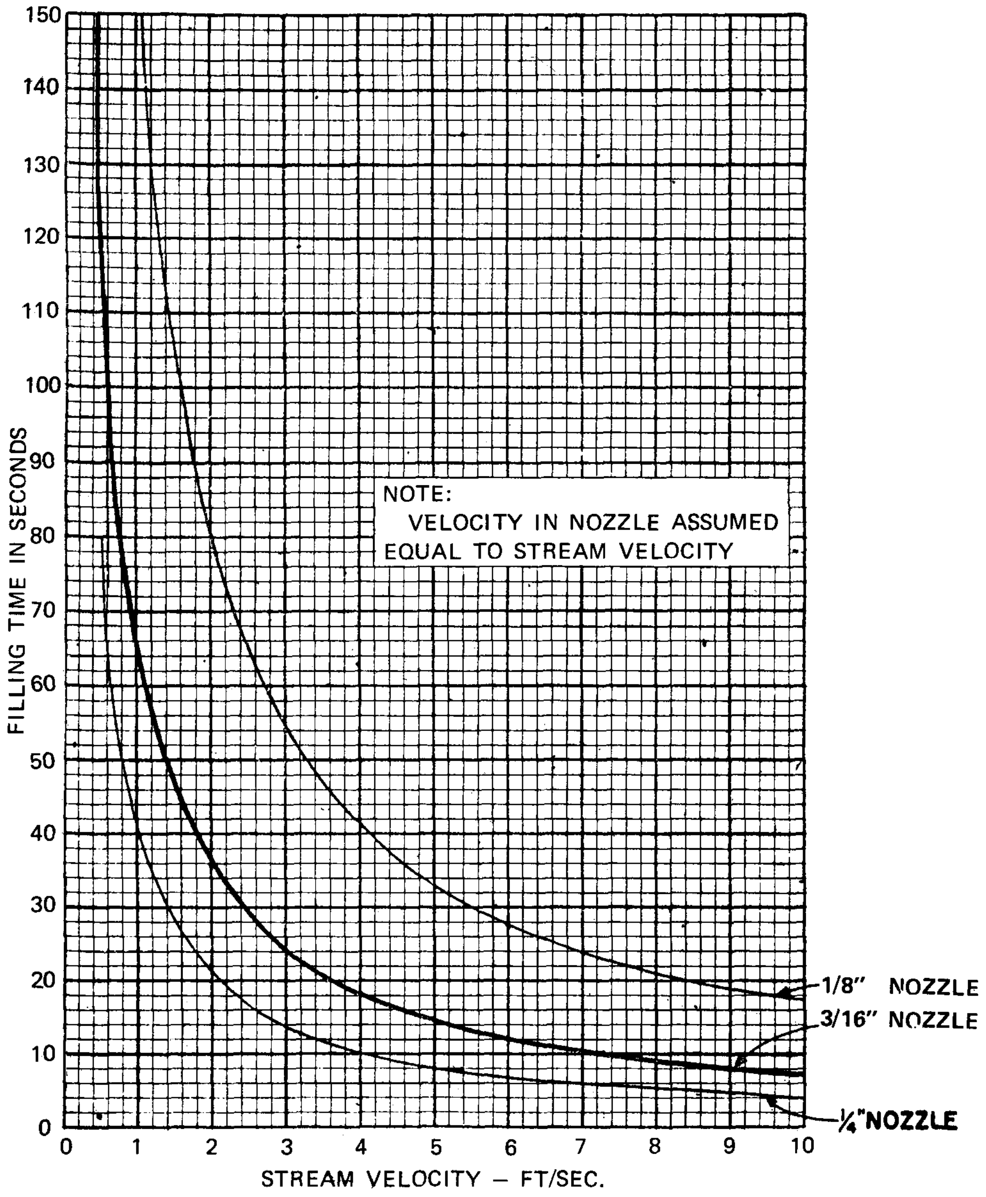
The D—49 suspended-sediment sampler should normally be used in stream depths of 15 feet or less, but depths of 20 feet can be sampled if necessary. These depths presume that sampling occurs throughout both the descending and ascending trips in the stream vertical. In general, the largest diameter nozzle that can be used within the operational limits of the equipment and personnel should be selected. However, a nozzle size which would require transit rates that are too great to be handled conveniently should not be selected. A transit rate which will produce a sample of not less than 350 c.c. and not more than 440 c.c. should be used for stream depths less than 10 feet. Similarly the sample obtained should approximate 380 to 440 c.c. for stream depths of 10 to 15 feet, and 400 to 440 c.c. for stream depths greater than 15 feet but not greater than 20 feet.

