Vessel Induced Physical Effects Related to Navigation Changes on the Kanawha River, West Virginia

by

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(ABSTRACT)

Abstract

The U.S. Army Corps of Engineers is investigating ways to improve lockage efficiency at the Marmet Locks on the Kanawha River, West Virginia. These improvements are needed to meet projected future river traffic demands. A physical effects prediction model has been developed to evaluate the changes on the river due to changes in future traffic patterns and tow configurations. The model has been verified based on the field measured data which cover a wide range of traffic conditions. The model consists of selected equations which simulate ambient velocities; wind waves; diverging waves; squat and backwater generated by the tows; and propeller jet velocities and its associated entrainment velocities. Based on the calculated velocities, concentrations of suspended sediment induced by the disturbance are estimated, at the time of disturbance and after suspended sediments have been allowed to settle. Field data on tow induced velocity changes in a back channel and a tributary are also analyzed. The effects of passing recreational boats has also been measured in the main channel.

The predictions include two most frequent cases: a loaded barge travelling downstream and an unloaded barge travelling upstream. For both cases, the simulations are made for eleven river cross sections by considering variables such as streamflows, seasons, boat horsepowers, propeller sizes, tow directions, tow configurations, and bottom sediment size distributions.

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List of Symbols

$A_i =$ Area of subsection i (ft^2)

$A_c =$ cross-sectional area of tow configuration (ft^2)

$A_m =$ cross-sectional area of channel (ft^2)

$B =$ coefficient represented by the growth intensity of waves when ship approaches to v_{cr}

$B_c =$ width of channel (ft)

$B_1 =$ distance from side of tow to shore (ft)

$b =$ tow width (ft)

$\bar{b} =$ radius of propeller jet (ft)

$b_j =$ distance from the jet centerline to a point where the velocity is equal

$x =$ to half of the jet centerline velocity

$C =$ sediment concentration (ppm)

$C_A =$ sediment concentration induced by ambient flow (ppm)

$C_B =$ sediment concentration induced by backwater (ppm)

$C_P =$ sediment concentration induced by propeller (ppm)

$C_m =$ constant $= 0.081$

$C_o =$ initial sediment concentration due to disturbance (ppm)

$C_z =$ Chezy's coefficient

$c =$ rate of expansion for propeller jet

$D =$ depth of channel (ft)

$D_P =$ diameter of propeller (ft or m)

$D_o =$ equivalent diameter of propeller (ft)

D_{vg} = depth of velocity sensor below elevation of propeller shaft (ft)

d = draft (ft)

d_p = distance from water surface to propeller axis (ft)

d_{50} = mean sediment size (ft)

d_{75} = sediment size with 75 percent by weight finer than the specified sieve size (ft)

F = fetch length (ft)

g = gravitational acceleration (ft/s^2)

H = diverging wave height (ft)

H_w = height of wind wave (ft)

k_s = Nikuradse sand roughness height, taken as mean bottom sediment size d_{50}

L = length of tow (ft)

n = blockage ratio

n' = Manning roughness coefficient

P_e = running propeller horsepower (hp)

Q = flow rate (ft^3/sec)

ΔQ = change in flow rate (ft^3/sec)

R = hydraulic radius (ft)

r = radial distance from propeller axis (ft)

S = distance from sailing line (ft)

SQ = squat (ft)

T = wave period (sec)

U_o = initial propeller jet velocity (ft/s)

U_w = wind velocity (ft/s)

$u =$ velocity at a radial distance r from propeller axis (ft/s)

$u' =$ instantaneous velocity fluctuations in longitudinal direction (ft/s)

$\bar{u} =$ mean velocity in longitudinal direction (ft/s)

$u_* =$ shear velocity (ft/s)

$V(y) =$ velocity induced by wave at depth y (ft/s)

$V_a =$ ambient velocity (ft/s)

$V_{cr} =$ velocity of critical flow (ft/s)

$V_{e\bar{b}} =$ entrainment velocity at the edge of propeller jet (ft/s)

$V_{eyo} =$ vertical entrainment velocity near channel bed (ft/sec)

$V_S =$ tow speed (ft/s)

$V_{S'} =$ measured tow speed (ft/s)

$\Delta V =$ average backwater flow velocity (ft/s)

$\Delta V(z) =$ velocity of backwater at a distance z from tow (ft)

$v' =$ instantaneous velocity fluctuations in tranverse direction (ft/sec)

$\bar{v} =$ mean velocity in tranverse direction (ft/s)

$y =$ depth from water surface (ft)

$y' =$ distance from channel bed (ft)

$y_{pb} =$ distance from channel bed to the propeller axis (ft)

$z =$ distance from the edge of tow in the tranverse direction (ft)

$z_g =$ depth of velocity sensor above channel bed (ft)

$z_o =$ submergence of jet nozzle centerline (ft)

$\alpha = \max(1, 0.114\frac{B_c}{b} + 0.75)$

$\alpha_e =$ entrainment coefficient

$\beta = 1 - \exp(-\frac{D^2}{4C^2}x)$

$\Theta =$ channel side slope (degrees)

$\lambda =$ wave length (ft)

$\rho =$ density of water (slug/ft^3)

$\tau_c =$ critical shear stress to initiate sediment motion (lb/ft^2)

$\tau_o =$ sheer stress (lb/ft^2)

$\tau_s =$ shear stress acting on the sediment on slope (lb/ft^2)

$\Phi =$ angle of repose of the bed material (degrees)

Chapter 1 Introduction

The Kanawha River, which serves West Virginia as a navigable waterway mainly for coal barge traffic, is controlled and restricted through a system of locks and dams managed by the Army Corps of Engineers. Four dams maintain the navigable pools of the Kanawha, each increasing the head of the water approximately 24 feet. Tow traffic on the Kanawha is increasing steadily. Because of this increase, the Corps is investigating several alternatives to increase lock capacity at the Marmet Locks. Lock and dam improvement have been approved for the Gallipolis and the Winfield Locks, which control the two pools below the Marmet Dam. The Marmet Locks and Dam is located 67.7 miles upriver of the influence of the Kanawha River into the Ohio River.

Because of the existing queue and the expected rise in the tonnage of coal, the Marmet Dam will likely handle 3x3 tow configurations through its locks. This change alone, from a 1x5 to a 3x3 configuration, would almost double the tonnage with each tow, thus reducing the existing traffic. The environmental impacts of the project will not only affect the construction area, but the entire Marmet Pool. With changing tow configuration, physical effects on the pool induced by the tows have to be investigated. This information will also provide the basis for the evaluation of biological and ecological environmental impacts. TVA set up a series of velocity, wave height, and temporal instrument packages to measure the changes induced by the tow passage. The instruments were placed at areas selected by the Army Corps of Engineers and provided a representation of the tow-induced changes. The objective of this research has been the development of a computer model consisting of several equations to simulate physical effects in the river due to tow passage. This model has been verified by comparing its simulations with TVA's field data. The model has also been used to predict water velocity and suspended sediment concentrations induced by a tow passage at selected cross sections along the Marmet Pool. These cross-sections were selected by the U. S. Army Corps of Engineers, Huntington District following coordination with the U.S. fish and Wildlife Service and the West Virginia Department of Natural Resources. These cross sections represent several major features of the Pool, including straight channel reaches, river bends, steep banks, and wide and narrow stretches. Factors such as streamflow, engine horsepower, propeller size, tow direction, season, and tow configuration are considered in the predictions using the developed equations in the model as the predictive tool. By investigating the prediction output, the reader can make the necessary judgements on the increase of tow configuration from a 1x5 to a 3x3. Judgements should be made while keeping in mind the duration of each velocity effect and the normal conditions of the tow. In addition to the increasing commercial traffic, the recreational traffic is increasing. The recreational traffic's effects on the pool have also been discussed.

This thesis is set up into four main parts. First, several simulation equations are collected. Field data is then collected. The simulated data is compared with the collected data. After the simulated equations are chosen and verified, a prediction model is created.

Chapter 2. Equations for Simulations

To develop a model for the evaluation of physical effects caused by tow passage, each impact due to the disturbance must be estimated. One or more individual mechanisms are is responsible for each impact. The contributions of each mechanism have to be combined. This is to be done for the velocity distribution and wave effects at different locations along several cross sections, such as the mid-channel and the shore.

Ambient conditions before a tow passes include velocity associated with a streamflow, wind generated waves, and ambient suspended sediment concentration. As the tow passes, there is a sudden increase in depth at a given cross section due to the displacement of water volume by the tow. When the tow passes, the propeller jet entrains the ambient water into a jet and the high jet velocity impinges the channel bed and affects the shores. The tow passage also creates diverging waves which travel toward the shores. At the same time, there is a surge of water to bring water to the rear end of the tow to fill the volume emptied by the barges. The displacement caused by the leaving tow reduces the water level, producing squat. These changes in velocity distribution will cause sediment resuspension near the channel bed and at the shores. As the barge leaves, suspended sediment will begin to settle to the channel bed and the velocities will return to the ambient condition. Therefore, the velocity distribution in a navigable waterway due to the tow passage consists of a number of components. They are ambient velocity, wind wave induced velocity, diverging wave induced velocity, propeller jet velocity and backwater velocity. Each velocity has its own time phase, peak and duration. At different stage of tow passage, each component plays its own role or in conjunction with others. The potential of sediment movement is related to the resultant velocities.

In this chapter, the hydraulic and hydrologic factors related to the sediment transport are presented in terms of theoretical or empirical equations to be included in a model. The model simulations have been compared with the measured field data in order to test the validity of the model for the Marmet Pool. Then a choice was made as to which equation has the best applicability in the model. The selected verified equations constitute the prediction model which will be used to predict physical effects on the river for future tow traffic conditions.

2.1 Diverging Wave

Three diverging wave equations were examined. All of them predicted wave height as a function of tow speed and blockage ratio. The blockage ratio, which is a coefficient representing the restrictiveness of the channel, is the ratio of the channel cross-sectional area to the barge cross-sectional area. The diverging wave originates at the bow of the boat and travels with an approximate 15 degree angle to the line of travel. Balanin and Bykov (1965) predicted the wave height near the ship by the following equation:

$$H = 2.5\frac{V_S^2}{2g}\left\{1-\left[1-\left(\frac{1}{4.2+\frac{A_c}{A_m}}\right)^{0.5}\right]\left(\frac{\frac{A_c}{A_m}-1}{\frac{A_c}{A_m}}\right)^2\right\} \tag{1}$$

where $H =$ diverging wave height (ft)

$V_S =$ tow speed (ft/s)

$A_c =$ cross-sectional area of channel (ft^2) $= B_c \times D$

$A_m =$ cross-sectional area of tow configuration (ft^2) $= b \times d$

$B_c =$ width of channel (ft)

$D =$ depth of channel (ft)

$b =$ tow width (ft)

$d =$ draft (ft).

Hochstein (U.S. Army Corps of Engineers, 1980) predicted the wave height with the equation

$$H = 0.0448 V_S^2 (\frac{d}{L})^{0.5} (\frac{n}{n-1})^{2.5} \tag{2}$$

where $L =$ length of tow (ft)

$n =$ blockage ratio $= A_c / A_m$.

Using the same variables, Bhowmik (1981) yielded the diverging wave height by:

$$H = 0.867\frac{V_S^2}{2g}(\frac{d}{\pi})^{0.26}(1-\frac{bd}{A_c})^{-3.0}. \tag{3}$$

A progressive wave produces a velocity profile as a function of depth. Hochstein estimated the wave induced velocity by the following equation:

$$V(y) = \frac{2\,\pi\, H}{(\pi\,\lambda\,/\,g)^{0.5}\,\sinh(4\pi y/\lambda)} \tag{4}$$

where $V(y) =$ velocity induced by the wave at depth y(ft/s)

$y =$ depth from water surface (ft)

$g =$ gravitational acceleration (ft/s^2)

$\lambda =$ wave length (ft), approximated by $\lambda = 10H$.

2.2 Propeller Jet

Van de Kaa and Blauw (U.S. Army Corps of Engineers,1980) considered the propeller jet to have a conical shape expanding from the shaft. The velocity distribution is assumed to be a Gaussian distribution with the maximum velocity along the shaft axis given by:

$$U_o = 2.956(P_e\,/\,D_p^2)^{1/3} \tag{5}$$

where $U_o =$ initial propeller jet velocity (meters/s)

$P_e =$ propeller horsepower (hp)

$D_p =$ diameter of propeller (meters).

The Gaussian velocity distribution is given by:

$$\frac{u}{U_o} = \left(\frac{D_p}{2\,c\,x}\right)\exp\left(-\frac{r^2}{2\,c^2\,x^2}\right) \tag{6}$$

where $u =$ velocity at a radial distance r from propeller axis (ft/s)

$c =$ rate of expanding propeller flow area.

$r =$ radial distance from propeller axis(ft).

Van de Kaa and Blauw assumed a conical shape, where c is equal to x / y. Changing U_o into English units and substituting into Eq.(5) produces

$$u(r) = 2.9(D_p P_e)^{1/3} / r. \tag{7}$$

Maxwell and Pazwash (1973) studied the jet in shallow water and assumed a P-distribution for velocity about the propeller axis given by:

$$\frac{u^2}{U_o^2} = \beta(\exp\{ - \frac{4\beta}{D_o^2} [y^2 + (y - z_o)^2]\} + \exp\{ - \frac{4\beta}{D_o^2} [y^2 + (y + z_o)^2\}]) \tag{8}$$

where $D_o =$ diameter of nozzle or jet (ft)

$\beta = 1 - \exp(- D^2 / 4C_m^2 x^2)$

$C_m = 0.081$

$y =$ vertical coordinate, origin at free surface, positive downward (ft)

$z_o =$ submergence of jet nozzle center line (ft).

Whereas Van de Kaa and Blauw's equation is applicable to two propellers, Maxwell and Pazwash's equation is for the case of one shaft. To make this equation applicable to the present study, the equivalent propeller diameter D_o is obtained by multiplying D_p by $\sqrt{2}$, and the sum of the horsepower of the two engines becomes the horsepower of one. The initial jet velocity in Maxwell and Pazwash was calculated by using Van de Kaa and Blauw's equation, Eq.(5).

2.3 Backwater Flow

Backwater flow calculations were based on an approach used by Hochstein (U.S. Army Corps of Engineers, 1980). Hochstein predicted the average backwater velocity by:

$$\Delta V = V_S((\frac{n-1}{n})^{2.5} B - B + 1)^{1/2} - 1 \tag{9}$$

where $\Delta V =$ the average backwater flow velocity (ft/s)

$V_S =$ tow speed (ft/s)

$B =$ coefficient represented by the growth intensity of waves when ship approaches to V_{cr}

$V_{cr} =$ velocity of critical flows

$n = A_c / A_m$.

An adjustment factor, α, derived by Fuehrer and Romisch (1977) is included to represent the maximum backwater velocity in a restricted waterway based on the average backwater velocity of Eq.(9):

$$\alpha = \Delta V_{max} / \Delta V = \max(1,\ \ 0.114 B_c / b + 0.75) \tag{10}$$

where $B_c =$ width of channel

$b =$ tow width.

The profile of the backwater velocity in the lateral direction is given by:

$$\Delta V(z) = K_1 \, e^{-z/K_2} \tag{11}$$

where $z =$ distance from edge of tow in the transverse direction.

Also

$$\int_0^{B_1} \Delta V(z)dz = K_1 K_2 (1 - e^{-B_1/b}) = B_1 \Delta V \tag{12}$$

where $B_1 =$ distance from side of tow to the shore (ft).

If z=0, then $\Delta V(0) = \Delta V_{max}$, and from Eq.(11),

$$K_1 = \alpha \Delta V \tag{13}$$

and from Eq.(12)

$$K_2 = B_1 / \alpha (1 - e^{-\alpha F(\alpha)}) \tag{14}$$

where $F(\alpha) = 0.42 + 0.52 \ln \alpha$.

Therefore, solving Eq.(10) for $\Delta V(z)$, one arrives at

$$\Delta V(z) = \alpha \Delta V \exp(-z\alpha(1 - \exp(-F(\alpha)\alpha)) / B_1) \tag{15}$$

where

$$\Delta V = V((\frac{n}{n-1})^{1.25} - 1). \tag{16}$$

2.4 Ambient Velocity

The ambient vertical velocity profile was based upon the Prandtl/von Karman logarithmic velocity distribution for turbulent open channel flows (Chow, 1965):

$$V_a = 2.5\, u_* \ln 30 \frac{y'}{k_s} \tag{17}$$

where V_a = ambient velocity at depth y'

y' = distance from the channel bed

u_* = friction velocity or shear velocity

k_s = Nikuradse sand roughness height, taken as mean bottom sediment size d_{50}.

The continuity equation gives

$$Q = VA = \int_0^{y'=D} bu\,dy'. \tag{18}$$

If channel width is taken to be 1 ft, Eq.(18) becomes

$$DV = \int_0^{y'=D} u\,dy' \tag{19}$$

or

$$V = \frac{1}{D}\int_0^{y'=D} u\,dy' \tag{20}$$

where V is the depth averaged ambient velocity. The calculation of V will be discussed in detail in Chapter 3.

2.5 Squat

As mentioned earlier, squat is expected during the passage of tow. Squat is defined as the maximum lowering of water level below the undisturbed mean water level, occuring immediately after the tow passage. The water surrounding the tow is drawn to replace the void created by the passing tow. Schijf and Jansen (1953) related the squat to the backwater velocity and the ambient velocity:

$$SQ = \frac{(V_a + \Delta V)^2 - V_a^2}{2g} \tag{21}$$

Gelencser (1977) found the following relation.

$$SQ = 2.0 \times 10^{-6}\left[\left(\frac{V_S A_m L^2}{S\, A_c^{1/2}}\right)^{1/3}\right]^{2.8} \tag{22}$$

where $S =$ distance to sailing line in meters (all units are in metric).

Gates and Herbich (1977) found

$$SQ = \frac{V_s^2}{22.6}\left(\left(\frac{A_c}{A_c - A_m}\right)^2 - 1\right). \tag{23}$$

Dand and White (1978) found

$$SQ = 0.39(V_s - V_a)^2 n^{1.4}. \tag{24}$$

Bhowmik et al. (1981) gave

$$SQ = 1.03 \frac{V_s^2}{2g} \left(\frac{A_m}{A_c} \right)^{0.81} \left(\frac{L}{S} \right)^{0.31}. \tag{25}$$

Balanin and Bykov (1965) gave

$$SQ = \frac{V_S^2}{2g} \left(\frac{A_c}{A_m} - 0.5 \right) / \left(\frac{A_c}{A_m} - 1 \right)^2. \tag{26}$$

2.6 Wind Waves

The wind wave height was calculated by using equations proposed by the U. S. Army Coastal Engineering Research Center (CERC). The equations were generated to predict wind waves over open bodies of water, such as reservoirs and oceans. To predict wind waves on inland waters such as streams, the fetch length must be adjusted for the local topography and the channel. At different locations on the Kanawha River, the mountains along the river produce a tunneling effect which intensifies the wind and changes its direction and the fetch length. But on other reaches the mountains shelter the river from the wind, creating another set of conditions. No equations are available in the literature to predict wind induced wave height for this situation. Therefore CERC's equations are used for this study with careful selection of the fetch length. This procedure may not be exact in all cases but does give the best approximation available. But the wind induced water velocity is so insignificant that the shortcomings of these equations is acceptable. Wind wave height and wave period are calculated using the CERC equations:

$$\frac{gH_w}{U_w^2} = 0.283 \tanh[0.53(g\frac{D}{U^2})^{0.75}] \tanh\left\{\frac{0.0125(g\frac{F}{U_w^2})^{0.42}}{\tanh[0.53(\frac{gD}{U_w^2})^{0.75}]}\right\} \qquad (27)$$

and

$$\frac{gT}{2\pi U_w} = 1.2 \tanh[0.833(g\frac{D}{U_w^2})^{0.375}] \tanh\left\{\frac{0.077(\frac{gF}{U_w^2})^{0.25}}{\tanh[0.833(g\frac{D}{U_w^2})^{0.375}]}\right\} \qquad (28)$$

where H_w = wind generated wave height (ft)

F = fetch length (ft)

U_w = wind wave velocity measured above the water surface(ft/s).

Based on the measured wind direction at the site above the water surface, in the main channel, a wind fetch length could be estimated from a location map. Because of the funneling effect in the valley, this fetch length is considerably different from the one estimated based on the wind direction above the mountain ridge. Eq.(4) is used to calculate velocity profile over depth due to waves.

Chapter 3. Field Measurement Data and Model Verification

3.1 Field Experiments

Three sites in the Marmet Pool were selected to monitor the impact of tow passage. They are the Watsons Island main channel and back channel and lower Cabin Creek. Two towboats, the Morris Harvey (rated 1000 hp) and the Valvoline (rated 3400 hp) were chartered for the tests. The 1000 to 3400 horsepower range includes a majority of the towboats using the Marmet Pool. The configuration of tows, direction of tow, boat horsepower, and boat speeds were varied to provide a wide range of traffic conditions so that the physical effects on the river might be evaluated.

The selected Watsons Island main channel site was at river mile 75.7. The Tennessee Valley Authority set up five velocity gages, two wave gages, a temperature sensor, a wind direction and velocity gage, and turbidity measuring instruments in the main channel (stations 3,4, and 5), as shown in Figure 1. Three velocity probes were located at the mid-channel, at 1.5, 8, and 16 feet from the bottom in a water depth of 22 feet. One velocity probe was located at the lateral quarter-point at its mid-depth of 9 feet (station 2). A near shore velocity probe was set up at the mid-depth in 3 feet of water (station 1). The 3 feet depth insured the gage was not in the wave breaking zone. Wave movements inside the breaking zone are very difficult to predict. All velocity gages were read at one second intervals and provided two velocity components, with the positive x-direction pointing downstream and positive y-direction pointing towards the island. Wave gages were set up near shore at upstream and downstream of the velocity gages, and were read every one-tenth second. The wave height was measured with reference to mean sea level. Sediment samples were collected at the locations of the velocity gages.

The test tows followed a prescribed path on the sailing line. Surveyors stationed on the left bank tracked a target on the towboat. Measurements of distance and bearings were taken at least once per minute and recorded.

The boats were run under patterns and speeds that might be seen under present and future traffic conditions. The engines can change the amount of horsepower to the shaft by altering the oil-gas ratio. It was assumed that the boats used modes of operation during these tests runs similar to normal operation. With this assumption, relationships between several variables can be established: horsepower generated by the vessel vs. RPM of the shaft; horsepower generated by the vessel vs. RPM of the propeller; running horsepower vs. tow speed; and RPM vs. tow speed. Without this assumption, predicting of future conditions is difficult.

3.2 Boat Tracking

Given the coordinates of the path of the tow during an experiment run, the distance from the tow center to the velocity gages could be found. A Fortran program, TRPLOT.FOR, was written to find these distances given the tracked coordinates. The program searched the coordinates and found the two consecutive coordinates closest to the gages. By using the law of sines and law of cosines, the distance from center of the tow to the gage was calculated. These distances were adjusted to take into account the off center position of the survey target on the towboat. The same program was used for the main channel, back channel and tributary.

For each tracked location of the tow, the surveyor recorded the corresponding time of each distance and bearing. Knowing the two points closest to the test section and the time the barge passed them, the average tow speed was found by using the computer program TRSP.FOR.

3.3 Velocity Data

Before any comparison of measured data and computer simulated values could begin, the raw data files had to be processed into a more usable form. KANAW.FOR was written to set up three velocity data files: maximum velocity, moving averages, time averages file. The maximum velocity file contained the 10 second averaged maximum positive and maximum negative velocities that occurred at each velocity measurement station. The raw data always contained a certain amount of fluctuation caused by the sensitivity of the velocity gages and flow turbulence as shown in Figure 2. A moving average placed on the data would reduce the sharp oscillations but adversely reduces the velocity peaks as indicated in Figure 3. A 10 second moving average proved to be a value that made the readings more continuous without a large reduction of velocity peaks. The last file averaged the row data files into 15 second intervals for all stations. The product of velocity fluctuation for the x and y components, $u'v'$, a value indicating the turbulence intensity, was calculated and averaged over a 15 second period.

3.4 Wave Height and Squat Data

The wave gage file was treated in a manner similar to the velocity data. A small moving average, 0.3 seconds, was applied. The moving average value had to be less than the wave period so that the average generated a smoother curve.

To measure the wave disturbances, data from the 0.3 seconds moving averages files were plotted. Figure 4 shows the first half minute of the wave gage data for a main channel experiment run. It was assumed that the disturbance at this early time was primarily due to wind waves. The average amplitude, peak to peak, was measured and recorded for each scenario. Immediately before the tow passage, a slight lowering of the water level known as drawdown occurs. As the tow passed the main channel test section, the depth increased for a very short period of time. As a tow moves away from the test section, the displacement, which was caused by the leaving barge, created a drop in average water level. This drop in water level is known as squat. The measured squat was taken as maximum drop in water level as shown in Figure 5. After the tow passed, there were a series of diverging waves created. The maximum diverging wave height was easily identified and was measured as indicated in Figure 6. The measured values of squat were compared to the simulated values as shown in Figures 7 through 12. A correlation coefficient was found to determine the equation which produced the best comparison.

3.5 Hydrologic Analysis

Streamflows are needed at TVA's field measurement sites and at the selected cross-sections where profiles were mapped. Two of TVA's three test sites were located at Watsons Island. The main channel site was at river mile 75.7, and the Watsons Island back channel site was at river mile 75.6. The tributary site was located on the lower reach of Cabin Creek which enters the Kanawha River at river mile 74.3. The experiments were conducted during the period of September 21-27, 27-29, 29-30, 1987, respectively, for each test site. Eleven cross-sectional profiles were mapped throughout the study area for the purpose of model prediction of future traffic impact evaluations. The cross-section at river mile 75.7 was mapped on September 20, 1987, prior to any study work. Sections at the arrival point, downstream of the Marmet Dam, at river mile 67 and the arrival point upstream of the London Dam at river mile 83.6, were mapped on September 27, 1987. The rest of the cross-sectional profiles were mapped on September 26, 1987. Streamflows for each of the river sections during the specific study dates have been computed based on the following procedures.

The two nearest USGS streamflow gaging stations to the Marmet Pool are downstream of the Pool at Charleston, West Virginia (Station 03198000) and upstream of the Pool at Kanawha Fall, West Virginia (Station 03193000). The streamflows at these two stations for the month of September, 1987 were obtained from the U. S. Geological Survey (USGS). Drainage areas between the two stations and for each large tributary were computed based on the USGS topographic map. Streamflow at any given river section between the two gaging stations was interpolated on the basis of contributing drainage area. River sections between any two tributaries are assumed to have the same discharge. Watsons Island divides the Kanawha River into the main channel and the back channel. Based on the channel widths, cross-sectional areas, and ambient velocities, it was concluded that 60 % and 40 % of the streamflow should be assigned for the main channel and the back channel, respectively. Table 1 shows the results of the streamflow computations. They were used to compute mean stream velocities and consequently for the computations of point velocities.

In order to gain an understanding of how streamflows in the Marmet Pool during the month of September, 1987 compare to the mean flows, statistical analysis was performed based on the 47 year records at the two gaging stations. Also, for the purposes for predicting any hydraulic impacts on the river due to future navigation conditions, it was decided that low and high flows having a 5 year return frequency for four seasons would provide useful information in connection with the environmental impact evaluations. Based on the Log-Pearson Type III method for streamflow frequency analysis, 5-year low and high flows were analyzed at both gaging stations. The results were then interpolated for all 11 selected river sections. Table 2 shows the mean, 5-year low and 5-year high flows for various river sections for each season. Tables 1 and 2 indicate the streamflows for the second half of September, 1987 were quite close to the 5-year low flows for the fall season. TVA's field experiments were intended to be studies for the low flow conditions.

The cross-sectional mean velocity for a given river section can be simply calculated by dividing the streamflow by the cross-sectional area. However, it is known that velocity distribution in a cross-section is nonuniform. A better presentation of velocity variation is to compute mean velocity for each of the five subsections which consists of two near shore subsections, two midway subsections and one central subsection. For a given subsection, discharge is divided by area to yield mean velocity. The discharge for the i-th subsection is found by $(Q_i/Q)Q$ where Q is the total discharge for the entire cross-section and the ratio Q_i/Q is calculated either by the Manning's equation (29) or the Chezy's equation (30) as follows:

$$\frac{Q_i}{Q} = \frac{(A_i R_i^{2/3})/n_i'}{\sum_{i=1}^{5}(A_i R_i^{2/3}/n_i')} \tag{29}$$

$$\frac{Q_i}{Q} = \frac{(CR^{1/2})_i A_i}{\sum_{i=1}^{5}[(CR^{1/2})_i A_i].} \tag{30}$$

In which, $i=$ 1 to 5 indicates subsections;

$R=$ hydraulic radius;

$A=$ area;

$C=$ Chezy's roughness coefficient; and

$n'=$ Manning's roughness coefficient.

The Chezy's roughness coefficient is calculated by the following equation:

$$C = 32.6 \log_{10}\frac{12.2R}{k_s} \tag{31}$$

where k_r in feet is the average height of channel roughness generally expressed by the mean bottom sediment size d_{50}. The Manning's roughness coefficient is calculated by either form of the Stricker's equation.

$$n' = 0.034\,(d_{50})^{1/6} \tag{32}$$

or

$$n' = 0.031\,(d_{75})^{1/6} \tag{33}$$

where d_{50} and d_{75} measured in feet are sediment size with 50 % and 75 % by weight finer than this particle size. Sediment sizes are available since bottom sediment samples at subsections have been collected and their size distributions analyzed.

Extensive comparisons were made between the results of Eq.(32) and Eq.(33) and between Eq.(29) and Eq.(30). Differences in results have been found to be insignificant. Therefore, Eq.(30) in conjunction with the use of Eq.(31) has been adapted for this study. A typical computer output of the calculation of Q_i/Q expressed in percent and mean velocity in each subsection for various flows and different seasons is shown in Appendix B. It should be noted that DH shown in Appendix B indicates the change in water level corresponding to the change in streamflow. The change referred to is the change of water level with respect to the base water level as determined when the cross-sectional profile was mapped. The relationship between the change in DH and the discharge Q was based on the established rating curve for the USGS gaging station at Kanawha Falls. Since no rating curves are available for the study sections in the Marmet Pool, the use of the established rating curve is considered to be a reasonable practice.

If a velocity profile for each subsection is needed in order to find velocity at a given depth, the following equation to describe velocity distribution over a water column is used:

$$V_a = 5.75\, u_* \log_{10} \frac{30y'}{k_s}. \tag{34}$$

where V_a is the point velocity at a distance y' from the channel bed, u_* is the shear velocity and k_s is the average height of channel roughness. u_* is found by a trial and error procedure such that the velocity profile would yield a depth averaged mean velocity, which is equal to the calculated mean velocity in the subsection. Figures 13 through 16 show the comparison of the calculated point velocities and measured velocities at various points for the cross-section at river mile 75.7 for different flow conditions during the last week of September, 1987. The comparison indicates that the procedures used for the hydrologic analysis are adequate to predict point velocities and mean velocities in subsections.

3.6 Ambient Velocity

The velocity gages were activated at the same time as the start of the boat tracking; therefore there was at least a couple of minutes of unaffected flow before the boat approached the test section and the velocity probes affected by the change in velocity. To find the ambient velocity, the velocities created in the 15 second time averaged file were averaged over the undisturbed period for all stations.

Using the procedures outlined in the section of hydrologic analysis, the ambient velocity was simulated for all stations. The ambient velocity at the river bottom was taken at a depth of 1.5 feet. The hydrologic analysis calculated the ambient velocity based upon the streamflows at the test site, interpolated from two USGS gaging stations.

Information about the tow configuration, the towboat engine rpm, engine rated hp, propeller rpm, and engine running horsepower was gathered during the field efforts by TVA for the Huntington District. Additional information was provided by the tow companies. The relationship between horsepower at the propeller and tow speed was established for use in developing prediction formulae. For an upstream scenario, the towboat is moving against the ambient velocity. Thus

$$V_S = V_{S'} + V_a \tag{35}$$

where $V_{S'} =$ tow speed measured (ft/s)

$V_s =$ true tow speed (speed relative to the bank)

$V_a =$ ambient velocity.

During downstream runs the boat is assisted by the ambient velocity.

$$V_S = V_{S'} - V_a \tag{36}$$

After the tow speeds were corrected, V_s vs. hp was graphed. The plotted graphs (Figures 17 and 18) showed that different tow configurations required different hp for the same speed. In other words, the 3x3 tows required more horsepower than the 1x5 configuration to travel at the same speed.

3.7 Comparison between Simulated Results and Measured Data

When comparing the measured values with the simulated values, the graphs of time variation of velocity and wave were normally inspected simultaneously. As stated before, a measured velocity could be the resultant of one or more individual component such as wind induced wave velocity, diverging wave velocity, backwater velocity, ambient velocity and propeller jet velocity. The simulated values for each component are based on either theoretical equations or empirical formula where one velocity component is predominant and other effects are insignificant. Each velocity component being investigated has its own time phase and duration. When measured and simulated values are compared, different combinations of velocity contributions had to be carefully studied.

All velocity components in the downstream direction are increased by the ambient velocity, and vice versa. Figure 19 shows a typical velocity variation recorded at a station 1.5 ft above channel bed, along the sailing line at the test section river mile 75.7. In this case, the tow is travelling in the same direction of the ambient velocity, i.e. downstream. Just before the tow runs over the station, a small velocity increase is noticed in the downstream direction due to water being pushed by the front end of the tow. The graph then shows a sharp velocity shift in direction. This is due to the propeller intake and jet. After the propeller effect decreases, the velocity returns to the downstream direction. This is caused by the resurge of water from the displacement of water commonly known as the backwater velocity.

At the shore, one more velocity component induced by the diverging wave must be included. The wave usually approaches the shore at a 15 degree angle. Under the water surface, the wave motion produces an oscillating velocity moving in the positive and negative direction.

3.7.1 Diverging Wave

The wave gage data for near shore stations located at the upstream and downstream of the test section were plotted over the period of tows wave disturbance. The highest amplitude difference was recorded as the measured maximum diverging wave height for each test run.

The simulated values were plotted against the measured values. Simulations by equations used by Hochstein and Bhowmik both showed fair comparisons to the measured values. Figures 20, and 21 show that the measured values were slightly higher than the simulated ones. The wave gage was at the shore and Balamin and Bykov's equation computed the ship diverging wave height close to the barge, which might explain the high simulated values. Because of the high simulated values, the Balamin and Bykov's equation was not compared to the measured values.

The wave heights were used to predict the wave induced velocities at various depth at the shore. The velocity due to the wave was negligible at locations other than the shore. At the shore, the velocity was on the order of 0.1 ft/s at a depth of 1.5 ft. At the shore bottom of 3 ft, the velocity had very small magnitude.

3.7.2 Wind Wave

Waves appearing during the first minute of each moving averaged wave file were considered to be the effect of the wind. By searching for the wind velocity data files, wind speed and direction were averaged for each tow scenario. The fetch length was estimated by using an enlarged map of the river for each cross-section. Inputting this information into the computer simulation program, the wind wave height and wind induced velocity were calculated. Simulated values proved to be higher than the measured values. But the magnitude of the simulated value was so small (less than 0.05 ft) that the wind induced velocity was negligible. Over-estimated fetch lengths could account for the high simulation values. As the wind speed increases, the wind is channeled in the direction of the river, thus the fetch length is extremely difficult to estimate. Furthermore, as discussed in section 2.6, the equations generally used for large water bodies are not exactly applicable for special cases such as a winding river entrenched in a deep, narrow valley.

3.7.3 Propeller

To find propeller effects, the first negative peak on the velocity history chart for a downstream run and the first positive peak for an upstream run were recorded. These values represented the propeller induced velocities plus the ambient flow velocities. To evaluate the propeller effect, the distance from TVA's velocity gages to the center of the towboat must be found as follows:

$$r^2 = S^2 + D_{vg}^2 \qquad (37)$$

where $r =$ radial distance from gage to the propeller (ft)

$S =$ horizontal distance from gage to sailing line (ft)

$D_{vg} =$ depth of the velocity gage below the elevation of propeller shaft (ft).

D_{vg} is best estimated by

$$D_{vg} = y - d + D_p / 2 \tag{38}$$

where $y =$ depth of the velocity gage (ft)

$d =$ draft (ft)

$D_p =$ diameter of propeller (ft).

Since the monitored towboats did not always travel directly over the gages, it was necessary to calculate this radial distance from the gage to the propellers so that velocity at the gage could be calculated.

The horsepower value used in the simulation equations was the running horsepower at the propeller and not the rated horsepower.

To compare the measured values with the simulated values, the ambient velocity was added to or subtracted from the simulated propeller jet velocity. At the sailing line, Blauw and Van de Kaa's (A.C.E., 1980) equation for propeller jet velocity provided the best comparison. Figures 22 and 23 show velocities on the sailing line at 8 and 1.5 feet from the channel bed in a channel depth of 22 feet.

The diverging wave velocity component at the shore was added to the simulated ambient velocity and propeller induced velocity. Maxwell and Pazwash's (1973) equation proved to be more consistent and showed better comparison with the measured data. Both propeller equations, however, simulated a lower value than the measured velocities. An adjustment value was applied to both propeller velocity equations, with the adjustment factor of 1.86 used for the shore and 1.25 for the lateral quarter point. The adjustment factors were used to provide the best correlation between the measured and simulated values so that the prediction model could better predict the velocities at the quarter lateral and shore locations. Figure 24 shows comparison between the adjusted simulated values and measured values at shore. The pitch of the propeller's axis is not included as a variable in the equations employed. Although not all towboats of similar horsepower have the same pitch, this varible is generally considered as a constant in all the equations available in the literature.

3.7.4 Backwater

To calculate backwater effects, the distance from the location of interest to the edge of the tow, measured tow speed, and channel and tow dimensions were inputted into the simulation program. Using Hochstein's equation, backwater velocity was calculated as a function of distance from the side of the tow. For a 3x3 configuration, the tow width is 105 feet; and for a 1x5 configuration, the tow width is 35 feet. The tow usually travelled close to the instrument package; therefore the mid-channel velocity sensor were within the width of the tow. To predict backwater velocity inside the tow width, the maximum value estimated at the side of the tow was used.

The backwater travelled in the same direction as the tow. For an upstream run the value was in the opposite direction as the ambient velocity. For downstream runs, the backwater was in the same direction as the ambient velocity. At the sailing line, the simulated backwater velocity was added to the simulated ambient velocity in order to compare them with the measured data. At the shore, the diverging wave velocity was also added. Figures 25 and 26 show the comparison of simulated and measured values at the mid-channel and shore. The comparison showed acceptable agreement.

3.8 Bottom Sediment Sampling Procedures

Bottom sediment samples were collected on September 19 and 20, 1987 in the Marmet Pool, at one cross-section in the Watsons Island main channel, one cross-section in the Watsons Island back channel and three cross-sections in Cabin Creek. These samples were taken before TVA set up their instruments for the field experiments on tow passage effects. On September 26 and 27, 1987, samples were collected for cross-sections at river miles 68.1, 73.1, 74.3, 75.8, 78.7, 80.2, 81.1, 81.6, at the arrival point downstream of the Marmet Dam and arrival point upstream of the London Dam. All the cross-sections, except the arrival points, were marked by bright pink surveyors flags on September 19, 1987, before any bed material sampling took place. Each section was specifically selected and marked by the staff of the U. S. Army Corps of Engineers, Huntington District following consultation and suggestions made by the U. S. Fish and Wildlife Service and the West Virginia Department of Natural Resources.

A cross-sectional profile was plotted for each section. These profiles are shown in Appendix A. Five bottom sediment samples were collected from each main channel cross-section and the back channel section. Samples at the two banks, mid-channel and a point between the mid-channel and each bank were collected. Three samples were collected from lower Cabin Creek, one along each cross-section. These samples were collected at each bank and the mid-point. The location from the bank was measured by use of a range finder. The deeper water depths were measured by the diver's depth gage. The near shore station depths were measured with a measuring rod.

Bed material ranges from very fine silt/clay with high organic content to large gravels and boulders. Most of the samples taken at shores and all samples from Cabin Creek are fine material. They were collected by a Model BMH-53 piston-type bed material hand sampler and a Model BMH-60 hand-line material sampler as recommended and supplied by the Federal Inter-Agency on Sediment Project. Additional samples were collected using an 80 pound "clamshell" type bed material sampler. The first two types of samplers are suitable for very small gravels, sand, silt and clay which are loosely or moderately compacted bed material. The clamshell sampler was used to retrieve larger sized bed material.

The material trapped inside the samplers was completely enclosed before the samplers were raised through the water column to the water surface for removal to the containers on board. No material was lost. When the clamshell sampler was used, a large volume of material was retrieved, but only a small portion taken from the center part of the larger volume was retrieved and packed into the sample container. Since the samples from the shores and from Cabin Creek were taken in water from one to five feet deep, the escape of fine bed material was very minimal, if any.

Three samples from the main channel for each river cross-section and coarse material at shores were collected by a diver. A diver was used for two major reasons. First, bed material containing coarse pebbles and larger cobbles prevented the closure of BMH-60 sampler and the clamshell sampler. The piston type sampler was too small for the large sized sediment and is designed for use in shallow locations. The clamshell sampler sometimes could collect bed material after several attempts; however, fine material escaped easily when the sampler was raised through a ten to twenty feet water column. Second, a diver could retrieve fines from locations between large objects and make note of the overall character of the bottom and objects too large to retrieve. The general procedure was to anchor the boat and then record the position and depth of the water at the sample site. The diver carefully entered the water at the downstream end of the boat to avoid any disturbance of bed material located at the upstream end of the boat. The diver was specifically instructed that representative and undisturbed bed material was to be sought and no fine material should be allowed to escape. The diver took a sediment container with cap and approached the sample site. He used the container to carefully cut the river bed as deeply as the edge of the container could penetrate. The lid was used to gently scoop as much sediment into the container as possible, scooping from the upstream to the downstream direction. The container was sealed immediately after collection and brought to the surface. This procedure worked very well for most of the samples. The diver sampling method accounted for 42 of the total 80 samples. Fine material samples accounted for 35% of the total samples. The remaining samples consisted of larger gravels to boulders, too large to retrieve. In some cases, no binding material existed. In some other instances the interstitial binding material was too scanty to use the scooping method described above to sample them. In those situations reasonable effort was made by the diver to collect as much material as possible. For the case of trace amount of fines, the diver paid special attention to collect fine material between large stones. Rocks were removed to expose the binding material, if necessary. At these sites the average size of the stones greater than the 6-inch container opening was reported since they were not collected. At some sample sites, very small amounts of bed material was collected. At two sites, nothing was yielded in spite of many attempts. The sampling crew adhered rigorously to the selected cross-sections. When one sampling method did not work at the designated sample site the sample crew tried another sampling method such as the diver.

