A STUDY OF THE METHODS USED IN

MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS

SPONSORED BY THE

SUBCOMMITTEE ON SEDIMENTATION

FEDERAL INTER-AGENCY RIVER BASIN COMMITTEE

PROGRESS REPORT

FIELD TESTS ON SUSPENDED SEDIMENT SAMPLERS COLORADO RIVER AT BRIGHT ANGEL CREEK NEAR GRAND CANYON, ARIZONA

AUGUST 1951

A Study of Methods Used in

MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS

A Cooperative Project

Sponsored by the

Subcommittee on Sedimentation
Federal Inter-Agency River Basin Committee

Participating Agencies

Tennessee Valley Authority
Corps of Engineers ** Geological Survey
Soil Conservation Service ** Coast and Geodetic Survey
Bureau of Reclamation ** Forest Service
Federal Power Commission

PROGRESS REPORT

FIELD TESTS ON SUSPENDED SEDIMENT SAMPLERS

COLORADO RIVER AT BRIGHT ANGEL CREEK

NEAR GRAND CANYON, ARIZONA

Published by
Project Offices of Cooperating Agencies
at
St. Anthony Falls Hydraulic Laboratory
Minneapolis, Minnesota

August 1951

The cooperative study of methods used in

MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS

covers phases indicated by the following report titles.

Report No. 1

FIELD PRACTICE AND EQUIPMENT USED IN SAMPLING SUSPENDED SEDIMENT

Report No. 2

EQUIPMENT USED FOR SAMPLING BED-LOAD AND BED MATERIAL

Report No. 3

ANALYTICAL STUDY OF METHODS OF SAMPLING SUSPENDED SEDIMENT

Report No. 4

METHODS OF ANALYZING SEDIMENT SAMPLES

Report No. 5

LABORATORY INVESTIGATIONS OF SUSPENDED SEDIMENT SAMPLERS

Report No. 6

THE DESIGN OF IMPROVED TYPES OF SUSPENDED SEDIMENT SAMPLERS*

Report No. 7

A STUDY OF NEW METHODS FOR SIZE ANALYSIS OF SUSPENDED SEDIMENT SAMPLES

Report No. 8

MEASUREMENT OF THE SEDIMENT DISCHARGE OF STREAMS

Report No. 9

DENSITY OF SEDIMENTS DEPOSITED IN RESERVOIRS

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* In preparation for publication at a future date.

Miscellaneous and progress reports titled as follows have been prepared:

PRELIMINARY FIELD TESTS OF THE US SEDIMENT-SAMPLING EQUIPMENT IN THE COLORADO RIVER BASIN
APRIL 1944

FIELD CONFERENCES ON SUSPENDED SEDIMENT SAMPLING
SEPTEMBER 1944

PROGRESS REPORT, COMPARATIVE FIELD TESTS ON SUSPENDED SEDIMENT SAMPLERS
DECEMBER 1944

PROGRESS REPORT, COMPARATIVE FIELD TESTS ON SUSPENDED SEDIMENT SAMPLERS*
JANUARY 1946

STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS
(Paper presented at ASCE convention, Spokane, Washington)
JULY 1946

PRELIMINARY REPORT ON US DH-48 (HAND) SUSPENDED SEDIMENT SAMPLER**
APRIL 1948

OPERATION AND MAINTENANCE OF US P-46 SUSPENDED SEDIMENT SAMPLER
FEBRUARY 1949

INVESTIGATION OF INTAKE CHARACTERISTICS OF DEPTH-INTEGRATING SUSPENDED SEDIMENT SAMPLERS AT THE DAVID TAYLOR MODEL BASIN*

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* In preparation for publication at a future date.
** For limited distribution.

SYNOPSIS

The operating characteristics and the sampling accuracy of the US P-46, US P-46S, and US D-43 suspended sediment samplers were the major subjects of investigation in tests performed in the Colorado River near Grand Canyon, Arizona, during May and June of 1947. The primary purpose of the tests was to determine the suitability of the P-46 and P-46S samplers for operation under relatively difficult field conditions. The conduct of the investigation, the performance of the instruments, and the data obtained from the tests are presented and discussed in this report.

This investigation afforded the first opportunity to make a comprehensive and precise study of sampling operations, with special emphasis on an evaluation of the factors which influence the accuracy of the samples collected. Incidental to the requirements of the basic study, data were obtained which should be of general interest in the field of sediment transportation. The distribution of sediment throughout the depth in a stream of this size has rarely been investigated. Such data, with respect to total concentration as well as the various sizes of sediment, are presented in this report.

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I. INTRODUCTION

1. Previous tests--A few investigations of the field operation of suspended sediment samplers of the US series have been made under the sponsorship of the cooperative project titled "A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS". In general these were preliminary tests conducted to aid in the further development of the sampler. Some of these investigations have been reported in "Preliminary Field Tests of the US Sediment-Sampling Equipment in the Colorado River Basin" and in two Progress Reports "Comparative Field Tests on Suspended Sediment Samplers". The data in this group of reports pertain to several types of sediment samplers, including the US D-43 and the US P-43, both 50-lb. samplers. The US P-43 was the forerunner of the 100-lb. US P-46, and the two instruments have many points in common.

Extensive laboratory tests of the samplers and of sampler intake nozzles were made in conjunction with the development and calibration of these instruments. Some of these data have been included in Report No. 5 "Laboratory Investigation of Suspended Sediment Samplers" and in the forthcoming Report No. 6 "The Design of Improved Types of Suspended Sediment Samplers" published by the cooperative project. In addition there are many unpublished tests which relate mainly to the intake ratio, or filling characteristics, of various samplers and nozzles. However, the laboratory investigations undertaken thus far have been of insufficient scope to define the field operational behavior and accuracy of the samplers.

The information available on the smaller US suspended sediment samplers with attendant sampling techniques was considered inapplicable to the 100-lb. samplers. More comprehensive and detailed tests were required to properly evaluate these samplers, and to more clearly define their limitations. A study of the electrically operated mechanism for the P-46 sampler was particularly needed to facilitate further development. The sediment sampling tests covered by this report were made for the purpose of providing specific and authentic information on the operation of these instruments under relatively rigorous field conditions. The tests were conducted at the Colorado River gaging station near Grand Canyon, Arizona, in May and June of 1947.

It is anticipated that data of Report No. 5 "Laboratory Investigation of Suspended Sediment Samplers" may be compared with the results of these field investigations. From Fig. 15 of that report, a 30^{o} angle between the velocity approaching the sampler and the axis of the intake nozzle would seem to have a serious effect on the accuracy of the sample collected. When a sampler is lowered or raised through a stream, the velocity approaching the nozzle is the resultant of the vectors composed of the stream velocity and the vertical rate of movement of the sampler. However, the depth-integrating sampler is designed to operate with a ratio of unity between the horizontal stream velocity and the velocity in the intake nozzle of the sampler. Within proper operational limits, this ratio remains very close to unity. The data in Fig. 15 relate the resultant velocity, as distinguished from the horizontal stream velocity, to the velocity in the intake nozzle. In order to make the data of Fig. 15 comparable to field integration with a sampler having the nozzle horizontal, the relative sampling rate figures for the curves should be divided by the cosine of the angle of deviation. Where the 30° curve shows a sampling rate of 1.00, the corrected rate would be 1.15 corresponding to the same error in concentration. Correcting the 20° curve by similar methods, and plotting the results for both curves leads to the conclusion that the effect of angle of approach is largely, if not entirely, the result of the interpretation of the relative sampling rate or intake ratio.

2. Grand Canyon gaging station--The gaging station on the Colorado River at Bright Angel Creek, near Grand Canyon, Arizona, was chosen for the site of these tests for many reasons. The velocity, depth, and sediment content of the stream were considered suitable. Several previous tests of sediment samplers had been made there. Sediment records at that point dated back to 1925 and the length of sediment record combined with the general importance of the station made it especially desirable from the standpoint of its prominence in the sedimentation field.

The discharge of the Colorado River during the time of these investigations was about 50,000 sec. ft. Fig. 1 shows the stream flow data for the period covered by these investigations. The river was approximately 300 ft. wide, and the depth varied from 22 to 26 ft. at the point where the samples were taken. Cable Sta. 200 near the middle of the stream was used for all sampling. The effective point of suspension of the sampler was about 35 ft. above the water surface. The mean velocity in the sampling vertical varied from 7.2 to 8.1 ft. per sec. Rocky walls confine the flow of the river at this site. A sharp bend in the channel 1,000 ft. upstream from the sampling point may have influenced the flow somewhat. The stream bed was covered with sand and gravel at all times during the tests, but there is a rocky constriction in the channel a few hundred feet downstream. The flow in the river was turbulent, consisting of a continual series of boils and eddies. Velocity readings obtained with the current meter showed variations during the time of observation, and the differences between consecutive observations were frequently large. There were indications of rapid changes in the bottom configurations of the stream, and perhaps because of these fluctuations the shape of the vertical velocity curve changed rather rapidly.

This station was equipped with the usual items of stream gaging equipment including:

- Colorado type of stream gaging car on standard cableway with:
  - Sounding reel of 24 in. circumference
  - Brake for reel
  - Two depth indicators operating from the reel
  - Angle indicator
  - Suspension cable
- Current meters and earphones
- Sounding weights, hanger bar and connector
- Stop watch, thermometer, note book, measurement blanks, etc.

Records of gage height, discharge, and water temperature, were obtained from the Surface Water Branch of the Water Resources Division, U. S. Geological Survey, through the courtesy of Mr. John H. Gardiner, District Engineer, Tucson, Arizona.

3. Sediment sampling equipment--The main items of equipment which were used for the sediment sampling procedures were as follows:

US D-43 suspended sediment sampler No. 3

US P-46 suspended sediment sampler No. 2

US P-46S suspended sediment sampler No. 1

Eight 6-volt dry batteries of the "hot shot" type

Supply of pint milk bottles (sample containers) with caps

Supply of 4-ounce sample bottles (for shipping size analysis samples)

Assortment of hand tools

Insulated wire, battery clips, and switches

Laboratory equipment for the determination of sediment concentration

Laboratory equipment for the size analysis of sediment samples.

The US D-43 sampler used in these tests was one of the earliest models. However, the sampling characteristics of the instrument should be the same as those of later ones. Samplers of this series weigh 50 lbs. and have no valve to control sampling. The collection of the sample continues during the time the instrument is immersed in the stream.

The US P-46 sampler, weighing 100 lbs., is designed to collect samples of the suspended sediment at any point beneath the surface of a stream. The point samples are integrated over the duration of the time of sampling. The rate at which the sample is collected depends almost entirely on the velocity in the stream at the sampling point. The instrument may also be used to obtain depth-integrated samples, that is, samples collected continuously over a range in depth.

The P-46 contains a valve that is powered with a clock-type spring which must be wound for every four or five samples. Rotation of the valve is controlled by an electrically operated escapement. The diving bell principle is used to equalize the air pressure in the sample bottle with the external hydrostatic pressure prior to the start of sampling.

The US P-46S sampler used in these tests was the first of three of a special series to be fabricated, having been completed only a few days before being shipped to Grand Canyon for these investigations. This sampler is identical to the P-46 in appearance and general dimensions, differing only in the mechanism for operating the valve. The P-46S, which was formerly designated the US D-47 sediment sampler in Report No. 8 and elsewhere, allows rotation from one valve position to a second position only. The sampler may be assembled to integrate either downward from the water surface or upward to the surface, for one-way integration beginning or ending at the water surface. It may be used also for round-trip integration under the same limitations of depth and transit rate as the D-43, but it is not adaptable to partial integration of a vertical. This sampler is much less versatile than the US P-46, but is simpler and requires somewhat less electric current to operate. Both the P-46 and P-46S may be operated on the same type of electrical circuit. The sampling characteristics of the two instruments should be identical when used in a similar manner.

The eight 6-volt dry batteries were connected in series and used to supply operating current for the P-46 and P-46S samplers. Connection from one terminal of this group of batteries was made to the commutator on the sounding reel and from the commutator ring to the insulated core wire in the suspension cable. The other end of the insulated core wire was connected to the binding post of the sampler. The return circuit was through the sampler body, main portion of the suspension cable, sounding reel, and by way of a knife switch, back to the other terminal of the series of batteries.

The bottles, tools, and miscellaneous supplies were of the type generally used in sediment sampling and stream gaging.

Laboratory equipment for determination of the sediment concentration in the samples was available at the Grand Canyon gaging station. Concentration determinations were made by a method of decantation combined with evaporation over a steam bath. Corrections were made for dissolved solids. The concentrations were expressed in parts per million of solid matter based on the dry weight of the solid matter, and the total weight of the sediment mixture.

The size gradations of sixty of the sediment samples obtained in these tests were determined in the Lincoln, Nebraska laboratory of the U. S. Geological Survey. Four samples were broken in transit to Lincoln. The samples were analyzed by the bottom-withdrawal tube method, distilled water being used for the settling medium.

4. Personnel--The field work on which this report was based was performed by Russell P. Christensen, Byrnon C. Colby, Roy E. Cabell, and Joseph W. Ravdin. The report was prepared by Byrnon C. Colby, Walton H. Durum, and Robert A. Krieger, and was reviewed and edited by Paul C. Benedict and Martin E. Nelson.

II. OPERATION AND TEST PROCEDURE

5. Operation of the samplers--The US P-46 was used for 217 samples and found to be entirely adequate for sampling under the conditions of these tests. While there are undoubtedly possibilities for improving the speed and ease with which the sampler could be made to operate, still the sampler was found to be dependable, and its operation always appeared consistent and reliable. Out of every ten samples, one or two were generally spoiled by failure to wind the spring when necessary, by using the wrong length of sampling time, or by neglecting to set the valve properly prior to sampling. However, these difficulties tend to disappear with experience. The sampler spring which was of ordinary spring steel broke once and the sampler had to be disassembled and the spring repaired. The springs now in use are corrosion resistant and spring trouble seems to have been eliminated. The P-46 was used for obtaining about 150 samples over a period of several days without being disassembled, cleaned, or oiled. When it was finally taken apart it was for the purpose of demonstration and not on account of instrument failure.

The US P-46S sampler was used to collect 82 samples but gave considerable trouble. The spring with which the sampler was equipped gradually lost its shape or temper or both. A substitute spring not made for that instrument did not fit satisfactorily. Spring trouble with the P-46S seems to have been eliminated with the more recent springs installed in those samplers. The P-46S was delivered from the manufacturer with a winding device which was obviously unsuitable. It was hastily replaced with a makeshift mechanism which also proved unsatisfactory. The winding device was rebuilt again at the Grand Canyon station, but the workmanship was not sufficiently good to give thoroughly reliable operation. However, it was found possible to keep the P-46S operating sufficiently to complete the tests which had been planned for that instrument. With the exception of the spring and winding device the sampler proved satisfactory. Samples could be taken with the P-46S almost as rapidly as with the D-43.

No mechanical difficulty was experienced in the operation of the US D-43 sampler. However, due to its inadequate weight the sampler drifted downstream excessively. Under the conditions of high velocity and coarse sediment found at Grand Canyon, it was difficult to maintain suitable transit rates while integrating depths greater than about 12 ft. The sampler is not designed to operate in streams as deep and swift as the Colorado at Grand Canyon.

6. General test procedure--Although the ability of the samplers to operate under the conditions at Grand Canyon was of primary importance, a study of the accuracy of the results obtained with these samplers was also urgently desired. To that end samples were collected under various conditions and using a variety of depth-integration processes.

Samples were obtained May 30, 31, June 1-4 and 6-8, 1947. In general, the velocity of the stream was first determined. About ten observations of velocity were made with the current meter to define a vertical velocity curve for those days on which depth-integration data were to be obtained. Then about 10 point-integrated samples were taken to determine a vertical curve of sediment concentration. The computed velocities from these point samples were also available on which to base a vertical curve of nozzle velocities. Depth-integration samples were taken in one or both directions over the whole depth or over partial depths.

Samples with the P-46 were collected according to procedures in the preliminary report "Operation and Maintenance of US P-46 Suspended Sediment Sampler". Samples with the P-46S were taken with the same type of suspension. The P-46S was operated from the water surface downward, or upward to the water surface. The D-43 collects a sample from the time it enters the water until it is withdrawn. This sampler was lowered to the desired depth, rapidly reversed, and raised back to the water surface.

When the samplers were used to obtain depth-integrated samples, the rate at which the samplers were raised or lowered was kept uniform throughout the duration of any given sampling time. Since the samplers were lowered and raised by hand, "uniform" used in this sense is only a relative term. Because of the downstream drift of the samplers the rate of operation of the drum was not a precise measure of the rate at which the sampler was lowered or raised.

The sediment samples obtained were processed at the sediment laboratory at the Grand Canyon gaging station, with the exception of about 60 samples which were sent to Lincoln, Nebraska for determination of particle size.

Most of the test data compiled in these investigations may be found in the form of computation sheets in the appendix of this report.

The angle or angles which the suspension cable made with the vertical have been recorded for most of the samples. For others the angles have been computed from other observations and the basis of comparison indicated on the computation sheets in the appendix. In many cases the average angles for a group of samples were recorded. The type of angle indicator on the gaging car is probably accurate to within one degree when observations are made over a few seconds time. However, for depth-integrated samples, the angles at the water surface or at the stream bed must be observed instantaneously, and that usually at a time when the gaging car is swinging because of the rapid operation of the suspension reel. Such observations are open to considerable error. For that reason only one average angle for a group of similar integrations was sometimes recorded, on the assumption that the over-all average was more nearly representative of each sample than a single reading would be.

Stream velocities were obtained with a small Price current meter which had been rated at the Bureau of Standards at Washington, D. C. Corrections to depth involved in soundings and in the placement of the meter for velocity observations were made according to "Method for Correcting Soundings of Deep Swift Rivers" prepared by G. C. Stevens of the Water Resources Division of the Geological Survey, Washington, D. C.

III. INTAKE RATIOS

7. General comments--The intake ratio, or the relation of the velocity in the nozzle of the sampler to that in the stream at the sampling point, is an important index of the accuracy of a sediment sample. Any condition which causes the intake ratio to depart from unity may cause an inaccuracy in the concentration of sediment collected in the sample. However, the intake ratio may usually vary several percent from unity before the sediment concentration shows any serious inaccuracy, especially if the particles of sediment involved are of relatively small size. Minor departures from ideal sampling conditions generally show up more quickly in the intake ratio than in the sediment concentration. The intake ratio is a convenient and sensitive indication of sampling conditions, and, therefore, can be used as a convenient basis for one type of study of the effect of various factors on the accuracy of sampling.

In relating the intake ratio and the sediment concentration of field samples, there may be instances in which the intake ratio for an individual sample was apparently much too low, and yet the sediment concentration seemed unaffected. This type of sample may result if the intake nozzle was obstructed or partly obstructed for all or a portion of the sampling time. Complete obstruction for part of the sampling time might result in a sample which was correct in concentration over that part of the sampling period when the intake was operating satisfactorily. A partial obstruction of the nozzle tip might not have any appreciable effect on the sediment concentration if the intake velocity based on the net area of the intake remained close to unity. While any sample which has an intake ratio differing from unity should be considered doubtful, the concentration in such a sample is not necessarily erroneous. In any study of samples taken in a stream of turbulent flow, the possible variation in velocity during the time of sampling should be considered. The fact that a nozzle velocity was 20 percent greater or less than that expected, would indicate that the intake ratio varied, that the stream velocity fluctuated while the intake ratio remained constant, or that the difference was made up of a combination of the two. Ordinarily, the intake ratio will remain relatively constant regardless of fluctuations in velocity.

8. Stream velocities from current meter observations--Velocity observations taken with a small Price current meter were used as the basis for determining the intake ratios for the various samples taken in these tests. There were five days (May 30, 31, June 3, 4 and 6) on which a complete vertical velocity curve was determined from current meter observations. On June 2 a vertical velocity curve was defined for the upper portion of the depth only. Velocity data for these days have been plotted and tabulated on Figs. 3-8. All velocities obtained with the current meter have been plotted with the exception of those for June 1. The apparent change in velocity during the tests on that day was so great that any comparison of the velocities in the nozzle of the sampler with those from the current meter would require corrections for time, and there were not sufficient data on which to base such a correction.

The current meter observations for the Grand Canyon investigations were made by standard methods of procedure. The observed soundings and depths for placement of the meter were corrected for the angle in the sounding line. The current meter velocities plotted on the figures will be considered basic data. These velocities are not listed nor the computations included within the tabulated data presented with this report. The double velocity readings shown on Fig. 5 should be noted. The velocity readings on this plate were taken in duplicate, and the readings were consecutive at each depth. An observation extended over approximately 50 sec. The variation in velocity over consecutive 50-sec. intervals was as great as 7 percent. Obviously this would indicate a much greater probable variation between the 8- or 10-sec. intervals which make up the usual sampling time.

When the sampler was being used for depth-integration, the observed stream velocities required a correction for the downstream drift of the sampler in order to make the observed figures equal to the velocity past the sampler nozzle. The angle in the suspension line to the sampler was changing almost constantly during the process of depth-integration. The angle was 0° at the moment the sampler touched the water going downward; the angle was perhaps 18° by the time the sampler reached the stream bed. Several forces which influence this angle are indicated to some extent in "Method for Correcting Soundings of Deep Swift Rivers". The corrections made here are derived from data in that booklet, which data were based on several simplifications of actual conditions, but are probably accurate enough for the present purpose. Actually, in depth-integration, the effective weight of the sampler is altered by the resistance of the water to the vertical movement of the sampler; the velocity against the sampler and suspension line varies as the sampler drifts downstream, or is towed upstream during integration; and the effective weight of the suspension line changes with differences in angles and rate of movement of the line which alter the drag and uplift on the line. A complete analysis of the changing forces with respect to various positions of the sampler suspension is beyond the scope of this report.

The magnitude and seriousness of this correction might be more readily grasped from the consideration of a concrete instance. Assume the sampler enters the water directly beneath the suspension point but drifts downstream until the suspension line makes an angle of 15° (a very conservative figure) with the vertical when the sampler reaches a point 20 ft. below the water surface. With the point of suspension 35 ft. above the water surface, when the angle becomes 15° the line enters the water 9.4 ft. downstream from the point directly underneath the suspension. See Fig. 2. In addition the sampler is 2.7 ft. downstream from the point at which the line enters the water. The sampler is then 12.1 ft. downstream from the point of suspension. If a sampling time of 8 sec. elapsed during the downward integration, and the average stream velocity for the 20 ft. of depth was 7.0 ft. per sec. then a total flow of 56 linear ft. would have passed the sampler nozzle if the sampler had not drifted 12.1 ft. downstream. However, the actual flow past the sampler nozzle was only 56 minus 12.1 or 43.9 linear ft. The average velocity past the sampler nozzle was then 43.9 divided by 8 or about 5.5 ft. per sec. If the sampler were used to integrate upward from the

20-ft. depth, the sampler would be drawn upstream. It might be expected to emerge from the water about 4 ft. downstream from the suspension point. It would therefore be drawn 8.1 ft. upstream. For an 8-sec. duration of the upward sampling trip, the linear flow past the intake nozzle would be 64.1 ft. In this case the velocity past the nozzle would be about 8.0 ft. per sec. The correction for a round-trip sample composed of the downward and upward integration would have been made only on the basis of the net downstream drift of 4 ft. If the sample had been taken over the 16-sec. period, the linear flow past the nozzle would have been 112 minus 4 or 108 ft. The velocity past the nozzle would have been 108 divided by 16 or 6.75 ft. per sec. Even this deviation from the assumed mean velocity of 7.0 ft. per sec. is large enough to be significant.

The stream velocities for June 3 and 6 were corrected for a change in velocity with time during the sampling day. The change in velocity was computed on the basis of the change in the mean velocity determined from the morning and afternoon nozzle velocity curves. The current meter velocities were considered to have the same rate of change with time as shown by the nozzle velocities.

The corrected velocity was based on the observed current meter velocity corrected for the downstream drift of the sampler, and on June 3 and 6 corrected also for the change in velocity with time.

The vertical velocity curves are quite irregular in shape. The bottom of the stream was probably changing during the time of some of these tests. On June 4, the depth was 22.3 ft. in the morning, and 26.0 ft. in the afternoon. There was a major change in the vertical velocity curve attendant upon this change in depth. However, this change appears to have occurred subsequent to the completion of most of the tests for that day. The velocity curves seem to have been changing during the time over which the tests were made on June 3 and 6. On these days the velocities have been considered as changing uniformly with time from the start of operations until the end. The change has been assumed of equal numerical value from the surface to the bottom of the stream. Actually the change was perhaps more nearly a percentage correction to the morning curve. The corrections made for the change in velocity with time are obviously only approximations, but the available data do not justify greater refinement.

The shape of individual vertical velocity curves may have been influenced by fluctuations in velocity which extended over relatively long periods of time. Each observation made with the current meter covered an interval of about 50 sec. Observations were taken as rapidly as possible beginning at the stream bed and working upward. Some of the fluctuations in velocity probably extended over periods longer than one velocity observation, and for that reason may have given a deformed shape to the resulting vertical velocity curve.

The study of intake ratios for this investigation has been based mainly on the data for the six days on which vertical velocity curves were defined by current meter velocities. The vertical velocity curves were based on current meter observations at the mid-point of each tenth of the stream depth. The current meter observations were generally followed by a set of point-integrated samples taken at the same depths as the current meter velocities. These point samples were followed by depth-integrated samples collected in various ways. At the end of the sampling day, about five more point-integrated samples were taken at points distributed throughout the depth of the stream. On June 4, additional current meter observations were made at the end of the day to substantiate the velocities shown by the point samples.

9. Nozzle velocities based on point samples--The velocity of flow in the intake nozzle was computed for each of the sediment samples. The computation was based on the volume of the sample, the time during which it was collected, and the cross-sectional area of the nozzle. The volume of the sample in cubic centimeters was considered numerically equal to the weight of the sample in grams. This relation would be true of pure water at maximum density. However, at the water temperature of these tests, pure water would be at less than maximum density; but the presence of sediment in the sample would tend to make the mixture heavier than pure water. The error in the conversion of weight to volume appears to be about 0.1 percent and will be neglected.

The nozzle velocities of the point-integrated samples were used to define vertical curves of nozzle velocity in relation to depth. If the velocities in the nozzle for the morning and afternoon samples did not show any definite difference, all were used to determine one daily curve. If the afternoon samples indicated a significant difference, separate vertical velocity curves were based on morning and afternoon samples. On June 3 and 6, the two days on which such a difference appeared, the rate of change in velocity with time was determined from the spread between the morning and afternoon curves. This rate of change was applied to current meter and to point sample velocities before using them as a basis for comparison with other samples.

No detailed discussion of the daily velocity data presented in Figs. 3-8 will be attempted. A study of these plates will indicate how the daily velocity curves have been determined, and will also show that an occasional observation has been disregarded. A careful investigation of these figures will reveal the variations in individual observations, and will indicate the probable range in errors which enter into the computations based on individual samples or on group averages.

The types of information presented on the daily velocity curves will be discussed briefly. The daily plates show all the current meter and point sample velocities on which the curves were based. The velocity from the morning curves is tabulated for each tenth of the depth of the stream for both the current meter and the point sample curves. The legend includes the approximate mean time for the observations on which each curve was based. The computations along the lower portion of the plates are largely self-evident. The current meter mean corrected for time consists of the current meter mean velocity taken from the curve, and corrected on the basis of the time shown along the bottom of the tabulation. This correction on the basis of time, applies only to those days on which the morning and afternoon point samples indicated a change in velocity during the sampling day. When groups of depth-integrated samples were taken in a similar manner, the current meter velocity for the group was corrected for the downstream drift of the sampler on the basis of the average angles of the sounding line, and the average time over which the samples were taken. The point sample mean corrected, is the point sample mean velocity from the vertical velocity curve, with corrections for changes in velocity with time and for changes caused by the downstream drift of the sampler. The ratio of the average nozzle velocity for the group of samples to the current meter mean velocity corrected, and to the point sample mean corrected, has also been shown. The transit rate for a group of samples is the average rate of vertical movement of the sampler. The figure was obtained by taking the depth over which the samples were integrated and dividing by the average sampling time for the group. This transit rate was divided by the current meter mean velocity corrected. The result was the ratio of the vertical transit rate of the sampler to the stream velocity past the intake nozzle. The time recorded along the bottom of the table is the mean time for the observations in the group. The times for two groups may be almost identical because the samples in the two groups were intermixed. The abreviations "sb" for stream bed and "ws" for water surface have been used.

No attempt will be made to analyze the differences or correlate the discrepancies shown on the daily data, other than to point out the presence of rather extreme variations in the individual velocity observations.

Fig. 9 is presented as a summary of the data which relate most directly to the comparison of current meter and point sample velocities. The shapes of the average curves appear quite regular and normal. The daily curves show marked variations. The average intake ratio for the point samples was very close to unity near the water surface. However, the ratio gradually decreased with an increase in depth until it was only about 0.92 near the stream bed. The mean velocity from the average curve for the current meter was 7.74 ft. per sec., while that for the point samples was 7.57 ft. per sec. These figures indicate an average intake ratio of 0.98 for the point-integrated samples. This is a very satisfactory average ratio. However, the ratio of 0.92 near the stream bed is low enough to indicate an appreciable error in sediment concentration in the point samples taken near the bed of the stream.

10. Effect of depth-integration on intake ratios--The vertical movement of the sampler during depth-integration might be expected to influence the sampling characteristics of the instrument. One of the most important problems involved in depth-integration is the determination of the effect of the vertical movement on the relation between the velocity in the nozzle and that in the stream at the sampling point. The Grand Canyon data will next be analyzed in an attempt to evaluate this effect.

A breakdown of the intake ratios for various divisions of the depth-integrated samples might be made on the basis of direction of integration, instrument, size of nozzle, relative transit rate, etc. However, the smaller divisions would consist of so few samples as to be inconclusive, and perhaps misleading. The average intake ratio for some of the kinds and variations in integration procedure used at Grand Canyon are presented in Table I. A few of the more inconsistent depth-integrated samples were not used in determining these average intake ratios. The discarded samples have been indicated on the computation sheets in the appendix.

Perhaps the most significant difference shown by the intake ratios is that between the ratios obtained when sampling downward and those

TABLE I

SUMMARY OF DATA FOR DEPTH-INTEGRATED SAMPLES

OPERATION	No. SAMPLES	AVERAGE RATIOS	
		INTAKE*	CONCENTRATION
Samples depth-integrated with P-46 and P-46S	128	0.98	1.00
Integrated downward	52	1.04	0.99
Integrated upward	66	0.94	1.01
Integrated round trip	10	1.00	1.06
Integrated over full depth	63	0.99	1.00
Integrated downward	24	1.07	1.00
Integrated upward	39	0.94	1.00
Integrated over partial depth	65	0.97	1.01
Integrated downward	28	1.01	0.98
Integrated upward	27	0.92	1.02
Integrated round trip	10	1.00	1.06
Samples depth-integrated with P-46	72	0.99	1.03
Integrated downward	31	1.04	0.99
Integrated upward	31	0.93	1.05
Integrated round trip	10	1.00	1.06
Integrated over full depth	26	1.02	1.03
Integrated downward	13	1.10	0.98
Integrated upward	13	0.94	1.07
Integrated over partial depth	46	0.97	1.03
Integrated downward	18	1.01	1.00
Integrated upward	18	0.93	1.04
Integrated round trip	10	1.00	1.06
Samples depth-integrated with P-46S, 3/16-in. noz.	28	0.95	0.97
Integrated downward	10	0.97	0.97
Integrated upward	18	0.94	0.97
Integrated over full depth	19	0.95	0.99
Integrated downward	5	0.95	1.02
Integrated upward	14	0.94	0.98
Integrated over partial depth	9	0.96	0.94
Integrated downward	5	0.99	0.93
Integrated upward	4	0.92	0.95
Samples depth-integrated with P-46S, 1/8-in. noz.	28	0.99	0.98
Integrated downward	11	1.08	1.00
Integrated upward	17	0.93	0.97
Integrated over full depth	18	1.01	0.98
Integrated downward	6	1.12	1.04
Integrated upward	12	0.95	0.96
Integrated over partial depth	10	0.96	0.97
Integrated downward	5	1.04	0.95
Integrated upward	5	0.88	0.99
Samples depth-integrated with D-43, 1/8-in. noz.	12	1.44	0.86
Integrated over full depth	9	1.50	0.84
Integrated over partial depth	3	1.25	0.91

* Computed on basis of horizontal stream velocity.

obtained when sampling upward. This difference appears to be about 10 percent.