The volume of sample collected at a vertical is dependent primarily upon the local stream velocity and the duration of submergence of the instrument. Because the operator has no control over the stream velocity and depth encountered, he must regulate the volume of the sample by selecting a nozzle of appropriate size or by varying the sampling time (total time of submergence of the instrument).

A chart showing the relation between stream velocity and corresponding filling time (time of submergence of the sampler) to produce samples 395 c.c. in volume for the three standard nozzle diameters is attached. The filling time in seconds represents the total time of submergence of the instrument, that is, the time involved in traversing the stream vertical in both the downward and upward directions. Use of those filling time curves will provide acceptable sample volumes and will permit minor variations in the total time of submergence without invalidating the sample. Enter the sampling time curve with the stream velocity and determine the sampling time to secure a sample volume of 395 c.c. for the respective nozzle sizes. Then select the largest diameter nozzle than can be traversed conveniently throughout the depth of the stream in the time indicated, at a uniform rate through each direction of travel.

If the estimated mean velocity of flow in a stream vertical is 4—feet per second, a sediment sampler equipped with a 1/4—inch diameter intake nozzle will accumulate a sample of 395 c.c. in 10 seconds of submergence. The sampler must be lowered from the water surface to the stream bed at a uniform rate in 5 seconds and raised from the bed of the stream at a uniform rate to break the water surface at the expiration of the remaining 5 seconds. The time used in traversing the stream vertical need not be the same in both directions of travel. However, the rate at which the sampler moves vertically in any one direction must remain uniform. Thus, in the above example, the stream vertical could be traversed at a uniform downward rate in 6 seconds and at a uniform rate upward to clear the water surface in 4 seconds, a total submergence period of 10 seconds. If the 1/4—inch diameter nozzle requires a vertical transit rate greater than allowable for the stream depth, than a smaller diameter nozzle should be used.

Chart Showing "Filling Time for Sample of 400 C.C." appears on next page.



FILLING TIME
FOR SAMPLE OF 400 c.c.

POINT-INTEGRATING SUSPENDED-SEDIMENT SAMPLER, P–61

1. DESCRIPTION

This is a 100–pound electrically operated sampler for collection of suspended-sediment samples at any point beneath the surface of a stream, or for taking a sample continuously over a range of depth.

The sampler is made of cast bronze, 2 feet 4 inches long, is streamlined and equipped with tail fins to orient it in the stream. The sampler head is hinged to provide access to the round pint bottle sample container (not furnished). A nozzle for collecting the sample projects into the current from the sampler head. An exhaust port is provided to permit escape of air from the sample container as it is filled with the sample. An electrically acutated valve mechanism to start and stop the sampling process is located in the sampler head. The valve has two positions, (1) the equalizing position for balancing the pressure in the sample container with the hydrostatic pressure at closed, and (2) the sampling position. The valve is held in the equalizing position by a spring. Solenoids, when electrically energized, holds the valve in the sampling position. The compression chamber in the body of the sampler permits operation to depths of 50 feet.

The sampler is used to take a suspended-sediment sample at any point beneath the surface of the stream or to obtain a sample continuously over a range of depth. In outward appearance the P–61 point-integrating suspended sediment sampler resembles the P–46 sampler, and requires the same or similar equipment for its operation. Some safety features and a less complicated mechanism have been incorporated in the newer P–61 sampler.

Diagram of Point-Integrating Suspended-Sediment Sampler, P–61 appears on next page.