3.9 Laboratory Sediment Analysis

The information of sediment size distribution is required for the determinations of streamflow velocities at various locations in the Marmet Pool. It is also useful to the prediction of sediment resuspension and settling in conjunction with other analyses presented later in this report.

Laboratory analysis of sediment samples involves three major procedures. They are determination of organic material, mechanical sieve analysis for particle size coarser than No. 200 sieve (0.074 mm) and hydrometer analysis for the soil fraction finer than No. 200.

Samples collected from the field were first air dried, weighed and processed for the removal of organic material. Where samples contain a significant quantity of coal, the U. S. Geological Survey manual suggests that separation and quantification be based on difference in specific gravity. A mixture of bromoform and acetone adjusted to a specific gravity of 1.95 was used as the medium. After stirring and settling processes, the floating light organic material was skimmed off. The material settled was air dried and analyzed for sediment size distribution. The organic material was also air dried and weighed. Percent organic material contents were then calculated based on the ratio of the dry weight of organic material to the dry weight of the sample (Kuo et al, 1988).

Both the organic material and sediment were analyzed for size distribution. For a given river section, five samples were collected, one at the middle of the channel, one at each shore and one each for the mid-point between the shore and the central point. These samples were designated with a number 1 through 5 from the right descending shore to the left descending shore in sequence. For an example, Sample 80.2-3 is the designation for the mid-channel sample at river mile 80.2. According to the U. S. standard sieve sizes, fines contain silt (0.005 mm - 0.074 mm) and clay (< 0.005 mm). Sand contains fine sand (0.0074 mm - 0.42 mm) and coarse to medium sand (0.42 mm - 4.76 mm). Anything coarser than 4.76 mm is considered as gravels or boulders. The size distribution curve for a given sample illustrates the percent by weight finer than a given grain diameter. The curve is made-up by two segments, one for the sand and the gravels and the other for the fines. There is some overlap between the two segments within the range of fine sand. The former curve segment is determined by standard sieve analysis and the latter is obtained through hydrometer analysis. Both analyses follow the procedures outlined in the American Society of Testing Materials (ASTM) manual.

3.10 Laboratory Study of the Sediment Suspension and Turbidity

One of the project objectives is to attempt to predict the concentration of suspended solids and the turbidity generated due to different water velocities induced by river traffic in the Kanawha River. Once the relationships between water velocity and suspended solids concentration, and between water velocity and turbidity, have been established, a turbidity and a suspended solids concentration can be predicted in the field if a water velocity is known. These relationships were derived based on laboratory experiment data since generation of turbidity in a laboratory flume is under controlled conditions and a reasonable wide range of turbidity may be covered.

A total of 16 samples consisting predominately of fines were taken from the Kanawha River, and the relationships mentioned above were determined for each sample. The samples were all taken from sites near shore.

An Armfield S8 Sediment Transport Channel was used to run the raw samples (Figure 27). The dry sample was placed in the sediment chamber so the sample material was level with the bottom of the fabricated tank. Tap water was then added and allowed to saturate the sample as to approximate natural conditions. Once the sample was thoroughly soaked, additional tap water was slowly added until it was three inches above the bottom of the flume. The speed control knob was then set to 0.25 feet per second according to a calibration curve. After a steady state condition was reached (about five minutes), water and suspended solids were removed with the aid of a ninety degree suction pipet. Depth-integrating samples were taken to insure that representative samples for the water column were obtained. The water and suspended solids mixture was then strained through a filter and allowed to air dry. With the flume still running at 0.25 ft/s, another representative sample was withdrawn and the turbidity was measured with the Hach XR Turbidimeter. The speed control dial was then set to 0.50, 0.75, 1.00 and 1.25 fps, and all of the above described steps were repeated. For concentration determination, a 400 ml sample of the mixture was taken at each velocity reading. Water temperature was almost equal to a constant room temperature of $24^{\circ}C$ in the laboratory. After filtering, the suspended particles were allowed to air dry, and the net weight was measured.

To measure the turbidity, a sample cell was filled and then placed in the turbidimeter that gives a direct reading of the turbidity value. The maximum allowable turbidity reading by the instrument is 1999 nephelometric turbidity units (NTU). In the event that a turbidity reading was above this limit, half of the sample cell was filled with the mixture and the other half with water and the reading was taken and doubled. Turbidity was read directly from the turbidimeter in NTUs so no calculations were required. Concentration however is defined as the weight of dry solids divided by the weight of dry solids plus the weight of the water. For the weight of water a density of 0.9972 g/ml was used, giving a total weight of water for 400 ml of 398.88 gm. The weight of the solids was determined in the laboratory. All concentration units are given in parts per million (PPM).

Four sets of graphs are presented, with each set including two graphs: concentration vs. velocity and concentration vs. turbidity. Each individual chart contains four individual samples (Figures 28 through 35). In some cases the concentration for 0.5 fps is less than the concentration at 0.25 fps for a given sample. This is probably due to the depth-integration sampling technique which has an error amplified due to the very small weights of suspended solids involved. The readings of the turbidity and concentration of suspended solids which are presented in the figures need to be adjusted when these figures are used for field conditions. The total mass of sediment being eroded and entrained into the water column per unit area of channel bed subjected to a given near bed water velocity is assumed practically the same as the mass eroded and entrained in the field. It was assumed that the resuspension of bottom sediment material is under a steady state condition with constant water velocity. An instantaneous velocity such as an impulse above mean velocity over a short time period, a typical phenomena commonly seen due to river traffic, probably would have minimal effect. Furthermore, the sediment samples in the laboratory sediment flume do not have the same degree of compaction as in the field. In many cases, the fine sediment on shore is protected by the organic material, such as leaves, which lie on top of the channel bed. It should be noted that application of the laboratory derived experiment results to the field conditions represents conservative higher values. The following equation has been developed for the purpose of field application to predict concentration of suspended solids for silty bed material:

$$C = \frac{1.043}{h} C' \tag{39}$$

where C' is the concentration of suspended solids for a given water velocity as obtained from Figures 28, 29, 30 and 31. C is the concentration in the field, and h is the water depth measured in feet at the location of interest. Once the concentrations are known, the turbidity readings are provided through the relationship curves between turbidity and concentration as shown in Figures 32, 33, 34 and 35. Since different sediment samples collected at different river sections along the Marmet Pool have different characteristics in terms of size distribution and percent of organic material contents, it is advised that figures 28 through 35 are for specific sites, and are not intended for general application.

In the laboratory study, the parameter of critical velocity instead of critical shear stress was used since the critical velocity is easy to measure in both the laboratory and in the field. Equation 39 was not used in the prediction for various tows and flow conditions. There are two reasons which contribute to this decision. Out of all the sediment samples collected in the Marmet Pool, the majority of them fall into the sand range. Therefore, the Colby chart, i.e. Figure 36, is applicable. As discussed earlier, equation 39, when applied to the field situations, overestimates the sediment concentrations. If special attention is needed for the sediment on the shore, which has high fines and organic matter, equation 39 should be used to get a rough estimation in terms of the potential of sediment resuspension due to tow traffic.

3.11 Sediment Concentration

Using Colby's relationship (ASCE, 1965) between average streamflow velocity and concentration of suspended sediment in ppm (Figure 36), the concentration was found and compared with the measured values. The simulated concentrations were based on the simulated velocities due to the tow passages and had to be adjusted to the time when sediment samples were taken in the field for concentration determination. Concentrations were normally high at the moment when an impulse of velocity occurred during the tow passage. As time proceeded, sediment particles gradually settled. When samples were taken a few minutes later, the concentrations had already decreased. The turbulent flow which was responsible for sediment resuspension lasted for a few minutes; therefore, it was assumed that the sediment was uniformly distributed in the water column. The fall velocity of sediment as a function of particle diameter is given by Rouse (ASCE, 1965), shown in Figure 37. Based on the mechanics of sedimentation, the concentration C_P at time t can be found in terms of the initial concentration C_o at the time of disturbance. Since the information on size distribution of bottom sediment is available, the particle sizes are divided into groups. Fall velocity of the mean particle size of a group is calculated. The time required for a group to deposit at the channel bed is computed. When a group of sediment is completely removed from the column due to settling, the concentration of sediment decreases. A computer program has been developed to keep track of the processes. Figures 38 through 47 show the relationship between C_P/C_o and t based on bottom sediment properties for the selected river sections. By obtaining a relationship over time, sediment concentrations measured by TVA can be compared to simulated results. To find C_p from the information presented in figures 38 through 47, the following procedures should be followed:

1. Find C_o from tables included in Appendix C for a given tow and flow condition. C_o is the sediment concentration induced by the propeller jet velocity at the maximum disturbance.

2. For a specified time after the initial disturbance, a value of C_p/C_o can be found from these figures for a given sediment sample.

3. Find C_p by taking the product of C_o and C_p/C_o . This C_p value is then used in equation 40.

The initial concentration C_o is primarily due to propeller jet velocity. In the river, turbulence intensity drops sharply after the propeller effect disappears. By the time TVA mid-channel samples were collected, the backwater effect had become more critical and kept some of the sediment remaining in suspension. The backwater velocity yielded its own concentration. Therefore, at any time t, the total sediment concentration C is given by the sum of contribution from propeller jet velocity, backwater velocity and ambient velocity:

$$C = C_P + C_B + C_A \tag{40}$$

where $C =$ concentration at time t

$C_A =$ ambient velocity induced concentration

$C_P =$ concentration induced by propeller jet velocity

$C_B =$ concentration induced by backwater velocity.

The effect of diverging waves and wind are negligible at the sailing line. Colby's relationship was used to calculated C_A, C_P and C_B. Figure 48 shows a typical comparison between measured and simulated concentration at a station on the sailing line, 1.5 ft. above channel bed. This comparison gives an acceptable correlation.

The particle size subject to movement by flow is related to the shear stress τ_o near the channel bed. The τ_o is a function of the velocity fluctuations near the channel bed:

$$\tau_o = | - \rho \overline{u'v'} | \tag{41}$$

with

$$\overline{u'v'} = \overline{uv} - \overline{u}\,\overline{v} \tag{42}$$

where $\rho =$ density of water $= 1.94$ slug / ft^3

$u' =$ instantaneous velocity fluctuation in longitudinal direction

$v' =$ instantaneous velocity fluctuation in transverse direction

$\overline{u} =$ mean velocity in longitudinal direction

$\overline{v} =$ mean velocity in transverse direction.

Figure 49 shows a plot of $u'v'$ over time. Based on measured τ_o and using Shields'and Lane's curves (ASCE, 1965), which express critical shear stress as a function of grain size (Figure 50), a particle size affected is obtained. The relationship between shear stress and grain size was derived using natural sediment. Referring to the bottom sediment size distribution curves (Kuo et al, 1988), the percentage by weight of sediment is obtained. For the Watsons Island main channel, all test tow traffic scenarios affected 100 % of the sediment at the channel bottom along the sailing line. After the tow passed the test section, the value of $u'v'$ dropped sharply. Based on the $u'v'$ vs. time curves, the time of the maximum $u'v'$ was recorded for all test scenarios. A collection time was recorded for all TVA's suspended sediment samples. The time between maximum $u'v'$ and the collection time, ΔT, was found for each sample. Following the procedure outlined in the foregoing section, a concentration C_p at the collection time was calculated. This C_p was used in the calculation of C in Eq.(40).

3.12 Recreational Boating

Seven recreational boating scenarios were gaged as they went by the Watsons Island main channel cross section. Moving average velocity files were created, and from them the velocities and bottom shear stresses were graphed. At mid-channel station, the ambient velocity was 0.2 ft/s. There was no more than a 0.1 ft/s change in velocity for any of the recreational boat passages. This variation could be from the ambient velocity itself. There was a negligible increase in shear stress or turbulence as indicated by Figure 51.

At the shore station, the disturbances due to the recreational boats were measurable. Recreational boats traveling along the mid-channel sailing line induced a small change in velocity, about 0.2 ft/s. Scenarios of boats that travelled close to the shore (75 to 100 feet) created much larger changes in velocity, about 1.6 ft/s. Figure 52 shows the effect of a john-boat travelling upstream close to shore, followed by a runabout travelling upstream and then downstream at high velocity. The first peak was caused by the john-boat and the second and the third peaks were caused by the runabout. There is a significant difference in near shore velocities for the same boat travelling near shore and on the sailing line. The same scenario shows little effect to the shear stress at the sailing line (Figure 53). Recreational boats travelling closer to the sailing line generate more effect on the velocity at the shore than at the bottom of mid-channel (Figure 54).

The concentration increase at the shore due to the recreational boats is a function of how far the boat is from the shore. The sediment concentration near channel bed, on the sailing line is not affected. The boat effects will produce some sediment concentration increase at the shore, but the duration of impact for a recreational boat is too short to produce a significant amount of bed disturbance.

3.13 Back Channel

Scenarios were run to monitor the effects of velocity and wave changes in the Watsons Island back channel due to a typical tow passage in the main channel. Tow tracking data were not taken, but the boats were instructed to follow the same path taken during the main channel test runs. Velocities were measured at four stations. The deep water package containing two sensors at different depths was located in the center of the channel approximately 500 ft from the mouth of the island (stations 3 and 4, Figure 1). A shoreline gage, station 2, was placed at the same cross section on the mainland shore. The TVA john- boat, station 5, anchored at the center of the channel at 150 ft from mouth of island.

As a tow goes upstream, the island shields the back channel from most of the direct propeller effects. After the tow boat has pushed the barges upstream about 1300-1500 feet from the island, the angle of the propeller jet can now possibly affect the back channel. But, at this distance, the effect is very small with velocity increases of less than 0.25 ft/s. The backwater could have some effect, but the blockage ratio is very large since the area of the channel just above the island, river mile 75.8, is almost twice that of the main channel alone past the island. This will produce an increase in backwater velocity of less than 0.25 ft/s. Figures 55 and 56 show the velocity versus the tow speed at the center and shore, 500 ft from the mouth of the island. The change in velocity is similar and small for all tow passages.

As the tow travels downstream, the back channel stations are always protected by the island from the impact of the propeller jet. The backwater may possibly affect the velocity in the back channel, but again the changes produced are of small magnitude. Figure 57 shows the velocity fluctuations for the runs with controlled tow passage. There is no significant difference in velocity variations between the downstream runs and the upstream runs. Two of the runs were normal traffic unloaded barges. Again, there are no significant differences between these runs and the loaded barges runs (Figure 58). The concentration affected by these velocities was measured. A velocity of 0.25 ft/s will produce a concentration increase of about 2 ppm. The shear stress created by the higher velocities was low, as can be seen in Figures 59 and 60. Concentration monitoring at all stations showed no significant increase due to traffic in the main channel.

One recreational passage through the back channel was monitored. A john-boat traveling near the center of the back channel at medium speed (8-10 ft/sec) was monitored. The maximum flow velocity created at 500 feet inside the mouth at the shore and center was 0.32 and 0.28 ft/sec, respectively.

3.14 Tributary

Cabin Creek (river mile 74.3) was determined to be the best site to test the effects of the tow passage on a tributary that has been drowned by backwater from mainstream dams. Three velocity gaging stations were set up by TVA along the tributary: one at the mouth, one at 150 ft inside channel and one at 700 ft inside channel of Cabin Creek (Figure 61). Velocity measurements were taken at one second intervals for the two downstream stations. Velocity measurements 700 feet inside the tributary mouth were taken about 4 times a minute.

As the tow passed the drowned tributary, the water level in the river at first decreased due to the displacement of water. This in turn causes a surge of flow from the tributary into the river. The water velocity in the tributary was increased between 0.1 and 0.6 ft/sec. This velocity increase is noticed at the tributary mouth and 150 feet inside the channel, though not as high an increase occurs at the mouth. The velocity reaches a peak then starts to decrease as the water height returns to normal condition. Because the velocity was taken only four times a minute, a moving average velocity file could not be produced for the section 700 feet inside the tributary mouth. Because similar flows are produced at this section as the downstream sections for a smaller cross-sectional area, slightly higher velocities were produced during the tests scenarios. These values were still realitively low, between 0.4 and 0.9 ft/sec.

Because no sediment concentration samples were taken during the tests for the Cabin Creek scenarios, no sediment concentration simulation was made. By inspecting the u′v′ and velocity graphs at the two downstream stations, there is no significant difference between a 1x5 tow and a 3x3 tow (Figures 62 and 63). Therefore, it can be assumed that a change in tow configuration will not have any significant effect on the increase of sediment concentration in the tributary. The $u'v'$ and maximum velocity was plotted versus the tow speed. Figures 64 through 67 show the magnitude of velocity and $u'v'$ remained constant for all Cabin Creek scenarios.

3.15 Selected Prediction Equations

In Chapter 2, several equations are proposed for predicting velocities, wave heights and sediment concentrations. The simulation results for TVA's ficld experiment runs are shown in tables 3-20. The simulation results shown in the tables were generated from the simulation program, KANAWHA.FOR. Using the inputted data (tow direction, boat information, channel information, tracking information) the simulated results were generated for several equations. Using the generated velocities, several combinations were added together to provide the maxima needed for the suspended sediment concentration simulation and to be used for the comparison between the maxima and the measured data. For simplicity, the velocities shown in these tables were abbreviated: PW is Maxwell's propeller velocity, PV is Van de Kaa's propeller velocity, DIV is the Illinois State Water Survey's diverging wave velocity, BCK is the backwater velocity, AV is the average velocity, BCKA is an adjusted backwater velocity. Using the different combinations of velocity components, suspended sediment concentrations were calculated. The simulation program calculated velocities and concentrations for the five stations in the Watsons Island main channel where TVA collected data, as well as three points on the channel bed (shore, quarter lateral, and mid-channel). The purpose of providing these tables was to show the method used in acquiring the simulated values for the corresponding test situation. Each equation's simulated values were compared against the measured values. Correlation coefficients were calculated to assist in finding the equation that best predicted the field conditions. The following equations were chosen for the prediction model:

- Diverging wave: Bhowmik
- Squat: Bhowmik
- Backwater: Hochstein
- Propeller: Shore, quarter point: adjusted Maxwell and Pazwash

  Center: Van de Kaa and Blauw
- Ambient velocity: Prandtl/von Karman
- Wind: C.E.R.C.
- Concentration: Colby

Chapter 4. Prediction

4.1 Prediction Model

The Fortran program, KANAWHA.FOR, provides a simulation for the test situations for the Watsons Island main channel test section. After the equations which provided the best simulations were determined, a computer program was written to predict the physical effects on the river due to future tow traffic. The predictive model is considered to be well verified based on TVA's field experiment data at the test sites in the Marmet Pool. The model is adequate for predictions for the entire reach of the Marmet Pool. However, the application of the model to other navigation systems needs to be carefully evaluated before its use. The prediction output was divided as follows:

- Season: fall, winter, spring and summer
- Streamflow: 5-year high, mean, and 5-year low flow
- Configuration of tow: 1x5 and 3x3

- Tow rated engine horsepower: 1000 and 3400 hp

- Loading: loaded and unloaded barges

The most common situations of river traffic are upstream unloaded and downstream loaded tows. Upstream loaded tows would prove to be the most critical since it requires a large horsepower for the towboat to push the barges against the stream velocity. Given the frequency of occurrence of this unusual traffic scenario, basing conclusion regarding tow effects on the river is not recommended. Similarly, the unloaded downstream traffic conditions are less frequent than the downstream loaded conditions.

Eleven different cross sections were investigated using the prediction program; nine cross sections within the Marmet Pool, one at the arrival point downstream of the Marmet Dam, and one at the arrival point upstream of the London Dam. An example of the prediction output is shown in Appendix C for a downbound loaded tow at river mile 73.1. Data files are set for each cross section. Five subsections for each cross section were considered. A point was selected for each subsection where sediment properties were available. Water depth, sediment size distribution and the distance from the point of interest to the sailing line are included in the file.

The program was run for each season's mean, 5-year high and 5-year low flows. For each change in stream flow, there was an associated change in water depth. The mean ambient velocities for five subsections of a cross section were inputted for the four seasons. The bottom ambient point velocity was calculated.

Each cross section, season, and streamflow was coupled with a 3x3 or 1x5 tow configuration using 2 different rated horsepowers at different running horsepowers. The relationship between running horsepower versus still water tow speed, created from the field test data, was used to predict the different tow speeds for the 1x5 and 3x3 configurations. The still water tow speed was adjusted by the ambient velocity when needed.

For each simulated situation, the maximum positive and maximum negative water velocities due to tow passage were calculated. Using Colby's relationship, the sediment concentration at each subsection was found for both maximums. For certain runs with high ambient velocities, the maximum negative value would never become negative. Therefore, the output is listed with terms "Maximum" and "Minimum".

The predictions made for various tow and flow conditions are generally for the main channel at the selected cross-sections in the Marmet Pool. At any given cross-section, the predictions include velocity and suspended sediment information at the mid-channel, quarter points, and the shores. Back channels and drowned tributaries exist at some locations in the Marmet Pool. Typical examples are the back channel of Watsons Island and Cabin Creek tributary. To predict the physical effects due to tow passage on back channels and tributaries, one needs to obtain the predicted velocity and squat at the shore of the river cross-section which is in front of the back channel or tributary in question. The shore location is the same as the mouth of the back channel or the tributary.

During the field experiments conducted by TVA, velocities at various stations inside the side channel of Watsons Island and Cabin Creek were monitored for various tow passage scenarios. As discussed in Chapter 3, the tow induced changes in velocity and shear stress are too small to be considered significant. Also, the changes are not significantly related to the tow configuration, speed and direction of travel. Since the tow traffic scenarios considered in the field experiments represent the projected future tow traffic, the experimental results should reflect the future conditions. Therefore, no predictions are necessary except for other flow conditions. Based on the experimental data, an attempt has been made to correlate the velocities at locations in the back channel to the tow speed of the tows in the main channel. Referring to the map of the back channel of Watsons Island (Figure 1), two stations inside the back channel are considered. The ratios of the velocities at these stations to that of the tow speed at the mouth are presented in Tables 21 and 22. The average values were determined for the stations 500 feet inside the mouth at the mid-channel and the shore. These values are found in Table 24. For Cabin Creek, the velocities at two stations inside the tributary have been correlated with the squat produced at the mouth of the channel, river mile 74.3 (Table 23). Correlation values between the velocities and the squat are shown in Table 24. As discussed in Section 3. the magnitude of velocity at any point inside the tributary is directly related to the change in water level in the main channel caused by the tow passage. Therefore, the variable of squat, not the velocity, is selected as the reference variable.

Prediction results on velocity at the shore for river mile 74.3 are multiplied by the correlation factor listed in Table 24 in order to predict the velocities at the stations off the main channel. The velocity inside the back channel is found by multipling the tow speed to the correlation factor listed. Then the Colby Chart or figures 28 through 35 is used to predict the sediment concentration based on the velocity at the location of interest. The factors listed in Table 24 for Cabin Creek and Watsons Island back channel helps calculated the change in velocity due to the tow passage. Therefore, to find the resulting velocity, the ambient velocity must be added to the change in velocity. For the back channel, the ambient velocities can be found in Appendix B (pp. 10-12). Since tributaries are not controlled waterways, the ambient flow values are not dependent on the Marmet Pool's ambient flow but are more a function of rainfall and runoff coefficients. For drowned tributaries other than Cabin Creek in the Marmet Pool, the correlation factors serve as a first approximation, and reduction should be applied to take into consideration tributary meandering and the angle of confluence. There is another back channel in the Marmet Pool located at river mile 71.0. This back channel is very narrow (less than 1/5 of the width of the main channel). The factors listed in Table 24, when applied to this back channel, represent a conservative value since the physical effects due to tow traffic on this narrow side of the channel should be minimum. At least 50% reduction of these factors is recommended.

4.2.1. Prediction at Selected Cross Sections

Since there were many variables taken into consideration for the prediction runs, the output can be analyzed by numerous approaches. To show the general trend of some quantities, predicted values at river mile 73.1 were analyzed (Appendix C). River mile 73.1 was chosen because it represented a majority of the Marmet Pool characteristics such as width and channel shape. The other river miles that were studied each had a special characteristic (arrival point, sharp bend, sand bar, very wide) and therefore predicted values may have limited application to those specific type of areas.

The propeller effect on the river bed becomes more critical during low flows for the loaded downstream tows. During the low flows the propeller shaft is closer to the river bed, producing higher propeller induced velocities, thus producing higher propeller induced sediment concentrations. During high flows and downstream tows, the propeller's effect at the channel bottom is reduced because of higher depths and counter-acting ambient velocities. The lowest river flows are generally occur during the summer.

Therefore the effects from the propeller are better seen by investigating the summer predictive runs.

The propeller jet for the case of a downstream tow shoots upstream, opposite to the ambient velocity. If the ambient velocity is increased, the resulting magnitude of the propeller jet velocity is decreased. The tow speed relative to the bank has been taken into consideration. For downstream passages, the ambient velocity aids the tow speeds, so the tow speeds are increased with the higher ambient velocities. Therefore the tow can travel at a given velocity with lower running horsepower. Figures 68 through 70 show the concentrations produced by the propeller jet during the loaded downstream tows. The propeller jet is reduced by the ambient velocity. Therefore, the induced suspended sediment concentration decreases.

The backwater velocities created by a downstream tow passage are generated in the same direction as the tow; therefore, the resulting velocities become higher with increasing ambient velocities. For low flow conditions, the magnitude of the backwater velocity is much lower than the propeller jet for the downstream tows and therefore produces a much lower concentration. The backwater effect is much longer in duration than the propeller jet. Figures 71 through 73 show the backwater effects during the downstream loaded cases. During both high and low flows, there is a noticeable difference between the 1x5 and 3x3 tows due to the backwater effect.

The diverging wave height and squat effects were graphed as a function of the tow speed as shown in Figures 74 through 79. For both the diverging wave height and squat, the change in flow conditions has little effect on the change in their magnitude.

The unloaded upstream run was also analyzed because it represented a majority of the upstream bound traffic. The propeller jet in this case is in the same direction as the ambient velocity. As the ambient velocity increases, the tow speed is reduced. To investigate a more critical case, the winter flows were analyzed because high flows generally occurred in the winter. Because the barges were empty for the upstream traffic, the speed versus horsepower graphs used to predict the downstream runs could not be used. With no substantial data for the relationship of horsepower to tow speed for this case, it was assumed that the boat could travel the same speed with 50 percent of the horsepower of a loaded tow. For example, if a tow boat could travel 6 feet per second at 1000 horsepower during a downstream loaded run, it was assumed that it could travel 6 feet per second with 500 hp during an unloaded upstream run. The tow speeds used for this calculation were based on still water tow speeds. The upstream prediction runs took into consideration the ambient velocities effect on the tow speed. Since the tow is traveling against the streamflow, larger running horsepower is required. Consequently, high propeller jet velocities result. The propeller effect on the channel bed became a strong function of the ambient velocity. With very high velocities, the tow speed was reduced about 2 feet per second for the range of streamflows studied. With the high ambient velocities and propeller velocities acting in the same direction, the concentrations produced were as high as 120 to 270 ppm (Figures 80 through 82). The backwater effect on concentration was greatly reduced, to the range of less than 50 ppm (Figures 83 through 85). Also, the draft of the unloaded barges resulted in very low backwater velocities in the channel. Because the backwater velocity acted in the opposing direction of the ambient velocity during the upstream runs, the resulting velocities were small. The concentration estimated based on the resulting velocity actually decreased due to increasing tow speeds since the backwater velocities increase as the tow speeds increase.

The unloaded barges, with a draft of only 2 feet, produced a very large blockage ratio and resulted in a very small diverging wave height and squat. Figures 86 through 91 show the very low values for various tow speeds.

Due to the redundancy of the data, plotting all scenarios is not necessary. But to show the effect of a different cross-sectional shape, graphs were plotted for river mile 74.3. River mile 74.3 is another section of the river closer to the downstream reach of the Marmet Pool. Its cross-sectional area is close to that of river mile 73.1, therefore the variations in flows will produce similar changes in the ambient velocities at both river sections. The major difference, as seen in Appendix A, is that river mile 74.3 is very wide and shallow whereas, 73.1 is more narrow and deep.

At a wide and shallow cross-section, the propeller effect becomes more important. The range of velocities increases and therefore produces much higher sediment concentrations. Figures 92 through 94 show the concentrations as a function of the tow speed for 5-year low, mean and 5-year high flows. For the 5-year low flow situation, the sediment concentration is as high as 350 ppm. Since the channel cross-sectional area is about the same, the backwater effect is similar to that of river mile 73.1 (Figures 95 through 97). As noted earlier, the reader must inspect normal traffic situations. Even though the graphs shows concentrations for high tow speeds, the higher horsepower boat will rarely travel in the higher velocity range. Noting this fact, the normal tow speeds of 6-8 fps produce concentrations on the order of 40-100 ppms for 5-year low flow situations due to the propeller.

Prediction results for four of the eleven cross sections should be interpreted differently from other sections. River miles 67.0 and 68.1 are the arrival points downstream and upstream of the Marmet Dam. River miles 81.6 and 83.6 are the arrival points of the

London Dam. At the upstream locations, river miles 68.1 and 83.6, the depths are the greatest of their respective pools. With greater depths, the propeller shaft is furthest away from the channel bed, producing lower jet velocities near the channel bed. But these cross-sections must be analyzed differently because the tow sailing path and tow speeds are different than those sections away from the dam. Sudden starting and stopping of tows are common in this area. With the initial starting of tows, the tow speed is very low, but a high horsepower is required to help accelerate the barges. The graphs created to relate horsepower to tow speed are not applicable to these areas. Instead the reader must look at the horsepower versus the concentration relationship instead of the tow speed versus concentration relationship. The sailing line of the tows is different near the dams. The boats travel closer to the shore to position themselves for passage through the locks. The backwater velocities at the arrival points is almost negligible. The blockage ratio at the upstream arrival points is very high and the tow speeds are very small. Since it is assumed that the tow speeds are low, the squat and diverging wave heights will also be low.

The downstream arrival points are more critical than the upstream arrival points. The depths at the downstream arrival points are approximately 18 feet, which is about half the depth of the upstream arrival points. The same traveling characteristics (quick accelerations and different sailing lines) are present downstream. With a much smaller depth, much higher bottom velocities will be produced.

The prediction program was later modified to predict velocities and concentrations of tows traveling off the sailing line. Because of the limitless possibilities of tows traveling off the sailing line, only two prediction runs were examined at a given cross-section, river mile 73.1, to show the effects of the changing velocities and concentrations. The velocities and concentrations were calculated for the same five points as the on sailing line prediction runs. The main purpose of producing data for off-sailing line runs is to find the changing effect at the shore.

4.2.2. Prediction Limitations

The sediment bed existing at each cross-section is a reflection of the physical effects to which it is subject. The ambient velocities increase as the cross-sections become more shallow and narrower. The depths generally increase from the upstream cross-sections to the downstream sections of a given pool. Therefore the maximum propeller jet velocities at the streambed increase from the downstream sections to the upstream sections.

Over time the smaller silty sediment is washed downstream and the larger sand to gravel material exists upstream. In a given cross section, the shores represent an area of lower velocities where finer material resides. The sediment distributions show that, in general, the coarse material exists closer to the center of the channel. In some shallow areas, smaller sized material is non-existent or exists as binding material for the larger rocks. At river miles 80.2 and 81.1, the channel bed is made up of rocks over 3 inches in diameter. In some areas the channel is washed down to the large rock stratifications. Colby's relationships between sediment concentration and velocity were based upon sediment beds in the sand range. This can be applied to the Marmet Pool because most of the sediment collected was in the sand range. At some locations upstream, specifically above 80.2, there is little sediment in or below the sand range. Therefore the prediction runs overestimate the amount of sediment affected by propeller jet or backwater at these locations.

The velocity effects on sediment concentrations at the shoreline are relatively small compared to the velocities at the sailing line. Since the estimation of concentration is based upon Colby's relationship, $C \propto V^{2.5}$, a small change in velocity could produce a large change in concentration. Therefore, a wide range of sediment concentrations is predicted. For shallow sections, such as river miles 67.0 and 81.1, the propeller effect becomes substantial during low flows for downstream loaded runs. In this case, the propeller is close to the channel bed without a high counter-acting ambient velocity. Concentrations in the Marmet Pool as high as 700 ppm can be produced in low flow situations at shallow sections. This calculation assumes that a sand based material exists at this river section. At shallow and narrow cross-sections, diverging wave heights of 1.05 feet and squat heights of 0.50 feet can be produced.

For upstream tows the propeller jet velocity is added to the ambient flow, producing high resulting velocities and suspended sediment concentrations during high flows. At the same river miles, 67.0 and 81.1, the cross-sectional area is smaller, producing high ambient velocities. Concentrations as high as 1500 ppm at river mile 67 and 1000 ppm at river mile 81.1 can be produced by the 3400 horsepower boat. The ambient velocity itself contributes to 3.66 ft/sec of the resulting velocity (5.27 ft/sec) that produces this critical situation. The resulting velocities produced by the tow passage are as high as 5-6 ft/sec near the sailing line. Near the shore velocities as high as 4.5 ft/sec and concentrations as high as 650 ppm can be produced. Eighty percent of these high velocities are contributed by the ambient velocity which plays a major role.

4.2.3 Sediment Movement on Slopes

Scouring of the substrate material at a given location subject to the ambient velocity alone or the combined velocities due to the ambient velocities and vessel induced velocity components is a very complicated physical phenomena. Instead of using a single equation to predict the scour depth, one needs to consider two distinct processes. They are the resuspension and settling of the bed material. The Shield Diagram shown in Figure 98 can be used to find a sediment size affected by a critical velocity near the channel bed. Any sizes finer than this size will be suspended. However, some of the suspended sediment will settle after the passage of the tow. The amount of sediment that will eventually settle is a function of time. The time required for a given sediment size to settle is a function of the water depth and the fall velocity of the sediment size. The particle fall velocity can be found from figure 37. The disturbance of the bed material due to the tow passage is a temporal process. Practically all the suspended material will settle after the tow effects diminish. Typical time is between 20 and 30 minutes, based on the field data gathered by TVA. Any significant scouring of bed material has to be due to very high velocity such as high ambient velocities during high flows. In this case, sediment remains suspended and transported downstream.

The predictions made for various tow and flow conditions are applicable to most locations within the Marmet Pool. However, a special case requires some discussions concerning the tow traffic effects on the sediment movement on slopes. There are basically two types of slopes: slopes next to the shore where the water depth is lesser than 3 ft and slopes near the shore where the depth is greater than 3 ft. The former has mild slope and contains fine sediment with high organic contents. The latter has a steep slope and contains most of noncohesive bed material since the fine material has been washed away by the stream velocity, especially during high flows. Fine sediment that stayed on the slopes in shallow water areas is generally well compacted and frequently covered by tree leaves. Erosion potential on this type of bed material at such locations is minimal. Noncohesive materials such as sand on deep water slopes is more vulnerable to be washed away by high velocities. The following equation is used to explain the mechanics of sediment movement at the channel side slopes (Chow,1959; ASCE, 1975):

$$\frac{\tau_s}{\tau_c} = \sqrt{1 - \frac{\sin^2\Theta}{\sin^2\Phi}} \tag{43}$$

in which $\tau_s =$ shear stress acting on the sediment on slope by the flow

$\tau_c =$ critical shear stress to initiate the sediment motion for a given sediment size d not on the slope (lb/ft^2)

$\Theta =$ channel side slope (degree)

$\Phi =$ angle of repose of the bed materials (degree).

The equation yields the required shear stress τ_s to keep the sediment on the slope. If τ_c, Θ, andΦ are known, τ_s for the channel side slope is approximately equal to 75 % of τ_o at the main channel bed:

$$\tau_s = 0.75\tau_o = 0.75\gamma\, R\, S_o \tag{44}$$

where $\gamma =$ specific weight of water (lb/ft^3)

$R =$ hydraulic radius (ft)

$S_o =$ longitudinal side slope (ft/ft).

τ_c is sometimes refered to as the permissible unit tractive force. τ_c for noncohesive materials can be found from Figure 99. For cohesive materials, τ_c is a function of sediment void ratio and type of clay as provided in Figure 100. The void ratio describes the soil compactness, such as 1.2-2.0 for loose conditions and 0.2-0.3 for very compact conditions. The angle of repose Φ is very important in the computation of τ_r and is given in Figure 101 for various sediment size and sediment roundness. For cohesive and fine noncohesive materials, the cohesive forces are extremely large as compared to the shear stress and the gravity. Therefore, the angle of repose need be considered only for coarse noncohesive materials.

To apply the information in Appendix C for the slope environment, one needs to follow the following procedures:

1. Find the predicted velocity at the shore for a given tow and flow conditions. The shore location is where the slope is.

2. Corresponding to this velocity is a particle size which will be affected as shown in Figure 98.

3. For this particle size, take 75% of the stress as shown in Figure 50.

4. Alternatively, τ_r can be calculated by Equation 44 if γ, R, and S_o are known. S_o in general is not easy to estimate accurately.

5. Select τ_c from either Figure 99 or 100.

6. Based on the Θ value given and the Φ value selected from Figure 101, one calculates $\tau_c \times (1 - \sin^2\Theta / \sin^2\Phi)^{1/2}$.

7. If the τ_r value obtained from step (3) is greater than the value obtained from step (6), the sediment which stays on the slope will be washed away.

It should be noted that the velocity obtained from step (1) has taken into consideration all effects due to tow passage.

One of the components of the resulting velocity is due to the diverging wave, which in general is small, especially near the bottom and if the shore is far away from the sailing line. Therefore, the direction of the diverging wave or the angle of wave attack on the shore has very little impact on the velocity which causes sediment movement on the slope. The remaining components which form the resulting velocity have been included in the computation results shown in Appendix C. It should be further noted that if the slope exists at a location other than the predicted site, as shown in Appendix C, a new computer run should be made to generate the velocity at that location of interest. No information is currently available in the literature to predict the force required to break loose compacted cohesive bed materials. However, the procedures have already considered the initial state of the soil compaction. For an example, it takes 0.8 pounds per square foot to dislodge very compact sandy clay, and it takes only 0.05 pounds per square foot for the loose sandy clay as shown in Figure 100. It is understood that the bed material might change from a compact state to a loose state under a small force applied for a long duration. The typical tow passing time at a cross-section is 15 to 20 minutes if one considers how long it takes from the start of drawdown until the velocity field and suspended sediment concentration field to go back to ambient conditions. This duration is too short to have a significant impact in breaking up compacted material. Stream velocity alone during high flows plays an important role in the sediment disintegration processes because of its large magnitude and long duration. The state of compactiveness of the cohesive bed materials varies over time. A suggested approach to estimate the sediment compactiveness or find the void ratio would be through laboratory testing of undisturbed sediment samples taken from the field at the time of interest. This variable is then included in the computation just discussed.

Chapter 5. Summary

The U.S. Army Corps of Engineers is investigating ways to improve lockage efficiency at the Marmet Locks on the Kanawha River, West Virginia. These improvements are needed to meet projected future river traffic demands. To find the physical effects of the proposed improvement on the river due to changes in future tow traffic patterns and tow configurations, a physical prediction model has been developed and verified. The potential of sediment movement is related to the resultant velocity. The tow induced velocity distribution, squat, and wave effects at different locations, such as mid-channel and at shore for selected river sections, have been investigated. The velocity distribution in a navigable waterway due to the tow passage consists of several components. They are ambient velocity, wind wave induced velocity, diverging wave induced velocity, propeller jet velocity and backwater velocity. Each velocity has its own time phase, peak and duration. At a different stage of tow passage, each component plays its own role or in conjunction with others.

The Marmet Pool is a deep pool bordered on both sides by mountainous terrain. The bed consists mostly of sand to gravel deposits resting on a bedrock layer. The widths of the pool range from 500 to 1000 feet. A majority of the commercial traffic on the Marmet Pool is coal-loaded barges. The barges commonly produce a draft of 9 feet when loaded.

Three sites in the Marmet pool were chosen to monitor the impact of tow passage. They are the Watsons Island main channel and back channel and Cabin Creek. Tennessee Valley Authority established gages at the sites to monitor various scenarios of tow traffic. The symmetric characteristic of the cross-section allowed use of velocity gages on one half of the cross section. Location of gages chosen by the Army Corps of Engineers provided spatial representation of tow-induced effects. The configuration of tows, direction of tows, boat horsepower, and boat speeds were varied to provide a wide range of traffic conditions so that the physical effects on the river might be evaluated.

The data collected by TVA was processed into a more usable form using moving time averages. By the use of these generated files and graphs, waves and velocity components could be evaluated. To select a suitable prediction model for the project site, the equations which best predicted the wave and velocity components were selected on the basis of correlation between measured and simulated values.

A hydrologic analysis was made to predict the ambient velocity. The streamflows of the two nearest USGS gaging stations to the Marmet pool were obtained. Drainage areas between the two stations and for each large tributary were computed based on the USGS topographic map. Streamflow at any given river section between the two gaging stations was interpolated on the basis of contributing drainage area. To make the prediction model applicable to different seasons, a frequency analysis was performed based on the 47 year records at the two USGS gaging stations. For the purposes of predicting any hydraulic impact on the river due to the future navigation conditions, it was decided that

5-year lows flows and 5-year high flows would provide useful information in connection with the environmental impact evaluations.

Using the chosen equations for the velocity estimation, the suspended sediment concentrations were found by using Colby's chart, which relates the average velocity and suspended sediment concentration. The simulated concentrations were based on the simulated maximum velocities due to tow passages at the time of disturbance and had to be recalculated for the time after the disturbance. The initial concentration is primarily due to the propeller jet velocity. The turbulence intensity drops sharply after the propeller effects disappear. The backwater effect became more critical later. Using Rouse's relationship of particle fall velocity as a function of diameter, the relationship between initial concentration and concentration at a later time could be determined. Through the relationship of concentration as a function of time, the simulated concentrations were found and showed a good comparison with TVA's measured data. The effects of the tow induced velocity at the shore caused little disturbance to the sediment. Therefore the suspended sediment levels remained close to the ambient condition.

The sediment concentration increase at the shore due to recreational boats is a function of how far the boat is from the shore. The observed sediment concentration near the channel bed, on the sailing line, was found to be insignificant. The boat effects will produce some concentration increase at the shore, but the duration of impact for a recreational boat is too short to produce a significant amount of bed disturbance.

For upbound tows, Watsons Island shields the back channel from the direct propeller jet effect. The effect becomes very small with velocity increase of less than 0.25 ft/s. The associated backwater velocities were of the magnitude less than 0.25 ft/s. As the tow travels downstream, the back channel is again protected by the island from the impact of the propeller jet. The backwater may possibly affect the velocity in the back channel, but the changes produced are of small magnitude. There is no significant difference in tow induced velocities due to the downstream runs and the upstream runs. There is no significant difference between loaded and unloaded barges runs. An increase in velocity of 0.25 ft/s will produce only a concentration increase of about 2 ppm. Concentration monitored by TVA at all stations in the back channel showed no significant increase due to traffic in the main channel.