The intake ratios for upward integration generally check each other very closely. The possible exception is the low ratio on June 2 for the five P-46S samples integrated upward over a partial depth using a 1/8-in. nozzle. The same relation does not show up on the samples integrated over the full depth, so the probability is that the difference shown on June 2 is not significant. Table I seems to indicate that an intake ratio of 0.94 was about normal for upward integration under the conditions at Grand Canyon.

The intake ratios for downward integration show greater variations than those for upward integration. The relatively high intake ratios shown by the samples taken with the P-46 on May 30 and 31, and with the P-46S with 1/8-in. nozzle on June 6, are among the more obvious discrepancies. The relative transit rates for these series of samples were near the theoretical maximum permissible as determined by equation (5) of Report No. 6. (The relative transit rates for several groups of depth-integrated samples, including those referred to above, are shown on Figs. 3-8.) The rates for the downward integration of the P-46 on May 30 and 31 were 0.43 and 0.42 respectively, against a theoretical maximum of 0.40; and the value for the P-46S with 1/8-in. nozzle on June 6 was 0.17, compared to a theoretical maximum of 0.18. Because these transit rates are the averages for a group of samples, the theoretical maximum values were probably seriously exceeded on some samples. Furthermore, these theoretical values are for non-turbulent flow. The rather turbulent flow at the Grand Canyon no doubt resulted in instantaneous transit rates much higher than the average. The results listed above seem to check the fact that these limiting downward transit rates are effective, and that the result of high transit rates begins to appear at these limits. An intake ratio of 1.09 would be fairly representative of the intake ratios for downward integration on the three days mentioned. The downward integration of all partial depths and the downward integration over the full depth on June 6 with the 3/16-in. nozzle were within the accepted limits of transit rates, and the intake ratios from those samples should be comparable. The average intake ratio for downward integration for these samples was 1.00. The most obvious criticism of this value is that it may be slightly low because based on figures for June 2 and 6 when the relation between the current meter and the point samples indicated that the intake ratios obtained might be slightly low.

In studying the effect of the integration process on the intake ratio, primary consideration might be given to those samples taken with the P-46 sampler, because that instrument was used for both point-integrated and depth-integrated samples. The depth-integrated samples taken with the P-46 have been given somewhat more weight than samples taken with the P-46S, but the difference between the two samplers seems very small.

The average intake ratio for the point-integrated samples has been previously given as 0.98. The average for the depth-integrated samples taken with the P-46 and P-46S is also 0.98. After attempting to appraise these figures and those for the upward and downward integration, the following deductions have been made. The vertical transit of the samplers during downward integration probably increased the intake ratio about 4 percent, while upward integration decreased the intake ratio about 4 percent. These figures are based on integration within accepted limits of relative transit rates. The ratios were computed from the corrected horizontal velocity of the stream. For downward integration the sampler probably rides nearly level and these figures are in no way questionable. If on upward integration the sampler is assumed to tilt upward along the resultant of the horizontal velocity and of the vertical movement of the sampler, the actual intake ratio for upward integration under the conditions at Grand Canyon would have been from 5 to 8 percent less than that for the point-integrated samples. It seems probable on the basis of experience at the David Taylor Model Basin that the sampler does tilt upward in this way.

The differences between the P-46 and the P-46S with the 3/16-in. nozzles were very small. The result with the 1/8-in. nozzle operating upward over partial depths was obtained from only five samples. There is no apparent reason why these should have a low intake ratio. Probably the intake ratio for the 1/8-in. nozzle operating upward should be taken as the average of all samples taken upward, which would give an average ratio of 0.92 for the 1/8-in. nozzle operating upward and corrected as indicated.

There remains the matter of depth-integration on a round-trip basis. Ten such samples were taken with the P-46 on June 3, each sample consisting of both a downward and an upward integration taken continuously over the same range of depth. For the round-trip integration covering the lower half of the depth, the first sample was collected from the mid-point of the depth down to the bottom and back up to the mid-point again; the second sample was taken from the bottom up to the mid-point and back to the bottom again. The average intake ratio for all of the ten round-trip samples with the P-46 sampler was 1.00. There is no reason to believe that these samples were not satisfactory. An analysis of the transit rates at which the sampler was raised and lowered would show that most of the transit rates were well within acceptable limits. It was impossible to integrate over the entire depth on a round-trip basis with the P-46 or P-46S. Such integration was attempted with the P-46S with the 1/8-in. nozzle, but the limitations of the operator and equipment were such that the 100-lb. sampler could not be lowered and raised at any uniform rate which was fast enough to traverse the total depth before the sample bottle was completely filled. Round-trip integration with the P-46 or P-46S should give results equivalent to a combination of an upward and a downward sample. The intake ratio found for the 10 samples integrated on a round-trip basis is about 1 or 2 percent higher than an average of upward and downward integration would indicate. One of the 10 samples was responsible for practically all of this excess.

Twelve usable samples were taken with the D-43 sampler with a 1/8-in. nozzle. This sampler was light enough to be moved faster than the other samplers, but had the disadvantage that all samples taken with it had to be integrated on a round-trip basis from the surface of the stream downward and back to the surface again. Nine samples were collected with the D-43 integrating over the complete depth of the stream. The average intake ratio for these 9 was 1.50. The relative transit rates for these samples were excessive. It should be noted that although the sampler was lowered and raised at a uniform rate of speed, the relative transit rate for downward integration was much greater than that for upward integration. The downstream drift of the sampler was responsible for this difference. These samples emphasize the effect of high relative transit rates, and show that average transit rates, uncorrected for the downstream drift of the sampler may be very misleading when applied to round-trip integration. The lower average intake ratio (1.25) for the three samples integrated over the partial depth probably reflects the influence of the lower, but still excessive, relative transit rates applying to these samples. Those samples taken over the partial depths could have been integrated at fairly satisfactory transit rates if longer sampling times had been used. The integration of the entire depth of the stream on a round-trip basis would be impossible without the use of excessive transit rates.

The results obtained with the D-43 sampler show that the limitations on allowable relative transit rates must be respected regardless of the physical possibility of exceeding those limits. Of course the D-43 is inadequate for integration of the complete depth of the stream at Grand Canyon when the flow is 50,000 sec. ft. with a depth of over 20 ft. and a mean velocity in the vertical of about 8 ft. per sec. as it was not designed for such conditions.

Nozzle velocities obtained on June 8 cannot be reduced to the same type of intake ratio discussed above, because no current meter velocities were taken on that day. The data of June 8 are discussed briefly in Section 17.

IV. SEDIMENT CONCENTRATIONS OBTAINED IN SAMPLES

11. Accuracy of point-integrated samples--The most important consideration in connection with these instruments is the degree in which samples taken with them represent the sediment content of the stream. Before this feature may be investigated, the sediment content of the stream must be known. The only available means for determining the sediment load in the Colorado River at Grand Canyon involved the use of the instruments under investigation. The first problem in this study of sediment concentrations was the evaluation of the accuracy of some of these samples as a basis of comparison with other samples of more doubtful nature.

Theoretical considerations and laboratory tests support the hypothesis that the present types of US samplers sample accurately as long as the intake ratio is unity and the nozzle is pointing directly into the approaching flow. (See Report No. 5 "Laboratory Investigation of Suspended Sediment Samplers" published by the cooperative project.) These conditions were fulfilled at Grand Canyon during the collection of point-integrated samples taken near the stream surface with the P-46 sampler. However, the intake ratio was as low as 0.92 near the bottom of the stream. From Fig. 13 of Report No. 5, the error in concentration near the bottom for a velocity of 6.5 ft. per sec. would be about plus 2.0 percent. The 0.15 mm. sediment size given in Fig. 13 is roughly equivalent to the effective size of sediment obtained at Grand Canyon. On the basis of the average curves of current meter velocity and velocity in the intake nozzle, the error in concentration in the point samples taken near mid-depth would be very small, perhaps in the nature of plus 0.5 percent. A study of these two curves and the concentration corrections corresponding to various intake ratios, indicates that the concentrations in the point samples probably averaged about 0.8 percent high as a result of the low intake ratios.

One other possible source of error in the sediment concentrations obtained from the point samples is the possibility of an accumulation of sediment in the sampler nozzle prior to the opening of the intake below the water surface. In an attempt to evaluate this error, the sampler was allowed to remain at the sampling point for 15 sec. after sampling ceased on each of the point samples which were taken on the morning of May 30. At the end of the 15 sec., the sampler was raised as rapidly as possible. The contents of the sampler nozzle were drained into a composite sample for the 11 point samples taken on the morning of May 30. The same procedure, except with a 30-sec. delay, was used for the 10 point samples on the morning of May 31. The average concentration for the 11 samples of May 30 was 4650 p.p.m. based on the results of 10 samples (one bottle was broken), while the average concentration for the 10 samples of May 31 was 4200 p.p.m. The concentration in the composite sample for May 30 was 5570 p.p.m. while that in the composite sample for May 31 was 7750 p.p.m. The excess concentration in the nozzle drainings was 920 p.p.m. for the 15-sec. delay, and 3550 p.p.m. for the 30-sec. delay. These figures may be combined to indicate an excessive concentration in the composite samples of 1490 p.p.m. for a 15-sec. delay. The nozzle drainings averaged about 2 cc. per sample. On the basis of a

350-cc. sample, the inclusion of one nozzle draining would increase the concentration in the sample by 8 p.p.m. This would amount to an excess of about 0.2 percent for the 15-sec. delay, or about 0.4 percent for a 30-sec. delay.

The accumulation of sediment in the nozzle prior to sampling was also studied from another angle. On June 1 and 7, samples were taken at each of two depths in the stream. At each depth, a set of five point samples was obtained by the usual method of lowering the P-46 to the predetermined depth and taking a normal point sample as soon as possible. Intermixed among the five standard point-integrated samples were others taken as follows: The sampler was lowered to the given depth and left in place for 30 secs. then a sample was taken for about 2 secs. and the sampler closed; the sampler was left in place for 30 secs. opened for 2 secs. and closed; this procedure was repeated until four or five samples had been accumulated in one bottle, each of these samples being preceded by the stated delay. The same process was followed for delays of 60 and 120 secs. The average concentration based on the five normal point-integrated samples was used as a standard of comparison. Presumably the errors in any one of the cumulative samples taken on June 1 would be five times that of a single sample taken following the same delay, while on June 7 it would be four times that of a single sample taken following the designated delay. In analyzing the results a process of graphically averaging the sample data was used, and it was assumed that the error in concentration accumulated in proportion to the length of the delay preceding the sample. See Fig. 10 for a plotting of these data. Indicated errors in percent for the four different depths and

30-sec. delays are:

June 1	0.15 depth	plus 4% for five accumulations
June 1	0.85 depth	plus 6% for five accumulations
June 7	0.80 depth	plus 5% for four accumulations
June 7	0.92 depth	plus 0% for four accumulations

This shows an average error of about plus 0.8 percent for one sample taken following a 30-sec. delay. A 15-sec. delay would be about the average time required to place the sampler before taking the point samples reported herein. It seems reasonable to assume that the errors in the concentrations of the point samples averaged about plus 0.4 percent because of the accumulation of sediment in the sampler nozzle prior to sampling.

The above treatment of the errors resulting from accumulation of sediment in the nozzle is obviously not conclusive. There is considerable evidence to show that the fluctuations in sediment concentration near the bottom of the stream were large enough to give deceptive results in this comparison of errors. The data for the 0.92 depth on June 7 probably showed no correction because on that day three of the normal samples were taken consecutively, and all three were high in concentration. At other times consecutive cumulative samples appeared to have too high concentrations. The indicated correction to the point samples for accumulation of sediment in the nozzle prior to sampling has been determined as 0.2 percent by one method and 0.4 percent by another method. The agreement is not entirely satisfactory, but inasmuch as the actual quantities involved are small, the value of 0.4 percent has been chosen as the more logical value for use in this report.

A combination of the corrections indicated by the intake ratios and by the accumulation of sediment prior to sampling, leads to the following conclusion. The sediment concentrations obtained in the point samples taken at Grand Canyon are probably very slightly high near the water surface; about 1.0 percent high at mid-depth; and about 2.5 percent high near the stream bed. The average correction applicable to these samples would then be about minus 1.2 percent. A correction of 1.0 percent will be considered during discussion of the concentrations in the samples, but it has not been applied to the actual figures listed in the report.

12. Distribution of sediment with depth--Figs. 11-17 show the individual concentrations obtained from the point samples of May 30, 31, June 2, 3, 4, 6, and 8. Also shown are curves of the vertical distribution of sediment concentration with depth. Curves giving the value of the product of the current meter velocity and the concentration are shown for the data from the morning samples of each day for which such information is available. These latter curves indicate the relative quantities of sediment transported at the various depths in the stream.

Some tabular data have also been included on these figures. The concentrations at the mid-point of each tenth of the depth have been listed from the concentration curve based on the morning samples. The same information has been shown for the concentrations in the afternoon with the exception of June 4 and 8. On June 4 the change to the afternoon curve appears to have occurred subsequent to the completion of most, if not all, of the depth-integrated sampling. On June 8 the afternoon samples were averaged with those taken in the morning.

Fig. 18 shows all the morning curves of sediment concentration. This plate is presented to facilitate the study of the daily variations in the concentration curves. A concentration curve which is an average of the daily curves is also given. A curve which represents the product of the average concentrations multiplied by the average velocities from Fig. 9 is also shown. This curve gives the relative quantities of sediment transported at the various depths, based on average conditions during the time of these tests.

13. <u>General relation between depth- and point-integrated samples</u>-- The concentration for each depth-integrated sample has been shown at the bottom of Figs. 11-17. These have been divided into the groupings which seemed most logical on the basis of the purpose for which the samples were taken. The average concentration of the group has been computed. The concentrations for a very few samples have been omitted from the averages because the intake ratios indicated that something was definitely wrong with the samples.

Whenever the samples within a group were similar enough to be directly comparable, the corresponding concentration was computed from the point sample data as follows: The concentration was first taken from that portion of the morning concentration curve over which the samples were later depth-integrated; this concentration was then corrected to the time of the group of depth-integrated samples. The mean time for the group is shown at the bottom of the plate. The concentration correction based on time was computed, assuming that the change in concentration between the mean for the morning curve and that for the afternoon curve occurred at a uniform rate between the times at which the samples defining the curves were taken. The actual change probably was anything but a uniform one, but there seems to be no other logical assumption to make.

The ratio between the average concentration for a group of depth-integrated samples and that based on the point samples is shown for each group for which such a comparison seemed justified. The relative transit rates applying to each group of depth-integrated samples have been included for comparison.

A summary of the ratios of the concentrations from the depth-integrated samples to those from the point samples is included in Table I on page 32 under the heading "average ratios - concentration". The ratio for individual depth-integrated samples may be found on the computation sheets in the appendix. This ratio of the concentration in a sample to that shown by the point samples, which is the best indication of how accurately the sample reflects the concentration in the stream, has been called the "concentration ratio". The data in Table I show the average concentration ratio based on all samples which fall into the operational division indicated. A few samples have been omitted because these did not have both a satisfactory intake ratio and a satisfactory concentration ratio. A detailed study of the omitted samples may be made from the computation sheets.

The average concentration ratio for all samples depth-integrated with the P-46 and P-46S samplers shows that the concentrations determined from the point samples and from the depth-integrated samples were very nearly the same. This does not mean, however, that the movement of the samplers during depth-integration had no effect on the sampling efficiency.

14. <u>Accuracy of samples integrated downward</u>--The concentrations for the point samples have previously been determined to be about 1.0 percent high. Therefore, the depth-integrated samples should show relative concentrations of about 0.99 in order to duplicate the concentrations in the stream. This value obtained for the downward integration samples at Grand Canyon. The intake ratio for downward integration was a very few percent over unity. The evidence suggests that the P-46 or P-46S suspended sediment samplers integrating downward under the conditions at Grand Canyon and operating with an intake ratio from 1.00 to 1.05 gave very satisfactory results.

Perhaps the best comparison of depth- and point-integrated samples would be obtained by using only the figures for the P-46 because that was the instrument used for the point samples. As far as downward integration is concerned, the P-46 alone gives practically the same answer as both instruments studied together. The ratios for the P-46S sampler appear to be more erratic than those for the P-46, but this is mainly, if not entirely, due to the smaller number of observations taken with the P-46S. When the variation in concentration of the individual samples, and the magnitude and uncertainty of the corrections to the point sample data are considered, the presence of some discrepancies in the average ratios would be expected, especially in those based on a very few samples.

15. <u>Accuracy of samples integrated upward</u>--The samples taken with the P-46 may be the best indication of what actually happens on upward integration, not only because the P-46 was the instrument used for the

point samples, but mainly because there was a better balance between samples integrated upward and those integrated downward with this instrument. The P-46S sampler requires a major change in the mechanism to alter it for operation in the opposite direction. For that reason, all the upward integration was usually finished before any of the downward was taken. The comparison of the upward and downward integration was therefore dependent upon the correction of the concentration based on time. Moreover, the P-46S sampler was operated upward on two days on which there are no comparable figures for downward integration.

The concentration ratios for the P-46 indicate a greater difference in the upward and downward integration than that shown by the entire group of upward and downward samples. The concentrations in samples integrated upward appear to be excessively high. Even discounting the effect of the high ratios on June 3, the upward integration shows concentration ratios of about 1.04, which is considerably higher than the average for all samples integrated upward.

Because of this disturbing indication, a study was made of upward integrated samples for which comparable downward samples were available for comparison. The results indicated a concentration difference of 5.0 percent between the upward and downward integration, using only those samples collected at acceptable transit rates. A representative concentration ratio for upward integration of all samples should probably have been a little higher than the 1.01 shown in Table I. However, the value 1.05, given for upward integration with the P-46 is possibly high. A concentration ratio of 1.03 based on comparison with the concentrations from the point samples would perhaps be most typical of the samplers operating upward under the conditions at Grand Canyon. Remembering the correction applicable to the concentrations from the point samples, the samples integrated upward under the conditions at Grand Canyon might be expected to show sediment concentrations about 4.0 percent greater than those in the stream.

Two sources of such an error have already been discussed in this report. The accumulation of sediment in the nozzle prior to sampling was credited with increasing the sediment concentration in a point sample by 0.4 percent. The intake ratio for upward integration averaged about 0.94. From Fig. 13 of Report No. 5, the error caused by this intake ratio at a stream velocity of 7.5 or 8.0 ft. per sec. would be around 2.0 percent. During upward integration the samplers may have tilted upward somewhat, then the average intake ratio for upward integration would be perhaps 0.91 and the error caused by the low intake ratio would be about 3.0 percent. The sum of these two corrections is 3.4 percent, which approximates the 4.0 percent excess of concentration believed to be present in the upward samples.

There remains one other possible source of discrepancy between the concentration of samples integrated upward and that for point-integrated samples. Although the accumulation of sediment in the intake nozzle prior to sampling has already been considered, it was discussed only for an instrument suspended above the stream bed. There is the possibility that a sampler resting on the stream bed might accumulate additional sediment by picking up bed load or saltation load which may be present either due to the normal high concentrations of coarser material, or due to abnormal concentrations of moving material created by the disturbance of the sampler. The data obtained at Grand Canyon are not sufficiently precise to establish the presence or absence of such an error.

The errors involved in upward integration with the P-46 and P-46S are not very large. Much, if not most, of the total error is the result of the low intake ratios found on upward integration. The use of a sampler, or sampler nozzle, constructed to give higher intake ratios might be an improvement. However, when allowed a choice of direction of integration the use of downward integration is preferable.

16. Accuracy of round-trip integration--On June 3, 10 P-46 samples were integrated over a portion of the depth on a round-trip basis. These show an average concentration ratio of 1.06, which indicates an excess concentration of about 7.0 percent over that in the stream. However, as has been pointed out, the ratios on June 3 were all high. The average concentration ratio for downward integration of 10 samples on that day was 1.05; for 10 samples integrated upward the average concentration ratio was 1.07; and the average for the 10 integrated on a round-trip basis was 1.06. These round-trip samples were not only integrated in both directions to comprise one sample, but the round-trip integration was begun at the bottom of the depth to be integrated for the first sample, and at the top for the next sample. The indications are that the round-trip integration gives concentrations equal to that which would be given by a combination of an upward and a downward sample.

A few samples were collected with the D-43 sampler operating over the full depth of the stream. The sediment concentrations in all these samples were low. This would be expected because of the very high intake ratios for these samples. Most of the error in concentration probably resulted directly from these intake ratios. Such data as that of Figs. 13 and 16 of Report No. 5, indicate that the error in concentration due to an intake ratio of 1.50 (for a 1/8-in. nozzle and mean velocities over 7 ft. per sec.) would be about 12.0 percent negative. The error actually observed was 15.0 percent negative. Whether the extrapolation of corrections is inexact at these extreme departures from normal sampling, or whether there is some effect of the angle at which the flow approaches the nozzle, is impossible to tell from the meager data available.

Four samples were collected with the D-43 operating over part of the depth of the stream. Of these one was obviously erroneous. The average concentration obtained from the other 3 is almost precisely that which would be expected from the intake ratio for those samples.

The important result of these tests of the D-43 suspended sediment sampler is to emphasize the control exerted by the intake ratio on the accuracy of sediment samples collected. While the presence of an intake ratio of approximately unity might not guarantee exact sampling with the D-43, still these tests suggest that the sampling would be quite accurate if the intake ratio were near unity. The difference in relative transit rates for the D-43 on upward and downward integration shows the effect of the downstream drift of the sampler, and indicates the lack of uniformity of operation which results under such conditions.

17. Miscellaneous samples--On June 4, 5 P-46S samples were integrated over the complete depth. These samples were so taken because the P-46S failed to close at the bottom of the stream after a normal

downward integration from the water surface to the stream bed. The samples were kept as an indication of the errors to be expected when the sampler continues sampling after the sample bottle has become practically full. The average concentration ratio for the 5 samples was 1.22, on a day when most of the concentration ratios were slightly low.

Data collected on June 8 (see Fig. 19) have not been discussed previously. The P-46 sampler was used to obtain 6 point-integrated samples in the morning and 5 in the afternoon. These determined a concentration curve for the day. Four samples were depth-integrated downward from the water surface at various transit rates using the P-46S with 3/16-in. nozzle. These samples show an average intake ratio of 1.04 based on the velocities from the point samples. The average concentration ratio for the 4 was 1.02. Neither of these figures appears very significant. Twelve samples were depth-integrated downward from the water surface at various transit rates using the P-46S with a 1/8-in. nozzle. The nozzle velocities and concentrations for these samples have been plotted in Fig. 19. The effect of the relative transit rate on the sampling action is clearly evident. On previous days a 1/8-in. nozzle with 1-1/2-in. taper (at .25 in. on the diameter per ft. of length) had been used. On June 8 a nozzle with 2-in. taper in the discharge end was used.

V. SIZE ANALYSIS OF SAMPLES

18. Procedure and treatment of the data--Of the 313 suspended sediment samples collected in these tests, 60 were analyzed for size gradation by the U. S. Geological Survey at Lincoln, Nebraska. Size analyses were made by the bottom withdrawal tube method. Distilled water was used as the settling medium, and no deflocculating agent was used to disperse the sediment.

Results of the analyses were submitted in the form of percentage finer than each of approximately ten different sizes. These data have been converted into percentage of the total sample contained within the size ranges bounded by the designated sizes. The percentage has then been translated into p.p.m. of sediment of each size range contained in the sample. This information for each sample may be found on the computation sheets in the appendix.

The discussion of the results of the size analyses will be limited to three sizes of sediment: Smaller than 0.0625 mm.; between 0.0625 mm. and 0.125 mm.; and greater than 0.125 mm. The divisions were chosen on a rather arbitrary basis, but the following considerations entered into the selection. The finest sediment size was based on the natural division at 0.0625 mm. which is approximately the upper limit of the silt and clay sizes, and also the upper limit for the operation of Stokes' Law; sediment below this size appeared to be quite uniformly distributed throughout the stream depth. A rather limited range of size was taken between 0.0625 mm. and 0.125 mm. This was intended mainly to emphasize the changes occurring in sediment behavior around this critical size. The remainder of the sediment, above 0.125 mm., is indicative of the action of the mass of coarser sediments.

These size data have been presented on the basis of the concentration of sediment of the various sizes expressed in p.p.m. This has been done to show a more obvious comparison between the analyses at various depths and between samples of different concentration.

19. Distribution of sediment sizes with depth--The distribution of sediment with respect to depth has been shown for the total sediment indicated by the point samples taken in the morning of each day, and for each of the three size groups as defined by the four or five of those samples which were analyzed for size (see Figs. 20-25). These figures cover daily data for May 30, 31, June 2, 3, 4, and 6. A summary of this information, in the form of curves representing the average distribution of sediment of each size, has been shown in Fig. 27. No detailed discussion of these plates will be made. However, a few of the more obvious or significant features of these data should be mentioned.

The points on which the curves for the three sizes of sediment were based, have been plotted in two different ways. The concentrations in p.p.m. of the various sizes have been plotted as actually taken from the individual samples. The concentrations have also been plotted on the basis of the concentrations of each size of sediment determined by applying the percentage of that given size to the concentration taken from the daily curve of total sediment concentration. If the sample under consideration plots on the total concentration curve, then the two sets of figures are the same. However, some of the samples analyzed for size had concentrations which deviated from the curve considerably. For these, the two types of plotting are significantly different. There is a definite indication that the figures for the coarser sediments are more nearly comparable when corrected to the concentration from the curve, while those for the finer sediments compare better when taken directly from the sample.

The analyses indicate that in some cases sediment which should have been in one size group was found in the next group. The analyses of those samples were probably inaccurate. There may have been some experimental error involved, the limitations of the method of analysis may have been responsible, or some type of flocculation of the sediment may have occurred. The difference between the samples in these cases is of such a nature that there seems little possibility that it actually reflects variations in the samples themselves.

The curve for the sediment larger than 0.125 mm. is very similar to the curve for the distribution of the total sediment load. About 55 percent of the sediment was contained in this size range. The concentration of sediment of this size was more than twice as great near the stream bed as at the water surface.

Sediment in the size group from 0.125 mm. down to 0.0625 mm. comprised about 18 percent of the total sediment. The increase in sediment of this size was about 55 percent from the water surface to the stream bed. There seems to be a very slight break in this curve around mid-depth.

The sediment in the finest size range makes up the remainder of the total. The curve for this size seems to show a very slight increase from the water surface down to mid-depth or just below, and then shows a very small decrease between mid-depth and the bottom. While a moderately uniform distribution of sediment of this size would be expected throughout the depth of the stream, it is difficult to account for a decrease in concentration of these finer particles near the stream bed. An examination of the concentration curves for the finer sizes of sediments suggests the possibility that the bottom withdrawal tube method of size analysis is slightly affected by the presence of the greater concentration of coarser particles found in samples taken near the bed of the stream. Some of the sediment of about 0.0625 mm., which in a sample taken near the water surface would appear in the smaller size range, probably appears in the coarser range in samples taken near the stream bed.

The concentration at the time of the sample at 0.95 depth on June 4, should be about the same as that for a similar depth on June 3 and 6. It should be noted that the excessive concentration in this sample is composed entirely of an excess of the coarser sizes of sediment. The excess probably consists of saltation load rather than of true suspended sediment. This sample was taken about 1.2 ft. above the stream bed, based on a depth determined some time previously. Because of changes in the stream bed, and possible inaccuracies in the placing and correction of the elevation of the sampler, the actual distance above the stream bed may have been considerably less. Sand waves were no doubt present on the bottom some of the time, and these may have had an influence on the samples. In a determination of the suspended sediment load of the stream such a sample should be disregarded entirely or used with extreme precautions. The determination of bed load or saltation load was not attempted in this investigation. That such a load was present seems indicated by these samples, but even without the samples, the presence of some bed-load movement would be axiomatic under the conditions of sand bed and high bottom velocity found at Grand Canyon.

A summary of the size data from the curves of Figs. 20-27 may be found in Table II. The concentrations for each of the three size groups and for the total sample have been shown for the average curves of Fig. 27. On June 2, the integration covered only the upper portion of the total depth, and for that reason the data of June 2 were not included in the average curves. The table shows first the size distribution based on the average curves. Then the data for the daily curves are shown; first the actual figures from the daily curve are listed, then the figures based on the average size distribution applied to the daily concentration. There are no clear-cut indications of changes in the

TABLE II

COMPARISON OF DAILY SIZE DATA

Source of Data	Size mm.			Total
	<0.0625	.0625-.125	>0.125	
Concentration in p.p.m from average curves of Fig. 27	1115	745	2300	4160
Percentage of each size of sediment	26.8	17.9	55.3	100.0
Concentration in p.p.m. from curves of May 30	1281	851	2376	4508
Average size distribution applied to concentration of May 30	1208	807	2493	4508
Concentration in p.p.m. from curves of May 31	1186	740	2246	4172
Average size distribution applied to concentration of May 31	1118	747	2307	4172
Concentration in p.p.m. from curves of June 2	1140	917	2050	4107
Integration to 0.60d only, not comparable to average curves				
Concentration in p.p.m. from curves of June 3	970	798	2047	3815
Average size distribution applied to concentration of June 3	1023	683	2109	3815
Concentration in p.p.m. from curves of June 4	990	729	2358	4077
Average size distribution applied to concentration of June 4	1093	730	2254	4077
Concentration in p.p.m. from curves of June 6	1150	610	2473	4233
Average size distribution applied to concentration of June 6	1135	758	2340	4233

proportions of the various sizes of sediment, either with time or with changes in total concentration.

There are many considerations involved in attempting to choose from the size data on the point-integrated samples, some standard for use as a basis for comparison with the size data for the depth-integrated samples. There would be some justification for using the average curves as the standard for all samples taken during the series of tests at Grand Canyon. On the other hand there may be slight variations in the distribution of sizes between the days involved, and these variations may be defined in part by the differences in the size curves from day to day. After considering the alternatives and studying the various samples in the light of the two, the decision was made to base comparisons directly on the daily curves. After determining the base to be used, there remain the differences in concentration between the individual depth-integrated samples and the daily curve. It has been assumed that the percentage distribution of sediment between the various size groups remains the same throughout the sampling day. The sediment concentration has previously been corrected for time as a basis for the ratio of the concentration in the depth-integrated samples to that of the point samples. Using the corrected concentration and the daily distribution of sizes, figures were computed which were considered representative of the concentration of sediment of each size which was present at the time of each depth-integrated sample. In the same manner in which the sediment concentration of each depth-integrated sample was compared with the concentration from the point samples, the concentration of each of the three sizes of sediment was compared with this standard based on the point samples.

20. <u>Size distribution in depth-integrated samples</u>--Comparisons of the distribution of sediment into size groups have been computed and are presented in tabular form on the daily size data, Figs. 20-25. The comparisons have not been made on a percentage basis because the probable inaccuracies in the size determinations would make tremendous percentage errors. These data are largely self-explanatory, but a few notes might be helpful. Each depth-integrated sample for which size data are available has been listed by sample number. The instrument, the size of nozzle, the direction and range of depth over which the sample was integrated, have all been shown. The concentrations of sediment in the three size ranges have been shown as actually found in the sample. For comparison, concentrations based on the daily size curves have been corrected to the time of the individual sample and listed also. The ratio of the total concentration in the sample to that from the curves has been given in the right-hand column. In cases where the sample was integrated over a partial depth, the data from the curves were taken for that partial depth. The values from the daily curves have been derived to represent as nearly as possible the sediment conditions in the stream at the time of the corresponding sample.