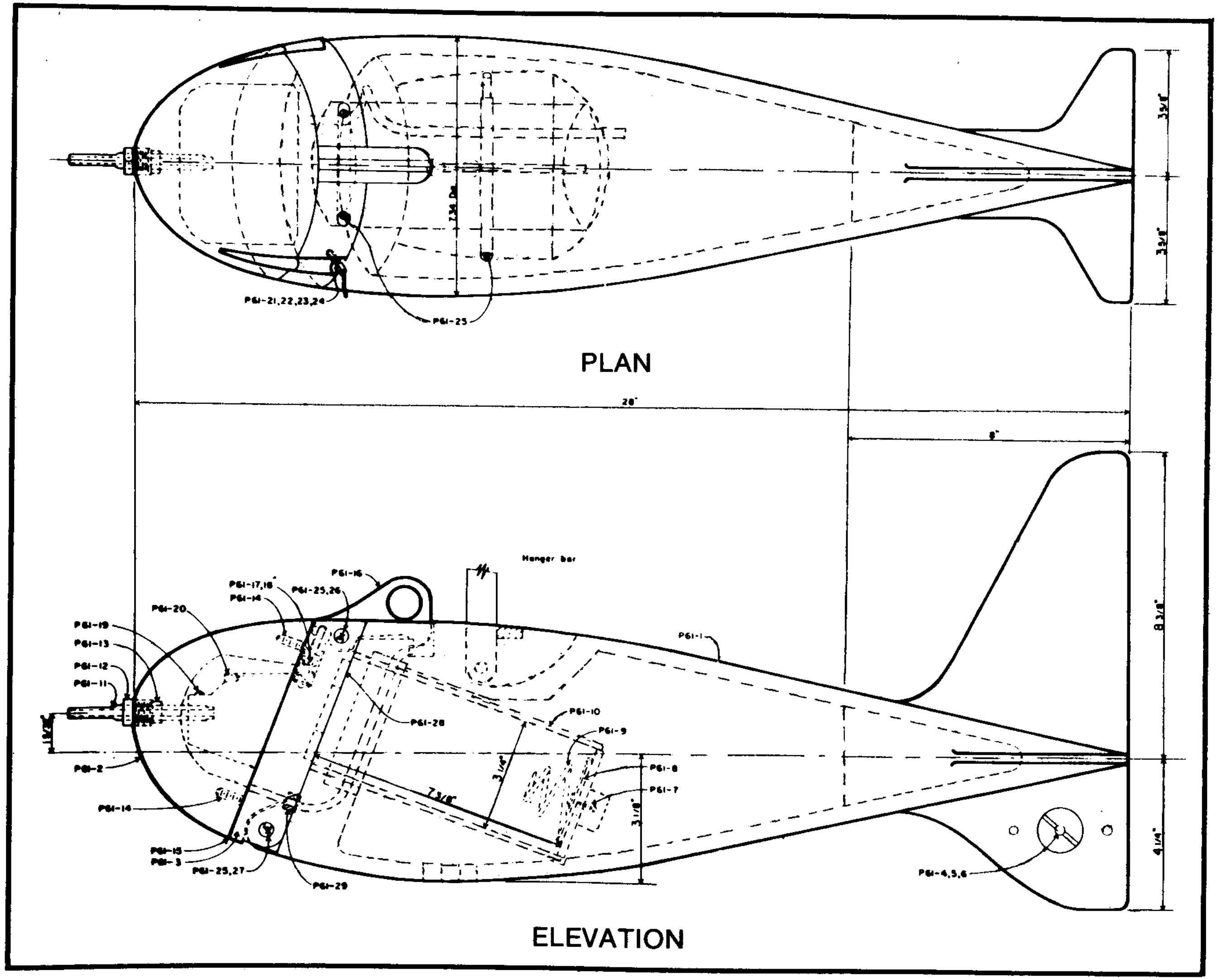
2. BASIC DESIGN

The sampler is simple in design and operation. A standard rotary solenoid turns a rotary valve through an angle of 45. When the solenoid is not energized, the valve is in the equalizing position: The air chamber in the body is connected to the cavity in the sampler head and the head cavity is connected through the valve to the sample bottle; the intake and air exhaust passages are closed. When the solenoid is energized, the valve is in the sampling position: The intake and air exhaust passages are open; but the connection from the bottle to the head cavity is closed.

The sampler is designed for suspension on a cable with an insulated core so that electric power can be delivered to the solenoid.

3. POWER SUPPLY

The resistance of the solenoid is about 24 ohms and the minimum current to move the valve into the sampling position is about one ampere. With a suspension line



POINT-INTEGRATING SUSPENDED SEDIMENT SAMPLER, P–61 that is 100 ft. long, the minimum voltage needed would be about 36 volts. A current supply of 48 volts is recommended. This can be obtained from eight 6–volt "hot Shot" batteries, by eight or ten 6–volt lantern type batteries, from storage batteries, or from a storage battery and Eicor dynamotor.

