UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL AND PROTOTYPE STUDIES OF CASA COLORADA CHANNELIZATION--MIDDLE RIO GRANDE PROJECT, NEW MEXICO

Hydraulic Laboratory Report No. Hyd-477

DIVISION OF ENGINEERING LABORATORIES

OFFICE OF ASSISTANT COMMISSIONER AND CHIEF ENGINEER
DENVER, COLORADO

May 1961

HYD 477

CONTENTS

CONTENTS--Continued

CONTENTS--Continued

FOREWORD

The studies described in this report were performed in the Hydraulic Laboratory by the Sediment Investigations Unit. Since steel jacks and jetties are used extensively in the channelization of the Rio Grande in the Middle Rio Grande Valley, conferences were held with representatives of the Hydraulic Laboratory, Canals, and Hydrology Branches of the Commissioner's Office, Denver, Colorado, and of the Regional and Project offices. Many ideas and methods of approach were suggested during these conferences.

The cooperation of the Project office in obtaining the comprehensive field data is greatly appreciated.

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Office of Assistant Commissioner
and Chief Engineer
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Investigations Section
Denver, Colorado
May 1961

Laboratory Report No. Hyd-477
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SUMMARY

The purpose of this study was to develop information for effective design of jetty fields. Tests were made to establish velocity reduction and recovery relationships of jetty fields in terms of the Froude number. The data are given in equation, design curve, and finally in nomograph form. The nomograph presents the values of all variables involved with velocity reductions caused by jetty fields.

Tests were also made with the movable bed model of the Casa Colorada prototype reach. The suspended sediment in the model consisted of a lightweight, granular, plastic material. This study was directed toward determining the effect of tie back spacing and depth of flow on friction values within the jetty field. Tie back spacings of 250 and 500 feet were studied and compared with a control section having no jetty fields installed.

Field data collected by project personnel were analyzed to establish correlation of the model performance with the prototype.

A set of general friction curves was developed, leading to a method of estimating the time to fill a jetty field with sediment.

INTRODUCTION

Steel jacks and jetties have been used successfully by the Corps of Engineers, highway departments, railway companies, and others to prevent damage to riverbanks, levees, bridge abutments, and other structures. The Bureau of Reclamation is using them to channelize the Rio Grande in the Middle Rio Grande Valley. The individual jack unit consists of three angle irons, 12 or 16 feet in length, joined at their centers. A network of wire is laced to the angle irons. These units are threaded with cables to form the front and tie back lines which makes a jetty field. Figure 1 shows a typical modeled jack unit. Figure 2 shows a plan and cross section of a typical jetty field installation.

Jetty fields incorporate some of the good features of walls and groins but are permeable, reducing the possibilities of overconfining the river and causing end scour such as occurs with impermeable groins. Jetty fields act as sediment traps by reducing the velocities within them. In most cases, sediment deposits are stabilized by vegetation. The alinement of the Middle Rio Grande is being improved with jetty fields which cause the phreatic water surface to lower thereby reducing evaporation and transpiration losses.

REVIEW OF PREVIOUS STUDIES

The investigations described in this report supplement previous work described in the paper "Use of Steel Jetties for Bank Protection and Channelization in Rivers," by E. J. Carlson and P. F. Enger, presented at the Hydraulics Division Meeting, ASCE, Madison, Wisconsin, August 1956.

The data in the above-cited reference presented velocity change in the jetty field in terms of unit discharge, number of tie back lines, and depth of flow for a range of simulated flow conditions. It should not be extrapolated beyond these conditions. The number of tie back lines varied from 1 to 7. The velocity of approach was equal to or less than 4.16 feet per second. The Froude number ranged from 0.066 to 0.300. The model was always operated at depths greater than critical. The tie back jacks represented in that study were made with 12-foot by 3-inch by 3-inch by 1/4-inch angle irons laced with No. 6 wire. In the model study, the jetty field width equaled the channel width.

JETTY FIELD VELOCITY RECOVERY CONCEPT

In the earlier study, velocity reduction tests were based on the comparative number of tie back lines through which the flow passed. The spacing of tie back lines was changed but was not used as an independent variable. The study covered by this report is based on a velocity recovery concept as follows. Consider a simple jetty field consisting of one tie back line and one continuous frontline. As flow passes through the tie back line, a velocity reduction occurs and some of the flow moves out to the channel due to the damming effect of the tieback. Downstream from the tieback, flow passes into the jetty field from the channel. The velocity increases in the field until it attains normal velocity for the slope and roughness of the river section. To maintain a velocity in the jetty field lower than the normal velocity for the river section, the tiebacks must be spaced so there is not complete velocity recovery between them. Hydraulic model studies were conducted to relate tie back spacing with velocity recovery.

VELOCITY RECOVERY STUDIES IN FIXED BED SECTIONAL MODEL

The fixed bed model was arranged in an open channel flume 13 feet wide with a continuous frontline of 1:16 scale jacks dividing the channel along the centerline, Figure 3. One tie back line of scale jacks was placed at an angle of 67.5° with the frontline at its upstream end. Flows of 8.33, 16.67, and 25.0 cubic feet per second per foot of width representing total discharges of 5,000, 10,000, and 15,000 cubic feet per second for the middle Rio Grande in the Casa Colorada area were used in the study. Prototype depths represented were 4 to 8 feet.

From dimensional analysis, the following relationship was adopted:

$$\frac{V_R}{V_o} = f\left(N_f, \frac{X}{Y}, \sin\phi\right) \qquad (1)$$

where

V_o = Velocity in the normal river channel upstream from a jetty field.

V_R = Velocity reduction in the jetty field ($V_R = V_o$ - velocity in jetty field).

X = Tie back spacing or distance downstream from a tieback.

Y = Depth in normal river channel upstream from a jetty field installation.

$N_F = \frac{V_o}{\sqrt{gY}}$, Froude number of normal flow in the river channel upstream.

where g is acceleration of gravity

ϕ = angle between a tie back line and a frontline.

Velocity and depth measurements were made at 1-foot intervals across the model channel at one section upstream from the tie back line and at four sections downstream from the tie back line. Experimental points were plotted on a dimensionless graph of $\frac{V_R}{V_o}$ versus $\frac{X}{Y}$ using Froude number as a parameter. Straight lines, drawn through the data for different Froude numbers, converged at a value of $\frac{X}{Y}$ equal to 160, indicating this to be the point of complete velocity recovery. A graph was plotted on semilog paper of Froude numbers versus $\frac{V_R}{V_o}$. The values of $\frac{V_R}{V_o}$ occurring where the parameter lines crossed the $\frac{V_R}{V_o}$ axis or $\frac{X}{Y}$ equal 0 were used. The points thus plotted showed little scatter. The relationship between $\frac{V_R}{V_o}$ and Froude number plotted as a straight line on semilog paper resulted in the equation

$$\frac{V_R}{V_o} = 0.108 \ln N_F + 0.308 \tag{2}$$

Combining the velocity recovery relationship with a tie back angle correction results in the following relationship:

$$\frac{V_R}{V_o} = \left(0.108 \ln N_F + 0.308\right)\left(1 - \frac{1}{160}\frac{X}{Y}\right)\left(\frac{\text{Sin } 67.5°}{\text{Sin } \phi}\right) \tag{3}$$

An adaptation of this equation in graph form is given in Figure 5.

It is assumed that after velocity in the jetty fields has reached its minimum, the design velocity reduction will occur immediately upstream from any line and the maximum total velocity reduction is immediately downstream from any line. The velocity reduction ratio immediately upstream from any line will be the specified design value, $\frac{V_R}{V_o}$. The additional velocity reduction through the line designated as line n, will be:

$$\frac{V_{R_n}}{V_o - V_R} = \left[0.108 \ln\left(1 - \frac{V_R}{V_o}\right) N_F + 0.308\right]\left[\frac{\text{Sin } 67.5°}{\text{Sin } \phi}\right] \tag{4}$$

Adding this additional reduction to the reduction immediately upstream of line "n" and applying the spacing factor to line n+1 gives

$$\frac{V_R}{V_o} = \left(\frac{V_R}{V_o} + \frac{V_{R_n}}{V_o}\right)\left(1 - \frac{1}{160}\frac{X}{Y}\right) \tag{5}$$

This means when flow has stabilized in the jetty field, the velocity reduction upstream of any line is equal to the velocity reduction upstream from any succeeding line.

Substituting in (5) the value of V_{R_n} in (4) and solving for $\frac{X}{Y}$ gives

$$\frac{X}{Y} = 160 \left\{ \frac{\left[1 - \frac{V_R}{V_o}\right]\left[0.108 \ln\left(1-\frac{V_R}{V_o}\right) N_F + 0.308\right]\left[\frac{\text{Sin } 67.5°}{\text{Sin } \phi}\right]}{\frac{V_R}{V_o} + \left[1-\frac{V_R}{V_o}\right]\left[0.108 \ln\left(1-\frac{V_R}{V_o}\right) N_F + 0.308\right]\left[\frac{\text{Sin } 67.5°}{\text{Sin } \phi}\right]} \right\} \qquad (6)$$

This equation gives the tie back spacing ratio desired for design. A graphical representation of this equation is shown in Figure 4.

USE OF DESIGN GRAPHS FOR JETTY UNITS

The graph of $\frac{X}{Y}$ versus $\frac{V_R}{V_o}$ with N_F as a parameter, Figure 4, is to be used to find a tie back spacing that will maintain a design velocity reduction once this reduction has been obtained immediately upstream from any one line in the jetty field. Enter the graph with the desired velocity ratio $\frac{V_R}{V_o}$ and read the spacing-depth ratio $\frac{X}{Y}$ opposite the Froude number N_F. The proper Froude number to be used should be based on the depth and velocity of the flow upstream from the jetty field.

The graph in Figure 5 is to be used for special conditions or to design a jetty field so that the velocity is quickly reduced to the desired amount. By entering the graph with the $\frac{V_R}{V_o}$ value which occurs immediately upstream from any line on the right scale and proceeding around the graph counterclockwise, the $\frac{V_R}{V_o}$ value immediately upstream from the next line may be found. This process may be repeated as many times as is necessary. This graph is an adaptation of Equation (3). The velocity reduction ratio downstream of any line "n" is the sum of the reduction ratio up to the line and the reduction ratio through the line.

$$\frac{V''_{R_n}}{V_o} = \frac{V_{R_{n-1}}}{V_o} + \frac{V'_{R_n}}{V_o} \qquad (7)$$

The velocity reduction through line "n" is:

$$\frac{V'_{R_n}}{Vo} = 0.108 \ln\left(1-\frac{V_{R_{n-1}}}{Vo}\right) N_F + 0.308 \qquad (8)$$

Substituting (8) in (7) gives:

$$\frac{V''_{R_n}}{Vo} = \frac{V_{R_{n-1}}}{Vo} + \left[1-\frac{V_{R_{n-1}}}{Vo}\right]\left[0.108 \ln\left(1 - \frac{V_{R_{n-1}}}{Vo}\right) N_F + 0.308\right] \qquad (9)$$

This is the value found on the vertical axis of the graph. The second part applies the recovery factor to the next line:

$$\frac{V_{Rn}}{V_o} = \left\{\frac{V_{Rn-1}}{V_o} + \left[1-\frac{V_{Rn-1}}{V_o}\right]\left[0.108 \ln\left(1-\frac{V_{Rn-1}}{V_o}\right) N_F + 0.308\right]\right\} \left\{1 - \frac{1}{160}\frac{X}{Y}\right\} \quad (10)$$

As an example, take a case where the Froude number for normal flow at the design discharge is 0.4. To find the proper spacing to maintain the velocity reduction of 15 percent once it has been obtained on the upstream side of a tie back line, enter the single graph and read 83 as the spacing ratio. To design the first few lines, use the double graph. First choose a trial spacing ratio for the first lines. For the example, choose a spacing ratio of 70. Then enter the graph for the first line at a $\frac{V_R}{V_o}$ value of zero and proceed counterclockwise around the chart. Read the value of the velocity reduction immediately upstream from the second line as 11.6 percent. Since this value is less than the desired 15 percent, it is necessary to go around again. For the second line, enter the graph on the right side at $\frac{V_R}{V_o} = 0.116$ and find that the velocity reduction immediately upstream of the third line is 16.1 percent. Therefore, a design using the first two spaces at a ratio of 70 and all lines thereafter placed at a spacing ratio of 83 would be satisfactory.

The velocity used in the Froude number must be the same as used in the velocity ratio and the depth must be the same as that in the spacing ratio. Both graphs are drawn for a tie back angle of 67.5°, and the equations given should be used for other angles.

The data used in arriving at these relationships came from a study using a straight flume in the laboratory where the flow is parallel to the jetty field. The graphs and equations should not be applied directly to curves and stream meanders. The information here will undoubtedly be useful under such circumstances, but the design procedure must be modified to fit the situation.

It is noted that, as a rule, the method will indicate closer spacing for the smaller flows. This is a natural condition since the jetties offer less resistance to the smaller flows. For this reason, it is suggested that the design flow at a specific reach be the lowest flow which is difficult to control in that reach.

The jacks represented in this study were made of 4- by 4- by 1/4-inch angles 16 feet long and laced with No. 6 wire on 15-inch spacing. For any other jacks that are geometrically similar, a conversion factor must be applied to the tie back spacing determined from Equation (3) or from the graphs. The equation for the adjusted tie back spacing X_a is as follows:

$$X_a = X\left(\frac{L}{16}\right) \qquad (11)$$

where

X = the tie back spacing determined from Equation (3)

L = the length of the angle iron of the geometrically similar jack

NOMOGRAPH FOR JETTY TIE BACK SPACING

A nomograph was constructed from the fixed bed model data, Figure 6, to assist in determining proper jetty tie back spacing based on the velocity recovery principle. The nomograph provides a method for solving Equation (3). The variables and parameters being in nomograph form in one place makes interpolation simple. An example is provided on the nomograph.

COMPARISON OF EARLIER STUDIES WITH VELOCITY RECOVERY STUDIES

To compare the fixed bed model studies described in the section "Review of Previous Studies," page 3, with the fixed bed studies described in this report, tests were conducted using two tie back lines. Velocity measurements were taken upstream from the first tieback, between the two tiebacks and at four cross sections downstream from the second tieback. Velocity reduction or recovery was determined for each cross section. The resulting data were plotted to relate the velocity recovery with distance downstream from the tiebacks and distance between tiebacks. The data compared very well with that produced from the earlier studies for unit discharges greater than 10 cubic feet per second, velocity reductions greater than 49 percent, and the number of tie back lines six or more. In the lower ranges of velocity reductions and unit discharges the earlier studies gave higher values.

MOVABLE BED MODEL--CASA COLORADA REACH

Six tests were made with the movable bed model shown in Figure 7. The model was operated to simulate a hydrograph, as shown in Table 1, with steps of 5,000 cubic feet per second, a maximum discharge of 15,000 cubic feet per second, and a minimum discharge of 5,000 cubic feet per second.

Two sediments were used to represent the prototype material. A uniform sand with mean diameter 0.2 millimeter represented the bedload and a lightweight plastic represented the suspended load. The black color of the plastic material made it easy to distinguish between suspended and bedload deposits. The size analyses of these two sediments are shown in Figure 8 with the settling velocity characteristics of the plastic material shown in Figure 9. The control weir at the downstream end of the model was shaped to represent the natural river cross section. Cross sections at six ranges after each test are shown in Figure 10.

The effectiveness of the jetty fields is expressed as the difference in jetty field bed elevation with respect to the adjacent 600-foot channel bed elevation. Test 8 with a discharge of 5,000 cubic feet per second, was used as the base for comparing scour and deposition produced by the simulated hydrograph.

The second column of Table 1 gives the difference in bed elevation of the jetty field from that of the channel after Test 8. The other columns show how much greater (+) or less (-) the differences in jetty field and channel elevation were for each succeeding test, than for Test 8. The summation of the changes in difference in elevation when divided by the number of ranges, results in the average change in jetty field bed elevation compared to the base Test 8.

Lowering of jetty field elevations with respect to channel elevations, during Tests 12 and 13, indicated a greater deposit in the channel than in the jetty field during the receding flows of the hydrograph. Table 1 also shows that on the ascending portion of the hydrograph, scour in the channel increased with increase in discharge. These phenomena are typical of the sedimentation action in the prototype.

MOVABLE BED MODEL--TIE BACK SPACING STUDY

To compare jetty fields of different tie back spacings, the Casa Colorada movable bed model was modified. The walls of the model were changed to provide nearly constant jetty field and channel widths. The prototype channel width was 600 feet, and the jetty field widths were 450 feet on each side of the channel. The downstream control was changed to a level weir rather than representing a natural river cross section. Tie back spacings of 250 and 500 feet were studied. The tie back angle was maintained approximately 67° throughout the study.

A control test was made as a basis for comparing the effectiveness of the different tie back spacings. In preparation for the control run, the bed was shaped to a plane surface sloping to the control weir. The condition of the bed, before a test, is shown in Figure 11. The model was operated so as to represent the following prototype discharges:

5,000 cubic feet per second
10,000 cubic feet per second
15,000 cubic feet per second
10,000 cubic feet per second
5,000 cubic feet per second

The duration for each step of discharge was approximately 10 days. Figure 12 shows typical photographs of the bed after producing this hydrograph in the model. The bed was reshaped to its initial flat cross section, and the above hydrograph was repeated for each of the tie back spacings studied.

Lightweight granular plastic, representing suspended sediments, was continually introduced during the tests. The characteristics of the plastic sediment is shown in Figures 8 and 9. The rate at which the plastic was added to the model was in proportion to the product of the discharge and time for each stage of the hydrograph.

Sediment samples were taken with the US DH-48 wading-type hand sampler at the downstream control weir. The samples were obtained in the nappe of the flow and consequently, the sample represented total load. The samples were integrated in vertical and horizontal directions. The total length of the weir was 7 feet, and the horizontal integration covered a length of 1 foot for each sample. For each river discharge, samples were also obtained at the control weir in regions that appeared to have maximum, minimum, and average concentration of suspended load. These regions of the weir were determined by observing the concentration of black plastic that was used to represent the suspended load. Concentration versus discharge in log-log coordinates is plotted in Figure 14.

During these tests, average velocities were measured in both jetty fields and in the channel. Bed and water surface elevations were also measured. The location of suspended and bed sediment deposits were recorded and photographs taken.

Core samples 4 inches in diameter were taken from the jetty fields and the channel. Figure 15 shows cores taken at an upstream range line after the last test. The core with the greatest depth of black plastic sediment was on the inside of the curve. Deposits in the jetty field on the inside of the curve tended to crowd the flow into the channel and into the jetty field on the outside of the curve. The results of these tests indicated jetty field installations should be constructed only on the outside of curves initially. They should be constructed on the inside of curves only as the need develops.

Figure 13 gives the results of the scour and deposition tests in the form of smoothed curves. It shows model velocity plotted against model depth for prototype jetty tie back spacing of 250 feet, 500 feet, and infinity. The prototype discharges representing the step hydrograph are shown giving model depths and velocities for each discharge.

PROTOTYPE DATA ANALYSIS

Considerable field data from the Casa Colorada prototype reach and data from other jetty fields near Albuquerque were furnished by the Middle Rio Grande Project. These data appear in Tables 2 through 5 and in Figures 16 through 24. The purpose of obtaining these data was to verify the laboratory model. To do this, the prototype river characteristics were determined, analyses were made, and a set of river curves developed.

The data that were furnished consist of river cross sections, velocities, discharge measurements, slope measurements, and size analyses of suspended and bed sediment, both in the jetty fields, and in the main river channel. Most of the field data were obtained at range lines corresponding to measuring stations on the model. Average prototype curves were developed from the data.

Initial plots were made of the average discharge and other river characteristics. The general trend could be determined for some of the curves, but for others no trend was evident. This was due to the normal scatter of data points, and the limited range and amount of data. For the curves in which the general trend could be determined, points of inflection were difficult to locate.

To overcome these difficulties, analyses were made of data taken at points across the river sections. Using the point-data allowed the investigation of much greater depths and velocities and their relation to Manning's "h" value. Using point values made it possible to determine effects the jetty fields had on the average river characteristics. It permitted extrapolation of the data and a definite location of the critical inflection on the curves plotted from the average river characteristics.

A plot of point depth versus point Manning's "n" was made. To calculate the "n" values, the slope associated with each point was assumed to be the same as for the average river section. Values of point velocity versus point depth and point velocity versus point "n" values were also plotted. The three curves were first drawn by eye, averaging the scatter of data. The small inconsistencies between the curves, when reading "n" values from corresponding velocities and depths, were corrected by weighting the differences equally. The resulting curves are shown in Figures 25 through 27.

A plot of the average flow width versus the average flow area was made. There was a gap in the field data for areas less than 500 square feet. Using the cross section for the lowest discharge measured during the field data program and assuming that this cross section did not change its shape for lower discharges, the width and area were computed to fill the gap. The plot of these data are shown in Figure 28.

A plot was also made of the average depth of flow section versus the average area of flow section, Figure 29. The curve was computed by dividing flow areas from Figure 28 by their corresponding widths to obtain the depth.

Using values from curves in Figures 25 through 29, the river characteristics, including velocity, depth, width, Manning's "n", flow area, and square root of slope were plotted against river discharge. These curves are shown in Figure 30. It is noted that the maximum scatter of values of depth and width occur at a discharge of 5, 200 cubic feet per second. The average depth is 2.0 feet and the average width 500 feet. This is the low flow which is most difficult to control and corresponds closely with the value of dominant discharge determined independently in another office.

From the velocity-discharge measurements, average velocities in the jetty fields and in the river channels were calculated. These averaged velocities were plotted against the 90 percent finer size of the suspended sediment in Figure 31. Another plot was made of the velocity reduction in percent of channel velocity versus the ratio of the 90 percent finer sizes of the suspended sediment in the channel to that in the jetty field. This ratio represents the relative size of the sediment expected to settle in the jetty field with respect to the suspended sediment in the channel for given velocity reductions. Points on this curve are shown as solid dots in Figure 32. To cross check Figures 31 and 32, velocity reduction curves were calculated from Figure 31, assuming velocities 2, 4, and 6 feet per second in the channel. These calculated curves are shown in Figure 32, and they indicate that Curves 31 and 32 are consistent.

Cross sections of the Casa Colorada prototype reach are shown in Figures 16 through 24. These sections verify that the jetty fields are preventing scour and, in most cases, causing deposits within the jetty fields.

To determine the prototype carrying capacity for suspended sediment, velocity and sediment concentration were plotted. There was considerable scatter of points, and a curve determined by the least squares method was fitted to a second-degree polynomial. This curve is shown in Figure 33.

FRICTION FACTOR ANALYSIS

A friction factor analysis was made of the tie back spacing model data. The Darcy-Weisbach friction factor being nondimensional was selected for the analysis. This friction factor (f) for open channel flow, assuming that the hydraulic radius is equal to depth, is expressed by the following equation:

$$f = 8g\left(\frac{SY}{V^2}\right) \tag{12}$$

where

g = acceleration of gravity
S = slope
Y = depth
V = Velocity

To obtain results that can be applied to rivers other than the Middle Rio Grande, new scaling factors were determined that did not reflect the characteristics of that particular river. To do this, parabolic curves were drawn through the prototype curves of discharge versus width, depth, and velocity. These curves were then adjusted by distributing deviations equally among the three variables, making the final curves consistent with the continuity equation. New scale factors of prototype to model of these variables were computed.

Since frictional resistance is fundamentally a function of the Reynolds number, the new scale factors were plotted against the unit discharge for the control run of the model. This is essentially equivalent to plotting them versus Reynolds number, the unit discharge being equal to the velocity times depth, and the viscosity and density being constant.

Prototype friction factors and unit discharges were computed and are plotted with the relative tie back spacing $\frac{X}{Y}$ as a parameter in Figure 34 where X is the tie back spacing and Y is the initial depth in the jetty field. Typical of friction curves, the values of "f" become constant for large values of Reynolds numbers. For Reynolds numbers greater than 100, 000, "f" values become constant in this study.

The percentage increase in friction factor was determined from Figure 34. This percentage increase versus the reciprocal of the relative tie back spacing with the unit discharge as a parameter, is plotted in Figure 35. The reciprocal of the relative tie back spacing $\frac{Y}{X}$ may be considered as the relative depth in the jetty field.

In using the curves in Figures 34 and 35, it should be noted that the solid portion of the curves in Figure 34 represents the limits of the model data. The dashed portions of the curves are considered to be reasonable extrapolations of the model data.

PROPOSED METHOD FOR COMPUTING DEPOSITION IN A JETTY FIELD

Using comprehensive field data and the friction factor analysis of this study, rational designs can be made of jetty field installations. The minimum field data required is similar to that plotted in Figures 33 and 36.

The point data analysis described in this report makes it convenient to obtain these curves from the usually small range of values available from the field.

The design channel width should correspond to the low most difficult discharge to control. Judging from the deviations in width and depth in Figures 28 and 29, the design channel width for Casa Colorada study reach should be about 500 feet. The corresponding river discharge is about 5,000 cubic feet per second. For this design example, a tie back spacing of 250 feet was selected, and levee to levee width of 1,400 feet was assumed. The channelization length was 2 miles.

The installation of a jetty field causes an increase of hydraulic roughness. This increase in roughness causes a reduction of velocity in the jetty field. Consequently, the sediment-carrying capacity of flow in the jetty field is reduced. However, this does not necessarily mean that there will be deposition of sediment in the jetty field only. The jetty field also causes constriction of flow in the channel, and there is scour in the channel above certain discharges.

For convenience, and to simplify the computations, the process of scour and deposition is assumed to occur nonconcurrently and that deposition occurs only in the jetty field, and scour occurs only in the channel. Both phenomena are recorded as relative deposition. In field installations, deposition and scour may or may not occur at the same time.

For a constant total river discharge, the flow in the jetty field gets progressively less, and the terminal depth of flow approaches zero. The above series of events occurs for all practical tie back spacings. The information desired is the average rate of relative deposition in the jetty field for the selected tie back spacing, and the time for the jetty field system to stabilize.

Suspended sediment concentration and a varying hydrograph are major influences upon the rate of relative deposition.

To determine the average rate of relative jetty field deposition for the hydrograph year, average rates for constant river discharges were computed and are shown in Column 2 of Table 6. Since 5,000 cubic feet per second just covers the width of the design channel, the rate of deposition was assumed to be zero in the jetty field for all flows below 5,000 cubic feet per second. The rate of deposition was calculated for a discharge of 10,800 cubic feet per second since this discharge just covers the levee to levee width of 1,400 feet which was selected for the example design. A computation was also made for 7,500 cubic feet per second to determine deposition values for this intermediate discharge. The rates of deposition for 15,000 and 17,000 cubic feet per second were extrapolated. The average rates of deposition for the intervals between discharges are listed in Column 3. The corresponding percent of time on the hydrograph for the discharge interval is entered in Column 4. As can be seen, the percentage is small for the last two discharge intervals. Column 5 divided by 100 is the average rate of relative jetty field deposition for the hydrograph year, and in this design example it amounts to 0.68 foot per year.

To compute the average rates of relative deposition shown in Column 2 of Table 6, the information plotted in Figure 37 must be computed for the constant total river discharges of Column 1. For the remainder of this analysis, only the computation for 10,800 cubic feet per second river discharge will be considered. An example computation for determining the jetty field depth for one unit design channel discharge (10 cubic feet per second per foot) is shown in Table 7.

Using the design widths and the continuity equation, the unit discharge in the jetty field is 6.44 cubic feet per second. Various depths of flow are assumed for the jetty field, Column 3. Using these depths, the velocities are computed, Column 4, using a slope of 0.000829. The friction factor is computed and entered in Column 5. This friction factor represents friction for the hydraulic characteristics assumed to exist for the values in Columns 1 through 4. To solve for the depth that will actually be obtained, advantage is taken of the friction factor analysis of this study. Ratios of assumed depths to the tie back spacing are computed and are listed in Column 6. The percentage increase in friction factor caused by the tiebacks at the assumed depths is determined from Figure 35 and appears in Column 7. The friction factor that would occur at a unit discharge of 6.44 cubic feet per second with respect to the bed roughness alone is 0.0170. This value can be read from Figure 36 and when multiplied by one plus the decimal percentage of friction increase, results in the combined friction for the bed and tiebacks. The depth that exists in the jetty field must be consistent with both systems of determining the friction. The depth must have the same value of friction associated with it for both methods of computing friction. The depth can be determined by interpolation or by cross plotting Column 5, and Column 9 versus Column 3 on the same coordinates. The jetty field depth for this example is 1.86 feet. The remaining values of Figure 37 can now be computed or determined from Figure 36. The above computations are repeated for enough values of unit design channel discharges to define the curves in Figure 37.

The computation of the time rate of relative deposition for the constant river discharge at 10,800 cubic feet per second appears in Table 8. Values of unit discharge (q_c) in Column 1, Table 8 for the design channel are assumed for the range indicated in Figure 37. The average channel unit discharge for each interval is entered in Column 2. By continuity and using the design widths, values of the unit discharge (q_f) for the jetty field are determined, Column 3. For each of the assumed values of q_c, the differences in depth between the channel and jetty field (Δy) are computed from values determined in Figure 37 and are listed in Column 4.

From Column 4, the second differences of depth ($\Delta^2 y$) for the unit discharge intervals are computed and appear in Column 5. The values of channel and jetty field discharges and velocities were determined from the continuity equation, the selected design width, and Figure 37. The values for these variables appear in Columns 6 through 9. From Figure 33, the corresponding values of suspended sediment concentration in parts per million by weight in channel and jetty field are entered in Columns 10 and 11, respectively. The QC terms (discharge x concentration) in Columns 12, 13, and 14 are proportional to the sediment-carrying capacities for the design channel and jetty field. The QC term in Column 15 is proportional to the river sediment-carrying capacity prior to installation of the jetty field. This term is constant since the computation concerns one total discharge. Whether there is deposit in the jetty field or scour in the channel is noted in Column 16 which is headed Remarks.

The rate of scour or deposition, whichever occurs, is proportional to the values of the difference between the river sediment-carrying capacity before and after channelization. The sediment-carrying values times a constant (1.20) times the unit weight of water divided by the unit weight of the sediment gives the in-place volume of the solids scoured or deposited per second, Column 20. The factor (1.20) is an approximate value and converts the suspended load to total load. In Column 18 are the areas associated with the scour and deposition. These areas times the change in depth difference, Column 5, result in the volume to be scoured or deposited at the rate given in Column 20. These volumes are entered in Column 19. Dividing the values in Column 19 by those in Column 20 gives the incremental times (ΔT) to deposit or scour the incremental volumes, Column 21. The sum of Column 21 is the total time for the flow to be completely channelized for the discharge that had originally covered the total jetty field installation width. This time is 2.77×10^6 seconds. The average relative rate of jetty field deposition is 37.2 feet per year for the constant river discharge of 10,800 cubic feet per second. In the example, the relative deposition (difference in channel and jetty field bed elevations) amounted to 3.27 feet in 32 days to reach complete channelization.

SUMMARY AND CONCLUSIONS

The model and prototype study indicated that jetty fields are successful in alining rivers that carry considerable amounts of suspended sediments. The model studies showed that suspended sediment deposited in the jetty fields on the inside of the curves, tended to crowd the flow to the outside of the curves. This suggests that jetty fields be placed initially on the outside of curves only, and placed on the inside of curves only if experience shows they are required.