As the tow passed the drowned tributary (Cabin Creek), there was first a lowering of the water level due to the displacement of water in the main channel at river mile 74.3, in front of the tributary. This in turn caused a surge of flow from the tributary to this river section. The water velocity in the tributary was increased by a maximum of 0.2 ft/s. This increase is noticed at the tributary mouth and 150 feet from the tributary mouth. The velocity reaches a peak then starts to decrease as the water height returns to normal condition. Because no sediment concentration samples were taken during the TVA tests for the Cabin Creek scenarios, no sediment concentration simulation was made. By inspecting the bottom shear stress and velocity at all stations in the tributary, there was no significant difference between a 1x5 tow and a 3x3 tow. Therefore, it can be concluded that a change in tow configuration will not have a significant effect on the increase of sediment concentration in the tributary since the sediment disturbance is mainly caused by the increased water velocity or shear stress.

The propeller effect on the river bed becomes more critical during the low flows for the loaded downstream tows. During the low flows the propeller shaft is closer to the river bed producing higher propeller induced velocities, thus producing higher propeller induced sediment concentrations. During high flows and downstream tows, the propeller's effect at the channel bottom is reduced because of higher depths and counter-acting ambient velocities. The propeller jet for the case of a downstream tow shoots upstream, opposite to the ambient velocity. If the ambient velocity is increased, the resulting magnitude of the propeller jet velocity is decreased. The tow speed relative to the bank has been taken into consideration. For the downstream tows, the ambient velocity aids the tow speeds, so the tow speeds are increased with the higher ambient velocities. Therefore, the tow can travel at a given velocity with lower running horsepower. Propeller jet velocity is reduced by the ambient velocity. Therefore, the induced suspended sediment concentration decreases. The backwater velocities created by a downstream tow passage are generated in the same direction as the tow; therefore, the resulting velocities become higher with increasing ambient velocities. For low flow conditions, the magnitude of the backwater velocities is much lower than the propeller jet for the downstream tows and therefore produces a much lower concentration. The backwater effect is much longer in duration than the propeller jet. For both high and low flows, a noticeable difference occurs between the 1x5 and 3x3 tows due to the backwater effect. For both the diverging wave height and squat, the change in flow conditions has little effect on the change in their magnitude.

The unloaded upstream run was also analyzed because it represented a majority of the upstream bound traffic. The propeller jet in this case is in the same direction as the ambient velocity. As the ambient velocity increases, the tow speed is reduced. The upstream prediction runs took into consideration the ambient velocities effect on the tow speed. Since the tow travels against the streamflow, larger running horsepower is required. Consequently, high propeller jet velocities result. The propeller effect on the channel bed became a strong function of the ambient velocity. With very high velocities, the tow speed was reduced about 2 feet per second for the range of streamflows studied.

Also, the draft of the unloaded barges resulted in very low backwater velocities in the channel. Because the backwater velocity acted in the opposing direction of the ambient velocity during the upstream runs, the resulting velocities were small. The concentration estimated based on the resulting velocity actually decreased due to increasing tow speeds since the backwater velocities increase as the tow speeds increase. The unloaded barges with a draft of only 2 feet, produced a very large blockage ratio and resulted in a very small diverging wave height and squat.

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Tables

Table 1. Streamflows for Selected River Sections on Specific Dates

Section at River Mile	Streamflow (cfs)/Date	
67.0	2744 cfs, Sept.	27, 1987
68.1	2744	26
73.1	2724	26
74.3	2720	26
	2686	29
	3329	30
75.6	1076	26
	1261	27
	1225	28
	1061	29
75.7	2375	20
	1891	21
	1253	22
	1418	23
	1545	24
	1703	25
	1614	26
	1892	27
75.8	1076	26
78.7	2682	26
80.2	2682	26
81.1	2630	26
81.6	2630	26
83.6	2625	27

Table 2. Streamflow Frequency Analysis for Selected River Sections

River Section (mile)	5-Year Low Flow (cfs)				Mean Flow (cfs)				5-Year High Flow (cfs)			
	Fall	Win.	Spr.	Sum.	Fall	Wint.	Spr.	Sum.	Fall	Win.	Spr.	Sum.
67.0	2854	9074	5593	2611	10765	22838	15823	6351	24317	36443	29177	11870
68.1	2854	9074	5593	2611	10765	22838	15823	6351	24317	36443	29177	11870
73.1	2820	8859	5517	2581	10563	22390	15530	6247	23855	35914	28583	11660
74.3	2814	8818	5502	2575	10524	22303	15474	6228	23766	35812	28470	11619
75.6	1105	3394	2154	1102	4085	8644	6009	2427	9222	13998	11022	4518
75.7	1657	5092	3231	1517	6128	12967	9013	3640	13832	20997	16532	6777
75.8	1105	3394	2154	1102	4085	8644	6009	2427	9222	13998	11022	4518
78.7	2749	8398	5354	2517	10130	21429	14902	6024	22866	34780	27313	11209
80.2	2749	8398	5354	2517	10130	21429	14902	6024	22866	34780	27313	11209
81.1	2661	7832	5154	2439	9599	20248	14131	5750	21651	33387	25751	10655
81.6	2661	7832	5154	2439	9599	20248	14131	5750	21651	33387	25751	10655
83.6	2653	7781	5136	2432	9550	20141	14062	5725	21541	33261	25610	10605

Table 3. Scenario 1 Simulation

RUN S1-VALVOLINE-DOWNSTREAM-5x1 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	10.63	STA. 1 DIST. 288.01	WIDTH 500.00	FETCH LENGTH (FT)	350.00
TOW WIDTH (FT)	35.00	STA. 2 DIST. 159.53	DEPTH	WIND SPEED (MPH)	7.00
TOW LENGTH (FT)	1025.00	STA. 3 DIST. 26.83	CENTER 22.00		
HORSEPOWER	480.00	STA. 4 DIST. 26.83	QUARTER 18.00		
RPMS (PROPELLER)	150.00	STA. 5 DIST. 26.83	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.22620	.00000	.00000	.00000	.00000	.00000	.00000	-.00562
BALAMIN AND BYKOV	-1.55265	-.00005	.00000	.00000	-.00305	.00000	.00000	-.19247
ILLINOIS STATE WATER SURV	-.18147	.00000	.00000	.00000	.00000	.00000	.00000	-.00371
BACKWATER								
HOCSTEIN	.10576	.27781	.71216	.57452	.75325	.67023	.23235	.10576
PROPELLER								
MAXWELL	-.25590	-.46114	-2.42063	-2.17047	-2.64950	-3.16660	-.45899	-.25589
BLAAU AND VAN DE KAA	-.11062	-.19966	-1.12589	-1.02829	-1.18673	-1.87423	-.19906	-.11063
AMBIENT VELOCITY	.13410	.18265	.32197	.34083	.28110			
MEAN AMBIENT VELOCITY						.30095	.16965	.14004
SURFACE						.34377	.23406	.15555
MIDDEPTH						.31034	.18265	.13410
BOTTOM						.23271	.06330	.08431
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.24223	-.00068	-1.38650	-1.25511	-1.89625	-2.26366	-.16335	-.07144
2. PV+DIV+BCK+AV	-.09695	.26080	-.09176	-.11293	-.43348	-.97130	.09658	.07382
3. PV+DIV+AV	-.20271	-.01701	-.80392	-.68745	-1.18673	-1.64152	-.13577	-.03194
4. PW+DIV+AV	-.34799	-.27849	-2.09866	-1.82963	-2.64950	-2.93389	-.39570	-.17720
5. BCK+DIV+AV	.46606	.46046	1.03413	.91536	.75325	.90294	.29564	.19569
6. PW+DIV+BCKA+AV	-.34799	-.27849	-2.09866	-1.82963	-2.64950	-2.93389	-.39570	-.17720
7. PV+DIV+BCKA+AV	-.20271	-.01701	-.80392	-.68745	-1.18673	-1.64152	-.13577	-.03194

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.17	.00	23.30	17.61	56.15	92.36	.06	.01
EQ.2	.01	.21	.01	.02	.89	8.57	.01	.01
EQ.3	.10	.00	5.04	3.24	15.05	37.44	.03	.00
EQ.4	.48	.26	74.67	50.78	143.74	191.43	.69	.07
EQ.5	1.09	1.05	10.22	7.25	4.19	6.98	.30	.10
EQ.6	.48	.26	74.67	50.78	143.74	191.43	.69	.07
EQ.7	.10	.00	5.04	3.24	15.05	37.44	.03	.00

DIVERGING WAVE HEIGHT	
HOCSTEINS	.51028
BALAMIN AND BYKOV	.90970
ILL. STATE WATER	.48477

WIND WAVE HEIGHT .03014

SQUAT (FT)	
SCHIJF AND JANSEN	.00881
GELENCSER	.11445
DAND	.10679
GATES AND HERRICH	.29926
BHOWMIK	.15073
BALAMIN AND BYKOV	.05251

Table 4. Scenario 2 Simulation

RUN S2-MORRIS HARVEY-UPSTREAM-5x1 STANDARD

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	6.01	STA. 1 DIST. 307.92	WIDTH 500.00	FETCH LENGTH (FT)	350.00
TOW WIDTH (FT)	27.00	STA. 2 DIST. 175.93	DEPTH	WIND SPEED (MPH)	9.50
TOW LENGTH (FT)	925.00	STA. 3 DIST. 46.66	CENTER 22.00		
HORSEPOWER	500.00	STA. 4 DIST. 46.66	QUARTER 18.00		
RPMS (PROPELLER)	285.00	STA. 5 DIST. 46.66	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.00007	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	.00355	.00000	.00000	.00000	.00000	.00000	.00000	.00000
ILLINOIS STATE WATER SURV	.00003	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	-.03042	-.09930	-.29907	-.24127	-.31632	-.34950	-.08305	-.03042
PROPELLER								
MAXWELL	.20748	.36254	1.25694	1.17329	1.31795	2.23560	.36116	.20747
BLAAU AND VAN DE KAA	.08968	.15697	.58441	.56695	.59188	1.78186	.15665	.08969
AMBIENT VELOCITY	.13410	.18265	.32197	.34083	.28110			
MEAN AMBIENT VELOCITY						.30095	.16965	.14004
SURFACE						.34377	.23406	.15555
MIDDEPTH						.31034	.18265	.13410
BOTTOM						.23271	.06330	.08431
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.31123	.44589	1.27984	1.27286	1.00162	2.11881	.34140	.26136
2. PV+DIV+BCK+AV	.19343	.24032	.60732	.66651	.27556	1.66507	.13689	.14357
3. PV+DIV+AV	.22386	.33962	.90638	.90778	.59188	2.01456	.21995	.17400
4. PW+DIV+AV	.34166	.54520	1.57891	1.51412	1.31795	2.46831	.42446	.29178
5. BCK+DIV+AV	.10361	.08335	.02290	.09957	-.31632	-.11679	-.01976	.05388
6. PW+DIV+BCKA+AV	.34166	.54520	1.57891	1.51412	1.31795	2.46831	.42446	.29178
7. PV+DIV+BCKA+AV	.22386	.33962	.90638	.90778	.59188	2.01456	.21995	.17400

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.35	.96	18.60	18.32	9.34	76.70	.45	.21
EQ.2	.09	.17	2.29	2.97	.25	38.97	.03	.04
EQ.3	.14	.45	7.06	7.09	2.13	66.56	.13	.07
EQ.4	.45	1.69	33.56	29.84	20.20	117.79	.84	.29
EQ.5	.02	.01	.00	.01	.37	.02	.00	.00
EQ.6	.45	1.69	33.56	29.84	20.20	117.79	.84	.29
EQ.7	.14	.45	7.06	7.09	2.13	66.56	.13	.07

DIVERGING WAVE HEIGHT		WIND WAVE HEIGHT		SQUAT (FT)	
HOCSTEINS	.16850		.04200	SCHIJF AND JANSEN	.00155
BALAMIN AND BYKOV	.25150			GELENCSER	.02600
ILL. STATE WATER	.15566			DAND	.02369
				GATES AND HERRICH	.07290
				BHOWMIK	.03697
				BALAMIN AND BYKOV	.01279

Table 5. Scenario 3 Simulation

RUN S3-MORRIS HARVEY-DOWNSTREAM-5x1 STANDARD

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	6.41	STA. 1 DIST. 278.47	WIDTH 500.00	FETCH LENGTH (FT)	500.00
TOW WIDTH (FT)	135.00	STA. 2 DIST. 148.93	DEPTH	WIND SPEED (MPH)	8.00
TOW LENGTH (FT)	185.00	STA. 3 DIST. 17.45	CENTER 22.00		
HORSEPOWER	470.00	STA. 4 DIST. 17.45	QUARTER 18.00		
RPMS (PROPELLER)	280.00	STA. 5 DIST. 17.45	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.29195	.00000	.00000	.00000	-.00001	.00000	.00000	-.00907
BALAMIN AND BYKOV	-.65397	.00000	.00000	.00000	-.00016	.00000	.00000	-.04050
ILLINOIS STATE WATER SURV	-.03904	.00000	.00000	.00000	.00000	.00000	.00000	-.00020
BACKWATER								
HOCSTEIN	.60620	.81574	1.08499	.87529	1.14758	.83460	.68225	.60620
PROPELLER								
MAXWELL	-.22470	-.41931	-2.78532	-2.31740	-3.31422	-2.91086	-.41705	-.22469
BLAAU AND VAN DE KAA	-.09714	-.18164	-1.42446	-1.20935	-1.54982	-1.74552	-.18113	-.09715
AMBIENT VELOCITY	.13410	.18265	.32197	.34083	.28110			
MEAN AMBIENT VELOCITY						.30095	.16965	.14004
SURFACE						.34377	.23406	.15555
MIDDEPTH						.31034	.18265	.13410
BOTTOM						.23271	.06330	.08431
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.22365	.57909	-1.37836	-1.10127	-2.16665	-1.84355	.32850	.45674
2. PV+DIV+BCK+AV	.35122	.81675	-.01751	.00677	-.40225	-.67820	.56442	.58429
3. PV+DIV+AV	-.25499	.00101	-1.10249	-.86852	-1.54983	-1.51281	-.11783	-.02192
4. PW+DIV+AV	-.38255	-.23665	-2.46335	-1.97656	-3.31423	-2.67815	-.35375	-.14946
5. BCK+DIV+AV	1.03226	.99839	1.40696	1.21612	1.14759	1.06731	.74555	.69958
6. PW+DIV+BCKA+AV	-.38255	-.23665	-.66653	-.49961	-1.40913	-2.67815	-.35375	-.14946
7. PV+DIV+BCKA+AV	-.25499	.00101	.69433	.60844	.35527	-1.51281	-.11783	-.02192

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.14	2.00	22.91	12.20	81.67	51.88	.41	1.03
EQ.2	.49	5.27	.00	.00	.72	3.12	1.86	2.05
EQ.3	.20	.00	12.23	6.26	31.86	29.76	.02	.00
EQ.4	.62	.16	117.13	63.09	269.62	148.15	.50	.04
EQ.5	10.17	9.26	24.27	16.12	13.69	11.17	4.08	3.41
EQ.6	.62	.16	2.97	1.32	24.38	148.15	.50	.04
EQ.7	.20	.00	3.34	2.30	.51	29.76	.02	.00

DIVERGING WAVE HEIGHT	
HOCSTEINS	.54316
BALAMIN AND BYKOV	.67853
ILL. STATE WATER	.35752

WIND WAVE HEIGHT .04035

SQUAT (FT)	
SCHIJF AND JANSEN	.02045
GELENCSER	.01540
DAND	.25650
GATES AND HERRICH	.47878
BHOWMIK	.09703
BALIMIN AND BYKOV	.01455

Table 6. Scenario 4 Simulation

RUN S4-MORRIS HARVEY-UPSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	5.58	STA. 1 DIST. 267.37	WIDTH	500.00	FETCH LENGTH (FT)	650.00
TOW WIDTH (FT)	105.00	STA. 2 DIST. 138.56	DEPTH		WIND SPEED (MPH)	6.00
TOW LENGTH (FT)	615.00	STA. 3 DIST. 6.11	CENTER	22.00		
HORSEPOWER	1000.00	STA. 4 DIST. 6.11	QUARTER	18.00		
RPMS (PROPELLER)	360.00	STA. 5 DIST. 6.11	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.00077	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	.13243	.00000	.00000	.00000	.00000	.00000	.00000	.00205
ILLINOIS STATE WATER SURV	.00018	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	-.38568	-.55914	-.78826	-.63591	-.83373	-.60635	-.46764	-.38568
PROPELLER								
MAXWELL	.30104	.57942	5.47998	3.80860	9.43197	.93302	.57575	.30103
BLAAU AND VAN DE KAA	.13009	.25104	3.59626	2.27751	5.67488	2.24448	.25022	.13011
AMBIENT VELOCITY	.13410	.18265	.32197	.34083	.28110			
MEAN AMBIENT VELOCITY						.30095	.16965	.14004
SURFACE						.34377	.23406	.15555
MIDDEPTH						.31034	.18265	.13410
BOTTOM						.23271	.06330	.08431
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.05024	.20294	5.01369	3.51352	8.59824	.55938	.17140	-.00034
2. PV+DIV+BCK+AV	-.12070	-.12545	3.12997	1.98243	4.84114	1.87083	-.15413	-.17126
3. PV+DIV+AV	.26497	.43369	3.91823	2.61834	5.67488	2.47719	.31351	.21441
4. PW+DIV+AV	.43592	.76208	5.80195	4.14943	9.43197	1.16573	.63904	.38534
5. BCK+DIV+AV	-.25235	-.37649	-.46629	-.29508	-.83373	-.37364	-.40435	-.30137
6. PW+DIV+BCKA+AV	.43592	.76208	4.44040	2.96862	8.01129	1.16573	.63904	.38534
7. PV+DIV+BCKA+AV	.26497	.43369	2.55668	1.43753	4.25420	2.47719	.31351	.21441

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.00	.11	862.83	317.70	3928.01	1.82	.07	.00
EQ.2	.02	.03	229.59	63.62	781.96	54.06	.05	.07
EQ.3	.22	.89	431.58	139.04	1222.08	118.99	.36	.12
EQ.4	.90	4.33	1300.55	507.03	5094.67	14.31	2.64	.64
EQ.5	.19	.60	1.09	.30	5.58	.58	.73	.32
EQ.6	.90	4.33	613.39	197.86	3220.23	14.31	2.64	.64
EQ.7	.22	.89	130.03	25.79	543.83	118.99	.36	.12

DIVERGING WAVE HEIGHT	
HOCSTEINS	.21108
BALAMIN AND BYKOV	.45219
ILL. STATE WATER	.18286

WIND WAVE HEIGHT .03325

SQUAT (FT)	
SCHIJF AND JANSEN	.01079
GELENCSER	.26773
DAND	.13684
GATES AND HERRICH	.27094
BHOWMIK	.08823
BALAMIN AND BYKOV	.04754

Table 7. Scenario 5 Simulation.

RUN S5-MORRIS HARVEY-DOWNSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	5.61	STA. 1 DIST. 248.63	WIDTH 500.00	FETCH LENGTH (FT)	250.00
TOW WIDTH (FT)	105.00	STA. 2 DIST. 119.16	DEPTH	WIND SPEED (MPH)	2.00
TOW LENGTH (FT)	615.00	STA. 3 DIST. 7.39	CENTER 22.00		
HORSEPOWER	1000.00	STA. 4 DIST. 7.39	QUARTER 18.00		
RPMS (PROPELLER)	360.00	STA. 5 DIST. 7.39	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.00088	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	-.14081	.00000	.00000	.00000	.00000	.00000	.00000	-.00230
ILLINOIS STATE WATER SURV	-.00021	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	.38266	.57601	.79349	.64013	.83927	.61037	.48175	.38266
PROPELLER								
MAXWELL	-.32369	-.67302	-5.23386	-3.73038	-8.24273	-2.06779	-.66752	-.32368
BLAAU AND VAN DE KAA	-.13990	-.29189	-3.30412	-2.19759	-4.69690	-2.24448	-.29061	-.13991
AMBIENT VELOCITY	.13410	.18265	.32197	.34083	.28110			
MEAN AMBIENT VELOCITY						.30095	.16965	.14004
SURFACE						.34377	.23406	.15555
MIDDEPTH						.31034	.18265	.13410
BOTTOM						.23271	.06330	.08431
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.19219	.08564	-4.11840	-2.74941	-7.40347	-1.22471	-.12247	.14329
2. PV+DIV+BCK+AV	.37599	.46677	-2.18866	-1.21662	-3.85763	-1.40140	.25444	.32706
3. PV+DIV+AV	-.00667	-.10924	-2.98215	-1.85675	-4.69690	-2.01177	-.22731	-.05560
4. PW+DIV+AV	-.19047	-.49037	-4.91188	-3.38954	-8.24273	-1.83508	-.60422	-.23937
5. BCK+DIV+AV	.51764	.75866	1.11546	.98096	.83927	.84308	.54505	.46697
6. PW+DIV+BCKA+AV	-.19047	-.49037	-3.54367	-2.20407	-6.81469	-1.83508	-.60422	-.23937
7. PV+DIV+BCKA+AV	-.00667	-.10924	-1.61393	-.67128	-3.26885	-2.01177	-.22731	-.05560

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.09	.01	496.44	159.50	2579.86	16.44	.03	.04
EQ.2	.60	1.09	84.02	16.14	413.09	24.01	.20	.40
EQ.3	.00	.02	200.41	52.93	718.24	66.30	.14	.00
EQ.4	.09	1.26	814.50	287.20	3488.54	51.21	2.26	.17
EQ.5	1.46	4.28	12.64	8.81	5.68	5.76	1.69	1.09
EQ.6	.09	1.26	325.42	85.69	2043.93	51.21	2.26	.17
EQ.7	.00	.02	35.70	3.03	259.38	66.30	.14	.00

DIVERGING WAVE HEIGHT	
HOCSTEINS	.21389
BALAMIN AND BYKOV	.45821
ILL. STATE WATER	.18529

WIND WAVE HEIGHT .00701

SQUAT (FT)	
SCHIJF AND JANSEN	.01094
GELENCSER	.22561
DAND	.13866
GATES AND HERRICH	.27455
BHOWMIK	.09144
BALAMIN AND BYKOV	.04817

Table 8. Scenario 6 Simulation

RUN S6-VALVOLINE-UPSTREAM-5x1

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	7.76	STA. 1 DIST. 217.74	WIDTH 500.00	FETCH LENGTH (FT)	850.00
TOW WIDTH (FT)	27.00	STA. 2 DIST. 89.22	DEPTH	WIND SPEED (MPH)	7.00
TOW LENGTH (FT)	925.00	STA. 3 DIST. 43.45	CENTER 22.00		
HORSEPOWER	400.00	STA. 4 DIST. 43.45	QUARTER 18.00		
RPMS (PROPELLER)	144.50	STA. 5 DIST. 43.45	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.00829	.00000	.00000	.00000	.00000	.00000	.00000	.00001
BALAMIN AND BYKOV	.09246	.00000	.00000	.00000	.00000	.00000	.00000	.00104
ILLINOIS STATE WATER SURV	.00458	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	-.03726	-.19605	-.33483	-.27012	-.35415	-.45152	-.16397	-.03726
PROPELLER								
MAXWELL	.31853	.77266	1.49123	1.39254	1.56318	2.42224	.76100	.31851
BLAAU AND VAN DE KAA	.13769	.33574	.67576	.64999	.68992	1.76383	.33257	.13770
AMBIENT VELOCITY	.08524	.12903	.21298	.22546	.18595			
MEAN AMBIENT VELOCITY						.19908	.11985	.08902
SURFACE						.22741	.16534	.09888
MIDDEPTH						.20529	.12903	.08524
BOTTOM						.15394	.04471	.05359
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.37480	.70563	1.36938	1.34788	1.20903	2.12466	.64175	.33485
2. PV+DIV+BCK+AV	.19396	.26872	.55391	.60533	.33577	1.46624	.21331	.15404
3. PV+DIV+AV	.23122	.46477	.88874	.87545	.68992	1.91776	.37728	.19131
4. PW+DIV+AV	.41206	.90169	1.70421	1.61800	1.56318	2.57618	.80572	.37211
5. BCK+DIV+AV	.03970	-.06702	-.12185	-.04466	-.35415	-.29759	-.11926	.01632
6. PW+DIV+BCKA+AV	.41206	.90169	1.70421	1.61800	1.56318	2.57618	.80572	.37211
7. PV+DIV+BCKA+AV	.23122	.46477	.88874	.87545	.68992	1.91776	.37728	.19131

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.59	3.49	22.50	21.52	15.85	77.30	2.67	.43
EQ.2	.09	.23	1.77	2.27	.43	27.26	.12	.05
EQ.3	.15	1.08	6.68	6.40	3.28	57.96	.60	.09
EQ.4	.77	6.95	41.60	35.95	32.63	132.84	5.07	.58
EQ.5	.00	.00	.03	.00	.50	.31	.02	.00
EQ.6	.77	6.95	41.60	35.95	32.63	132.84	5.07	.58
EQ.7	.15	1.08	6.68	6.40	3.28	57.96	.60	.09

DIVERGING WAVE HEIGHT		WIND WAVE HEIGHT	SQUAT (FT)	
HOCSTEINS	.28124	.04376	SCHIJF AND JANSEN	.00195
BALAMIN AND BYKOV	.41977		GELENCSER	.03528
ILL. STATE WATER	.25980		DAND	.03954
			GATES AND HERRICH	.12168
			BHOWMIK	.06871
			BALAMIN AND BYKOV	.02135

Table 9. Scenario 7 Simulation

RUN S7-VALVOLINE-DOWNSTREAM-5x1 STANDARD

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	7.84	STA. 1 DIST. 231.39	WIDTH 500.00	FETCH LENGTH (FT)	550.00
TOW WIDTH (FT)	27.00	STA. 2 DIST. 102.85	DEPTH	WIND SPEED (MPH)	6.00
TOW LENGTH (FT)	925.00	STA. 3 DIST. 29.88	CENTER 22.00		
HORSEPOWER	400.00	STA. 4 DIST. 29.88	QUARTER 18.00		
RPMS (PROPELLER)	144.50	STA. 5 DIST. 29.88	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.00964	.00000	.00000	.00000	.00000	.00000	.00000	-.00001
BALAMIN AND BYKOV	-.10272	.00000	.00000	.00000	.00000	.00000	.00000	-.00127
ILLINOIS STATE WATER SURV	-.00539	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	.03807	.18058	.41314	.33329	.43697	.45635	.15103	.03807
PROPELLER								
MAXWELL	-.29969	-.67108	-2.08972	-1.90316	-2.25356	-2.82786	-.66380	-.29967
BLAAU AND VAN DE KAA	-.12957	-.29132	-.96088	-.89080	-1.00295	-1.76383	-.28924	-.12958
AMBIENT VELOCITY	.08524	.12903	.21298	.22546	.18595			
MEAN AMBIENT VELOCITY						.19908	.11985	.08902
SURFACE						.22741	.16534	.09888
MIDDEPTH						.20529	.12903	.08524
BOTTOM						.15394	.04471	.05359
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.18601	-.36146	-1.46360	-1.34440	-1.81659	-2.21757	-.46805	-.20802
2. PV+DIV+BCK+AV	-.01590	.01829	-.33476	-.33204	-.56598	-1.15354	-.09350	-.03793
3. PV+DIV+AV	-.05397	-.16229	-.74789	-.66533	-1.00295	-1.60989	-.24453	-.07600
4. PW+DIV+AV	-.22409	-.54205	-1.87674	-1.67769	-2.25356	-2.67392	-.61909	-.24609
5. BCK+DIV+AV	.13296	.30961	.62612	.55875	.43697	.61029	.19574	.09168
6. PW+DIV+BCKA+AV	-.22409	-.54205	-1.87674	-1.67769	-2.25356	-2.67392	-.61909	-.24609
7. PV+DIV+BCKA+AV	-.05397	-.16229	-.74789	-.66533	-1.00295	-1.60989	-.24453	-.07600

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.08	.53	27.12	21.36	49.77	87.18	1.10	.11
EQ.2	.00	.00	.43	.42	1.88	13.89	.01	.00
EQ.3	.00	.06	4.11	2.96	9.38	35.45	.18	.01
EQ.4	.14	1.66	54.54	39.80	91.21	147.49	2.42	.18
EQ.5	.03	.34	2.50	1.81	.91	2.32	.10	.01
EQ.6	.14	1.66	54.54	39.80	91.21	147.49	2.42	.18
EQ.7	.00	.06	4.11	2.96	9.38	35.45	.18	.01

DIVERGING WAVE HEIGHT		WIND WAVE HEIGHT		SQUAT (FT)	
HOCSTEINS	.28729		.03100	SCHIJF AND JANSEN	.00296
BALAMIN AND BYKOV	.42880			GELENCSER	.05052
ILL. STATE WATER	.26539			DAND	.04039
				GATES AND HERRICH	.12430
				BHOWMIK	.06887
				BALAMIN AND BYKOV	.02181

Table 10. Scenario 8 Simulation

RUN S8-VALVOLINE-UPSTREAM-5x1 STANDARD

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	10.00	STA. 1 DIST. 232.60	WIDTH 500.00	FETCH LENGTH (FT)	550.00
TOW WIDTH (FT)	27.00	STA. 2 DIST. 103.94	DEPTH	WIND SPEED (MPH)	7.50
TOW LENGTH (FT)	925.00	STA. 3 DIST. 28.13	CENTER 22.00		
HORSEPOWER	800.00	STA. 4 DIST. 28.13	QUARTER 18.00		
RPMS (PROPELLER)	173.40	STA. 5 DIST. 28.13	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.15431	.00000	.00000	.00000	.00000	.00000	.00000	.00274
BALAMIN AND BYKOV	.71628	.00000	.00000	.00000	.00022	.00000	.00000	.04785
ILLINOIS STATE WATER SURV	.10632	.00000	.00000	.00000	.00000	.00000	.00000	.00135
BACKWATER								
HOCSTEIN	-.04861	-.22891	-.53930	-.43507	-.57041	-.58213	-.19146	-.04861
PROPELLER								
MAXWELL	.37567	.83696	2.76427	2.49634	3.00492	3.65966	.82789	.37564
BLAAU AND VAN DE KAA	.16236	.36311	1.27884	1.17599	1.34185	2.22177	.36057	.16238
AMBIENT VELOCITY	.08524	.12903	.21298	.22546	.18595			
MEAN AMBIENT VELOCITY						.19908	.11985	.08902
SURFACE						.22741	.16534	.09888
MIDDEPTH						.20529	.12903	.08524
BOTTOM						.15394	.04471	.05359
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.56661	.73708	2.43795	2.28673	2.43451	3.23147	.68115	.38336
2. PV+DIV+BCK+AV	.35331	.26323	.95252	.96638	.77144	1.79358	.21383	.17009
3. PV+DIV+AV	.40192	.49215	1.49182	1.40145	1.34185	2.37571	.40529	.21870
4. PW+DIV+AV	.61523	.96599	2.97725	2.72180	3.00492	3.81360	.87260	.43197
5. BCK+DIV+AV	-.11768	-.09988	-.32631	-.20961	-.57041	-.42819	-.14674	.00224
6. PW+DIV+BCKA+AV	.61523	.96599	2.97725	2.72180	3.00492	3.81360	.87260	.43197
7. PV+DIV+BCKA+AV	.40192	.49215	1.49182	1.40145	1.34185	2.37571	.40529	.21870

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	1.88	3.95	113.77	95.03	113.32	251.13	3.16	.63
EQ.2	.50	.22	8.11	8.45	4.49	48.02	.12	.06
EQ.3	.72	1.27	28.62	24.01	21.25	105.79	.74	.13
EQ.4	2.38	8.44	199.48	155.04	204.74	399.98	6.34	.88
EQ.5	.02	.01	.40	.12	1.92	.86	.04	.00
EQ.6	2.38	8.44	199.48	155.04	204.74	399.98	6.34	.88
EQ.7	.72	1.27	28.62	24.01	21.25	105.79	.74	.13

DIVERGING WAVE HEIGHT		WIND WAVE HEIGHT	SQUAT (FT)	
HOCSTEINS	.46747	.03920	SCHIJF AND JANSEN	.00505
BALAMIN AND BYKOV	.69772		GELENCSER	.06706
ILL. STATE WATER	.43183		DAND	.06572
			GATES AND HERRICH	.20225
			BHOWMIK	.11189
			BALAMIN AND BYKOV	.03549

Table 11. Scenario 9 Simulation

RUN 99-VALVOLINE-DOWNSTREAM-5x1 STANDARD

INPUT

BOAT INFORMATION		TRACKING		CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	10.00	STA. 1 DIST.	228.64	WIDTH	500.00	FETCH LENGTH (FT)	3000.00
TOW WIDTH (FT)	27.00	STA. 2 DIST.	99.34	DEPTH		WIND SPEED (MPH)	2.00
TOW LENGTH (FT)	925.00	STA. 3 DIST.	32.55	CENTER	22.00		
HORSEPOWER	800.00	STA. 4 DIST.	32.55	QUARTER	18.00		
RPMS (PROPELLER)	173.40	STA. 5 DIST.	32.55	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.15417	.00000	.00000	.00000	.00000	.00000	.00000	-.00273
BALANIN AND BYKOV	-.71582	.00000	.00000	.00000	-.00021	.00000	.00000	-.04779
ILLINOIS STATE WATER SURV	-.10621	.00000	.00000	.00000	.00000	.00000	.00000	-.00135
BACKWATER								
HOCSTEIN	.04846	.23666	.50761	.40951	.53690	.58207	.19793	.04846
PROPELLER								
MAXWELL	-.38218	-.87522	-2.45298	-2.25927	-2.61826	-3.41764	-.86497	-.38216
BLAAU AND VAN DE KAA	-.16518	-.37990	-1.11841	-1.04765	-1.15982	-2.22177	-.37700	-.16519
AMBIENT VELOCITY	.08524	.12903	.21298	.22546	.18595			
MEAN AMBIENT VELOCITY						.19908	.11985	.08902
SURFACE						.22741	.16534	.09888
MIDDEPTH						.20529	.12903	.08524
BOTTOM						.15394	.04471	.05359
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.40265	-.50953	-1.73239	-1.62430	-2.08136	-2.68164	-.62232	-.28284
2. PV+DIV+BCK+AV	-.18564	-.01421	-.39781	-.41268	-.62293	-1.48577	-.13435	-.06587
3. PV+DIV+AV	-.23410	-.25087	-.90542	-.82219	-1.15983	-2.06783	-.33228	-.11433
4. PW+DIV+AV	-.45111	-.74619	-2.24000	-2.03381	-2.61826	-3.26371	-.82025	-.33130
5. BCK+DIV+AV	.28788	.36569	.72060	.63497	.53690	.73600	.24265	.10478
6. PW+DIV+BCKA+AV	-.45111	-.74619	-2.24000	-2.03381	-2.61826	-3.26371	-.82025	-.33130
7. PV+DIV+BCKA+AV	-.23410	-.25087	-.90542	-.82219	-1.15983	-2.06783	-.33228	-.11433

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.72	1.40	43.56	36.35	72.95	148.69	2.45	.27
EQ.2	.08	.00	.70	.77	2.46	28.29	.03	.00
EQ.3	.16	.19	7.03	5.36	14.11	71.63	.42	.02
EQ.4	.99	4.08	89.68	68.37	139.03	258.23	5.33	.42
EQ.5	.28	.55	3.70	2.60	1.62	3.93	.17	.02
EQ.6	.99	4.08	89.68	68.37	139.03	258.23	5.33	.42
EQ.7	.16	.19	7.03	5.36	14.11	71.63	.42	.02

DIVERGING WAVE HEIGHT	
HOCSTEINS	.46738
BALANIN AND BYKOV	.69758
ILL. STATE WATER	.43175

WIND WAVE HEIGHT .01991

SQUAT (FT)	
SCHIJF AND JANSEN	.00448
GELENCSER	.05853
DAND	.06570
GATES AND HERRICH	.20221
BHOWMIK	.11246
BALANIN AND BYKOV	.03548

Table 12. Scenario 10 Simulation

RUN S10-VALVOLINE-UPSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING		CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	6.02	STA. 1 DIST.	237.40	WIDTH	500.00	FETCH LENGTH (FT)	550.00
TOW WIDTH (FT)	105.00	STA. 2 DIST.	109.36	DEPTH		WIND SPEED (MPH)	7.50
TOW LENGTH (FT)	615.00	STA. 3 DIST.	23.56	CENTER	22.00		
HORSEPOWER	400.00	STA. 4 DIST.	23.56	QUARTER	18.00		
RPMS (PROPELLER)	144.50	STA. 5 DIST.	23.56	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.00294	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	.25753	.00000	.00000	.00000	.00001	.00000	.00000	.00717
ILLINOIS STATE WATER SURV	.00084	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	-.40608	-.62364	-.85058	-.68619	-.89965	-.65429	-.52159	-.40608
PROPELLER								
MAXWELL	.29214	.63170	2.51462	2.20915	2.81137	3.11681	.62534	.29212
BLAAU AND VAN DE KAA	.12629	.27400	1.18892	1.06324	1.27157	1.76383	.27227	.12630
AMBIENT VELOCITY	.09626	.13987	.24656	.26100	.21526			
MEAN AMBIENT VELOCITY						.23046	.12992	.10052
SURFACE						.26325	.17923	.11165
MIDDEPTH						.23765	.13987	.09626
BOTTOM						.17820	.04847	.06051
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.01475	.14793	1.91059	1.78396	1.91172	2.64071	.15222	-.05345
2. PV+DIV+BCK+AV	-.18059	-.20977	.58489	.63806	.37192	1.28774	-.20085	-.21927
3. PV+DIV+AV	.22549	.41387	1.43547	1.32424	1.27157	1.94203	.32074	.18682
4. PW+DIV+AV	.39134	.77157	2.76117	2.47015	2.81137	3.29501	.67381	.35263
5. BCK+DIV+AV	-.31277	-.48377	-.60402	-.42519	-.89965	-.47609	-.47312	-.34557
6. PW+DIV+BCKA+AV	.39134	.77157	1.31794	1.23251	1.30040	3.29501	.67381	.35263
7. PV+DIV+BCKA+AV	.22549	.41387	-.00776	.08661	-.23941	1.94203	.32074	.18682

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.00	.04	57.35	47.30	57.45	142.40	.05	.00
EQ.2	.08	.12	2.06	2.63	.58	18.93	.10	.13
EQ.3	.14	.78	25.68	20.47	18.27	60.05	.38	.08
EQ.4	.67	4.49	161.42	118.04	169.80	265.25	3.07	.50
EQ.5	.35	1.21	2.26	.84	6.91	1.16	1.14	.47
EQ.6	.67	4.49	20.20	16.73	19.46	265.25	3.07	.50
EQ.7	.14	.78	.00	.01	.17	60.05	.38	.08

DIVERGING WAVE HEIGHT	
HOCSTEINS	.24577
BALAMIN AND BYKOV	.52652
ILL. STATE WATER	.21292

WIND WAVE HEIGHT .03920

SQUAT (FT)	
SCHIJF AND JANSEN	.01257
GELENCSER	.08166
DAND	.15933
GATES AND HERRICH	.31547
BHOWMIK	.10659
BALAMIN AND BYKOV	.05535

Table 13. Scenario 12 Simulation

RUN S12-VALVOLINE-UPSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	9.62	STA. 1 DIST. 236.49	WIDTH 500.00	FETCH LENGTH (FT)	550.00
TOW WIDTH (FT)	35.00	STA. 2 DIST. 108.24	DEPTH	WIND SPEED (MPH)	4.00
TOW LENGTH (FT)	1025.00	STA. 3 DIST. 24.58	CENTER 22.00		
HORSEPOWER	1400.00	STA. 4 DIST. 24.58	QUARTER 18.00		
RPMS (PROPELLER)	202.00	STA. 5 DIST. 24.58	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.09027	.00000	.00000	.00000	.00000	.00000	.00000	.00099
BALAMIN AND BYKOV	.87935	.00000	.00000	.00000	.00044	.00000	.00000	.06954
ILLINOIS STATE WATER SURV	.06938	.00000	.00000	.00000	.00000	.00000	.00000	.00060
BACKWATER								
HOCSTEIN	-.09278	-.30522	-.62749	-.50622	-.66369	-.60643	-.25528	-.09278
PROPELLER								
MAXWELL	.44528	.96892	3.69907	3.27227	4.10538	4.68417	.95917	.44526
BLAAU AND VAN DE KAA	.19241	.42014	1.73852	1.56603	1.84986	2.67689	.41743	.19242
AMBIENT VELOCITY	.09626	.13987	.24656	.26100	.21526			
MEAN AMBIENT VELOCITY						.23046	.12992	.10052
SURFACE						.26325	.17923	.11165
MIDDEPTH						.23765	.13987	.09626
BOTTOM						.17820	.04847	.06051
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.53903	.80357	3.31813	3.02705	3.44168	4.25594	.75236	.41398
2. PV+DIV+BCK+AV	.28615	.25479	1.35758	1.32081	1.18617	2.24866	.21062	.16114
3. PV+DIV+AV	.37893	.56001	1.98507	1.82703	1.84986	2.85509	.46590	.25392
4. PW+DIV+AV	.63181	1.10879	3.94562	3.53327	4.10538	4.86237	1.00764	.50676
5. BCK+DIV+AV	-.08680	-.16535	-.38094	-.24522	-.66369	-.42823	-.20681	-.03326
6. PW+DIV+BCKA+AV	.63181	1.10879	2.77407	2.48729	2.89350	4.86237	1.00764	.50676
7. PV+DIV+BCKA+AV	.37893	.56001	.81352	.78104	.63798	2.85509	.46590	.25392

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	1.64	5.03	270.52	209.00	299.78	544.45	4.18	.78
EQ.2	.28	.20	21.96	20.33	15.03	90.65	.12	.06
EQ.3	.61	1.82	63.86	50.58	52.38	177.33	1.09	.20
EQ.4	2.56	12.43	440.12	322.75	492.05	791.64	9.50	1.38
EQ.5	.01	.06	.62	.18	2.94	.86	.11	.00
EQ.6	2.56	12.43	163.55	120.36	184.11	791.64	9.50	1.38
EQ.7	.61	1.82	5.21	4.64	2.63	177.33	1.09	.20

DIVERGING WAVE HEIGHT	
HOCSTEINS	.41777
BALAMIN AND BYKOV	.74477
ILL. STATE WATER	.39687

WIND WAVE HEIGHT .02026

SQUAT (FT)	
SCHIJF AND JANSEN	.00684
GELENCSER	.11313
DAND	.08742
GATES AND HERRICH	.24500
BHOWMIK	.13117
BALAMIN AND BYKOV	.14146