4. OPERATION

In normal sampling, the sampler is lowered to the desired sampling position and a switch is held closed to energize the solenoid for the length of time that sampling is to continue. The negative side of the power supply can be grounded to the reel that holds the suspension cable.

The sampler should require little or no lubrication or maintenance other than cleaning. The desirable interval for cleaning should be determined by field experience. No recommendations as to cleaning frequency are made at this time.

5. ASSEMBLY AND DISASSEMBLY

Most of the assembly procedure for the sampler will be obvious to anyone who has had experience with the P–61 type of sampler and details will not be discussed except for some special items.

A standard threaded hanger bar pin can be used, or a plain 3/8" diameter pin that is at least 3" long can be used. For a plain pin, the hanger bar should have a smooth hole rather than the standard threaded hole.

The catch does not have to be removed to take off the head cover, but if the catch is to be disassembled, care should be used that the pin and spring under the catch do not fly out and strike someone or get lost.

To disassemble the operating mechanism, first remove the brass screw in the end of the valve plug. Then the brass washer, spring and spring boss, and valve arm can be removed. Note the shape of the valve arm and which side is upward. Two small punch marks on each piece show the orientation of the valve arm on the square end of the valve plug. The end of the clock-type spring is also placed on the marked side of the square end of the valve plug. Note that there is a thin washer between the valve arm and the valve body.

The solenoid must be removed before the valve plug can slide out of the valve body. The set screw should first be loosened, then the band that holds the solenoid can be removed. Note the direction in which the solenoid leads point, and remove the solenoid. The valve plug can then be removed from the valve body. There is a thick washer on the large end of the valve plug.

To reassemble, place the valve plug in the valve body, with the two washers in place. Assemble the valve arm right side up and with the pairs of punch marks on the arm and square end of the valve showing. Add the clock-type spring with the end of the spring on the marked side of the square end of the valve. The spring should be wound about 1/2 revolution and mounted so that movement of the valve to the sampling position will further tighten the spring. The brass washer and screw can then be added. Align the top to the valve arm with the mark on the valve body and attach the solenoid with the leads pointing upward. Fasten the solenoid band and tighten the set screw. Energize the solenoid and check to see that the valve arm is drawn down tighty against the stop. The solenoid must not bind against the valve wheel.

6. ADJUSTMENTS

The valve stop can be moved along the head base so that the valve alignment will be precise when the valve arm is tight against the stop.

The solenoid can be turned so that when it is energized it will hold the valve arm snug against the stop. However, the arm should not strike the stop until the solenoid is very near the end of its stroke.

The clock-type spring must provide sufficient force to dependably return the valve plug to the initial position whenever the solenoid is not energized. The spring should not be overly tight or the solenoid will require excessive electrical current to turn the valve to the sampling position.

The voltage used to energize the solenoid must be sufficient to turn the valve to the sampling position. The resistance of the solenoid is about 24 ohms and that of the suspension line averages about an ohm for every 10 ft. Also, there is some resistance in the connections, connecting wires and ground return. The voltage can be three times the resistance for a very few seconds at a time, but it should not exceed 1.5 times the resistance for more than two minutes at a time. If the sampler should stick in the equalizing position when a series of samples is first started, the voltage can be applied to the sampler head directly, but only for a few seconds at a time, to loosen the valve.

7. SPARE PARTS

Extra nozzles, gaskets, and screw should be kept on hand. Preferably the solenoid is the only major item that is likely to give trouble. It is suggested that a spare should be kept on hand for immediate substitution whenever necessary.

8. WARNING

Do not allow the sampler to nose downward by more than ten degrees when a sample is in the bottle. If the sampler nose tilts downward, sample may discharge through the equalizing passage.

No. Sukatan 50 / 75

JABATAN PARIT DAN TALIAYER

(J.P.T. 11c)

DATA KADARALIR ENAPAN AMPAIAN

APPENDIX '4'

SUKATAN—CHERAKINAN—HITONGAN

Sungai PAHANG   Nama Setesen JAMBATAN BARU TEMERLOH   No. Setesen 3424511.