The tabular data on Figs. 20-25 might be used as the basis for any type of detailed study. An analysis of the material led to the conclusion that the type of sampler, size of nozzle, and direction of integration have no appreciable effect on the distribution of size within the sample except as these factors are reflected in the ratio of the concentration in the sample to that in the stream. The relation between this concentration ratio and the distribution of sediment into the various size groups will be discussed further.

Table III has been prepared in an attempt to better evaluate the relation between the concentration ratio and the size distribution of a sample. The samples have been listed according to concentration ratio in descending order. The figures shown for each size group represent the difference in p.p.m. between the sample and the comparative values based on the daily curves. Averages have been shown for the following groups of concentration ratios: above 1.05; 1.05 to 1.00; 1.00 to 0.95; and less than 0.95.

In spite of the discrepancies found in individual samples, there is a very distinct relation between the concentration ratio of the sample and the distribution of sediment within the size groups of the sample. The concentration ratios apparently have no effect on the quantity of the finer sediments (settling diameters less than 0.0625 mm.) collected in the sample. The samples with the maximum and minimum concentration ratios as well as the averages for groups of samples show this clearly.

The fact that the concentration ratios do not affect the concentrations of the finer sediments means that the excess sediment contained in samples of high concentration ratios was made up of the coarser sediments. Conversely the deficiency in sediment samples with low concentration ratios resulted from a reduction in the quantity of the coarser sediments.

Comparing the averages on an over-all basis there seems a deficiency in the sediment in the 0.0625 mm. to 0.125 range when the depth-integrated samples are compared to the point-integrated samples. If

TABLE III

RELATION BETWEEN CONCENTRATION RATIO AND SIZE DISTRIBUTION IN DEPTH-INTEGRATED SEDIMENT SAMPLES

Sample No.	Instrument and Nozzle	Integration	DEPARTURE FROM DAILY CURVES - P.P.M. Size mm. <0.0625	.0625-.125	>0.125	Total	Conc. Ratio	Sample p.p.m.
242	P-46S,3/16	1.00-0.00d	+ 40	+ 82	+ 752	+ 874	1.23	4751
8	P-46, 3/16	1.00-0.00d	- 29	- 1	+ 524	+ 494	1.11	4985
44	P-46, 3/16	1.00-0.00d	+ 22	+154	+ 124	+ 300	1.07	4472
257	P-46S,3/16	0.00-1.00d	+ 90	+ 92	+ 29	+ 211	1.06	3942
Totals			+123	+327	+1429	+1879		
Averages			+ 31	+ 82	+ 357	+ 470	1.117	
174	P-46, 3/16	*0.33-0.67d	-116	- 96	+ 393	+ 181	1.05-	3825
155	P-46, 3/16	*0.50-1.00d	+ 53	+ 51	+ 50	+ 154	1.04	4376
176	P-46, 3/16	*0.00-0.33d	-252	-112	+ 473	+ 109	1.04	3119
101	P-46, 3/16	0.60-0.00d	+ 5	+ 57	+ 68	+ 130	1.03	4085
252	P-46S, 1/8	0.00-1.00d	+ 84	- 47	+ 12	+ 49	1.01	3819
Totals			-226	-147	+ 996	+ 623		
Averages			- 45	- 29	+ 199	+ 125	1.024	
20	P-46, 3/16	0.00-1.00d	-149	- 81	+ 229	- 1	1.00-	4347
29	P-46S, 1/8	1.00-0.00d	-148	+ 41	+ 78	- 29	.99	4125
172	P-46, 3/16	*0.67-1.00d	- 7	+ 13	- 86	- 80	.98	4187
156	P-46, 3/16	*0.00-0.50d	- 12	-164	+ 105	- 71	.98	3224
212	P-46S,3/16	1.00-0.00d	+ 65	- 64	- 169	- 168	.96	3909
247	P-46S, 1/8	1.00-0.00d	+168	+107	- 445	- 170	.96	3666
129	D-43, 1/8	*0.00-0.60d	+170	- 71	- 247	- 148	.95+	2908
Totals			+ 87	-219	- 535	- 667		
Averages			+ 12	- 31	- 77	- 95	.974	
57	P-46, 3/16	0.00-1.00d	+ 2	- 28	- 195	- 221	0.95-	4148
25	P-46S,3/16	1.00-0.00d	+ 22	-166	- 138	- 282	.93	3912
205	P-46S, 1/8	1.00-0.00d	+ 3	- 67	- 336	- 400	.90	3677
124	P-46S, 1/8	0.60-0.00d	-215	-270	+ 119	- 366	.89	2984
185	D-43, 1/8	*0.00-1.00d	- 93	- 11	- 383	- 487	.88	3590
109	P-46S, 1/8	0.00-0.60d	+ 49	-110	- 386	- 447	.88	3303
102	P-46, 3/16	0.00-0.60d	+ 84	- 83	- 477	- 476	.88	3459
114	P-46S,3/16	0.00-0.60d	+ 68	- 74	- 797	- 803	.78	2845
Totals			- 80	-809	-2593	-3482		
Averages			- 10	-101	- 324	- 435	.886	
	Grand Totals		- 96	-848	- 703	-1647		
	Averages		- 4	- 35	- 29	- 68	0.979	

* Round trip. Samples taken in direction shown and return.

this difference had appeared in either the largest or smallest size groups it would have been more significant. At present the deviation in this size group is considered to reflect errors in samples and analyses, rather than any basic difference between the types of samples.

Previously, the concentration in a sample was found to be accurate when the integration proceeded with the same velocity in the intake nozzle as that in the stream at the sampling point. Now, the concentration ratio has been shown to be an index of the dependability of the size distribution in the sample. If the concentration of a given sample is the same as that in the stream, or the same as the average of a group of samples taken at the same time, place, and over the same range of depth, then the size distribution within that sample may be assumed representative of the size distribution in the stream or group of samples. If the concentration ratio is high there will be an excess of the coarser sediments. If the ratio is low there will be a deficiency in the coarser sediments. This seems to be true whether the high ratio is the result of inaccurate sampling, caused by a low intake ratio, or whether it is the result of fluctuations in the sediment content of the stream.

This discussion of the size analyses of the depth-integrated samples at Grand Canyon has been based on comparisons with the size gradation from the point samples. The concentrations in the point samples were considered to be about 1.0 percent high. It now appears that the concentrations of the various sizes of sediment contained in those samples must have been slightly in error. The concentration of sediment of settling diameters less than 0.0625 mm. was probably correct. The excess would have to be distributed over the other sizes. The concentration of sediments larger than 0.125 mm. was probably 2.0 percent high, while that in the intermediate range between 0.125 and 0.0625 mm. is estimated to be from 0.5 to 1.0 percent high. This does not in any way invalidate the conclusions reached from the comparisons of the depth-integrated samples with the point-integrated samples.

Several conclusions have been established concerning the effect of erroneous intake ratios on the sediment concentrations in the samples, and of the relation of abnormal sediment concentration ratios to the distribution of sediment sizes within the sample. It appears probable that the intake ratio would have no effect on the concentration of sediment in the sample provided all the sediment to be sampled was smaller than 0.0625 mm. That would seem to indicate that all samples taken in such a stream would have the proper concentration regardless of how taken. Within limits of normal variations in intake ratios this may be true.

21. Size distribution in cumulative samples--Data on the size gradation in the cumulative samples taken on June 1 and 7 are presented in Table IV. The sample number, the type of integration and the depth at which the sample was taken have been entered. The average concentration is the average of the five point-integrated samples taken at that depth. The concentration in p.p.m. of total sediment and of sediment in the three size groups has been given, also the ratio of the total sample concentration to the average. These data emphasize the relation of concentration ratio and size distribution, but otherwise do not seem particularly valuable.

TABLE IV

SIZE DISTRIBUTION IN CUMULATIVE SAMPLES

Sample No.	Operation	Concentration - p.p.m. Average	Sample	Conc. Ratio	CONCENTRATION - P.P.M. Size mm. <0.0625	.0625-.125	>0.125
			JUNE 1				
74	Point-integrated 0.85d	4869	5652	1.16	1130	678	3844
76	Cumulative (5) 0.85d	4869	5151	1.06	1288	927	2936
82	Cumulative (5) 0.15d	3835	3982	1.04	1234	557	2191
83	Point-integrated 0.15d	3835	4170	1.09	1209	667	2294
			JUNE 7				
267	Point-integrated 0.92d	6851	7874	1.15	1811	1181	4882
272	Cumulative (4) 0.92d	6851	7211	1.05	1875	1226	4110
274	Point-integrated 0.92d	6851	5524	0.81	1823	884	2817
282	Cumulative (4) 0.80d	5748	5791	1.01	1737	1042	3012

VI. CONCLUSIONS

22. Operation of samplers--The US P-46 suspended sediment sampler was very satisfactory from the standpoint of mechanical operation. While there are undoubtedly many improvements possible, still the sampler proved very dependable. Some skill and experience with the instrument are required for consistent operation of this sampler.

The sampler size and design proved adequate for the velocities encountered in these tests. Satisfactory operation at velocities up to 10 ft. per sec., with depths of 25 ft., seems assured. While these tests indicated no depth limitations, the theoretical limit for equilization of pressure in the bottle is about 140 ft. or 75 ft. with head pressurized to prevent leakage. The operational limitation on the sampler seems to be the downstream drift of the instrument which is a function of velocity and depth. Presumably the P-46 will operate satisfactorily until such combinations of velocity and depth are reached as would give deflections in the suspension line in excess of 30 deg. The sampler could probably be operated normally up to a discharge of about 75,000 sec. ft. at the Grand Canyon station.

The accuracy of the P-46 sampler was quite satisfactory for use in obtaining point-integrated samples. The concentrations in point samples taken with this instrument were probably very slightly high. Accumulation of sediment in the nozzle prior to sampling was a very minor factor in sampling accuracy. Samples taken near the water surface appeared to be very accurate. The intake ratio near the water surface was close to unity, but as the depth to the sampling point increased, the intake ratio decreased. At a depth of 23 ft. the intake ratio was about 0.92. This would indicate an excess in sediment concentration of about 2.0 percent at the stream velocities found at that depth. The mean excess of sediment in the point samples taken throughout a sampling vertical was judged to be about 1.0 percent. In precise work a correction might be applied to point samples collected at depths greater than 12 or 15 ft.

The P-46 sampler was found to be very satisfactory for depth integration downward from the water surface. Samples taken in this manner appeared to be very accurate as long as the downward transit rates were not excessive. Under some conditions, a smaller nozzle for the P-46 might be very desirable, even though a smaller nozzle would be more subject to plugging with debris.

The P-46 sampler was found to be somewhat less satisfactory for depth integration upward from the stream bed toward the water surface. Concentrations obtained from samples integrated upward seemed to average about 4.0 percent high in sediment concentration. The low intake ratios for upward sampling would account for 2.0 or 3.0 percent of this amount. The accumulation of sediment in the nozzle prior to sampling would not make up the remainder unless that accumulation is considerably greater when the sampler is at the stream bed than it is when the sampler is suspended a short distance above the bed.

The US P-46S suspended sediment sampler was subject to mechanical difficulties, which seem to have been remedied since that time. This instrument is simpler, and slightly faster to operate than the P-46.

The limitations on the instrument as far as adaptability to depth and velocity conditions are concerned would be the same as for the P-46, with the added restriction that the sampler could not operate to greater depths than those allowable for a single one-way integration.

The US P-46S was found to be adequate for accurate depth integration downward. For upward integration it had the same drawbacks as the P-46. The two instruments should have the same characteristics as far as accuracy is concerned. The P-46S was equipped with a 1/8-in. nozzle in addition to the 3/16-in. size common to both the P-46 and P-46S. No significant differences were established in the operation of the two sizes of nozzle. The 1/8-in. nozzle allowed slower transit rates and had some advantages from that standpoint. The smaller nozzle was more subject to plugging with debris. Because this sampler is less versatile than the P-46 it is not currently manufactured for general field use.

The US D-43 suspended sediment sampler was simple and easy to operate. The sampler was inadequate to sample accurately under the conditions prevailing during these tests. The sampler was not designed for the depths and velocities encountered at Grand Canyon at the time of this investigation. The primary difficulty derived from the limitations which make accurate round-trip sampling impossible to depths greater than about 18 ft. Under the conditions of high velocity and coarse sediment found at Grand Canyon, accurate round-trip sampling becomes difficult in depths greater than about 12 ft. The light weight of the sampler was partly responsible for this difficulty because it allows the downstream drift to become such a serious factor that extra precautions are required to integrate at suitable relative transit rates. The point of suspension of the sampler was high above the water, which made the problem of downstream drift more serious than it would have been otherwise. These tests indicate that to utilize the full 18 or 19 ft. of possible range of accurate sampling depth, the rates of lowering and raising the sampler would have to be different when the downstream drift of the sampler was relatively great.

23. Intake ratios--These tests emphasize the importance of the intake ratio as a factor in sampling accuracy. In fact, theoretical considerations seem to be amply supported by the results obtained. Most of the difference in sediment concentrations found on upward and on downward integration appear to be the result of the difference in intake ratios. The extreme intake ratios obtained with the D-43 sampler show something of the errors in concentration which result from excessive intake ratios. If the intake ratio departs appreciably from unity, the resulting sample will be erroneous in concentration and in distribution of sediment sizes whenever sediment sizes greater than 0.0625 mm. are involved. Apparently, within reasonable limits, the variation in intake ratio would have no effect on samples taken where all sediment was smaller than the above size. The coarser the sediments encountered the greater will be the error resulting from an intake ratio which deviates from the standard. However, the fact that the computed intake ratio for an individual sample seems out of line by 10, or perhaps even 20 percent is not important. Departures of this magnitude may be the result of momentary variations in stream velocity, and the actual intake ratio may have been unity during collection of the sample. It is important that the instrument and method of operation are such that the average of a

group of samples taken under a given set of conditions will be close to unity. Both water temperature and stream velocity affect the intake ratio, but neither of these entered into this investigation to any significant degree.

In a discussion of intake ratios, the effect of the downstream drift of the sampler should be considered. Both downstream drift of the sampler as it is lowered through the water and the towing of the sampler upstream as it is raised, result in velocities past the intake nozzle which are quite different from those of the stream. Determination of the actual transit rate is less important for integration in one direction than it is for round-trip integration. If the sampling time for one-way integration is so chosen that a proper size of sample is obtained, the transit rate will tend to properly adjust itself provided integration is not attempted over too great a range of depth. In round-trip integration, the actual values of the relative transit rates for upward and downward integration are not readily apparent, and the permissible relative transit rates may be seriously exceeded without any realization of what is happening. Excessive transit rates will result in erroneous intake ratios.

24. Size data--Under usual investigational procedures, only a small fraction of the total number of suspended sediment samples is analyzed for size. It is therefore imperative that those samples which are analyzed for size should be representative of the group or of the stream on which they are intended to provide information. From these tests it appears that a sediment sample which contains a concentration greater than the normal will be composed of an abnormally high

proportion of the coarser sediments, and that one which has a low total concentration will be deficient in the coarser sizes of sediment. Therefore, if one of ten samples were to be analyzed for size, that one should have an average concentration of sediment. A satisfactory selection of the sample to be analyzed being generally impossible, there remains the necessity for making the best possible interpretation of those samples which have been analyzed for size. After a sample has been analyzed, the total concentration should be examined to see if the sample is truly representative of the condition desired. If the total concentration in the size sample were normal, then the distribution of sizes within the sample should be dependable. If the concentration were not normal, the results of the size distribution within the sample should be used only with the greatest care. Even in an abnormal sample, the concentration of sediments smaller than 0.0625 mm. would probably be satisfactory on the basis of p.p.m.

This concept seems important enough to justify further amplification. For the period of these tests the following seemed to be true. If the total concentration in a sample taken on May 31 were normal for that day, the size distribution of sediment in the sample was representative of the size gradation in the stream that day. In fact, it was not far from being representative of the size gradation in the stream on any day during the tests. When applying such a size analysis of a sample to another time when the concentration in the stream was different, the percentage distribution of size could be applied to the new concentration. However, if the size analysis were run on a May 31 sample which had a total concentration 20 percent higher than that in the stream at the time of sampling, then the size distribution shown would be erroneous. It could not be corrected by applying the percentages of the different sizes to the proper concentration at the time of sampling. The concentration of sediment of sizes less than 0.0625 mm., expressed in p.p.m., would probably be correct for the stream at the time at which the sample was taken. To determine the concentration of the smaller sizes of sediment in the stream at another time when the total concentration had changed, the concentration in the sample in p.p.m. should be multiplied by the ratio of the new total concentration to the total concentration in the stream at the time of sampling. The coarser sizes of sediment in the sample would contain an excess in p.p.m. equal to the total excess concentration in the sample. The proportions of this excess would probably be the greatest in the coarser sizes of sediment. The quantities of the coarser sediments in the sample would require correction before being representative of the concentration in the stream at the time of sampling. Within the limits of this investigation, the percentage distribution of sizes did not seem to change appreciably with changes in concentration, but this may not be a typical condition.

25. Miscellaneous observations--In the interests of flexibility and ease of handling of the P-46S and P-46 suspended sediment samplers, consideration should be given to the use of 5/32-in. nozzles. For some conditions of great depth and high velocities, the use of a 1/8-in. nozzle with the P-46 sampler would probably be justified.

Some of the samples indicated the presence of saltation load in the Colorado River at Grand Canyon. Even without these samples, some transportation of sediment as bed and saltation load would be almost axiomatic under the conditions of sand bed and high velocities encountered.

The sediment concentrations at the Grand Canyon station seemed to change rapidly within the period of a very few hours. There was probably a diurnal fluctuation, although such a condition may be confined to the period of spring snow run-off. It does suggest that the practice of taking daily samples at a definite time each day may lead to erroneous averages over a given time interval.

26. Suggestions for future investigations--These tests, and the results obtained, leave several questions unanswered or insufficiently determined. There are certain field tests and other more or less academic studies which seem to require further attention.

The decreased intake ratio in point samples taken at the deeper depths was not anticipated prior to these tests. A study of the cause of this decrease, and of its effect in deep streams is urgently needed. The relation of this decrease to the size and taper of intake nozzles should be considered.

The accumulation of sediment in the sampler nozzle prior to sampling should be made the subject of a more extensive and precise investigation. An important part of this study would be the accumulation of sediment in the nozzle when the sampler rests on the bottom of the stream. If possible the effect on the size distribution as well as on the total concentration should be determined. Probably better methods than those used in these investigations could be devised.

A more thorough comparison of the results obtained from upward and downward integration could be made. Alternate sampling of a heavily sediment laden stream might be undertaken with the P-46. One sample should be taken downward, then one upward, then one downward, etc. throughout a day at a time. The presence of sediment in sizes up to 1 mm. would be desirable. Transit rates for the first series of samples should be well within allowable limits. Progressively higher transit rates should be used on later series, until the effect of the transit rates becomes clearly obvious on the results of both downward and upward integration. Series should be run with both 3/16-in. and 1/8-in. nozzles. Complete data as to downstream drift, time of sampling, etc. should be recorded. Analyses of the samples for size gradation would be very desirable.

A study of the corrections to be made to size analyses of sediment samples of abnormal concentration would be valuable. The cost of a single size analysis is great enough that care should be exercised in selecting the samples to be analyzed for size.

The patterns found in the distribution of total and of various sizes of sediment, suggest the possibility of determining the distribution of sediment throughout the vertical without daily sampling of the entire vertical. Any relations developed might apply only to one stream and perhaps accurately to only one stage of the stream, but it may be possible to make reasonably accurate computations from samples which, because of inadequacy of equipment or for other reasons, do not comprise a complete integration of the stream vertical.

FIGURES

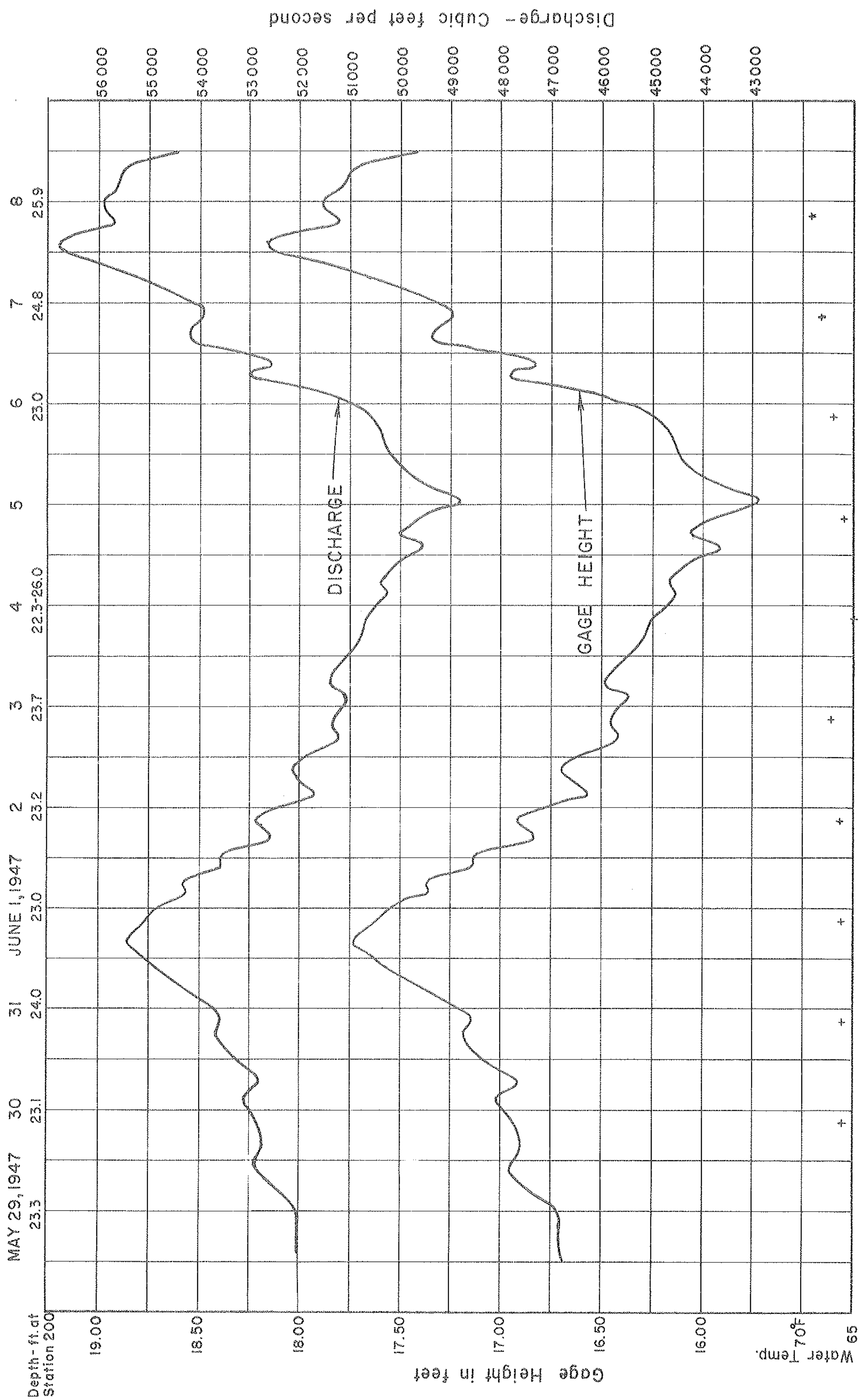


FIG. 1 — STREAM FLOW DATA-GENERAL
PERIOD OF SEDIMENT SAMPLER TESTS
COLORADO RIVER - GRAND CANYON, ARIZ.
MAY 28 - JUNE 8, 1947

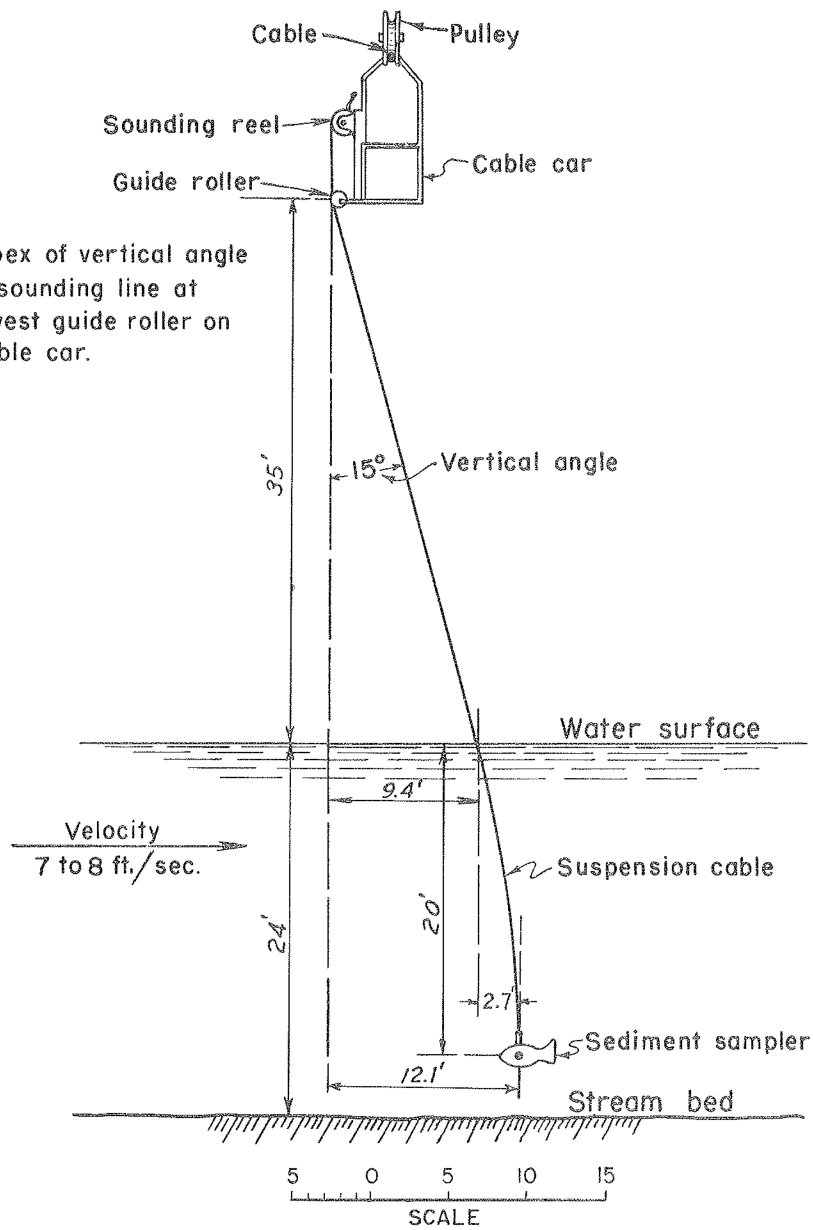
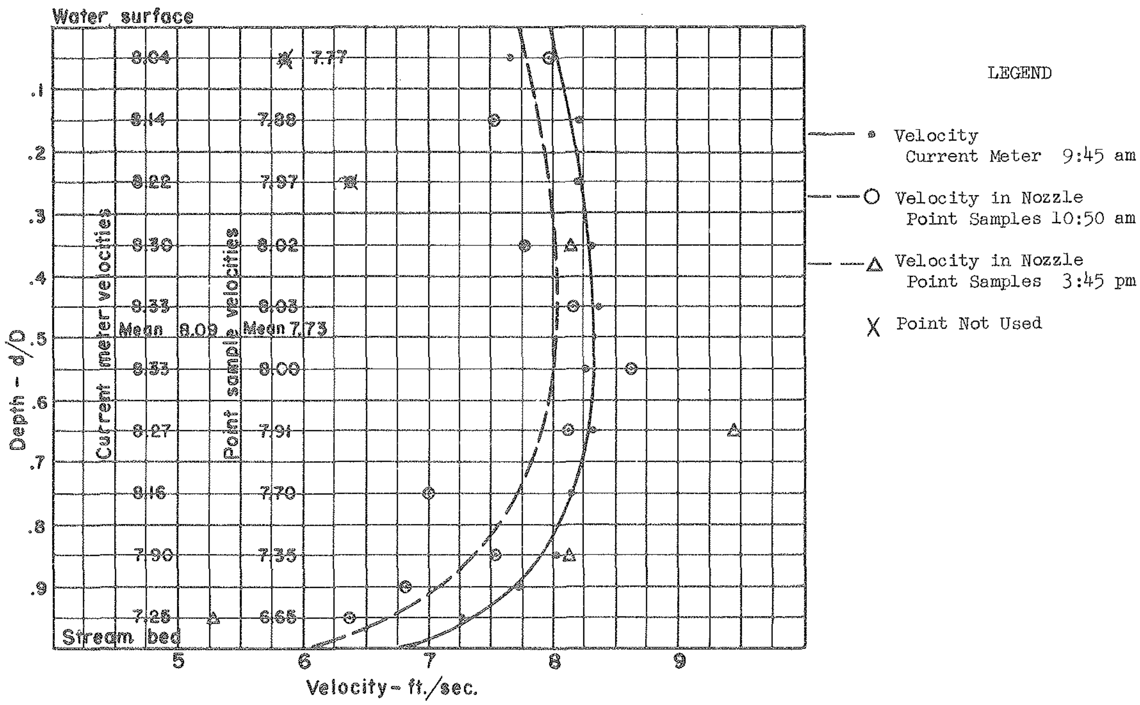


FIG. 2- SKETCH SHOWING
DOWN STREAM DRIFT OF SAMPLER
FOR TYPICAL CONDITIONS
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ. - 1947

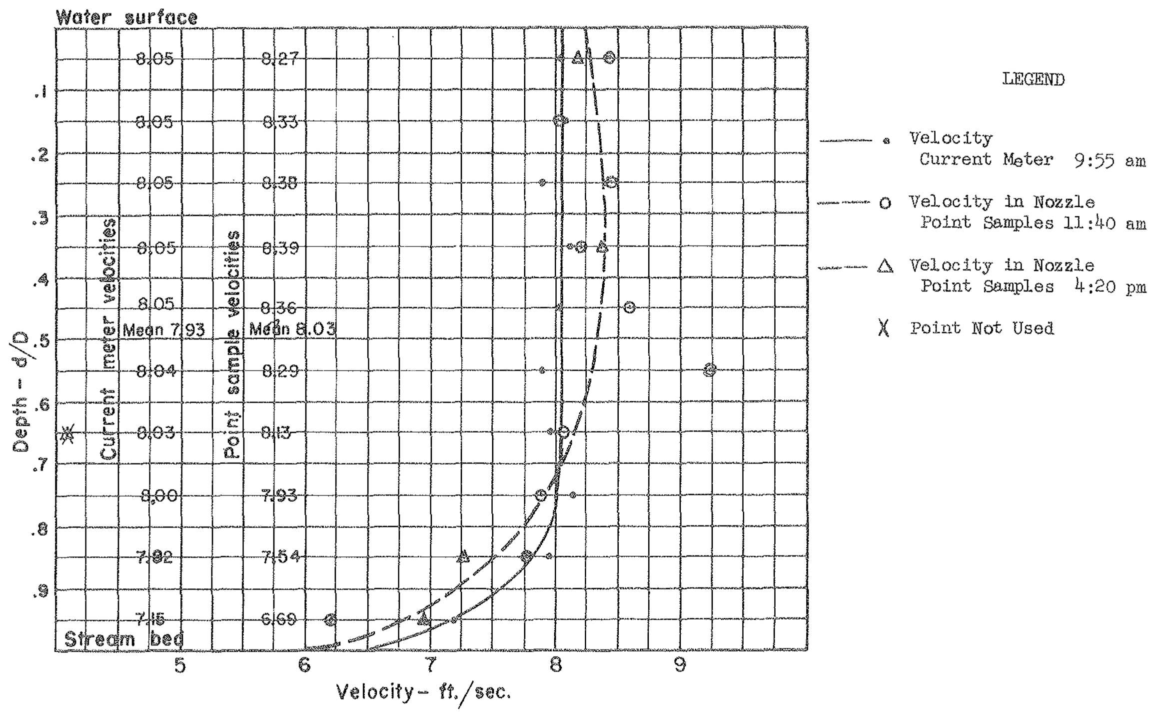


DEPTH-INTEGRATION DATA

Instrument	P-46		P-46S		
Nozzle	3/16"		3/16"	1/8"	
Integration	ws to sb	sb to ws	sb to ws	ws to sb	sb to ws
Nozzle Velocity	6.59	8.80	9.93	7.58	7.62
Do.	6.63	9.65	--		8.45
Do.	6.69	9.38	8.34		9.36
Do.	7.15	9.23	9.47		--
Do.	6.45	9.71	9.45		8.54
Average Nozzle Velocity	6.70	9.35	9.30	7.58	8.49
CM Mean Corrected for Time	8.09	8.09	8.09	8.09	8.09
CM Mean Corrected for Drift	6.23	9.63	9.59	7.14	8.98
Point Sample Mean Corrected	5.87	9.27	9.23	6.78	8.62
Noz. Vel./CM Mean Corrected	1.08	0.97	0.97	1.06	0.95
Noz. Vel./PS Mean Corrected	1.14	1.01	1.01	1.12	0.98
Tran. Rate/CM Mean Corrected	0.43	0.29	0.29	0.19	0.16
Time	12:35 pm	11:25 am	2:15 pm	3:20 pm	2:45 pm