Table 14. Scenario 13 Simulation

RUN S13-VALVOLINE-DOWNSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	8.96	STA. 1 DIST. 273.83	WIDTH 500.00	FETCH LENGTH (FT)	500.00
TOW WIDTH (FT)	105.00	STA. 2 DIST. 143.94	DEPTH	WIND SPEED (MPH)	8.00
TOW LENGTH (FT)	615.00	STA. 3 DIST. 14.13	CENTER 22.00		
HORSEPOWER	1050.00	STA. 4 DIST. 14.13	QUARTER 18.00		
RPMS (PROPELLER)	187.80	STA. 5 DIST. 14.13	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.29405	.00000	.00000	.00000	-.00001	.00000	.00000	-.00920
BALAMIN AND BYKOV	-2.83837	-.00084	.00000	.00000	-.02132	.00000	.00000	-.54205
ILLINOIS STATE WATER SURV	-.16026	.00000	.00000	.00000	.00000	.00000	.00000	-.00294
BACKWATER								
HOCSTEIN	.62198	.89470	1.26562	1.02102	1.33864	.97356	.74830	.62198
PROPELLER								
MAXWELL	-.34942	-.66317	-4.80996	-3.84222	-6.05005	-4.29888	-.65940	-.34941
BLAAU AND VAN DE KAA	-.15099	-.28716	-2.46824	-1.97149	-2.91909	-2.43235	-.28611	-.15100
AMBIENT VELOCITY	.09626	.13987	.24656	.26100	.21526			
MEAN AMBIENT VELOCITY						.23046	.12992	.10052
SURFACE						.26325	.17923	.11165
MIDDEPTH						.23765	.13987	.09626
BOTTOM						.17820	.04847	.06051
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.07476	.37141	-3.29778	-2.56020	-4.71142	-3.14712	.13737	.32389
2. PV+DIV+BCK+AV	.27319	.74741	-.95606	-.68947	-1.58046	-1.28059	.51066	.52230
3. PV+DIV+AV	-.34879	-.14729	-2.22168	-1.71049	-2.91910	-2.25415	-.23764	-.09968
4. PW+DIV+AV	-.54722	-.52330	-4.56341	-3.58121	-6.05006	-4.12068	-.61093	-.29809
5. BCK+DIV+AV	1.01229	1.03457	1.51218	1.28202	1.33865	1.15176	.79677	.69169
6. PW+DIV+BCKA+AV	-.54722	-.52330	-2.43604	-1.88870	-3.77241	-4.12068	-.61093	-.29809
7. PV+DIV+BCKA+AV	-.34879	-.14729	-.09432	-.01797	-.64145	-2.25415	-.23764	-.09968

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.01	.58	265.88	130.54	724.50	233.14	.04	.39
EQ.2	.24	4.10	8.20	3.27	33.66	18.63	1.41	1.50
EQ.3	.48	.04	87.63	42.03	188.73	91.28	.16	.01
EQ.4	1.71	1.51	662.35	335.20	1462.94	497.22	2.33	.31
EQ.5	9.62	10.23	29.73	18.69	21.11	13.83	4.91	3.30
EQ.6	1.71	1.51	113.52	55.53	387.96	497.22	2.33	.31
EQ.7	.48	.04	.01	.00	2.67	91.28	.16	.01

DIVERGING WAVE HEIGHT	
HOCSTEINS	.54415
BALAMIN AND BYKOV	1.16572
ILL. STATE WATER	.47140

WIND WAVE HEIGHT .04035

SQUAT (FT)	
SCHIJF AND JANSEN	.02783
GELENCSER	.19052
DAND	.35276
GATES AND HERRICH	.69846
BHOWMIK	.22578
BALAMIN AND BYKOV	.12256

Table 15. Scenario 14 Simulation

RUN S14-MORRIS HARVEY-UPSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING		CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	5.54	STA. 1 DIST.	250.18	WIDTH	500.00	FETCH LENGTH (FT)	300.00
TOW WIDTH (FT)	105.00	STA. 2 DIST.	120.79	DEPTH		WIND SPEED (MPH)	5.00
TOW LENGTH (FT)	615.00	STA. 3 DIST.	10.98	CENTER	22.00		
HORSEPOWER	1000.00	STA. 4 DIST.	10.98	QUARTER	18.00		
RPMS (PROPELLER)	360.00	STA. 5 DIST.	10.98	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.00068	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	.12419	.00000	.00000	.00000	.00000	.00000	.00000	.00181
ILLINOIS STATE WATER SURV	.00016	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	-.37804	-.56709	-.78289	-.63158	-.82806	-.60222	-.47429	-.37804
PROPELLER								
MAXWELL	.32172	.66416	4.56393	3.47423	6.20822	3.10138	.65874	.32170
BLAAU AND VAN DE KAA	.13903	.28795	2.61633	1.95532	3.16516	2.24448	.28672	.13904
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.04953	.24749	4.03762	3.11426	5.38017	2.68460	.23657	.00978
2. PV+DIV+BCK+AV	-.13315	-.12872	2.09002	1.59535	2.33710	1.82770	-.13545	-.17287
3. PV+DIV+AV	.24489	.43837	2.87291	2.22693	3.16516	2.42992	.33884	.20517
4. PW+DIV+AV	.42757	.81458	4.82051	3.74584	6.20822	3.28682	.71086	.38782
5. BCK+DIV+AV	-.27354	-.41667	-.52631	-.35997	-.82806	-.41678	-.42217	-.31192
6. PW+DIV+BCKA+AV	.42757	.81458	3.46578	2.56980	4.79507	3.28682	.71086	.38782
7. PV+DIV+BCKA+AV	.24489	.43837	1.51818	1.05089	1.75200	2.42992	.33884	.20517

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.00	.18	469.56	226.37	1052.01	149.15	.16	.00
EQ.2	.03	.03	73.81	34.55	101.03	50.63	.03	.07
EQ.3	.18	.92	180.45	88.21	236.92	112.72	.44	.11
EQ.4	.85	5.23	772.63	380.33	1572.97	263.40	3.56	.65
EQ.5	.24	.79	1.53	.53	5.47	.80	.82	.35
EQ.6	.85	5.23	305.72	131.92	761.23	263.40	3.56	.65
EQ.7	.18	.92	30.06	10.69	44.96	112.72	.44	.11

DIVERGING WAVE HEIGHT	
HOCSTEINS	.20821
BALAMIN AND BYKOV	.44605
ILL. STATE WATER	.18038

WIND WAVE HEIGHT .01985

SQUAT (FT)	
SCHIJF AND JANSEN	.01065
GELENCSER	.15402
DAND	.13498
GATES AND HERRICH	.26726
BHOWMIK	.08885
BALAMIN AND BYKOV	.04689

Table 16. Scenario 15a Simulation

RUN S15-VALVOLINE-UPSTREAM-3x3 JUMBO

INPUT

BOAT INFORMATION		TRACKING		CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	6.81	STA. 1 DIST.	265.00	WIDTH	500.00	FETCH LENGTH (FT)	500.00
TOW WIDTH (FT)	105.00	STA. 2 DIST.	136.07	DEPTH		WIND SPEED (MPH)	3.00
TOW LENGTH (FT)	615.00	STA. 3 DIST.	3.72	CENTER	22.00		
HORSEPOWER	720.00	STA. 4 DIST.	3.72	QUARTER	18.00		
RPMS	162.00	STA. 5 DIST.	3.72	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.01784	.00000	.00000	.00000	.00000	.00000	.00000	.00004
BALAMIN AND BYKOV	.63964	.00000	.00000	.00000	.00014	.00000	.00000	.03888
ILLINOIS STATE WATER SURV	.00659	.00000	.00000	.00000	.00000	.00000	.00000	.00001
BACKWATER								
HOCSTEIN	-.47006	-.68455	-.96236	-.77636	-1.01788	-.74028	-.57254	-.47006
PROPELLER								
MAXWELL	.31838	.61845	6.18778	4.11341	13.75569	.14528	.61452	.31836
BLAAU AND VAN DE KAA	.13760	.26789	3.74471	2.28780	9.46711	2.14517	.26679	.13761
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.02867	.08432	5.48200	3.60865	12.73781	-.40956	.09411	-.08553
2. PV+DIV+BCK+AV	-.20944	-.26624	3.03893	1.78305	8.44923	1.59034	-.25362	-.26629
3. PV+DIV+AV	.26062	.41831	4.00129	2.55941	9.46711	2.33061	.31892	.20378
4. PW+DIV+AV	.44140	.76887	6.44436	4.38501	13.75569	.33072	.66664	.38453
5. BCK+DIV+AV	-.38273	-.53414	-.70578	-.50476	-1.01788	-.55483	-.52041	-.40399
6. PW+DIV+BCKA+AV	.44140	.76887	4.84215	3.03852	12.06813	.33072	.66664	.38453
7. PV+DIV+BCKA+AV	.26062	.41831	2.39909	1.21292	7.77955	2.33061	.31892	.20378

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.00	.01	1108.92	342.47	11852.20	.76	.01	.01
EQ.2	.11	.23	211.31	47.23	3739.72	34.25	.20	.23
EQ.3	.21	.80	457.79	130.42	5148.18	100.25	.37	.11
EQ.4	.93	4.44	1746.94	592.14	14710.18	.42	2.98	.63
EQ.5	.63	1.60	3.49	1.36	9.77	1.78	1.48	.73
EQ.6	.93	4.44	782.42	211.23	10183.35	.42	2.98	.63
EQ.7	.21	.80	108.75	16.00	2965.27	100.25	.37	.11

DIVERGING WAVE HEIGHT

HOCSTEINS	.31462
BALAMIN AND BYKOV	.67400
ILL. STATE WATER	.27256

WIND WAVE HEIGHT .01439

SQUAT (FT)

SCHIJF AND JANSEN	.01609
GELENCSER	.51220
DAND	.20396
GATES AND HERRICH	.40384
BHOWMIK	.13187
BALAMIN AND BYKOV	.07086

Table 17. Scenario 15b Simulation

RUN S15-MORRIS HARVEY-DOWNSTREAM-3x3 JUM

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION		WIND AND ELEVATION	
TOW SPEED (FT/SEC)	5.63	STA. 1 DIST. 275.09	WIDTH	500.00	FETCH LENGTH (FT)	500.00
TOW WIDTH (FT)	105.00	STA. 2 DIST. 145.20	DEPTH		WIND SPEED (MPH)	3.00
TOW LENGTH (FT)	615.00	STA. 3 DIST. 16.13	CENTER	22.00		
HORSEPOWER	1000.00	STA. 4 DIST. 16.13	QUARTER	18.00		
RPMS (PROPELLER)	360.00	STA. 5 DIST. 16.13	SHORE	3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.00093	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	-.14479	.00000	.00000	.00000	.00000	.00000	.00000	-.00243
ILLINOIS STATE WATER SURV	-.00022	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	.39146	.56195	.79589	.64207	.84181	.61222	.46999	.39146
PROPELLER								
MAXWELL	-.29260	-.55310	-3.75712	-3.07884	-4.55786	-3.69792	-.54995	-.29258
BLAAU AND VAN DE KAA	-.12644	-.23956	-1.95574	-1.62885	-2.15578	-2.24448	-.23885	-.12646
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.20311	.15927	-2.70465	-2.16516	-3.71605	-2.90025	-.02783	.16500
2. PV+DIV+BCK+AV	.36926	.47280	-.90327	-.71517	-1.31397	-1.44681	.28327	.33113
3. PV+DIV+AV	-.02219	-.08915	-1.69916	-1.35724	-2.15578	-2.05903	-.18672	-.06033
4. PW+DIV+AV	-.18835	-.40268	-3.50054	-2.80723	-4.55786	-3.51247	-.49783	-.22646
5. BCK+DIV+AV	.49756	.71236	1.05247	.91368	.84181	.79767	.52212	.45758
6. PW+DIV+BCKA+AV	-.18835	-.40268	-2.12924	-1.61960	-3.12642	-3.51247	-.49783	-.22646
7. PV+DIV+BCKA+AV	-.02219	-.08915	-.32787	-.16961	-.72434	-2.05903	-.18672	-.06033

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.11	.05	152.31	81.51	371.89	185.32	.00	.06
EQ.2	.57	1.13	6.99	3.63	20.03	26.26	.27	.42
EQ.3	.00	.01	41.25	21.94	80.52	70.77	.08	.00
EQ.4	.09	.72	314.41	169.10	660.09	317.44	1.31	.14
EQ.5	1.31	3.59	10.74	7.22	5.73	4.93	1.50	1.03
EQ.6	.09	.72	77.77	36.05	228.86	317.44	1.31	.14
EQ.7	.00	.01	.41	.06	3.76	70.77	.08	.00

DIVERGING WAVE HEIGHT	
HOCSTEINS	.21519
BALAMIN AND BYKOV	.46099
ILL. STATE WATER	.18642

WIND WAVE HEIGHT .01439

SQUAT (FT)	
SCHIJF AND JANSEN	.01100
GELENCSER	.10927
DAND	.13950
GATES AND HERRICH	.27621
BHOWMIK	.08916
BALAMIN AND BYKOV	.04847

Table 18. Scenario 17a Simulation

RUN S17A-MORRIS HARVEY-DOWNSTREAM-1x5 JU

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	7.95	STA. 1 DIST. 256.46	WIDTH 500.00	FETCH LENGTH (FT)	250.00
TOW WIDTH (FT)	35.00	STA. 2 DIST. 126.71	DEPTH	WIND SPEED (MPH)	3.00
TOW LENGTH (FT)	1025.00	STA. 3 DIST. 3.74	CENTER 22.00		
HORSEPOWER	1000.00	STA. 4 DIST. 3.74	QUARTER 18.00		
RPMS (PROPELLER)	360.00	STA. 5 DIST. 3.74	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.00920	.00000	.00000	.00000	.00000	.00000	.00000	-.00001
BALAMIN AND BYKOV	-.22337	.00000	.00000	.00000	.00000	.00000	.00000	-.00549
ILLINOIS STATE WATER SURV	-.00633	.00000	.00000	.00000	.00000	.00000	.00000	-.00001
BACKWATER								
HOCSTEIN	.07773	.23447	.65159	.52566	.68918	.50122	.19610	.07773
PROPELLER								
MAXWELL	-.31381	-.63324	-5.89968	-3.92404	-14.10899	-.02820	-.62855	-.31379
BLAAU AND VAN DE KAA	-.13563	-.27451	-4.15109	-2.40077	-9.21995	-2.24448	-.27344	-.13564
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.14010	-.24836	-4.99152	-3.12678	-13.41981	.65847	-.38032	-.16995
2. PV+DIV+BCK+AV	.03808	.11038	-3.24293	-1.60351	-8.53078	-1.55781	-.02521	.00820
3. PV+DIV+AV	-.03965	-.12409	-3.89452	-2.12916	-9.21995	-2.05903	-.22131	-.06953
4. PW+DIV+AV	-.21783	-.48283	-5.64311	-3.65243	-14.10899	.15724	-.57642	-.24768
5. BCK+DIV+AV	.19211	.38488	.90816	.79726	.68918	.68666	.24822	.14387
6. PW+DIV+BCKA+AV	-.21783	-.48283	-5.64311	-3.65243	-14.10899	.15724	-.57642	-.24768
7. PV+DIV+BCKA+AV	-.03965	-.12409	-3.89452	-2.12916	-9.21995	-2.05903	-.22131	-.06953

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.04	.19	852.15	228.93	13723.03	2.87	.61	.06
EQ.2	.00	.02	253.64	35.05	3842.03	32.32	.00	.00
EQ.3	.00	.03	424.28	77.76	4779.37	70.77	.13	.01
EQ.4	.13	1.20	1202.95	354.27	15796.69	.05	1.98	.18
EQ.5	.09	.64	7.09	4.92	3.27	3.23	.19	.04
EQ.6	.13	1.20	1202.95	354.27	15796.69	.05	1.98	.18
EQ.7	.00	.03	424.28	77.76	4779.37	70.77	.13	.01

DIVERGING WAVE HEIGHT	
HOCSTEINS	.28538
BALAMIN AND BYKOV	.50876
ILL. STATE WATER	.27111

WIND WAVE HEIGHT .01075

SQUAT (FT)	
SCHIJF AND JANSEN	.00738
GELENCSER	.54807
DAND	.05972
GATES AND HERRICH	.16736
BHOWMIK	.08738
BALAMIN AND BYKOV	.02937

Table 19. Scenario 17b Simulation

RUN S17B-VALVOLINE-UPSTREAM-1x5 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	8.14	STA. 1 DIST. 238.94	WIDTH 500.00	FETCH LENGTH (FT)	250.00
TOW WIDTH (FT)	35.00	STA. 2 DIST. 111.53	DEPTH	WIND SPEED (MPH)	3.00
TOW LENGTH (FT)	1025.00	STA. 3 DIST. 21.65	CENTER 22.00		
HORSEPOWER	560.00	STA. 4 DIST. 21.65	QUARTER 18.00		
RPMS (PROPELLER)	156.00	STA. 5 DIST. 21.65	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	.01277	.00000	.00000	.00000	.00000	.00000	.00000	.00002
BALANIN AND BYKOV	.27140	.00000	.00000	.00000	.00001	.00000	.00000	.00791
ILLINOIS STATE WATER SURV	.00894	.00000	.00000	.00000	.00000	.00000	.00000	.00001
BACKWATER								
HOCSTEIN	-.07866	-.25341	-.54688	-.44118	-.57843	-.51320	-.21194	-.07866
PROPELLER								
MAXWELL	.32465	.69293	2.99091	2.58962	3.39589	3.54853	.68644	.32463
BLAAU AND VAN DE KAA	.14036	.30053	1.43052	1.25965	1.54755	1.97295	.29871	.14037
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	.36394	.58993	2.70061	2.42004	2.81746	3.22078	.52662	.31212
2. PV+DIV+BCK+AV	.17965	.19754	1.14022	1.09008	.96912	1.64520	.13889	.12785
3. PV+DIV+AV	.25831	.45095	1.68710	1.53126	1.54755	2.15840	.35083	.20651
4. PW+DIV+AV	.44260	.84334	3.24749	2.86123	3.39589	3.73398	.73856	.39078
5. BCK+DIV+AV	.01374	-.10300	-.29030	-.16958	-.57843	-.32775	-.15982	-.01256
6. PW+DIV+BCKA+AV	.44260	.84334	3.24749	2.86123	3.39589	3.73398	.73856	.39078
7. PV+DIV+BCKA+AV	.25831	.45095	1.68710	1.53126	1.54755	2.15840	.35083	.20651

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.54	2.11	151.67	111.44	170.84	248.80	1.53	.35
EQ.2	.07	.10	13.45	11.85	8.52	37.68	.04	.03
EQ.3	.21	.99	40.43	30.79	31.72	80.80	.49	.11
EQ.4	.94	5.76	254.64	178.40	288.71	376.95	3.97	.66
EQ.5	.00	.02	.29	.06	2.00	.40	.05	.00
EQ.6	.94	5.76	254.64	178.40	288.71	376.95	3.97	.66
EQ.7	.21	.99	40.43	30.79	31.72	80.80	.49	.11

DIVERGING WAVE HEIGHT		WIND WAVE HEIGHT	SQUAT (FT)	
HOCSTEINS	.29918	.01075	SCHIJF AND JANSEN	.00520
BALANIN AND BYKOV	.53337		GELENCSER	.10898
ILL. STATE WATER	.28422		DAND	.06261
			GATES AND HERRICH	.17546
			BHOWMIK	.09364
			BALANIN AND BYKOV	.03079

Table 20. Scenario 18 Simulation

RUN S18-VALVOLINE-DOWNSTREAM-1x5 JUMBO

INPUT

BOAT INFORMATION		TRACKING	CHANNEL INFORMATION	WIND AND ELEVATION	
TOW SPEED (FT/SEC)	5.54	STA. 1 DIST. 256.01	WIDTH 500.00	FETCH LENGTH (FT)	400.00
TOW WIDTH (FT)	35.00	STA. 2 DIST. 126.50	DEPTH	WIND SPEED (MPH)	2.00
TOW LENGTH (FT)	1025.00	STA. 3 DIST. 10.04	CENTER 22.00		
HORSEPOWER	360.00	STA. 4 DIST. 10.04	QUARTER 18.00		
RPMS (PROPELLER)	141.00	STA. 5 DIST. 10.04	SHORE 3.00		

	CALCULATED POINT VELOCITY					BOTTOM VELICITY		
	1	2	3	4	5	CENTER	QUARTER	SHORE
DIVERGING WAVE								
HOCSTEINS	-.00001	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BALAMIN AND BYKOV	-.00307	.00000	.00000	.00000	.00000	.00000	.00000	.00000
ILLINOIS STATE WATER SURV	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BACKWATER								
HOCSTEIN	.05415	.16333	.45400	.36626	.48020	.34923	.13660	.05415
PROPELLER								
MAXWELL	-.26155	-.52777	-3.93825	-2.94955	-5.51976	-2.50345	-.52380	-.26154
BLAAU AND VAN DE KAA	-.11308	-.22875	-2.14718	-1.56768	-2.86940	-1.70302	-.22766	-.11308
AMBIENT VELOCITY	.10518	.15042	.25658	.27161	.22401			
MEAN AMBIENT VELOCITY						.23982	.13971	.10983
SURFACE						.27395	.19275	.12200
MIDDEPTH						.24731	.15042	.10518
BOTTOM						.18544	.05212	.06612
WIND	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1. PW+DIV+BCW+AV	-.10223	-.21403	-3.22766	-2.31168	-5.03956	-1.96877	-.33507	-.14127
2. PV+DIV+BCK+AV	.04624	.08500	-1.43660	-.92981	-2.38920	-1.16834	-.03894	.00718
3. PV+DIV+AV	-.00791	-.07833	-1.89061	-1.29607	-2.86940	-1.51757	-.17554	-.04696
4. PW+DIV+AV	-.15638	-.37736	-3.68167	-2.67794	-5.51976	-2.31801	-.47167	-.19541
5. BCK+DIV+AV	.15933	.31374	.71058	.63787	.48020	.53468	.18873	.12027
6. PW+DIV+BCKA+AV	-.15638	-.37736	-3.68167	-2.67794	-5.51976	-2.31801	-.47167	-.19541
7. PV+DIV+BCKA+AV	-.00791	-.07833	-1.89061	-1.29607	-2.86940	-1.51757	-.17554	-.04696

	STA. 1	STA.2	STA.3	STA.4	STA.5	CENTER	QUARTER	SHORE
EQ.1	.02	.12	250.30	97.98	875.40	62.40	.43	.04
EQ.2	.00	.01	25.74	7.58	107.49	14.40	.00	.00
EQ.3	.00	.01	55.68	19.27	179.84	30.03	.07	.00
EQ.4	.05	.60	362.30	148.12	1130.52	98.73	1.13	.09
EQ.5	.05	.36	3.56	2.63	1.18	1.60	.09	.02
EQ.6	.05	.60	362.30	148.12	1130.52	98.73	1.13	.09
EQ.7	.00	.01	55.68	19.27	179.84	30.03	.07	.00

DIVERGING WAVE HEIGHT	
HOCSTEINS	.13855
BALAMIN AND BYKOV	.24700
ILL. STATE WATER	.13162

WIND WAVE HEIGHT .00854

SQUAT (FT)	
SCHIJF AND JANSEN	.00358
GELENCSER	.15583
DAND	.02899
GATES AND HERRICH	.08125
BHOWMIK	.04245
BALAMIN AND BYKOV	.01426

Table 21. Velocities Measured by TVA at the Watsons Island Station 4 in the Back Channel, 500 feet from Mouth at Center

Run Description	Measured Vel.	Meas. Ambient Vel.	ΔV	V_{boat}	$\frac{\Delta V}{V_{boat}}$
1000 hp 5x1 config. downstream	0.41	0.20	0.21	7.5	0.028
1000 hp 5x1 config. downstream	0.32	0.07	0.25	7.5	0.033
3400 hp 2x2 config. downstream	0.30	0.20	0.10		
800 hp 2x1 config. downstream	0.49	0.20	0.29		
3400 hp 5x1 config. upstream	0.51	0.17	0.34	9.6	0.035
3400 hp 5x1 config. downstream	0.57	0.20	0.37	9.5	0.038
1000 hp 3x3 config. upstream	0.48	0.20	0.28	6.0	0.046
1800 hp 3x1E config. upstream	0.39	0.20	0.19		
1000 hp 3x3 config. downstream	0.38	0.20	0.18		
3400 hp 3x3 config. upstream	0.47	0.20	0.27	6.5	0.042
1000 hp 3x1E config. upstream	0.25	0.20	0.05		

Table 22. Velocities Measured by TVA at the Watsons Island Station 2 in the Back Channel, 500 feet from Mouth at Shore

Run Description	Measured Vel.	Meas. Ambient Vel.	ΔV	V_{boat}	$\frac{\Delta V}{V_{boat}}$
1000 hp 5x1 config. downstream	0.41	0.20	0.21	7.5	0.028
1000 hp 5x1 config. downstream	0.25	0.07	0.18	7.5	0.024
3400 hp 2x2 config. downstream	0.35	0.20	0.15		
800 hp 2x1 config. downstream	0.47	0.20	0.27		
3400 hp 5x1 config. upstream	0.36	0.17	0.19	9.6	0.020
3400 hp 5x1 config. downstream	0.50	0.20	0.30	9.5	0.031
1000 hp 3x3 config. upstream	0.38	0.20	0.18	6.0	0.030
1800 hp 3x1E config. upstream	0.31	0.20	0.11		
1000 hp 3x3 config. downstream	0.31	0.20	0.11		
3400 hp 3x3 config. upstream	0.37	0.20	0.17	6.5	0.026
1000 hp 3x1E config. upstream	0.31	0.20	0.11		

Table 23. Correlation Between the Simulated Squat at River Mile 74.3 and the Change in Velocity Measured inside Cabin Creek

Run Description	Measured Vel.		Meas. Ambient Vel.		Squat	ΔV		$\frac{\Delta V}{Squat}$	
	sta.3	sta.4	sta.3	sta.4		sta.3	sta.4	sta.3	sta.4
1000 hp 5x1 tow downstream	0.67	0.53	0.32	0.26	0.43	0.35	0.27	0.81	0.62
3400 hp 5x1 tow upstream	0.68	0.82	0.35	0.34	0.41	0.33	0.48	0.80	1.16
3400 hp 5x1 tow downstream	0.52	0.52	0.26	0.12	0.21	0.40	0.40	2.00	2.00
1000 hp 3x3 tow upstream	0.52	0.65	0.27	0.28	0.21	0.25	0.37	1.25	1.77
1000 hp 3x3 tow downstream	0.53	0.69	0.29	0.19	0.40	0.24	0.50	0.60	1.26

Table 24. Correlation Factors Used to Compute Velocities for Locations in the Back Channel of Watsons Island and in Cabin Creek

Watson Island Back Channel	Cabin Creek
$\frac{V_{shore}}{V_{tow}} = 0.027$	$\frac{V_{mouth}}{Squat_{mouth}} = 1.09$
$\frac{V_{center}}{V_{tow}} = 0.037$	$\frac{V_{150}}{Squat_{mouth}} = 1.36$