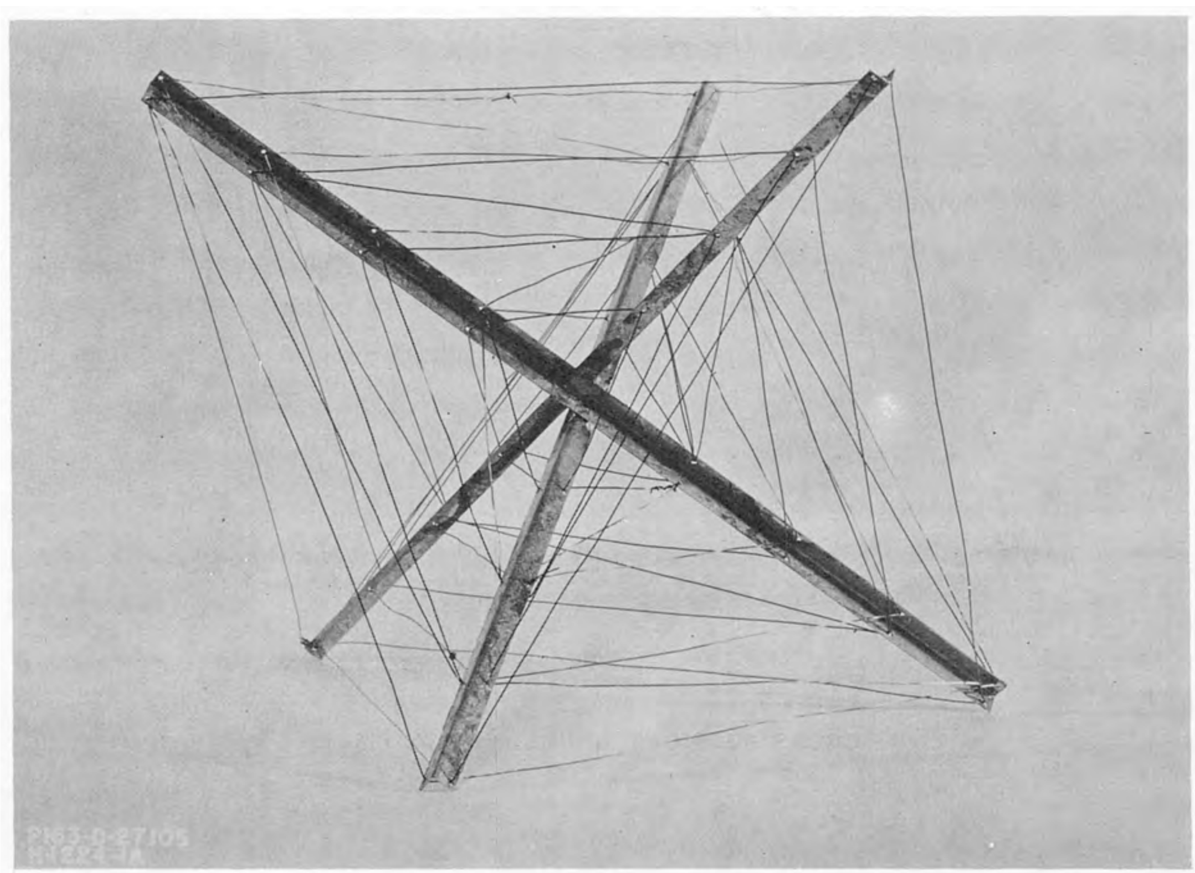
To compute relative rate of sediment deposition, comprehensive field data are required. The use of point data analysis described in this report aids greatly in extending field data and establishing inflections of river characteristic curves.

To select the design discharge, it is recommended that width and depth be plotted versus flow area. The design discharge would be the value corresponding to the flow area having the maximum scatter or deviation of data points with respect to depth and width. This would be the low, most difficult discharge to control. The average river width corresponding to this discharge should be selected for the design channel width.

Conservative values of initial channel and jetty field velocities can be determined from the results of the velocity recovery study. The relative rate of deposition for a jetty field installation can be computed by the procedure demonstrated in this report. Modifications and refinements may be desirable in future studies.

FIGURES

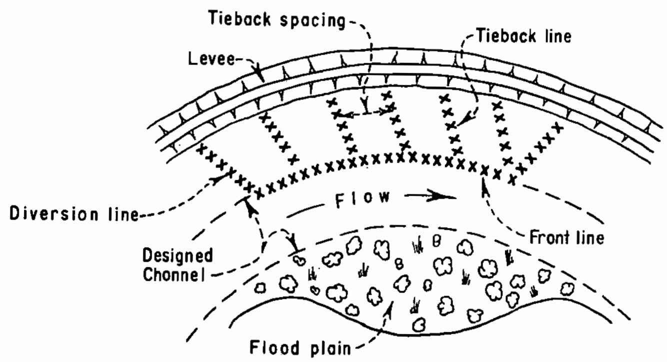
Figure 1



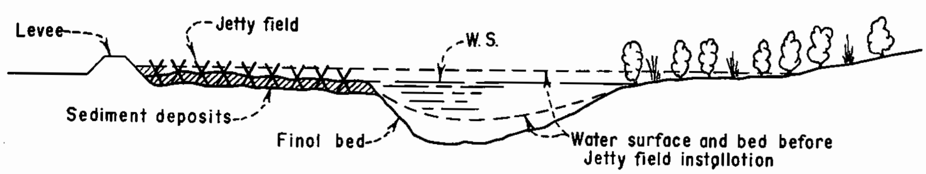
Middle Rio Grande Project
Casa Colorada Channelization

MODEL OF A SINGLE JACK UNIT

1:16 Scale



PLAN AT JETTY FIELD

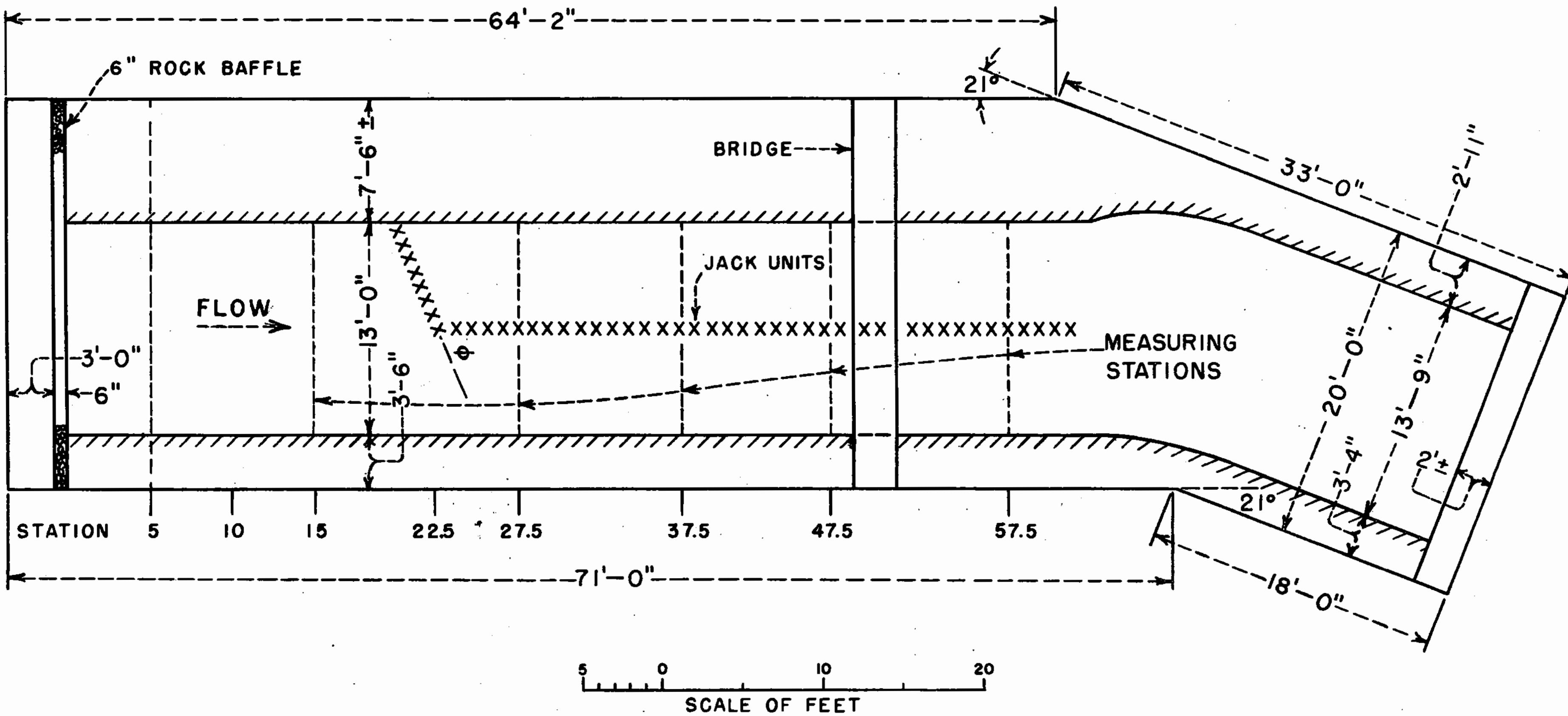


CROSS SECTION THROUGH JETTY FIELD

MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

PLAN AND CROSS SECTION OF JETTY FIELD



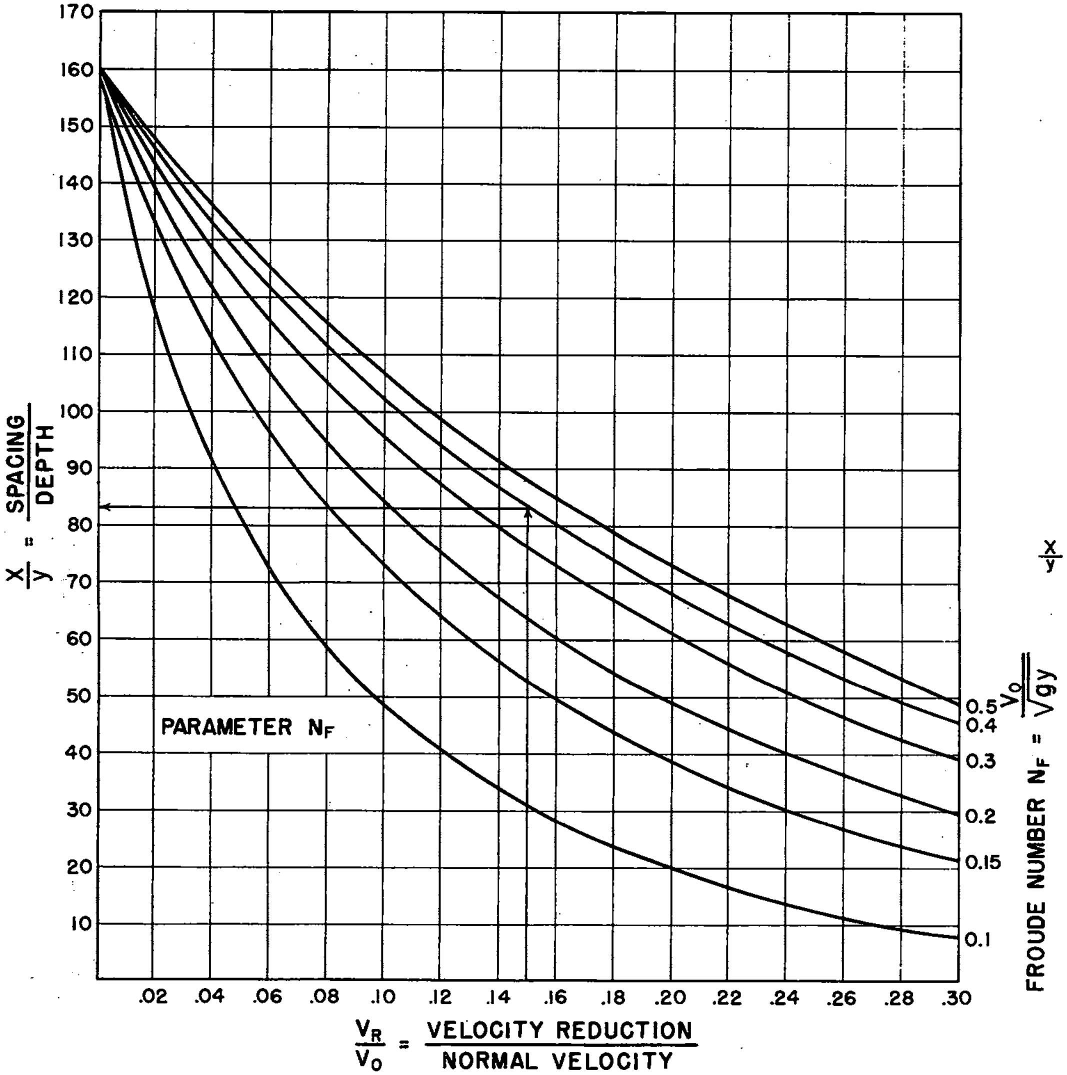
MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION
SECTIONAL MODEL ARRANGEMENT FOR VELOCITY RECOVERY STUDY

1:16 SCALE

564

FIGURE 3
REPORT HYD. 477



TIEBACK ANGLE $\Phi = 67.5°$

EXAMPLE

$V_0 = 4.54$ FT./SEC. DEPTH = 4.0 FT.

$$N_F = \frac{V_0}{\sqrt{gy}} = \frac{4.54}{\sqrt{32.2(4)}} = 0.400$$

FOR VELOCITY REDUCTION OF 15% READ $\frac{X}{y} = 83$

X = SPACING = 83(4) = 332'

$$\frac{X}{y} = 160\left[\frac{\left[1-\frac{V_R}{V_0}\right]\left[0.108\ \ln\left(1-\frac{V_R}{V_0}\right)N_F + 0.308\right]\left[\frac{\text{SIN. }67.5°}{\text{SIN. }\Phi}\right]}{\frac{V_R}{V_0} + \left[1-\frac{V_R}{V_0}\right]\left[0.108\ \ln\left(1-\frac{V_R}{V_0}\right)N_F + 0.308\right]\left[\frac{\text{SIN. }67.5°}{\text{SIN. }\Phi}\right]}\right]$$

MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION STEEL JETTY TIEBACKS SPACING FOR CONTINUED MINIMUM VELOCITY REDUCTION

SECTIONAL MODEL

1:16 SCALE

J.A.L.

FIGURE 4
REPORT HYD. 477

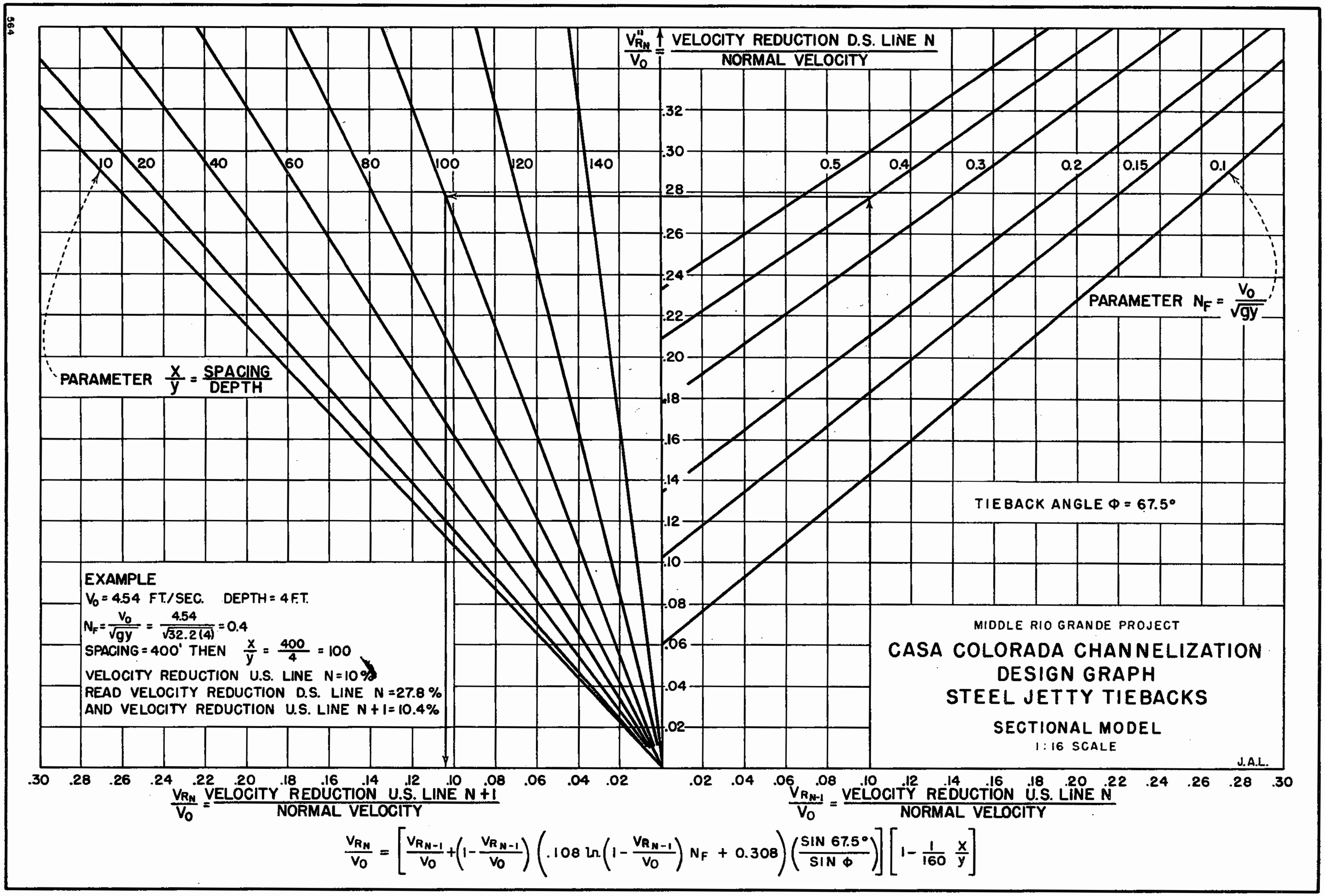
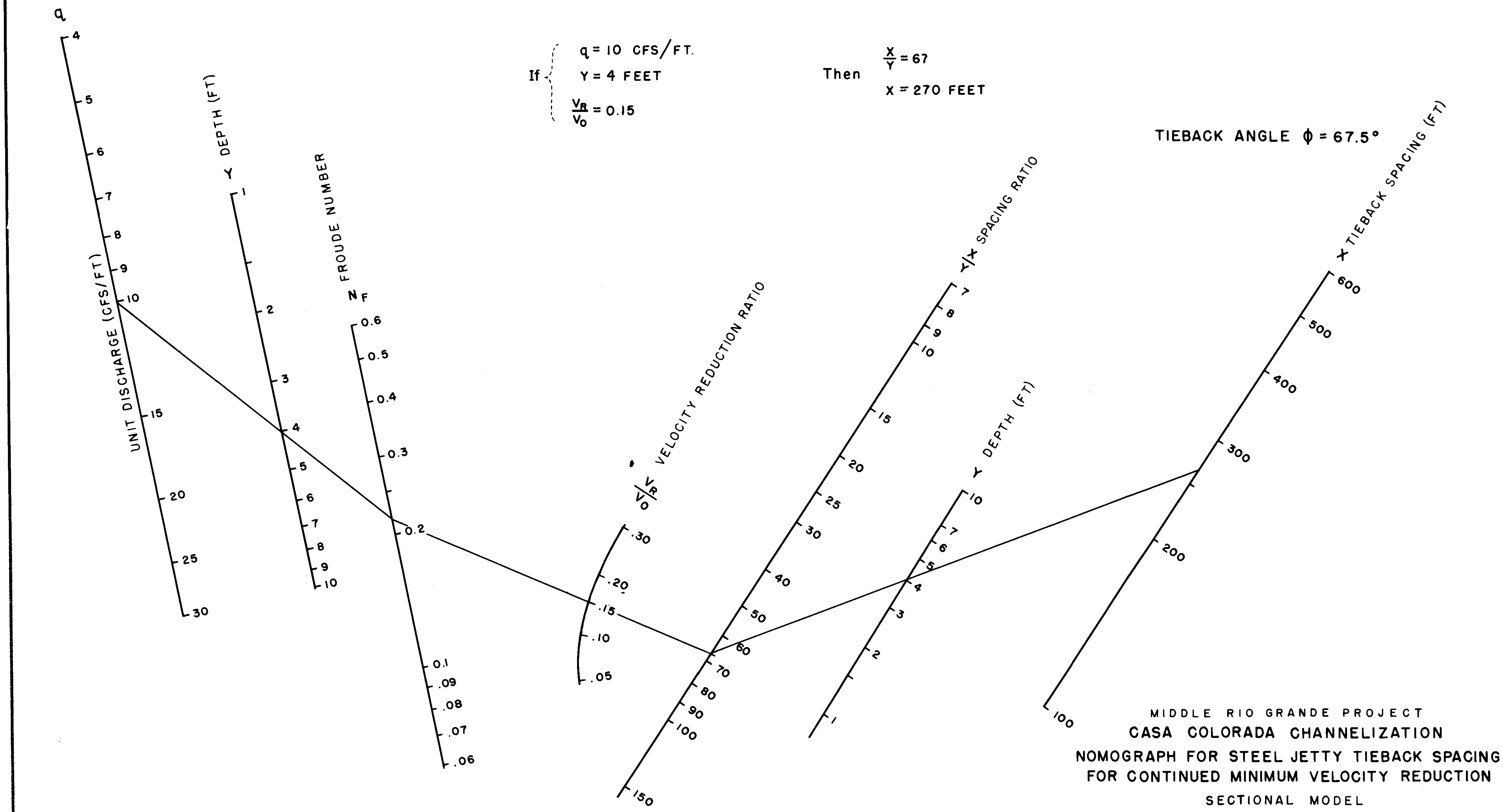


FIGURE 5
REPORT HYD. 477



MIDDLE RIO GRANDE PROJECT

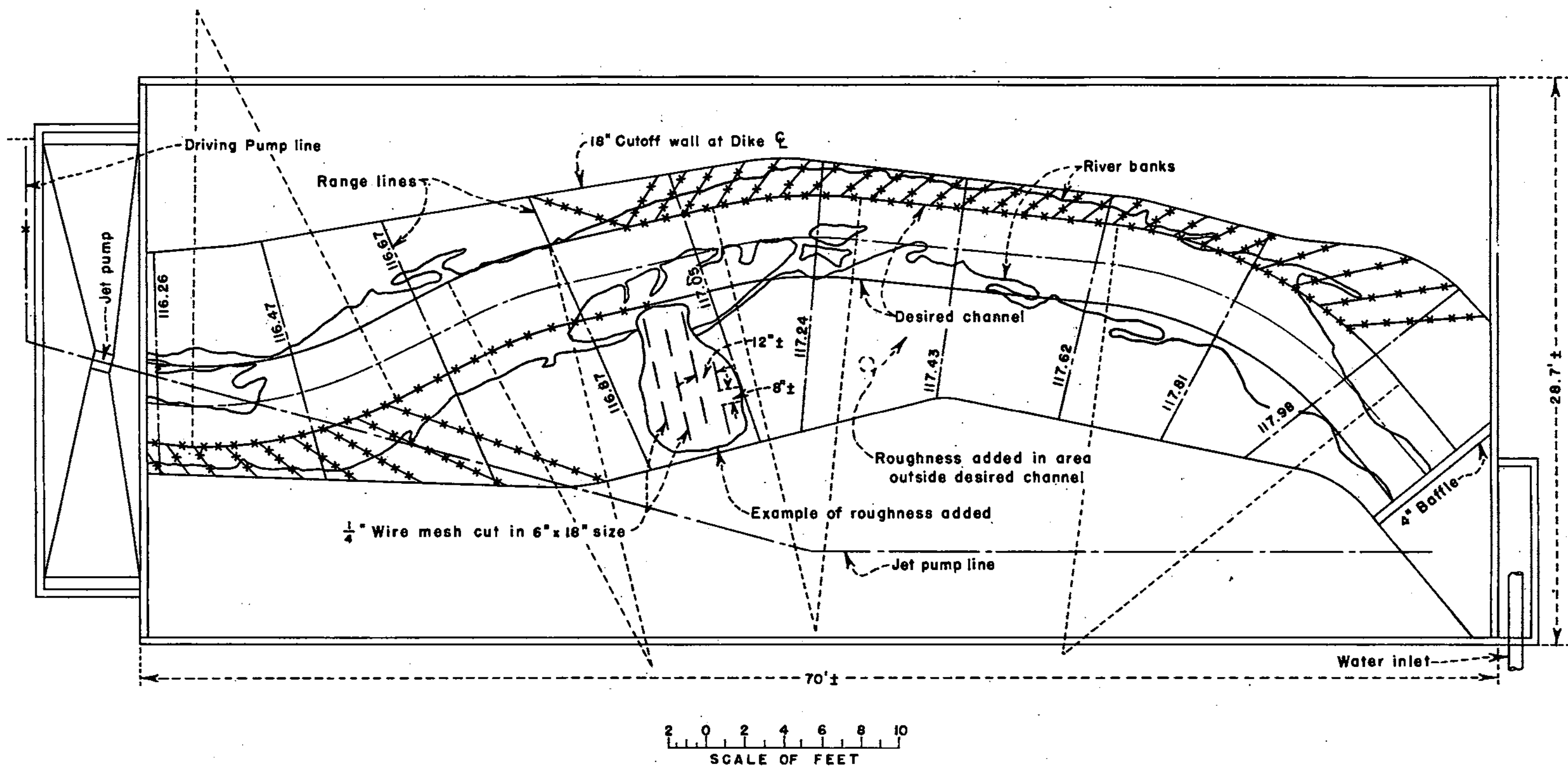
CASA COLORADA CHANNELIZATION

NOMOGRAPH FOR STEEL JETTY TIEBACK SPACING FOR CONTINUED MINIMUM VELOCITY REDUCTION

SECTIONAL MODEL

1:16 SCALE

564



MIDDLE RIO GRANDE PROJECT

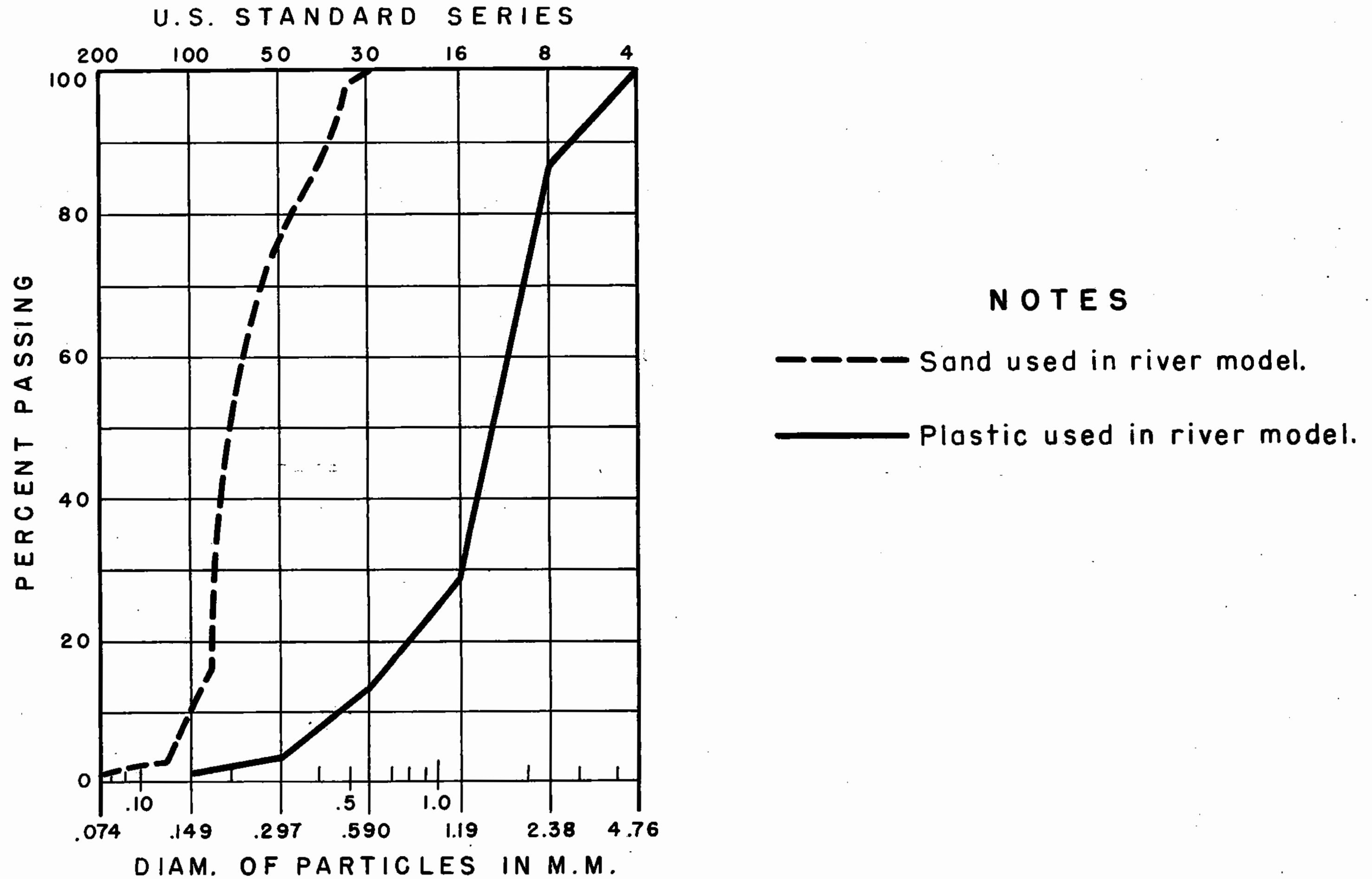
CASA COLORADA CHANNELIZATION

LAYOUT OF CASA COLORADA RIVER REACH
MOVABLE BED MODEL

1:140 HORIZONTAL, 1:22 VERTICAL SCALE

FIGURE 7
REPORT HYD. 477

564



MIDDLE RIO GRANDE PROJECT

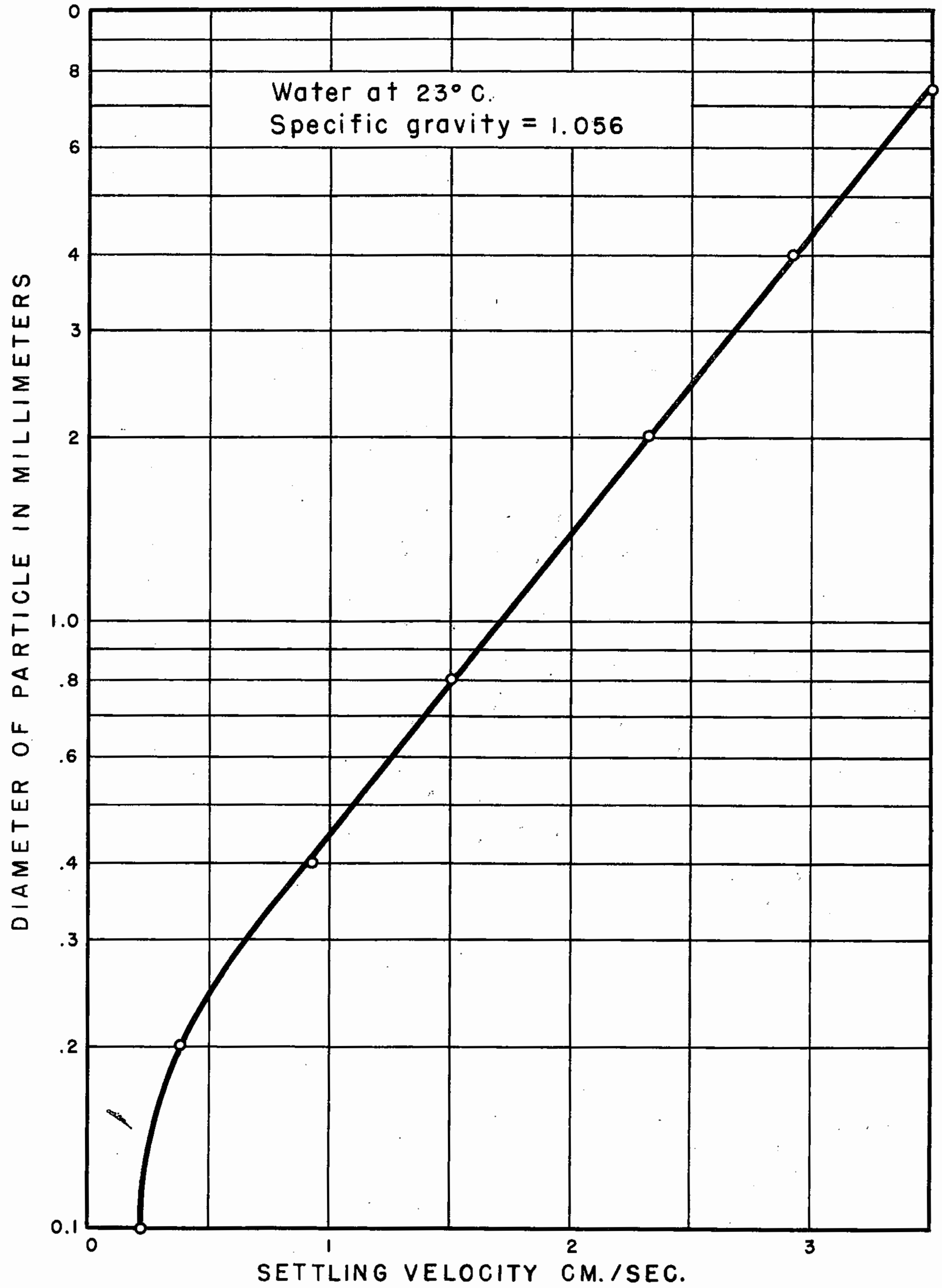
CASA COLORADA CHANNELIZATION

SIZE ANALYSES OF SEDIMENTS

MOVABLE BED MODEL

SCALE: 1:140 HORIZONTAL - 1:22 VERTICAL

FIGURE 8
REPORT HYD. 477



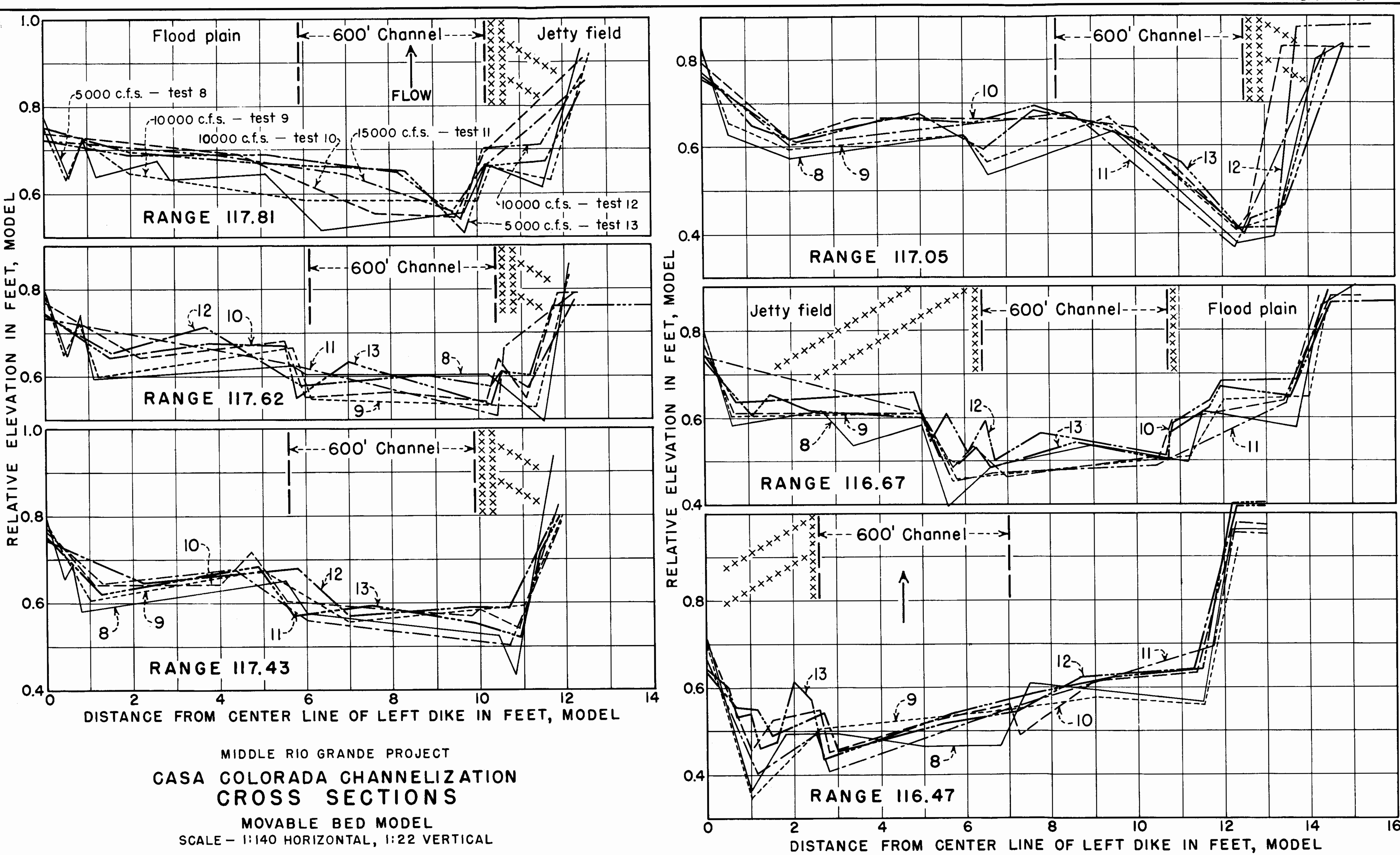
MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