FIG. 3--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--May 30, 1947

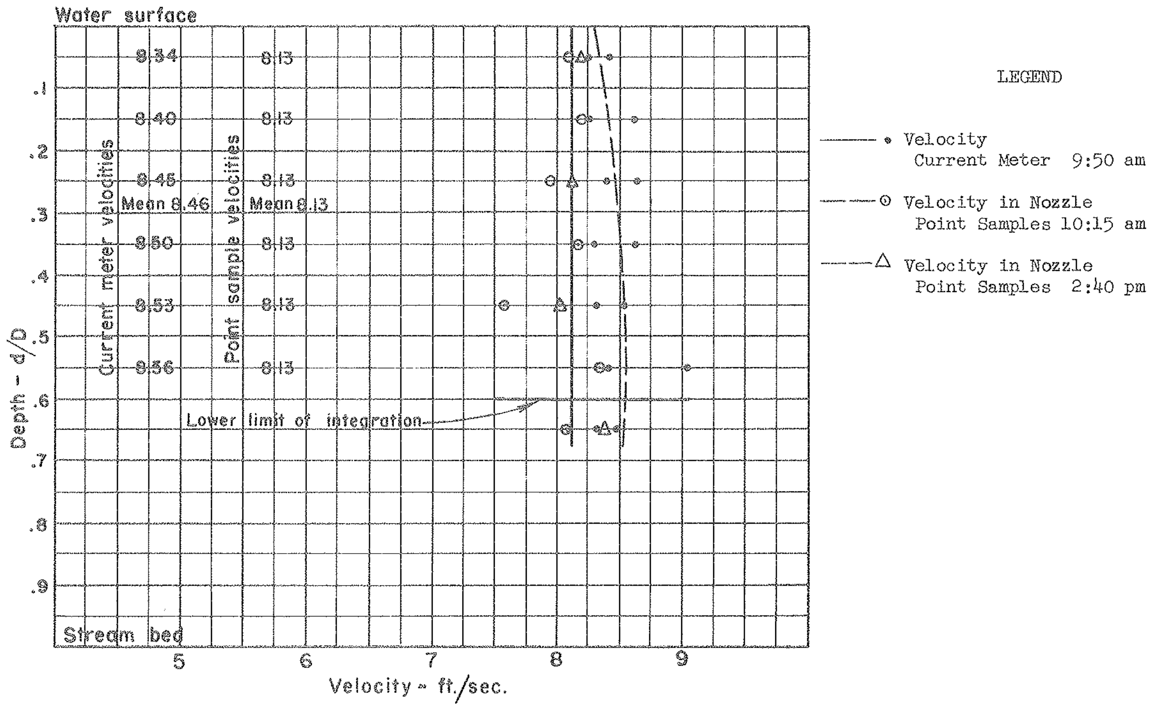


DEPTH-INTEGRATION DATA

Instrument	P-46		D-43		
Nozzle	3/16"		1/8"		
Integration	ws to sb	sb to ws	round trip		
Nozzle Velocity	6.41	8.90	11.23		
Do.	6.85	8.31	11.64		
Do.	7.04	8.91	10.98		
Do.	7.66	8.97	11.02		
Do.	7.05	8.40	11.69		
Average Nozzle Velocity	7.00	8.70	11.31		
CM Mean Corrected for Time	7.93	7.93	7.93		
CM Mean Corrected for Drift	6.15	9.31	7.45		
Point Sample Mean Corrected	6.25	9.41	7.55		
Noz. Vel./CM Mean Corrected	1.14	0.93	1.52		
Noz. Vel./PS Mean Corrected	1.12	0.92	1.50		
Tran. Rate/CM Mean Corrected	0.42	0.29	↓.66 ↑.40		
Time	1:45 pm	11:50 am	2:45 pm		

FIG. 4--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--May 31, 1947

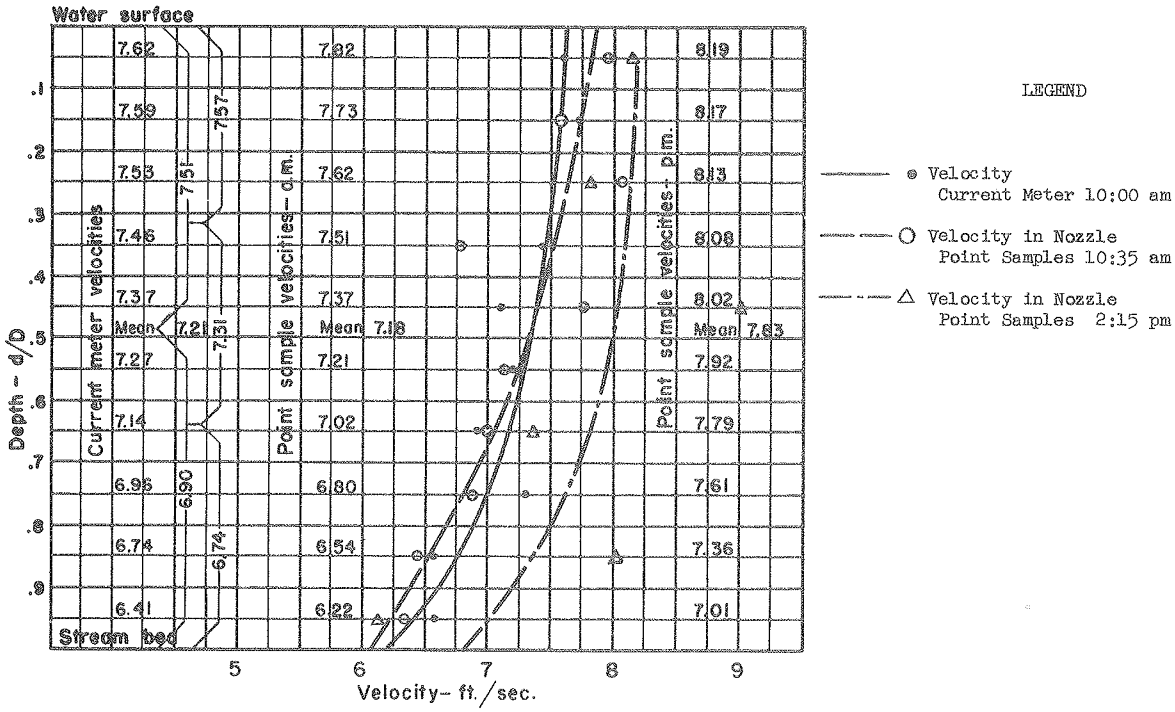


DEPTH-INTEGRATION DATA

Instrument	P-46		P-46S				D-43
Nozzle	3/16"		3/16"		1/8"		1/8"
Integration	ws to .6d	.6d to ws	ws to .6d	.6d to ws	ws to .6d	.6d to ws	ws-.6d-ws
Nozzle Velocity	8.05	8.07	7.53	8.47	8.62	8.41	10.73
Do.	7.35	8.14	8.03	8.05	8.29	6.96	--
Do.	7.09	8.09	7.57	9.02	8.20	7.17	9.07
Do.	6.59	8.20	7.22	8.51	8.12	7.42	9.86
Do.	7.53	7.24	7.61	8.03	9.03	8.74	
Average Nozzle Velocity	7.32	7.95	7.59	8.42	8.45	7.74	9.89
CM Mean Corrected for Time	8.46	8.46	8.46	8.46	8.46	8.46	8.46
CM Mean Corrected for Drift	7.66	8.92	7.67	8.91	8.09	8.74	7.92
Point Sample Mean Corrected	7.33	8.59	7.34	8.58	7.76	8.41	7.59
Noz. Vel./CM Mean Corrected	0.96	0.89	0.99	0.95	1.04	0.89	1.25
Noz. Vel./PS Mean Corrected	1.00	0:93	1.03	0.98	1.09	0.92	1.30
Tran. Rate/CM Mean Corrected	0.24	0.18	0.22	0.20	0.11	0.10	↓.38 ↑ .26
Time	10:55 am	10:55 am	12:10 pm	12:50 pm	11:45 am	1:15 pm	2:25 pm

FIG. 5--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--June 2, 1947

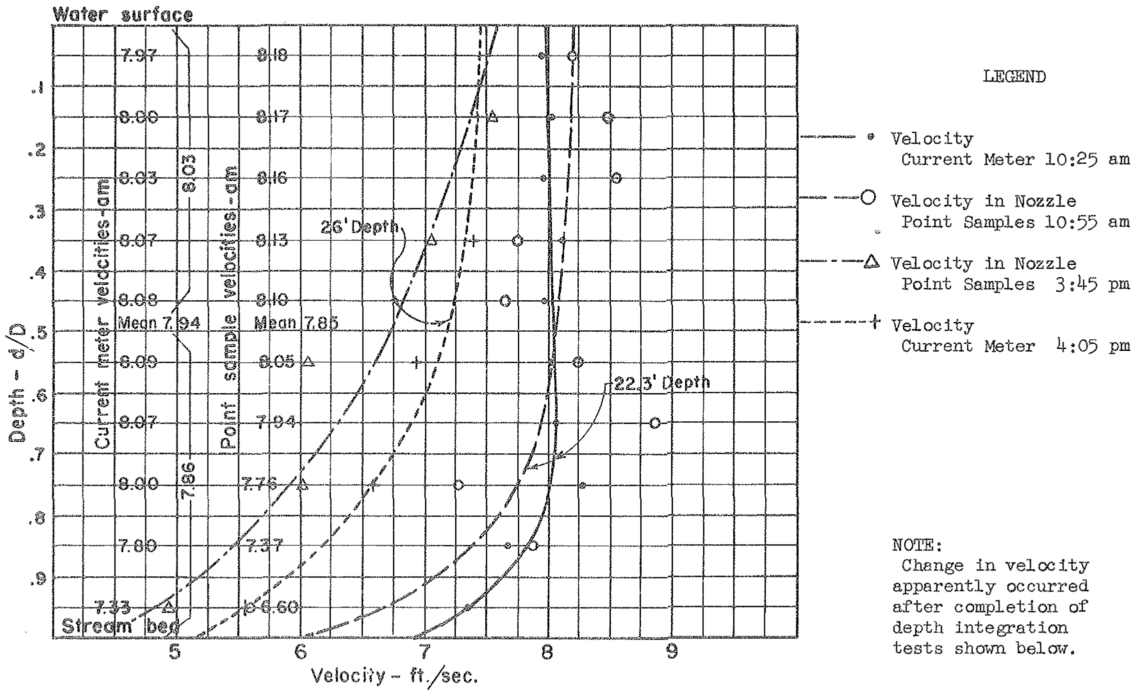


DEPTH-INTEGRATION DATA - - P-46 - 3/16" NOZZLE

Fractional Depth	Full Depth	Half Depth		Third Depth		
Integration	ws to sb	ws to .5d	.5d to sb	ws to .33d	.33d--.67d	.67d to sb
Do.	sb to ws	.5d to ws	sb to .5d	.33d to ws	.67d--.33d	sb to .67d
Do.		round trip	round trip	round trip	round trip	round trip
Nozzle Velocity	6.78	7.02	6.63	7.48	7.97	5.91
Do.	7.14	7.05	7.03	7.29	7.77	7.13
Do.		6.11	6.00	7.95	7.95	7.11
Do.		8.25	7.84	7.59	8.18	8.32
Do.		7.68	6.15	7.92	7.64	7.77
Do.		7.48	7.16	8.12	7.71	8.54
Average Nozzle Velocity	6.96	7.26	6.80	7.72	7.87	7.46
CM Mean Corrected for Time	7.52	7.50	7.47	7.77	7.72	7.68
CM Mean Corrected	7.40	7.72	7.16	7.96	7.80	7.26
Point Sample Mean Corrected	7.27	7.59	7.03	7.83	7.67	7.13
Noz.Vel./CM Mean Corrected	0.94	0.94	0.95	0.97	1.01	1.03
Noz.Vel./PS Mean Corrected	0.96	0.96	0.97	0.99	1.03	1.05
Time	11:45 am	11:40 am	11:30 am	1:10 pm	12:55 pm	12:40 pm

FIG. 6--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--June 3, 1947

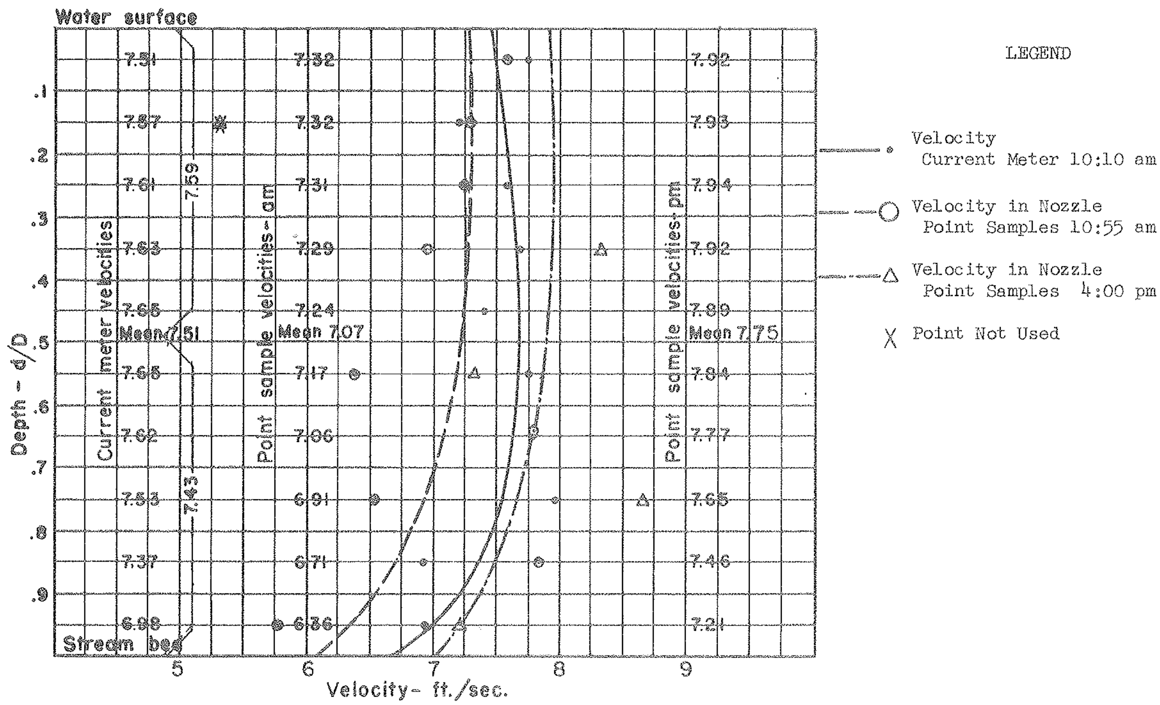


DEPTH-INTEGRATION DATA

Instrument	P-46-3/16" Nozzle		P-46S		D-43
Integration	ws to .5d	sb to .5d	3/16" Nozzle 1/8"		1/8" Nozzle
Do.	.5d to sb	.5d to ws			
Do.	ws to sb	sb to ws	sb to ws	sb to ws	round trip
Nozzle Velocity	7.84	8.69	9.21	8.91	11.35
Do.	7.25	8.06	8.84	8.12	10.48
Do.	6.35	9.32	9.28	7.04	11.31
Do.			9.10	7.25	11.11
Do.			8.25	9.24	10.94
Average Nozzle Velocity	7.15	8.69	8.94	8.11	11.04
CM Mean Corrected for Time	7.94	7.94	7.94	7.94	7.94
CM Mean Corrected for Drift	6.86	8.93	9.25	8.59	7.47
Point Sample Mean Corrected	6.77	8.84	9.16	8.50	7.38
Noz. Vel./CM Mean Corrected	1.04	0.97	0.97	0.94	1.48
Noz. Vel./PS Mean Corrected	1.06	0.98	0.98	0.95	1.50
Tran. Rate/CM Mean Corrected			0.28	0.14	↓ .62 ↑ .36
Time	11:40 am	11:40 am	12:45 pm	12:15 pm	10:00 am

FIG. 7--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Arizona--June 4, 1947



DEPTH-INTEGRATION DATA

Instrument	P-46			P-46S			
Nozzle	3/16"			3/16"		1/8"	
Integration	ws to sb	ws to.5d	.5d to sb				
Integration	sb to ws	.5d to ws	sb to .5d	ws to sb	sb to ws	ws to sb	sb to ws
Nozzle Velocity	6.83	--	7.95	6.35	8.18	7.42	8.70
Do.	8.25	--	6.39	7.16	8.65	9.07	--
Do.				6.67	8.01	8.37	9.12
Do.				5.86	8.71	8.70	6.38
Do.				6.15	8.14	8.00	7.79
Average Nozzle Velocity	7.54		7.17	6.44	8.34	8.31	8.00
CM Mean Corrected for Time	7.68		7.71	8.22	8.03	8.16	8.09
CM Mean Corrected for Drift	7.50		7.46	6.76	9.26	7.38	8.78
Point Sam. Mean Corrected	6.98		6.94	6.24	8.74	6.86	8.26
Noz. Vel/CM Mean Corrected	1.01		0.96	0.95	0.90	1.13	0.92
Noz. Vel/PS Mean Corrected	1.08		1.03	1.03	0.97	1.21	0.97
Tran Rate/CM Mean Corrected				0.35	0.28	0.17	0.15
Time	11:30 am	11:50 am	11:40 am	3:35 pm	2:10 pm	3:10 pm	2:35 pm

FIG. 8--VELOCITY AND INTAKE RATIO DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--June 6, 1947

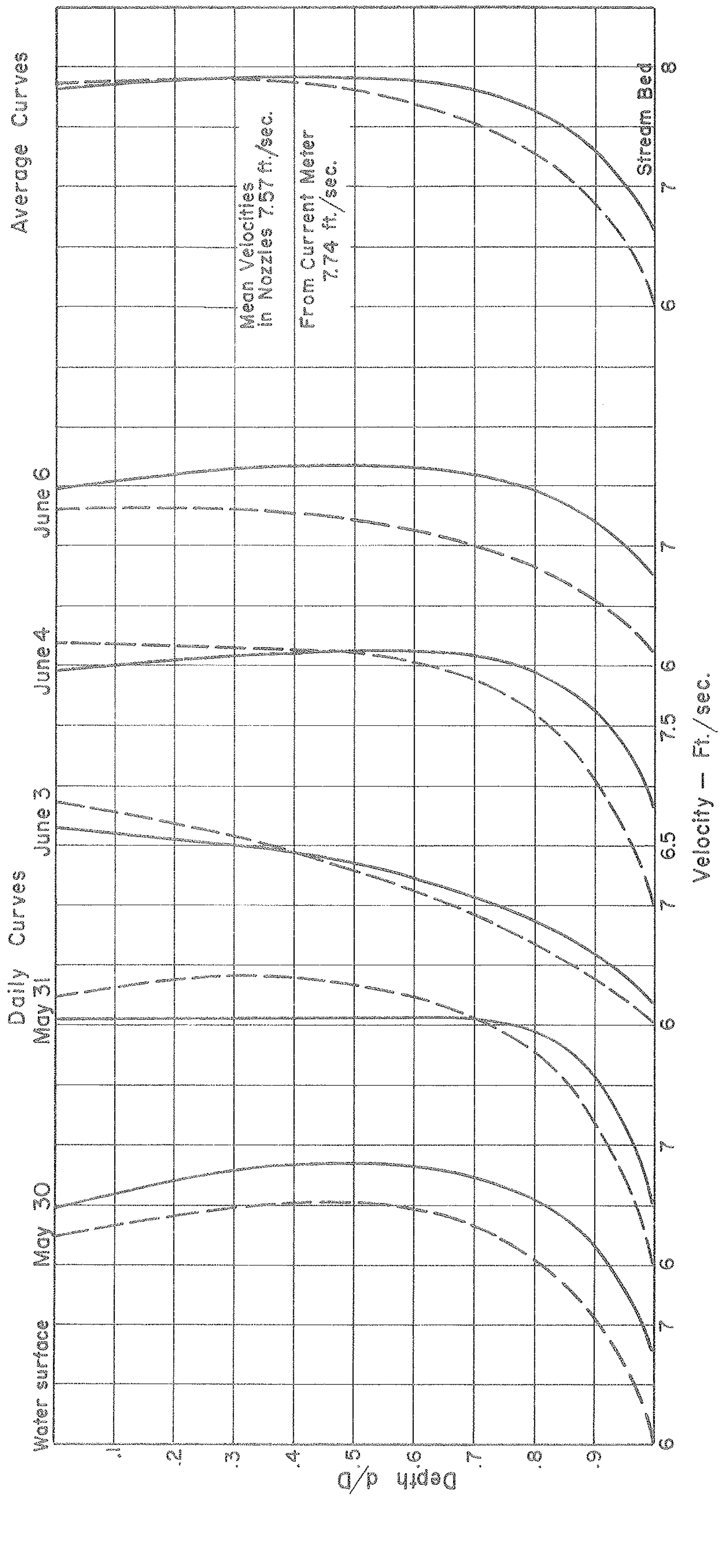


FIG. 9-DISTRIBUTION OF VELOCITY WITH DEPTH
DAILY AND AVERAGE CURRENT METER AND NOZZLE VELOCITY CURVES
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ.

LEGEND
—— Current meter velocity
— — Nozzle velocity

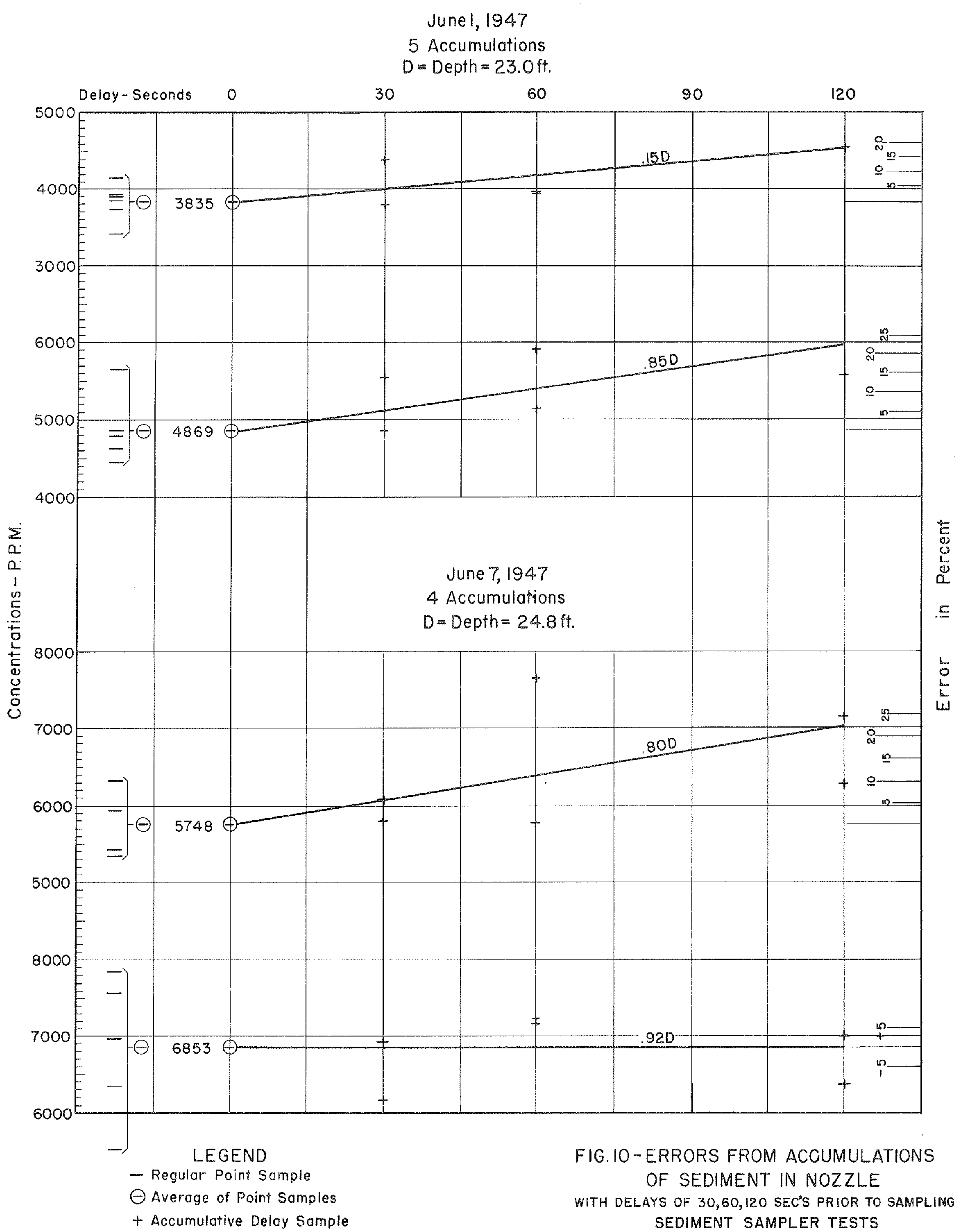
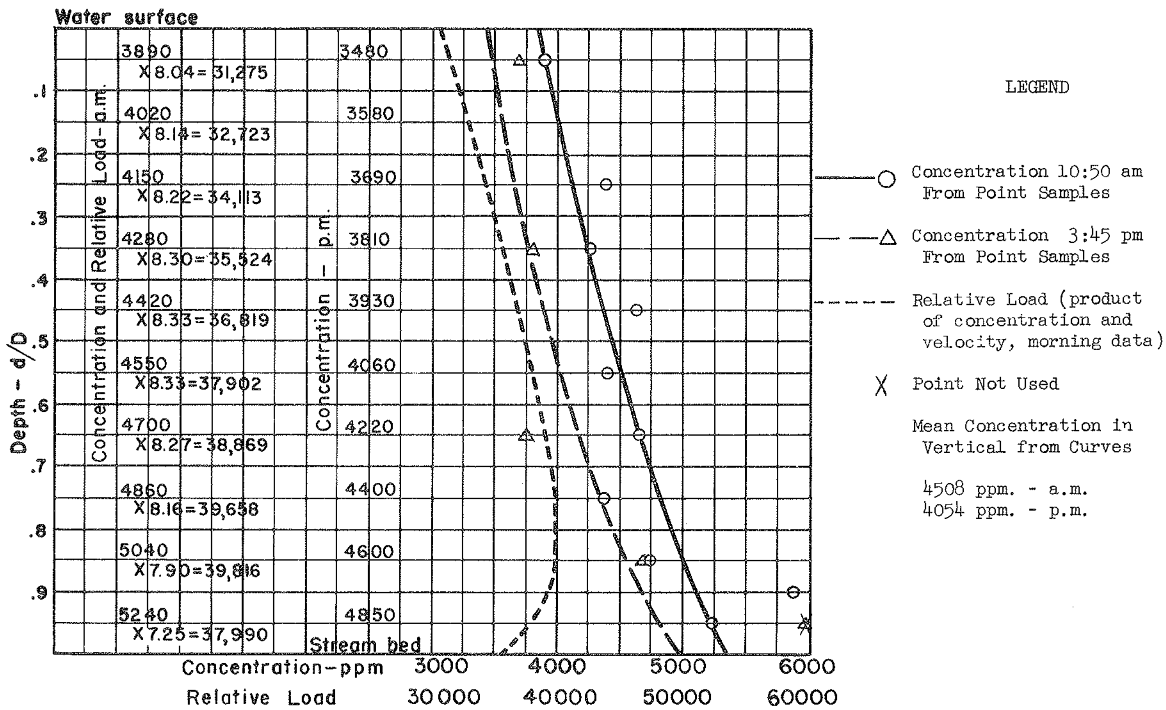


FIG. 10 - ERRORS FROM ACCUMULATIONS OF SEDIMENT IN NOZZLE
WITH DELAYS OF 30, 60, 120 SEC'S PRIOR TO SAMPLING
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ.