Figures

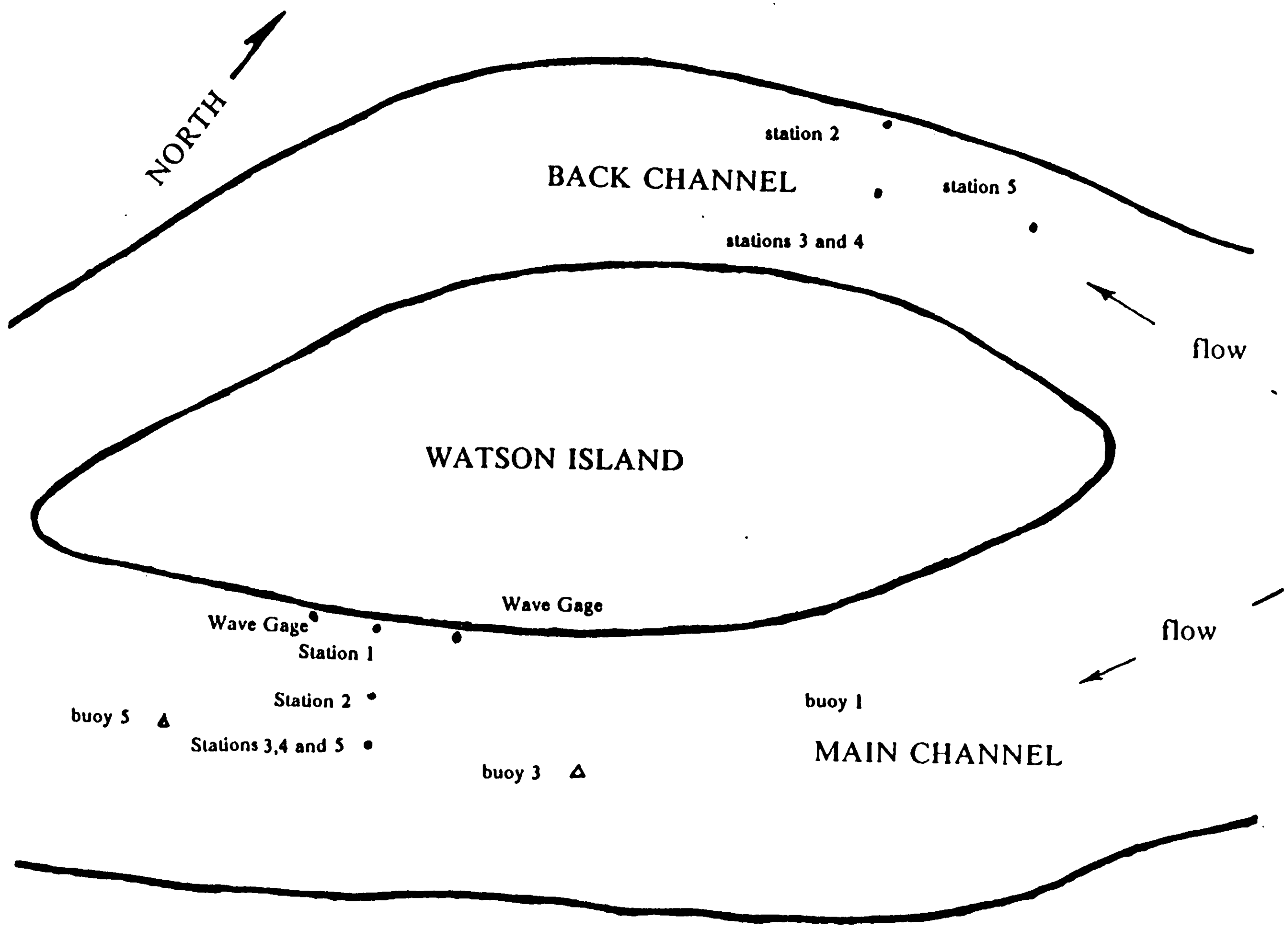


Figure 1. Test Station Location for Main Channel and Back Channel Scenarios

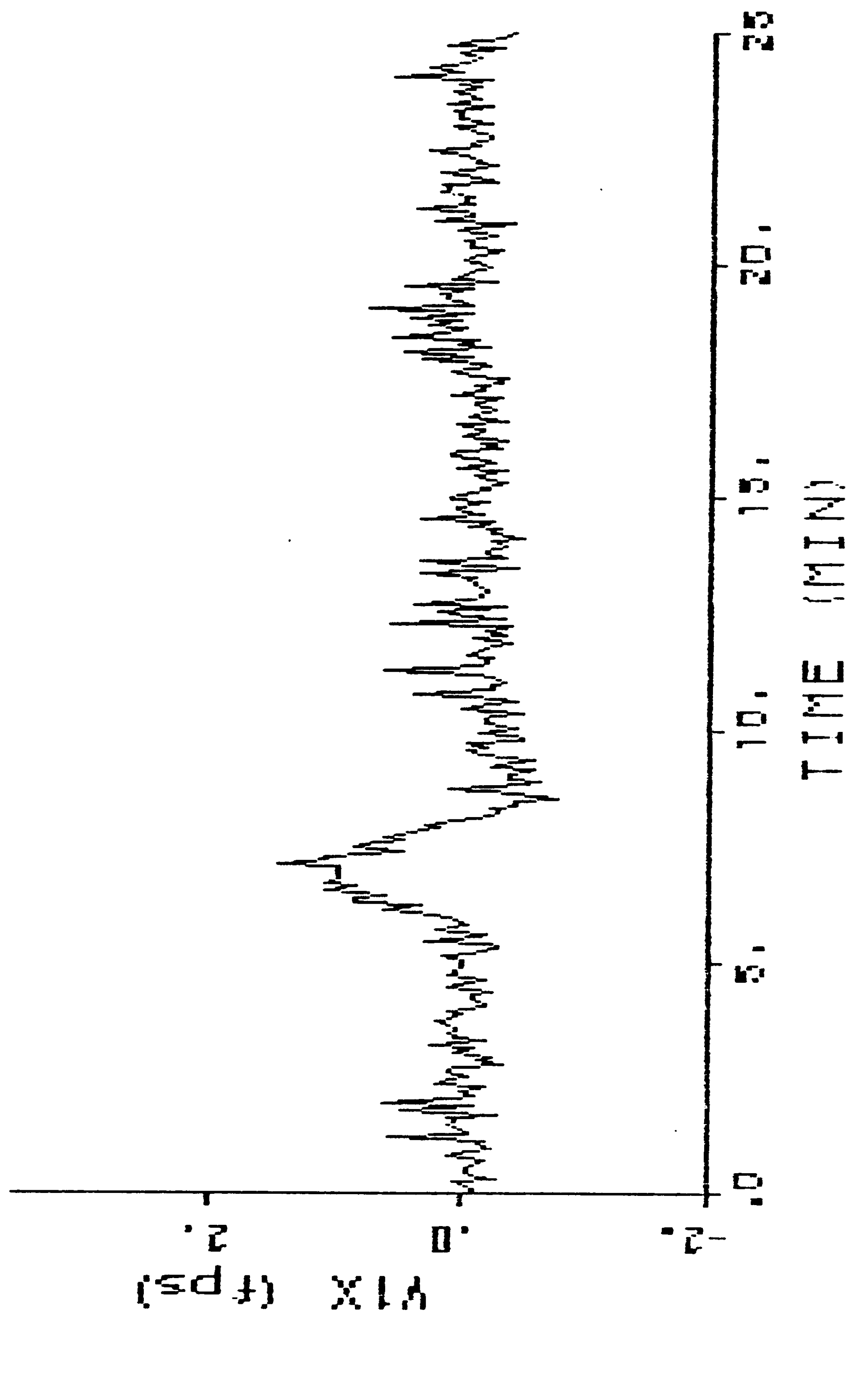


Figure 2. Example of TVA's Collected Raw Velocity Data of a Typical Tow Passage

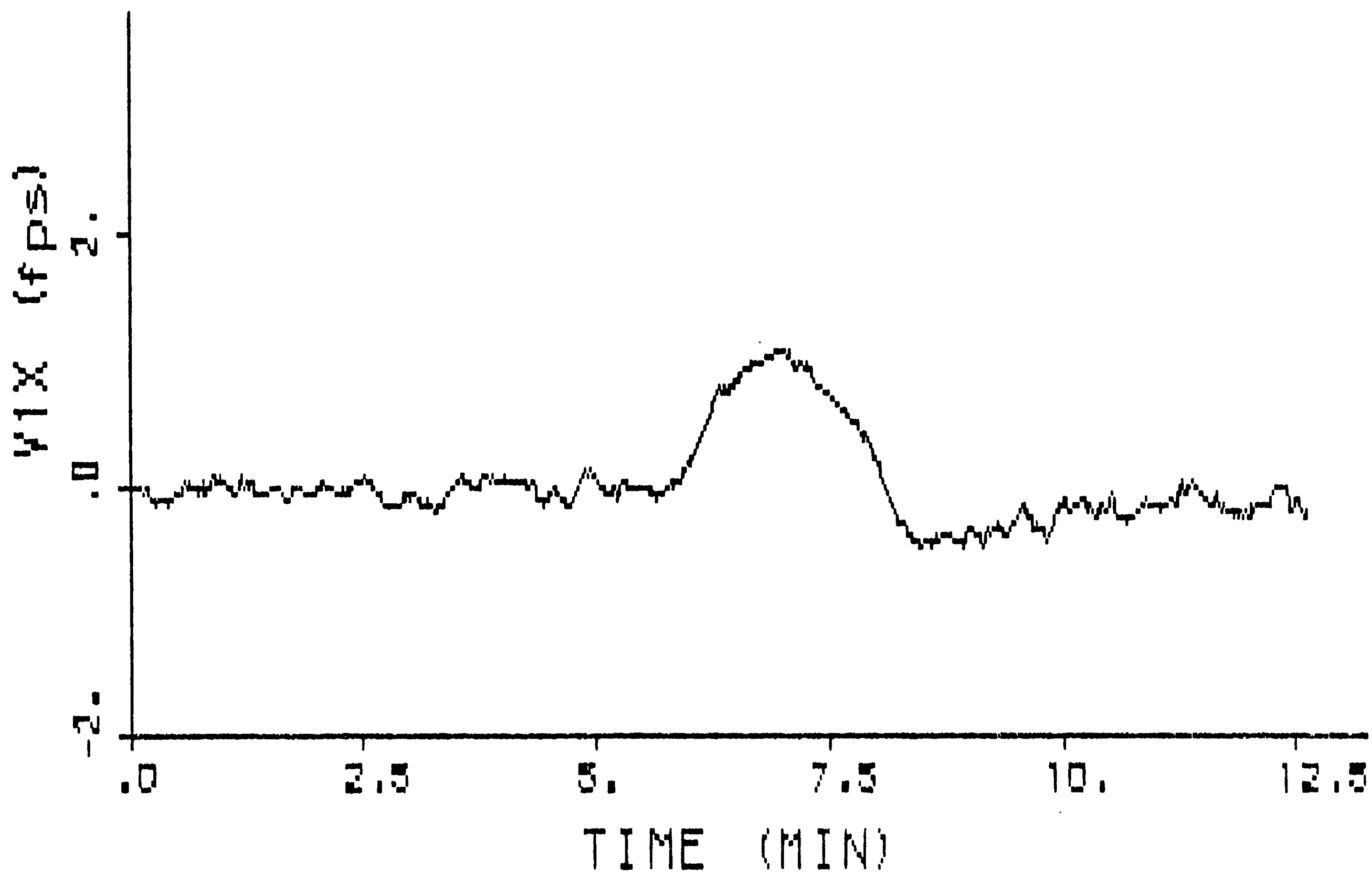


Figure 3. Example of 10 Second Moving Average Velocity of a Typical Tow Passage

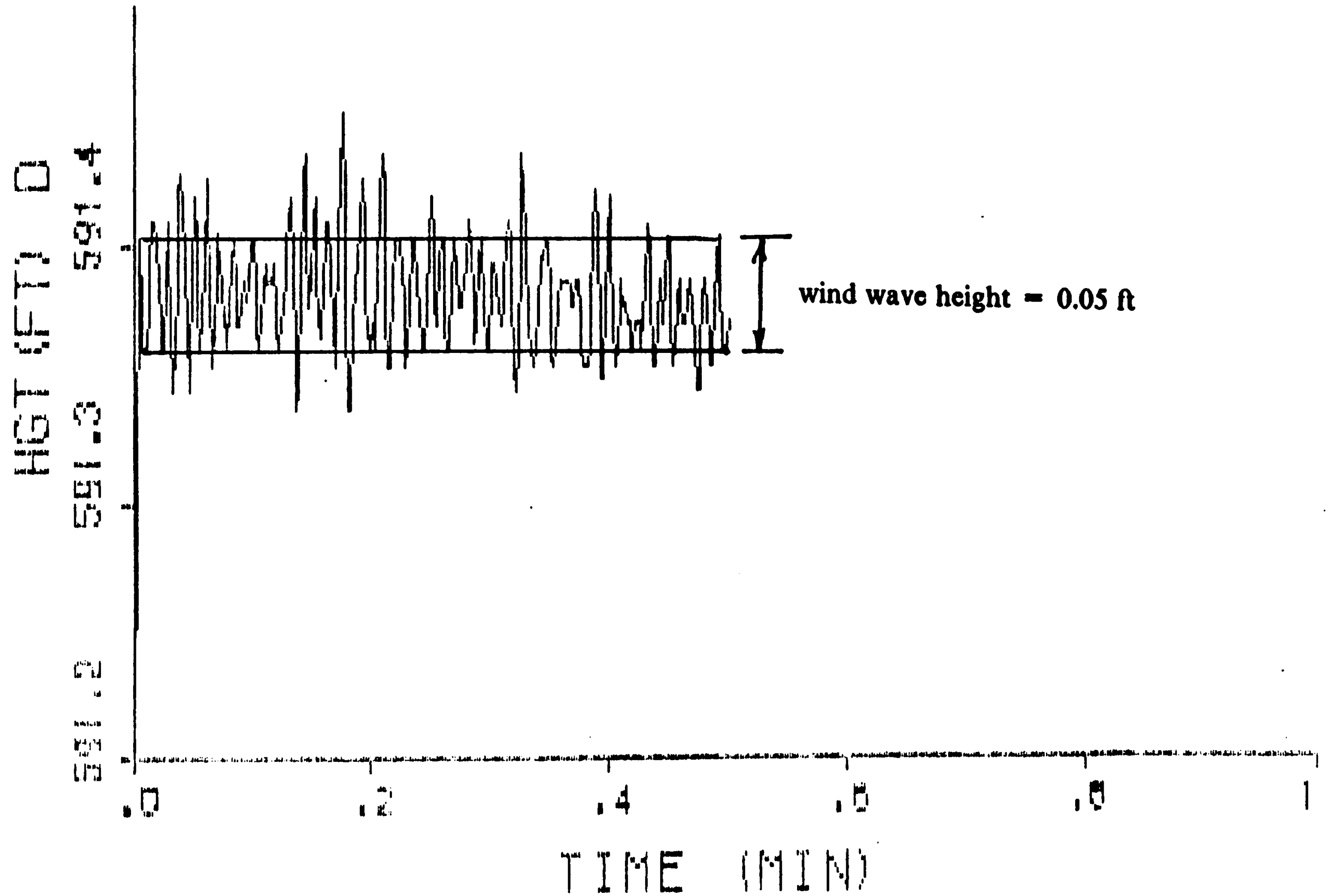


Figure 4. Example of Measured Wind Wave Height for a Typical Scenario

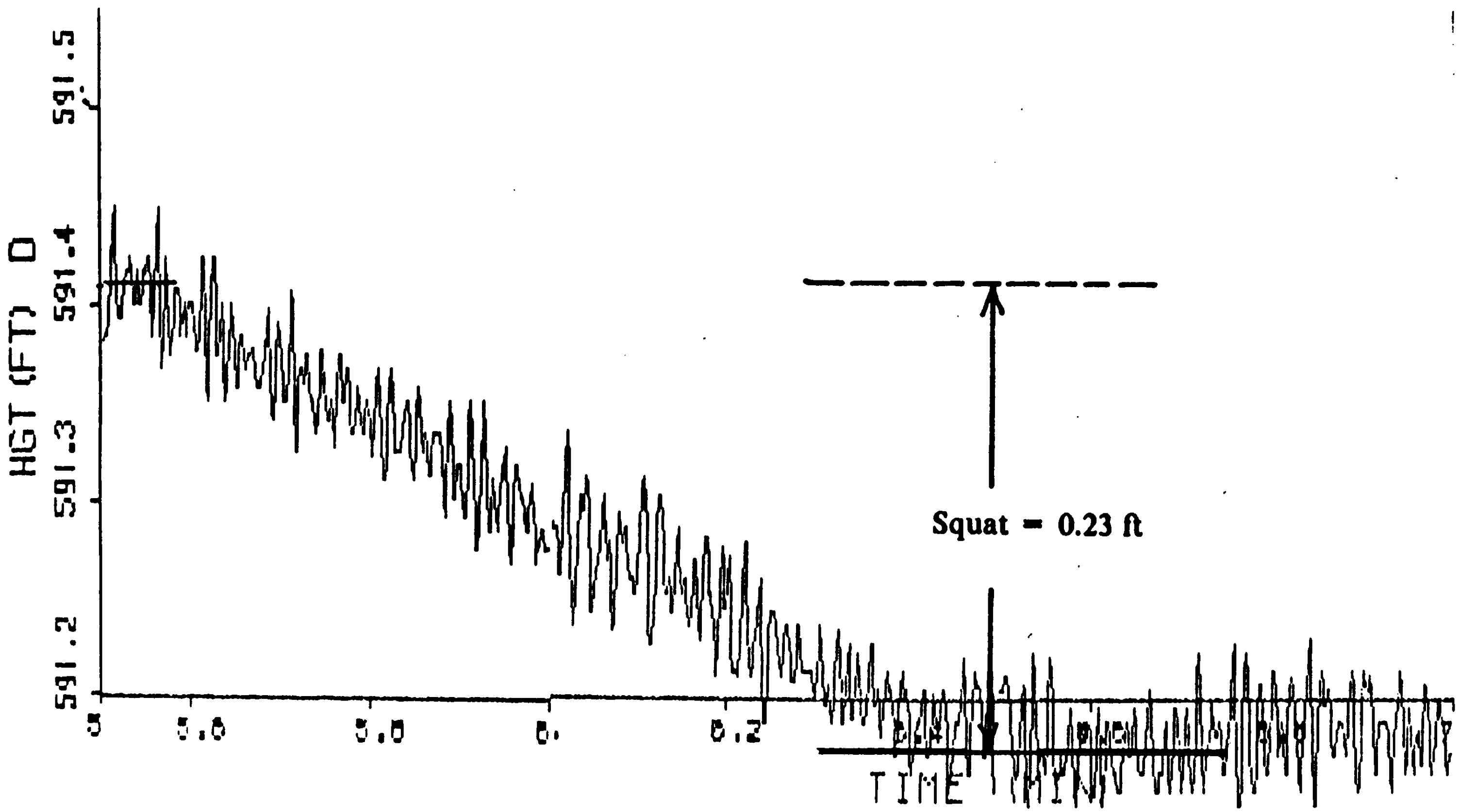


Figure 5. Example of Measured Squat for a Typical Tow Passage

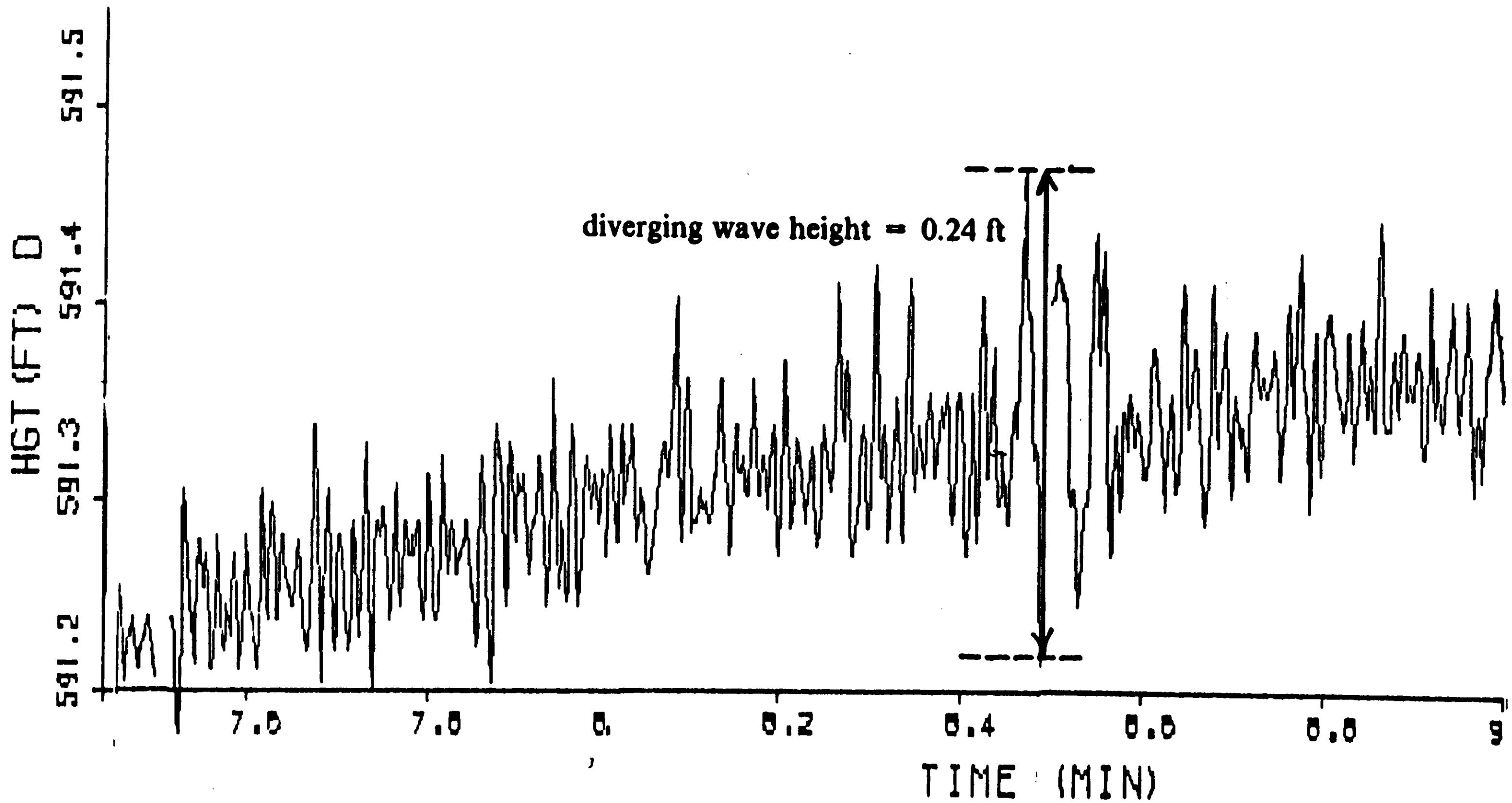


Figure 6. Example of Measured Diverging Wave Height for a Typical Tow Passage

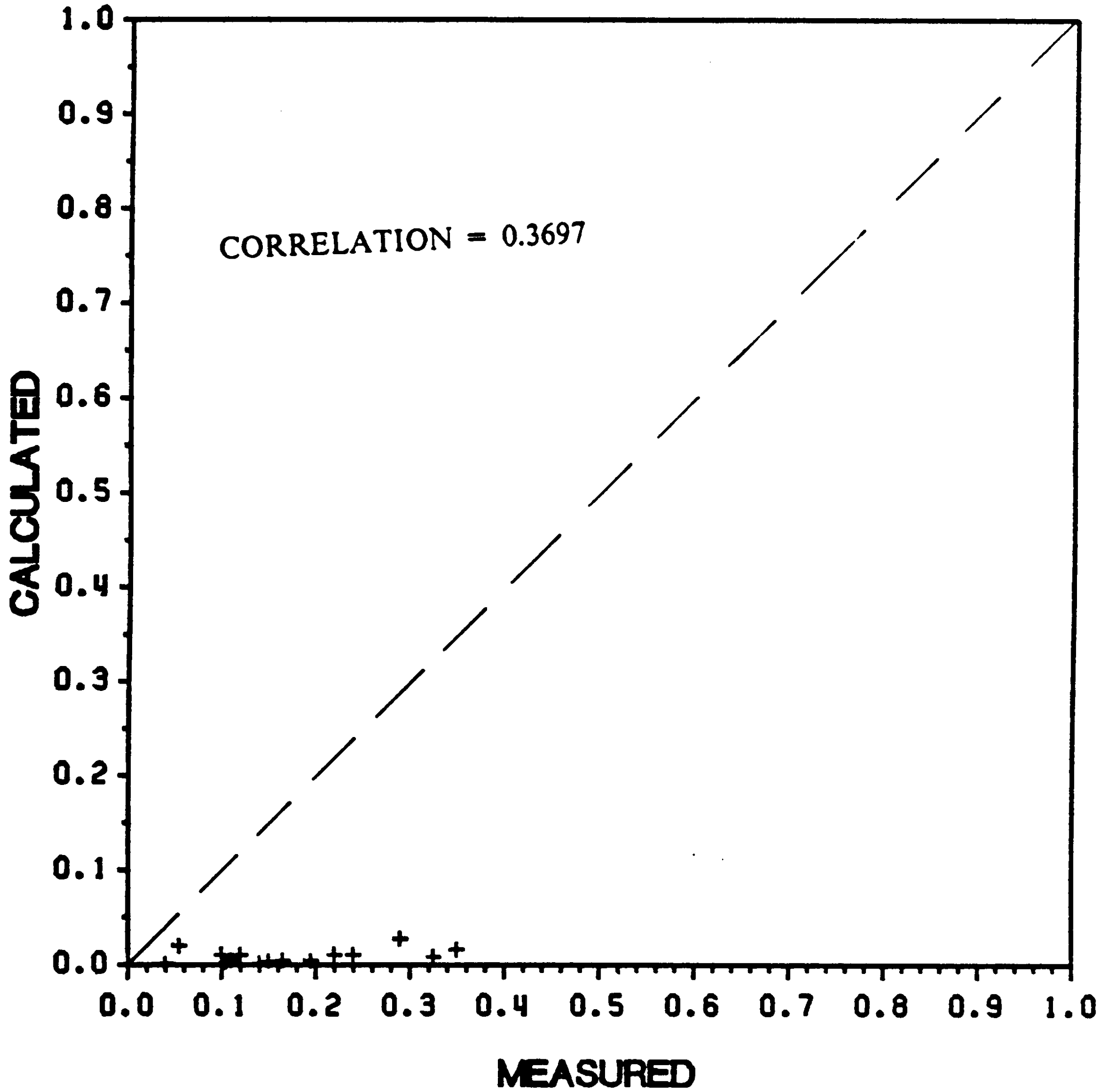


Figure 7. Comparison of Measured vs. Simulated Squat Using Schijf and Jansen Equation

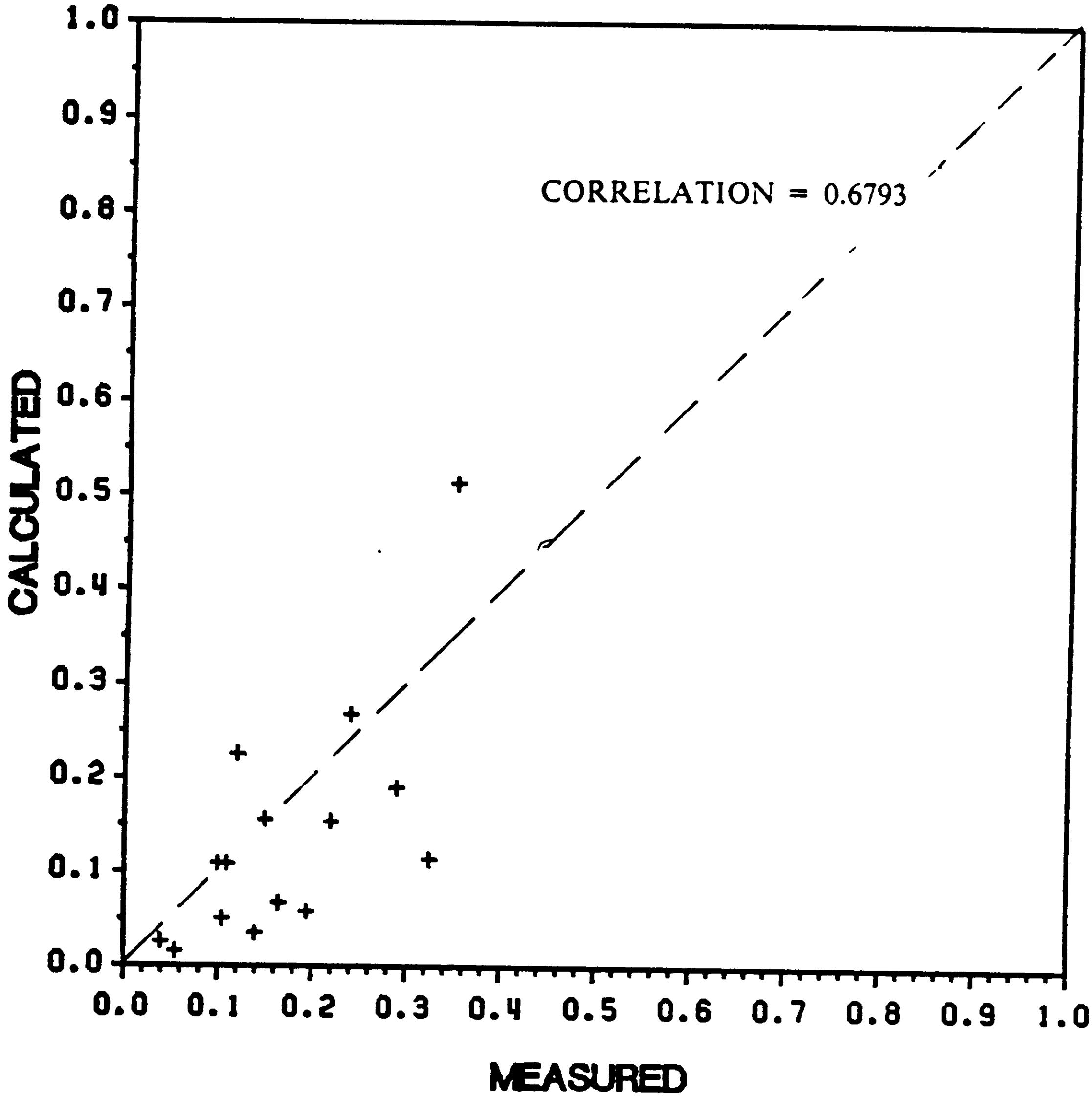


Figure 8. Comparison of Measured vs. Simulated Squat Using Gelencser Equation

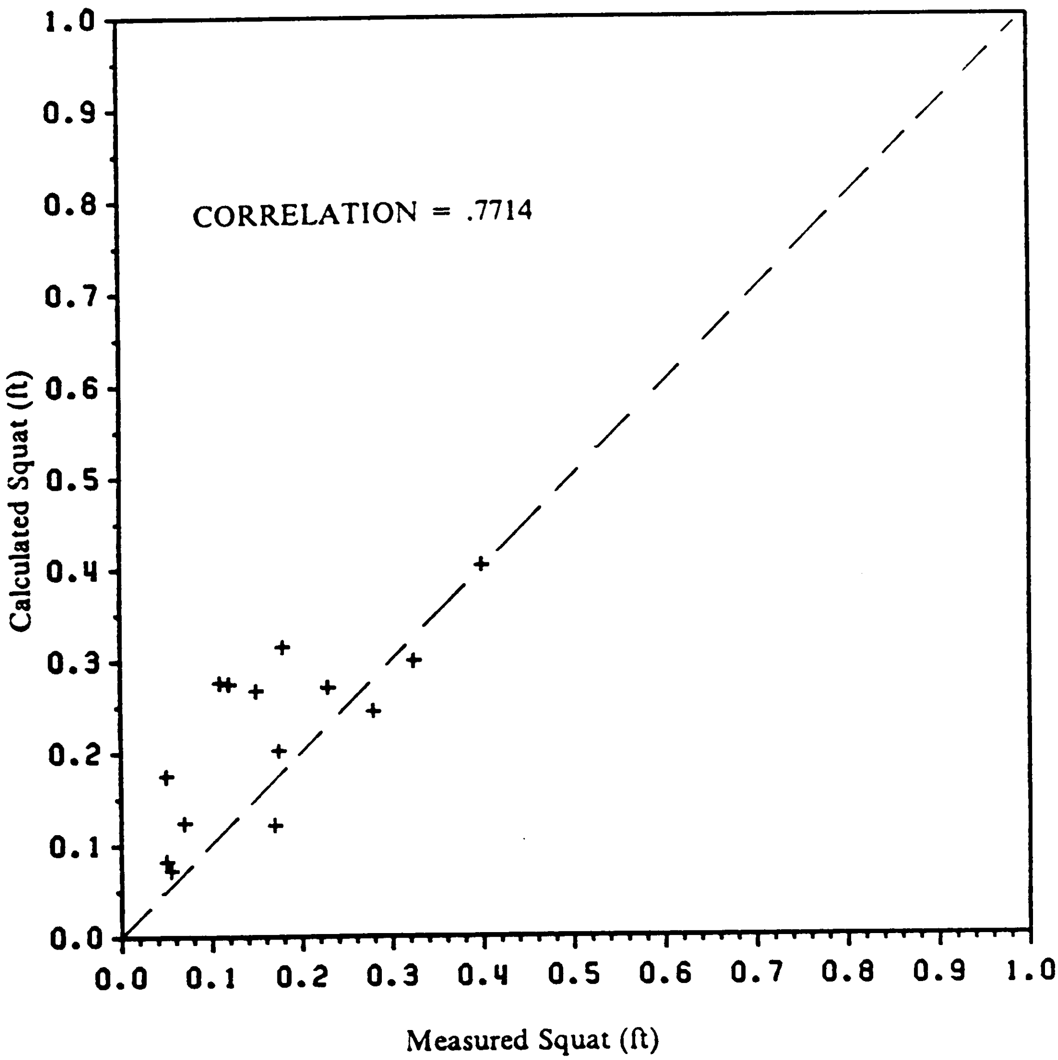


Figure 9. Comparison of Measured vs. Simulated Squat Using Gates and Herbich Equation

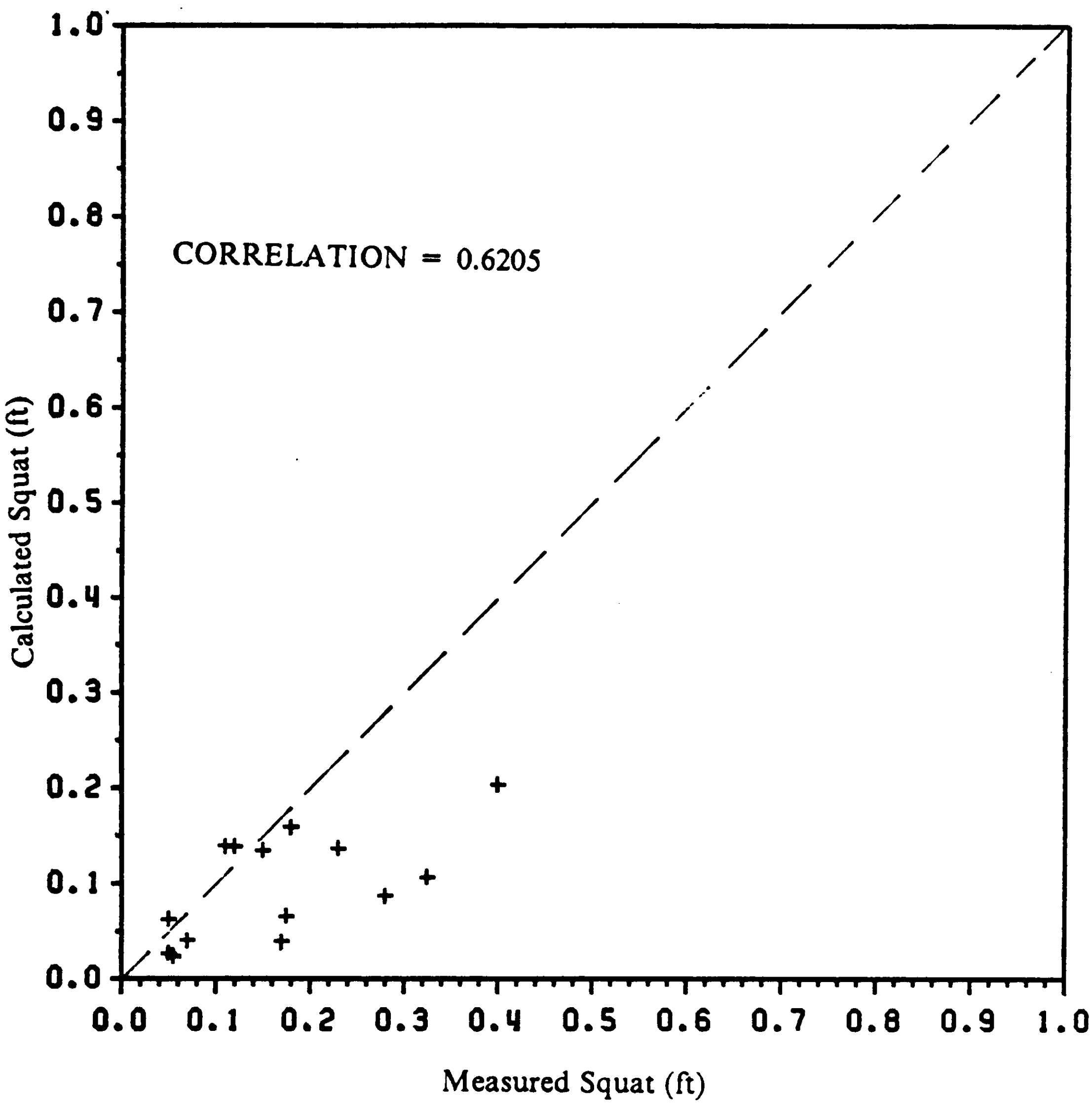


Figure 10. Comparison of Measured vs. Simulated Squat Using Dand and White Equation

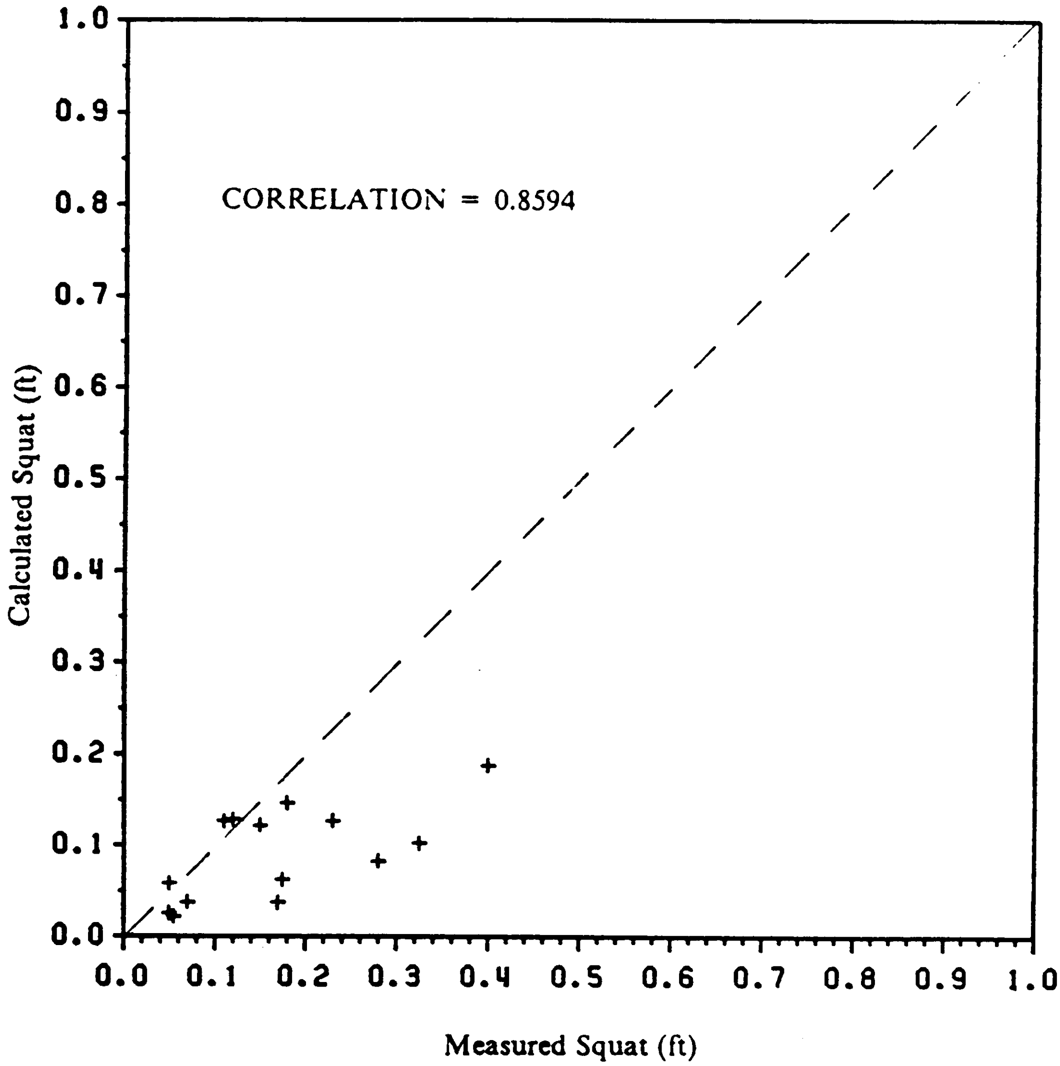


Figure 11. Comparison of Measured vs. Simulated Squat Using Bhowmik Equation

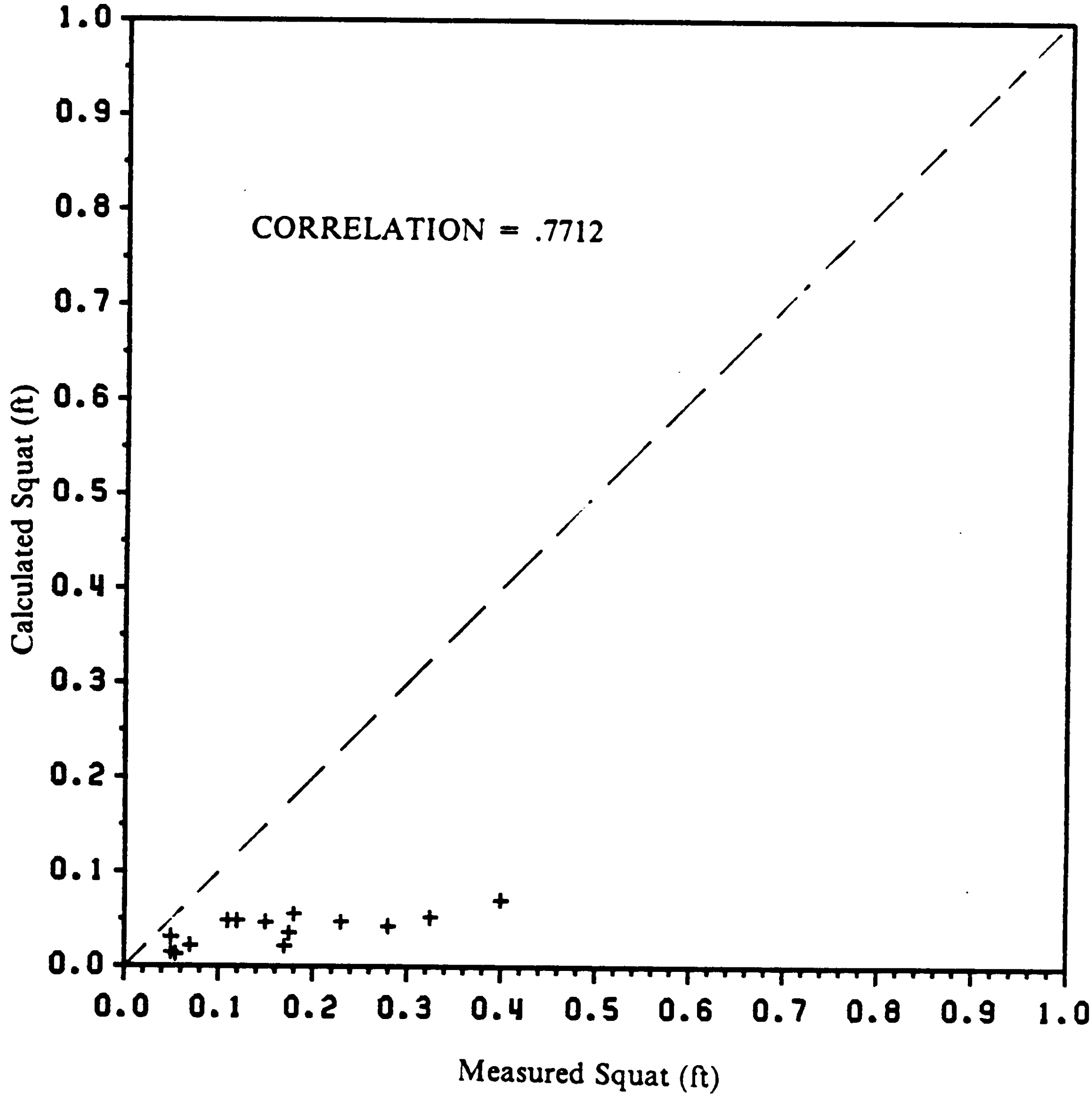


Figure 12. Comparison of Measured vs. Simulated Squat Using Balamin and Bykov Equation

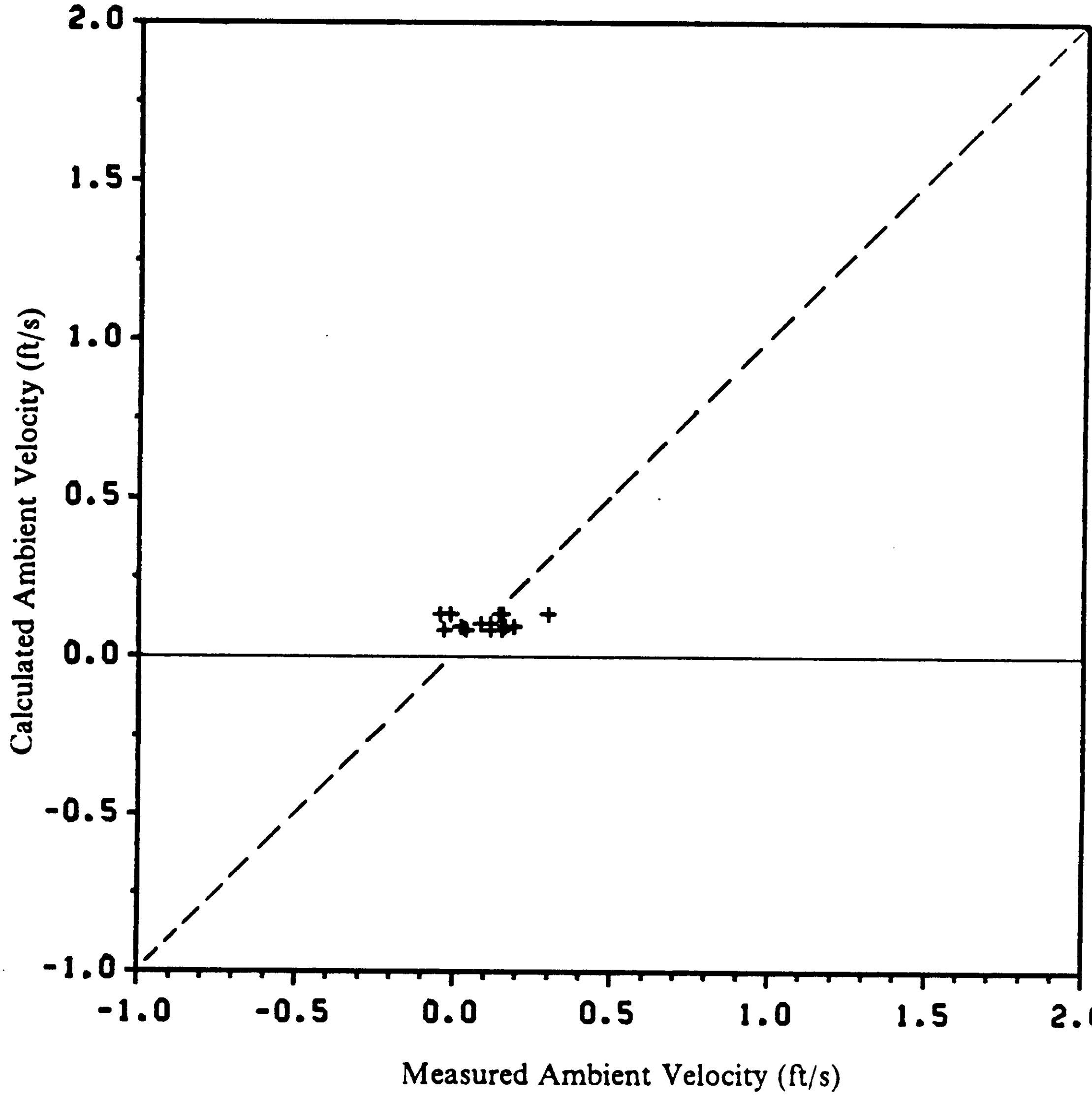


Figure 13. Comparison of Measured vs. Simulated Ambient Velocity at Shore

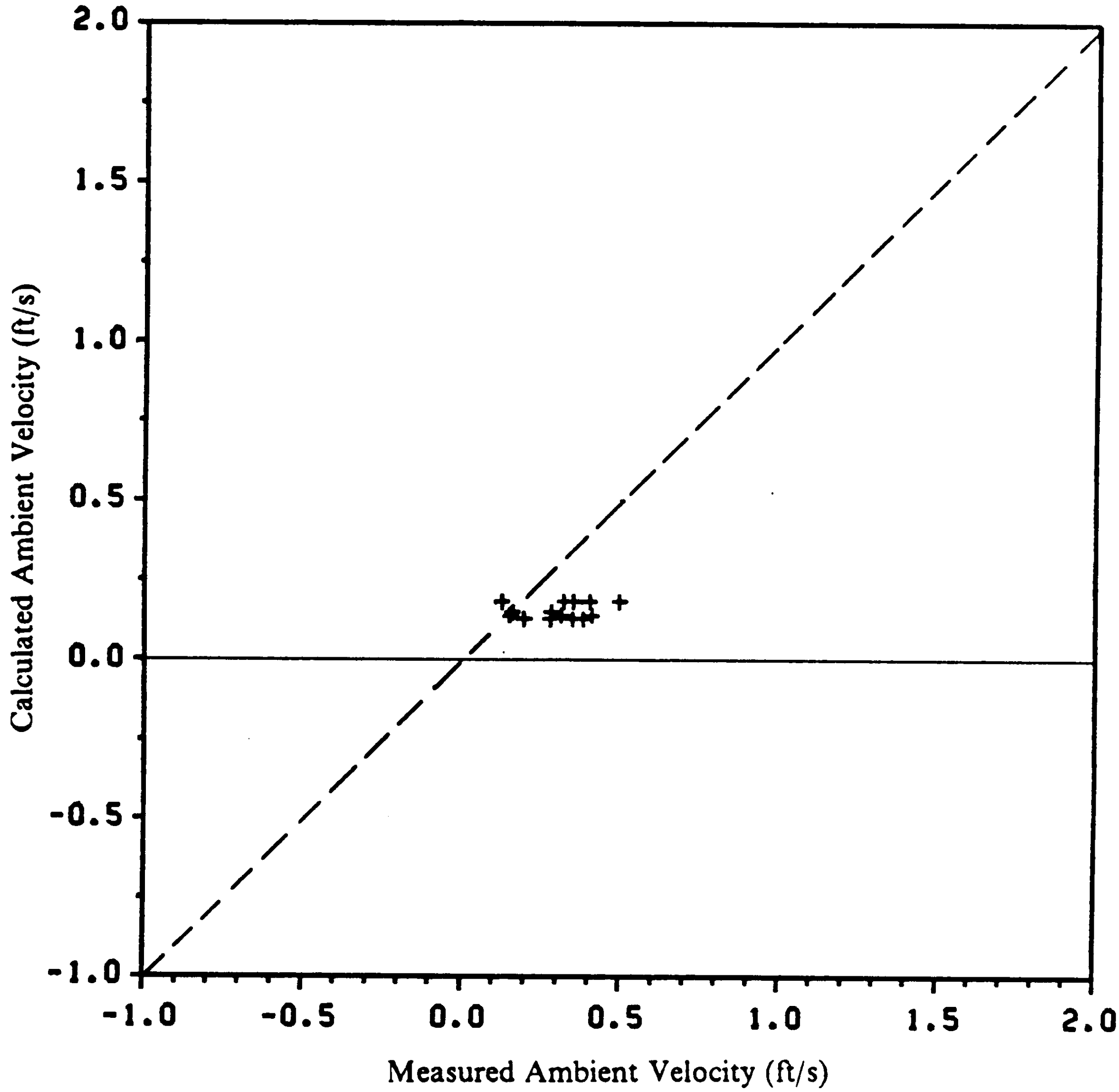


Figure 14. Comparison of Simulated vs. Measured Ambient Velocity at Lateral Quarter Point, 9 ft from channel bed

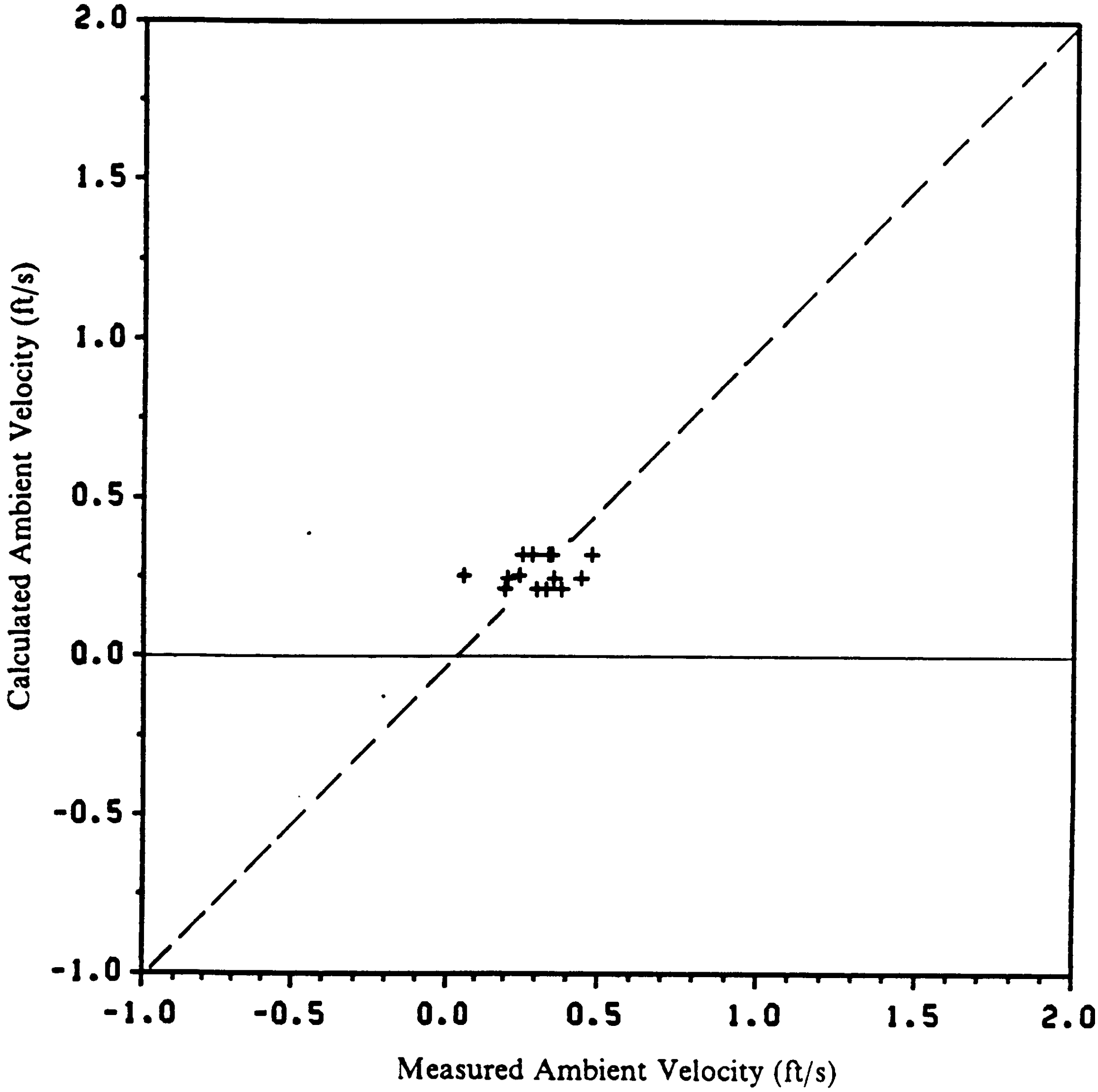


Figure 15. Comparison of Simulated vs. Measured Ambient Velocity at Mid-channel, 8 ft from Channel Bed