SETTLING VELOCITY CHARACTERISTICS OF PLASTIC MATERIAL

MOVABLE BED MODEL

SCALE: 1:140 HORIZONTAL — 1:22 VERTICAL



MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

CROSS SECTIONS

MOVABLE BED MODEL

SCALE — 1:140 HORIZONTAL, 1:22 VERTICAL

Figure 11

(a) Upstream view

(b) Downstream view

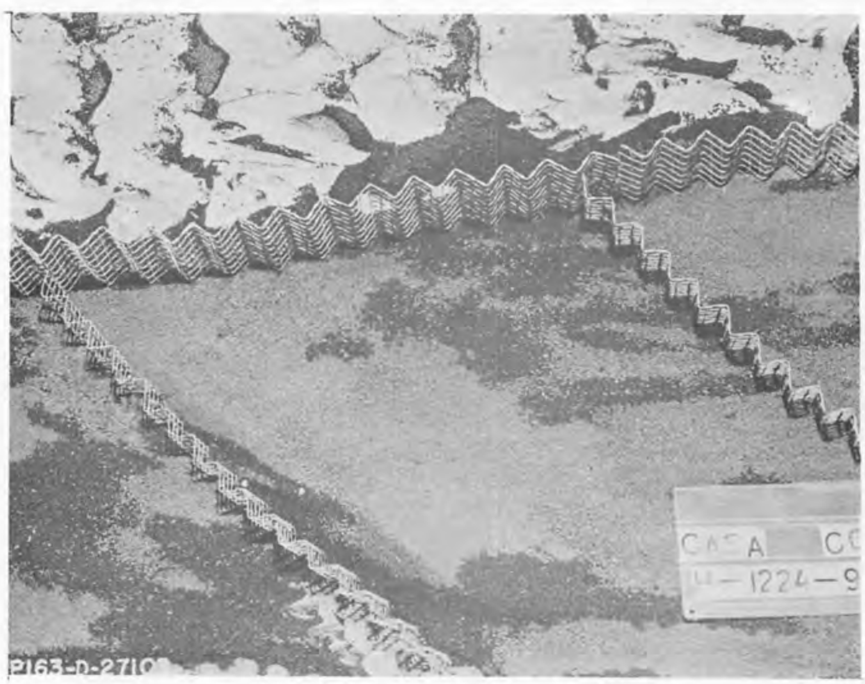
Middle Rio Grande Project
Casa Colorada Channelization

INITIAL CONDITION OF BED BEFORE 500-FOOT
TIE BACK SPACING STUDY

Movable Bed Model
Scale 1:140 Horizontal, 1:22 Vertical

Figure 12

(a) Upstream view

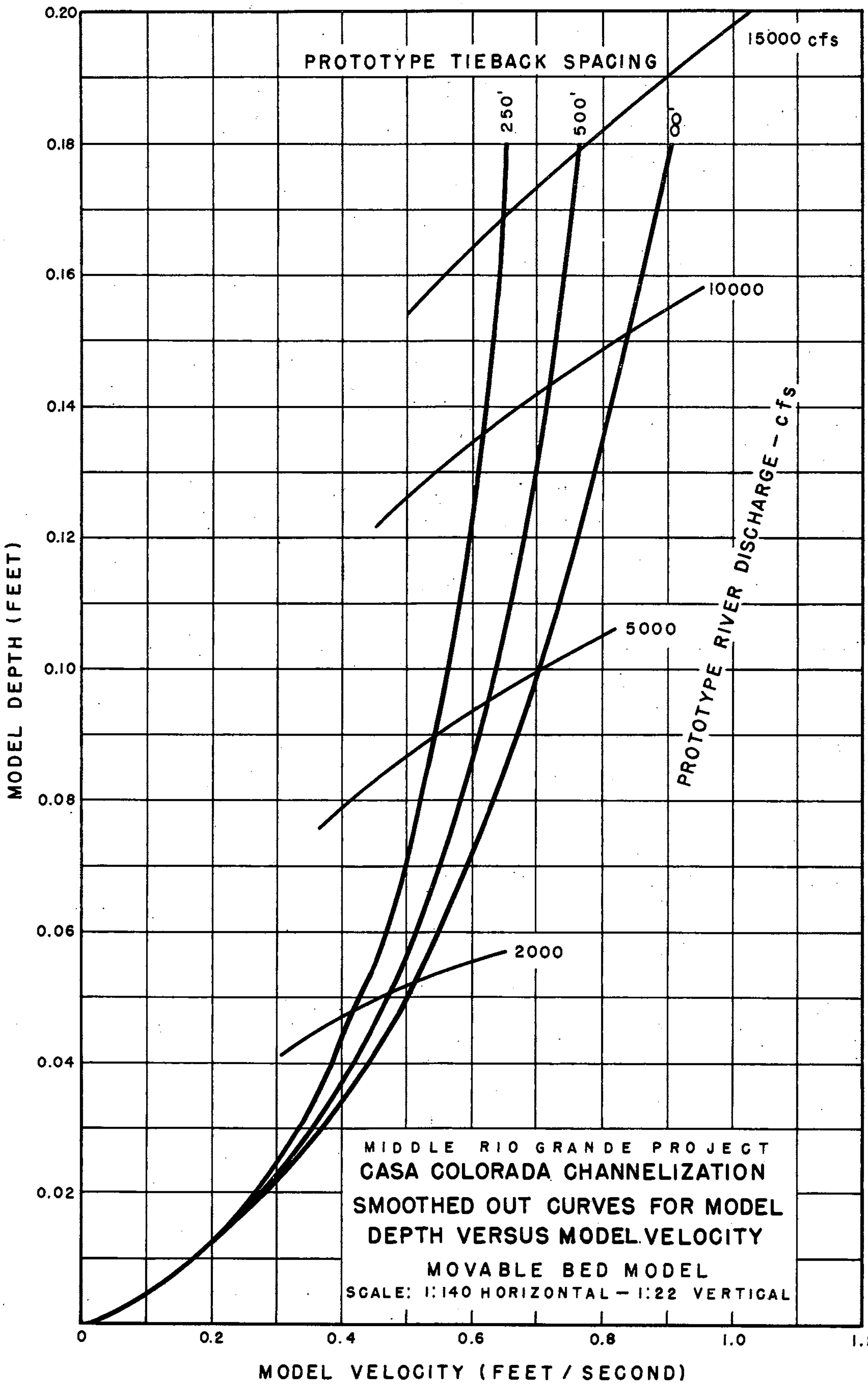


(b) Closeup of deposits in jetty field

Middle Rio Grande Project
Casa Colorada Channelization

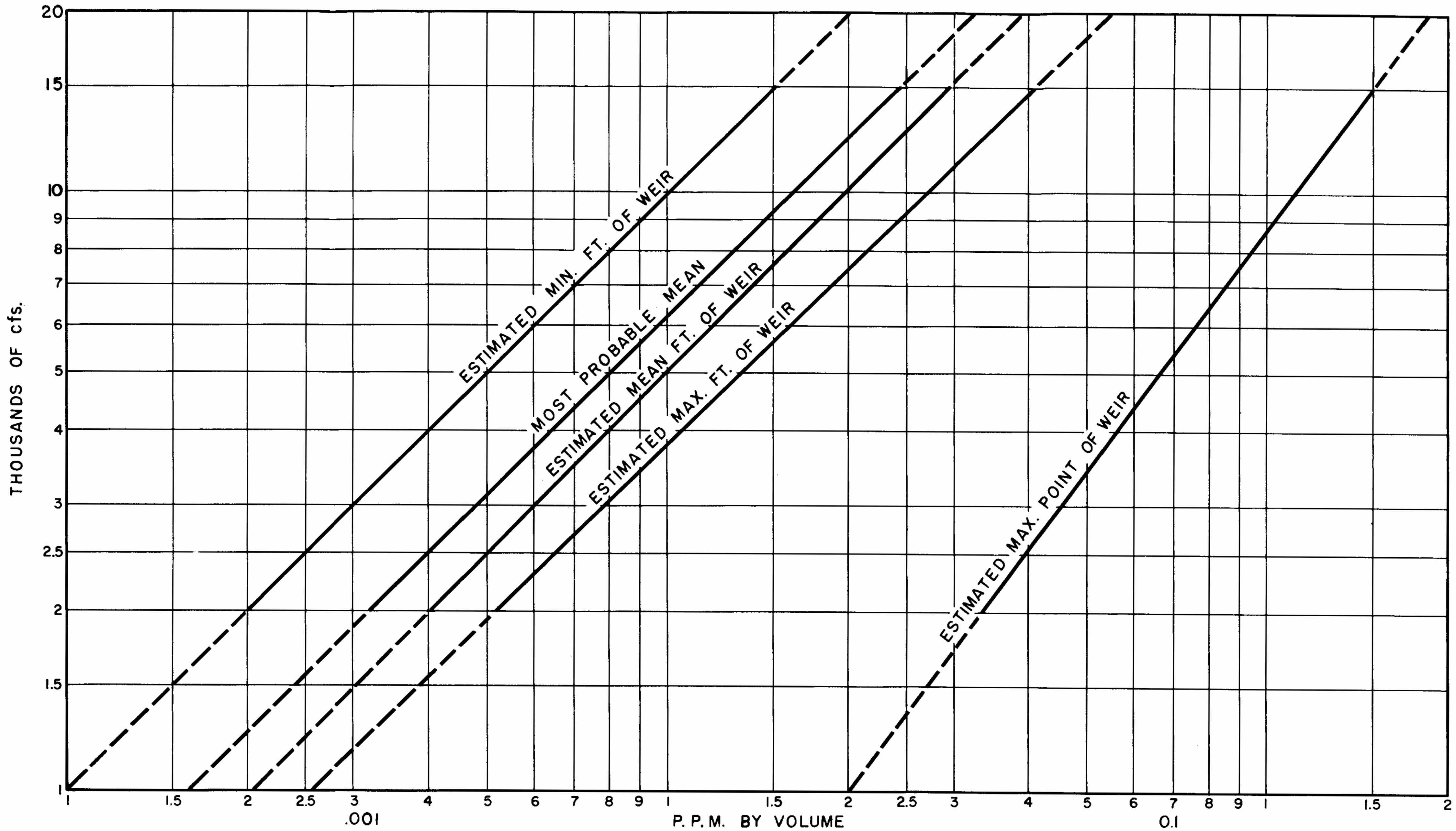
TYPICAL BED CONDITION AFTER MODEL HYDROGRAPH

Movable Bed Model
Scale 1:140 Horizontal, 1:22 Vertical



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
SMOOTHED OUT CURVES FOR MODEL DEPTH VERSUS MODEL VELOCITY
MOVABLE BED MODEL
SCALE: 1:140 HORIZONTAL — 1:22 VERTICAL

564



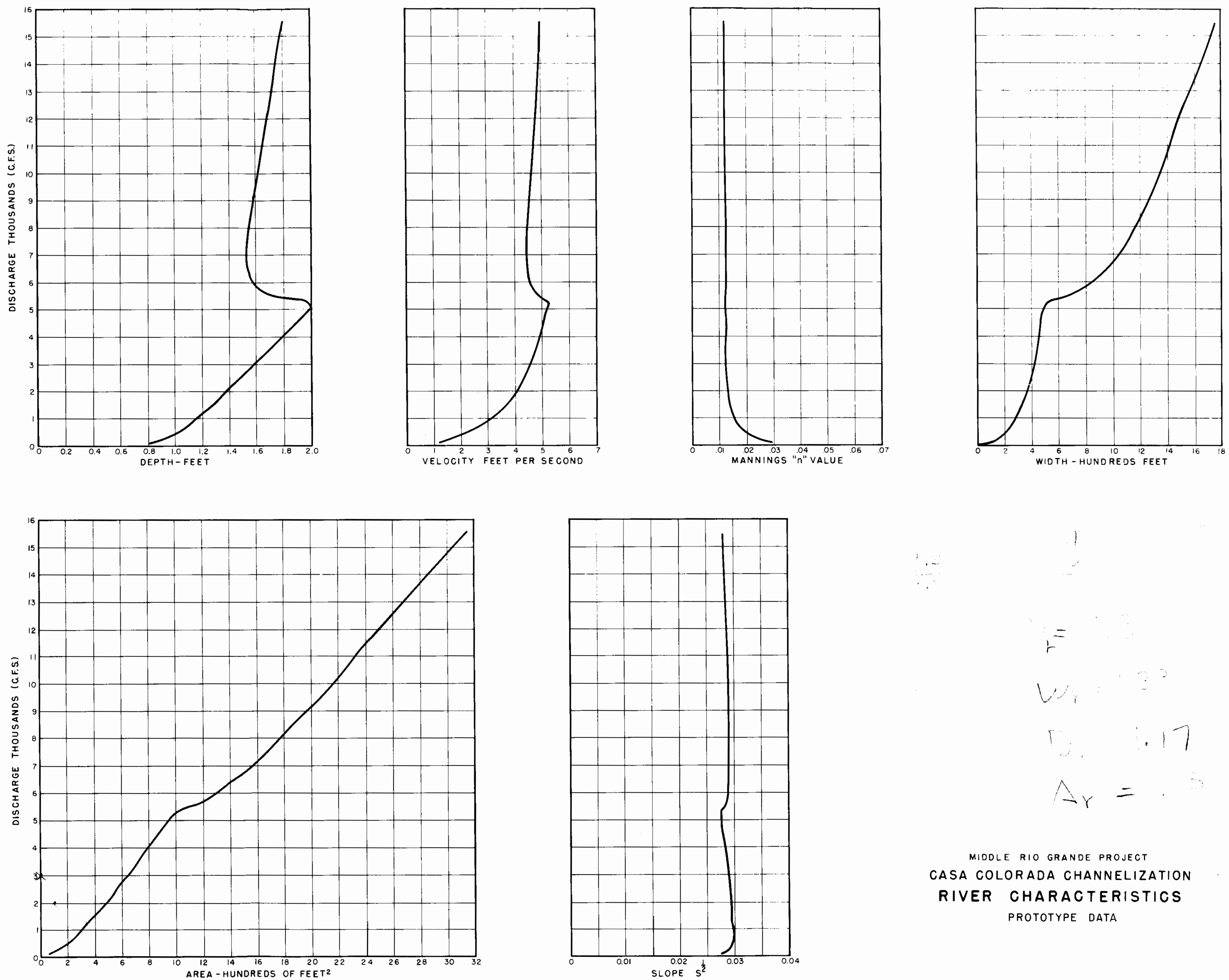
MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

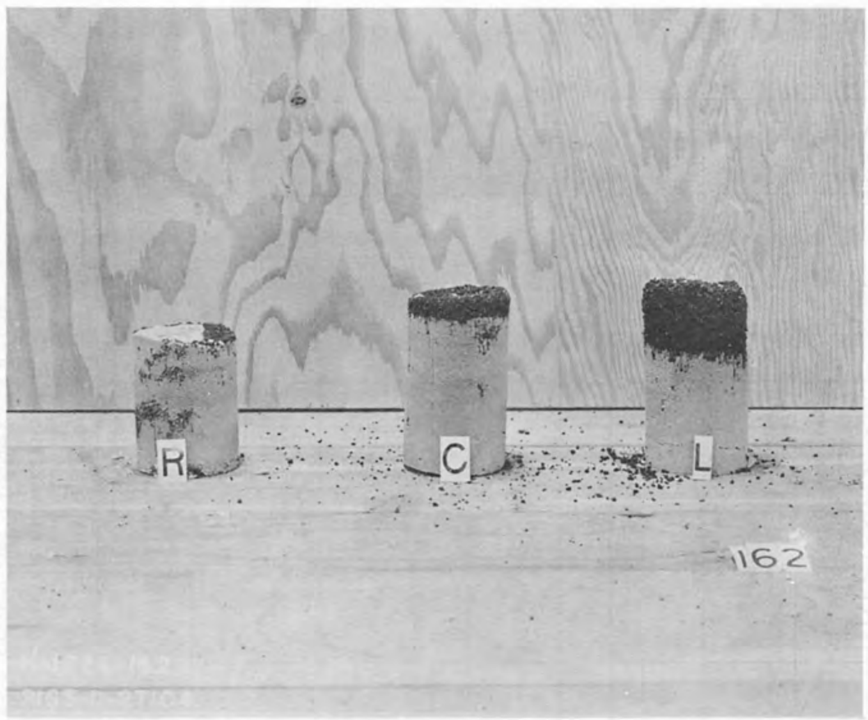
TERMINAL CONCENTRATION VERSUS TOTAL DISCHARGE

MOVABLE BED MODEL

1:140 HORIZONTAL; 1:20 VERTICAL SCALE



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
RIVER CHARACTERISTICS
PROTOTYPE DATA



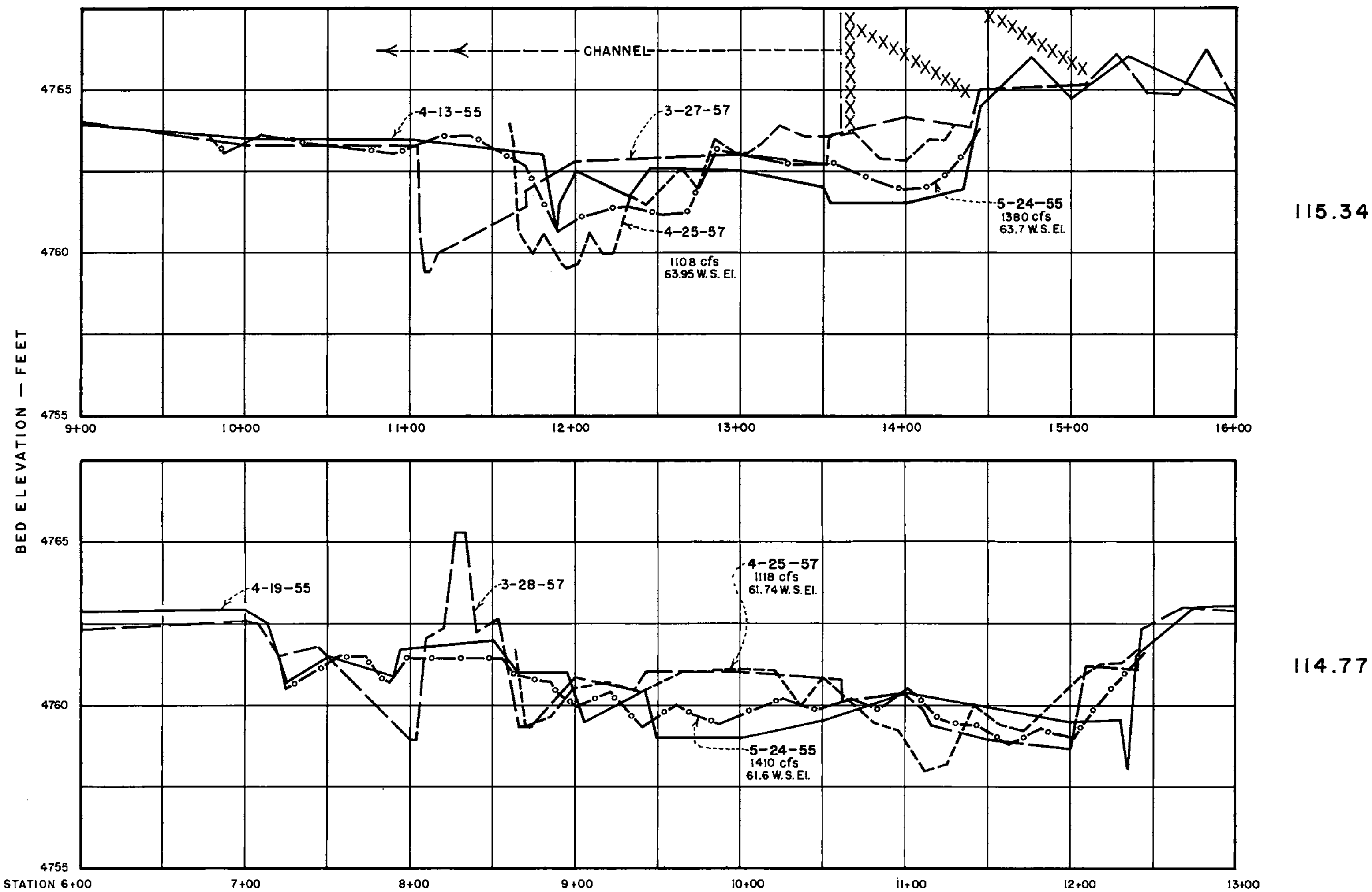
Outside Center Inside

Upstream Curve

Middle Rio Grande Project
Casa Colorada Channelization

CORE SAMPLES OF BED TAKEN FROM RIGHT JETTY FIELD, DESIGN CHANNEL AND LEFT JETTY FIELD IN UPSTREAM CURVE

Movable Bed Model
Scale 1:140 Horizontal, 1:20 Vertical



MIDDLE RIO GRANDE PROJECT

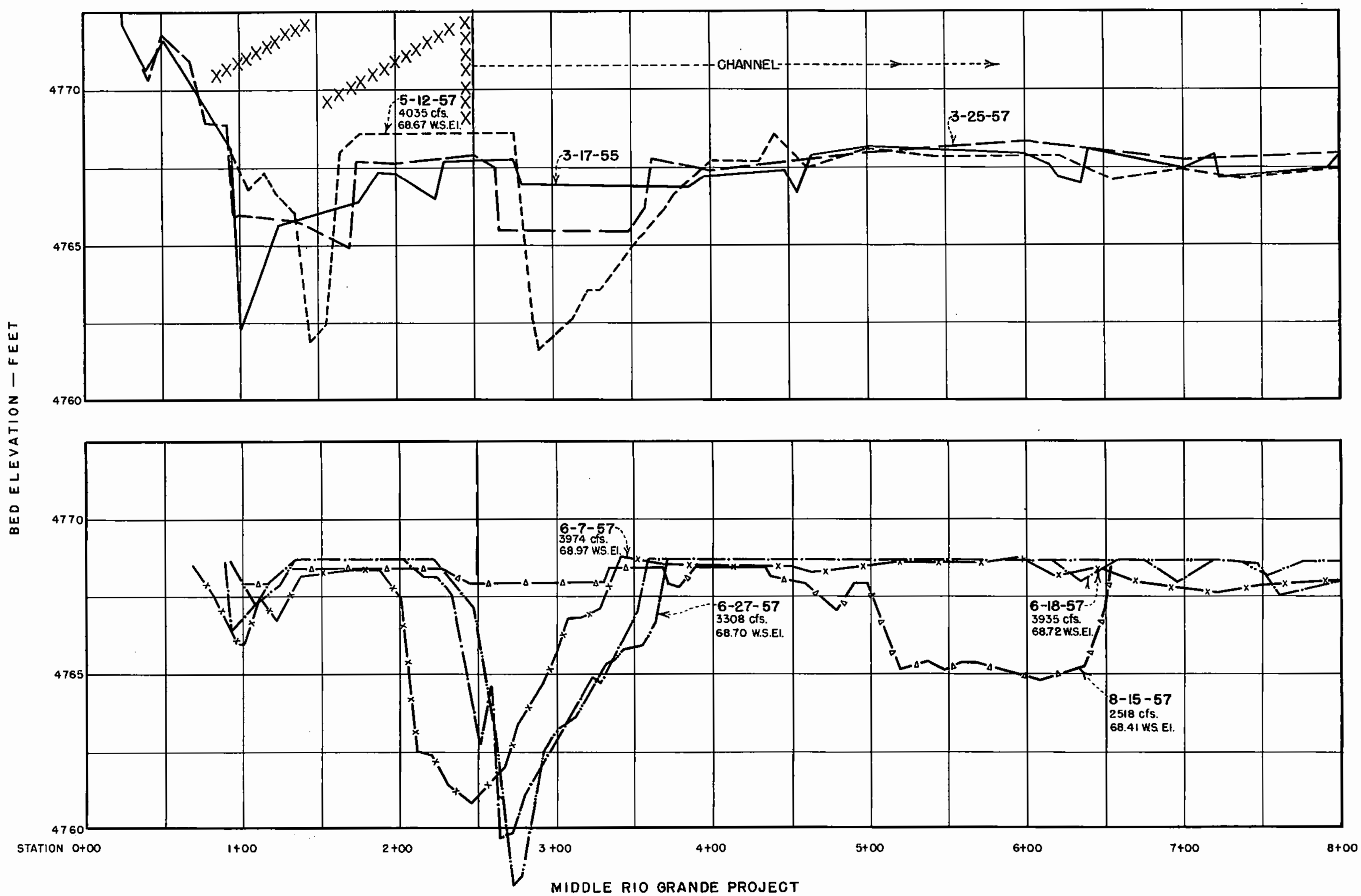
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGES 114.77 AND 115.34

FIELD DATA

564

FIGURE 16
REPORT HYD 477



MIDDLE RIO GRANDE PROJECT

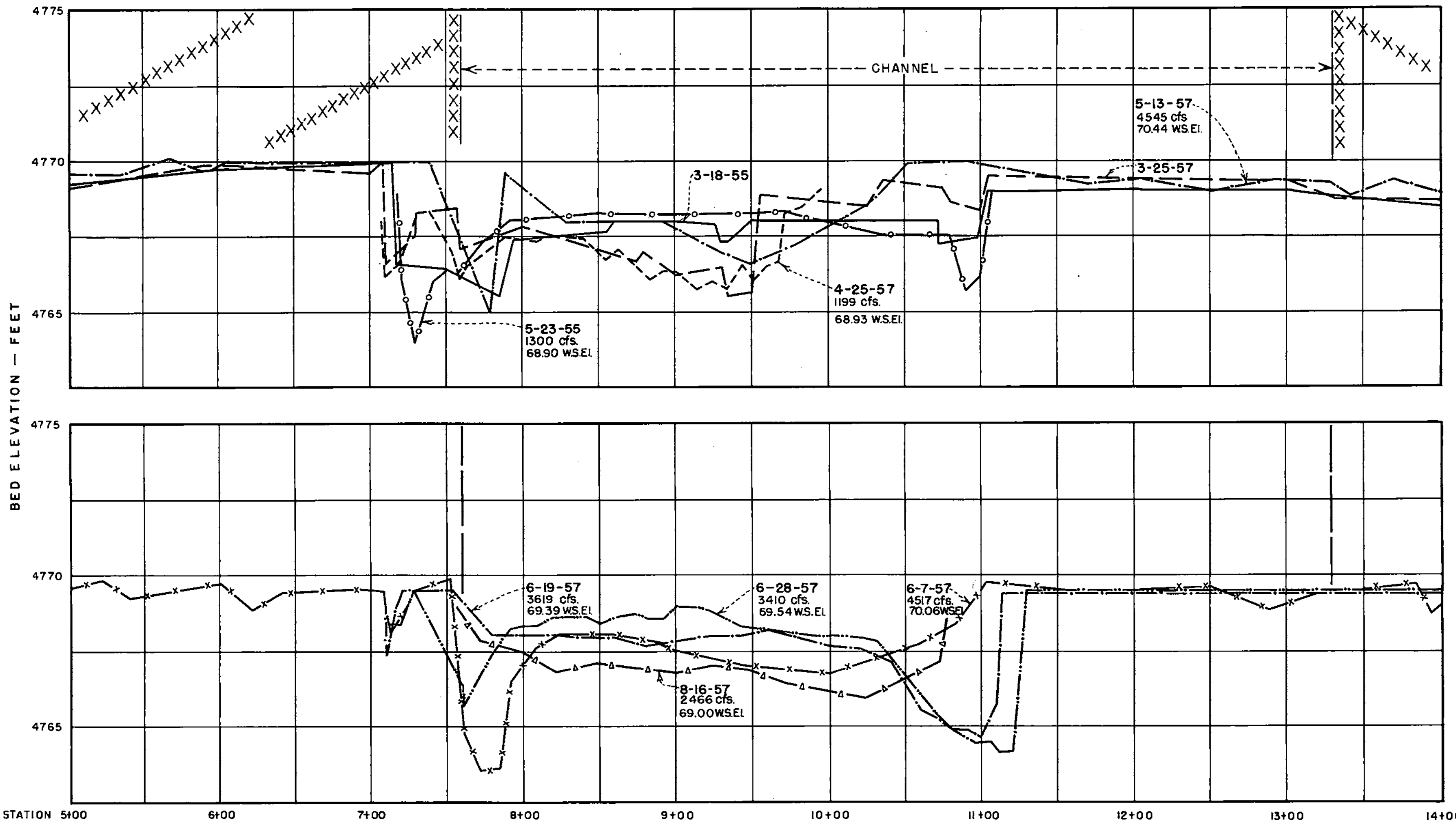
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 116.47