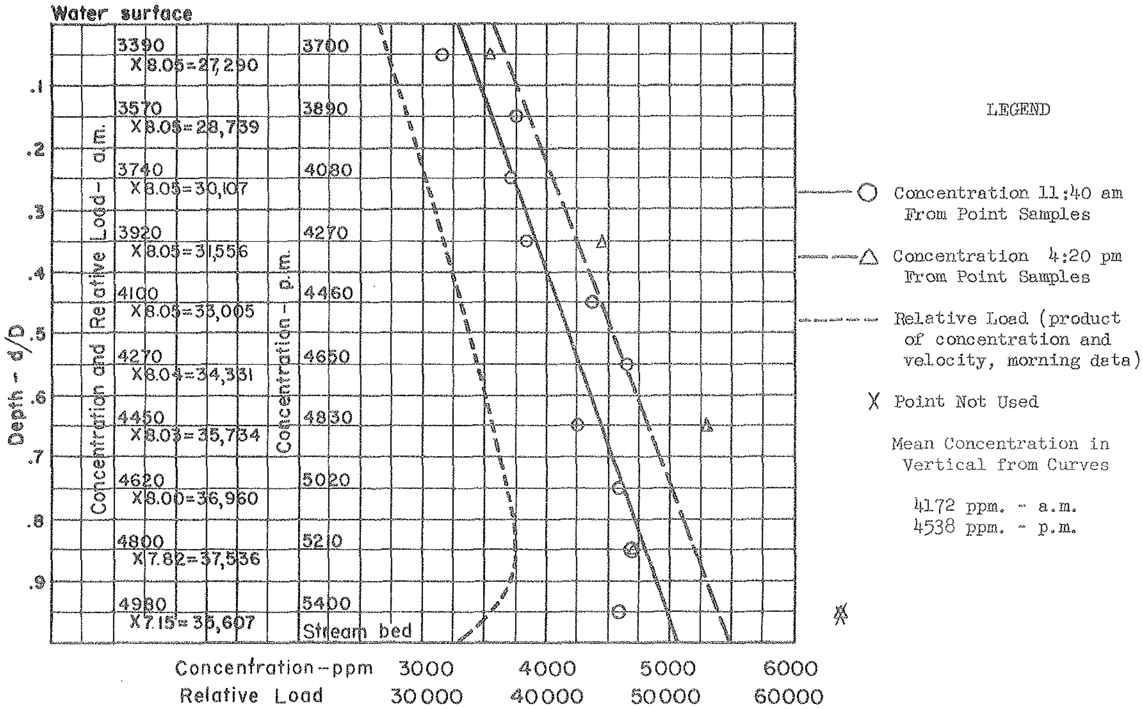


DEPTH-INTEGRATION DATA

Instrument	P-46		P-46S		
Nozzle	3/16"		3/16"	1/8"	
Integration	ws to sb	sb to ws	sb to ws	ws to sb	sb to ws
Sample Concentration	4196	4600	3516	4368	3595
Do.	4646	4985	4013		4125
Do.	4347	5019	3912		4002
Do.	4412	4501	3946		4122
Do.	4083	4336	4657		4440
Average Concentration	4337	4688	4009	4368	4057
Mean Concentration - a.m. Curve	4508	4508	4508	4508	4508
Mean Concentration Corrected	4350	4450	4190	4090	4150
Avg. Conc./Mean Conc. Corrected	1.00	1.05	0.96	1.07	0.98
Relative Transit Rate	0.43	0.29	0.29	0.19	0.16
Time	12:35 pm	11:25 am	2:15 pm	3:20 pm	2:45 pm

FIG. 11--SUSPENDED SEDIMENT CONCENTRATION DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--May 30, 1947

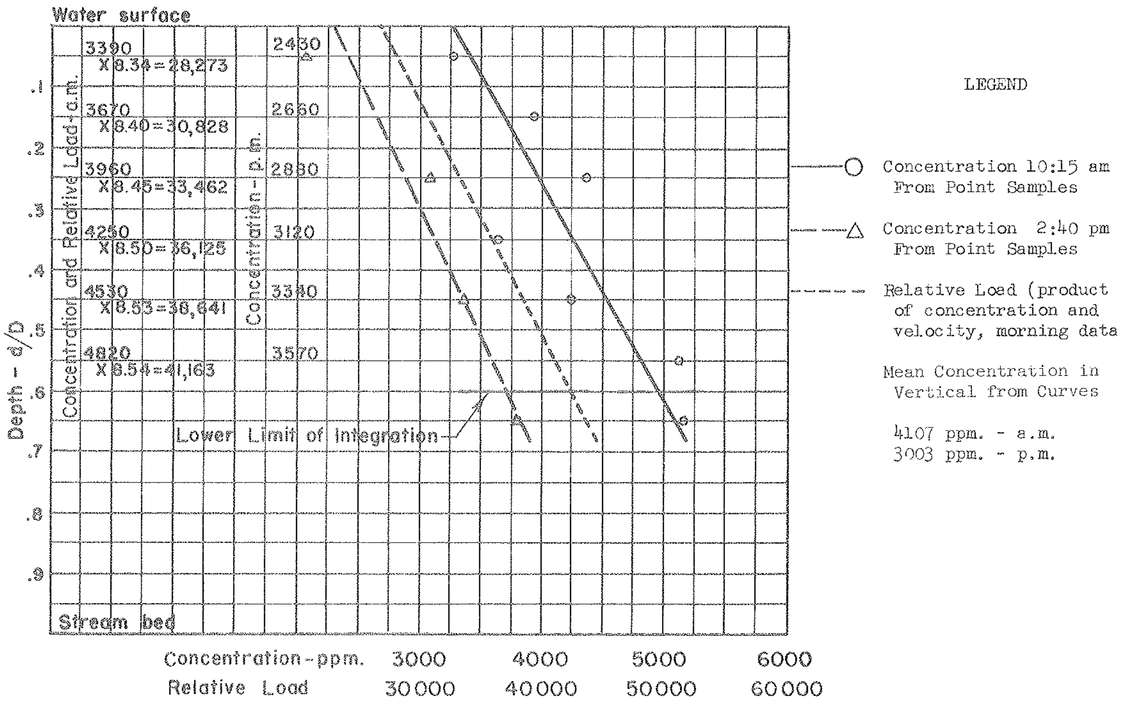


DEPTH-INTEGRATION DATA

Instrument	P-46		D-43	
Nozzle	3/16"		1/8"	
Integration	ws to sb	sb to ws	round trip	
Sample Concentration	4248	4706	3821	
Do.	3976	4472	3689	
Do.	4148	4568	--	
Do.	4276	3948	3665	
Do.	4266	4498	3679	
Average Concentration	4183	4438	3174	
Mean Concentration - a.m. Curve	4172	4172	4172	
Mean Concentration Corrected	4330	4180	4410	
Average Conc./Mean Conc. Corrected	0.97	1.06	0.84	
Relative Transit Rate	0.42	0.29	↓.66 ↑.40	
Time	1:45 pm	11:50 am	2:45 pm	

FIG. 12--SUSPENDED SEDIMENT CONCENTRATION DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--May 31, 1947

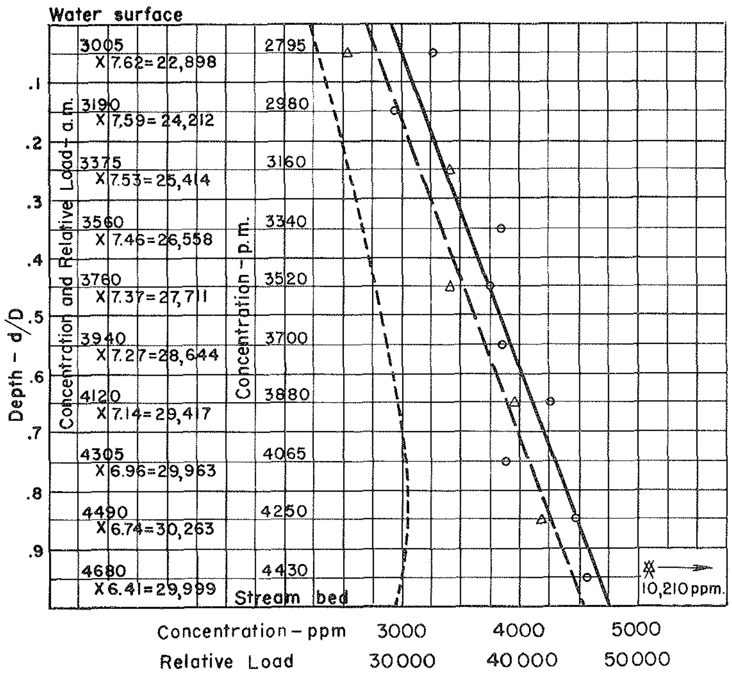


DEPTH-INTEGRATION DATA

Instrument	P-46		P-46S				D-43
Nozzle	3/16"		3/16"		1/8"		1/8"
Integration	ws to.6d	.6d to ws	ws to.6d	.6d to ws	ws to.6d	.6d to ws	ws-.6d-ws
Sample Concentration	3960	3587	3491	3355	3530	3463	2751
Do.	3533	4014	3520	3337	3741	3743	--
Do.	3459	4085	2845	--	3303	2984	2908
Do.	3685	3701	3750	3052	3611	3297	2727
Do.	3848	4387	3400	3356	3673	3142	
Average Concentration	3697	3955	3401	3275	3572	3326	2795
Mean Concentration-a.m. Curve	4107	4107	4107	4107	4107	4107	4107
Mean Concentration Corrected	3940	3940	3630	3460	3740	3360	3070
Avg. Conc/Mean Conc.Corrected	0.94	1.00	0.94	0.95	0.96	0.99	0.91
Relative Transit Rate	0.24	0.18	0.22	0.20	0.11	0.10	↓.38 ↑.26
Time	10:55am	10:55am	12:10pm	12:50pm	11:45am	1:15pm	2:25pm

FIG. 13--SUSPENDED SEDIMENT CONCENTRATION DATA - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--June 2, 1947



LEGEND

- ——— o Concentration 10:35 am From Point Samples
- — — △ Concentration 2:15 pm From Point Samples
- - - - - Relative Load (product of concentration and velocity, morning data)
- X Point Not Used

Mean Concentration in Vertical from Curves

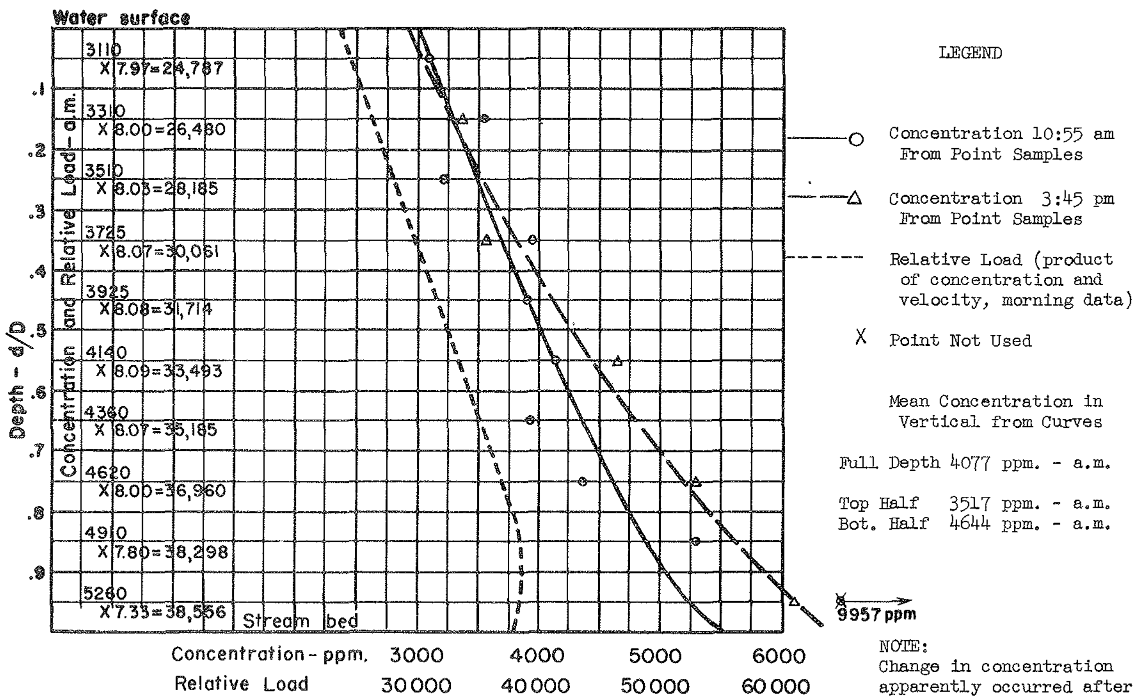
Full Depth	3815 ppm.	- a.m.
Full Depth	3585 ppm.	- p.m.
Top Half	3376 ppm.	- a.m.
Bot. Half	4298 ppm.	- a.m.
Top Third	3220 ppm.	- a.m.
Mid. Third	3844 ppm.	- a.m.
Bot. Third	4457 ppm.	- a.m.

DEPTH-INTEGRATION DATA - - P-46 - 3/16" NOZZLE

Fractional Depth	Full Depth	Half Depth		Third Depth		
Integration	ws to sb	ws to .5d	.5d to sb	ws to .33d	.33d--.67d	.67d to sb
Do.	sb to ws	.5d to ws	sb to .5d	.33d to ws	.67d--.33d	sb to .67d
Do.		round trip	round trip	round trip	round trip	round trip
Sample Concentration	4099	3436	4790	3420	3771	5509
Do.	5045	3318	4650	2907	3664	4280
Do.		3826	5499	2872	4340	4497
Do.		3371	4879	3283	3591	4057
Do.		3224	4376	3275	3739	4532
Do.		4100	4736	3119	3825	4187
Average Concentration	4572	3546	4822	3146	3822	4510
Mean Conc. - a.m. Curve	3815	3376	4298	3220	3844	4457
Mean Conc. Corrected	3740	3310	4240	3060	3700	4330
Avg. Conc./Mean Conc. Corrected	1.22	1.07	1.14	1.03	1.03	1.04
Time	11:45 am	11:40 am	11:30 am	1:10 pm	12:55 pm	12:40 pm

FIG. 14--SUSPENDED SEDIMENT CONCENTRATION DATA - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 3, 1947



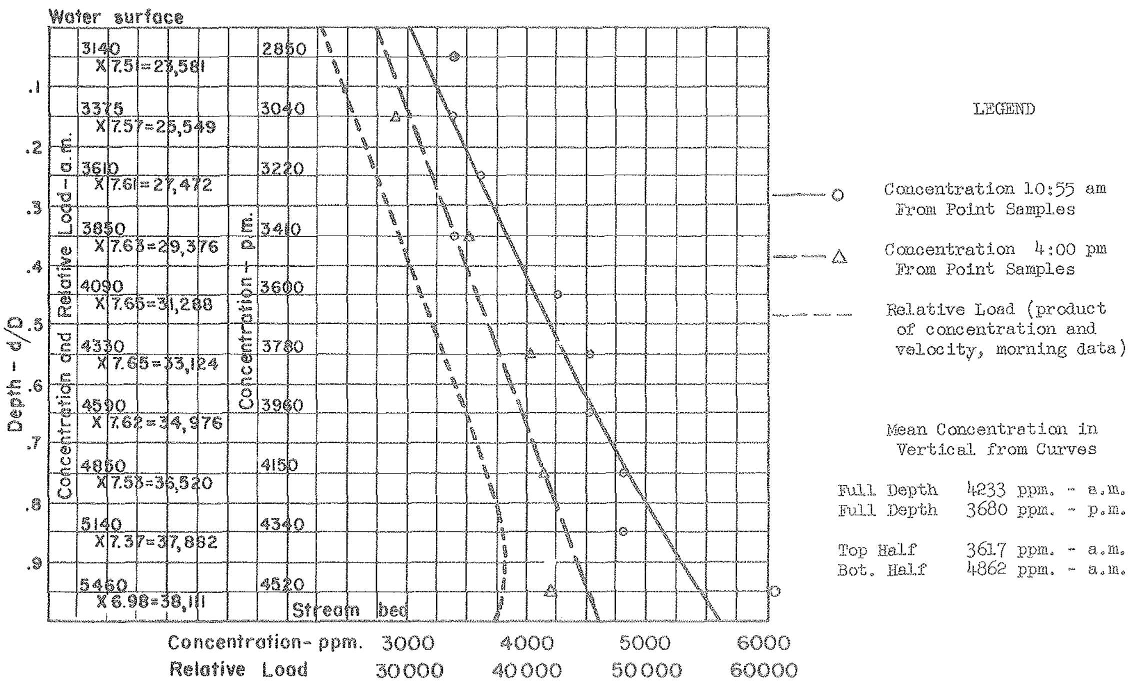
NOTE:
Change in concentration apparently occurred after completion of depth integration tests shown below.

DEPTH-INTEGRATION DATA

Instrument	P-46 - 3/16" Nozzle		P-46S		D-43
Integration	ws to .5d	sb to .5d	3/16" Nozzle	1/8"	1/8" Nozzle
Do.	.5d to sb	.5d to ws			
Do.	ws to sb	sb to ws	sb to ws	sb to ws	round trip
Sample Concentration	3075	4880	3649	3601	3674
Do.	4213	3422	3599	3677	3325
Do.	3609	3959	3736	3772	3590
Do.			3909	3834	3144
Do.			3819	3927	3266
Average Concentration	3632	4087	3742	3762	3400
Mean Concentration-a.m. Curve	4077	4077	4077	4077	4077
Mean Concentration Corrected	4077	4077	4077	4077	4077
Avg. Conc./Mean Conc. Corrected	0.89	1.00	0.92	0.92	0.83
Relative Transit Rate			0.28	0.14	↓.62 ↑.36
Time	11:40 am	11:40 am	12:45 pm	12:15 pm	10:00 am

FIG. 15--SUSPENDED SEDIMENT CONCENTRATION DATA - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 4, 1947

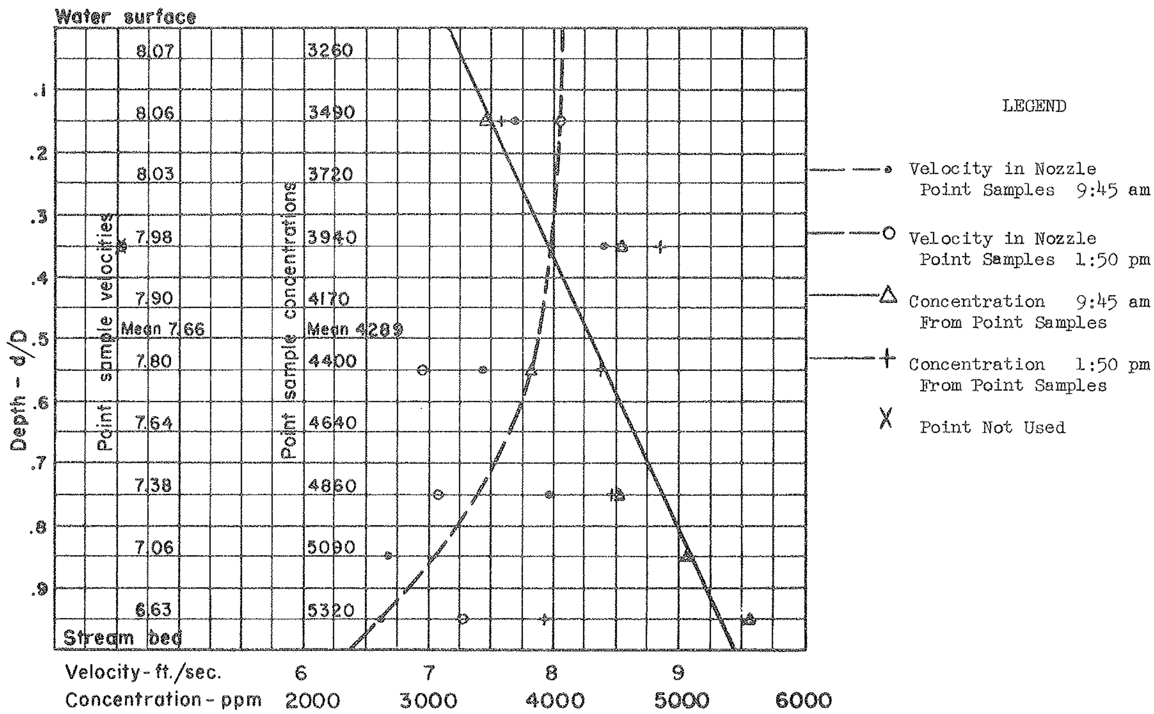


DEPTH-INTEGRATION DATA

Instrument	P-46			P-46S			
Nozzle	3/16"			3/16"		1/8"	
Integration	ws to sb	ws to .5d	.5d to sb				
Integration	sb to ws	.5d to ws	sb to .5d	ws to sb	sb to ws	ws to sb	sb to ws
Sample Concentration	4221	---	4253	3306	3576	3918	3792
Do.	4121	3387	5000	3784	4136	4217	4276
Do.				3942	4751	3819	3666
Do.				4113	4166	3646	3624
Do.				3830	3891	3781	3910
Average Concentration	4171	3387	4626	3795	4104	3876	3854
Mean Conc. - a.m. Curve	4233	3617	4862	4233	4233	4233	4233
Mean Concentration Corrected	4170	3520	4780	3730	3880	3770	3840
Avg. Conc/Mean Conc. Corrected	1.00	0.96	0.97	1.02	1.06	1.03	1.00
Relative Transit Rate				0.35	0.28	0.17	0.15
Time	11:30 am	11:50 am	11:40 am	3:35 pm	2:10 pm	3:10 pm	2:35 pm

FIG. 16--SUSPENDED SEDIMENT CONCENTRATION DATA -- SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 6, 1947



DEPTH-INTEGRATION DATA - P-46S

Integration	Tran. Rate	Nozzle Vel.	Vel. Ratio	Sample Conc.	Conc. Ratio	Tran. Rate	Nozzle Vel.	Vel. Ratio	Sample Conc.	Conc. Ratio
	3/16" Nozzle					Integrated from Water Surface to Stream Bed with 1/8" Nozzle				
ws to .23d	0.09	6.54	0.86	3206	0.94					
ws to .44d	0.17	7.94	1.11	3827	1.05	0.22	8.87	1.31	4419	1.03
ws to .75d	0.31	7.13	1.06	4246	1.06	0.20	7.38	1.08	3515	0.82
ws to sb	0.51	6.63	1.14	4392	1.02	0.26	9.07	1.37	3616	0.84
	1/8" Nozzle					0.26	8.41	1.27	3896	0.91
ws to .39d	0.07	8.62	1.12	3284	0.92	0.34	7.83	1.23	3875	0.90
ws to .46d	0.08	8.91	1.16	3545	0.97	0.40	8.20	1.33	3229	0.75
ws to .74d	0.15	8.78	1.21	3933	0.99	0.49	9.20	1.55	3507	0.82
ws to .72d	0.13	8.66	1.18	3733	0.94	0.62	10.24	1.84	3595	0.84

FIG. 17--VELOCITY AND SEDIMENT CONCENTRATION DATA - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 8, 1947

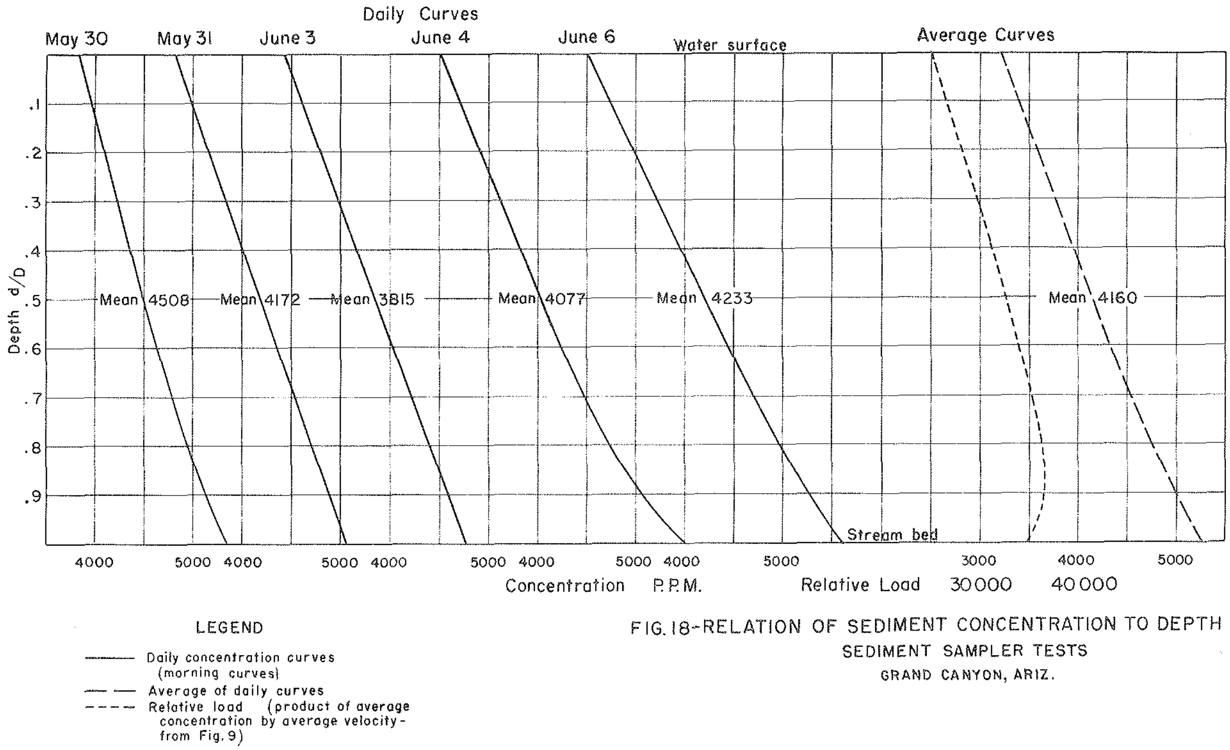


FIG. 18 - RELATION OF SEDIMENT CONCENTRATION TO DEPTH
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ.

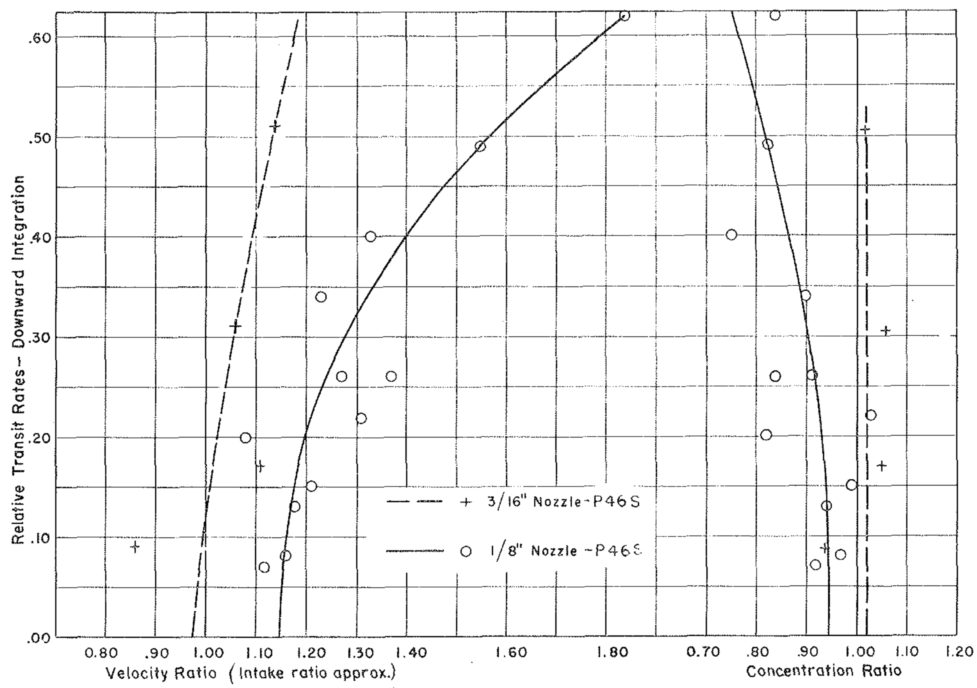
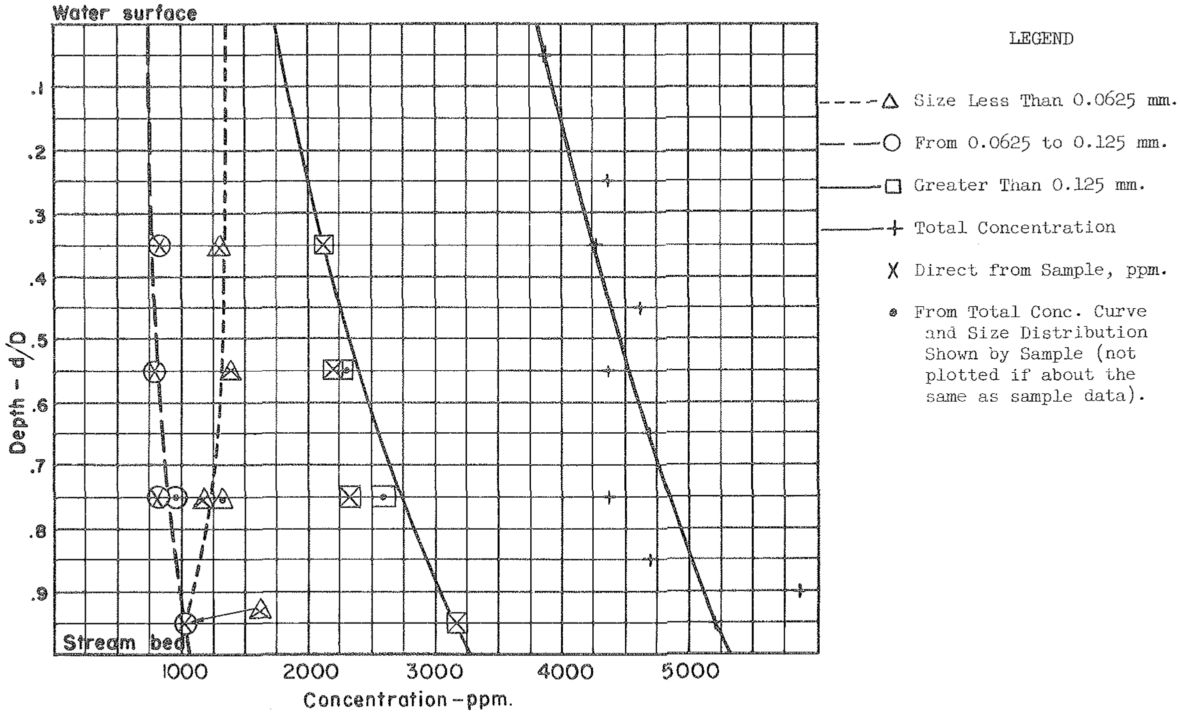


FIG. 19 - EFFECT OF EXCESSIVE DOWNWARD TRANSIT RATES
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ.