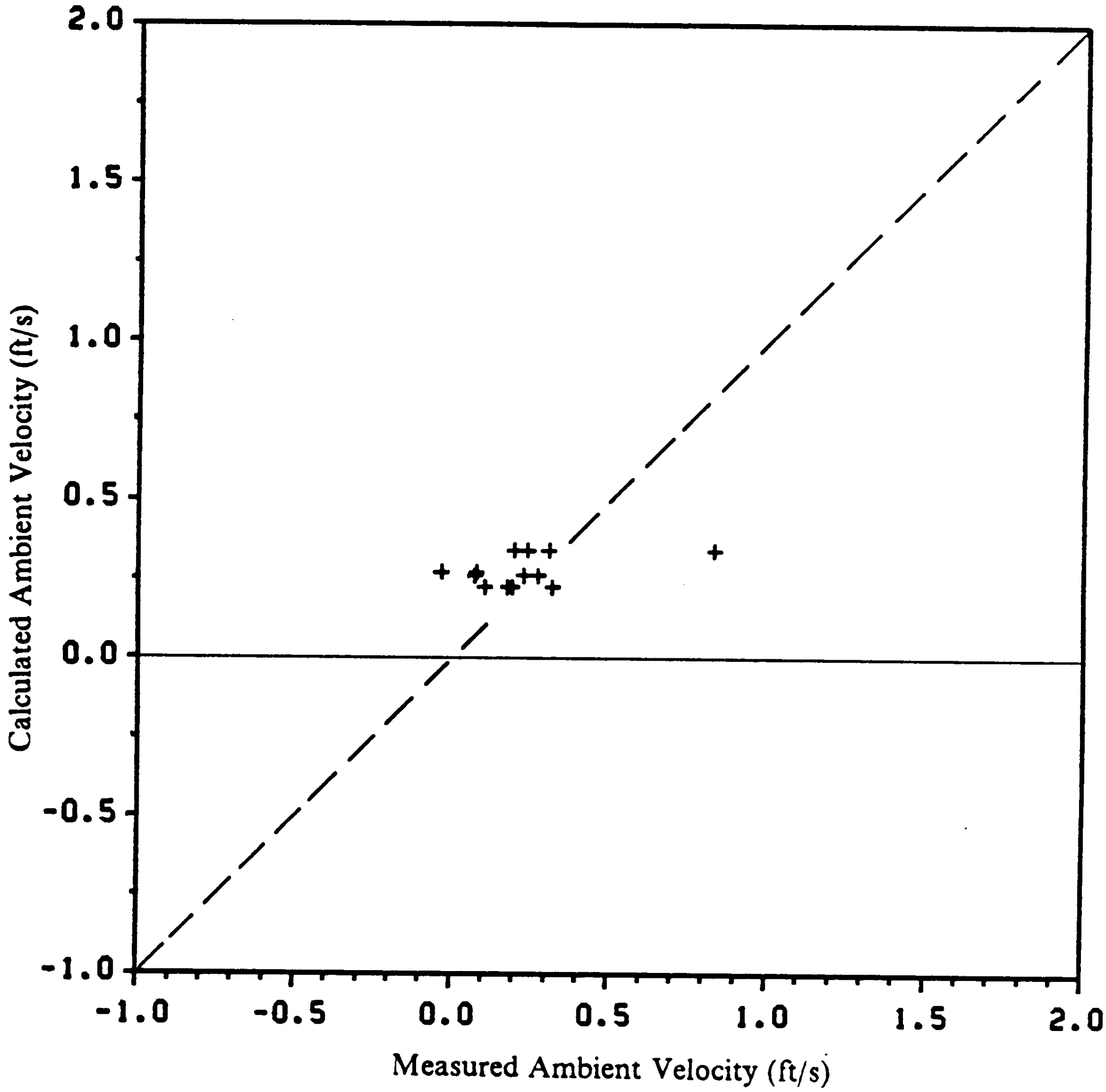


Figure 16. Comparison of Simulated vs. Measured Ambient Velocity at Mid-channel, 1.5 ft from Channel Bed

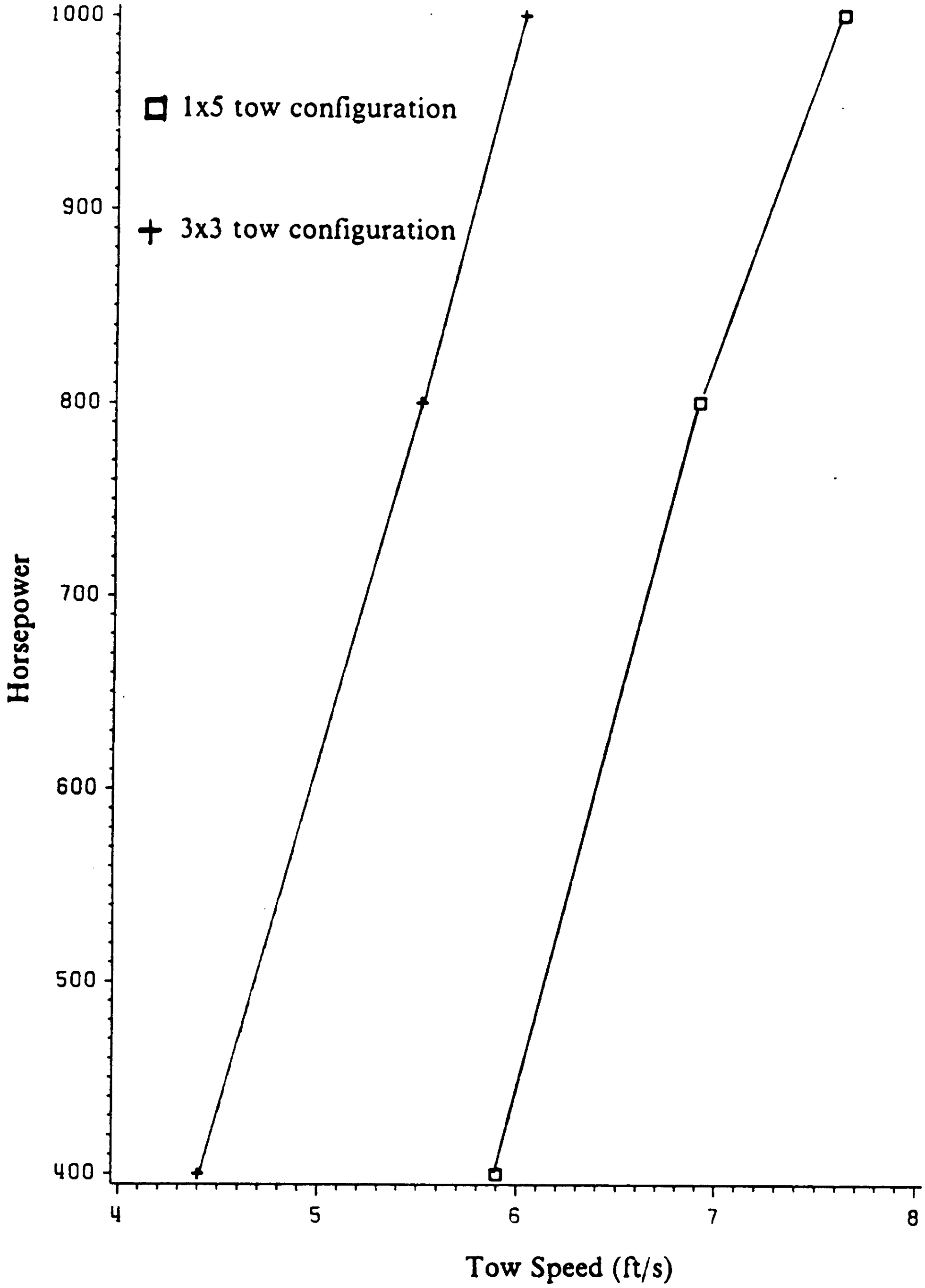


Figure 17. Running Horsepower vs. Tow Speed - 1000 Hp Towboat for 1x5 and 3x3 Tow Configurations

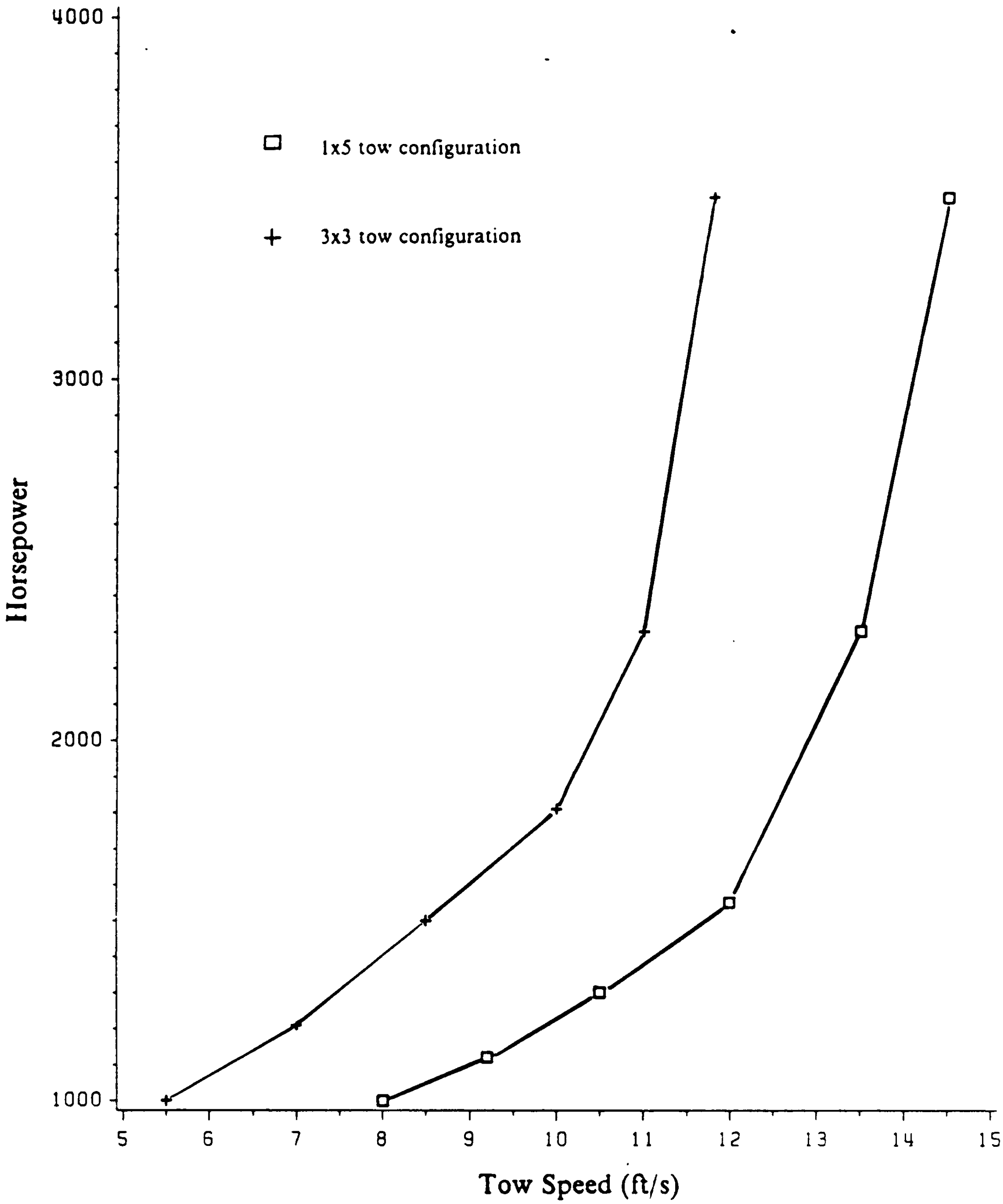


Figure 18. Running Horsepower vs. Tow Speed - 3400 Hp Towboat for 1x5 and 3x3 Tow Configurations

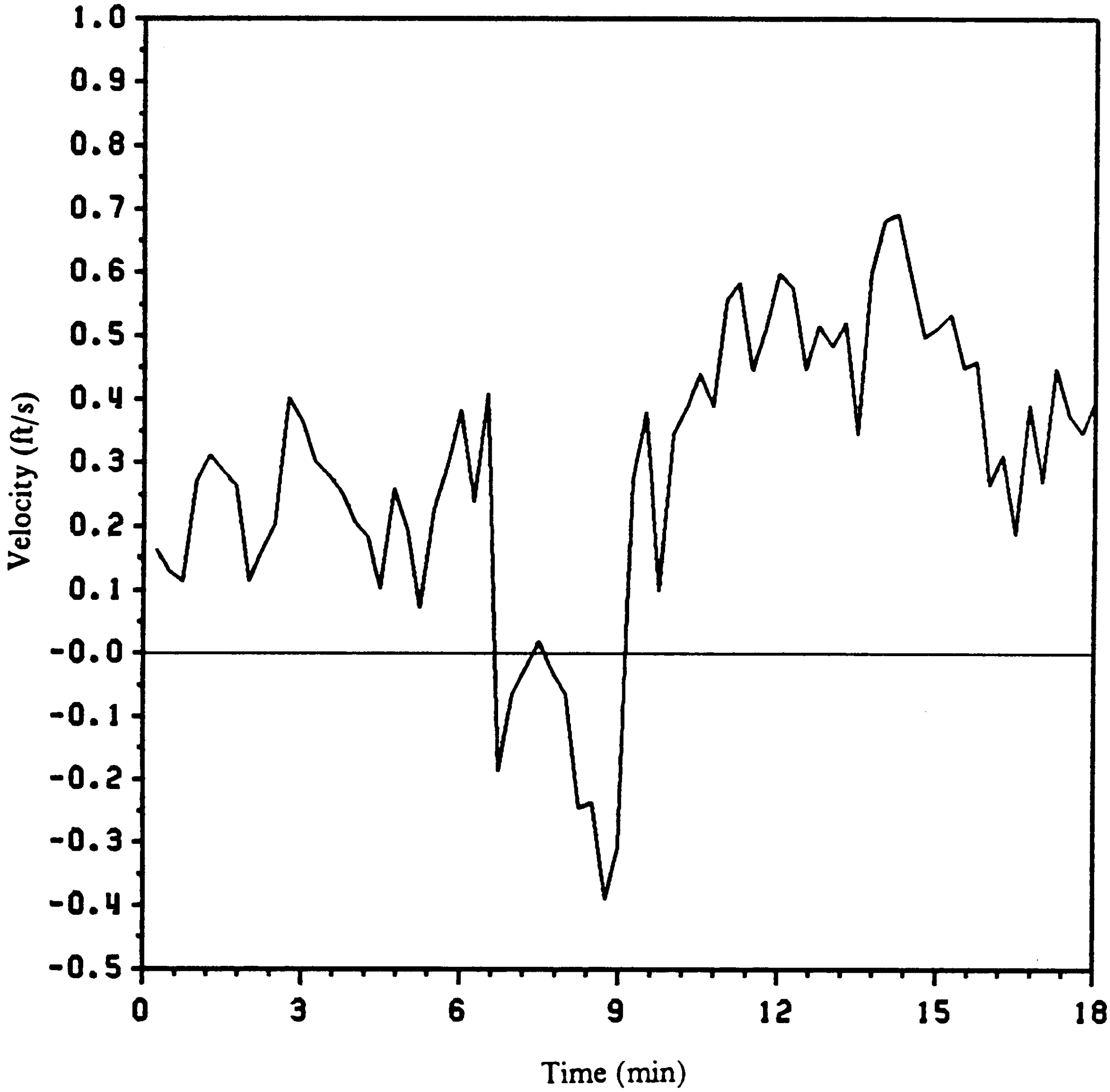


Figure 19. Velocity Variation at Sailing Line, 1.5 ft above Channel Bed for a Downbound Tow Passage

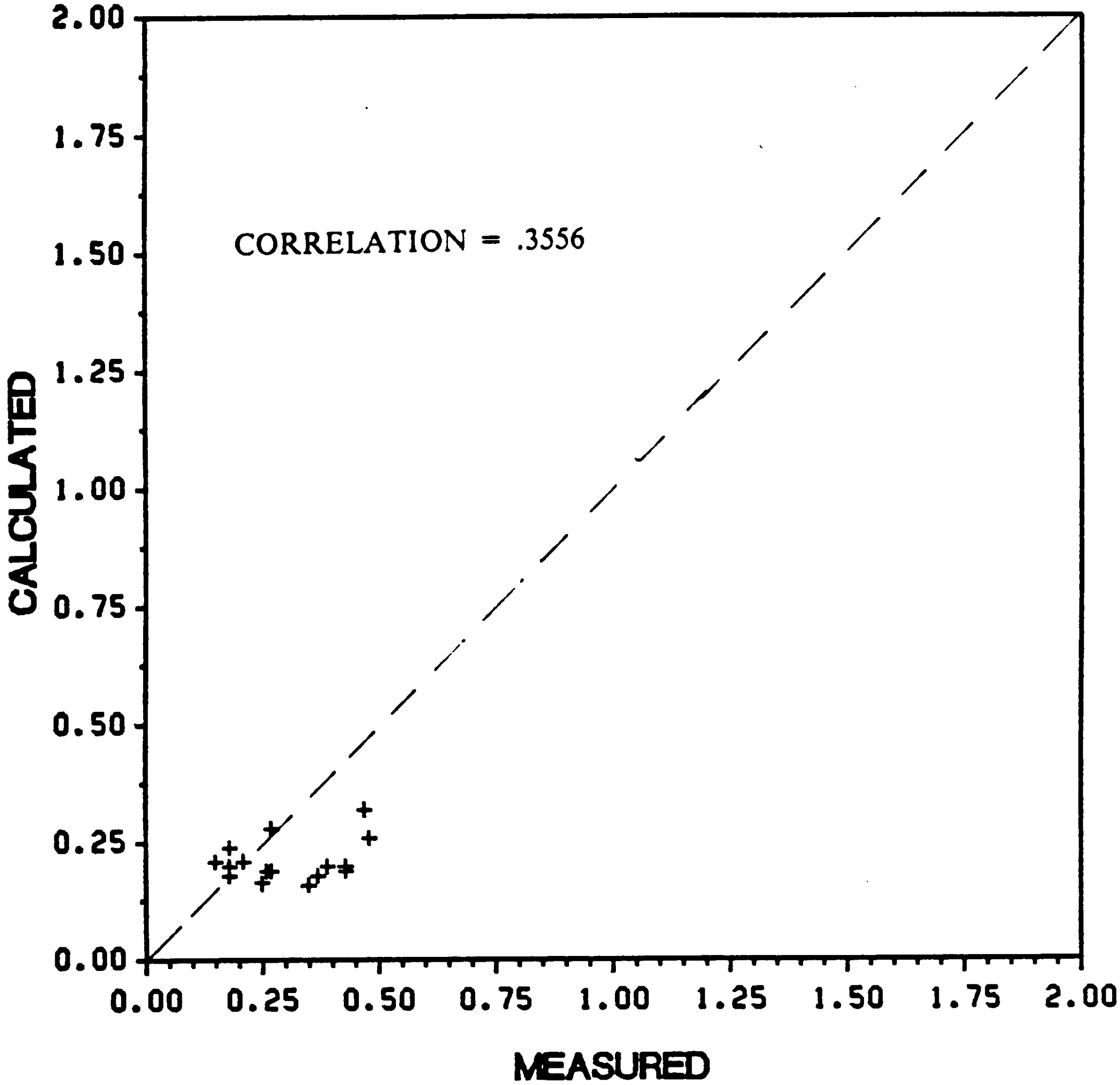


Figure 20. Comparison of Measured vs. Simulated Diverging Wave Height Using Bhowmik Equation

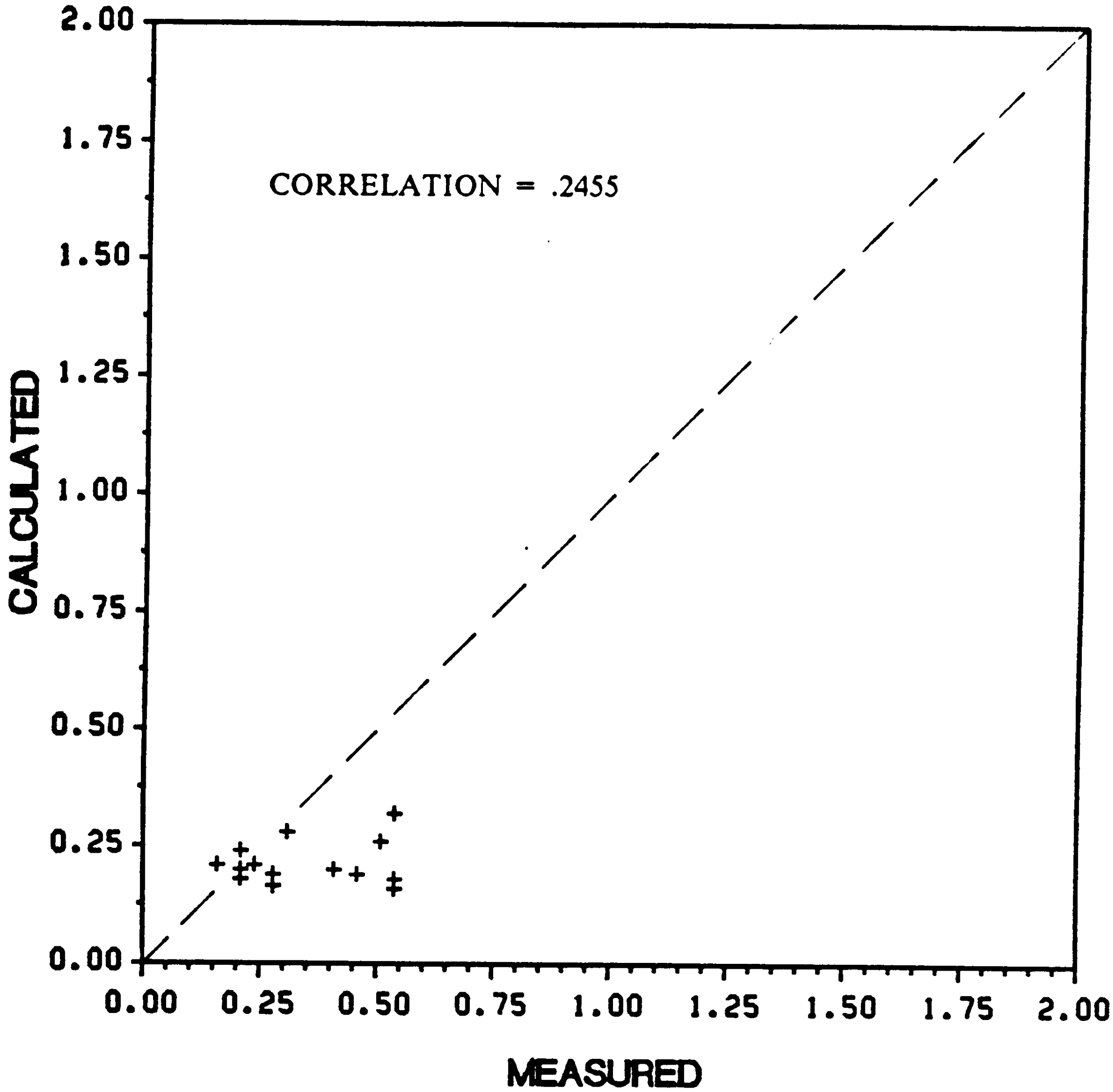


Figure 21. Comparison of Measured vs. Simulated Diverging Wave Height Using Hochstein Equation

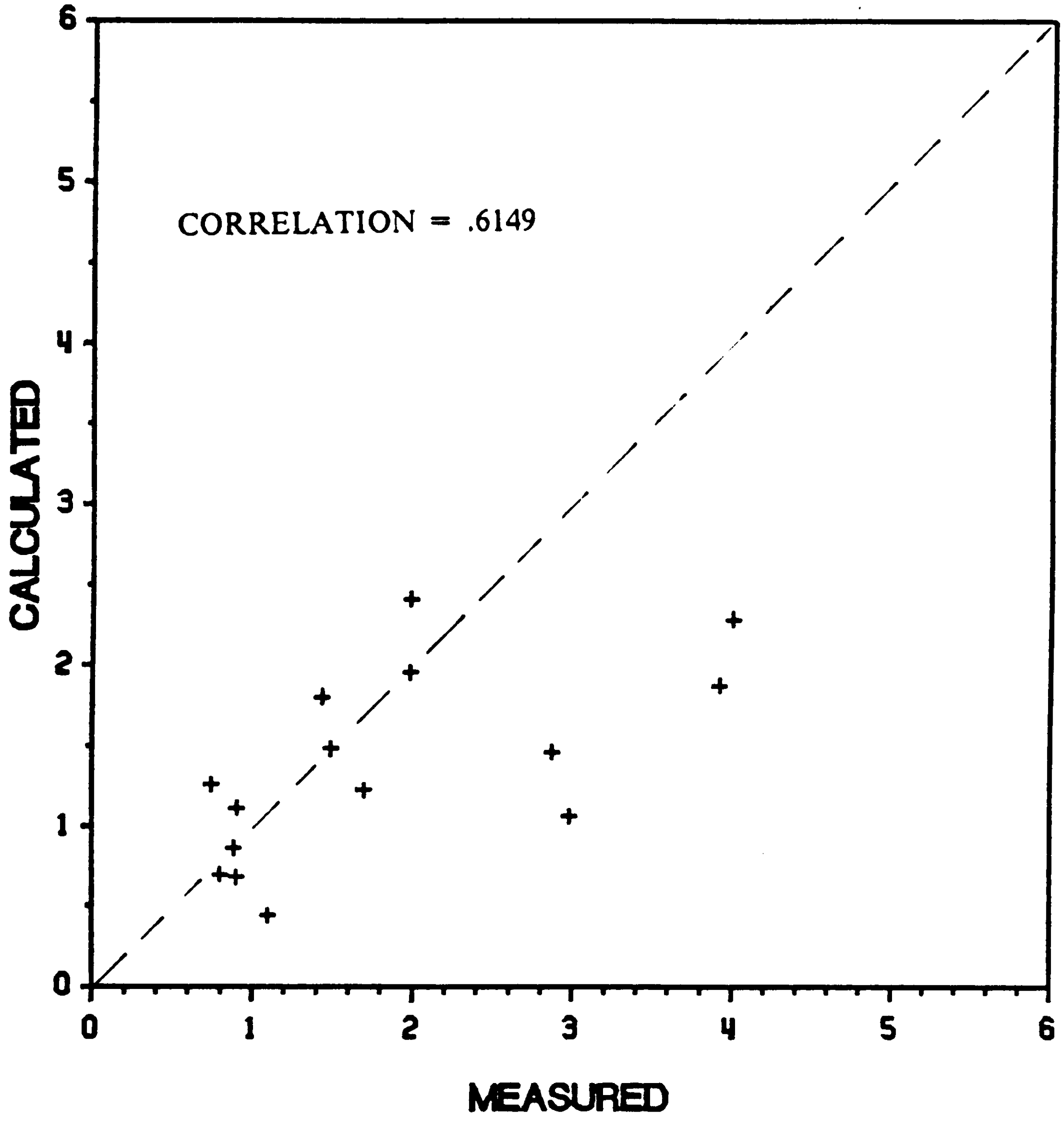


Figure 22. Comparison of Measured vs. Simulated Propeller Velocity at Mid-channel, 8 ft from Channel Bottom Using Van de Kaa Equation

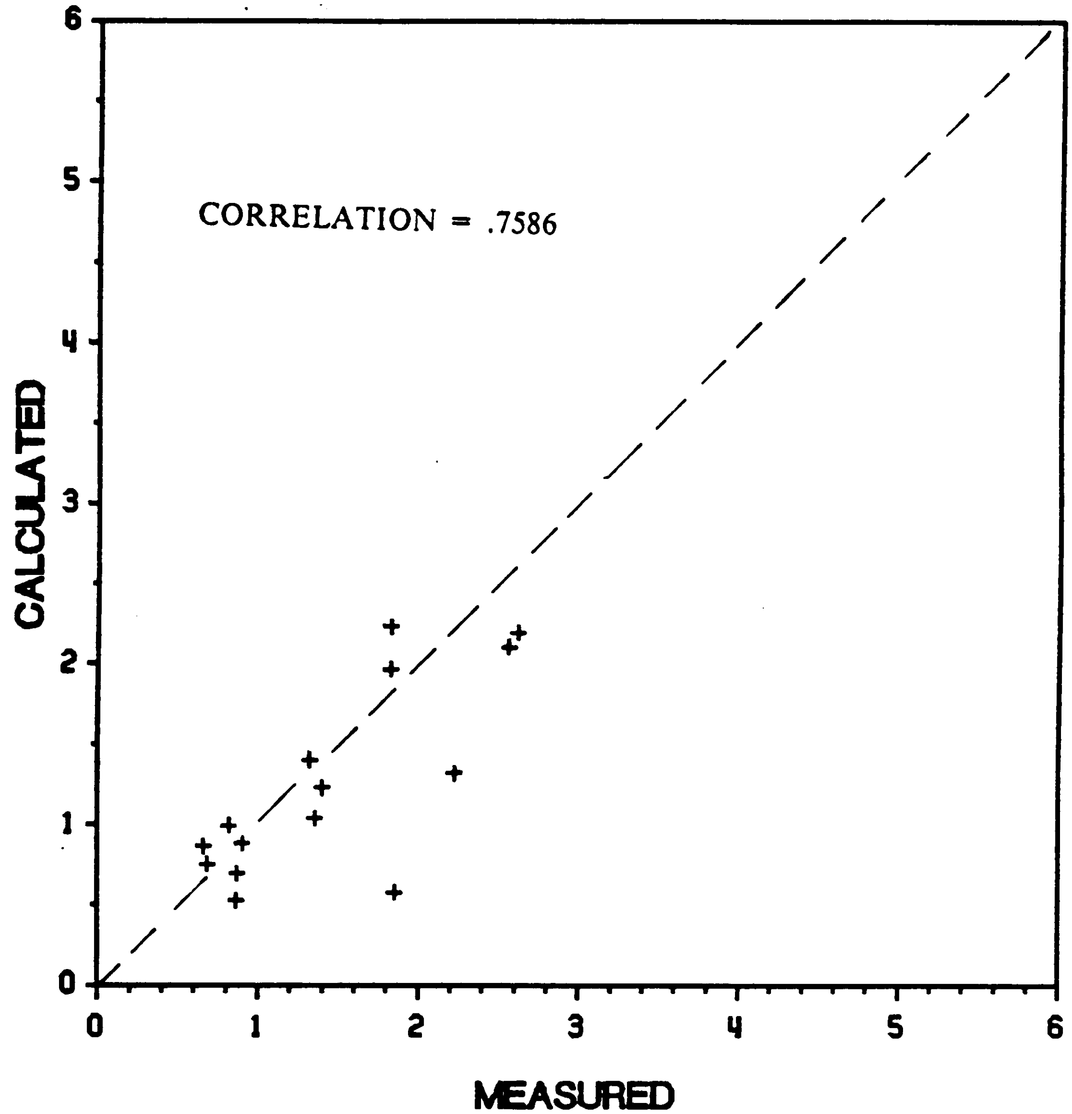


Figure 23. Comparison of Measured vs. Simulated Propeller Velocity at Mid-channel, 1.5 ft from Channel Bottom Using Van de Kaa Equation

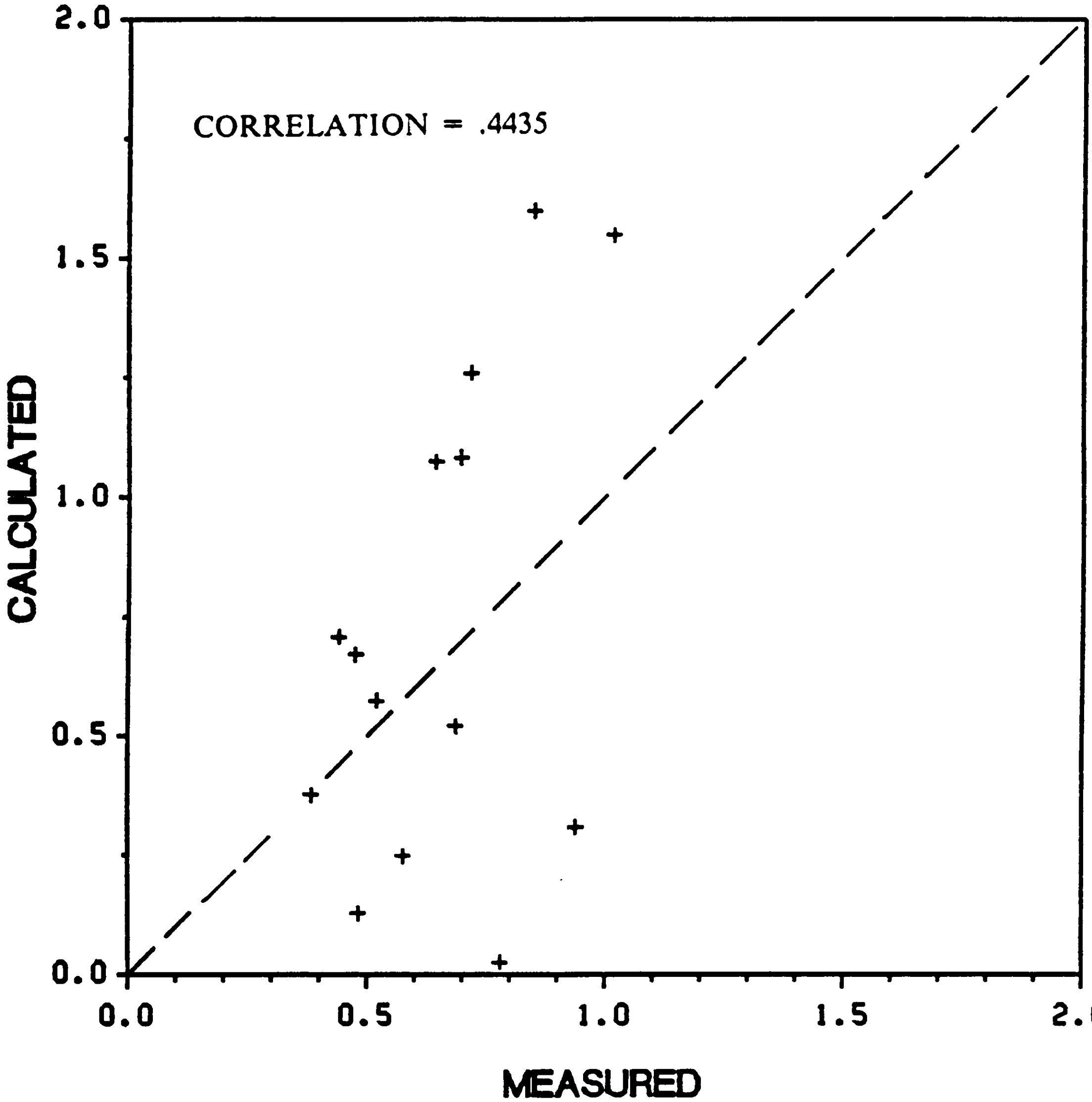


Figure 24. Comparison of Measured vs. Simulated Propeller Velocity at Shore Using Adjusted Maxwell and Pazwash Equation

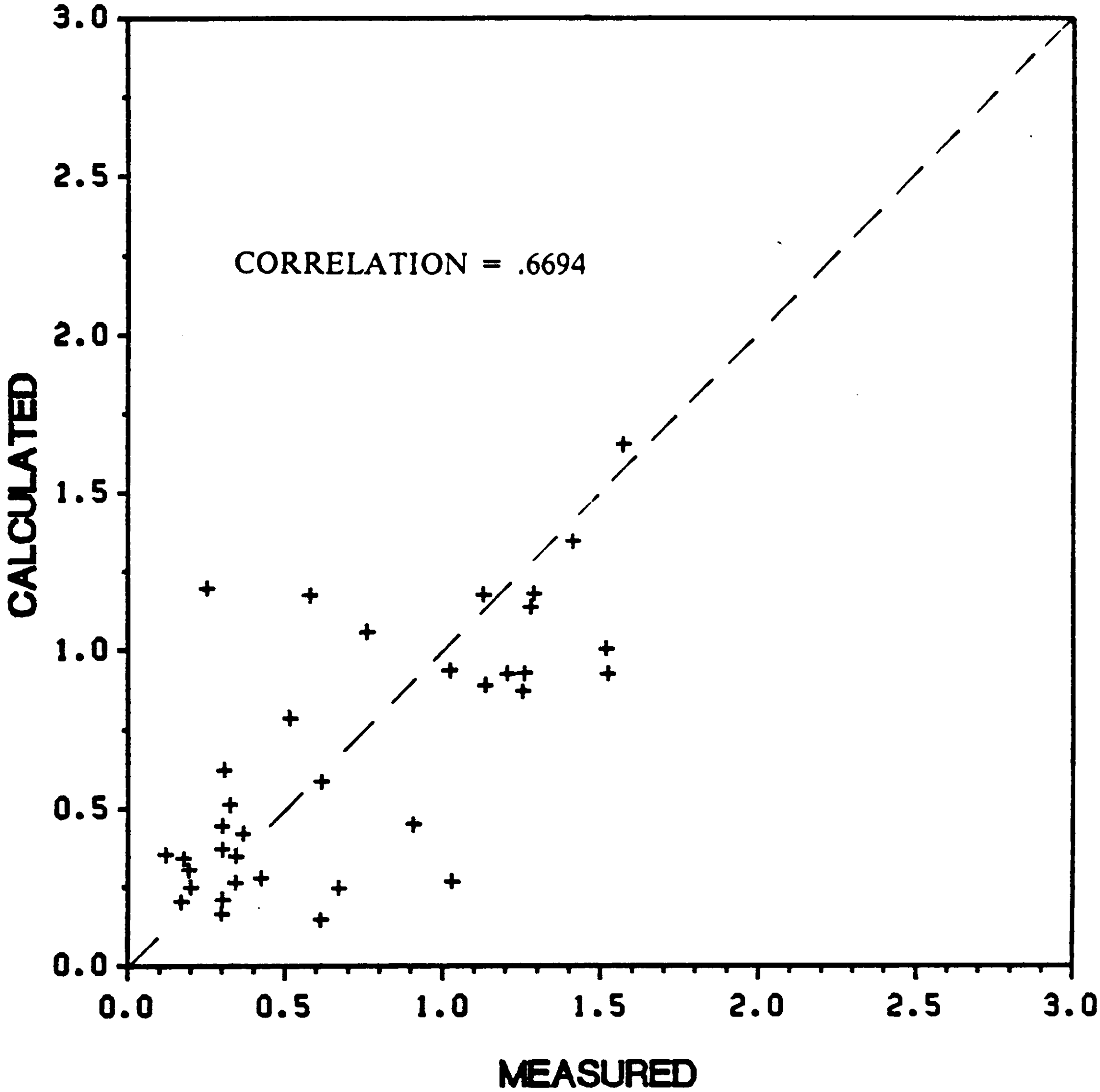


Figure 25. Comparison of Measured vs. Simulated Backwater Velocity at Mid-channel Using Hochstein Equation

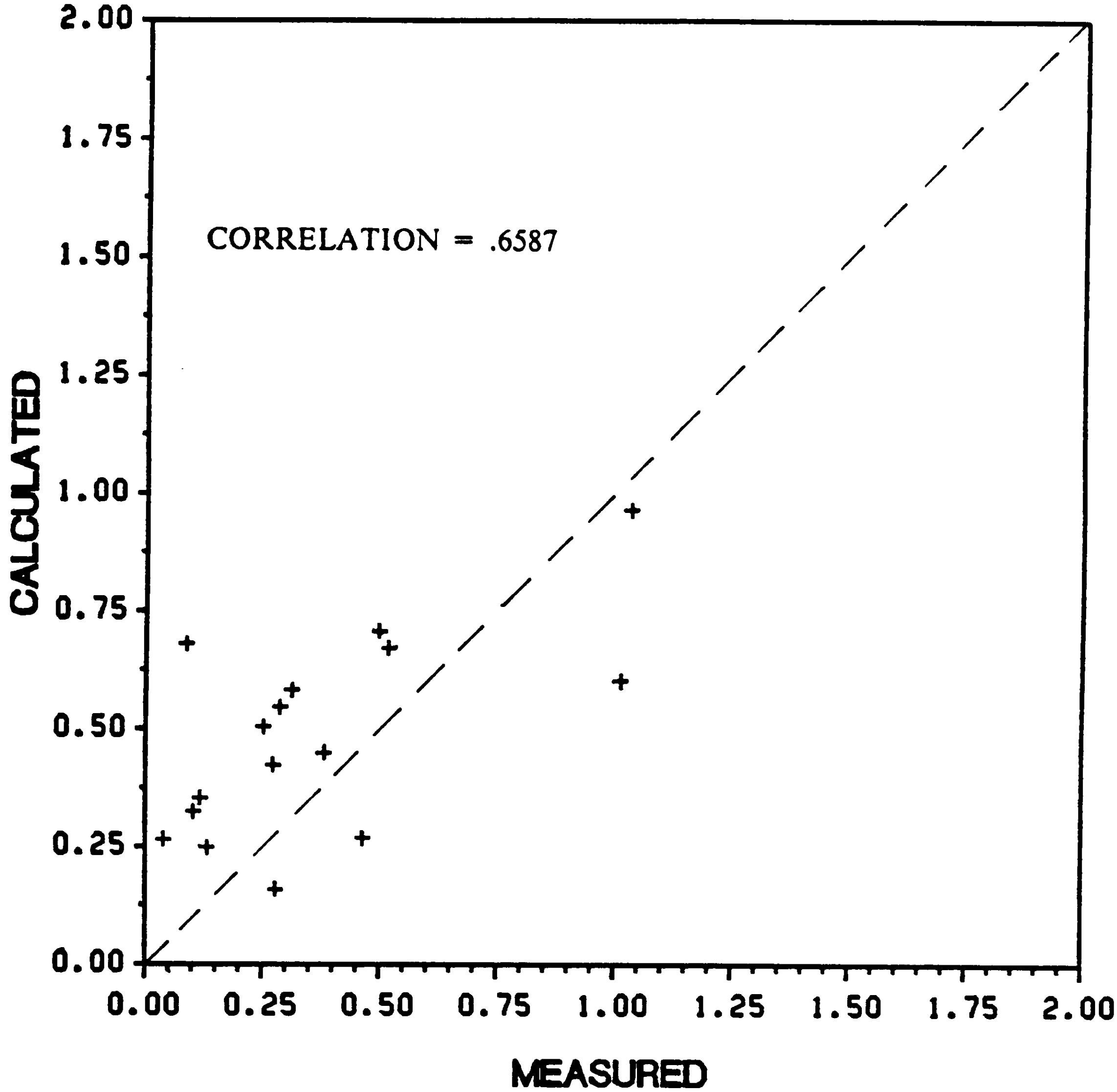


Figure 26. Comparison of Measured vs. Calculated Backwater Velocity at Shore Using Hochstein Equation