PROTOTYPE DATA

564

FIGURE 17
REPORT HYD. 477



MIDDLE RIO GRANDE PROJECT

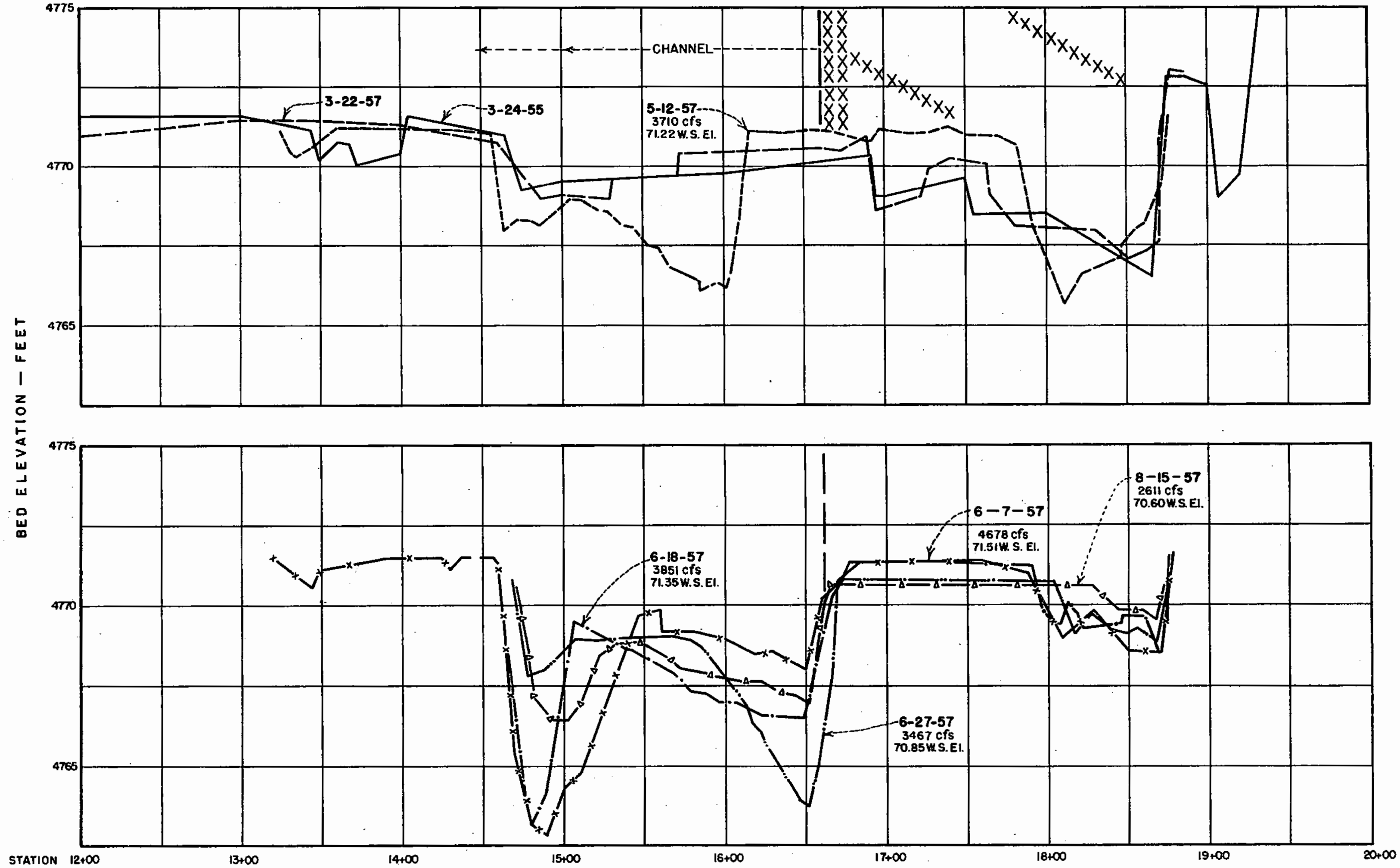
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 116.67

PROTOTYPE DATA

564

FIGURE 18
REPORT HYD. 477



MIDDLE RIO GRANDE PROJECT

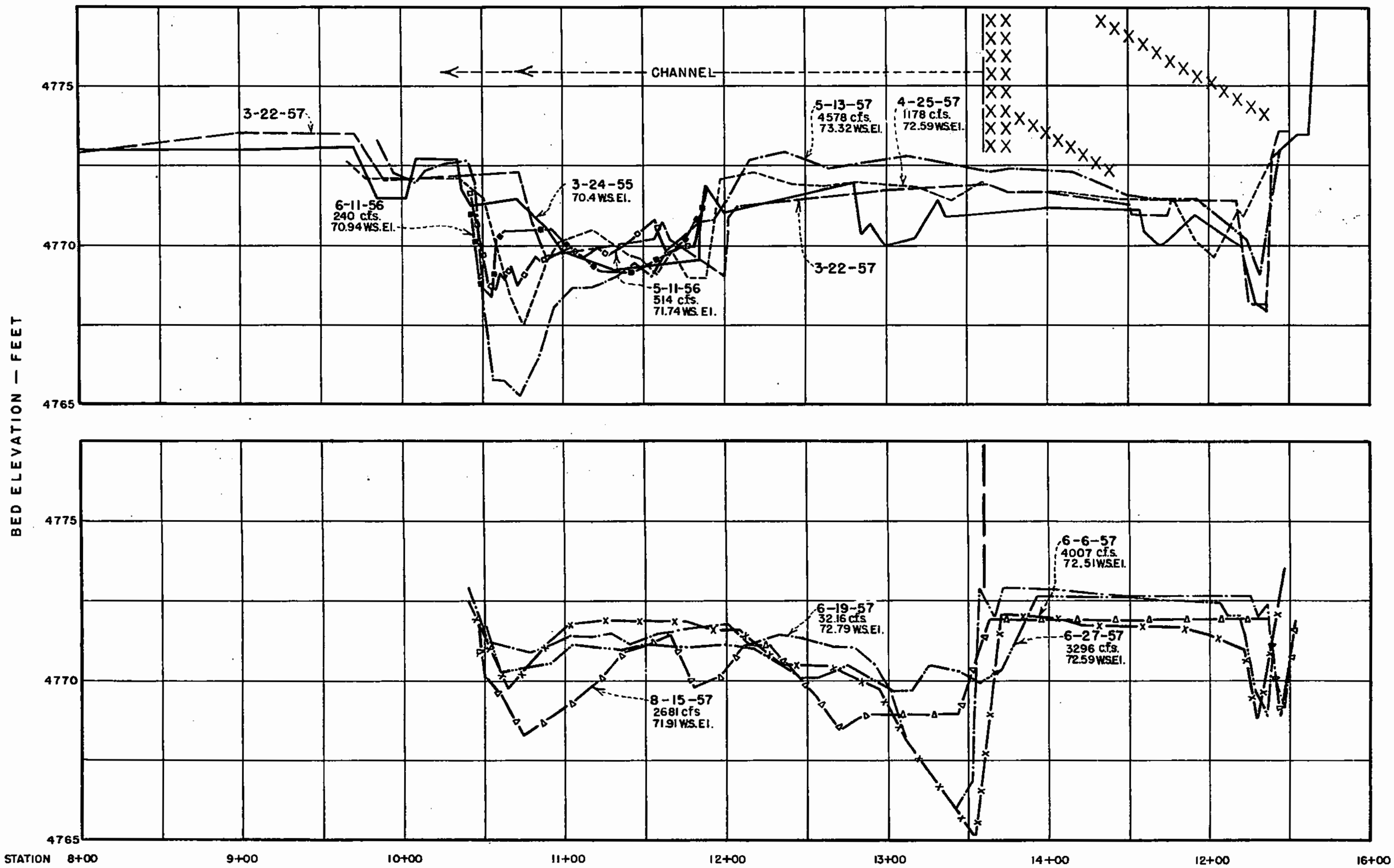
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 117.05

PROTOTYPE DATA

FIGURE 19
REPORT HYD. 477

564



MIDDLE RIO GRANDE PROJECT

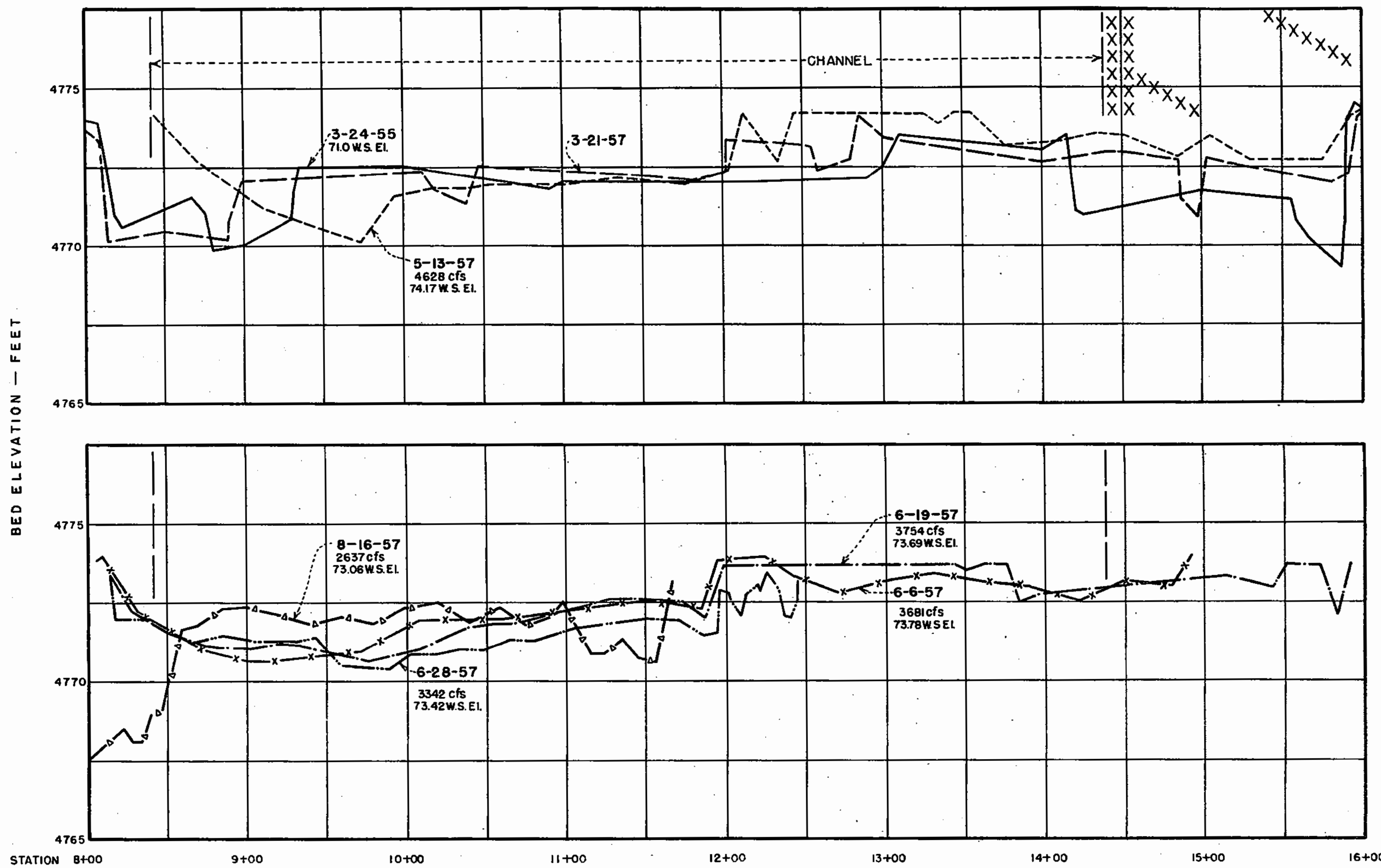
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 117.43

PROTOTYPE DATA

564

FIGURE 20
REPORT HYD. 477



MIDDLE RIO GRANDE PROJECT

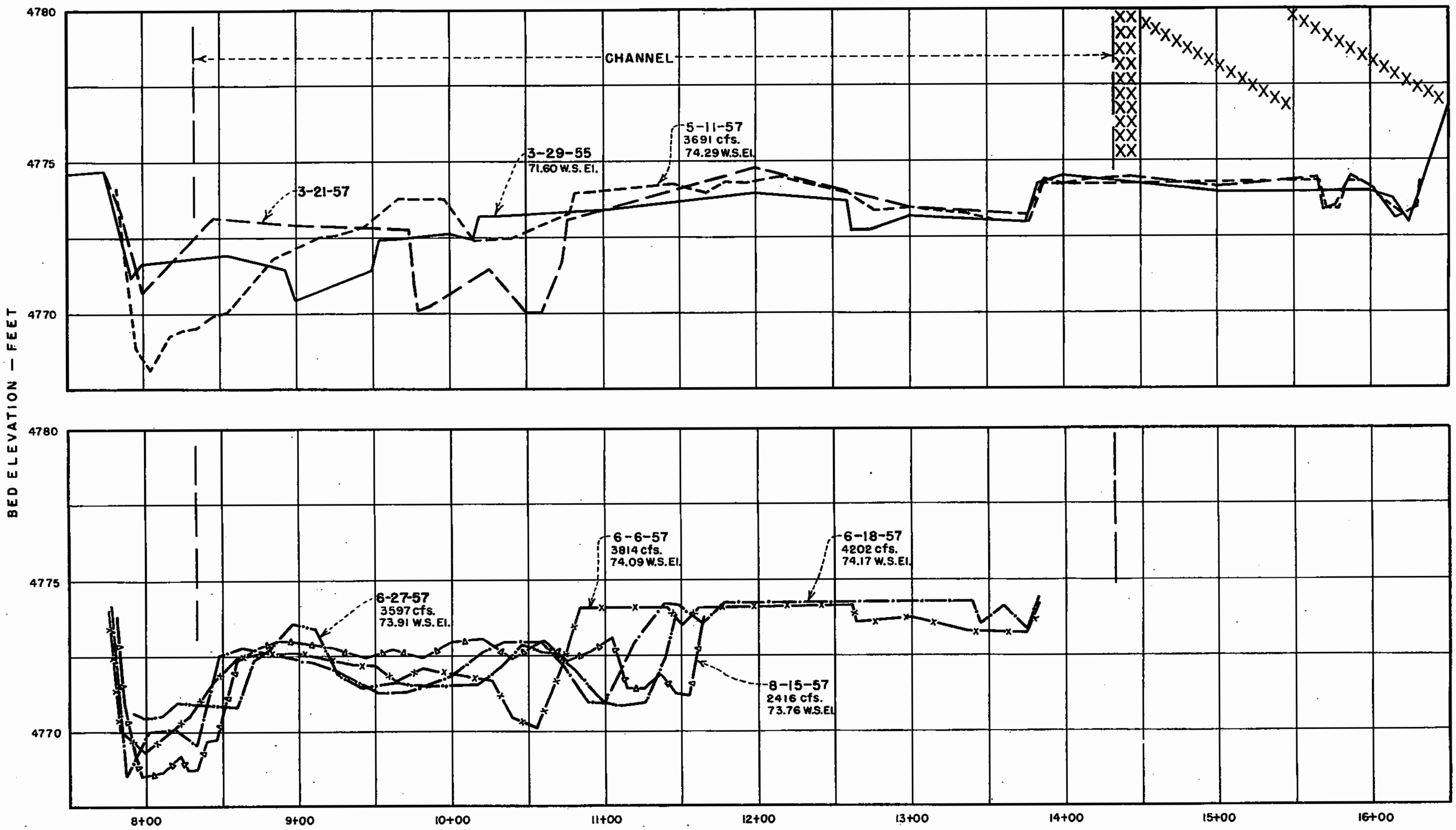
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 117.62

PROTOTYPE DATA

564

FIGURE 21
REPORT HYD. 477



MIDDLE RIO GRANDE PROJECT

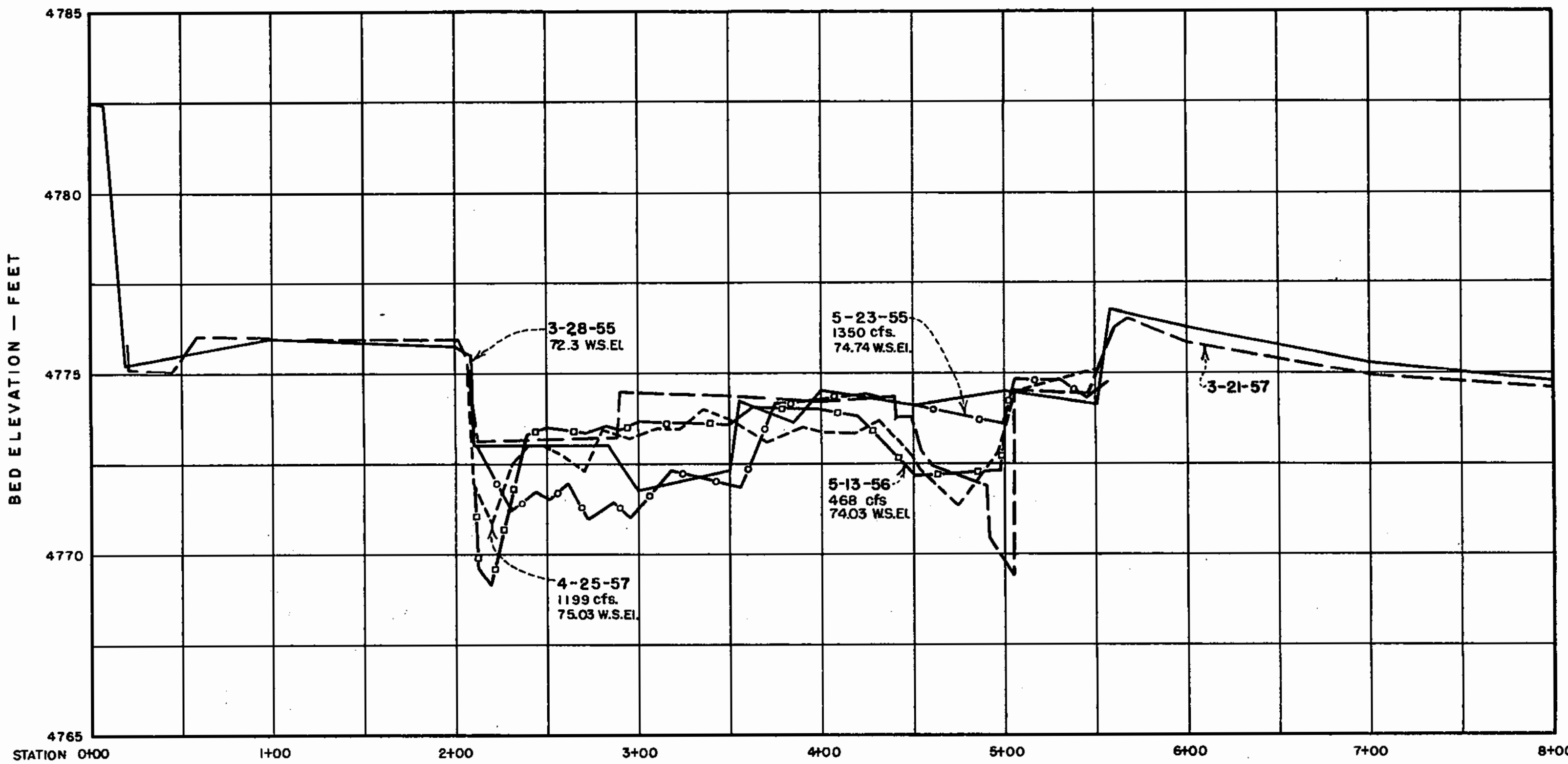
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 117.81