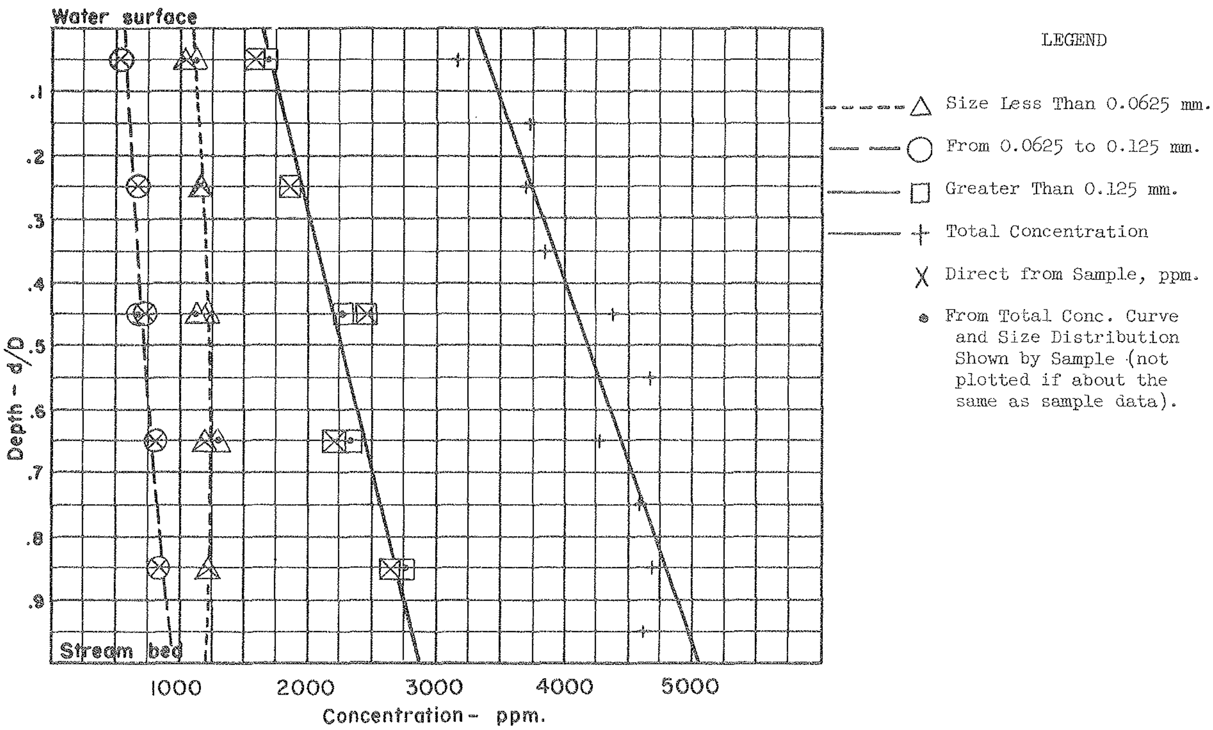


DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Data	Size, mm.			Total	Conc. Ratio
				<0.0625	.0625-.125	>0.125		
8	P-46;3/16	1.00-.00d	Sample	1247	847	2891	4985	1.11
			Daily Curves	1276	848	2367	4491	
20	P-46;3/16	.00-1.00d	Sample	1087	739	2521	4347	1.00
			Daily Curves	1236	820	2292	4348	
25	P-46S;3/16	1.00-.00d	Sample	1213	626	2073	3912	0.93
			Daily Curves	1191	792	2211	4194	
29	P-46S; 1/8	1.00-.00d	Sample	1032	825	2268	4125	0.99
			Daily Curves	1180	784	2190	4154	

FIG. 20--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - May 30, 1947

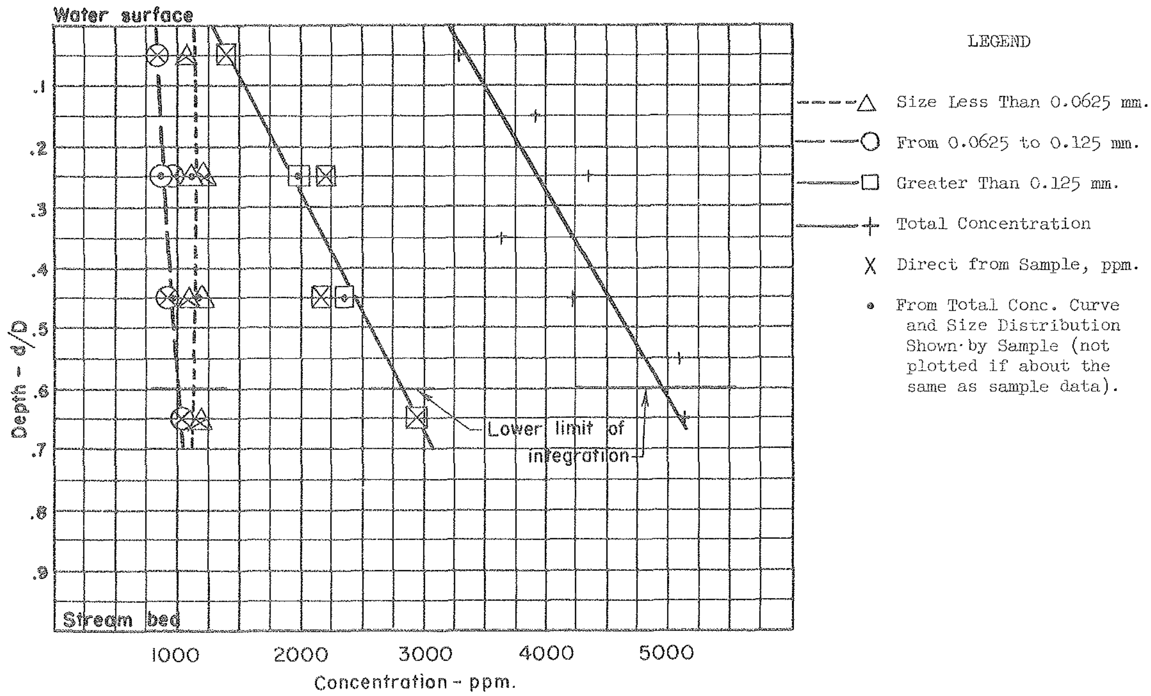


DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Data	Size, mm.			Total	Conc. Ratio
				< 0.0625	.0625-.125	>0.125		
44	P-46, 3/16	1.00-.00d	Sample	1208	894	2370	4472	1.07
			Daily Curves	1186	740	2246	4172	
57	P-46, 3/16	0.00-1.00d	Sample	1244	747	2157	4148	0.95
			Daily Curves	1242	775	2352	4369	

FIG. 21--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - May 31, 1947

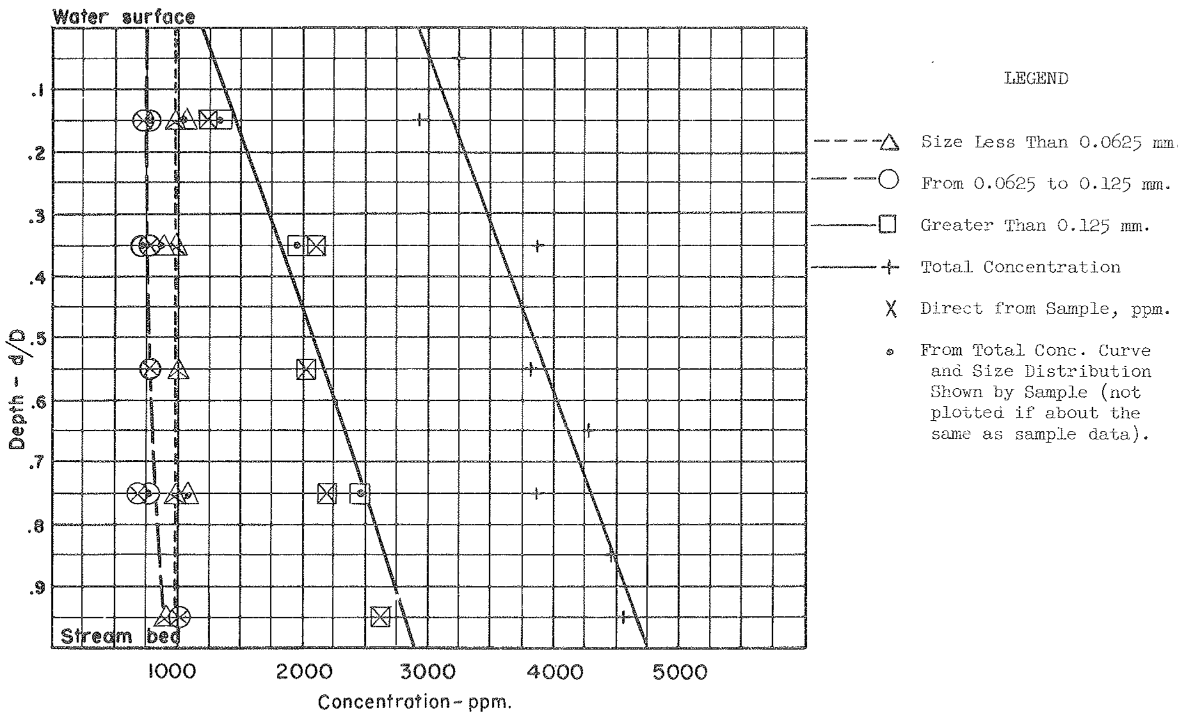


DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Date	Size, mm. <0.0625	.0625-.125	>0.125	Total	Conc. Ratio
101	P-46;3/16	0.60-.00d	Sample	1103	940	2042	4085	1.03
			Daily curves	1098	883	1974	3955	
102	P-46;3/16	0.00-.60d	Sample	1176	796	1487	3459	0.88
			Daily curves	1092	879	1964	3935	
109	P-46S; 1/8	0.00-.60d	Sample	1090	727	1486	3303	0.88
			Daily curves	1041	837	1872	3750	
114	P-46S;3/16	0.00-.60d	Sample	1081	740	1024	2845	0.78
			Daily curves	1013	814	1821	3648	
124	P-46S; 1/8	0.60-.00d	Sample	715	478	1791	2984	0.89
			Daily curves	930	748	1672	3350	
129	D-43; 1/8	0.00-.60d & return	Sample	1018	611	1279	2908	0.95
			Daily curves	848	682	1526	3056	

FIG. 22--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 2, 1947

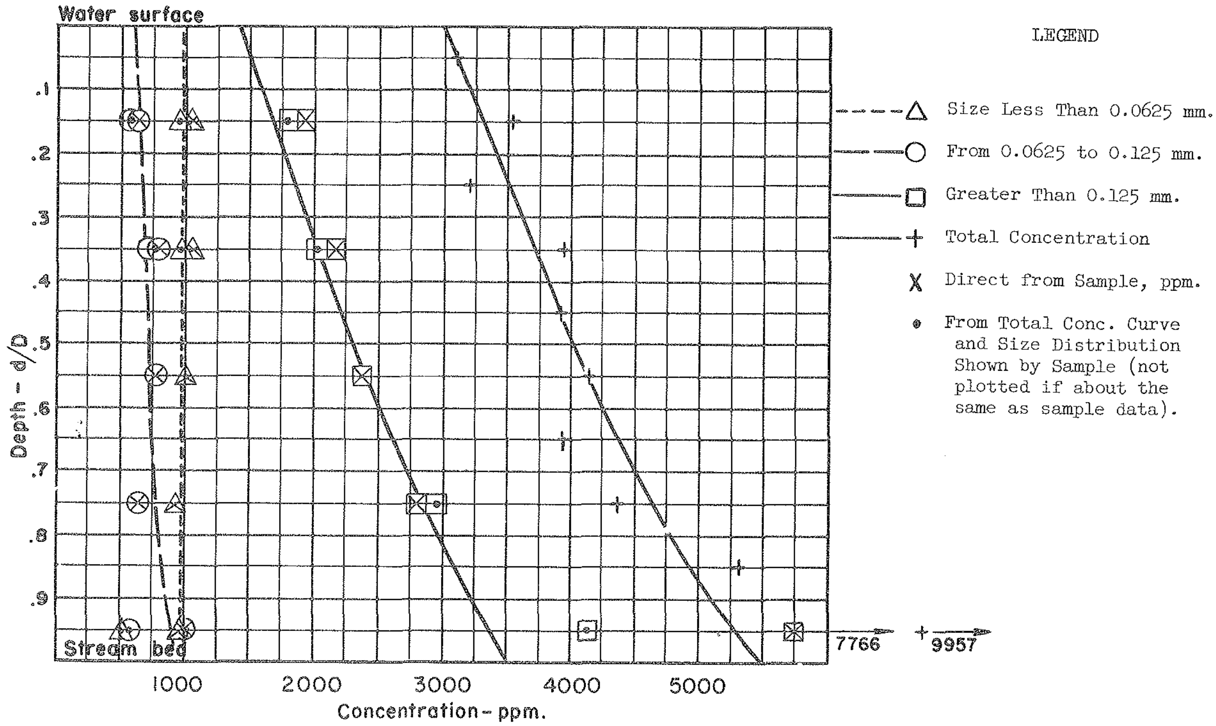


DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Data	Size, mm.			Total	Conc. Ratio
				<0.0625	.0625-.125	>0.125		
155	P-46;3/16	.50-1.00d & return	Sample	1006	875	2495	4376	1.04
			Daily curves	953	824	2445	4222	
156	do.	0.00-.50d & return	Sample	935	580	1709	3224	0.98
			Daily curves	947	744	1604	3295	
172	do.	0.67-1.00d & return	Sample	922	837	2428	4187	0.98
			Daily curves	929	824	2514	4267	
174	do.	0.33-.67d & return	Sample	804	650	2371	3825	1.05
			Daily curves	920	746	1978	3644	
176	do.	0.00-.33d & return	Sample	655	593	1871	3119	1.04
			Daily curves	907	705	1398	3010	

FIG. 23--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. - June 3, 1947

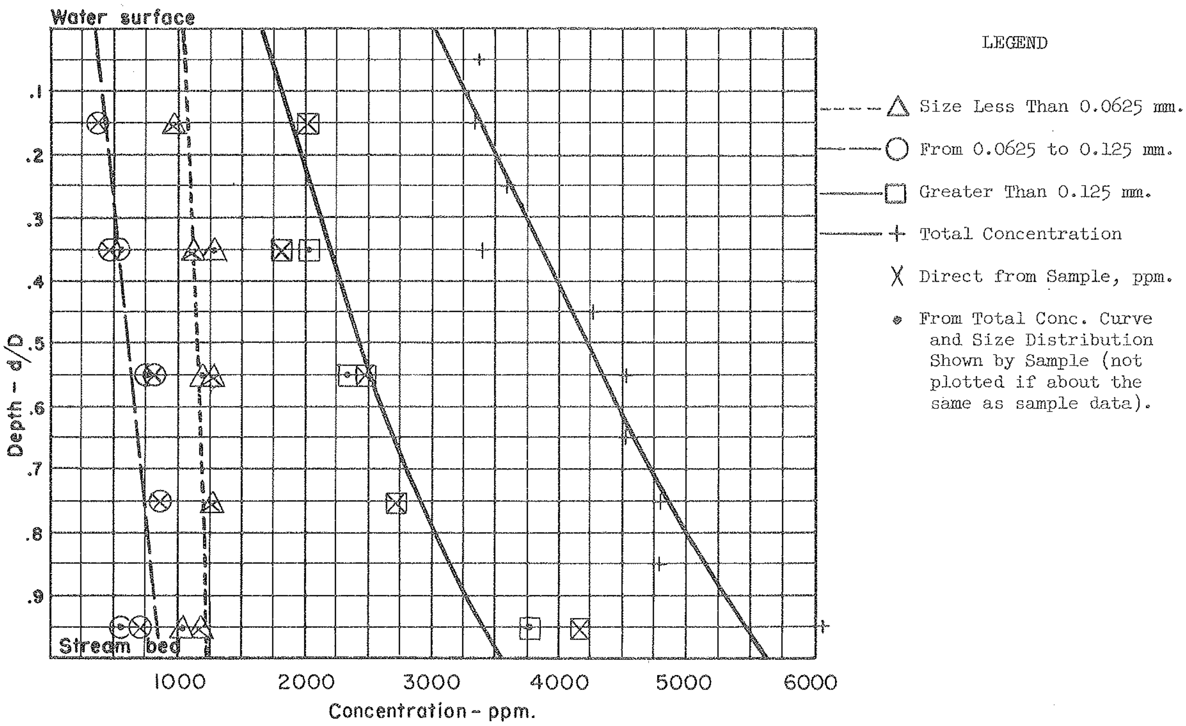


DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Data	Size, mm.			Total	Conc. Ratio
				<0.0625	.0625-.125	>0.125		
185	D-43; 1/8	0.00-1.00d & return	Sample	897	718	1975	3590	0.88
			Daily curves	990	729	2358	4077	
205	P-46S; 1/8	1.00-.00d	Sample	993	662	2022	3677	0.90
			Daily curves	990	729	2358	4077	
212	P-46S; 3/16	1.00-.00d	Sample	1055	665	2189	3909	0.96
			Daily curves	990	729	2358	4077	

FIG. 24--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.--June 4, 1947



DEPTH-INTEGRATION DATA - PPM.

Sample No.	Instrument and Nozzle	Integration	Source of Data	Size, mm. <0.0625	.0625-.125	>0.125	Total	Conc. Ratio
242	P-46S; 3/16	1.00-.00d	Sample	1093	641	3017	4751	1.23
			Daily curves	1053	559	2265	3877	
247	P-46S; 1/8	1.00-.00d	Sample	1210	660	1796	3666	0.96
			Daily curves	1042	553	2241	3836	
252	P-46S; 1/8	0.00-1.00d	Sample	1108	496	2215	3819	1.01
			Daily curves	1024	543	2203	3770	
257	P-46S; 3/16	0.00-1.00d	Sample	1103	630	2209	3942	1.06
			Daily curves	1013	538	2180	3731	

FIG. 25--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz. -- June 6, 1947

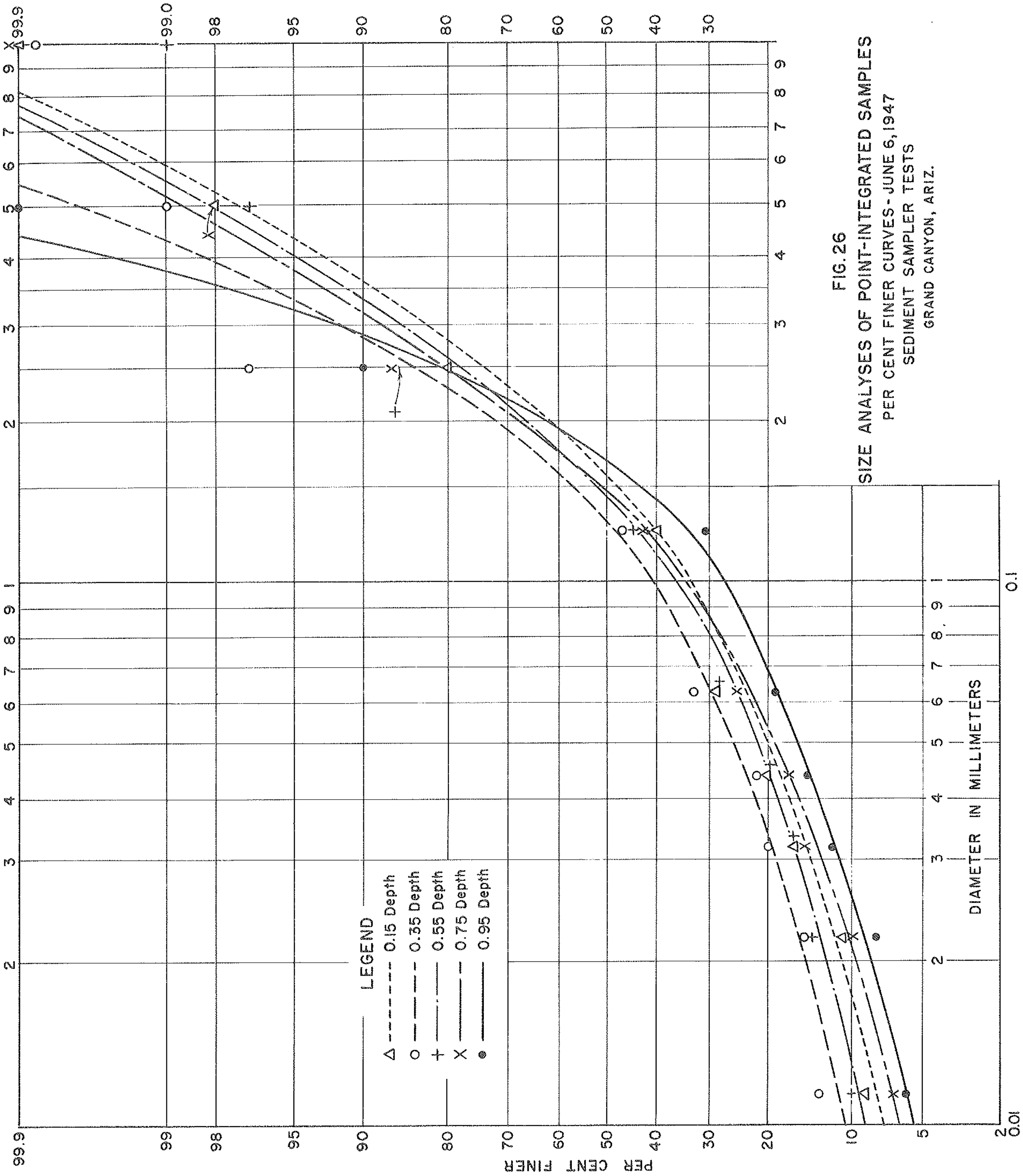
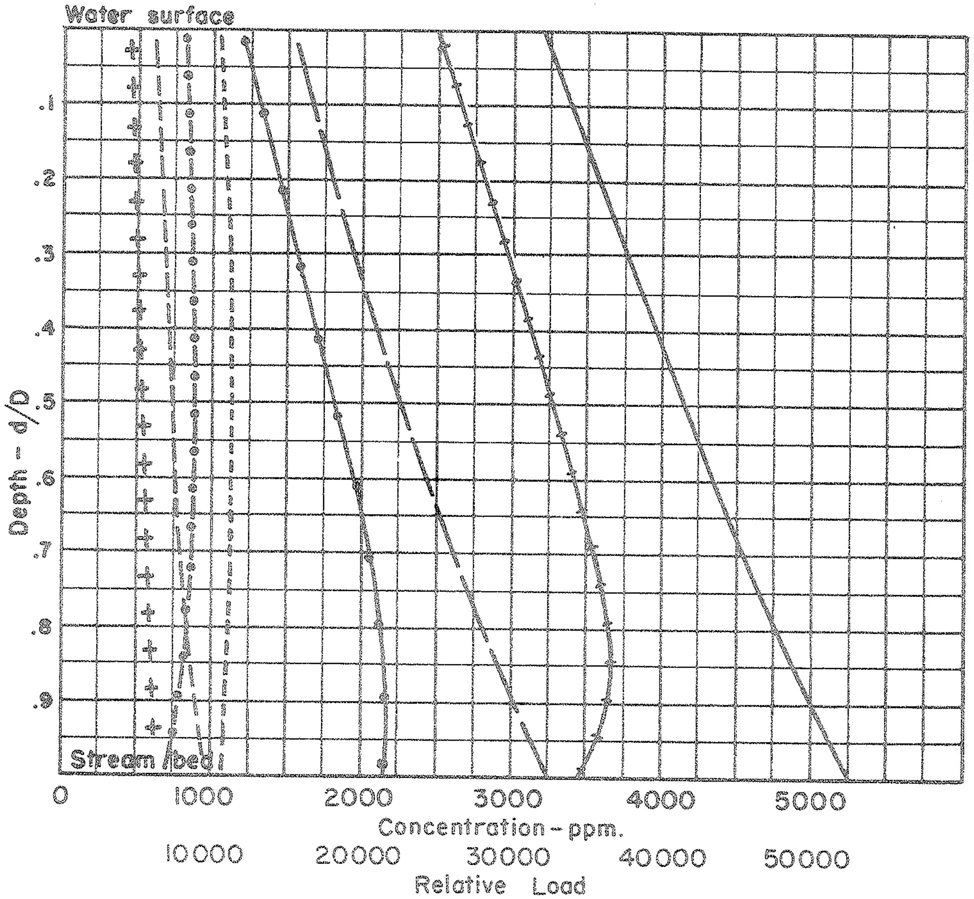


FIG. 26
SIZE ANALYSES OF POINT-INTEGRATED SAMPLES
PER CENT FINER CURVES - JUNE 6, 1947
SEDIMENT SAMPLER TESTS
GRAND CANYON, ARIZ.



LEGEND

CONCENTRATION CURVES

Size Less Than 0.0625 mm.
From 0.0625 to 0.125 mm.
Greater Than 0.125 mm.
Total Concentration

RELATIVE LOAD CURVES

Size Less Than 0.0625 mm.
From 0.0625 to 0.125 mm.
Greater Than 0.125 mm.
Total Concentration

Note:
Relative load values are product of concentration of sediment of a given size and velocity from average current meter velocity curve of Fig. 9.

SIZE DISTRIBUTION - AVERAGE

Size Less Than 0.0625 mm. - 1115 ppm.
From 0.0625 to 0.125 mm. - 745 ppm.
Greater Than 0.125 mm. - 2300 ppm.
Total Concentration - 4160 ppm.

FIG. 27--SIZE DISTRIBUTION OF SUSPENDED SEDIMENT AVERAGE - - SEDIMENT SAMPLER TESTS

Grand Canyon, Ariz.

APPENDIX

COMPUTATIONS

APPENDIX

DATA AND COMPUTATIONS

27. Explanation of computations on data sheets--Many of the more important computations essential to the report have been combined with base data to comprise Table V which will be discussed and explained briefly according to column headings.

HOUR: Watch time has been entered whenever it was recorded during the sampling day. Time for intermediate samples has been interpolated, except that a slight allowance has been made for changes in procedure which would have necessitated additional delays between certain samples.

SAMPLE NO.: Samples have been numbered in chronological order.

SAMPLER TYPE: The type of instrument used for the sample has been indicated.

NOZZLE SIZE: The D-43 sampler was equipped with a 1/8-in. nozzle having about 3 in. of taper. The P-46 had a 3/16-in. nozzle only. The taper in this instrument was incorporated in the valve block and nozzles were not tapered separately. The P-46S was equipped with a 3/16-in. nozzle with the taper in the valve block, also with 1/8-in. nozzles which had taper within the nozzles in addition to the taper in the valve block. The 1/8-in. nozzle used in the P-46S on June 8 had a nozzle taper of 2 in. while on other days a 1/8-in. nozzle with 1.5 in. of taper was used.

OPERATION: The type of integration -- PI for point integration, DI for depth integration, and Cum. for cumulative samples -- is indicated. The point-integrated samples were taken at one definite depth in the vertical, and the decimal fraction of the total depth has been shown for each point. The depth-integrated samples were taken over a definite range in depth, and the limits of integration have been given, i.e. -- from the surface to the stream bed would be 0.00-1.00d. The direction of integration was from the first listed depth to the second; and if for a round-trip integration, the direction was from the first to the second and then from the second to the third, the first and third points being the same. Cumulative samples consisted of five consecutive samples taken in one bottle on June 1, and of four in one bottle on June 7. The cumulative samples were taken at one definite depth and the depth has been indicated.

SAMPLING TIME: This is the observed time in seconds from start to end of the sampling period. For cumulative samples it is the sum of the sampling times for the four or five individual portions composing the total sample. Time was observed to tenths of seconds with a stop watch, the accuracy of the readings being about 0.2 sec.

SUSPENSION ANGLES: These are the angles in degrees that the suspension line made with the vertical at the cable car. Angles recorded are believed to be generally within two degrees of true values. The accuracy is probably within one degree when average figures are shown for a group of similar samples. Angles are listed for each of the depths and in the same order given under "OPERATION".

DRIFT: The upstream or downstream movement of the sampler in relation to the point of suspension has been given in feet. Plus signs indicate that the sampler was pulled upstream, while minus signs show that it drifted downstream. The drift has been computed on the basis of data on page 16 of the Geological Survey booklet "Method for Correcting Soundings of Deep Swift Rivers". Drift figures have been shown for depth-integrated samples only, and represent the upstream or downstream displacement of the sampler during the actual time of sampling.

VELOCITY CORRECTIONS -- DRIFT: These values represent the rate of upstream or downstream displacement of the sampler, and were obtained by dividing the drift in feet by the sampling time in seconds.

VELOCITY CORRECTIONS -- TIME: On two days, June 3 and 6, the velocity at the sampling section appeared to be changing during the sampling day. On June 4, there was a change in velocity, but that apparently did not occur until after the depth-integrated samples had been completed. On June 3 and 6, the correction was made by determining the mean velocity from the nozzle velocity curves for morning and afternoon. The difference was assumed to have occurred uniformly between the times of the two curves. The same rate of change in velocity with respect to time was then applied to the entire range of the velocity curve determined by the current meter observations.

STREAM VELOCITY: The stream velocity in feet per second was taken directly from the vertical velocity curve which was based on the current meter observations at the beginning of the sampling day. The velocity listed is that which corresponds to the depth or range of depth over which the individual sample under consideration was taken. On June 8, no current meter observations were made, and the stream velocity was taken from the vertical velocity curve based on the nozzle velocities from the point samples.

VELOCITY CORRECTED: This corrected velocity was obtained by applying the velocity corrections for drift and for time to the stream velocity originally observed. The result is presented as the best figure available for the actual velocity of flow past the intake nozzle during the time of sampling.

SAMPLE WEIGHT: This weight in grams was originally determined by subtracting the weight of the sample container from the total weight of the container and sample. The weight is considered basic data as far as this table is concerned.

NOZZLE VELOCITY: The velocity in the intake nozzle was computed by considering the weight of the sample in grams as numerically equivalent to the volume of the sample in cubic centimeters.

The sample volume was converted into cubic feet, and divided by the sampling time in seconds to obtain sample volume in cubic feet per second. This value was divided by the area of the inside of the intake nozzle tip in square feet. The result was then the average velocity of flow in the intake nozzle in feet per second.

INTAKE RATIO: The intake ratio, or relative sampling rate, is often defined as the ratio of the velocity in the intake nozzle to that in the stream at the sampling point. If the sampler operates in a horizontal position, that definition is probably sufficient. If the sampler tilts, the effective intake ratio would be the ratio of the velocity in the nozzle to that approaching the sampler along the axis of the intake nozzle. The figures in this column are all on the simple basis of the ratio of the velocity in the intake nozzle to the horizontal velocity of the water past the nozzle tip. That means merely that "NOZZLE VELOCITY" was divided by "VELOCITY CORRECTED".

SEDIMENT WEIGHT: For samples run for sediment concentration only, the sediment weight in grams was obtained by weighing the dry sediment remaining in an evaporating dish after the supernatant liquid had been removed by decantation and by evaporation. The sediment and the dish were weighed on an analytical balance, and the weight of the dish subtracted. An average correction for dissolved solids contained in the evaporated water was also subtracted from the weight of sediment. The correction for dissolved solids was taken as 0.005 or 0.006 grams depending upon the date of the sample. This amounted to about 0.3 percent of the sediment in an average sample.

SEDIMENT CONCENTRATION: The sediment concentration in parts per million of sediment by weight was determined by dividing the weight of sediment by the sample weight and multiplying the result by one million.

CONCENTRATION-POINT SAMPLES, from CURVE: The figures entered in this column represent the concentration in parts per million taken from the vertical concentration curve based on the point-integrated samples collected in the morning of the sampling day. The values were taken from the curve at the point or over the range for which the given sample was integrated.

On June 1 and 7, there were no vertical curves of sediment concentration, but the samples on these days were taken at definite depths for which the average concentration of five point-integrated samples was taken as a basis for concentration ratios.

CONCENTRATION-POINT SAMPLES, CORRECTION: This correction to the concentration from the morning curve was required because the concentration at the sampling vertical changed during the sampling day. The difference between the mean concentration from the morning curve and that from the afternoon curve was determined. This difference was assumed to have occurred uniformly with time between morning and afternoon. This time rate of change of concentration in parts per million was then applied throughout the sampling day.

CONCENTRATION-POINT SAMPLES, CORRECTED: The corrected value was derived by applying the correction to the figures from the curve. Granting that the correction may not be very precise, still these values for the concentration in the stream are the best that are available for comparison with the concentrations actually collected in the depth-integrated samples. It should be remembered that the concentration in these point samples was determined as being perhaps 1.0 percent high on the average, and about 2.5 percent high near the stream bed.

CONCENTRATION RATIO: This is the ratio of the concentration in the sample to that given in the column discussed immediately above.

SIZE DISTRIBUTION: The concentration in parts per million of sediment in each of the listed size ranges has been given. The left hand column shows sizes above 1.00 mm. Other columns show the bounding sizes in millimeters. The figure shown the farthest to the right for each sample includes all sediment finer than the upper limit of the size range for the column in which the figure appears.