Tarikh 1975 - 02 - 07   Waktu sukatan di-mulakan 1135 hrs.   Siap 1150 hrs.   Kumpulan Kerjaluar Zaba & Kumpulan

Sukatan berkaitan dengan kadaralir sungai—No. Sukatan 51 / 75   Penchontoh D 49 Susp. Sediment Sampler

Waktu	Bachaan tolok (m)	Jauh dari tanda permulaan (m)	Ukor dalam (m)	Chara cherapan	Botol Berat—Gram				Penapis Berat—Gram				Himpunan Enapan B. S. J.			Kadaralir mukakerat m³/s q.	Hasildharab Ss. q
					No.	Dengan chontoh	Kosong	Berseh	No.	Dengan chontoh kering	Penapis	Berseh	Chontoh Sc	Pugak purata Sv	Muka kerat purata Ss		
1135 hrs.	25.41	55	5.66	DIM	DID 26	476.7	59.9	416.8	15	0.0934	0.0748	0.0186	45	45	45	115.12	5180.4
1142 hrs.	25.41	115	2.89	DIM	SEL 90	387.1	57.6	329.5	17	0.0920	0.0778	0.0142	43	43	43	124.25	5342.75
1150 hrs.	25.41	195	0.97	DIM	DID 138	414.9	57.6	357.3	8	0.0981	0.0822	0.0159	45	45	45	119.81	5391.45
															Jumlah ..	359.18	15914.6

KADARALIR ENAPAN AMPAIAN TONNE SA-HARI

Gs 1375.0 t/h.   Bachaan Tolok Purata 25.41 m.

HIMPUNAN PURATA ENAPAN BAGI MUKA KERATAN (S) $\frac{\Sigma Ss\,q}{\Sigma q}$ = 44.31 B.S.J.

Cherakinan makmal oleh Zainal b. Bakri   Di-hitong oleh Mohd. Karim b. Bakar   No. lembaran 1 dari 1 helai.

Ketumpatan enapan (Ps) dalam t/m³.
(Ps biasa-nya di-anggap 2.65 t/m³).

Value of Ps is assumed as 2.65 t/m³

Ketumpatan champoran ayer enapan (ia-itu chontoh — Pm) dalam t/m³.

Di-mana: $Pm = \frac{Ps}{ds - (S \times 10^{-6})\ (ds - dw)}$ t/m³.

$$Pm = \left[\frac{2.65}{2.65 - (44.31 \times 10^{-6})(2.65-1)}\right] t/m^3$$

$= 1.000027589\ t/m^3$

$\simeq 1.0\ t/m^3$

Kadaralir enapan ampaian (Gs) dalam t/hari.

Di-mana: $Gs = Pm \times S \times q \times 86{,}400 \times 10^{-6}$ t/hari.

$Gs = (1.0 \times 44.31 \times 359.18 \times 86{,}400 \times 10^{-6})$ t/hari

$= 1375.078965$ t/hari

$= 1375$ t/hari

Chatetan—Kiraan Tambahan

$$\frac{\Sigma Ss\,q}{\Sigma q} = \left(\frac{15914.6}{359.18}\right) \text{ b.s.j.}$$

$= 44.30814633$ b.s.j.

$\simeq 44.31$ b.s.j.

PERINGATAN:
- Gs = Kadaralir enapan dalam tan sa-hari (t./hari).
- S = Purata berat himpunan enapan dalam muka kerat dalam biji sa-juta (b.s.j.).
- q = Kadaralir sungai dalam meter padu sa-saat (m³/s.).
- Pm = Ketumpatan champoran ayer enapan dalam tan sa-meter padu (t./m³).
- Ps = Ketumpatan tanah/enapan (t./m³).
- dw = Ketumpatan bandingan ayer = 1.0 (biasa-nya).
- ds = Ketumpatan bandingan tanah.
- 86,400 = Sa'at dalam sa-hari.

Cherakinan makmal oleh Zainal b. Bakri Di-hitong oleh Mohd. Karim b. Bakar No. lembaran 1 dari 1 helai.

8720—11-10-72—J.C.K., K.L.