PROTOTYPE DATA

FIGURE 22
REPORT HYD. 477

564



MIDDLE RIO GRANDE PROJECT

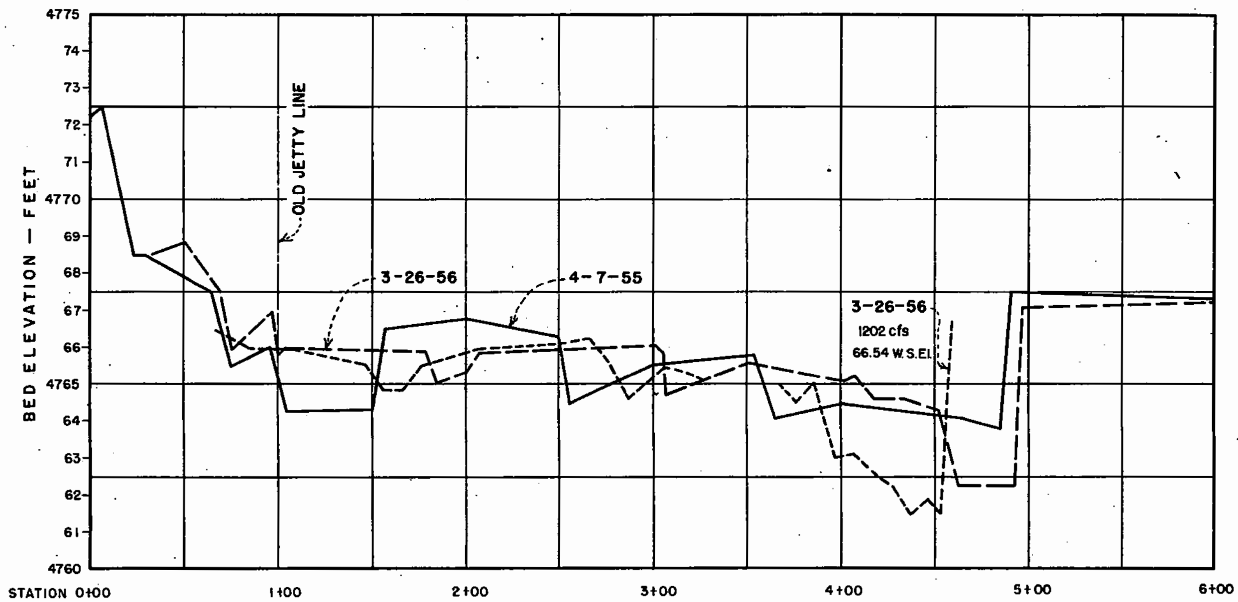
CASA COLORADA CHANNELIZATION

CROSS SECTIONS AT RANGE 118.15

FIELD DATA

FIGURE 23
REPORT HYD. 477

564



MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

CROSS SECTIONS ABOVE BOSQUE BRIDGE

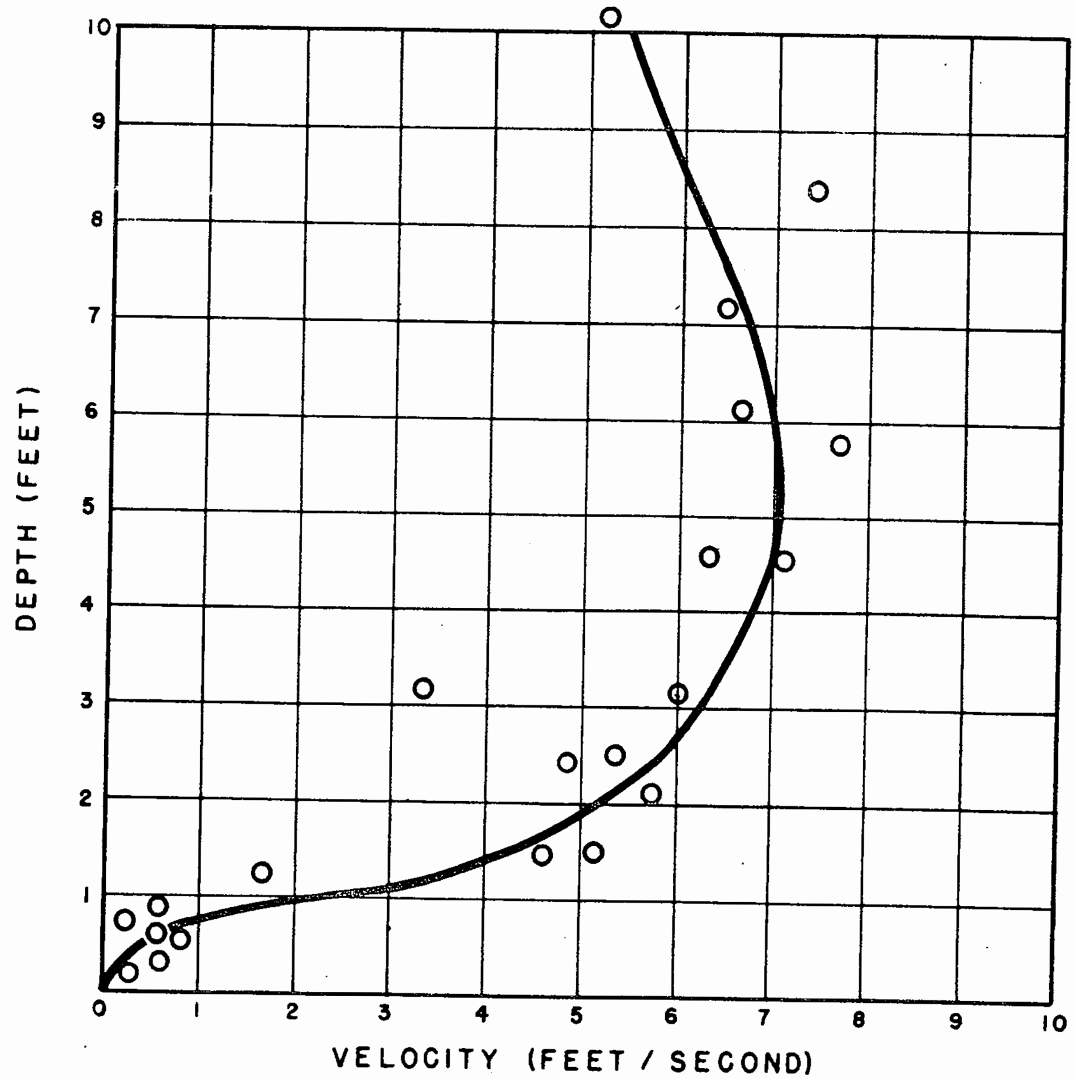
FIELD DATA

FIGURE 24
REPORT HYD. 477

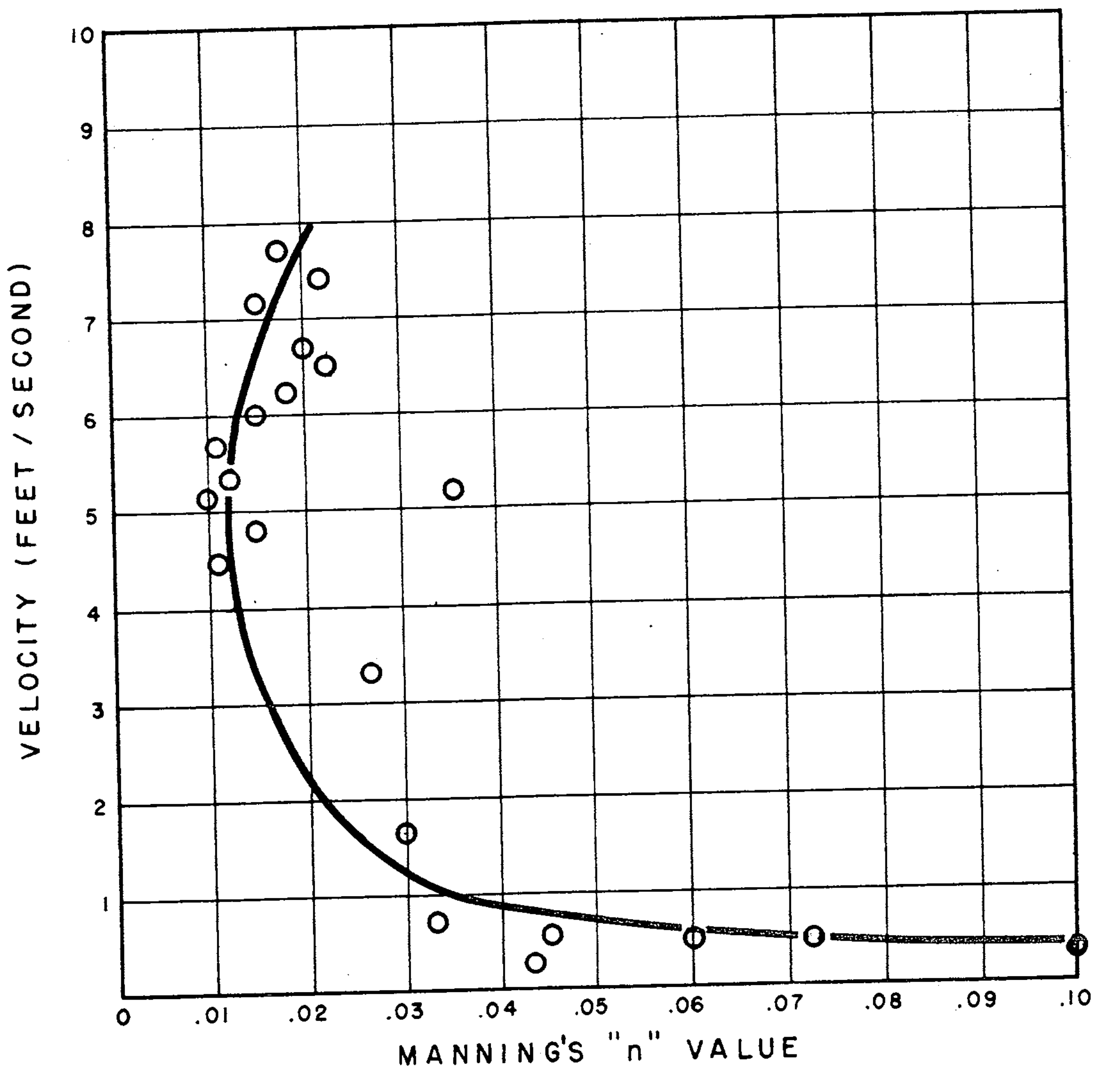
964

Figure 10
Report Hyd. 503

ATTACHED To Show missing data pts. in Figs 25—27.
RAD



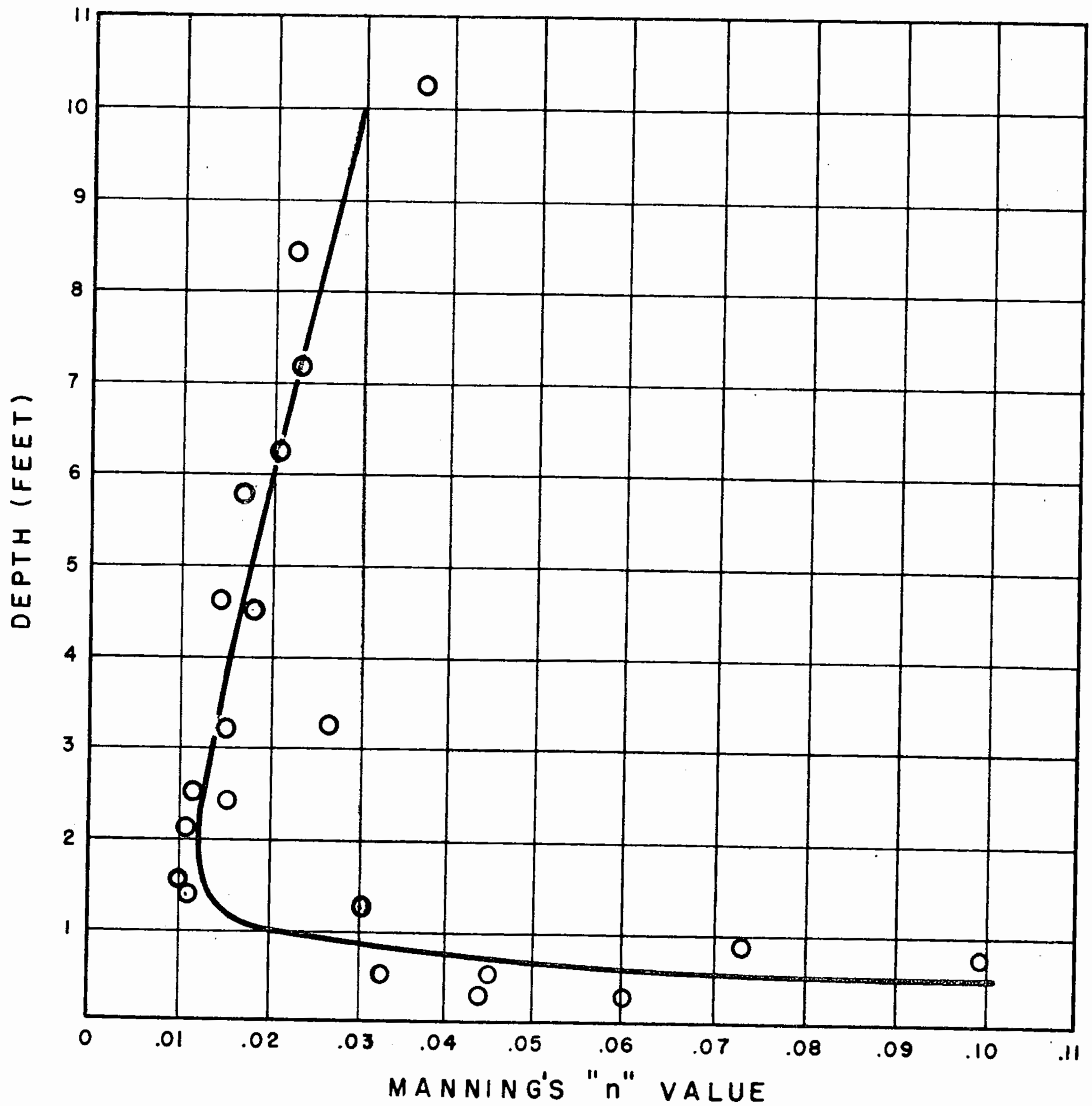
DEPTH VERSUS VELOCITY
PROTOTYPE DATA



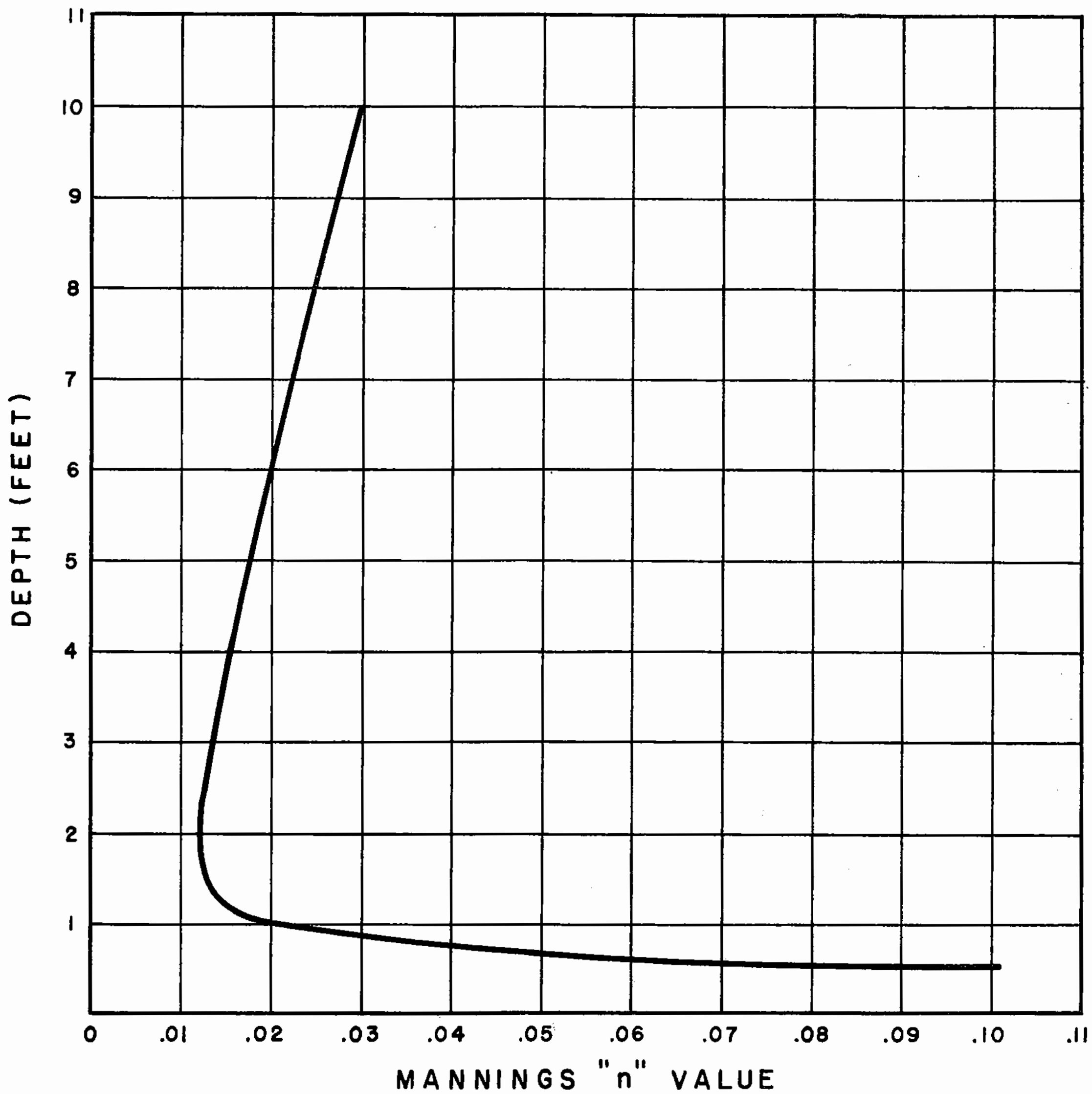
MANNING'S "n" VALUE VS. VELOCITY

PROTOTYPE DATA

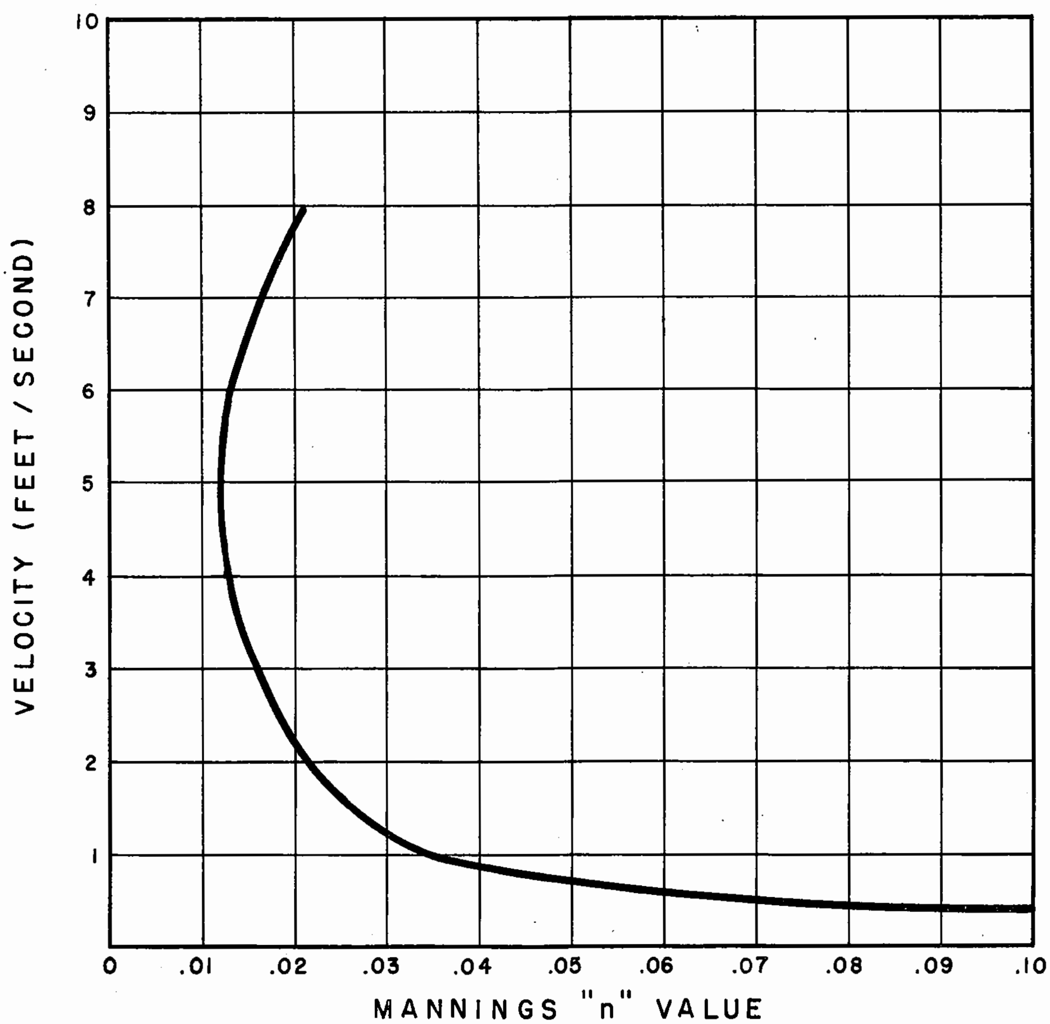
Figure 8
Report Hyd. 503



MANNING'S "n" VALUE VS. DEPTH
PROTOTYPE DATA



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
MANNING "n" VALUE VS DEPTH
PROTOTYPE DATA

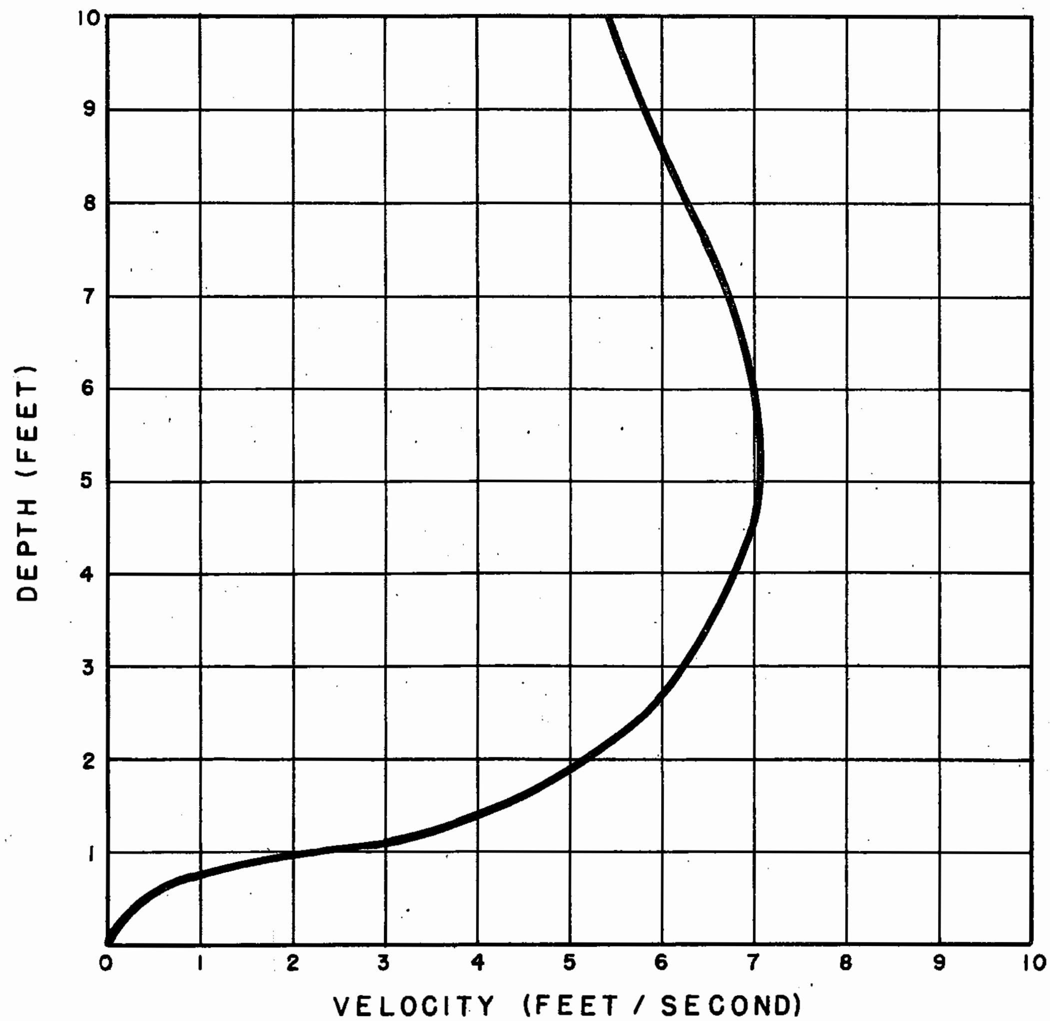


MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

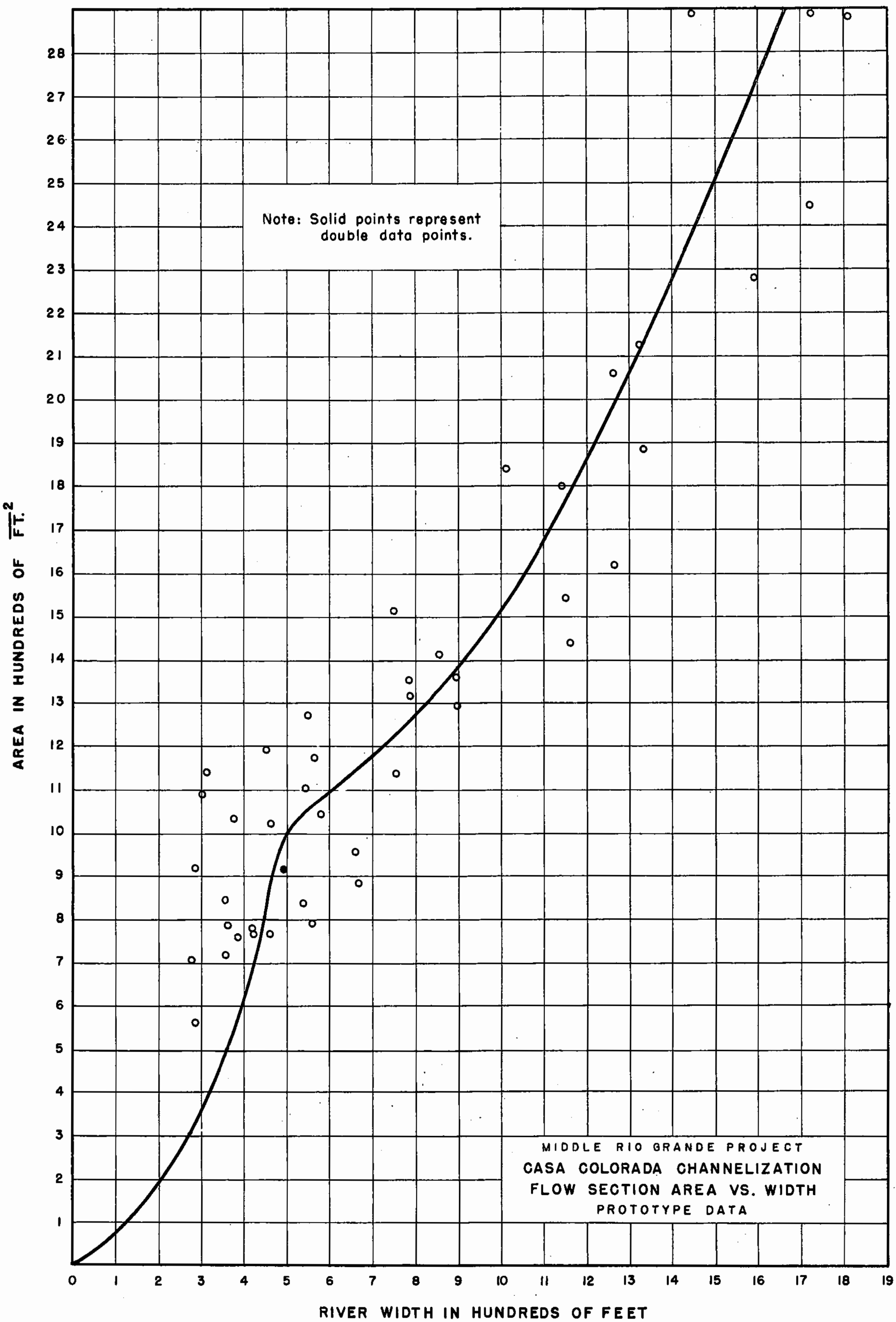
MANNING "n" VALUE VS VELOCITY

PROTOTYPE DATA

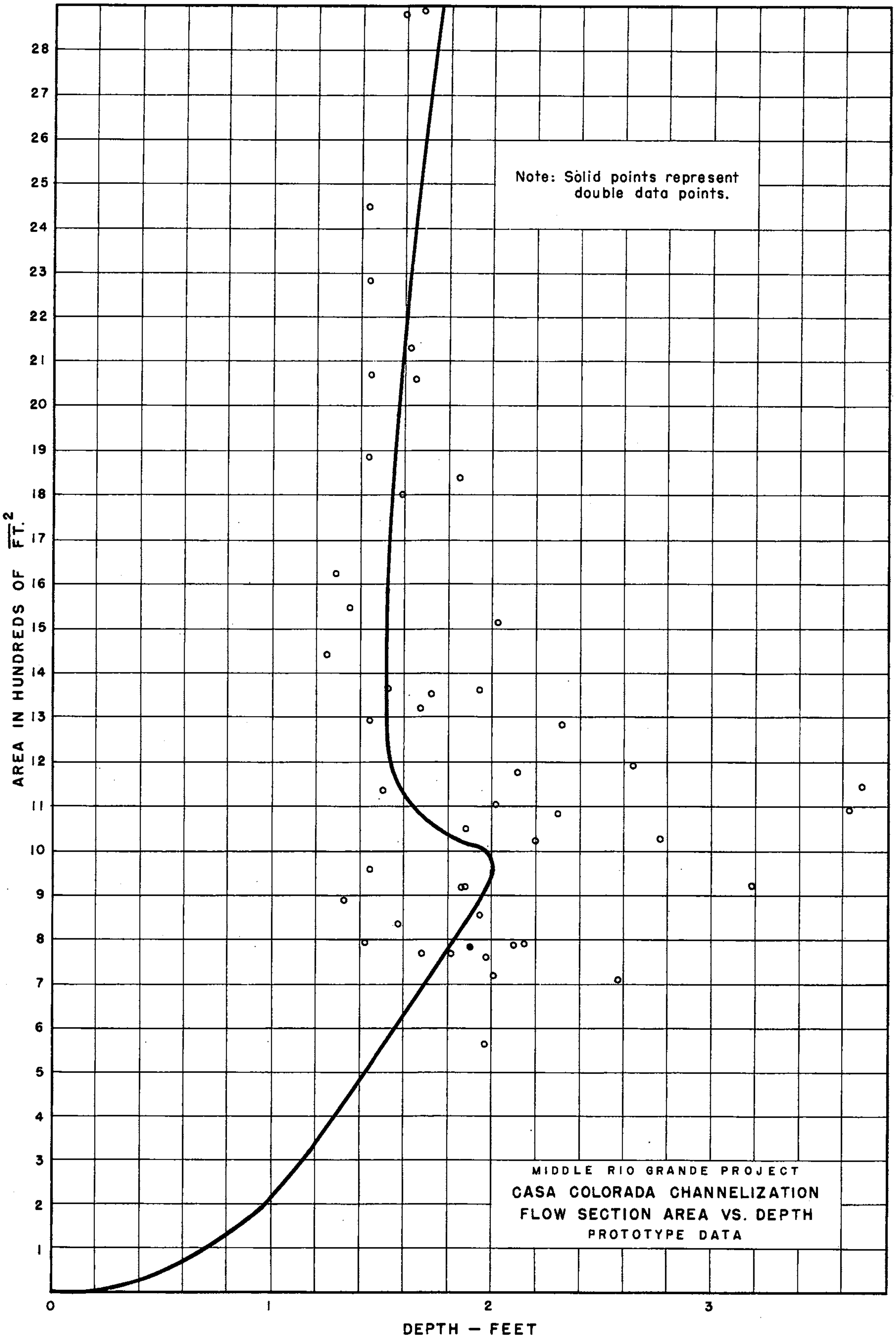


MIDDLE RIO GRANDE PROJECT

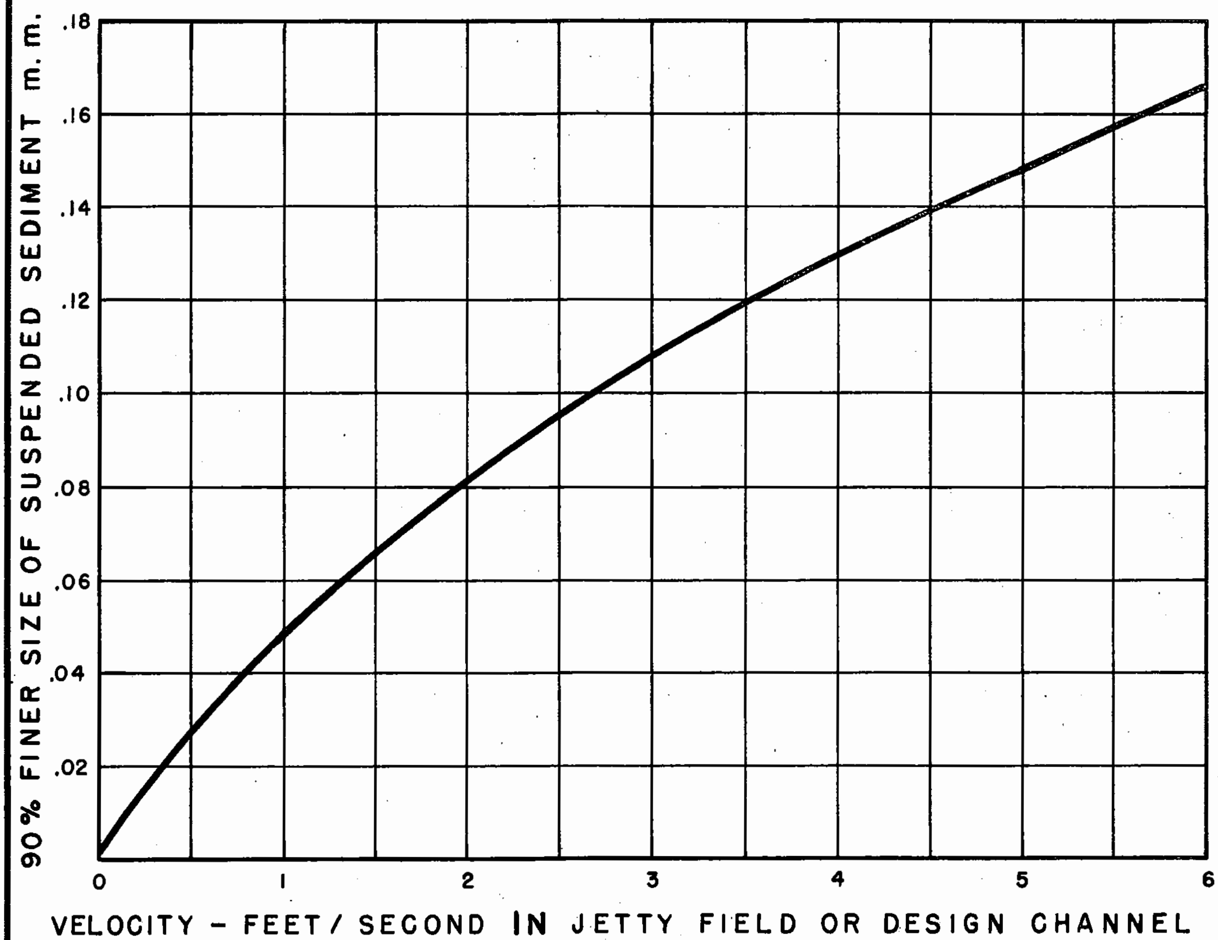
CASA COLORADA CHANNELIZATION
DEPTH VERSUS VELOCITY
PROTOTYPE DATA



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
FLOW SECTION AREA VS. WIDTH
PROTOTYPE DATA



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
FLOW SECTION AREA VS. DEPTH
PROTOTYPE DATA

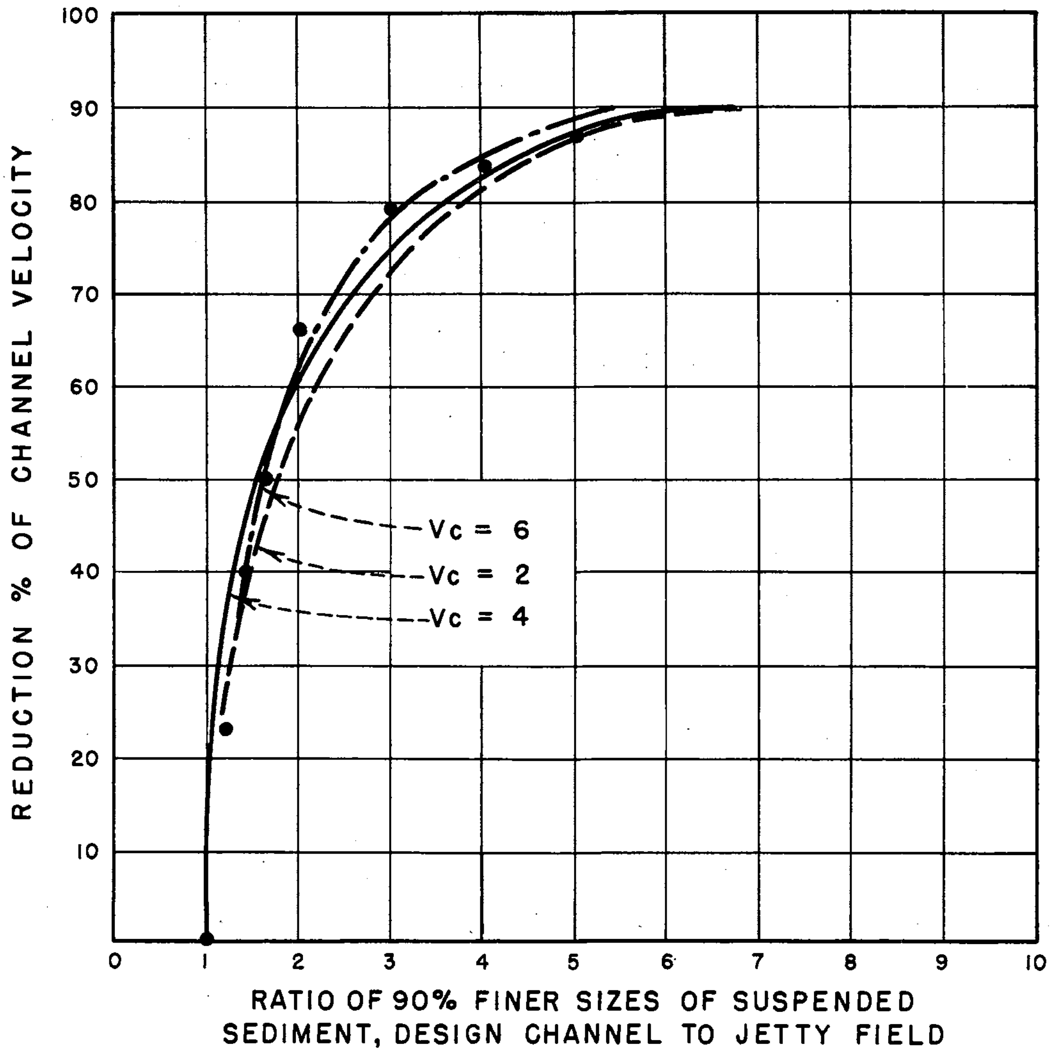


MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

90% FINER SIZE OF SUSPENDED SEDIMENT VERSUS VELOCITY OF JETTY FIELD OR DESIGN CHANNEL

PROTOTYPE DATA

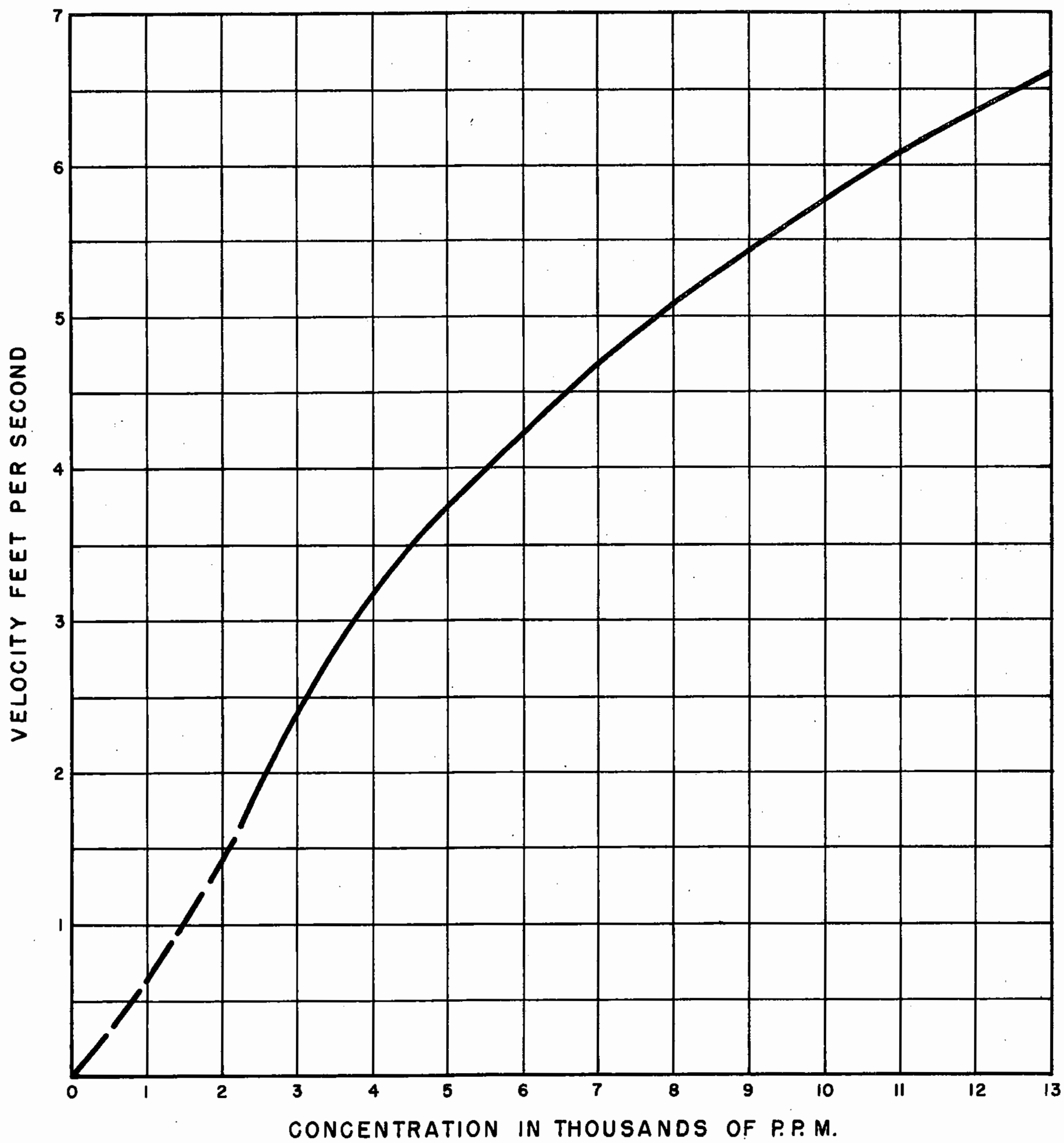


MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION

REDUCTION % OF CHANNEL VELOCITY VERSUS RATIO OF 90% SIZES OF SEDIMENT, DESIGN CHANNEL TO JETTY FIELD

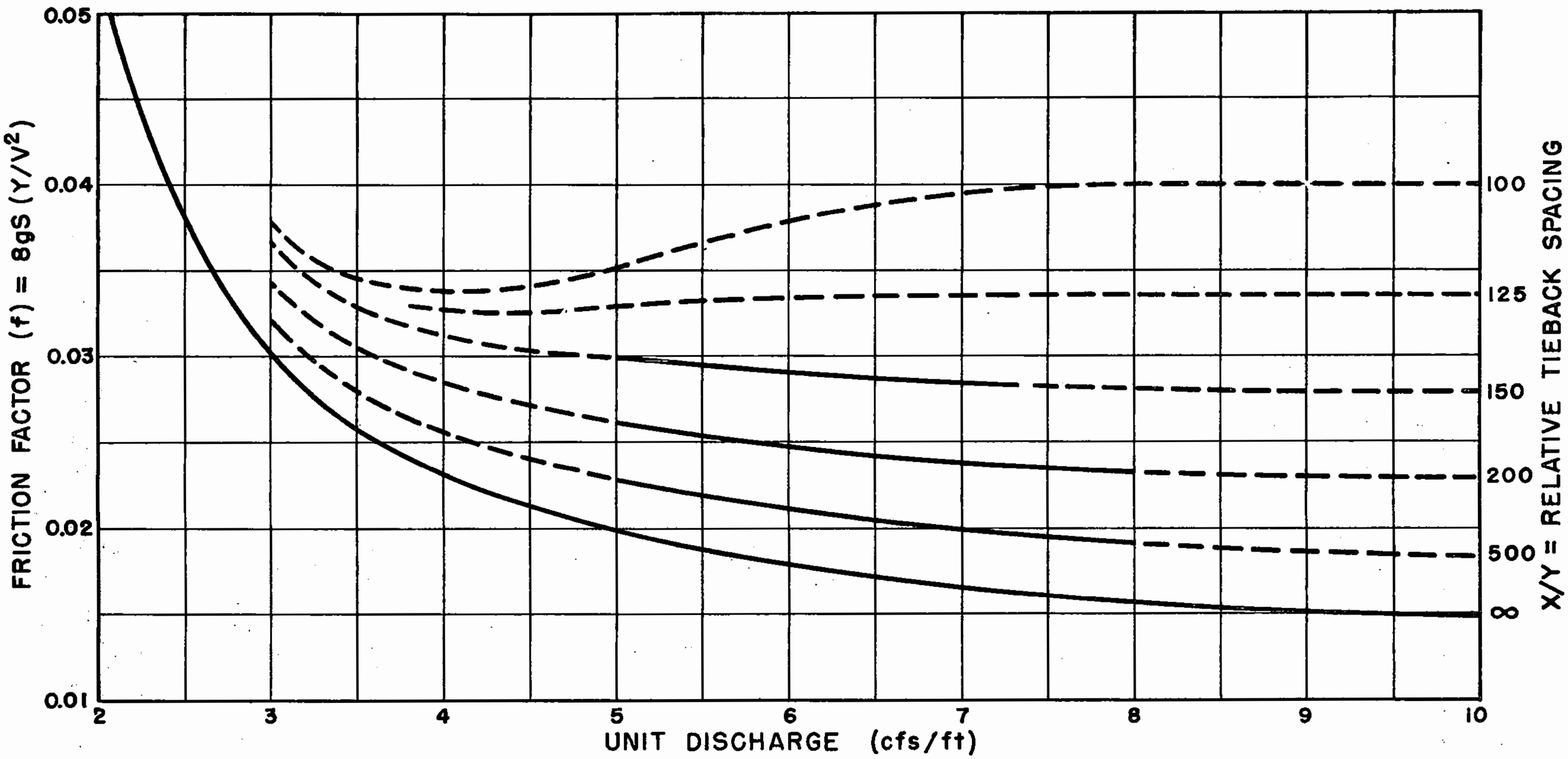
PROTOTYPE DATA



MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION
VELOCITY VERSUS CONCENTRATION