TABLE V

TABLE V

DATA SHEETS

HOUR	SAMPLE NO.	SAMPLER TYPE	NOZZLE SIZE	OPERATION	SAMPLING TIME secs.	SUSPENSION ANGLES degs.	DRIFT feet	VELOCITY CORRECTIONS DRIFT ft./sec.	VELOCITY CORRECTIONS TIME ft./sec.	STREAM VELOCITY ft./sec.	VELOCITY CORRECTED ft./sec.	SAMPLE WEIGHT gm.
MAY 30, 1947 — Stream Depth 23.1 ft. — Discharge 48,000 sec. ft. — Water Temp. 66°F												
10:00 am	1	P-46	3/16"	PI @ 0.95D	8.0	18°				7.28	7.28	277.2
	2	P-46	3/16"	PI @ 0.90D	8.2	18°				7.69	7.69	304.2
	3	P-46	3/16"	PI @ 0.85D	8.2	15°				7.91	7.90	336.5
	4	P-46	3/16"	PI @ 0.75D	8.1	15°				8.16	8.16	307.4
	5	P-46	3/16"	PI @ 0.65D	8.4	14°				8.28	8.28	370.7
	6	P-46	3/16"	PI @ 0.55D	8.1	10°				8.34	8.34	379.1
	7	P-46	3/16"	DI, 1.00-0.00D	8.4	20°-7°*	+12.6	+1.50		8.09	9.59	401.7
	8	P-46	3/16"	DI, 1.00-0.00D	8.0	20°-7°*	+12.6	+1.58		8.09	9.67	419.5
	9	P-46	3/16"	DI, 1.00-0.00D	8.6	20°-7°*	+12.6	+1.47		8.09	9.56	438.5
	10	P-46	3/16"	PI @ 0.45D	8.0	10°				8.33	8.33	355.7
	11	P-46	3/16"	PI @ 0.35D	8.0	9°				8.30	8.30	338.3
	12	P-46	3/16"	PI @ 0.25D	8.0	8°				8.22	8.22	275.4
	13	P-46	3/16"	PI @ 0.15D	7.9	6°				8.14	8.14	323.5
11:50 am	14	P-46	3/16"	PI @ 0.05D	7.9	6°				8.04	8.04	342.0
	15	P-46	3/16"	Nozzle drainings	-	-				-	-	21.0
	16	P-46	3/16"	DI, 1.00-0.00D	7.8	20°-7°*	+12.6	+1.62		8.09	9.71	390.8
	17	P-46	3/16"	DI, 1.00-0.00D	8.0	20°-7°*	+12.6	+1.58		8.09	9.67	421.6
	18	P-46	3/16"	DI, 0.00-1.00D	9.2	0°-19°*	-16.0	-1.74		8.09	6.35	329.8
	19	P-46	3/16"	DI, 0.00-1.00D	7.8	0°-19°*	-16.0	-2.05		8.09	6.04	280.7
	20	P-46	3/16"	DI, 0.00-1.00D	8.4	0°-19°*	-16.0	-1.90		8.09	6.19	304.7
	21	P-46	3/16"	DI, 0.00-1.00D	8.6	0°-19°*	-16.0	-1.86		8.09	6.23	333.6
1:00 pm	22	P-46	3/16"	DI, 0.00-1.00D	9.0	0°-19°*	-16.0	-1.78		8.09	6.31	315.2
2:00 pm	23	P-46S	3/16"	DI, 1.00-0.00D	8.0	20°-7°*	+12.6	+1.58		8.09	9.67	431.4
	24	P-46S	3/16"	DI, 1.00-0.00D	8.4	20°-7°*	+12.6	+1.50		8.09	9.59	318.5
	25	P-46S	3/16"	DI, 1.00-0.00D	8.3	20°-7°*	+12.6	+1.52		8.09	9.61	375.8
	26	P-46S	3/16"	DI, 1.00-0.00D	8.8	20°-7°*	+12.6	+1.43		8.09	9.52	452.6
2:30 pm	27	P-46S	3/16"	DI, 1.00-0.00D	8.5	20°-7°*	+12.6	+1.48		8.09	9.57	435.7
	28	P-46S	1/8"	DI, 1.00-0.00D	12.9	20°-5°**	+13.8	+1.07		8.09	9.16	237.0
	29	P-46S	1/8"	DI, 1.00-0.00D	15.5	20°-5°**	+13.8	+0.89		8.09	8.98	316.3
	30	P-46S	1/8"	DI, 1.00-0.00D	18.0	20°-5°**	+13.8	+0.77		8.09	8.86	406.8
	31	P-46S	1/8"	DI, 1.00-0.00D	16.9	20°-5°**	+13.8	+0.82		8.09	8.91	258.1
	32	P-46S	1/8"	DI, 1.00-0.00D	14.9	20°-5°**	+13.8	+0.93		8.09	9.02	306.3
	33	P-46S	1/8"	DI, 0.00-1.00D	16.9	0°-19°*	-16.0	-0.95		8.09	7.14	308.6
	34	P-46	3/16"	PI @ 0.05D	8.0					8.04	8.04	253.1
	35	P-46	3/16"	PI @ 0.35D	8.0					8.30	8.30	353.3
	36	P-46	3/16"	PI @ 0.65D	8.0					8.28	8.28	409.9
	37	P-46	3/16"	PI @ 0.85D	8.0	17°				7.91	7.91	352.6
4:00 pm	38	P-46	3/16"	PI @ 0.95D	8.0	20°				7.28	7.28	229.3
MAY 31, 1947 — Stream Depth 24.0 ft. — Discharge 49,200 sec. ft. — Water Temp. 66°F												
	39	P-46	3/16"	PI @ 0.95D	8.1	17°				7.18	7.18	272.8
	40	P-46	3/16"	PI @ 0.85D	8.1	15°				7.82	7.82	341.7
11:20 am	41	P-46	3/16"	PI @ 0.75D	8.0	14°				8.00	8.00	343.3
	42	P-46	3/16"	PI @ 0.65D	7.8	14°				8.03	8.03	341.8
	43	P-46	3/16"	DI, 1.00-0.00D	9.0	20°-7°	+12.8	+1.42		7.93	9.35	434.3
	44	P-46	3/16"	DI, 1.00-0.00D	8.4	20°-7°	+12.8	+1.52		7.93	9.45	379.0
	45	P-46	3/16"	PI @ 0.55D	8.0	13°				8.04	8.04	401.1
	46	P-46	3/16"	PI @ 0.45D	8.0	11°				8.05	8.05	372.7
	47	P-46	3/16"	DI, 1.00-0.00D	9.2	20°-8°	+12.1	+1.32		7.93	9.25	445.5
	48	P-46	3/16"	DI, 1.00-0.00D	9.3	19°-5°	+13.1	+1.41		7.93	9.34	453.1
	49	P-46	3/16"	PI @ 0.35D	8.1	8°				8.05	8.05	360.8
	50	P-46	3/16"	PI @ 0.25D	8.2	6°				8.05	8.05	376.7
	51	P-46	3/16"	DI, 1.00-0.00D	8.6	20°-7°	+12.8	+1.49		7.93	9.42	392.4
	52	P-46	3/16"	DI, 0.00-1.00D	8.8	0°-18°	-15.3	-1.74		7.93	6.19	306.5
	53	P-46	3/16"	PI @ 0.15D	8.0	5°				8.05	8.05	348.9
12:30 pm	54	P-46	3/16"	PI @ 0.05D	8.0	4°				8.05	8.05	365.7
2:00 pm	55	P-46	3/16"	Nozzle drainings	-	-				-	-	19.1
	56	P-46	3/16"	DI, 0.00-1.00D	9.0	0°-20°	-17.1	-1.90		7.93	6.03	334.8
	57	P-46	3/16"	DI, 0.00-1.00D	9.7	0°-19°	-16.2	-1.67		7.93	6.26	370.3
	58	P-46	3/16"	DI, 0.00-1.00D	9.4	0°-19°	-16.2	-1.72		7.93	6.21	390.8
	59	P-46	3/16"	DI, 0.00-1.00D	9.2	0°-18°	-15.3	-1.66		7.93	6.27	352.1
	60	D-43	1/8"	DI, 0.00-1.00-0.00D	12.1	0°-16°-10°	-6.2	-0.51		7.93	7.42	327.4
	61	D-43	1/8"	DI, 0.00-1.00-0.00D	13.5	0°-16°-10°	-6.2	-0.46		7.93	7.47	380.0
	62	D-43	1/8"	DI, 0.00-1.00-0.00D	13.0	0°-18°-10°	-6.2	-0.48		7.93	7.45	344.1
	63	D-43	1/8"	DI, 0.00-1.00-0.00D	13.1	0°-17°-10°	-6.2	-0.47		7.93	7.46	348.7
3:00 pm	64	D-43	1/8"	DI, 0.00-1.00-0.00D	13.0	0°-17°-10°	-6.2	-0.48		7.93	7.45	367.2
4:10 pm	65	P-46	3/16"	PI @ 0.95D	8.1	17°				7.18	7.18	306.1
	66	P-46	3/16"	PI @ 0.85D	8.6	15°				7.82	7.82	340.2
	67	P-46	3/16"	PI @ 0.65D	8.0	12°				8.03	8.03	177.1
	68	P-46	3/16"	PI @ 0.35D	8.0	8°				8.05	8.05	363.4
4:30 pm	69	P-46	3/16"	PI @ 0.05D	8.1	6°				8.05	8.05	359.5

*Angles not measured--these figures are the averages for similar integration on May 31.
**Angles not measured--these figures are based on comparison with May 30, 31, June 4.

TABLE V

DATA SHEETS

NOZZLE VELOCITY ft./sec.	INTAKE RATIO	SEDIMENT WEIGHT gm.	SEDIMENT CONC. ppm	CONCENTRATION-POINT SAMPLES CURVE ppm	CONCENTRATION-POINT SAMPLES CORRECT'N ppm	CONCENTRATION-POINT SAMPLES CORRECTED ppm	CONCEN-TRATION RATIO	SIZE DISTRIBUTION (1.0 0.5 .25 .125 .0625 .0442 .0312 .0221 .0156 .0110 mm.) ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
							MAY 30, 1947											
6.37	0.88	1.4517	5237						52	314	2776	1047	314	210	262	105	157	
6.83	0.89	1.787	5874															
7.55	0.96	1.593	4734															
7.00	0.86	1.3468	4381						88	394	1840	676	351	219	219	131	88	175
8.12	0.98	1.744	4705															
8.62	1.03	1.6649	4392						88	263	1845	790	439	132	220	132	483	
8.80	0.92	1.848	4600	4508	-05	4503	1.02											
9.65	1.00	2.0914	4985	4508	-17	4491	1.11		100	548	2243	847	349	150	199	100	449	
9.38	0.98	2.201	5019	4508	-29	4479	1.12											
8.20	0.98	1.652	4644															
7.79	0.94	1.4454	4273							43	2094	855	384	128	214	128	427	
6.34	0.77	1.207	4383															
7.53	0.93	-	-	Bottle	broken													
7.97	0.99	1.332	3895															
-	-	0.117	5571	4508	-102	4406	1.26											
9.23	0.95	1.759	4501	4508	-114	4394	1.02											
9.71	1.00	1.828	4336	4508	-126	4382	0.99											
6.59	1.04	1.384	4196	4508	-137	4371	0.96											
6.63	1.10	1.304	4646	4508	-149	4359	1.07											
6.69	1.08	1.3244	4347	4508	-160	4348	1.00		87	652	1782	739	261	130	130	87	479	
7.15	1.15	1.472	4412	4508	-172	4336	1.02											
6.45	1.02	1.287	4083	4508	-184	4324	0.94											
9.93	1.03	1.517	3516	4508	-196	4212	0.83											
(6.98)	(0.73)	1.278	4013	4508	-305	4203	0.95											
8.34	0.87	1.4703	3912	4508	-314	4194	0.93	39	39	313	1682	626	352	176	98	196	391	
9.47	0.99	1.786	3946	4508	-324	4184	0.94											
9.45	0.99	2.029	4657	4508	-333	4175	1.12											
7.62	0.83	0.852	3595	4508	-343	4165	0.86											
8.45	0.94	1.3046	4125	4508	-354	4154	0.99	41	81	619	1527	825	248	248	165	82	289	
9.36	1.06	1.628	4002	4508	-365	4143	0.97											
(6.34)	(0.71)	1.064	4122	4508	-376	4132	1.00											
8.54	0.95	1.360	4440	4508	-388	4120	1.08											
7.58	1.06	1.348	4368	4508	-413	4095	1.07											
5.82	0.72	0.932	3682															
8.14	0.98	1.348	3815															
9.43	1.14	1.540	3757															
8.12	1.03	1.664	4719															
5.29	0.73	1.363	5944															
							MAY 31, 1947											
6.21	0.86	1.259	4615															
7.77	0.99	1.6078	4705						94	329	2259	847	377	188	235	141	235	
7.90	0.99	1.584	4614															
8.07	1.00	1.4577	4265							85	2133	811	341	213	149	128	405	
8.90	0.95	2.044	4706	4172	-6	4166	1.13											
8.31	0.88	1.6948	4472	4172	0	4172	1.07			89	2281	894	313	224	134	179	358	
9.23	1.15	1.870	4662															
8.58	1.07	1.6304	4375							306	2144	744	394	219	131	175	262	
8.91	0.96	2.035	4568	4172	+18	4190	1.09											
8.97	0.96	1.789	3948	4172	+24	4196	0.94											
8.20	1.02	1.387	3844															
8.45	1.05	1.3932	3698					111	333	592	813	665	296	148	185	148	407	
8.40	0.89	1.765	4498	4172	+44	4216	1.07											
6.41	1.04	1.302	4248	4172	+50	4222	1.01											
8.03	1.00	1.306	3743															
8.42	1.05	1.1604	3173							63	1523	539	286	254	127	127	254	
-	-	0.148	7749															
6.85	1.14	1.331	3976	4172	+188	4360	0.91											
7.04	1.12	1.5361	4148	4172	+197	4369	0.95		166	290	1701	747	332	249	166	124	373	
7.66	1.23	1.671	4276	4172	+206	4378	0.98											
7.05	1.12	1.502	4266	4172	+214	4386	0.97											
11.23	1.51	1.251	3821	4172	+223	4395	0.87											
11.64	1.56	1.402	3689	4172	+232	4404	0.84											
10.98	1.47	-	-	Bottle	broken	-	-											
11.02	1.48	1.278	3665	4172	+248	4420	0.83											
11.69	1.57	1.351	3679	4172	+256	4428	0.83											
6.96	0.97	1.951	6374															
7.29	0.93	1.601	4706															
(4.07)	(0.51)	0.939	5302															
8.36	1.04	1.613	4439															
8.18	1.02	1.273	3541															

NOTE: Figure for the amount of sediment of smallest size includes all sediment within and less than that size.

Figures in parentheses considered to indicate erroneous samples - samples not used in Table I.

TABLE V (CONTINUED)

DATA SHEETS

HOUR	SAMPLE NO.	SAMPLER TYPE	NOZZLE SIZE	OPERATION	SAMPLING TIME secs.	SUSPENSION ANGLES degs.	DRIFT feet	VELOCITY CORRECTIONS DRIFT ft./sec.	VELOCITY CORRECTIONS TIME ft./sec.	STREAM VELOCITY ft./sec.	VELOCITY CORRECTED ft./sec.	SAMPLE WEIGHT gm.
				JUNE 1, 1947								
	Stream Depth 23.0 ft.			Discharge 49,900 sec. ft.							Water Temp. 66°F	
9:50 am	70	P-46	3/16"	PI @ 0.85D	7.9	19°						368.0
	71	P-46	3/16"	Cum 0.85D-30" delay	7.8	19°						361.5
	72	P-46	3/16"	Cum 0.85D-60" delay	7.6	19°						354.6
	73	P-46	3/16"	PI @ 0.85D	7.7	19°						343.6
	74	P-46	3/16"	PI @ 0.85D	8.0	19°						329.5
	75	P-46	3/16"	Cum 0.85D-120" delay	7.7	19°						351.8
	76	P-46	3/16"	Cum 0.85D-60" delay	8.0	19°						318.6
	77	P-46	3/16"	Cum 0.85D-30" delay	8.0	19°						327.0
	78	P-46	3/16"	PI @ 0.85D	8.0	19°						333.4
	79	P-46	3/16"	PI @ 0.85D	8.1	19°						366.6
	80	P-46	3/16"	PI @ 0.15D	8.0	6°						339.2
	81	P-46	3/16"	Cum 0.15D-30" delay	8.2	6°						353.2
	82	P-46	3/16"	Cum 0.15D-60" delay	7.9	6°						323.7
	83	P-46	3/16"	PI @ 0.15D	8.2	6°						327.0
	84	P-46	3/16"	PI @ 0.15D	8.0	6°						297.2
	85	P-46	3/16"	Cum 0.15D-120" delay	8.0	6°						319.6
	86	P-46	3/16"	Cum 0.15D-60" delay	8.0	6°						327.0
	87	P-46	3/16"	Cum 0.15D-30" delay	7.9	6°						346.0
	88	P-46	3/16"	PI @ 0.15D	8.0	6°						320.7
12:30 pm	89	P-46	3/16"	PI @ 0.15D	8.0	6°						313.2
				JUNE 2, 1947								
	Stream Depth 23.2 ft			Discharge 47,300 sec. ft.							Water Temp. 66°F	
	90	P-46	3/16"	PI @ 0.65D	8.0	14°				8.54	8.54	351.3
	91	P-46	3/16"	PI @ 0.55D	8.1	12°				8.54	8.54	367.2
	92	P-46	3/16"	PI @ 0.45D	7.9	10°				8.53	8.53	325.2
	93	P-46	3/16"	PI @ 0.35D	8.0	9°				8.50	8.50	354.1
	94	P-46	3/16"	PI @ 0.25D	9.1	6°				8.45	8.45	393.5
	95	P-46	3/16"	PI @ 0.15D	8.0	4°				8.40	8.40	357.9
10:30 am	96	P-46	3/16"	PI @ 0.05D	8.0	4°				8.34	8.34	352.8
	97	P-46	3/16"	DI, 0.60-0.00D	7.5	11°-7°	+3.9	+0.52		8.46	8.98	328.7
	98	P-46	3/16"	DI, 0.00-0.60D	7.5	0°-8°	-5.9	-0.79		8.46	7.67	328.0
	99	P-46	3/16"	DI, 0.60-0.00D	9.8	11°-7°	+3.9	+0.40		8.46	8.86	432.7
	100	P-46	3/16"	DI, 0.00-0.60D	7.8	0°-8°	-5.9	-0.76		8.46	7.70	311.6
	101	P-46	3/16"	DI, 0.60-0.00D	8.6	11°-7°	+3.9	+0.45		8.46	8.91	377.7
	102	P-46	3/16"	DI, 0.00-0.60D	7.6	0°-8°	-5.9	-0.78		8.46	7.68	292.7
	103	P-46	3/16"	DI, 0.60-0.00D	8.2	11°-7°	+3.9	+0.48		8.46	8.94	365.3
	104	P-46	3/16"	DI, 0.00-0.60D	7.4	0°-8°	-5.9	-0.80		8.46	7.66	265.1
	105	P-46	3/16"	DI, 0.60-0.00D	8.2	11°-7°	+3.9	+0.48		8.46	8.94	322.1
11:20 am	106	P-46	3/16"	DI, 0.00-0.60D	7.8	0°-9°	-6.7	-0.86		8.46	7.60	319.4
11:30 am	107	P-46S	1/8"	DI, 0.00-0.60D	12.2	0°-7°	-5.2	-0.43		8.46	8.03	254.1
	108	P-46S	1/8"	DI, 0.00-0.60D	16.0	0°-7°	-5.2	-0.32		8.46	8.14	319.7
	109	P-46S	1/8"	DI, 0.00-0.60D	17.9	0°-8°	-5.9	-0.33		8.46	8.13	354.8
	110	P-46S	1/8"	DI, 0.00-0.60D	17.9	0°-8°	-5.9	-0.33		8.46	8.13	351.4
	111	P-46S	1/8"	DI, 0.00-0.60D	17.1	0°-10°	-7.4	-0.43		8.46	8.03	372.2
	112	P-46S	3/16"	DI, 0.00-0.60D	8.4	0°-9°	-6.7	-0.80		8.46	7.66	343.2
	113	P-46S	3/16"	DI, 0.00-0.60D	8.5	0°-9°	-6.7	-0.79		8.46	7.67	371.0
	114	P-46S	3/16"	DI, 0.00-0.60D	8.0	0°-10°	-7.4	-0.93		8.46	7.53	328.8
	115	P-46S	3/16"	DI, 0.00-0.60D	9.2	0°-10°	-7.4	-0.80		8.46	7.66	360.3
	116	P-46S	3/16"	DI, 0.00-0.60D	8.3	0°-8°	-5.9	-0.71		8.46	7.75	343.2
	117	P-46S	3/16"	DI, 0.60-0.00D	7.0	11°-7°	+3.9	+0.56		8.46	9.02	322.2
	118	P-46S	3/16"	DI, 0.60-0.00D	8.9	11°-7°	+3.9	+0.44		8.46	8.90	389.0
	119	P-46S	3/16"	DI, 0.60-0.00D	7.5	9°-6°	+3.0	+0.40		8.46	8.86	367.8
	120	P-46S	3/16"	DI, 0.60-0.00D	8.4	10°-6°	+3.8	+0.45		8.46	8.91	387.9
	121	P-46S	3/16"	DI, 0.60-0.00D	8.0	10°-6°	+3.8	+0.48		8.46	8.94	349.2
	122	P-46S	1/8"	DI, 0.60-0.00D	13.9	10°-5°	+4.4	+0.32		8.46	8.78	283.0
	123	P-46S	1/8"	DI, 0.60-0.00D	14.5	10°-5°	+4.4	+0.30		8.46	8.76	243.4
	124	P-46S	1/8"	DI, 0.60-0.00D	15.3	10°-5°	+4.4	+0.29		8.46	8.75	264.3
	125	P-46S	1/8"	DI, 0.60-0.00D	17.6	10°-5°	+4.4	+0.25		8.46	8.71	315.4
1:30 pm	126	P-46S	1/8"	DI, 0.60-0.00D	16.4	10°-5°	+4.4	+0.27		8.46	8.73	346.6
2:15 pm	127	D-43	1/8"	DI, 0.00-0.60-0.00D	10.5	0°-16°-10°	-6.2	-0.59		8.46	7.87	272.3
	128	D-43	1/8"	DI, 0.00-0.60-0.00D	13.0	0°-16°-10°	-6.2	-0.48		8.46	7.98	399.5
	129	D-43	1/8"	DI, 0.00-0.60-0.00D	12.7	0°-15°-10°	-6.2	-0.49		8.46	7.97	278.4
2:35 pm	130	D-43	1/8"	DI, 0.00-0.60-0.00D	11.2	0°-16°-10°	-6.2	-0.55		8.46	7.91	266.2
	131	P-46	3/16"	PI @ 0.65D	8.2	12°				8.54	8.54	371.8
	132	P-46	3/16"	PI @ 0.45D	8.0	8°				8.53	8.53	348.2
	133	P-46	3/16"	PI @ 0.25D	8.0	4°				8.45	8.45	353.3
	134	P-46	3/16"	PI @ 0.05D	7.9	4°				8.34	8.34	352.8

TABLE V (CONTINUED)

DATA SHEETS

NOZZLE VELOCITY ft./sec.	INTAKE RATIO	SEDIMENT		CONCENTRATION-POINT SAMPLES			CONCEN-TRATION RATIO	SIZE DISTRIBUTION										
		WEIGHT gm.	CONC. ppm	CURVE ppm	CORRECT'N ppm	CORRECTED ppm		1.0	0.5	.25	.125	.0625	.0442	.0312	.0221	.0156	.0110 mm.	
								ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
JUNE 1, 1947																		
8.58		1.757	4774															
8.53		2.010	5560			4869	1.14											
8.60		2.092	5900			4869	1.21											
8.21		1.667	4852	Average of 5 Samples PI @ 0.85D				113	452	1131	2148	678	452	141	198	113	226	
7.59		1.8624	5652			4869	1.16											
8.42		1.997	5677			4869	1.17											
7.33		1.6412	5151			4869	1.06		51	567	2318	927	361	232	155	103	51	386
7.53		1.589	4859			4869	1.00											
7.68		1.538	4613															
8.34		1.633	4454															
7.81		1.343	3959															
7.94		1.342	3800			3835	0.99		80	120	1991	557	319	199	119	239	358	
7.55		1.2889	3982			3835	1.04		84	250	1960	667	375	167	125	125	417	
7.35		1.3635	4170			3835	1.09											
6.85		1.162	3910	Average of 5 Samples PI @ 0.15D														
7.36		1.447	4528			3835	1.18											
7.53		1.290	3945			3835	1.03											
8.06		1.519	4390			3835	1.14											
7.38		1.091	3402															
7.22		1.170	3736															
JUNE 2, 1947																		
8.08	0.95	1.8168	5172						103	569	2276	1034	466	259	155	103	207	
8.36	0.98	1.880	5114							212	1997	935	297	212	128	170	297	
7.59	0.89	1.3813	4248															
8.16	0.96	1.297	3663					44	87	480	1569	959	392	174	174	218	262	
7.95	0.94	1.7152	4359															
8.23	0.98	1.407	3931															
8.12	0.97	1.1606	3290					33	33	362	954	822	230	296	99	99	362	
8.07	0.90	1.179	3587	4107	-72	4035	0.89											
8.05	1.05	1.299	3960	4107	-92	4015	0.99											
8.14	0.92	1.737	4014	4107	-112	3995	1.00											
7.35	0.95	1.101	3533	4107	-132	3975	0.89											
8.09	0.91	1.5428	4085	4107	-152	3955	1.03	41	122	572	1307	940	327	204	163	123	286	
7.09	0.92	1.0124	3459	4107	-172	3935	0.88		69	242	1176	796	311	207	104	104	450	
8.20	0.92	1.352	3701	4107	-192	3915	0.95											
6.59	0.86	0.977	3685	4107	-212	3895	0.95											
7.24	0.81	1.413	4387	4107	-235	3872	1.13											
7.53	0.99	1.229	3848	4107	-257	3850	1.00											
8.62	1.07	0.897	3530	4107	-317	3790	0.93											
8.29	1.02	1.196	3741	4107	-337	3770	0.99		99	264	1123	727	330	198	132	99	331	
8.20	1.01	1.1719	3303	4107	-357	3750	0.88											
8.12	1.00	1.269	3611	4107	-377	3730	0.97											
9.03	1.12	1.367	3673	4107	-397	3710	0.99											
7.53	0.98	1.198	3491	4107	-417	3690	0.95											
8.03	1.05	1.306	3520	4107	-437	3670	0.96			114	910	740	284	228	142	114	313	
7.57	1.01	0.9353	2845	4107	-459	3648	0.78											
7.22	0.94	1.351	3750	4107	-483	3624	1.03											
7.61	0.98	1.167	3400	4107	-502	3605	0.94											
8.47	0.94	1.081	3355	4107	-607	3500	0.96											
8.05	0.90	1.298	3337	4107	-627	3480	0.96											
9.02	1.02	-	-	Bottle	broken	-	-											
8.51	0.96	1.184	3052	4107	-672	3435	0.89											
8.03	0.90	1.172	3356	4107	-692	3415	0.98											
8.41	0.96	0.980	3463	4107	-712	3395	1.02											
6.96	0.79	0.911	3743	4107	-732	3375	1.11		60	418	1313	478	269	149	119	89	89	
7.17	0.82	0.7886	2984	4107	-757	3350	0.89											
7.42	0.85	1.040	3297	4107	-777	3330	0.99											
8.74	1.00	1.089	3142	4107	-797	3310	0.95											
10.73	1.36	0.749	2751	4107	-1007	3100	0.89											
(12.72)	(1.59)	1.309	3277	4107	-1029	3078	1.06	29	58	378	814	611	204	247	73	203	291	
9.07	1.14	0.8096	2908	4107	-1051	3056	0.95											
9.86	1.25	0.726	2727	4107	-1073	3034	0.90											
8.34	0.98	1.405	3779															
8.01	0.94	1.177	3380															
8.14	0.96	1.088	3080															
8.23	0.99	0.732	2075															

Figures in parentheses considered to indicate erroneous samples - samples not used in Table I.

TABLE V (CONTINUED)

DATA SHEETS

HOUR	SAMPLE NO.	SAMPLER TYPE	NOZZLE SIZE	OPERATION	SAMPLING TIME secs.	SUSPENSION ANGLES degs.	DRIFT feet	VELOCITY CORRECTIONS DRIFT ft./sec.	VELOCITY CORRECTIONS TIME ft./sec.	STREAM VELOCITY ft./sec.	VELOCITY CORRECTED ft./sec.	SAMPLE WEIGHT gm.
JUNE 3, 1947												
Stream Depth 23.7 ft.				Discharge 45,700 sec. ft								Water Temp. 67°F
10:10 am	135	P-46	3/16"	PI @ 0.95D	8.2	15°			+0.03	6.42	6.45	282.5
	136	P-46	3/16"	PI @ 0.85D	8.0	13°			+0.04	6.75	6.79	279.9
	137	P-46	3/16"	PI @ 0.75D	8.1	13°			+0.06	6.97	7.03	302.7
	138	P-46	3/16"	PI @ 0.65D	10.0	11°			+0.07	7.14	7.21	380.4
	139	P-46	3/16"	PI @ 0.55D	9.9	10°			+0.09	7.27	7.36	383.8
	140	P-46	3/16"	PI @ 0.45D	10.1	7°			+0.10	7.37	7.47	426.5
	141	P-46	3/16"	PI @ 0.35D	9.8	6°			+0.12	7.46	7.58	361.9
	142	P-46	3/16"	PI @ 0.25D	9.9	5°			+0.13	7.53	7.66	435.3
	143	P-46	3/16"	PI @ 0.15D	9.8	5°			+0.15	7.59	7.74	405.6
	144	P-46	3/16"	PI @ 0.05D	9.6	5°			+0.17	7.62	7.79	415.6
11:00 am	145	P-46	3/16"	DI, 0.50-1.00D	8.8	10°-14°	-4.4	-0.50	+0.18	6.90	6.58	317.1
	146	P-46	3/16"	DI, 0.50-1.00D	9.3	10°-14°	-4.4	-0.47	+0.20	6.90	6.63	355.5
	147	P-46	3/16"	DI, 1.00-0.50D	10.5	15°-11°	+4.7	+0.45	+0.21	6.90	7.56	342.6
	148	P-46	3/16"	DI, 1.00-0.50D	9.6	15°-11°	+4.7	+0.49	+0.23	6.90	7.62	408.5
	149	P-46	3/16"	DI, 0.50-0.00D	9.0	10°-6°	+3.6	+0.40	+0.24	7.51	8.15	298.5
	150	P-46	3/16"	DI, 0.00-0.50D	9.0	0°-8°	-5.9	-0.66	+0.25	7.51	7.10	343.1
	151	P-46	3/16"	DI, 0.00-0.50D	7.5	0°-8°	-5.9	-0.79	+0.27	7.51	6.99	287.5
	152	P-46	3/16"	DI, 0.50-0.00D	9.4	10°-6°	+3.6	+0.38	+0.28	7.51	8.17	421.5
	153	P-46	3/16"	DI, 1.00-0.00D	9.7	15°-7°	+8.4	+0.87	+0.30	7.21	8.38	376.2
	154	P-46	3/16"	DI, 0.00-1.00D	9.9	0°-13°	-11.0	-1.11	+0.31	7.21	6.41	364.5
	155	P-46	3/16"	DI, 0.50-1.00-0.50D	9.7	10°-13°-11°	-0.8	-0.08	+0.32	6.90	7.14	324.0
	156	P-46	3/16"	DI, 0.00-0.50-0.00D	10.6	0°-8°-6°	-3.8	-0.36	+0.34	7.51	7.49	442.1
	157	P-46	3/16"	DI, 1.00-0.50-1.00D	10.8	15°-11°-14°	+0.9	+0.08	+0.35	6.90	7.33	420.2
12:05 pm	158	P-46	3/16"	DI, 0.50-0.00-0.50D	10.4	10°-3°-8°	+1.5	+0.16	+0.36	7.51	8.03	421.9
	159	P-46	3/16"	DI, 0.67-1.00D	6.8	13°-13°	-0.9	-0.13	+0.38	6.74	6.99	218.2
	160	P-46	3/16"	DI, 0.67-1.00D	10.1	13°-13°	-0.9	-0.09	+0.39	6.74	7.04	390.7
	161	P-46	3/16"	DI, 1.00-0.67D	8.4	14°-13°	+1.8	+0.21	+0.40	6.74	7.35	324.2
	162	P-46	3/16"	DI, 1.00-0.67D	9.0	14°-13°	+1.8	+0.20	+0.42	6.74	7.36	406.5
	163	P-46	3/16"	DI, 0.33-0.67D	8.4	9°-12°	-3.0	-0.36	+0.43	7.31	7.38	364.1
	164	P-46	3/16"	DI, 0.33-0.67D	7.9	9°-12°	-3.0	-0.38	+0.44	7.31	7.37	333.5
	165	P-46	3/16"	DI, 0.67-0.33D	8.1	13°-10°	+3.1	+0.38	+0.46	7.31	8.15	350.2
	166	P-46	3/16"	DI, 0.67-0.33D	9.0	13°-10°	+3.1	+0.34	+0.47	7.31	8.12	399.3
	167	P-46	3/16"	DI, 0.33-0.00D	8.8	8°-6°	+1.8	+0.20	+0.48	7.57	8.25	380.6
	168	P-46	3/16"	DI, 0.00-0.33D	8.2	0°-7°	-4.9	-0.60	+0.50	7.57	7.47	333.0
	169	P-46	3/16"	DI, 0.00-0.33D	9.4	0°-7°	-4.9	-0.52	+0.51	7.57	7.56	372.6
1:00 pm	170	P-46	3/16"	DI, 0.33-0.00D	8.4	8°-5°	+2.5	+0.30	+0.52	7.57	8.39	346.3
1:30 pm	171	P-46	3/16"	DI, 1.00-0.67-1.00D	9.2	14°-13°-13°	+0.9	+0.10	+0.62	6.74	7.46	426.5
	172	P-46	3/16"	DI, 0.67-1.00-0.67D	7.6	13°-13°-13°	0.0	0.00	+0.63	6.74	7.37	320.6
	173	P-46	3/16"	DI, 0.67-0.33-0.67D	9.6	13°-10°-13°	0.0	0.00	+0.64	7.31	7.95	402.2
	174	P-46	3/16"	DI, 0.33-0.67-0.33D	8.3	8°-12°-9°	-0.7	-0.08	+0.66	7.31	7.89	344.3
	175	P-46	3/16"	DI, 0.33-0.00-0.33D	8.1	8°-5°-8°	0.0	0.00	+0.67	7.57	8.24	357.6
	176	P-46	3/16"	DI, 0.00-0.33-0.00D	8.2	0°-7°-5°	-3.1	-0.38	+0.69	7.57	7.88	352.9
	177	P-46	3/16"	PI @ 0.95D	9.0	17°			+0.70	6.42	7.12	299.3
	178	P-46	3/16"	PI @ 0.85D	9.0	15°			+0.72	6.75	7.47	392.5
	179	P-46	3/16"	PI @ 0.65D	9.0	15°			+0.73	7.14	7.87	360.8
	180	P 46	3/16"	PI @ 0.45D	9.0	10°			+0.75	7.37	8.12	441.6
	181	P-46	3/16"	PI @ 0.25D	9.0	6°			+0.76	7.53	8.29	382.1
2:25 pm	182	P-46	3/16"	PI @ 0.05D	9.1	5°			+0.77	7.62	8.39	403.3
JUNE 4, 1947												
Stream Depth 22.3 ft (26.0 @ 3:30 pm)				Discharge 44,600 sec. ft.								Water Temp. 65°F
9:50 am	183	D-43	1/8"	DI, 0.00-1.00-0.00D	12.5	0°-19°-10°	-6.3	-0.50		7.94	7.44	342.4
	184	D-43	1/8"	DI, 0.00-1.00-0.00D	14.3	0°-19°-10°	-6.3	-0.44		7.94	7.50	361.8
	185	D-43	1/8"	DI, 0.00-1.00-0.00D	13.0	0°-19°-10°	-6.3	-0.48		7.94	7.46	355.1
	186	D-43	1/8"	DI, 0.00-1.00-0.00D	13.0	0°-19°-10°	-6.3	-0.48		7.94	7.46	348.9
	187	D-43	1/8"	DI, 0.00-1.00-0.00D	13.0	0°-19°-10°	-6.3	-0.48		7.94	7.46	343.2
10:10 am	188	P-46	3/16"	PI @ 0.95D	9.0	16°				7.36	7.36	272.8
	189	P-46	3/16"	PI @ 0.85D	9.0	16°				7.81	7.81	385.4
	190	P-46	3/16"	PI @ 0.75D	9.0	14°				8.00	8.00	356.2
	191	P-46	3/16"	PI @ 0.65D	9.1	14°				8.07	8.07	438.7
	192	P-46	3/16"	PI @ 0.55D	9.0	12°				8.09	8.09	402.9
	193	P-46	3/16"	PI @ 0.45D	9.0	10°				8.08	8.08	374.1
	194	P-46	3/16"	PI @ 0.35D	9.0	8°				8.07	8.07	379.0
	195	P-46	3/16"	PI @ 0.25D	9.0	7°				8.03	8.03	418.6
	196	P-46	3/16"	PI @ 0.15D	8.6	4°				8.00	8.00	396.4
	197	P-46	3/16"	PI @ 0.05D	8.5	3°				7.97	7.97	378.0
	198	P-46	3/16"	DI, 1.00-0.00D	7.4	18°-6°	+11.5	+1.55		7.94	9.49	374.3
	199	P-46	3/16"	DI, 0.00-1.00D	10.0	0°-17°	-14.3	-1.43		7.94	6.51	345.0
	200	P-46	3/16"	DI, 0.50-1.00D	7.6	10°-18°	-7.9	-1.04		7.86	6.82	299.1