NO. STESYEN | 3 | 4 | 2 | 4 | 5 | 1 | 1 |

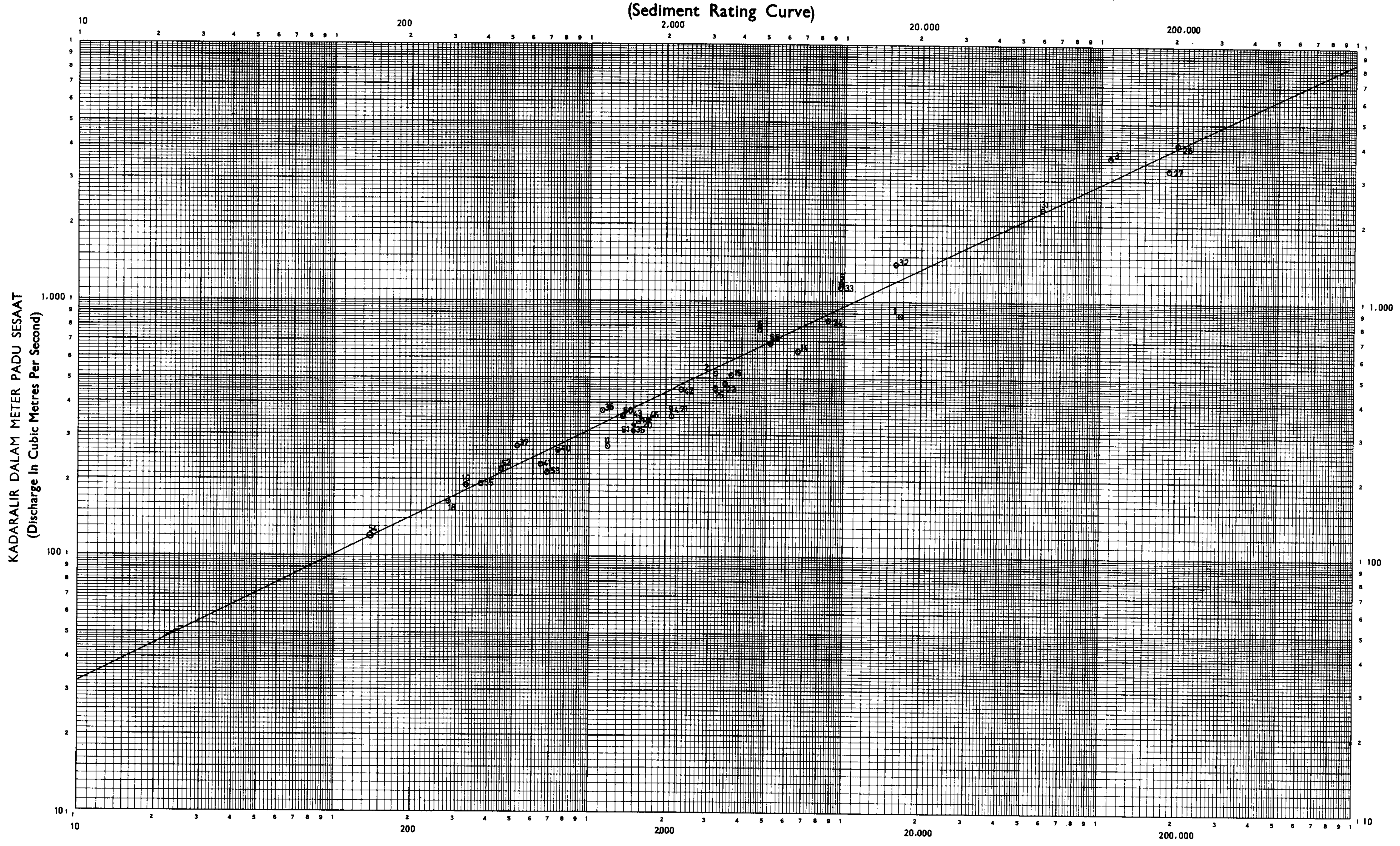
SUNGAI........................

DI........................

NEGERI: ....

TEMPUH: | 72 | 12 | 03 | KE | 76 | 11 | 06 |

GRAF KADARAN ENAPAN
(Sediment Rating Curve)



NOTE: POINT No. 44 OVERLAPPING POINT No. 35

APPROXIMATELY ONE-THIRD OF ORIGINAL PAPER SIZE 864mm x 559mm

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Disemak oleh:........................ Tarikh.....77.-06.-20.

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