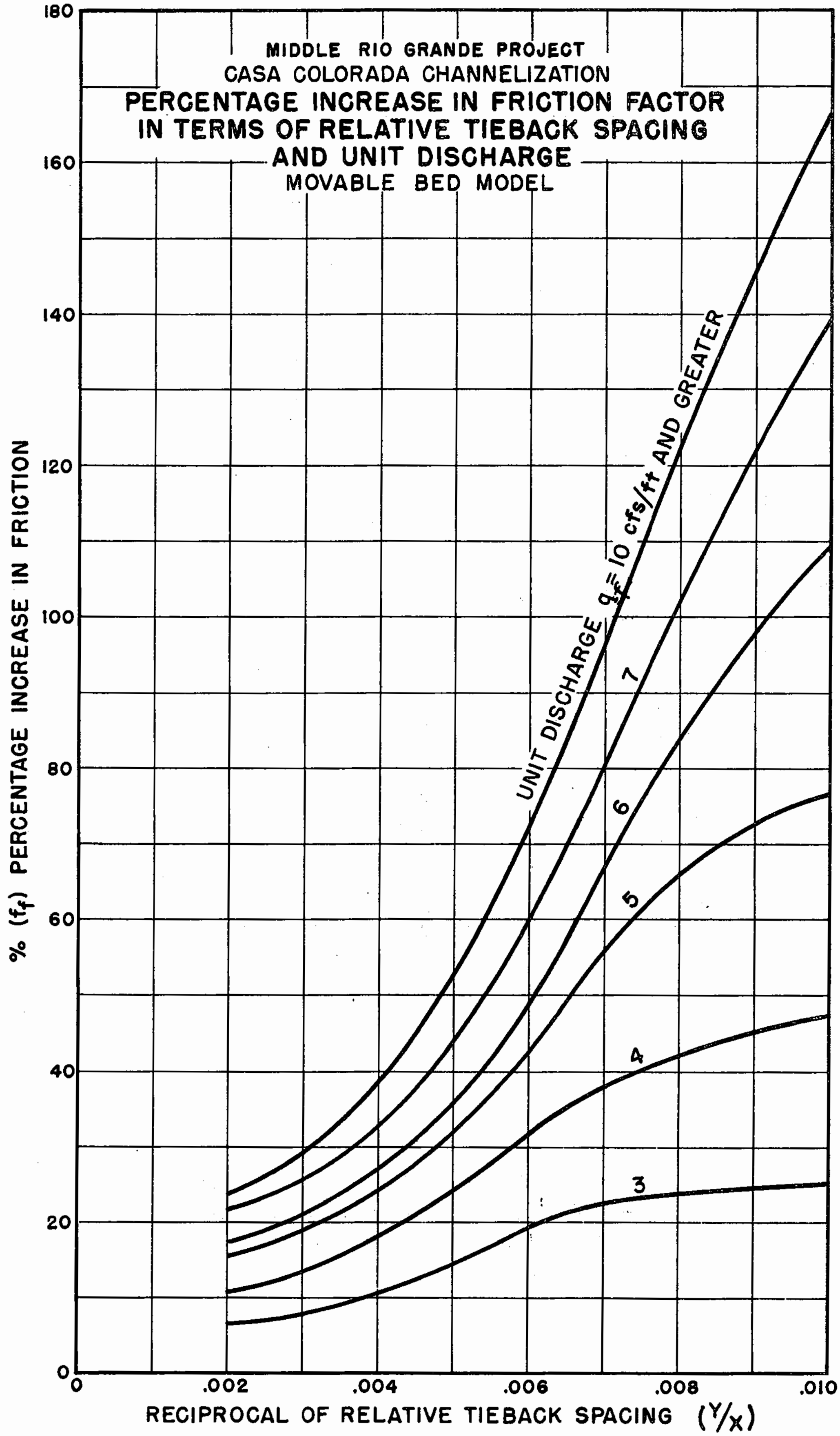
PROTOTYPE DATA

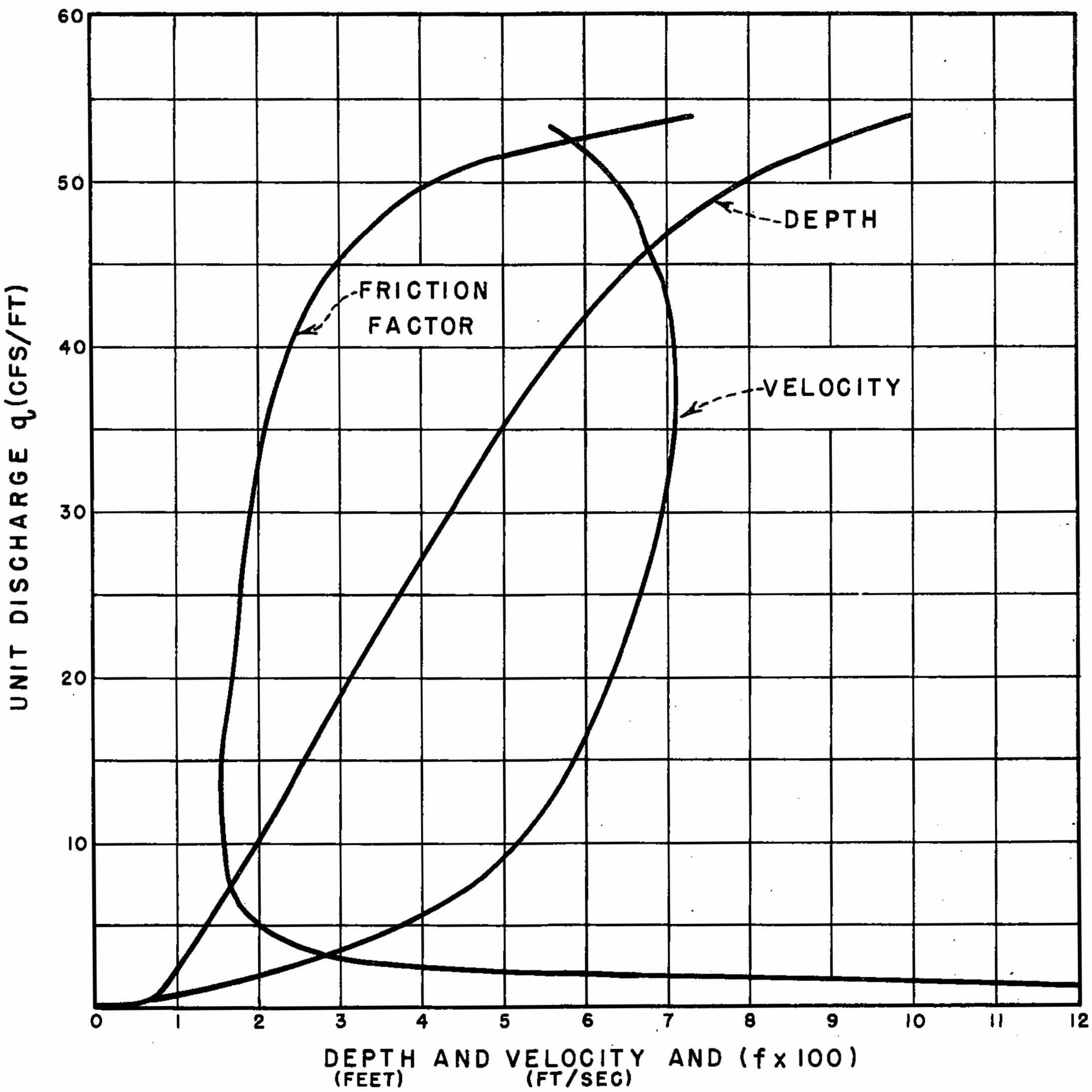


MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
FRICTION FACTOR IN TERMS OF RELATIVE TIEBACK SPACING AND UNIT DISCHARGE
MOVABLE BED MODEL
SCALE: 1:140 HORIZONTAL — 1:22 VERTICAL

FIGURE 34
REPORT HYD. 477

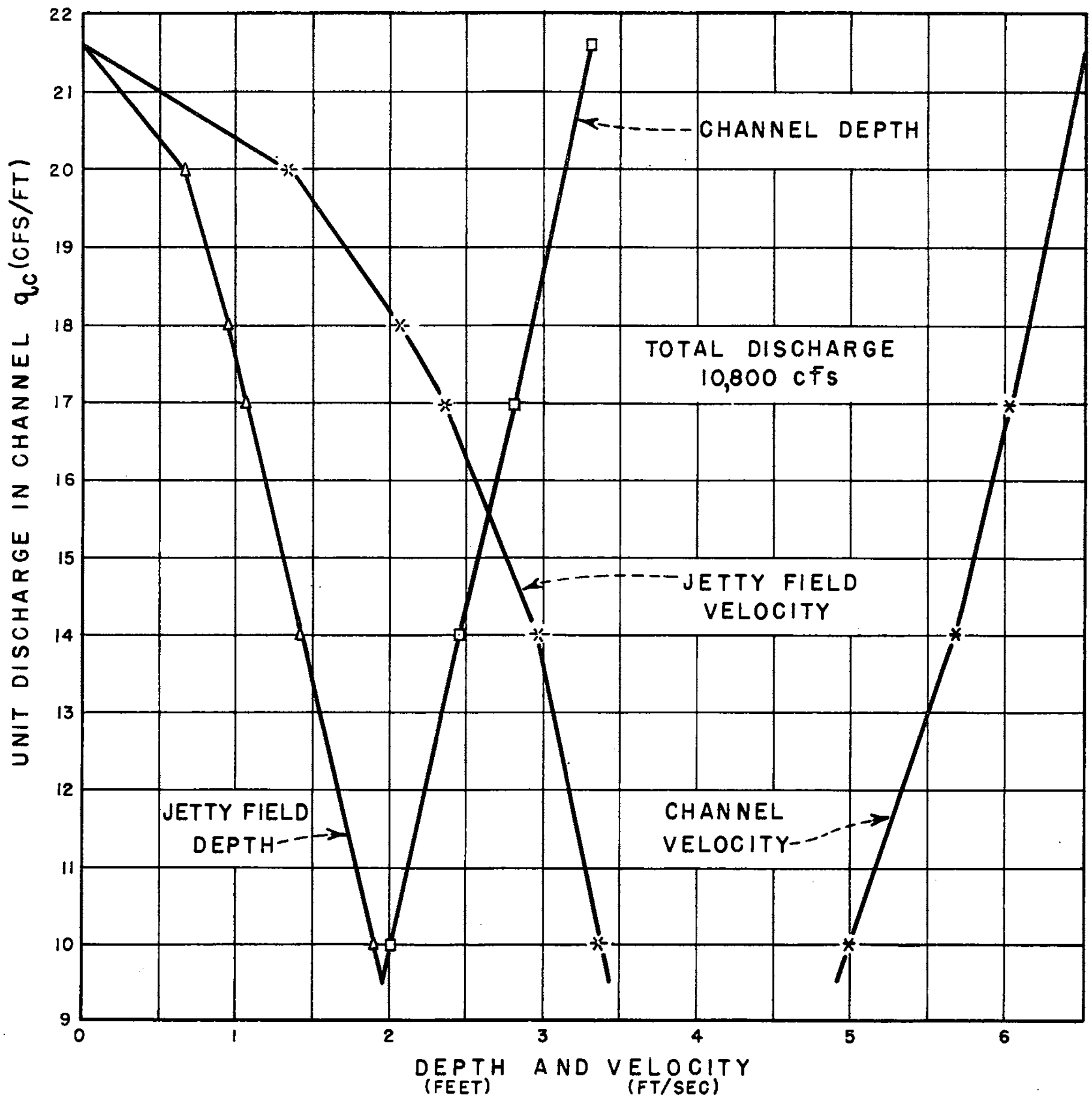
564


MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
PERCENTAGE INCREASE IN FRICTION FACTOR
IN TERMS OF RELATIVE TIEBACK SPACING
AND UNIT DISCHARGE
MOVABLE BED MODEL
% (f_f) PERCENTAGE INCREASE IN FRICTION
RECIPROCAL OF RELATIVE TIEBACK SPACING (Y/X)
UNIT DISCHARGE q_f = 10 cfs/ft AND GREATER
7
6
5
4
3
0
20
40
60
80
100
120
140
160
180
.002
.004
.006
.008
.010



MIDDLE RIO GRANDE PROJECT

CASA COLORADA CHANNELIZATION
DEPTH, VELOCITY AND FRICTION FACTOR
VERSUS UNIT DISCHARGE
PROTOTYPE DATA



MIDDLE RIO GRANDE PROJECT
CASA COLORADA CHANNELIZATION
COMPUTED DATA

TABLES

Table 1

RELATIVE CHANGE IN BED ELEVATIONS BETWEEN CHANNEL AND JETTY FIELD--RUNS 8 THROUGH 13
Movable Bed Model, Casa Colorada
(Middle Rio Grande Project)

Range		Difference in jetty field and channel bed elevations	Change in difference since Run 8				
	Test number	8	9	10	11	12	13
	Discharge-cfs	5,000	10,000	10,000	15,000	10,000	5,000
	Time in days	31	9.2	6.9	3.6	16	31
117.81		3.43	-0.31	2.42	1.58	-1.23	-1.76
117.62		-0.22	1.56	2.15	4.29	1.14	2.02
117.43		0.88	-0.04	-0.37	1.10	0.66	0.06
117.05		2.53	-0.29	0.95	-1.28	-3.23	-3.28
116.67		1.12	1.41	1.32	2.27	0.72	0.91
116.47		-0.11	1.21	0.22	0.29	1.06	0.21
		Σ =	+3.54	+6.69	+8.25	-0.58	-1.86
Average accumulated change in jetty field elevation (ft) since Run 8			+0.59	+1.12	+1.38	-0.15	-0.31

Table 2

ANALYSES OF RIVERBED MATERIAL BEFORE JETTY FIELD INSTALLATION
Casa Colorada Prototype Reach
(Middle Rio Grande Project)

Table 2

Range	Station	Total depth (ft)	Sample depth 1/ (ft)	Specific gravity	Volume weight (lbs/ cu ft)	Porosity (%)	.002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
							Percent finer than (size in millimeters)														
119.31	1+81	9.2	7.9	2.65	97.5	40.8						0.6	3.1	18.4	76.8	92.8	96.4	97.7	98.6	100	
	2+34	9.8	8.5	2.66	99.4	40.2						0.1	2.4	20.7	75.2	86.9	89.5	90.9	92.1	94.6	100
	4+00	9.3	7.0	2.64	98.1	40.5						0.9	3.4	27.0	73.2	88.5	91.6	93.1	95.6	98.4	100
	5+94	9.2	0.0-0.4									52.9	67.1	92.5	99.0	99.7	99.8	99.9	100		
	5+94	9.2	0.4-1.2									7.7	12.9	45.0	98.1	99.6	99.8	99.9	99.9	100	
	5+94	9.2	1.2-3.0									46.3	59.4	85.3	98.5	99.8	100				
	5+94	9.2	3.0-6.2	2.61	98.8	39.5						0.7	2.4	23.0	69.1	91.5	96.1	97.8	98.7	100	
	8+46	8.6	0.0-1.0									21.9	32.5	69.3	97.6	99.6	99.9	99.9	100		
	8+46	8.6	1.0-5.9	2.62	78.1	52.3						1.7	6.5	27.8	73.6	86.6	91.2	93.8	95.7	97.2	100
	12+26	8.5	0.0-2.6									2.7	6.1	30.1	88.5	97.5	99.3	99.7	100		
119.31	12+26	8.5	2.6-6.6	2.63	104.4	36.5						2.2	4.4	16.0	55.5	85.5	93.8	96.3	97.5	98.7	100
119.12	4+63	8.3	7.3	2.63	98.1	40.3						1.2	7.2	36.1	87.6	96.3	98.3	99.0	99.6	100	
	5+06	8.9	7.1	2.65	100.6	39.2						0.1	2.2	19.4	86.0	97.2	98.9	99.6	100		
	6+54	9.2	7.8	2.63	101.3	38.4						1.5	5.2	31.2	84.4	96.5	98.8	99.7	99.9	100	
	7+68	8.9	8.9	2.65	96.3	41.9						1.7	7.5	37.7	87.5	93.3	95.0	95.4	95.7	97.3	100
	8+32	8.6	8.6	2.63	81.9	50.2						2.0	7.8	49.4	95.7	99.1	99.9	100			
119.12	9+58	9.3	8.4	2.65	101.9	38.5						1.2	6.7	34.7	80.2	91.1	95.1	98.2	99.5	100	
118.93	3+28	8.6	7.8	2.65	100.6	39.2						0.2	2.4	20.4	79.3	92.9	95.5	96.5	97.7	99.7	100
	4+95	8.6	8.0	2.63	105.6	35.7						1.0	2.1	12.0	52.3	77.5	86.6	91.3	94.8	96.6	100
	6+58	7.0	7.0	2.65	124.4	24.9						0.7	2.6	18.2	54.6	71.0	76.5	79.3	82.2	89.1	100
	7+61	7.7	0.0-1.8									1.8	7.6	40.3	95.8	98.7	94.6	100			
	7+61	7.7	1.8-5.6	2.63	100.6	38.8						1.5	4.7	21.1	60.2	75.9	80.9	82.8	84.7	89.5	100
	8+96	0.1	0.0-1.3									3.5	6.8	22.2	93.9	99.4	99.9	100			
	8+96	8.1	1.3-6.9	2.65	99.4	40.0						1.0	3.5	19.7	61.0	78.4	85.0	88.0	90.2	92.1	100
	9+13	9.3	0.0-1.1									94.1	96.4	98.1	99.5	99.8	99.9	100			
118.93	9+13	9.3	1.1-8.3	2.65	113.8	31.3						0.5	3.1	17.2	60.2	83.1	87.7	90.0	91.6	93.1	100

Table 2

Range	Station	Total depth	Sample depth 1/	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
118.74	3+20	9.4	7.6	2.68	81.9	51.1						3.7	13.7	55.9	91.6	95.0	96.7	97.7	98.3	100	
	4+07	9.4	9.4	2.66	93.8	43.6						0.7	2.7	17.1	82.4	96.6	98.8	99.5	99.7	100	
	4+94	9.1	7.4	2.65	86.9	47.5						1.7	6.6	33.4	81.7	90.6	92.9	93.7	94.7	96.2	100
	5+83	9.1	8.2	2.66	100.0	39.8						0.6	5.7	32.3	87.0	92.3	93.3	93.8	94.2	94.4	100
118.74	6+47	8.1	7.5	2.64	105.6	36.0						0.8	2.9	21.0	54.9	71.8	78.4	82.2	86.2	92.4	100
118.55	3+62	7.1	0.0-2.1									84.8	90.7	97.3	99.4	99.9	100				
	3+62	7.1	2.1-5.0	2.64	88.1	46.6						1.6	5.4	29.1	76.5	88.5	92.6	96.4	97.8	98.5	100
	4+40	8.9	7.8	2.64	98.8	40.2						0.5	3.2	18.7	72.4	90.6	95.2	97.2	98.8	100	
	5+31	6.9	5.8	2.66	85.6	48.5						0.9	2.7	20.2	71.9	87.0	90.1	91.4	92.1	93.5	100
	6+26	7.5	6.0	2.66	104.4	37.2						0.9	3.6	29.0	68.9	85.7	89.8	91.8	93.1	94.5	100
118.55	7+39	7.4	6.7	2.65	103.8	37.4						0.3	2.0	15.4	64.2	77.3	82.8	86.3	89.1	92.6	100
118.35	3+72		0.0-1.0									72.6	84.7	95.8	97.9	98.9	99.5	99.9	100		
	3+72		1.0-2.6									20.2	24.9	49.0	91.2	99.3	99.9	100			
	3+72		2.6-3.0									4.1	6.5	23.7	61.9	75.6	78.1	79.6	81.9	92.3	100
	4+38	7.5	5.5	2.62	90.0	45.0						1.7	4.3	23.0	58.5	75.3	80.8	84.4	88.1	95.6	100
	5+19	8.7	7.7	2.67	100.6	39.7						0.3	4.0	37.5	74.8	87.7	91.2	92.4	93.1	94.8	100
	6+19	8.9	7.3	2.63	101.3	38.4						0.6	2.7	16.7	60.8	80.2	86.0	88.4	91.0	95.9	100
118.35	6+75	8.5	7.4	2.65	93.8	41.5						2.2	10.1	45.9	89.2	94.7	96.1	96.7	97.0	98.1	100
118.15	2+10	9.6	7.6	2.66	100.0	39.8						0.5	3.2	18.6	67.6	82.6	86.7	89.0	90.0	90.7	100
	2+90	9.0	7.2	2.65	97.5	41.1						1.0	3.9	23.2	77.8	92.8	95.7	96.8	97.3	98.4	100
	3+58	8.4	8.4	2.63	105.6	35.7						1.3	5.4	29.1	62.3	81.0	86.2	89.0	92.0	94.6	100
	4+50	9.4	0.0-0.8									14.9	26.5	81.4	99.9	100					
	4+50	9.4	0.8-8.6	2.65	98.1	40.8						1.5	4.5	16.7	58.1	84.0	92.3	95.3	96.6	97.7	100
	5+49	9.6	0.0-2.8									39.4	53.4	78.9	99.2	99.7	100				
118.15	5+49	9.6	2.8-6.3	2.64	83.1	49.6						5.4	16.0	38.9	91.3	97.5	98.9	99.9	100		
117.98	5+50	9.0	0.0-1.3									0.6	3.5	23.5	93.9	99.1	100				
	5+50	9.0	1.3-7.7	2.64	100.6	39.3						1.5	4.7	23.2	82.5	93.1	95.7	96.6	97.4	99.0	100
	6+37	7.7	6.9	2.62	90.0	45.0						2.3	6.5	24.7	79.8	91.6	95.0	96.6	97.7	100	
	8+61	9.0	7.4	2.61	101.9	37.5						1.4	4.9	22.0	66.9	82.6	89.2	92.5	94.6	98.8	100
117.98	9+23	8.7	6.5	2.61	93.8	42.5						3.0	11.0	45.4	83.4	93.8	96.3	97.4	98.1	98.4	100

Table 2

Range	Station	Total depth	Sample depth 1/	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
117.81	7+93	9.2	7.5	2.62	100.6	38.5						1.9	7.0	36.0	76.0	88.1	92.2	93.5	94.2	94.4	100
	8+55	9.5	8.0	2.64	100.6	39.0						1.3	4.2	26.3	67.1	84.7	89.7	92.4	94.5	98.0	100
	9+51	7.5	7.0	2.73	99.4	41.8						2.2	11.4	35.7	64.2	82.9	88.9	91.2	92.5	95.5	100
	12+72	9.8	0.0-0.4									30.7	39.2	80.0	99.5	100					
	12+72	9.8	0.4-2.5									1.1	5.7	39.3	96.0	99.8	100				
	12+72	9.8	3.5-3.1									1.7	4.3	18.0	73.1	96.0	99.0	99.8	100		
	12+72	9.8	3.1-8.6	2.64	92.5	43.9						1.1	3.5	21.6	69.7	89.4	94.5	96.2	97.9	99.3	100
	13+77	9.5	0.0-0.4									24.1	43.8	71.3	93.8	97.6	99.5	100			
117.81	13+77	9.5	0.4-8.0	2.66	101.9	38.7						1.1	3.2	15.4	50.9	75.4	81.1	83.4	86.1	93.6	100
117.62	8+45	9.5	7.6	2.63	98.1	40.3						0.7	3.4	20.3	75.2	90.5	94.4	95.8	96.7	97.6	100
	9+29	8.5	6.7	2.64	96.3	41.7						1.4	3.9	24.1	64.8	81.3	86.4	88.7	90.7	92.8	100
	10+95	7.4	0.0-1.4									32.3	36.9	66.1	97.6	99.5	99.9	100			
	10+95	7.4	1.4-6.0	2.64	90.0	45.4						1.4	3.6	18.8	66.8	85.8	91.5	93.9	94.5	96.1	100
	14+24	8.5	0.0-1.5									82.8	87.4	98.6	99.7	99.9	100				
	14+24	8.5	1.5-5.5	2.63	102.5	37.6						0.9	3.7	19.7	66.1	85.9	90.9	92.9	93.8	96.7	100
	15+58	9.4	0.0-2.5									1.4	7.3	68.2	98.3	99.6	99.9	99.9	100		
117.62	15+58	9.4	2.5-6.6	2.63	102.5	37.6						0.4	2.6	20.4	73.9	90.7	94.9	97.3	98.5	100	
117.43	10+45	9.4	0.0-0.8									31.9	37.3	68.6	99.5	100					
	10+45	9.4	0.8-1.9									2.8	12.2	78.3	96.1	97.1	98.7	100			
	10+45	9.4	1.9-7.5	2.67	93.1	43.5						2.7	10.7	50.0	87.9	96.6	98.4	99.3	100		
	10+94	9.7	8.5	2.66	99.4	40.2						0.8	3.3	22.1	86.4	96.7	98.7	99.4	99.9	100	
	12+01	9.0	7.8	2.66	73.1	56.0						0.8	5.5	27.8	86.6	95.4	97.5	98.4	99.3	100	
	12+89	8.2	8.2	2.65	101.9	38.5						1.4	8.0	43.0	89.2	94.8	95.6	95.9	96.2	97.4	100
117.43	14+72	9.5	8.2	2.62	90.6	44.7						0.6	3.2	23.5	80.6	94.6	97.5	98.6	99.3	100	
117.24	13+81	8.7	6.5	2.66	94.4	43.2						0.9	4.2	24.7	87.5	96.2	97.4	98.1	98.4	100	
	14+96	8.4	6.2	2.62	95.6	41.6						1.2	4.0	30.3	87.2	94.2	95.3	95.7	95.9	98.7	100
	15+57	7.8	6.2	2.62	94.4	42.4						0.9	4.1	27.2	83.7	93.4	95.2	96.1	96.7	97.5	100
	16+54	8.8	7.3	2.65	96.3	41.9						1.2	4.7	22.6	74.4	91.4	93.4	94.0	94.8	94.8	100
	17+49	9.6	0.0-0.6									26.7	35.7	45.9	98.9	99.6	99.7	99.8	100		
	17+49	9.6	0.6-2.5									0.7	4.7	42.6	85.3	95.3	97.9	99.0	99.6	100	

Table 2

Range	Station	Total depth (ft)	Sample depth [1] (ft)	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
117.24	17+49	9.6	2.5-8.4	2.64	100.6	39.0						2.1	4.7	26.2	79.5	92.5	94.5	95.6	96.5	96.9	100
117.05	13+74	8.4	0.0-2.6									6.1	24.2	87.5	96.8	97.7	99.0	100			
	13+74	8.4	2.6-7.9	2.62	98.1	40.1						1.9	4.1	23.1	83.7	97.3	98.7	99.1	99.6	100	
	15+03	9.2	8.6	2.70	94.4	44.1						1.9	6.1	26.5	86.8	97.9	99.2	99.8	100		
	17+00	9.7	8.2	2.65	103.1	37.7						1.4	5.7	33.5	75.8	85.6	86.9	87.6	88.7	90.9	100
117.05	17+52	9.2	7.2	2.61	96.9	40.6						1.0	3.4	25.5	78.0	91.3	93.9	95.2	96.0	97.6	100
116.87	13+25	9.2	7.5	2.72	104.4	38.6						2.0	5.7	25.4	73.8	89.0	92.7	94.7	96.0	97.6	100
	13+75	9.2	6.9	2.62	106.9	34.4						0.4	3.6	19.8	74.9	89.8	92.5	93.5	94.1	95.5	100
	14+91	8.9	8.7	2.57	91.3	43.2						1.2	5.6	28.8	81.8	93.9	96.1	97.0	97.5	100	
	15+80	7.9	6.3	2.61	91.3	44.1						2.1	7.0	29.3	87.0	95.7	97.5	98.5	99.3	100	
	17+31	9.2	0.0-2.9									37.3	56.8	88.1	99.8	100					
116.87	17+31	9.2	2.9-5.7	2.69	95.6	43.1						1.4	4.2	23.0	79.3	85.8	87.5	88.3	88.9	89.2	100
116.67	8+02	7.6	4.3	2.63	111.3	32.7						0.5	2.6	17.1	85.1	95.9	97.2	97.6	97.8	98.5	100
	8+58	9.0	7.5	2.58	96.3	40.3						2.2	7.5	27.7	73.7	87.3	91.1	93.5	95.1	97.6	100
	9+31	9.9	8.5	2.65	83.1	49.8						7.5	11.6	24.5	66.5	88.1	93.7	95.7	97.8	98.9	100
	10+54	9.5	8.3	2.60	100.0	38.5						2.5	6.5	30.4	68.3	86.1	92.1	94.9	97.2	100	
116.67	10+98	9.9	9.3	2.67	86.9	47.9						2.1	6.8	23.2	54.7	74.3	81.0	84.6	87.9	91.4	100
116.47	1+82	9.0	8.5	2.64	94.4	43.6						1.4	5.1	31.7	86.1	97.2	98.8	99.5	100		
	2+87	9.0	7.4	2.61	103.8	36.4						3.7	6.3	18.0	58.7	81.1	89.2	91.3	92.9	93.3	100
	3+84	9.2	8.8	2.65	96.3	41.9						2.2	6.0	26.5	73.5	91.4	95.7	97.9	99.2	100	
	4+56	8.9	7.9	2.64	97.5	40.9						0.4	2.7	17.9	48.5	65.7	73.1	77.4	80.4	85.4	87.3
116.47	6+33	8.0	6.6	2.60	94.4	38.8						1.2	4.4	23.8	71.8	88.5	91.8	93.2	94.1	94.7	100
116.26	0+81	9.5	8.7	2.67	96.3	42.3						7.6	11.3	20.6	89.5	95.6	97.0	99.2	99.5	100	
	1+84	7.6	0.0-0.4	2.66								1.2	5.8	39.9	93.9	98.1	99.5	100			
	1+84	7.6	0.4-1.2	2.80								0.5	3.7	42.6	94.5	98.9	99.6	100			
	1+84	7.6	1.2-3.5	2.64								0.9	6.2	33.0	85.2	96.7	98.6	99.1	99.5	100	
	1+84	7.6	3.5-5.0	2.64								0.2	1.6	11.9	69.4	94.0	97.5	98.5	99.9	100	
	1+84	7.6	5.0-6.8	2.67								0.2	2.2	15.8	37.5	74.4	86.9	91.9	94.9	100	
	1+84	7.6	6.8-7.6	2.66								0.4	4.4	41.7	93.1	99.1	99.7	100			
	2+41	8.2	0.0-0.4	2.69								0.7	6.6	56.0	97.9	99.4	99.8	99.9	100		