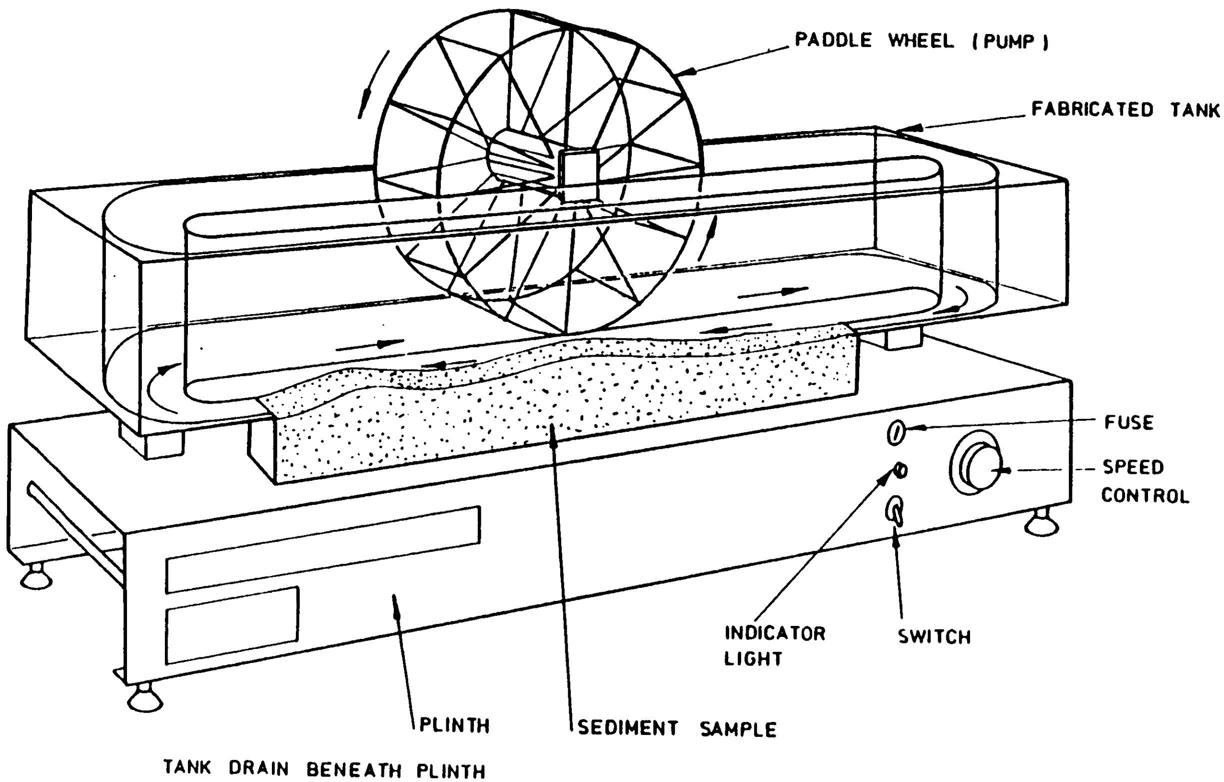


Figure 27. Sketch of an Armfield S8 Sediment Transport Channel

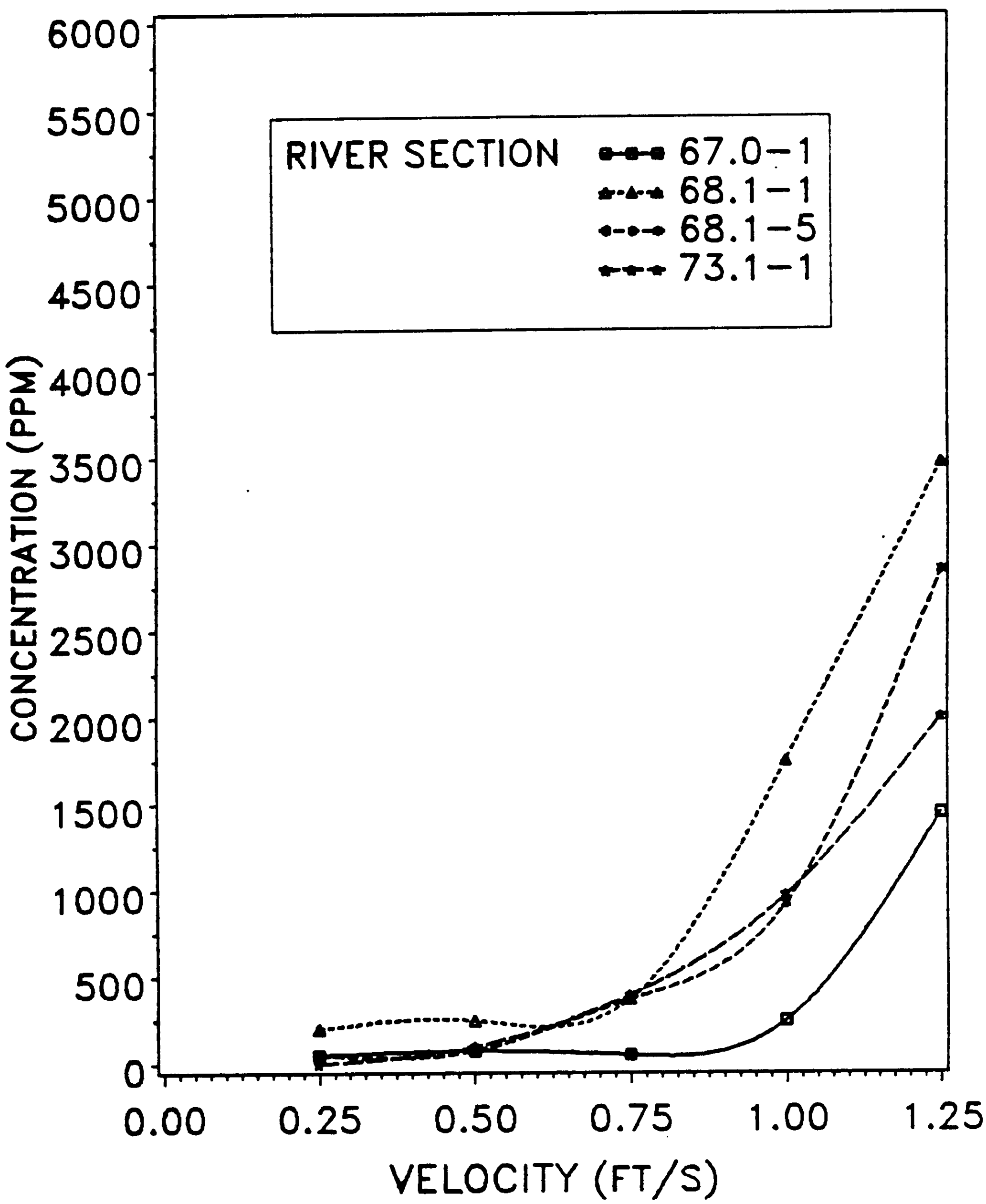


Figure 28. **Concentration of Natural Sediments vs. Velocity for River Miles 67.0, 68.1, and 73.1**

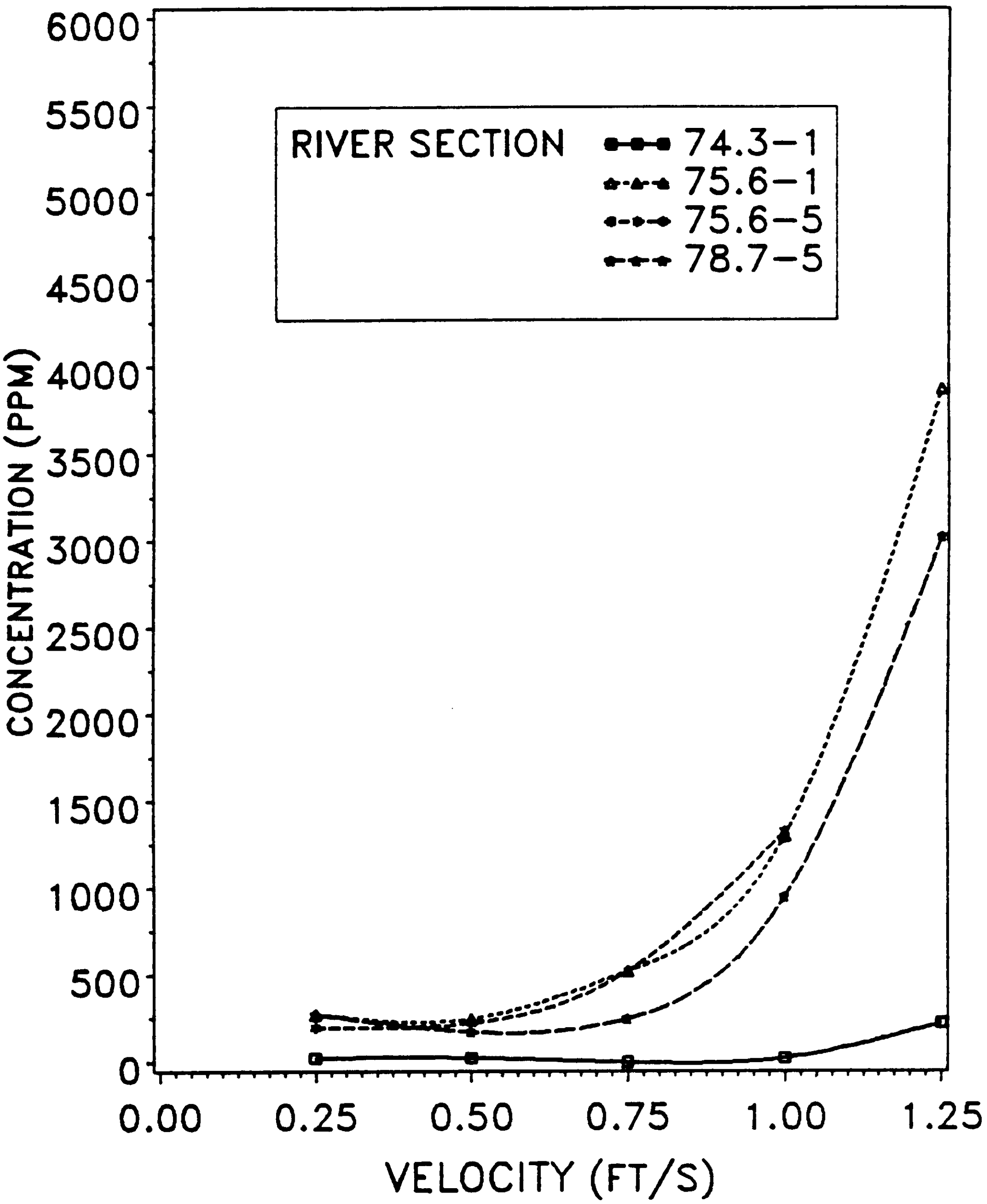


Figure 29. Concentration of Natural Sediments vs. Velocity for River Miles 74.3, 75.6, and 78.7

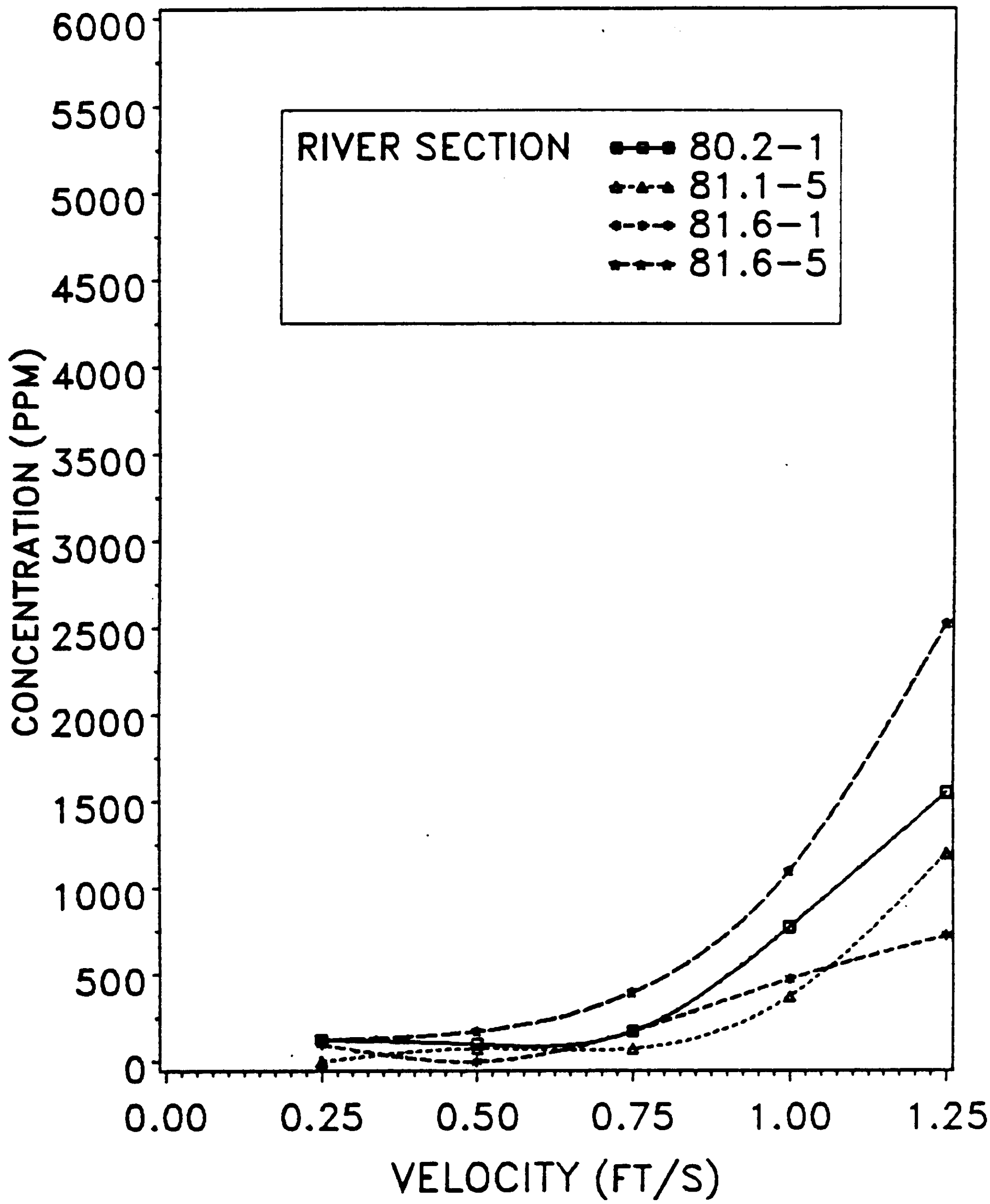


Figure 30. **Concentration of Natural Sediments vs. Velocity for River Miles 80.2, 81.1, and 81.6**

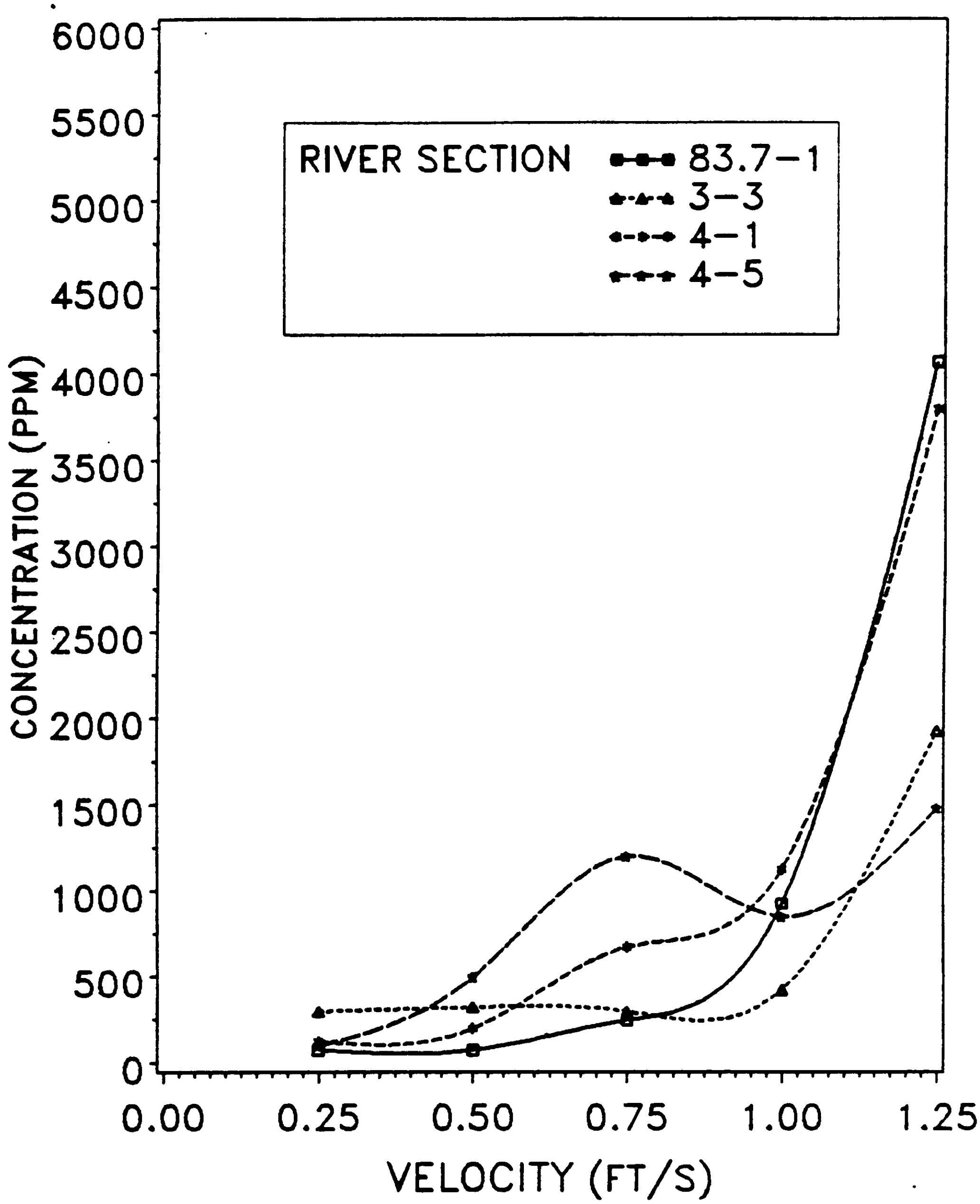


Figure 31. Concentration of Natural Sediments vs. Velocity for River Miles 83.7 and Cabin Creek

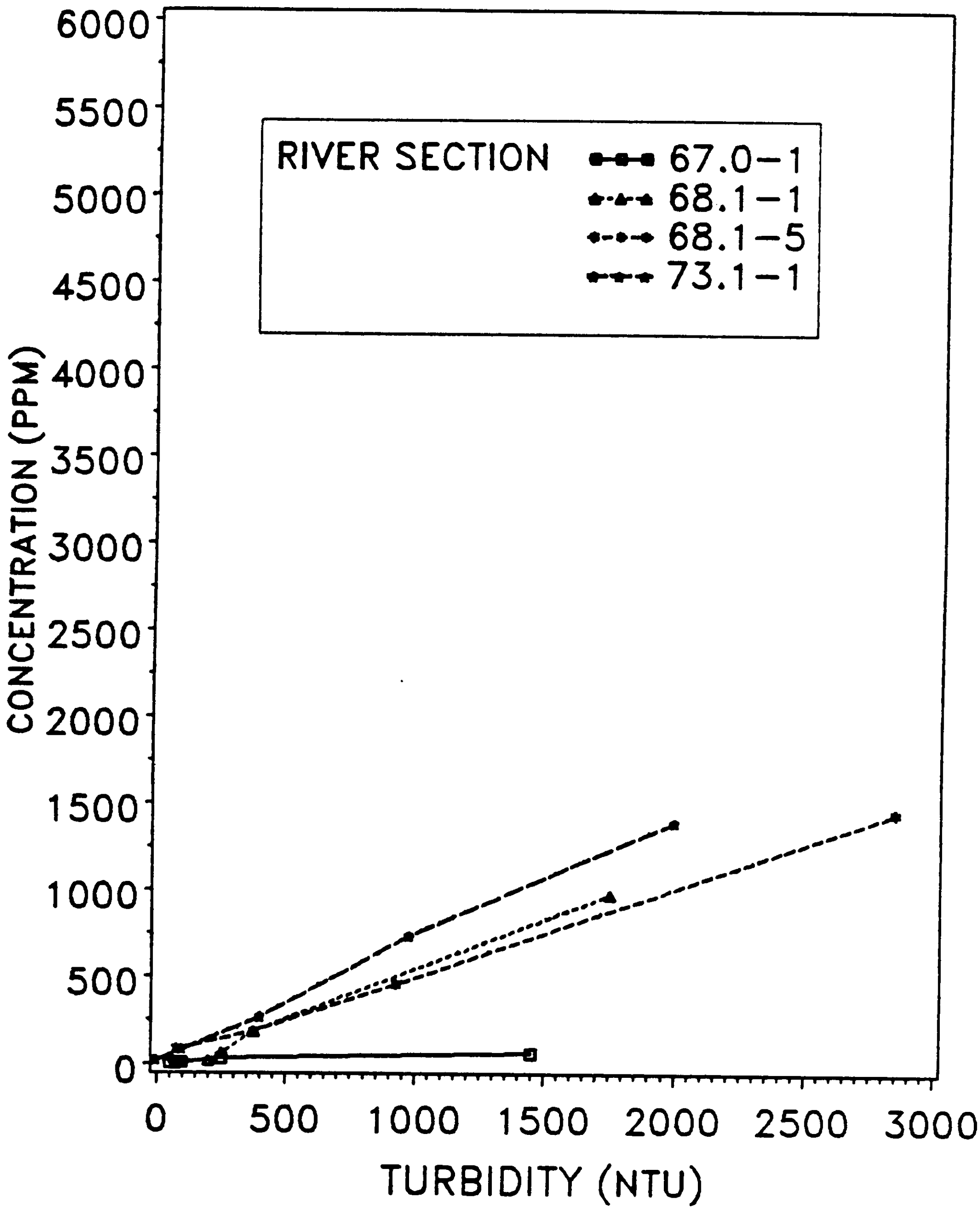


Figure 32. Concentration of Natural Sediments vs. Turbidity for River Miles 67.0, 68.1 and 73.1

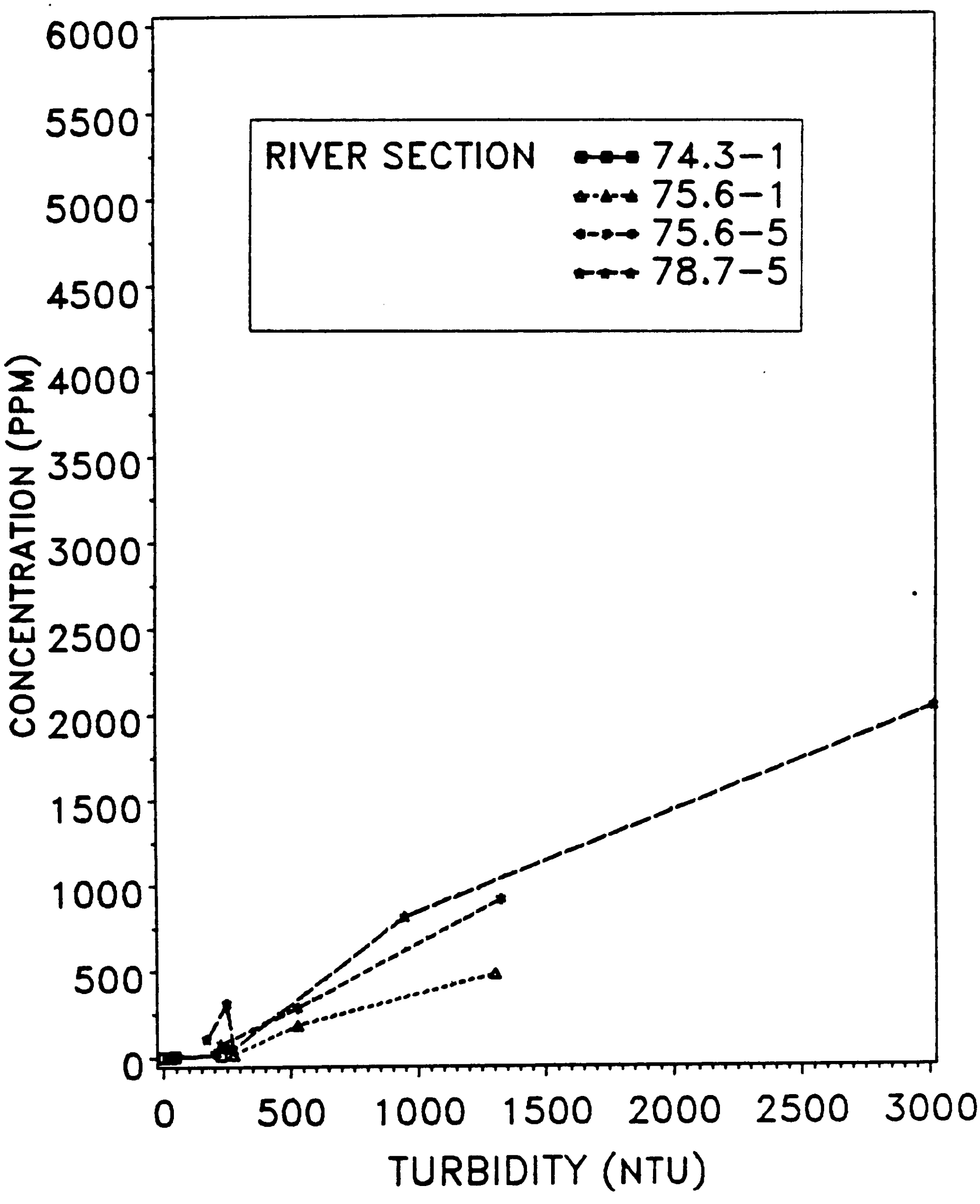


Figure 33. Concentration of Natural Sediments vs. Turbidity for River Miles 74.3, 75.6 and 78.7

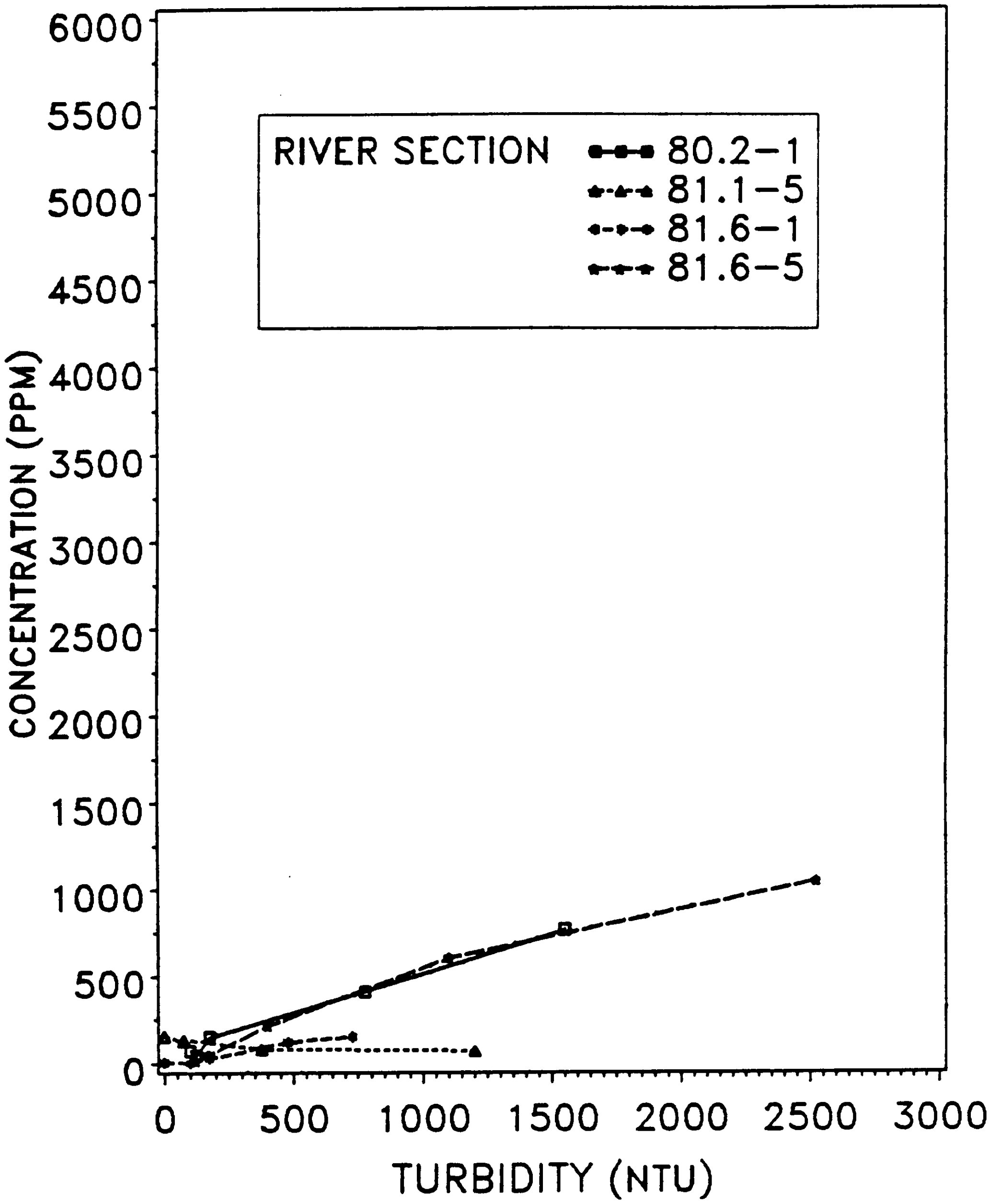


Figure 34. Concentration of Natural Sediments vs. Turbidity for River Miles 80.2, 81.1 and 81.6

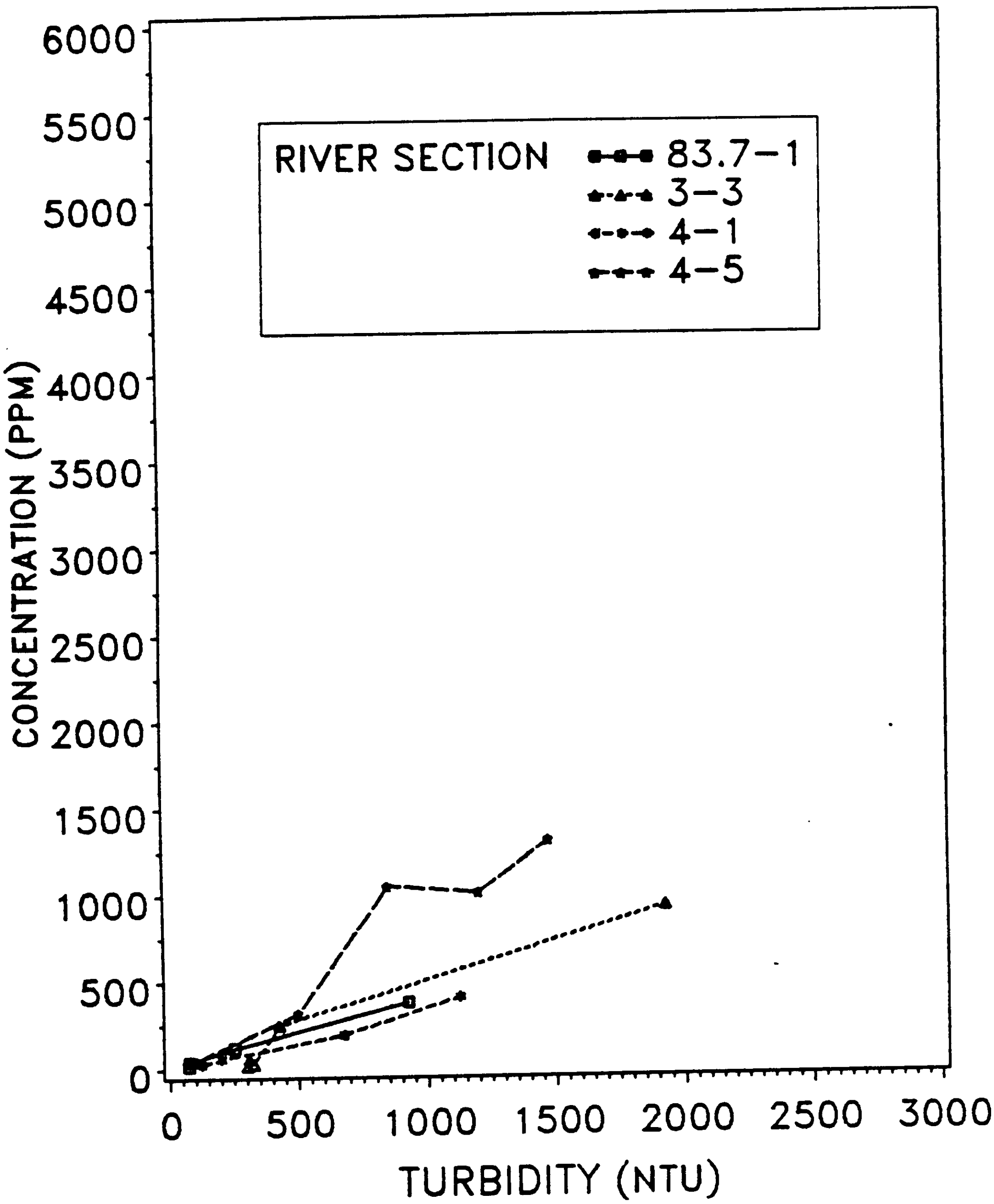


Figure 35. Concentration of Natural Sediments vs. Turbidity for River Miles 83.7 and Cabin Creek

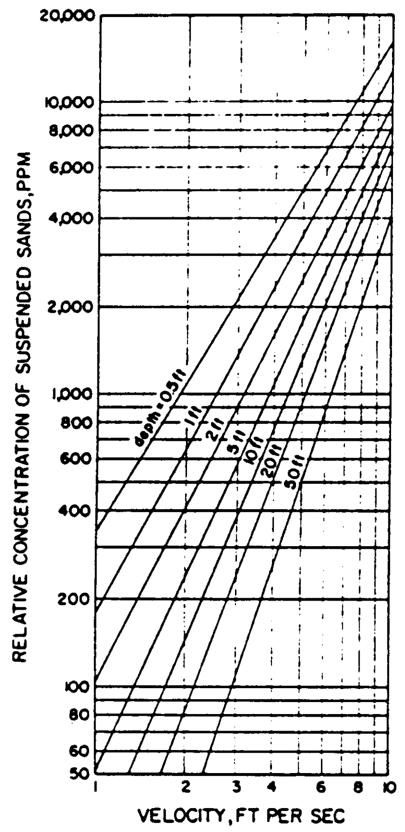


Figure 36. Colby's Chart of Relative Concentration against Mean Velocity

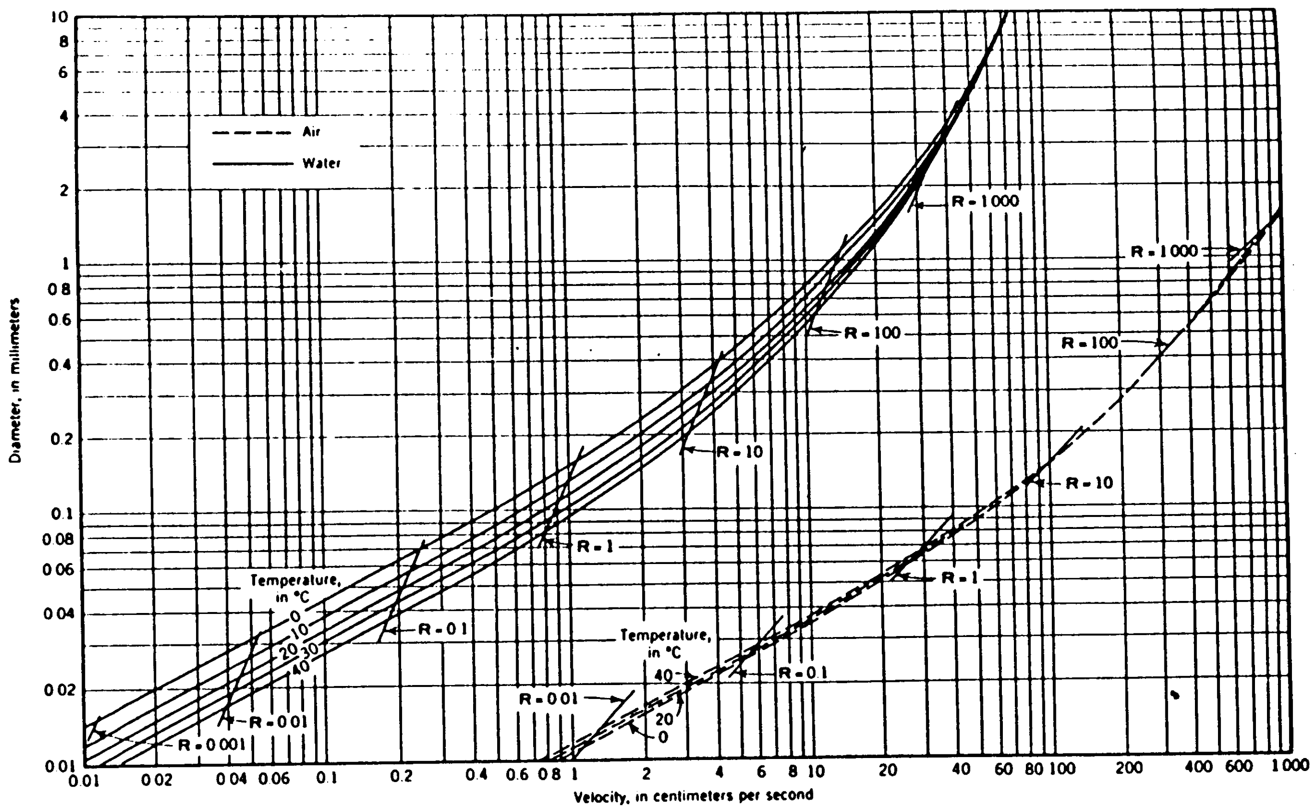


Figure 37. Fall Velocity of Quartz Spheres in Air and Water (ASCE, 1975)