TABLE V (CONTINUED)

DATA SHEET

NOZZLE VELOCITY ft./sec.	INTAKE RATIO	SEDIMENT		CONCENTRATION-POINT SAMPLES			CONCEN-TRATION RATIO	SIZE DISTRIBUTION										
		WEIGHT gm.	CONC. ppm	CURVE ppm	CORRECT'N ppm	CORRECTED ppm		1.0 0.5 .25 .125 .0625 .0442 .0312 .0221 .0156 .0110 mm.										
								ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
JUNE 3, 1947																		
6.35	0.98	1.2976	4593						92	827	1699	1010	253	115	184	138	275	
6.44	0.95	1.255	4484															
6.89	0.98	1.1724	3873							78	2130	697	271	77	194	116	310	
7.00	0.97	1.624	4269															
7.14	0.97	1.4758	3845					19	58	365	1596	808	269	77	211	154	288	
7.77	1.04	1.603	3758															
6.79	0.90	1.3962	3858					39	77	501	1504	791	251	116	193	135	251	
8.10	1.06	2.054	4719															
7.62	0.98	1.1845	2920							29	1197	730	350	73	190	88	88	175
7.97	1.02	1.359	3270															
6.63	1.01	1.519	4790	4298	-30	4268	1.12											
7.03	1.06	1.653	4650	4298	-35	4263	1.09											
6.00	0.79	1.884	5499	4298	-39	4259	1.29											
7.84	1.03	1.993	4879	4298	-44	4254	1.15											
6.11	0.75	1.142	3826	3376	-48	3328	1.15											
7.02	0.99	1.179	3436	3376	-53	3323	1.03											
7.05	1.01	0.954	3318	3376	-58	3318	1.00											
8.25	1.01	1.421	3371	3376	-62	3314	1.02											
7.14	0.85	1.898	5045	3815	-67	3748	1.35											
6.78	1.06	1.494	4099	3815	-71	3744	1.09											
6.15	0.86	1.4178	4376	4298	-76	4222	1.04			416	2079	875	350	131	153	153	219	
7.68	1.03	1.4252	3224	3376	-81	3295	0.98	32	97	419	1161	580	194	226	97	64	354	
7.16	0.98	1.990	4736	4298	-85	4213	1.12											
7.48	0.93	1.730	4100	3376	-90	3286	1.25											
5.91	0.85	1.202	5509	4457	-95	4362	1.26											
7.13	1.01	1.672	4280	4457	-100	4357	0.98											
7.11	0.97	1.458	4497	4457	-105	4352	1.03											
8.32	1.13	1.649	4057	4457	-110	4347	0.93											
7.97	1.08	1.373	3771	3844	-115	3729	1.01											
7.77	1.05	1.222	3664	3844	-120	3724	0.98											
7.95	0.98	1.520	4340	3844	-125	3719	1.17											
8.18	1.01	1.434	3591	3844	-130	3714	0.97											
7.95	0.96	1.093	2872	3220	-135	3085	0.93											
7.48	1.00	1.139	3420	3220	-140	3080	1.11											
7.29	0.96	1.083	2907	3220	-145	3075	0.95											
7.59	0.90	1.137	3283	3220	-150	3070	1.07											
8.54	1.14	1.933	4532	4457	-186	4271	1.06											
7.77	1.05	1.3425	4187	4457	-190	4267	0.98		42	126	2260	837	293	126	126	126	251	
7.71	0.97	1.504	3739	3844	-195	3649	1.02											
7.64	0.97	1.3168	3825	3844	-200	3644	1.05	38	57	708	1568	650	306	77	153	77	191	
8.12	0.99	1.171	3275	3220	-205	3015	1.08											
7.92	1.01	1.1008	3119	3220	-210	3010	1.04			62	1809	593	218	94	187	156		
6.13	0.86	3.056	10210															
8.03	1.07	1.655	4217															
7.38	0.94	1.433	3972															
9.04	1.11	1.499	3394															
7.83	0.94	1.301	3405															
8.16	0.97	1.031	2556															
JUNE 4, 1947																		
11.35	1.53	1.258	3674	4077	0	4077	0.90											
10.48	1.40	1.203	3325	4077	0	4077	0.82											
11.31	1.52	1.2748	3590	4077	0	4077	0.88		72	754	1149	718	179	126	197	72	323	
11.11	1.49	1.097	3144	4077	0	4077	0.77											
10.94	1.47	1.121	3266	4077	0	4077	0.80											
5.58	0.76	2.7162	9957						100	398	7368	1095	249	249	100	398		
7.88	1.01	2.046	5309															
7.29	0.91	1.5599	4379					44	175	832	1752	657	219	88	175	131	306	
8.87	1.10	1.728	3939															
8.25	1.02	1.6737	4154						42	208	2118	789	291	125	166	83	332	
7.66	0.95	1.463	3911															
7.75	0.96	1.4948	3944							434	1696	789	355	197	79	394		
8.56	1.07	1.345	3213															
8.49	1.06	1.4053	3545						71	390	1454	638	319	106	106	142	319	
8.19	1.03	1.177	3114															
9.32	0.98	1.482	3959	4077	0	4077	0.97											
6.35	0.98	1.245	3609	4077	0	4077	0.89											
7.25	1.06	1.260	4213	4644	0	4644	0.91											

TABLE V (CONTINUED)

DATA SHEETS

HOUR	SAMPLE NO.	SAMPLER TYPE	NOZZLE SIZE	OPERATION	SAMPLING TIME secs.	SUSPENSION ANGLES degs.	DRIFT feet	VELOCITY CORRECTIONS DRIFT ft./sec.	VELOCITY CORRECTIONS TIME ft./sec.	STREAM VELOCITY ft./sec.	VELOCITY CORRECTED ft./sec.	SAMPLE WEIGHT gm.
						JUNE 4 (CONT.)						
	201	P-46	3/16"	DI, 1.00-0.50D	7.6	18°-11°	+7.1	+0.93		7.86	8.79	358.6
	202	P-46	3/16"	DI, 0.50-0.00D	8.8	10°-5°	+4.2	+0.48		8.03	8.51	385.7
	203	P-46	3/16"	DI, 0.00-0.50D	8.4	0°-9°	-6.6	-0.79		8.03	7.24	358.0
12:00 m	204	P-46S	1/8"	DI, 1.00-0.00D	18.6	18°-4°	+12.7	+0.68		7.94	8.62	399.1
	205	P-46S	1/8"	DI, 1.00-0.00D	18.6	18°-4°	+12.7	+0.68		7.94	8.62	363.8
	206	P-46S	1/8"	DI, 1.00-0.00D	20.2	18°-4°	+12.7	+0.63		7.94	8.57	343.3
	207	P-46S	1/8"	DI, 1.00-0.00D	20.4	18°-4°	+12.7	+0.62		7.94	8.56	356.8
	208	P-46S	1/8"	DI, 1.00-0.00D	18.0	18°-4°	+12.7	+0.71		7.94	8.65	402.1
	209	P-46S	3/16"	DI, 1.00-0.00D	9.0	18°-6°	+11.5	+1.28		7.94	9.22	449.7
	210	P-46S	3/16"	DI, 1.00-0.00D	8.1	18°-6°	+11.5	+1.42		7.94	9.36	388.7
	211	P-46S	3/16"	DI, 1.00-0.00D	9.0	18°-6°	+11.5	+1.28		7.94	9.22	453.2
	212	P-46S	3/16"	DI, 1.00-0.00D	8.4	18°-6°	+11.5	+1.37		7.94	9.31	415.2
1:00 pm	213	P-46S	3/16"	DI, 1.00-0.00D	8.7	18°-6°	+11.5	+1.32		7.94	9.26	389.6
	214	P-46S	3/16"	DI, 0.00-1.00-0.00D	overtime					7.94		455.5
	215	P-46S	3/16"	DI, 0.00-1.00-0.00D	overtime					7.94		431.6
	216	P-46S	3/16"	DI, 0.00-1.00-0.00D	overtime					7.94		452.2
	217	P-46S	3/16"	DI, 0.00-1.00-0.00D	overtime					7.94		443.8
1:30 pm	218	P-46S	3/16"	DI, 0.00-1.00-0.00D	overtime					7.94		446.2
3:30 pm	219	P-46	3/16"	PI @ 0.95D	9.0					5.55	5.55	242.0
	220	P-46	3/16"	PI @ 0.75D	9.0					6.62	6.62	294.2
	221	P-46	3/16"	PI @ 0.55D	9.0					7.09	7.09	296.9
	222	P-46	3/16"	PI @ 0.35D	9.1					7.32	7.32	348.8
4:00 pm	223	P 46	3/16"	PI @ 0.15D	9.0					7.42	7.42	368.8
						JUNE 6, 1947						
	Stream Depth 23.0 ft.				Discharge 46,100 sec. ft.							Water Temp. 67°F
10:30 am	224	P-46	3/16"	PI @ 0.95D	8.2	16°			+0.05	7.00	7.05	256.7
	225	P-46	3/16"	PI @ 0.85D	9.0	13°			+0.06	7.37	7.43	383.1
	226	P-46	3/16"	PI @ 0.75D	8.5	11°			+0.07	7.53	7.60	302.0
	227	P-46	3/16"	PI @ 0.65D	9.1	12°			+0.09	7.62	7.71	384.9
	228	P-46	3/16"	PI @ 0.55D	9.0	8°			+0.10	7.65	7.75	311.8
	229	P-46	3/16"	PI @ 0.45D	-	7°			+0.11	7.65	7.76	260.8
	230	P-46	3/16"	PI @ 0.35D	9.0	6°			+0.12	7.64	7.76	339.3
	231	P-46	3/16"	PI @ 0.25D	9.0	5°			+0.13	7.61	7.74	353.4
	232	P-46	3/16"	PI @ 0.15D	9.0	4°			+0.14	7.57	7.71	357.0
	233	P-46	3/16"	PI @ 0.05D	9.1	4°			+0.15	7.51	7.66	376.5
	234	P-46	3/16"	DI, 0.00-1.00D	9.0	0°-16°	-13.5	-1.50	+0.17	7.51	6.18	333.8
	235	P-46	3/16"	DI, 1.00-0.00D	7.9	16°-7°	+9.1	+1.15	+0.18	7.51	8.84	354.0
	236	P-46	3/16"	DI, 0.50-1.00D	9.0	8°-16°	-7.7	-0.86	+0.19	7.43	6.76	388.4
	237	P-46	3/16"	DI, 1.00-0.50D	9.3	16°-10°	+6.2	+0.67	+0.20	7.43	8.30	322.8
	238	P-46	3/16"	DI, 0.50-0.00D	7.5	8°-5°	+2.7	+0.36	+0.22	7.59	8.17	211.1
12:00 m	239	P-46	3/16"	DI, 0.00-0.50D	8.0	0°-8°	-5.8	-0.72	+0.23	7.59	7.10	(463.7)
2:00 pm	240	P-46S	3/16"	DI, 1.00-0.00D	10.2	18°-7°	+10.8	+1.06	+0.50	7.51	9.07	453.3
	241	P-46S	3/16"	DI, 1.00-0.00D	7.7	18°-7°	+10.8	+1.40	+0.51	7.51	9.42	362.2
	242	P-46S	3/16"	DI, 1.00-0.00D	8.5	18°-7°	+10.8	+1.27	+0.52	7.51	9.30	369.8
	243	P-46S	3/16"	DI, 1.00-0.00D	9.5	18°-7°	+10.8	+1.14	+0.53	7.51	9.18	449.1
	244	P-46S	3/16"	DI, 1.00-0.00D	8.7	18°-7°	+10.8	+1.24	+0.54	7.51	9.29	384.2
	245	P-46S	1/8"	DI, 1.00-0.00D	16.4	18°-5°	+12.1	+0.74	+0.54	7.51	8.79	344.7
	246	P-46S	1/8"	DI, 1.00-0.00D	18.0	18°-5°	+12.1	+0.67	+0.55	7.51	8.73	208.6
	247	P-46S	1/8"	DI, 1.00-0.00D	17.6	18°-5°	+12.1	+0.69	+0.56	7.51	8.76	386.3
	248	P-46S	1/8"	DI, 1.00-0.00D	18.8	18°-5°	+12.1	+0.64	+0.57	7.51	8.72	290.3
2:45 pm	249	P-46S	1/8"	DI, 1.00-0.00D	18.2	18°-5°	+12.1	-0.66	+0.58	7.51	8.75	341.4
3:00 pm	250	P-46S	1/8"	DI, 0.00-1.00D	17.5	0°-17°	-14.4	-0.82	+0.63	7.51	7.32	313.9
	251	P-46S	1/8"	DI, 0.00-1.00D	20.2	0°-16°	-13.5	-0.67	+0.64	7.51	7.48	442.5
	252	P-46S	1/8"	DI, 0.00-1.00D	18.0	0°-17°	-14.4	-0.80	+0.65	7.51	7.36	363.9
	253	P-46S	1/8"	DI, 0.00-1.00D	17.4	0°-17°	-14.4	-0.83	+0.66	7.51	7.34	365.9
	254	P-46S	1/8"	DI, 0.00-1.00D	18.1	0°-17°	-14.4	-0.80	+0.67	7.51	7.38	350.2
	255	P-46S	3/16"	DI, 0.00-1.00D	10.0	0°-17°	-14.4	-1.44	+0.68	7.51	6.75	345.4
	256	P-46S	3/16"	DI, 0.00-1.00D	9.0	0°-17°	-14.4	-1.60	+0.69	7.51	6.60	350.4
	257	P-46S	3/16"	DI, 0.00-1.00D	10.0	0°-17°	-14.4	-1.44	+0.70	7.51	6.77	362.3
	258	P-46S	3/16"	DI, 0.00-1.00D	10.0	0°-17°	-14.4	-1.44	+0.72	7.51	6.79	317.8
3:45 pm	259	P-46S	3/16"	DI, 0.00-1.00D	10.2	0°-17°	-14.4	-1.41	+0.73	7.51	6.83	340.5
	260	P-46	3/16"	PI @ 0.95D	9.0	18°			+0.74	7.00	7.74	352.7
	261	P-46	3/16"	PI @ 0.75D	8.9	15°			+0.75	7.53	8.28	419.4
	262	P-46	3/16"	PI @ 0.55D	8.6	11°			+0.76	7.65	8.41	342.5
	263	P-46	3/16"	PI @ 0.35D	8.5	7°			+0.77	7.64	8.41	385.3
4:10 pm	264	P-46	3/16"	PI @ 0.15D	9.0	4°			+0.78	7.57	8.35	257.9

Figures in parentheses considered to indicate erroneous samples - samples not used in Table I

TABLE V (CONTINUED)

DATA SHEETS

NOZZLE VELOCITY ft./sec.	INTAKE RATIO	SEDIMENT		CONCENTRATION-POINT SAMPLES			CONCEN-TRATION RATIO	SIZE DISTRIBUTION										
		WEIGHT gm.	CONC. ppm	CURVE ppm	CORRECT'N ppm	CORRECTED ppm		1.0 ppm	0.5 ppm	.25 ppm	.125 ppm	.0625 ppm	.0442 ppm	.0312 ppm	.0221 ppm	.0156 ppm	.0110 mm. ppm	ppm
JUNE 4 (CONTINUED)																		
8.69	0.99	1.750	4880	4644	0	4644	1.05											
8.06	0.95	1.320	3422	3517	0	3517	0.97											
7.84	1.08	1.101	3075	3517	0	3517	0.87											
8.91	1.03	1.437	3601	4077	0	4077	0.88											
8.12	0.94	1.3376	3677	4077	0	4077	0.90	37	110	331	1544	662	221	221	147	55	349	
7.04	0.82	1.295	3772	4077	0	4077	0.93											
7.25	0.85	1.368	3834	4077	0	4077	0.94											
9.24	1.07	1.579	3927	4077	0	4077	0.96											
9.21	1.00	1.641	3649	4077	0	4077	0.90											
8.84	0.94	1.399	3599	4077	0	4077	0.88											
9.28	1.01	1.693	3736	4077	0	4077	0.92											
9.10	0.98	1.6232	3909	4077	0	4077	0.96	39	78	899	1173	665	274	117	117	39	508	
8.25	0.89	1.488	3819	4077	0	4077	0.94											
		1.855	4072	4077	0	4077	1.00											
		2.003	4641	4077	0	4077	1.14											
		2.475	5473	4077	0	4077	1.34											
		2.430	5475	4077	0	4077	1.34											
		2.380	5334	4077	0	4077	1.31											
4.95	0.89	1.482	6124															
6.02	0.91	1.555	5286															
6.08	0.86	1.383	4658															
7.05	0.96	1.245	3569															
7.55	1.02	1.245	3376															
JUNE 6, 1947																		
5.76	0.82	1.5557	6060							606	3576	727	242	182	242	121	364	
7.84	1.06	1.845	4816															
6.54	0.86	1.4577	4827						96	531	2076	869	386	145	241	145	338	
7.79	1.01	1.738	4515															
6.37	0.82	1.4130	4532					45	91	499	1812	816	362	227	45	182	453	
..	-	1.117	4283															
6.94	0.89	1.1529	3398						34	68	1699	475	374	68	170	51	459	
7.24	0.94	1.283	3630															
7.31	0.95	1.1997	3361						67	605	1344	370	286	151	168	67	303	
7.62	0.99	1.274	3384															
6.83	1.15	1.409	4221	4233	-63	4170	1.01											
8.25	0.93	1.459	4121	4233	-71	4162	0.99											
7.95	1.18	1.652	4253	4862	-80	4782	0.89											
6.39	0.77	1.614	5000	4862	-89	4773	1.05											
(5.17)	(0.63)	0.715	3387	3617	-98	3519	0.96											
(10.53)	(1.48)	2.092	(4512)	3617	-107	3510	(1.29)											
8.18	0.90	1.621	3576	4233	-340	3893	0.92											
8.65	0.92	1.498	4136	4233	-348	3885	1.06											
8.01	0.86	1.7570	4751	4233	-356	3877	1.23		95	523	2399	641	237	95	143	95	523	
8.71	0.95	1.871	4166	4233	-364	3869	1.08											
8.14	0.88	1.495	3891	4233	-372	3861	1.01											
8.70	0.99	1.307	3792	4233	-380	3853	0.98											
(4.81)	(0.55)	0.892	(4276)	4233	-388	3845	(1.11)											
9.12	1.04	1.4163	3666	4233	-397	3836	0.96		37	623	1136	660	183	257	110	110	550	
(6.38)	(0.73)	1.052	3624	4233	-405	3828	0.95											
7.79	0.89	1.335	3910	4233	-413	3820	1.02											
7.42	1.01	1.230	3918	4233	-448	3785	1.04											
9.07	1.21	1.866	4217	4233	-455	3778	1.12											
8.37	1.14	1.3898	3819	4233	-463	3770	1.01	76	153	917	1069	496	229	153	153	115	458	
8.70	1.19	1.334	3646	4233	-471	3762	0.97											
8.00	1.08	1.324	3781	4233	-479	3754	1.01											
6.35	0.94	1.142	3306	4233	-486	3747	0.88											
7.16	1.08	1.326	3784	4233	-494	3739	1.01											
6.67	0.98	1.4283	3942	4233	-502	3731	1.06	118	79	1184	828	630	158	197	118	118	512	
5.86	0.86	1.307	4113	4233	-510	3723	1.10											
6.15	0.90	1.304	3830	4233	-517	3716	1.03											
7.22	0.93	1.492	4230															
8.67	1.05	1.735	4137															
7.33	0.87	1.377	4020															
8.34	0.99	1.353	3512															
5.28	0.63	0.747	2896															

Figures in parentheses considered to indicate erroneous samples - samples not used in Table I.

TABLE V (CONTINUED)

DATA SHEETS

HOUR	SAMPLE NO.	SAMPLER TYPE	NOZZLE SIZE	OPERATION	SAMPLING TIME secs.	SUSPENSION ANGLES degs.	DRIFT feet	VELOCITY CORRECTIONS DRIFT ft./sec.	VELOCITY CORRECTIONS TIME ft./sec.	STREAM VELOCITY ft./sec.	VELOCITY CORRECTED ft./sec.	SAMPLE WEIGHT gm.
				JUNE 7, 1947								
Stream Depth 24.8 ft.				Discharge 49,800 sec. ft.								Water Temp. 68°F
10:00 am	265	P-46	3/16"	PI @ 0.92D	9.9	17°						312.7
	266	P-46	3/16"	PI @ 0.92D	10.0	18°						319.5
	267	P-46	3/16"	PI @ 0.92D	9.8	17°						338.4
	268	P 46	3/16"	Cum 0.92D-30" delay	7.8	18°						237.6
	269	P-46	3/16"	Cum 0.92D-60" delay	5.4	18°						192.7
	270	P-46	3/16"	Cum 0.92D-120" delay	9.8	19°						416.9
	271	P-46	3/16"	Cum 0.92D-120" delay	6.2	18°						310.4
	272	P-46	3/16"	Cum 0.92D-60" delay	9.2	18°						314.5
	273	P-46	3/16"	Cum 0.92D-30" delay	8.2	17°						368.7
	274	P-46	3/16"	PI @ 0.92D	9.2	17°						355.0
	275	P-46	3/16"	PI @ 0.92D	9.0	17°						341.9
	276	P-46	3/16"	PI @ 0.80D	8.8	15°						355.5
	277	P-46	3/16"	PI @ 0.80D	9.0	15°						302.5
	278	P-46	3/16"	Cum 0.80D-30" delay	9.0	16°						402.3
	279	P-46	3/16"	Cum 0.80D-60" delay	8.0	16°						330.1
	280	P-46	3/16"	Cum 0.80D-120" delay	8.0	16°						170.1
	281	P-46	3/16"	Cum 0.80D-120" delay	9.2	16°						429.3
	282	P-46	3/16"	Cum 0.80D-60" delay	7.8	16°						332.6
	283	P-46	3/16"	Cum 0.80D-30" delay	8.1	16°						334.8
	284	P-46	3/16"	PI @ 0.80D	9.2	16°						398.5
	285	P-46	3/16"	PI @ 0.80D	9.0	16°						328.4
2:40 pm	286	P-46	3/16"	PI @ 0.80D	9.4	15°						366.8
				JUNE 8, 1947								
Stream Depth 25.9 ft.				Discharge 50,900 sec. ft.								Water Temp. 69°F
9:30 am	287	P-46	3/16"	PI @ 0.95D	9.0	20°						323.8
	288	P-46	3/16"	PI @ 0.85D	9.0	18°						326.4
	289	P-46	3/16"	PI @ 0.75D	9.1	16°						394.0
	290	P-46	3/16"	PI @ 0.55D	9.2	14°						371.0
	291	P-46	3/16"	PI @ 0.35D	9.0	10°						410.6
	292	P-46	3/16"	PI @ 0.15D	9.0	7°						372.9
	293	P-46S	3/16"	DI, 0.00-0.23D	9.2	0°-6°	-4.0	-0.43	0	8.06*	7.63	326.9
	294	P-46S	3/16"	DI, 0.00-0.44D	9.4	0°-11°	-7.9	-0.84	0	8.01*	7.17	405.0
	295	P-46S	3/16"	DI, 0.00-0.75D	9.4	0°-14°	-11.2	-1.19	0	7.89*	6.70	363.6
	296	P-46S	3/16"	DI, 0.00-1.00D	8.6	0°-18°	-15.6	-1.81	0	7.66*	5.85	309.6
	297	P-46S	1/8"	DI, 0.00-0.39D	18.4	0°-9°	-6.4	-0.35	0	8.03*	7.68	383.1
	298	P-46S	1/8"	DI, 0.00-0.46D	19.2	0°-9°	-6.5	-0.34	0	8.01*	7.67	412.4
	299	P-46S	1/8"	DI, 0.00-0.74D	18.0	0°-14°	-11.1	-0.62	0	7.89*	7.27	380.9
	300	P-46S	1/8"	DI, 0.00-0.72D	19.2	0°-14°	-11.1	-0.58	0	7.90*	7.32	400.5
	301	P-46S	1/8"	DI, 0.00-1.00D	17.5	0°-18°	-15.6	-0.89	0	7.66*	6.77	375.0
	302	P-46S	1/8"	DI, 0.00-1.00D	19.2	0°-18°	-15.6	-0.81	0	7.66*	6.85	342.0
	303	P-46S	1/8"	DI, 0.00-1.00D	14.8	0°-18°	-15.6	-1.04	0	7.66*	6.62	328.3
12:00 m	304	P-46S	1/8"	DI, 0.00-1.00D	14.8	0°-18°	-15.6	-1.05	0	7.66*	6.61	301.1
1:15 pm	305	P-46S	1/8"	DI, 0.00-1.00D	12.0	0°-18°	-15.6	-1.30	0	7.66*	6.36	326.6
	306	P-46S	1/8"	DI, 0.00-1.00D	10.5	0°-18°	-15.6	-1.49	0	7.66*	6.17	208.4
	307	P-46S	1/8"	DI, 0.00-1.00D	9.0	0°-18°	-15.6	-1.73	0	7.66*	5.93	199.9
	308	P-46S	1/8"	DI, 0.00-1.00D	7.5	0°-18°	-15.6	-2.08	0	7.66*	5.58	185.0
	309	P-46	3/16"	PI @ 0.95D	9.0	13°						355.2
	310	P-46	3/16"	PI @ 0.75D	9.0	15°						346.3
	311	P-46	3/16"	PI @ 0.55D	9.1	11°						343.1
	312	P-46	3/16"	PI @ 0.35D	9.0	8°						218.1
2:00 pm	313	P-46	3/16"	PI @ 0.15D	9.0	5°						395.4

*Based on velocity in nozzle for point samples.

TABLE V (CONTINUED)

DATA SHEETS

NOZZLE VELOCITY ft./sec.	INTAKE RATIO	SEDIMENT		CONCENTRATION-POINT SAMPLES			CONCENTRATION RATIO	SIZE DISTRIBUTION										
		WEIGHT gm.	CONC. ppm	CURVE ppm	CORRECT'N ppm	CORRECTED ppm		1.0	0.5	.25	.125	.0625	.0442	.0312	.0221	.0156	.0110 mm.	
								ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
JUNE 7, 1947																		
5.82		2.362	7554															
5.89		2.231	6983															
6.35		2.6647	7874			6851	1.15	394	630	2441	1417	1181	236	315	236	158	866	
5.62		1.640	6923			6851	1.01											
6.57		1.376	7141			6851	1.04											
7.83		2.918	6999	Average of 5 Samples PI @ 0.92D		6851	1.02											
9.22		1.982	6385			6851	0.93											
6.30		2.2679	7211			6851	1.05	72	144	1875	2019	1226	433	289	144	144	865	
8.29		2.278	6178			6851	0.90											
7.11		1.9610	5524			6851	0.81	166	221	718	1712	884	552	166	166	939		
7.00		2.165	6332															
7.44		2.102	5913															
6.19		1.911	6317															
8.23		2.336	5807			5748	1.01											
7.60		2.524	7646			5748	1.33											
3.92		1.216	7149	Average of 5 Samples PI @ 0.80D		5748	1.24											
8.60		2.680	6243			5748	1.09											
7.84		1.9261	5791			5748	1.01	58	58	1390	1506	1042	521	116	174	58	868	
7.60		2.033	6072			5748	1.06											
7.97		-	-															
6.72		1.756	5347															
7.18		1.986	5414															
JUNE 8, 1947																		
6.63		1.808	5584															
6.68		1.653	5064															
7.97		1.780	4518															
7.42		1.410	3801															
8.40		1.871	4557															
7.62		1.298	3481															
6.54	0.86	1.048	3206	3405	0	3405	0.94											
7.94	1.11	1.550	3827	3645	0	3645	1.05											
7.13	1.06	1.544	4246	4000	0	4000	1.06											
6.63	1.14	1.360	4392	4289	0	4289	1.02											
8.62	1.12	1.258	3284	3588	0	3588	0.92											
8.91	1.16	1.462	3545	3670	0	3670	0.97											
8.78	1.21	1.498	3933	3985	0	3985	0.99											
8.66	1.18	1.495	3733	3960	0	3960	0.94											
8.87	1.31	1.657	4419	4289	0	4289	1.03											
7.38	1.08	1.202	3515	4289	0	4289	0.82											
9.07	1.37	1.187	3616	4289	0	4289	0.84											
8.41	1.27	1.173	3896	4289	0	4289	0.91											
7.83	1.23	0.878	3875	4289	0	4289	0.90											
8.20	1.33	0.673	3229	4289	0	4289	0.75											
9.20	1.55	0.701	3507	4289	0	4289	0.82											
10.24	1.84	0.665	3595	4289	0	4289	0.84											
7.27		1.396	3930															
7.09		1.563	4513															
6.94		1.506	4389															
4.46		1.061	4865															
8.08		1.428	3612															