<u>Table 2</u>

Range	Station	Total depth (ft)	Sample depth 1/ (ft)	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
116.26	2+41	8.2	0.4-1.8	2.62								0.7	5.6	44.3	97.0	99.1	99.6	100			
	2+41	8.2	1.8-3.0	2.62								0.3	4.6	48.7	97.1	99.8	100				
	2+41	8.2	3.0-3.9	2.65								0.3	3.1	29.5	71.7	80.4	83.8	85.9	87.5	88.9	100
	2+41	8.2	3.9-4.5	2.62								0.8	2.9	26.7	77.0	89.5	93.8	96.0	96.8	100	
	2+41	8.2	4.5-6.0	2.72								0.3	2.0	18.6	57.7	83.1	92.2	95.4	97.0	100	
	2+41	8.2	6.0-7.1	2.62								0.2	2.0	11.3	52.9	79.5	86.3	88.6	89.8	91.3	100
	2+41	8.2	7.1-8.2	2.65								0.4	2.8	13.6	77.1	96.1	98.2	98.7	98.8	100	
	3+06	7.8	0.0-0.4	2.66								50.7	53.4	74.9	97.6	99.4	99.8	99.9	100		
	3+06	7.8	0.4-2.6	2.61								0.5	3.7	26.2	95.2	99.4	99.8	99.9	100		
	3+06	7.8	2.6-3.8	2.66								0.5	3.6	30.5	78.7	92.8	95.8	96.6	97.2	98.1	100
	3+06	7.8	3.8-4.4	2.63								0.5	2.8	11.4	36.9	69.8	81.1	87.1	91.7	98.5	100
	3+06	7.8	4.4-5.3	2.57								0.4	2.5	8.8	40.9	74.1	86.5	92.8	96.9	100	
	3+06	7.8	5.3-7.0	2.58								0.5	2.5	16.0	55.3	81.3	91.3	95.4	97.6	97.6	100
116.26	3+06	7.8	7.0-7.8	2.62								0.4	2.4	18.4	84.8	99.2	99.9	100			
116.26	4+46	9.4	7.2	2.62	101.9	37.8						0.9	2.7	21.1	68.8	88.4	93.9	96.7	98.4	100	
Above	1+03	9.8	9.1	2.63	95.0	42.2						1.3	7.5	34.0	83.3	95.6	97.8	98.4	98.8	98.9	100
	1+50	9.5	7.6	2.66	88.1	47.0						1.4	7.8	30.6	84.2	95.2	97.7	98.9	99.4	100	
Bosque	2+55	8.8	7.9	2.69	96.9	42.4						0.7	4.1	19.2	74.2	92.1	95.8	97.6	99.2	100	
	3+64	9.5	8.6	2.62	98.8	39.7						1.1	4.0	22.8	57.2	76.2	85.4	90.8	94.4	96.4	100
Bridge	4+68	7.8	6.8	2.64	95.6	42.0						1.5	4.7	22.0	75.8	90.9	93.7	95.0	96.7	98.8	100
115.87	1+36	9.4	8.0	2.66	96.9	41.7						1.4	7.1	40.5	94.1	99.0	99.6	99.7	100		
	3+05	7.4	5.9	2.60	86.9	46.5						20.5	24.1	43.4	80.4	93.2	95.9	96.7	97.3	97.3	100
	4+53	4.8	2.8	2.66	91.9	44.7						1.2	6.3	39.6	85.7	88.8	89.6	90.0	90.0	91.5	100
	5+24	4.0	0.0-1.0	2.62								93.5	96.1	98.9	99.7	99.9	100				
	5+24	4.0	1.0-3.8	2.60	100.0	38.5						1.2	7.7	41.3	88.5	96.6	98.3	99.1	99.8	100	
	6+53	8.4	0.0-1.1	2.58								43.1	49.7	97.2	99.2	99.8	100				
115.87	6+53	8.4	1.1-7.3	2.67	75.0	55.1						0.5	4.7	28.4	93.1	97.7	98.7	99.2	99.5	100	
940.4	4+02	9.1	7.9	2.64	102.5	37.8						1.9	4.4	23.8	55.2	75.2	83.5	87.3	90.3	95.0	100
	4+57	7.7	7.7	2.60	103.1	36.5						1.2	3.4	19.4	55.5	74.3	81.6	85.6	89.4	95.8	100

Table 2

Range	Station	Total depth (ft)	Sample depth 1/ (ft)	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
940.4	5+60	7.8	7.0	2.65	96.9	41.5						0.8	3.9	20.8	59.6	77.2	83.5	86.5	88.9	93.5	100
	7+00	9.0	0.0-4.6	2.64	98.1	40.5						2.7	5.5	32.6	88.9	95.8	98.0	99.1	99.7	100	
	7+00	9.0	4.6-7.9	2.71	47.5	72.9	40.8	49.2	59.0	80.2	88.6	95.8	97.1	98.4	99.2	99.8	100				
	7+63	8.1	0.0-6.1	2.64	100.0	39.4						4.2	11.2	36.9	89.2	95.9	97.8	99.4	100		
940.4	7+63	8.1	6.1-8.1	2.65	56.3	66.0	45.2	51.6	63.6	74.2	80.8	88.4	91.1	95.6	98.8	99.8	100				
115.52	7+21	9.6	8.8	2.63	83.8	49.0						1.6	8.3	32.9	78.5	94.6	97.3	98.4	99.1	100	
	7+73	9.4	0.0-5.7	2.63	95.6	41.8						0.8	3.0	21.4	80.0	92.4	95.2	96.4	97.1	100	
	7+73	9.4	5.7-9.4	2.59	48.1	70.3	48.4	66.4	72.0	85.4	91.4	96.5	98.6	99.5	99.8	99.9	100				
	8+12	9.2	6.2	2.68	86.3	48.5						2.3	8.6	38.6	85.0	94.0	97.0	99.0	99.4	100	
	8+39	8.8	0.0-7.3	2.69	91.9	45.4						1.4	8.0	39.7	89.5	95.3	97.4	98.8	99.4	100	
115.52	8+39	8.8	7.3-8.8	2.51	50.6	67.7	43.2	48.2	56.0	66.8	75.0	82.4	87.0	91.8	94.2	96.8	98.2	100			
115.52	8+80	8.6	0.0-6.1	2.67	92.5	44.6						0.4	3.1	20.7	86.9	95.6	97.0	97.7	98.2	98.8	100
115.52	8+80	8.6	6.1-8.6	2.60	70.0	56.9	19.0	20.8	31.2	54.2	86.0	96.6	98.9	99.4	99.7	99.9	100				
115.34	7+78	7.8	7.5	2.63	100.0	39.2						1.3	4.9	32.0	69.1	84.7	91.9	95.5	97.7	100	
	8+79	8.9	0.0-0.5									54.6	78.6	97.5	99.5	99.8	100				
	8+79	8.9	0.5-7.2	2.66	95.0	42.9						2.0	5.9	26.8	68.1	82.6	86.2	87.8	89.7	92.6	100
	11+90	9.3	8.1	2.63	101.3	38.4						2.3	5.5	25.2	69.2	87.1	92.0	92.6	93.5	96.4	100
	13+54	7.4	6.7	2.65	96.9	41.5						0.6	2.7	21.4	63.4	80.9	85.9	87.8	89.4	91.4	100
115.34	14+36	8.9	7.7	2.65	95.6	42.3						0.4	2.8	24.1	83.7	94.4	96.6	97.3	97.7	98.8	100
115.15	7+02	8.5	7.0	2.65	83.1	49.8						1.4	6.3	25.5	75.5	88.6	92.2	93.7	94.5	98.1	100
	9+02	9.6	0.0-0.6									13.1	21.0	64.8	98.3	99.5	99.8	100			
	9+02	9.6	0.6-9.0	2.64	96.3	41.7						0.8	3.5	16.9	54.8	79.4	87.9	91.5	94.0	96.1	100
	10+50	8.6	7.2	2.66	95.0	42.9						1.1	4.1	18.5	62.5	87.3	93.8	96.0	97.0	98.3	100
	11+82	8.1	6.9	2.61	101.9	37.6						1.0	4.4	24.4	62.0	81.9	87.4	89.7	91.5	94.8	100
115.15	13+50	8.0	6.5	2.63	91.9	44.1						0.6	3.5	24.1	83.1	96.8	98.7	99.3	99.8	100	
114.96	8+49	8.1	8.1	2.63	91.3	44.5						1.9	8.8	46.3	90.5	94.6	96.3	97.7	98.3	100	
	9+44	8.4	8.4	2.63	108.1	34.2						0.3	2.7	23.4	66.9	84.0	89.5	92.6	94.5	96.0	100
	10+50	8.4	7.4	2.65	100.0	39.6						0.6	2.9	19.0	60.9	79.4	84.4	86.6	88.1	91.3	100
114.96	11+88	8.3	8.3	2.66	98.1	41.0						0.7	4.0	26.7	80.4	93.7	96.9	98.0	98.8	100	
114.77	7+24	7.9	7.4	2.63	85.0	48.3						2.2	10.0	47.5	86.6	97.2	99.2	99.8	99.9	100	

Table 2

Range	Station	Total depth (ft)	Sample depth [1] (ft)	Specific gravity	Volume weight (lbs/cu ft)	Porosity (%)	Percent finer than (size in millimeters) .002	.005	.009	.019	.05	.0625	.125	.25	.5	1.0	2.0	4.0	8.0	16.0	32.0
114.77	9+05	7.9	7.2	2.66	98.8	40.6						1.0	3.4	24.3	71.5	91.0	95.5	97.5	98.7	100	
	10+48	8.0	7.6	2.67	93.1	44.2						0.7	4.2	23.3	63.5	81.9	88.2	91.1	92.9	95.3	100
	11+40	8.1	7.2	2.65	92.5	44.9						0.7	3.6	25.2	77.1	93.1	96.2	97.3	98.4	100	
114.77	12+30	8.7	8.0	2.64	100.6	39.0						2.0	6.4	32.0	75.4	87.9	91.6	93.7	94.7	96.3	100
114.55	2+56	8.8	8.2	2.65	86.9	47.5						1.1	5.6	36.5	93.9	98.0	99.3	99.9	100		
	6+16	8.8	8.1	2.65	98.1	40.8						0.4	4.4	24.4	66.4	84.5	89.4	91.4	92.6	94.8	100
	8+72	8.3	8.1	2.62	103.8	36.6						0.9	5.2	27.5	56.0	76.8	84.7	88.3	90.4	94.4	100
	9+25	7.8	7.0	2.63	100.6	38.8						0.3	1.8	13.3	61.8	78.5	83.0	84.7	86.0	92.1	100
114.55	10+05	7.8	7.1	2.60	95.0	41.5						1.4	5.9	28.0	65.5	82.6	90.2	93.7	96.3	98.4	100
114.32	6+39	8.2	7.0	2.64	78.1	52.7						2.4	5.2	24.8	55.7	74.3	81.8	85.3	87.4	90.1	100
	7+00	7.8	7.4	2.62	99.4	39.3						1.8	4.8	26.6	69.5	87.4	93.7	96.2	97.4	98.6	100
	7+49	8.7	8.4	2.65	98.1	40.8						0.6	2.8	21.3	63.0	83.0	88.3	90.4	92.1	93.5	100
114.32	8+06	8.6	7.8	2.60	92.5	43.1						1.2	5.7	32.1	70.4	84.5	88.0	89.4	90.9	93.5	100
941-A	1+30	8.9	7.3	2.64	81.9	50.4						5.4	14.3	40.1	70.8	90.7	94.5	95.7	96.5	97.7	100
	4+28	8.0	8.0	2.65	89.4	46.0						7.5	12.9	46.9	82.6	95.6	98.1	98.5	99.0	100	
	4+76	9.4	7.6	2.62	97.5	40.6						4.0	9.1	27.6	71.4	91.7	95.9	96.7	97.6	100	
	6+77	8.9	7.9	2.66	100.0	39.8						2.6	5.9	27.4	76.1	93.1	97.8	98.3	99.2	100	
941-A	7+43	8.8	8.0	2.66	101.3	39.1						1.2	3.9	18.8	68.5	88.3	93.1	95.3	96.7	98.4	100
113.92	1+22	8.5	0.0-0.5									74.4	80.2	97.0	99.1	99.7	100				
	1+22	8.5	0.5-7.9	2.65	105.0	36.6						1.4	4.9	25.5	84.6	96.6	98.3	99.0	99.6	100	
	6+09	8.1	7.6	2.63	100.6	38.8						1.5	6.1	34.4	67.6	87.3	92.3	94.3	95.4	99.1	100
	6+80	9.0	8.5	2.65	109.4	34.0						23.3	25.0	40.2	81.0	84.4	92.1	95.1	97.0	98.6	100
113.92	7+64	8.6	7.2	2.65	94.4	41.9						2.5	9.3	35.2	74.2	87.6	92.4	94.7	96.7	98.7	100
113.72	2+64	7.5	6.4	2.68	113.8	32.1						0.5	2.4	18.6	85.8	97.1	98.8	99.6	99.9	100	
	5+04	9.5	8.0	2.65	100.6	39.2						2.0	8.4	40.4	77.6	92.0	95.8	97.2	98.6	100	
	6+10	8.1	6.2	2.67	102.5	38.6						0.5	2.1	15.8	63.4	88.2	92.9	94.4	95.8	97.8	100
	7+75	9.0	8.4	2.64	105.6	36.0						0.5	2.2	16.3	53.0	76.6	84.7	88.2	90.3	92.6	100
	9+78	9.5	7.7	2.68	90.6	45.9						1.3	4.5	21.5	78.7	92.4	94.2	94.8	95.3	96.5	100
113.72	10+65	8.4	6.6	2.63	101.9	38.0						0.8	4.9	29.4	74.2	87.4	91.4	93.0	94.2	94.8	100

[1] Sample depth is depth of sample in tube and not equal to total depth because of compaction.

Table 3

AVERAGE PROTOTYPE RIVER DATA
CASA COLORADA PROTOTYPE REACH
MIDDLE RIO GRANDE PROJECT

Date	Section	Station	Width (feet)	Velocity (fps)	Average depth (feet)	Sample depth (feet)	Area (sq ft)	Q_w Discharge (cfs)	Measured slope (ft/ft)
4-25-57	Casa Colorada	118.15	337.0	2.07	1.72	1.72	578.2	1,199	0.000755
	Casa Colorada	117.43	553.0	1.49	1.43	1.43	790.0	1,178	0.000645
	Casa Colorada	116.67	285.0	2.14	1.97	1.97	560.4	1,199	0.000725
	Casa Colorada	Above Bosque Br	392.0	2.03	1.51	1.51	592.5	1,202	0.000750
	Casa Colorada	115.34	279.0	2.50	1.59	1.59	443.0	1,108	0.000800
	Casa Colorada	114.77	377.0	2.00	1.48	1.48	558.7	1,118	0.000855
5-11-57	Casa Colorada	117.81	665.0	4.17	1.33	1.33	884.5	3,691	0.000761
5-12-57	Casa Colorada	116.47	781.0	3.06	1.69	1.69	1319.7	4,035	0.000754
	Casa Colorada	117.05	490.0	4.07	1.86	1.86	911.3	3,710	0.000754
5-13-57	Casa Colorada	117.43	558.0	3.90	2.11	2.11	1175.1	4,578	0.000747
	Casa Colorada	116.67	1258.0	2.80	1.29	1.29	1620.5	4,545	0.000747
	Casa Colorada	117.62	750.0	4.08	1.51	1.51	1135.0	4,628	0.000747
6- 6-57	Casa Colorada	117.81	406.5	4.53	2.07	2.07	842.3	3,814	0.000736
	Casa Colorada	117.62	651.5	3.87	1.46	1.46	951.1	3,681	0.000736
	Casa Colorada	117.43	487.5	4.39	1.87	1.87	912.2	4,007	0.000736
6- 7-57	Casa Colorada	117.05	557.0	4.47	1.88	1.88	1045.7	4,678	0.000739
	Casa Colorada	116.67	1146.0	2.92	1.35	1.35	1545.0	4,517	0.000739
	Casa Colorada	116.47	893.0	3.07	1.45	1.45	1292.5	3,974	0.000739
6-18-57	Casa Colorada	117.81	440.0	4.92	1.94	1.94	854.3	4,202	0.000750
	Casa Colorada	116.47	381.5	5.22	1.98	1.98	753.8	3,935	0.000750
	Casa Colorada	117.05	289.0	4.19	3.18	3.18	918.3	3,851	0.000750
6-19-57	Casa Colorada	117.62	532.0	4.48	1.58	1.58	838.1	3,754	0.000771
	Casa Colorada	117.43	372.0	4.12	2.10	2.10	781.5	3,216	0.000771
	Casa Colorada	116.67	411.0	4.64	1.90	1.90	779.6	3,619	0.000771
6-27-57	Casa Colorada	117.81	366.0	4.57	2.15	2.15	787.8	3,597	0.000740
	Casa Colorada	117.05	273.0	4.91	2.58	2.58	705.6	3,467	0.000740
	Casa Colorada	117.43	358.0	4.58	2.01	2.01	719.6	3,296	0.000740
	Casa Colorada	116.47							0.000740
6-28-57	Casa Colorada	116.67	455.0	4.45	1.68	1.68	766.4	3,410	0.000754
	Casa Colorada	117.62	420.0	4.36	1.82	1.82	765.8	3,342	0.000754

Rio Grande

Date	Section	Station	Width (feet)	Velocity (fps)	Average depth (feet)	Sample depth (feet)	Area (sq ft)	Q_w Discharge (cfs)	Measured slope (ft/ft)
4-22-58	Casa Colorada	116.47	894	4.03	1.52	1.52	1,360	5,480	0.000672
	Casa Colorada	117.81	460	5.69	2.22	2.22	1,020	5,800	0.000672
4-23-58	Casa Colorada	117.05	310	5.69	3.68	3.68	1,140	6,490	0.000655
	Casa Colorada	117.43	450	5.58	2.64	2.64	1,190	6,640	0.000655
4-24-58	Casa Colorada	116.47	1,254	3.15	1.64	1.64	2,060	6,480	0.000611
	Casa Colorada	117.62	780	4.97	1.73	1.73	1,350	6,710	0.000611
4-30-58	Casa Colorada	116.47	856	4.44	1.65	1.65	1,410	6,260	0.000653
	Casa Colorada	117.05	300	5.45	3.63	3.63	1,090	5,940	0.000653
	Casa Colorada	117.43	372	5.92	2.77	2.77	1,030	6,100	0.000653
	Casa Colorada	117.81	465	5.70	2.32	2.32	1,080	6,160	0.000653
5- 1-58	Casa Colorada	116.67	700	4.41	1.94	1.94	1,360	6,000	0.000645
	Casa Colorada	117.62	545	5.30	2.02	2.02	1,100	5,830	0.000645
5-19-58	Casa Colorada	116.47	1,133	4.25	1.59	1.59	1,800	7,650	0.000652
	Casa Colorada	117.05	746	5.36	2.02	2.02	1,510	8,090	0.000652
	Casa Colorada	117.43	548	6.02	2.32	2.32	1,270	7,650	0.000652
	Casa Colorada	117.81	1,156	5.25	1.25	1.25	1,440	7,560	0.000652
5-20-58	Casa Colorada	116.67	1,713	3.16	1.43	1.43	2,450	7,750	0.000663
	Casa Colorada	117.62	1,002	4.14	1.84	1.84	1,840	7,610	0.000663
5-27-58	Casa Colorada	116.47	1,587	3.90	1.44	1.44	2,280	8,900	0.000648
	Casa Colorada	117.81	1,442	3.71	1.44	1.44	2,070	7,690	0.000648
5-28-58	Casa Colorada	116.67	1,726	3.05	1.67	1.67	2,890	8,810	0.000608
	Casa Colorada	117.05	1,804	3.03	1.60	1.60	2,880	8,740	0.000608
	Casa Colorada	117.43	1,319	4.71	1.43	1.43	1,890	8,900	0.000608
	Casa Colorada	117.62	1,314	3.88	1.62	1.62	2,130	8,260	0.000608

Table 4

**SIEVE-SIZE ANALYSIS PROTOTYPE BED MATERIAL
CASA COLORADA PROTOTYPE REACH
MIDDLE RIO GRANDE PROJECT**

Table 4

U. S. BUREAU OF RECLAMATION

SIEVE-SIZE ANALYSIS
Bed Material
Rio Grande--Casa Colorada

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
April 25, 1957											
	118.15	3+06	0.5	34.3	96.0	99.3	99.8	100			
		3+56	0.3	23.8	86.2	96.7	97.6	98.4	99.5	100.0	
		4+06	0.3	29.5	95.4	99.5	99.8	99.8	100.0		
		4+56	0.2	22.9	85.6	96.9	98.9	99.5	99.9	100.0	
		5+16	0.5	33.4	88.4	96.9	99.2	99.7	100.0		
		5+66	0.2	46.0	99.1	99.8	99.9	100.0			
	117.43	10+97	0.5	44.1	97.2	100.0					
		11+67	0.5	35.5	98.8	99.7	99.8	100.0			
		11+97	0.4	20.2	70.7	91.0	96.1	98.4	99.7	100.0	
		12+37	0.4	22.6	82.3	97.8	98.9	99.3	99.8	100.0	
	116.67	7+68	0.9	84.6	99.3	99.9	100.0				
		8+74	0.3	29.6	75.1	93.8	97.1	98.3	99.3	100.0	
		9+23	0.2	18.0	76.1	94.6	97.2	98.4	99.0	100.0	
	Above Bosque Br.	3+16	0.2	23.7	92.0	99.3	99.9	100.0			
		3+66	0.3	30.4	97.2	99.4	99.6	99.7	100.0		
		4+16	0.1	15.6	77.0	96.3	98.8	99.8	100.0		
	115.34	13+49	0.3	69.7	99.8	99.9	100.0				
		13+22	0.3	33.3	78.7	95.0	98.4	99.2	99.8	100.0	
		12+84	0.1	7.6	34.7	76.8	92.8	97.5	99.4	100.0	
	114.77	9+02	99.0	99.4	99.8	99.8	99.8	100.0			
		10+52	16.8	78.2	96.2	99.5	99.9	100.0			
		11+02	0.2	45.4	98.9	99.9	100.0				
		11+52	0.2	47.4	99.4	99.9	100.0				
		12+02	0.1	17.3	70.3	96.3	99.1	99.5	100.0		

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
May 11-13, 1957											
	117.81	Main channel 7+65	0.7	30.2	95.8	99.4	99.6	99.8	100.0		
	May 11	Main channel 11+25	82.1	92.5	99.0	100.0					
		Main channel 8+25	1.5	54.9	96.5	99.3	99.5	99.6	100.0		
		Main channel 10+65	89.6	99.6	100.0						
		Main channel 7+15	1.1	59.5	96.8	99.4	99.8	100.0			
		Behind jacks 14+85	94.4	99.4	100.0						
		Behind jacks 12+55	86.5	99.3	100.0						
	117.62	Channel 9+19	2.4	84.5	97.7	98.6	98.7	99.2	100.0		
	May 13	Channel 9+94	1.7	58.9	99.1	100.0					
		Channel 10+94	1.3	59.8	99.4	99.9	100.0				
		Flood plain 13+34	98.3	99.9	100.0						
		Jetty field 15+24	55.4	99.5	100.0						
	117.43	Main channel 11+34	0.5	21.1	86.5	97.2	98.2	98.5	99.2	100.0	
	May 13	Main channel 11+84	3.4	61.3	90.8	96.9	98.0	98.8	100.0		
		Jetty field 12+21	88.2	97.8	99.8	100.0					

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
May 11-13, 1957											
	117.05 May 12	Main channel 14+95	2.7	87.9	100.0						
		Main channel 15+63	3.0	69.5	98.9	99.8	100.0				
		Main channel 15+77	1.9	40.1	96.6	99.6	99.8	100.0			
		Jetty field 18+32	2.8	84.8	99.3	100.0					
		Jetty field 18+52	0.8	38.2	98.2	99.7	99.9	100.0			
	116.67	Jetty field 5+68	92.3	97.5	98.7	99.6	100.0				
	May 13	Jetty field 6+98	98.3	99.7	100.0						
		Main channel 8+28	2.9	57.7	87.2	93.9	95.0	95.9	96.7	100.0	
		Main channel 9+08	1.5	51.9	98.2	100.0					
		Main channel 9+88	1.6	34.5	90.9	100.0					
		Jetty field 13+38	98.4	99.1	99.8	100.0					
	116.47	Jetty field 1+26	1.8	61.0	99.4	99.7	99.7	99.7	99.7	100.0	

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
May 11-13, 1957											
	May 12	Jetty field 1+58	5.9	96.9	99.8	99.8	99.9	99.9	100.0		
		Main channel 1+76	0.4	20.3	89.6	98.0	98.8	99.2	99.9	100.0	
		Main channel 2+26	0.5	34.7	90.3	96.9	97.9	98.5	99.4	100.0	
		Flood plain 5+86	88.7	97.9	100.0						
		Flood plain 8+18	97.9	99.9	100.0						
June 6 and June 7, 1957											
Date											
6 - 7-57	116.47	Jetty field 1+37	26.1	63.9	98.9	99.9	100.0				
		Jetty field 1+85	4.5	16.4	90.5	99.0	100.0				
		Jetty field 2+17	0.5	2.1	20.7	81.6	97.8	99.7	100.0		
		Main channel 2+57	1.1	6.1	41.7	93.4	99.6	100.0			
		Main channel 2+87	0.7	3.0	22.6	71.2	95.5	96.6	97.0	97.6	100.0
		Main channel 3+17	2.0	7.4	46.9	99.1	100.0				

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
June 6-7, 1957											
	117.81	9+07	1.0	5.0	51.7	100.0					
		9+67	0.5	2.9	28.4	85.7	96.3	97.8	99.1	99.8	100.0
	117.62	Jack field	44.4	67.3	84.7	97.8	98.2	98.4	99.0	100.0	
	117.05	Floodway	58.3	73.7	99.4	100.0					
	116.47	6+44	73.2	88.4	95.8	97.3	98.1	99.0	100.0		
		9+44	79.4	90.4	98.6	99.4	100.0				
	117.81	Main channel 8+30	3.3	13.2	75.9	97.4	99.8	100.0			
		Main channel 10+25	0.8	4.5	44.9	97.5	99.8	100.0			
		Flood plain 13+00	45.1	99.0	100.0						
		Flood plain 13+50	45.0	96.2	99.0	99.4	99.6	99.8	99.9	100.0	
	117.62	Main channel 8+89	3.2	10.1	75.6	97.6	99.3	99.6	100.0		
		Main channel 9+89	2.4	11.1	68.3	99.4	100.0				
		Main channel 10+89	1.5	7.2	61.6	100.0					
	117.43	Main channel 10+67	3.0	11.4	60.5	99.6	100.0				
		Main channel 11+30	0.8	3.9	37.9	97.4	98.8	98.9	98.9	99.1	100.0
		Main channel 12+35	0.9	4.9	52.4	97.2	100.0				

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
June 6-7, 1957											
		Jetty field 14+45	36.3	75.4	99.0	99.6	100.0				
Date 6-7-57	117.05	Main channel 14+99	0.8	3.8	29.8	92.5	99.5	99.8	100.0		
		Main channel 15+29	1.0	5.1	38.7	92.8	98.8	100.0			
		Main channel 15+99	0.7	4.4	36.0	97.3	100.0				
		Jetty field 18+09	25.2	62.7	98.4	99.1	99.3	99.6	99.8	100.0	
		Jetty field 18+49	7.9	21.1	87.8	99.4	99.8	100.0			
	116.67	Jetty field 4+22	11.5	26.4	81.2	97.5	99.0	100.0			
		Jetty field 7+22	35.7	94.2	97.2	98.7	99.5	100.0			
		Main channel 7+72	2.7	36.7	93.3	99.1	99.6	99.7	100.0		
		Main channel 8+82	3.8	17.6	92.8	98.8	99.3	99.5	99.6	99.6	100.0
		Main channel 9+82	1.0	5.1	36.1	78.6	93.2	96.8	98.3	99.0	100.0
		Flood plain 12+82	30.6	98.8	99.6	99.8	100.0				

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
June 18-19, 1957											
	117.81	8+33	0.7	4.0	54.2	100.0					
		9+08	0.7	4.4	43.3	98.6	100.0				
		9+98	1.6	8.4	68.7	99.4	100.0				
		13+43	34.0	92.4	99.9	99.9	100.0				
		Floodway									
	117.62	9+02	1.6	7.6	60.5	99.2	100.0				
		9+92	0.8	5.4	51.2	96.0	98.7	99.4	99.7	100.0	
		10+82	0.8	4.5	50.5	98.6	100.0				
		14+67	48.9	57.2	93.0	99.6	100.0				
	117.43	12+40	0.6	3.5	25.8	88.8	88.9	99.6	99.8	100.0	
		13+02	0.6	3.5	26.3	83.6	96.7	98.9	99.3	99.6	100.0
		13+90	0.3	2.2	46.3	97.5	99.9	100.0			
		14+65	1.9	10.2	73.9	97.2	100.0				
		14+45	98.1	98.8	99.8	100.0					
		15+24	97.6	98.2	100.0						
		15+30	97.9	98.9	99.7	100.0					
	117.05	15+09	1.2	8.7	88.3	99.4	100.0				
		15+79	1.7	3.7	66.0	98.8	100.0				
		16+29	2.5	14.0	81.9	99.4	100.0				
		17+05	4.7	18.3	89.6	99.4	100.0				
		17+65	10.4	40.0	98.9	100.0					
	116.67	7+40	1.6	7.0	63.5	99.3	100.0				
		8+60	0.9	5.9	48.6	91.0	98.7	99.2	99.5	100.0	
		9+80	0.7	6.9	79.8	97.9	99.8	99.8	99.9	100	
		10+60	1.2	6.0	60.3	99.1	100.0				
		15+20	73.4	80.2	91.8	99.1	100.0				

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
June 18-19, 1957											
	116.47	1+03	6.6	28.9	99.4	99.8	100.0				
		2+83	0.4	2.5	31.8	87.4	98.2	99.1	99.7	100.0	
		3+03	0.8	4.7	40.7	98.7	99.2	100.0			
		3+33	0.7	4.3	41.3	99.8	100.0				
		7+33	25.8	69.0	87.2	93.8	96.7	98.8	100.0		
		10+13	51.4	68.5	95.5	100.0					
June 27-28, 1957											
	117.81	8+41	1.2	6.9	59.7	99.7	100.0				
		9+41	0.4	3.4	41.2	95.5	99.7	99.7	99.7	99.7	100.0
		10+31	1.8	9.2	78.7	99.1	99.7	99.8	100.0		
	117.62	8+98	1.0	6.1	70.3	99.6	100.0				
		9+58	1.1	6.1	37.0	68.0	90.3	94.7	96.6	97.8	100.0
		10+63	2.4	11.8	82.2	100.0					
		14+46	92.6	97.6	99.5	100.0					
	117.43	11+19	0.8	4.2	38.5	89.6	97.7	99.4	99.9	100.0	
		12+24	0.7	4.1	41.0	99.4	100.0				
		13+04	0.6	3.5	30.5	88.9	98.4	99.5	99.8	100.0	
	117.05	15+08	0.7	4.7	61.1	92.0	97.8	98.4	98.9	99.3	100.0
		15+88	0.8	5.2	58.8	100.0					
		16+28	1.8	9.6	49.9	100.0					
	116.67	7+16	1.6	8.7	88.7	99.3	99.8	100.0			
		8+31	0.6	4.0	56.4	99.3	100.0				
		9+01	0.8	5.0	48.0	99.2	100.0				
		10+61	0.5	3.4	39.5	98.8	100.0				
		15+20	11.8	22.7	69.1	95.3	100.0				
	116.47	1+14	8.0	26.6	98.1	99.8	100.0				
		2+79	0.6	3.8	43.3	99.0	99.8	100.0			
		3+09	1.5	8.6	56.0	97.9	100.0				
		3+39	1.5	6.8	42.0	98.5	100.0				
		8+19	5.9	15.8	47.2	93.1	97.6	98.6	99.5	100.0	

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000	32.000
April 21-24, 1958												
	116.47	1+35	99.4	99.6	99.8	100.0						
		2+95	14.3	67.5	97.3	99.8	100.0					
		4+45	24.7	52.9	95.6	98.6	99.9	99.9	100.0			
		6+05	0.5	2.6	33.4	98.4	99.9	100.0				
		7+25	0.4	2.4	28.6	77.3	90.9	93.7	94.9	96.0	97.0	100.0
		8+15	0.4	1.4	22.3	93.5	99.8	99.8	100.0			
		9+75	92.4	99.8	100.0							
	116.67	4+30	99.1	94.4	99.8	100.0						
		7+14	47.8	85.3	99.4	99.8	100.0					
		9+24	7.8	36.9	97.9	99.8	100.0					
		10+44	0.4	2.0	22.6	75.2	94.2	97.6	98.5	99.4	100.0	
		11+94	1.3	5.2	37.4	93.2	99.8	99.9	100.0			
		15+04	85.0	99.2	99.8	100.0						
		16+44	92.4	99.3	100.0							
	117.05	14+87	1.1	7.0	78.7	99.9	100.0					
		15+57	1.7	10.6	77.6	99.5	100.0					
		16+37	6.1	17.3	82.7	99.4	99.9	100.0				
		18+27	86.1	92.8	99.8	100.0						
	117.43	11+65	1.0	5.4	60.6	98.0	99.9	100.0				
		12+55	0.5	3.0	25.8	93.0	99.7	100.0				
		13+30	2.8	13.1	75.4	98.2	99.9	100.0				
		15+10	18.2	55.1	98.8	99.6	99.8	99.9	100.0			
	117.62	Flood plain	86.6	99.4	100.0							
		9+52	0.6	3.7	44.5	97.4	99.9	99.9	100.0			
		10+27	0.5	2.7	23.4	82.6	97.7	99.6	100.0			
		11+52	3.3	13.7	71.9	98.9	100.0					
	117.81	8+32	1.3	6.4	59.0	97.1	100.0					
		9+67	0.8	3.9	35.2	92.8	99.5	100.0				
		11+02	3.7	13.0	78.0	99.0	100.0					
		12+77	80.9	93.4	99.8	100.0						

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
April 30-May 1, 1958											
	116.47	1+18	99.0	99.5	100.0						
		2+78	1.1	9.5	90.4	99.4	99.6	99.7	100.0		
		6+48	0.5	5.3	43.2	96.8	99.6	100.0			
		7+58	0.8	4.5	39.7	87.7	98.6	99.8	100.0		
		8+58	1.9	8.3	63.9	99.8	99.9	99.9	100.0		
		9+78	97.3	98.7	100.0						
	116.67	7+25	34.3	75.0	99.7	99.9	100.0				
		8+95	9.1	39.6	96.8	99.6	100.0				
		10+45	1.0	5.2	44.9	89.9	98.8	99.7	100.0		
		12+25	0.2	0.9	16.4	92.4	99.5	99.9	100.0		
		15+25	10.8	41.2	99.6	99.8	100.0				
	117.05	14+91	0.4	2.3	21.1	78.2	97.0	98.9	99.2	99.6	100.0
		15+51	1.2	7.2	68.2	99.8	100.0				
		16+01	0.7	4.9	38.6	97.1	100.0				
		18+41	94.1	96.3	99.7	100.0					
	117.43	10+89	1.6	11.6	69.1	99.6	100.0				
		11+94	1.7	8.6	56.7	91.2	98.0	99.4	100.0		
		12+84	1.0	6.2	45.2	93.2	99.8	100.0			
		In jack field	14.0	28.1	86.8	99.1	100.0				
		Behind jacks	81.7	98.8	100.0						
	117.62	East flood plain	16.5	44.9	99.2	100.0					
		9+65	0.6	4.1	49.1	98.0	100.0				
		10+65	1.3	7.2	50.7	97.6	99.4	99.9	100.0		

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000	32.000
April 30-May 1, 1958												
	117.62 (continued)	11+65	1.7	9.9	66.0	100.0						
		West flood plain	62.6	97.6	99.7	100.0						
		West flood plain	60.6	96.7	99.8	100.0						
	117.81	8+32	3.0	13.8	83.0	99.4	99.9	100.0				
		9+72	1.1	6.8	42.4	95.4	99.9	100.0				
		11+72	0.8	4.3	46.0	99.5	100.0					
		13+77	5.8	19.8	90.3	96.7	99.3	99.9	100.0			
		Behind jacks	96.7	98.2	99.6	100.0						
May 19-20, 1958												
	116.47	1+38	94.3	95.3	99.4	100.0						
		3+18	0.6	6.0	77.0	96.9	97.7	97.8	97.9	97.9	100.0	
		5+28	2.1	13.0	67.3	88.7	94.5	96.9	97.3	97.4	97.6	100.0
		6+78	0.7	4.4	42.8	96.9	100.0					
		7+98	0.2	1.2	16.3	87.2	99.1	99.9	100.0			
		9+48	34.3	53.7	99.1	100.0						
		16+28	68.1	84.4	96.6	99.5	100.0					
	116.67	--	95.1	97.9	99.4	100.0						
		4+44	99.1	99.4	99.9	100.0						
		8+74	5.3	18.7	96.8	99.8	99.4	100.0				
		10+24	2.0	11.1	60.7	98.6	100.0					
		12+C4	0.3	2.1	24.0	93.8	100.0					
		15+24	84.6	97.3	99.6	100.0						
		16+74	96.9	98.4	99.5	100.0						

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000	32.000
May 19-20, 1958												
	117.05	10+97	92.1	95.9	99.0	100.0						
		13+42	17.0	39.8	99.1	99.8	100.0					
		14+92	0.2	2.7	45.5	97.5	99.8	99.9	100.0			
		15+42	1.0	7.4	69.1	99.7	100.0					
		16+02	0.7	5.8	43.8	97.1	99.8	100.0				
		18+02	8.5	27.6	90.6	98.5	99.4	99.8	100.0			
	117.43	10+90	0.2	6.4	54.9	98.2	100.0					
		11+50	0.2	2.6	34.2	92.1	99.1	99.9	100.0			
		12+85	0.5	3.8	38.5	98.3	100.0					
		Right bank flood plain	25.1	91.4	99.9	100.0						
		Left bank flood plain	97.0	98.5	99.5	100.0						
	117.62	7+30	96.9	99.0	99.5	100.0						
		9+90	0.5	3.8	42.0	99.0	100.0					
		10+90	1.2	8.6	65.9	99.1	100.0					
		12+30	0.4	2.8	29.3	97.1	100.0					
		Right flood plain	92.1	98.6	99.6	99.9	100.0					
		Right flood plain	56.2	97.4	98.9	99.5	100.0					
	117.81	Left flood plain	50.5	92.1	98.4	99.3	99.8	99.9	100.0			
		8+50	0.7	2.7	47.7	96.1	99.6	99.9	100.0			
		9+70	2.6	15.8	79.1	99.5	100.0					
		11+70	0.7	4.6	43.2	97.8	100.0					
		13+60	83.7	90.9	98.7	100.0						
		15+25	97.6	99.0	99.9	100.0						

Table 4

Sample No.	Section	Sample	0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000
			Percent finer than (sieve size in mm)								
May 27-28, 1958											
	116.47	1+70	88.1	91.3	99.0	100.0					
		3+20	1.6	12.2	97.4	100.0					
		5+30	0.6	7.0	91.3	99.3	99.8	100.0			
		6+80	0.4	3.1	42.1	97.6	100.0				
		8+00	0.4	2.3	22.0	61.8	97.2	98.9	99.1	99.6	100.0
		9+30	91.5	98.7	100.0						
		16+50	82.2	94.0	98.4	100.0					
	116.67	2+74	93.5	96.5	98.6	100.0					
		4+44	98.3	98.8	100.0						
		8+34	0.7	8.4	92.9	99.5	100.0				
		10+44	1.0	8.2	74.8	99.6	100.0				
		12+24	0.6	3.9	28.6	94.8	100.0				
		15+24	91.9	97.9	100.0						
		19+24	75.8	85.9	93.2	99.0	100.0				
	117.05	2+83	96.3	98.1	100.0						
		8+63	68.2	84.9	94.1	96.7	97.4	97.4	97.4	98.3	100.0
		12+33	97.5	98.3	99.1	100.0					
		14+93	0.5	4.8	73.4	100.0					
		15+53	0.7	6.1	54.3	98.7	100.0				
		16+03	0.8	6.2	52.3	98.9	100.0				
		18+43	0.4	2.2	31.1	94.0	99.6	100.0			
	117.43	4+00	94.5	98.4	100.0						
		10+95	0.6	5.9	69.9	99.2	100.0				
		11+85	1.1	7.5	52.9	96.5	99.6	100.0			
		12+90	0.6	5.0	41.7	97.3	99.9	100.0			
		14+45	96.2	98.5	99.7	100.0					

Table 4

Sample No.	Section	Station	Percent finer than (sieve size in mm) 0.0625	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000	32.000
May 27-28, 1958												
	117.62	5+63	91.0	97.6	100.0							
		10+18	0.3	2.4	20.3	50.0	66.5	78.0	83.7	89.8	99.1	100.0
		11+18	1.2	7.7	62.1	98.8	100.0					
		12+18	0.6	4.8	38.7	93.1	99.3	100.0				
		Flood plain	62.9	78.3	99.0	100.0						
		Flood plain	85.7	95.6	100.0							
	117.81	0+60	87.3	91.6	96.4	100.0						
		7+30	39.7	92.8	99.0	99.4	99.6	99.9	100.0			
		9+10	1.1	3.7	48.3	97.0	99.7	100.0				
		10+10	2.7	16.7	72.0	96.6	100.0					
		11+30	1.0	6.6	45.1	97.9	100.0					
		14+10	72.1	87.4	99.6	100.0						
		16+10	90.3	96.4	97.8	99.0	100.0					
	117.81	Samples taken April 30, 1958										
		8+32	3.0	13.8	83.0	99.4	99.9	100.0				
		9+72	1.1	6.8	42.4	95.4	99.9	100.0				
		11+72	0.8	4.3	46.0	99.5	100.0					
		13+77	5.8	19.8	90.3	96.7	99.3	99.9	100.0			
		Behind jacks	96.7	98.2	99.6	100.0						

Table 5

SIEVE-SIZE ANALYSIS PROTOTYPE SUSPENDED MATERIAL
CASA COLORADA PROTOTYPE REACH
MIDDLE RIO GRANDE PROJECT

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finerthan (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
4-25-57	9:50 am	118.15 Main channel	1,199	1,200		55	38.0	57.7	72.9	77.0	90.0	99.5	100
4-25-57	1:20 pm	117.43	1,178	1,960		59	57.6	87.2	97.6	98.5	100		
4-25-57	12:30 pm	117.43		3,710		59	45.9	69.4	87.2	92.0	98.2	100	100
4-25-57	9:30 pm	116.67 Main channel	1,199	3,420		55	48.4	72.2	88.0	91.8	98.8	100	100
4-25-57	2:10 pm	Above Bosque Br: Flood plain	1,202	2,610		62	66	92	99.4	100			
4-25-57	2:10 pm	Above Bosque Br: Main channel		3,160		62	52.8	76.3	91.1	93.7	99.0	100	100
4-25-57	5:10 pm	115.34 Flood plain	1,108	2,700		64	60.5	85.5	97.9	98.9	100		
4-25-57	5:10 pm	115.34 Main channel		3,480		64	44.7	64.3	77.0	77.7	89.0	99.2	100
4-25-57	4:45 pm	114.77 Main channel	1,118	4,480		61	37.8	52.6	61.5	64.0	78.0	96.4	100
May 11, 12, and 13, 1957													
5-11-57	3:10 pm	117.81 Flood plain		3,650		62	52	74	98.8	99.8	100	100	
5-11-57	3:20 pm	117.81 Main channel	3,691	6,090		62	32	46	77.2	92.8	99.6	100	
5-11-57	3:25 pm	117.81 Behind jacks		1,830		62			91.1	96.2	99.8	100	100

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
May 11, 12, and 13, 1957													
5-12-57	11:45 am	116.47 Flood plain		4,340		58	43	64	87.5	96.9	100	100	100
5-12-57	12:50 pm	116.47 Behind jacks	4,035	5,040		58	43	58	91.3	97.1	99.9	100	100
5-12-57	12:50 pm	116.47 Main channel		8,140		58	27	39	65.2	85.4	97.7	100	100
5-12-57		117.05 Flood plain		7,000		58			91.3	97.6	99.8	100	100
5-12-57		117.05 Behind jacks	3,710	4,720		58	41	59	91.0	97.5	99.9	100	100
5-12-57		117.05 Main channel		7,900		58	30	37	69.0	86.4	98.2	100	100
5-13-57	1:19 pm	117.43 Flood plain	4,578	4,150		60	44	64	97.6	100	100	100	100
5-13-57	1:05 pm	117.43 Behind jacks		2,510		60	59	82	99.4	99.8	100	100	
5-13-57	12:18 pm	117.43 Main channel		7,210		60	24	35	66.6	87.0	98.9	100	100
5-13-57	1:20 pm	116.67 Flood plain		3,460		59	57	80	99.4	100	100	100	
5-13-57	1:20 pm	116.67 Behind jacks	4,545	2,950		59	54	78	97.2	99.4	99.9	100	100
5-13-57	1:20 pm	116.67 Main channel		6,580		59	28	39	70.0	89.3	99.2	100	100

Percent finer than (sieve size in mm): columns 0.0039 through 1.000.

Table 5

Date	Time	Section	Q_W Discharge cfs	Conc ppm	Q_S T/D	Temp °F	0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
							Percent finer than (sieve size in mm)						
May 11, 12, and 13, 1957													
5-13-57	5:00 pm	117.62 Flood plain		5,620		63	32	44	66.9	84.7	99	100	100
5-13-57	5:20 pm	117.62 Behind jacks	4,628	2,260		63	57	77	96.5	99.3	100	100	100
5-13-57	5:30 pm	117.62 Main channel		6,490		63	29	42	97.8	91.1	99.3	100	100
McGinnis and Skousen Contractors													
5-17-57	2:00 pm	893+00 Main channel		11,300		67	25	36	63	86	99	100	100
5-17-57	2:00 pm	893+00 Behind jacks		12,300		67	26.9	37.8	78.0	95.8	100	100	100
6-21-57	9:20 am	893+00 Main channel		15,300		67	48	62	76.8	91.5	99.2	100	100
6-21-57	9:45 am	893+00 Behind jacks		13,200		68	58	76	90.8	99.6	100	100	100
5-24-57	11:15 am	470+00 Skousen Contr		10,700		62	21.1	30.2	57.1	84.7	98.5	100	100
June 6 and 7, 1957													
6-6-57	12:10 pm	117.81 Flood plain	3,814	2,090		71	43	58	94.5	99.4	99.9	100	
6-6-57	12:25 pm	117.81 Main channel		4,900		71	21	30	62.7	91.7	99.6	100	100
6-6-57	2:05 pm.	117.62 Flood plain		1,130		74			97.7	99.5	100	100	
6-6-57	2:05 pm	117.62 Behind jack	3,181	935		74			98.1	99.5	100	100	
6-6-57	1:50 pm	117.62 Main channel		4,550		74	20	28	63.2	89.5	99.0	100	100

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
June 6 and 7, 1957													
6-6-57	2:10 pm	117.43 Behind jacks	4,007	2,000		73	38	54	90.8	99.0	100	100	
6-6-57	2:10 pm	117.43 Main channel		5,180		73	17	26	58.6	87.4	99.0	100	100
6-7-57	1:20 pm	117.05 Flood plain left side		3,220		72	32	45	85	98.8	99.8		
6-7-57	1:20 pm	117.05 Behind jacks	4,678	2,430		72	37	58	84.5	96.7	99.9		
6-7-57	10:00 am	117.05 Main channel		5,880		72	16	24	54.8	82.4	97.1	100	100
6-7-57	8:50 am	116.67 Flood plain West side		2,070		65			95.5	99.8	100	100	
6-7-57	8:50 am	116.67 Behind jacks West side	4,517	1,880		65	52	59	93.5	99.3	100	100	100
6-7-57	1:50 pm	116.67 Main channel		5,050		67	18	27	66.1	91.6	99.2	100	100
6-7-57	5:10 pm	116.47 Flood plain West side		2,040		74	41	60	94.9	99.6	100	100	100
6-7-57	5:10 pm	116.47 Main channel	3,974	5,320		73	17	25	58.2	85.0	97.1	100	100
6-7-57	5:10 pm	116.47 Behind jacks		4,800		73	22	29	66.7	88.4	97.3	100	

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finer than (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
June 18 and 19, 1957													
6-18-57	1:50 pm	117.81 Flood plain	4,202	2,030		72			81.3	97.5	100	100	
6-18-57	11:10 am	117.81 Main channel		3,890		67	15	23	55.7	87.8	99.0	100	100
6-18-57	1:40 pm	116.47 Flood plain		1,330		70			90.6	98.8	99.8	100	
6-18-57	11:10 am	116.47 Main channel	3,935	4,020		69	15	22	51.0	76.8	97.8	100	100
6-18-57	11:10 am	116.47 Behind jacks left side		2,050		68	28	41	78.9	93.8	99.4	100	100
6-18-57	6:10 pm	117.05 Behind jacks	3,851	1,740		73	29	43	83.5	99.3	100	100	100
6-18-57	6:05 pm	117.05 Main channel		3,640		73	15	23	56.2	87.0	99.1	100	100
6-19-57	9:00 am	117.62 Main channel	3,754	3,730		67	14	22	54.6	84.2	98.9	100	100
6-19-57	10:10 am	117.62 Behind jacks		847		67			87.8	98.0	99.4	100	
6-19-57	12:45 pm	117.43 Main channel	3,216	3,480		72	14	24	49.4	84.3	99.3	100	100
6-19-57	1:30 pm	117.43 Behind jacks		2,520		73	21	33	73.3	97.0	100	100	100

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
							Percent finer than (sieve size in mm)						
June 18 and 19, 1957													
6-19-57	10:15 am	116.67 Main channel		3,460		71	15	23	54.2	84.7	99.2	100	100
6-19-57	12:15 pm	116.67 Behind jacks right side	3,619	1,210		73	38	61	92.6	99.3	100	100	100
6-19-57	10:15 am	116.67 Behind jacks left side		1,820		69			78.6	94.5	99.6	100	
June 27 and 28, 1957													
6-27-57	10:45 am	117.81 Main channel	3,597	3,170		75	13	20	50.0	86.0	99.0	100	100
6-27-57	9:40 am	116.47 Flood plain		832		70			92.0	98.9	100		
6-27-57	11:30 am	116.47 Behind jacks	3,467	1,410		74			74.9	95.1	99.6	100	
6-27-57	10:00 am	116.47 Main channel		3,480		71	13	19	44.3	80.0	97.8	100	100
6-27-57	2:00 pm	117.05 Behind jacks	3,296	2,120		77	22	32	70.2	88.1	96.5	100	100
6-27-57	12:45 pm	117.05 Main channel		3,350		76	13	20	51.2	81.0	96.8	100	100
6-27-57	4:35 pm	117.43 Behind jacks west side		2,150		77	22	32	71.1	95.1	100	100	100
6-27-57	3:00 pm	117.43 Main channel		3,220		77	13	21	53.0	85.2	98.6	100	100

Table 5

Date	Time	Section	Q_W Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finer than (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
June 27 and 28, 1957													
6-28-57	11:10 am	116.67											
		Behind jacks right bank		1,170		72			90.4	99.3	100		
6-28-57	11:10 am	116.67	3,410										
		Main channel		4,070		69	11	16	40.9	78.9	96.6	99.9	100
6-28-57	8:50 am	116.67											
		Behind jacks left bank		1,420		70			81.8	96.6	99.9	100	
6-28-57	10:55 am	117.62											
		Behind jacks	3,342	916		74			95.3	99.8	100		
6-28-57	9:30 am	117.62											
		Main channel		3,380		72	14	22	48.0	86.1	99.1	100	100
4-22-58		116.47	5,478	8,127	120,201								
	8:35 am	Station 94-245	125	3,800	1,280	55	51	75	97	99	100		
	9:45 am	Station 255-875	5,285	8,300	118,400	55	22	35	70	91	99	100	
	10:50 am	Station 889-985	68	2,840	521	60	53	76	99	100			
4-24-58		116.67	6,476	7,924	138,560								
	9:35 am	Station 410-758	191	3,220	1,660	51	63	82	97	99	100		
	9:55 am	Station 758-1314	6,285	8,070	136,900	52	27	39	67	90	99	100	

Table 5

Date	Time	Section	Q_W Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finer than (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
4-23-58		117.05	6,490	9,753	170,910								
	10:45 am	Station 1447-1642	6,320	9,910	169,100	54	24	33	59	84	98	100	
	11:45 am	Station 1787-1871	170	3,940	1,810	59	51	69	93	99	100		
4-23-58		117.43	6,636	8,350	149,570								
	11:40 am	Station 1045-1375	6,510	8,390	147,500	55	27	38	69	91	99	100	
	10:35 am	Station 1375-1540	126	6,080	2,070	56	35	48	86	99	100		
4-24-58		117.62	6,714	8,416	152,560								
	9:40 am	E&W Flood plain	234	2,780	1,760	53	69	88	100				
	9:30 am	Station 852-1252	6,480	8,620	150,800	52	27	36	63	88	99	100	
4-22-58		117.81	5,800	8,437	132,134								
	10:10 am	Station 787-1207	5,796	8,440	132,100	55	23	36	76	90	100		
	11:35 am	Station 1272-1282	4	3,120	34	62	52	74	97	99	100		
4-30-58		116.47	6,259	6,026	101,840								
	9:45 am	Station 108-242	205	2,260	1,250	57	42	57	87	95	99	100	
	11:05 am	Station 242-878	5,953	6,230	100,100	54	16	23	44	79	99	100	
	12:20 pm	Station 912-978	101	1,790	490	60	51	67	91	99	100		
5- 1-58		116.67	6,002	5,497	89,081								
	8:55 am	Station 725	3	1,690	14	56	--	--	98	99	100		
	9:50 am	Station 775-1327	5,909	5,560	88,700	56	17	24	48	80	98	100	

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
							Percent finer than (sieve size in mm)						
	10:55 am	Station 1415-1545	90	1,510	367	60	--	--	95	99	99	100	
4-30-58		117.05	5,935	5,489	87,959								
	3:45 pm	Station 1461-1665	5,823	5,550	87,300	58	20	28	52	73	96	100	
	5:25 pm	Station 1789-1871	112	2,180	659	59	42	59	95	98	100		
4-30-58		117.43	6,102	4,773	78,641								
	2:50 pm	Station 1044-1359	5,972	4,810	77,600	57	21	31	54	85	99	100	
	3:45 pm	In jacks	26	3,350	235	58	26	40	70	83	97	100	
	4:05 pm	Behind jacks	104	2,870	806	58	30	46	82	98	100		
5- 1-58		117.62	5,825	4,952	77,881								
	8:50 am	Station 817-827	5	1,290	17	56	50	71	97	100			
	9:35 am	Station 890-1265	5,776	4,990	77,800	57	18	27	54	86	99	100	
	10:30 am	Station 1464-1588	44	535	64	60	--	--	99	100			
4-30-58		117.81	6,156	4,947	82,232								
	11:15 am	Station 792-1222	6,150	4,950	82,200	52	20	29	54	85	99	100	
	12 noon	Station 1372-1382	5	2,240	30	55	40	58	90	99	100		
	12:07 pm	Behind jacks	1	739	2	66	88	97	99	100			
5-19-58		116.47	7,651	3,867	79,885								
	10:05 am	Station 98-238	401	767	830	64	--	--	91	99	100		
	10:55 am	Station 258-858	7,228	4,050	79,000	64	15	21	39	79	99	100	
	12 noon	W Flood plain	22	925	55	68	56	69	88	98	100		

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finer than (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
5-20-58		116.67	7,753	3,065	64,170								
	11:35 am	E&W Flood plain	586	675	1,070	67	65	80	95	99	100		
	11:00 am	Station 772-1312	7,167	3,260	63,100	64	16	22	40	81	99	100	
5-19-58		117.05	8,089	4,053	88,510								
	3:15 pm	Station 852-1452	53	770	110	74			86	96	99	100	
	4:25 pm	Station 1462-1652	7,646	4,220	87,100	69	--	23	37	74	97	100	
	5:55 pm	Station 1662-1872	390	1,230	1,300	69	--	--	83	94	99	100	
5-19-58		117.43	7,650	3,445	71,160								
	--	E Flood plain	310	738	620	67	--	--	97	98	99	100	
	4:25 pm	Station 1045-1350	6,960	3,680	69,200	67	18	25	42	76	97	100	
	5:10 pm	W Flood plain	380	1,310	1,340	67	--	--	87	95	100		
5-20-58		117.62	7,610	3,099	63,685								
	12:45 pm	E&W Flood plain	240	652	420	71	65	88	96	99	100		
	--	Station 910-1290	7,295	3,210	63,200	68	16	23	41	79	99	100	
	--	Behind jacks	75	323	65	75	--	--	98	98	100		
5-19-58		117.81	7,557	3,348	68,310								
	12:10 pm	E&W Flood plain	222	733	440	68	70	86	97	99	100		
	--	Behind jacks	485	585	770	--	--	--	97	99	100		
		Station 770-1210	6,850	3,630	67,100	67	17	24	44	82	99	100	
5-27-58		116.47	8,898	2,726	65,480								
	--	Station 85-260	484	575	750	72	--	--	95	99	100		

Table 5

Date	Time	Section	Q_w Discharge cfs	Conc ppm	Q_s T/D	Temp °F	Percent finer than (sieve size in mm) 0.0039	0.0156	0.0625	0.125	0.250	0.500	1.000
	1:45 pm	Station 290-908	7,891	2,990	63,700	70	13	20	39	77	97	100	
	4:35 pm	Station 908-1672	523	726	1,030	74	--	--	95	98	100		
5-28-58		116.67	8,813	2,622	62,380								
	5:00 pm	Station 760-1334	8,070	2,820	61,400	72	12	20	38	78	98	100	
	--	E&W Flood plain	743	489	980	75	68	88	94	99	100		
5-28-58		117.05	8,740	3,509	82,805								
	10:00 am	Station 10-1447	472	538	685	68	--	--	95	98	100		
	11:15 am	Station 1447-1657	7,547	3,890	79,300	68	11	15	30	66	96	100	
	1:15 pm	Station 1657-1873	721	1,450	2,820	72	29	34	56	71	87	100	
5-28-58		117.43	8,904	3,411	82,010								
	10:00 am	Station 106-1035	267	525	380	70	--	--	98	100			
	12:10 pm	Station 1035-1355	8,271	3,620	80,800	68	11	16	29	63	94	100	
	12:50 pm	Station 1355-1550	366	836	830	70	--	--	84	97	100		
5-28-58		117.62	8,259	2,745	61,215								
	6:10 pm	Station 898-1278	7,210	3,060	59,600	72	11	18	34	72	98	100	
	5:35 pm	E&W Flood plain	891	614	1,480	72	--	--	92	98	100		
	--	Jackfield	158	315	135	72	--	--	98	100			
5-27-58		117.81	7,690	3,294	68,390								
	--	Station 760-1215	7,140	3,510	67,700	70	10	14	27	67	97	100	
	12 noon	E&W Flood plain	239	645	416	73	--	--	94	98	99	100	
		Jack field	311	326	274	77	--	--	99	100			

Table 6

COMPUTATION TABLE FOR AVERAGE RATE OF RELATIVE JETTY FIELD DEPOSITION FOR HYDROGRAPH YEAR

1	2	3	4	5
Discharge cfs Q	Average relative deposition ft/yr R	Average deposition for time interval	Percent of time from flow duration curve	Weighted average deposition times 100 3 x 4
0	0			
		0	96.00	0.0
5,000	*0			
		13.4	3.30	44.2
7,500	26.8			
		32.0	0.53	17.0
10,800	ψ37.2			
		40.4	0.15	6.1
15,000	ϕ43.7			
		44.7	0.02	0.9
17,000	ϕ45.7			
				$\Sigma = 68.2$

Average rate of deposition = 0.68 ft/yr

* Assumed zero since flow width equals design channel width

ψ See example computation in Table 8

ϕ These values were extrapolated. Since the percent of time is small, the errors of the weighted rates are small.

Table 7

COMPUTATION TABLE FOR ONE DESIGN CHANNEL UNIT DISCHARGE IN FIGURE 37

Design channel	Jetty field							
1	2	3	4	5	6	7	8	9
Unit discharge cfs/ft	Unit discharge cfs/ft	Y_f depth ft	V_f velocity ft/sec	Friction factor f_f	Y_f/X	$\%(f_f)$	f_{fb}	$f_{y/x}$
10	6.44	1.00	6.44	0.0052	0.004	29	0.017	0.0219
10	6.44	1.50	4.29	0.0174	0.006	53	0.017	0.0260
10	6.44	2.00	3.22	0.0411	0.008	91	0.017	0.0325
10	6.44	2.50	2.58	0.0802	0.010	121	0.017	0.0376

Tieback spacing (X) = 250 feet
Channel width = 500 feet
Levee-to-levee width = 1,400 feet
Total river discharge = 10,800 cfs

(1) q_c assumed = 10 cfs/ft

(2) q_f is then = 6.44 cfs/ft

(3) Y_f = assumed jetty field depth.

(4) $V_f = q_f/Y_f$

(5) $f_f = 8gS \frac{Y}{V^2}$; where slope = 0.000829

(6) $Y_f/X = Y_f/250$

(7) $\%(f_f)$ = percent increase in friction caused by tiebacks--from Figure 35

(8) f_{fb} = friction with respect to bed alone at q_f = 6.44 cfs/ft--from Figure 36

(9) $f_{fb}\,(1 + \%f_f/100)$ = friction for bed and tiebacks combined

Depth in jetty field for q_c = 10 is 1.86 feet determined by interpolating or by cross plotting (5) and (9) with respect to (3).

Table 8

COMPUTATION TABLE FOR AVERAGE RATE OF RELATIVE JETTY FIELD
DEPOSITION FOR TOTAL RIVER DISCHARGE OF 10,800 CFS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
q_c cfs/ft	q_c av cfs/ft	q_f av cfs/ft	ΔY ft	$\Delta^2 Y$ ft	Q_c cfs	Q_f cfs	V_c ft/sec	V_f ft/sec	C_c ppmw	C_f ppmw	$\frac{Q_c C_c}{10^6}$	$\frac{Q_f C_f}{10^6}$	12 + 13	$\frac{Q_r C_r}{10^6}$	Remarks	1.2(15 - 14)	$\frac{Area}{10^6}$ Ft2	$\frac{Vol}{10^6}$ Ft3	V_{ss} Ft3/sec	$\frac{\Delta T}{10^6}$ seconds
9.5			0.00																	
	9.75	6.58		0.11	4,875	5,925	4.97	3.40	7,700	4,350	37.5	25.8	63.3	74	Deposit	12.8	9.5	1.04	8.87	0.12
*10.0			0.11																	
	11.0	5.88		0.45	5,500	5,300	5.16	3.29	8,200	4,150	45.1	22.0	67.1	74	Deposit	8.28	9.5	4.28	5.74	0.75
12.0			0.56																	
	13.0	4.77		0.46	6,500	4,300	5.50	3.07	9,150	3,850	59.5	16.6	76.1	74	Scour	-2.52	5.28	2.38	1.74	1.37
14.0			1.02																	
	15.0	3.66		0.48	7,500	3,300	5.80	2.75	10,050	3,400	75.4	11.2	86.6	74	Scour	-15.1	5.28	2.53	10.5	0.24
16.0			1.50																	
	17.0	2.55		0.46	8,500	2,300	6.05	2.35	10,900	2,950	92.6	6.78	99.4	74	Scour	-30.5	5.28	2.43	21.1	0.12
18.0			1.96																	
	19.0	1.44		0.50	9,500	1,300	6.25	1.70	11,650	2,300	111.0	2.99	114.0	74	Scour	-48.0	5.28	2.64	33.3	0.08
20.0			2.46																	
	20.8	0.44		0.81	10,400	400	6.46	0.65	12,400	1,000	129.0	0.40	129.0	74	Scour	-66.0	5.28	4.28	45.7	0.09
21.6			3.27																	
				Σ = 3.27																Σ = 2.77 x 10^6

* See example computation Table 7

c) (design channel
f)Subscripts denoting (jetty field
r) (unchannelized river

q = Unit discharge, 1 2 3

Y = Depth, Figure 37

$\Delta Y = Y_c - Y_f$, $\Delta^2 Y$ is second diff. 4 5

Q = Discharge, 6 7

$Q_r = Q_c + Q_f$ = 10,800 cfs

River width = 1,400 feet

Channel width = 500 feet

Channelization length = 2 miles

Tieback spacing = 250 feet

V = Velocity 8 9 Figure 37

C = Concentration 10 11 , Figure 33

QxC terms are proportional to suspended sediment carrying capacities 12 13 14 15

17 proportional to sediment that will be scoured or deposited

1.2 is factor that converts suspended load to total load

18 is the area that is aggraded or degraded

19 = Volume scoured or deposited

V_{ss} = Volume of sediment settling per second in terms of its final bed occupying volume

ΔT = Time used in obtaining 19