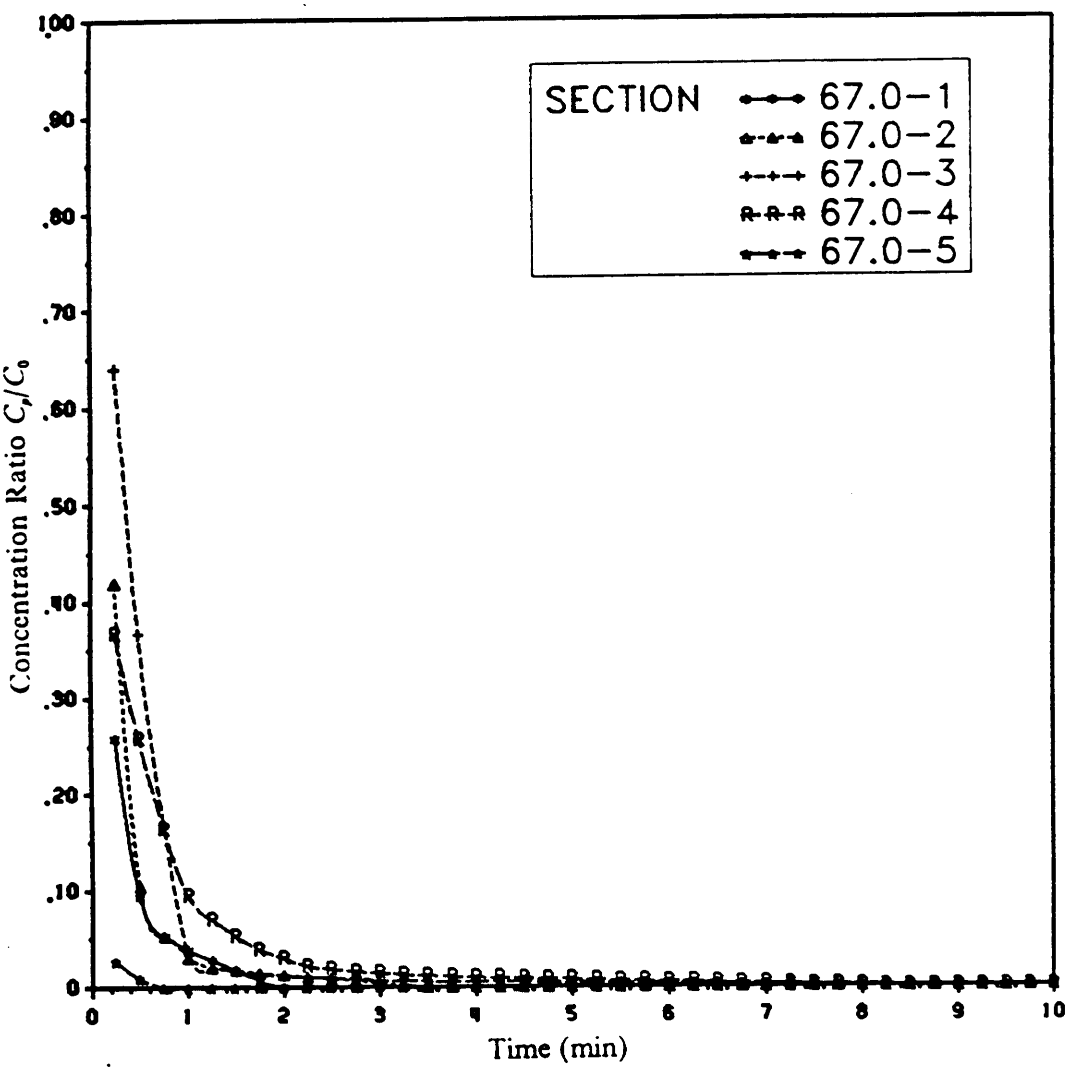


Figure 38. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 67.0

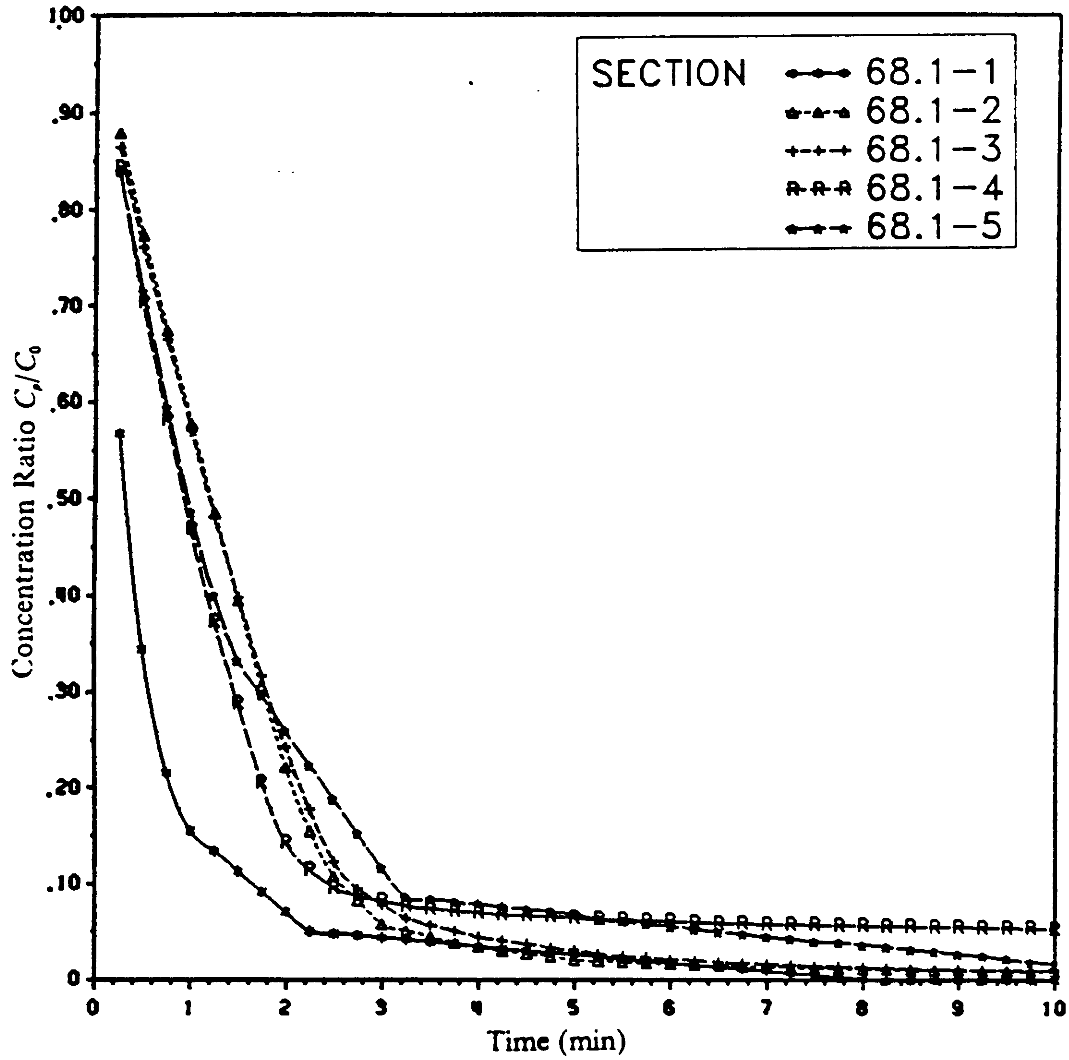


Figure 39. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 68.1

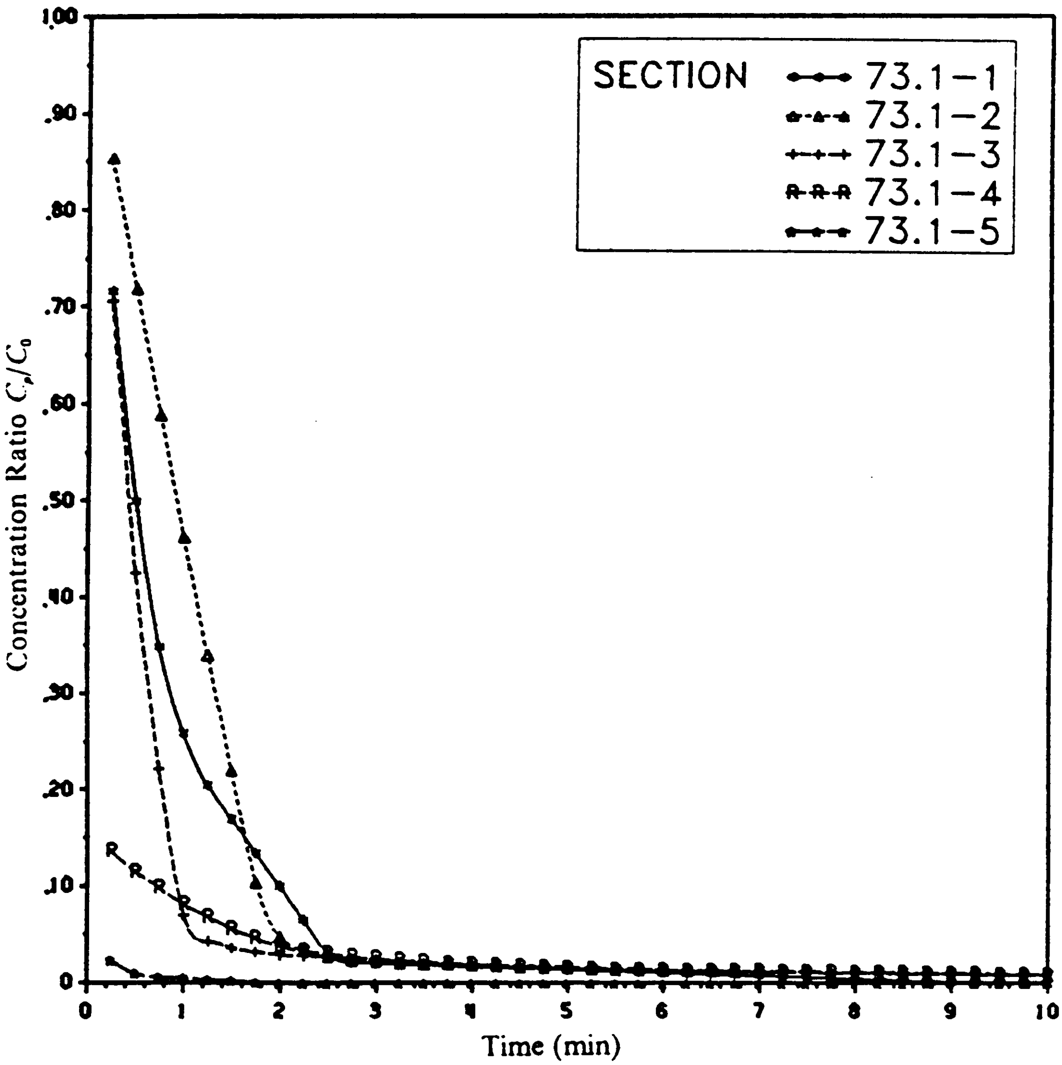


Figure 40. Ratio of Propeller Induced Concentration, C_p / C_0 vs. t for River Mile 73.1

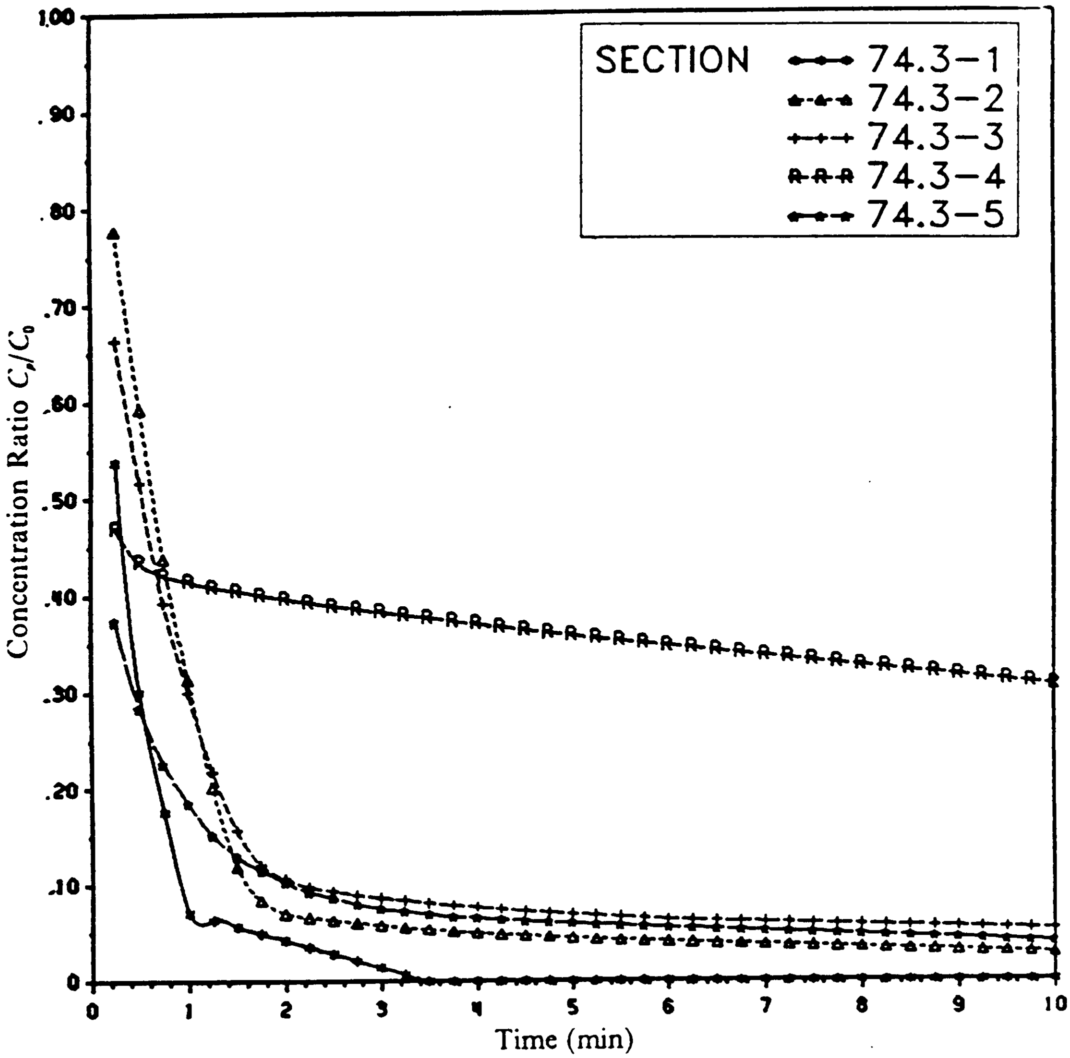


Figure 41. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 74.3

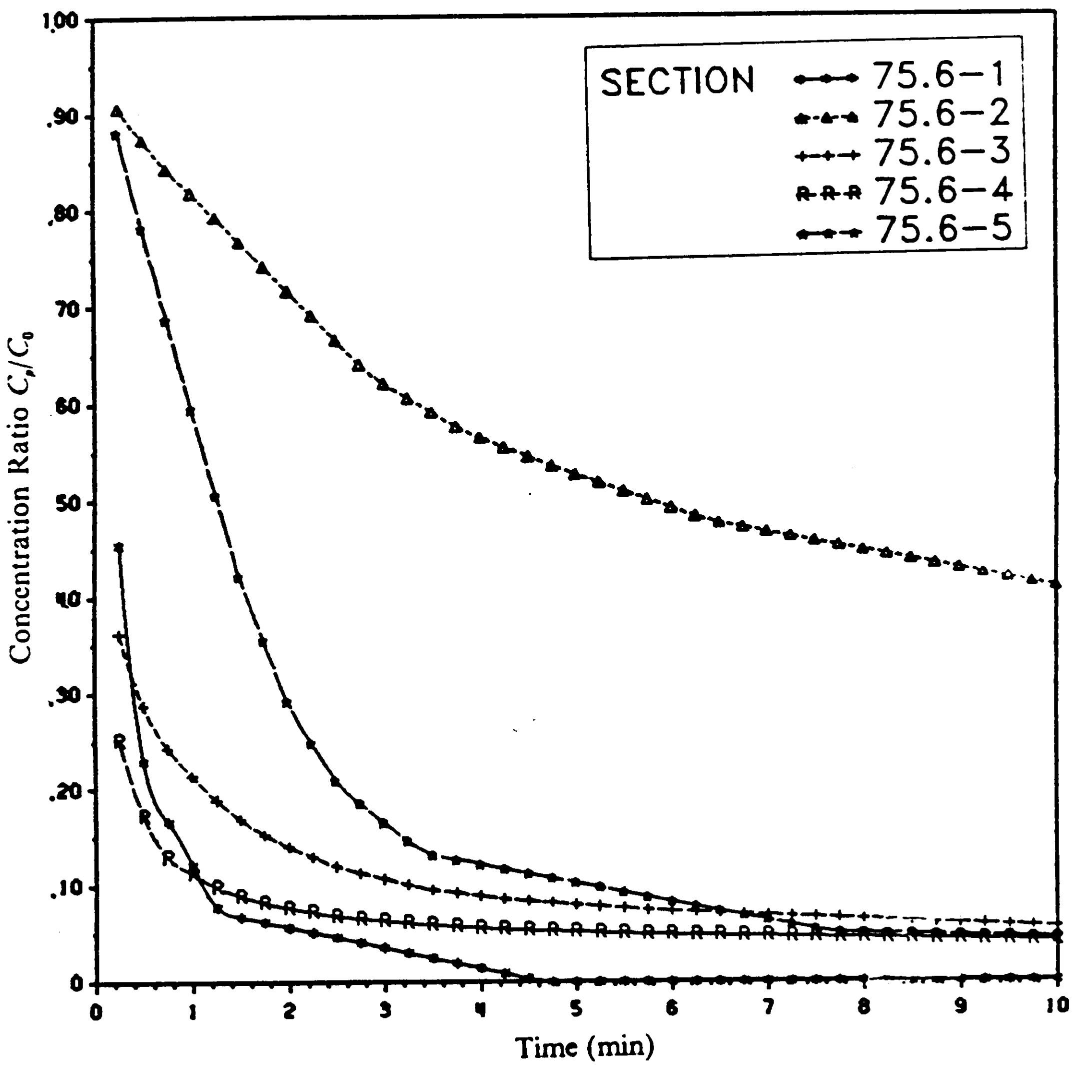


Figure 42. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 75.6

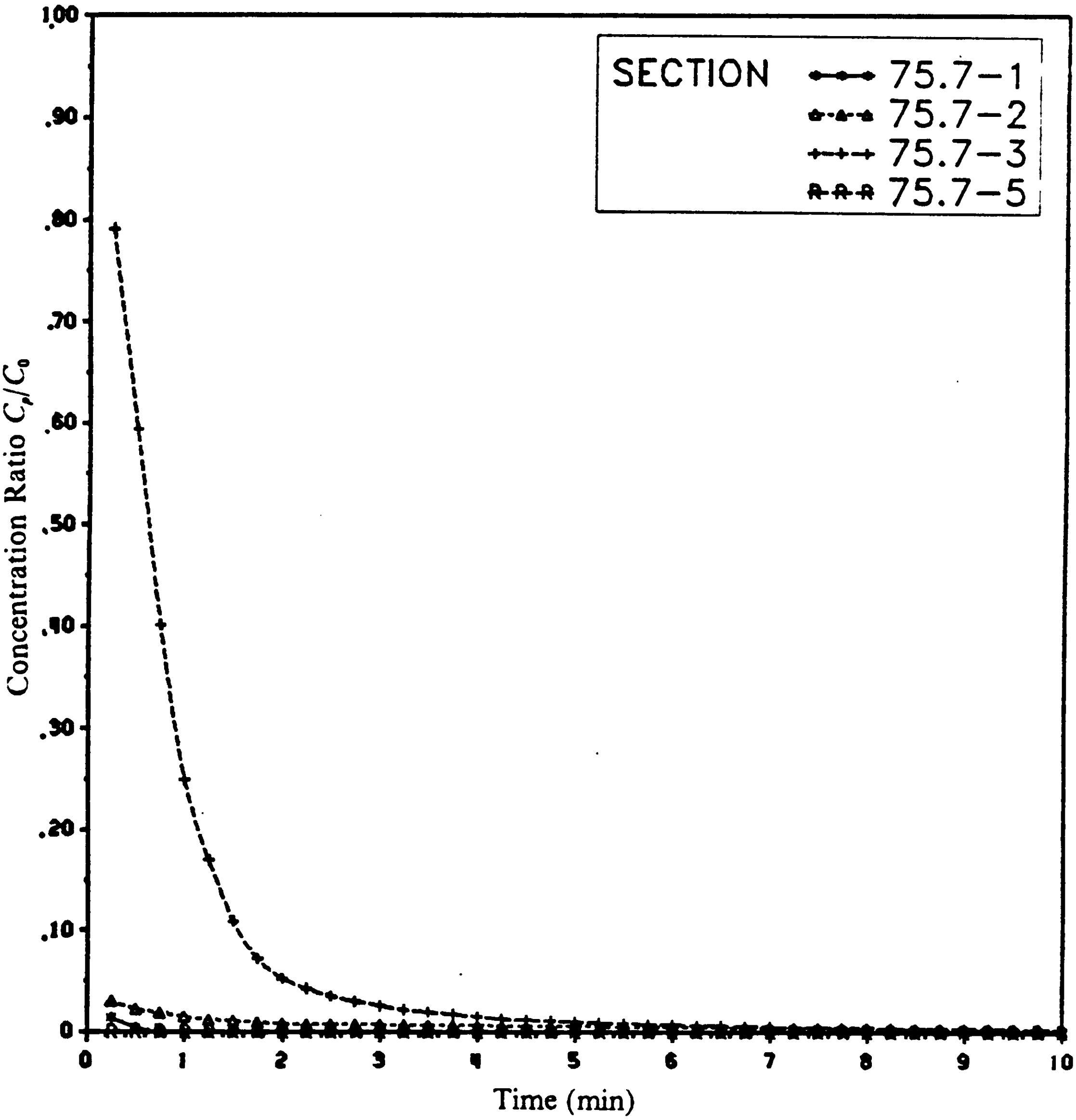


Figure 43. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 75.7 in Watsons Island Back Channel

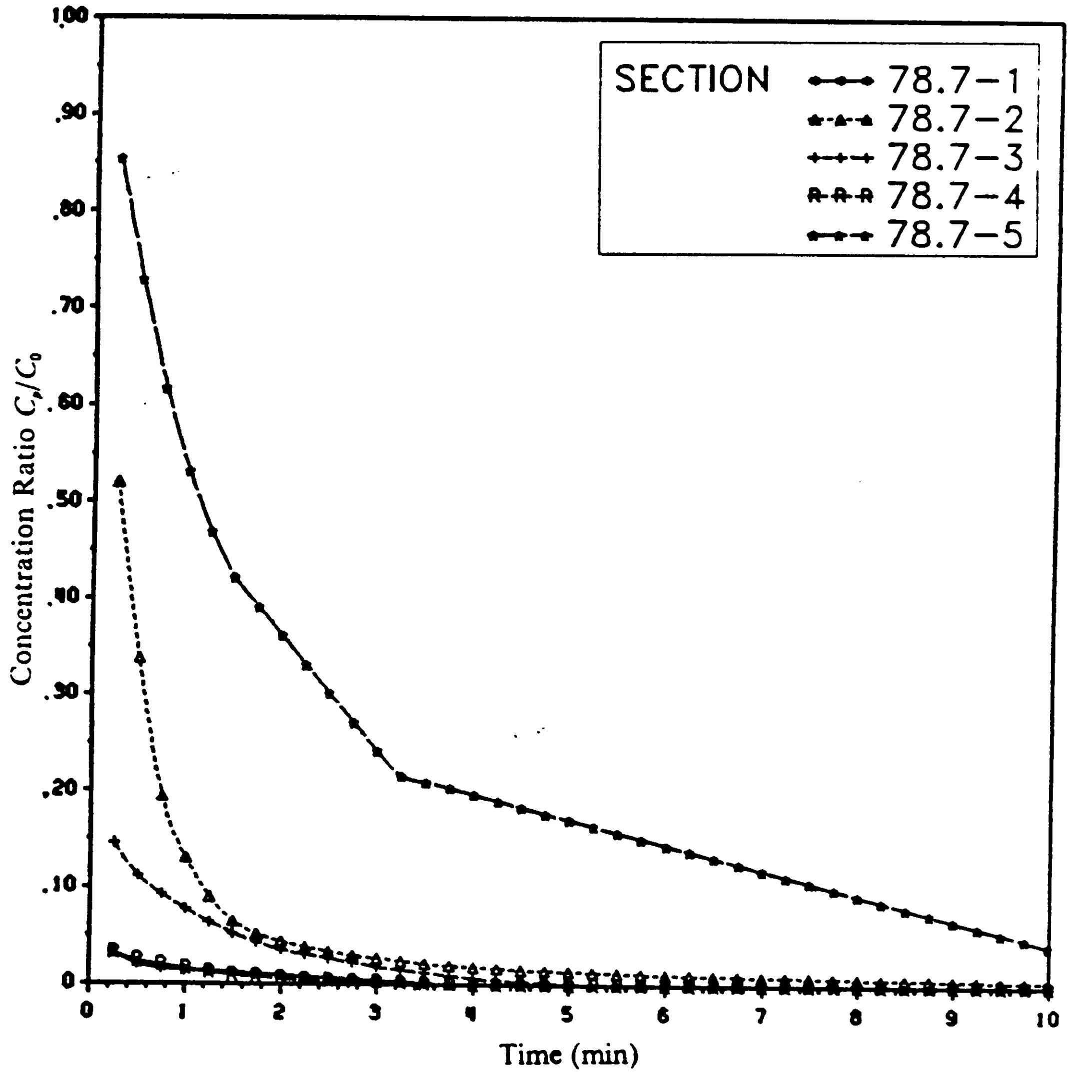


Figure 44. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 78.7

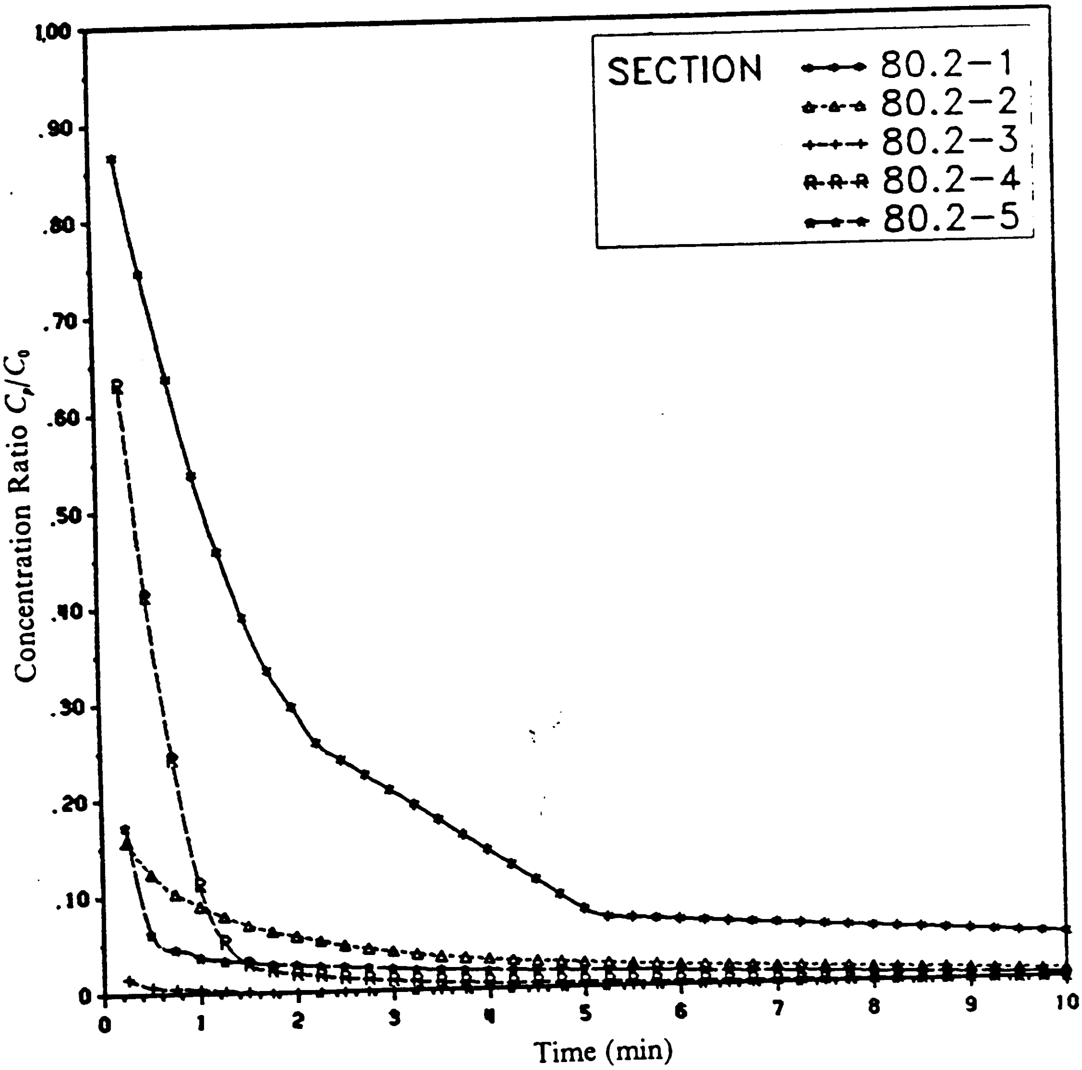


Figure 45. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 80.2

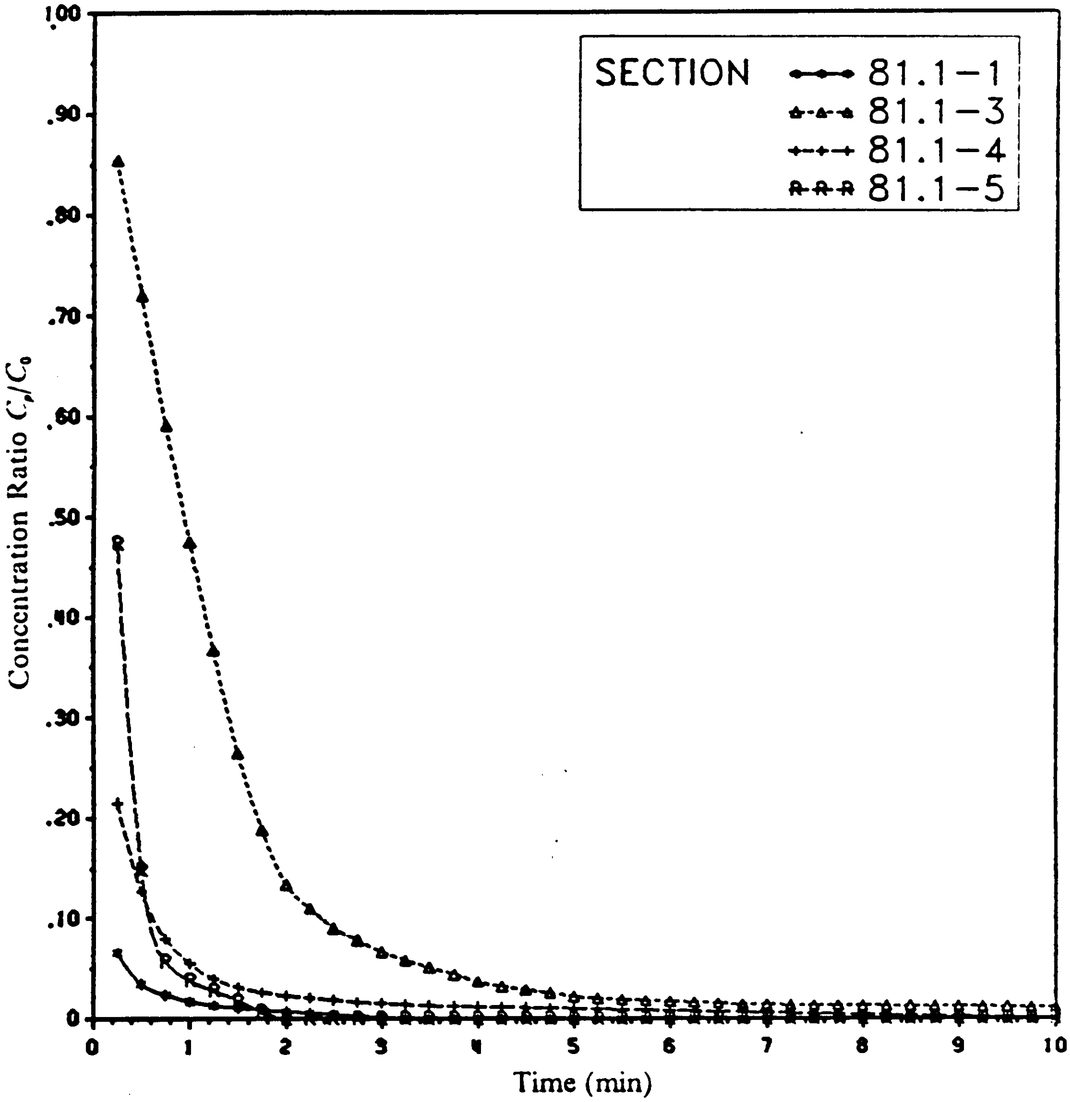


Figure 46. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 81.1

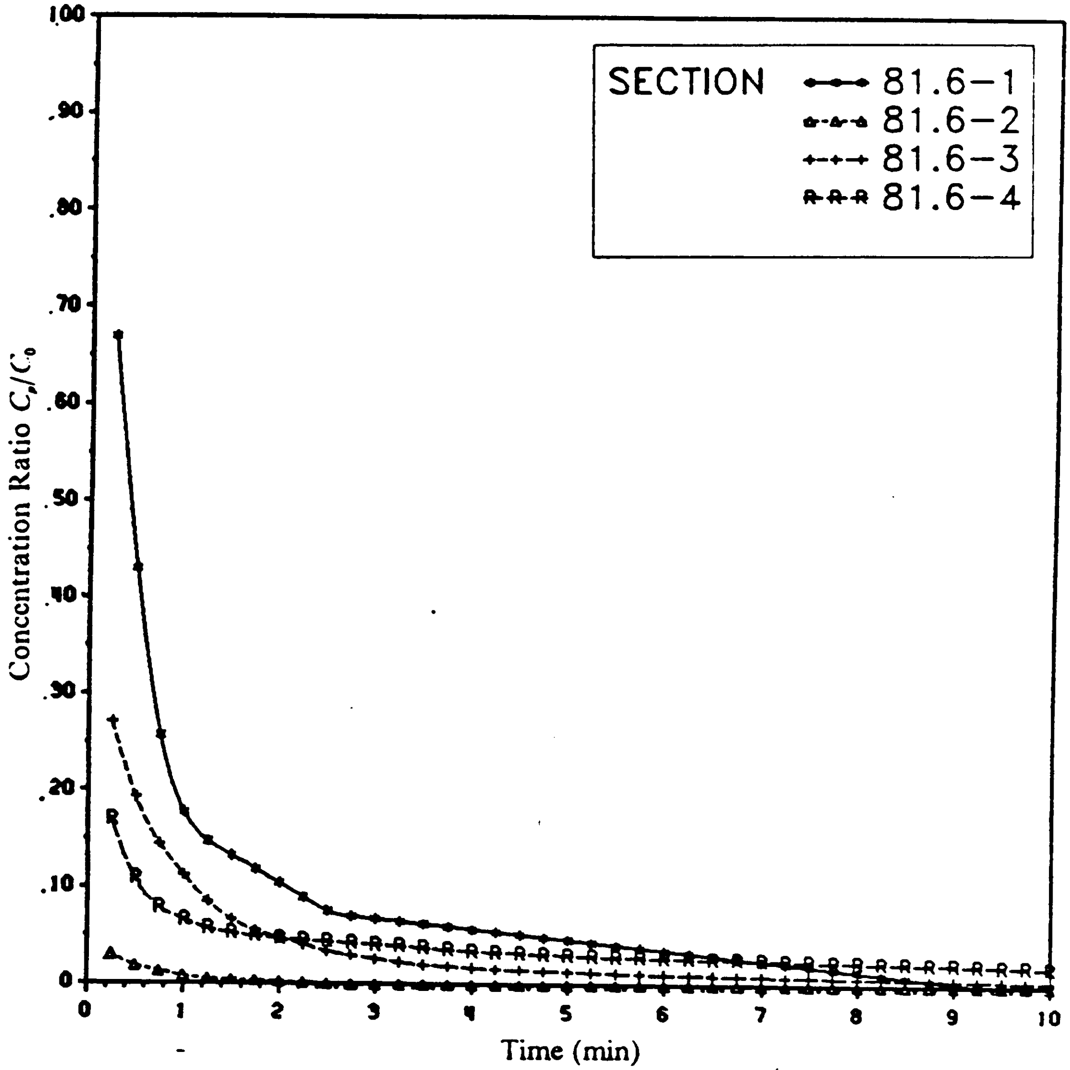


Figure 47. Ratio of Propeller Induced Concentration, C / C vs. t for River Mile 81.6

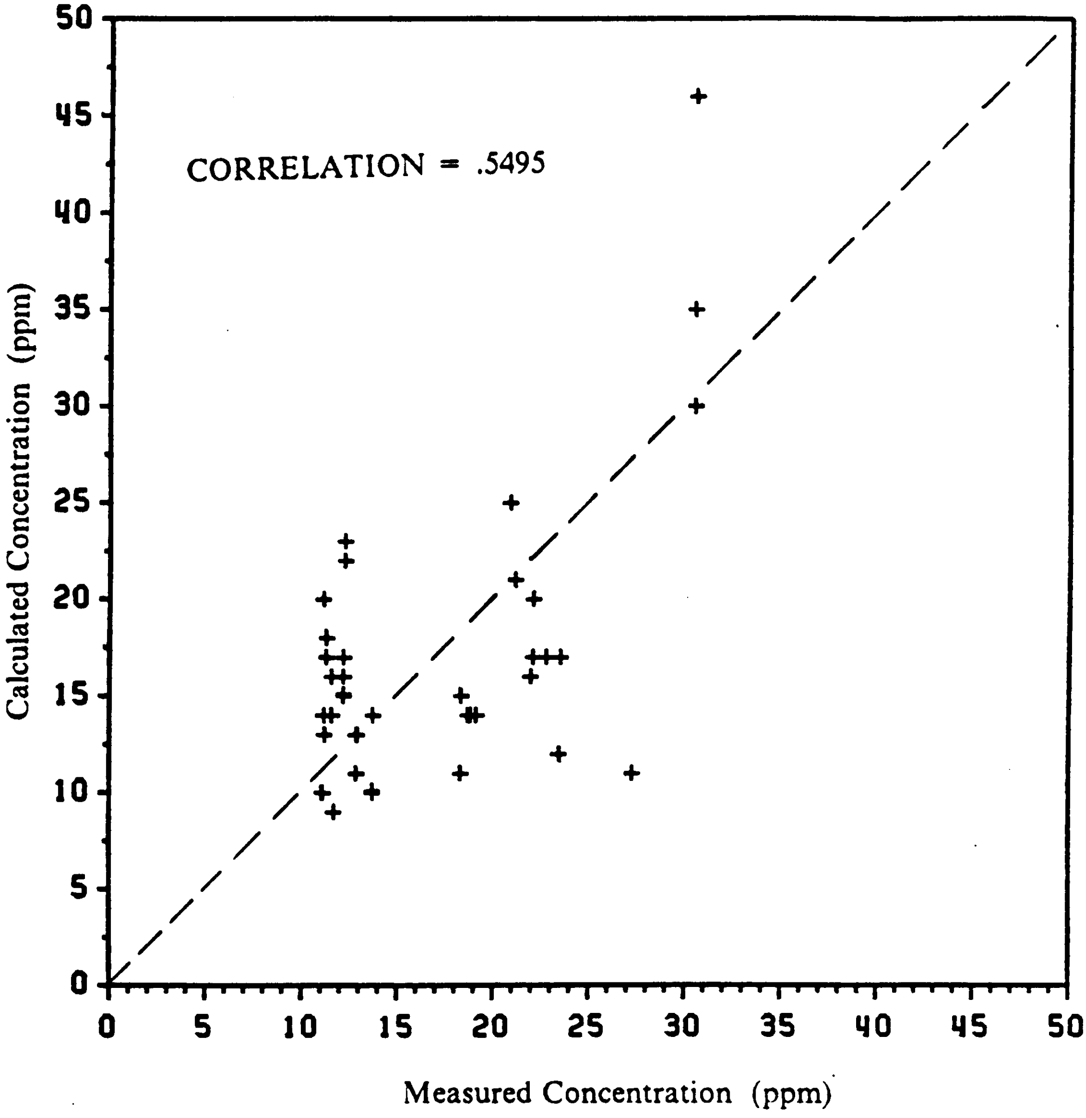


Figure 48. Comparison of Measured vs. Calculated Sediment Concentration at Sailing Line, 1.5 ft from Channel Bed

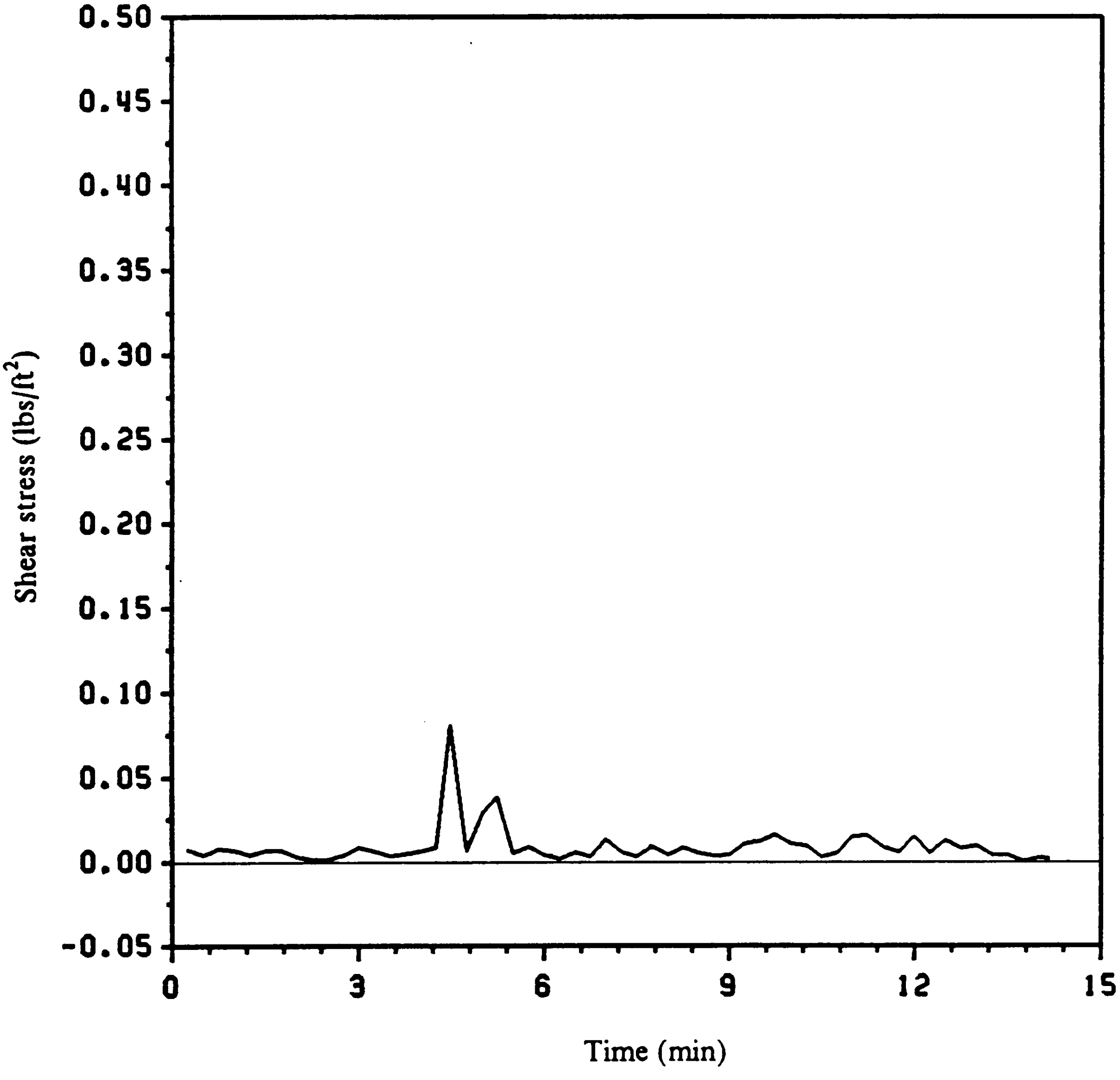


Figure 49. Example of Shear Stress, u'v' vs. time for a Typical Main Channel Tow Passage

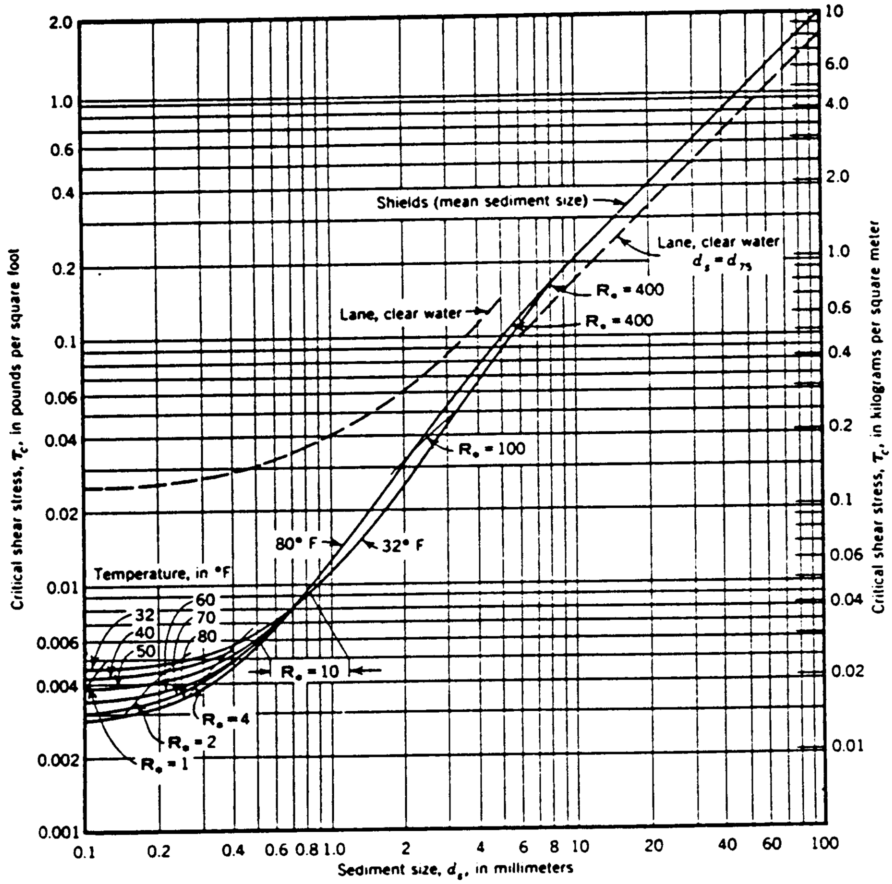


Figure 50. Critical Shear Stress for Quartz Sediment as a Function of Grain Size, Shields and Lane (ASCE, 1975)

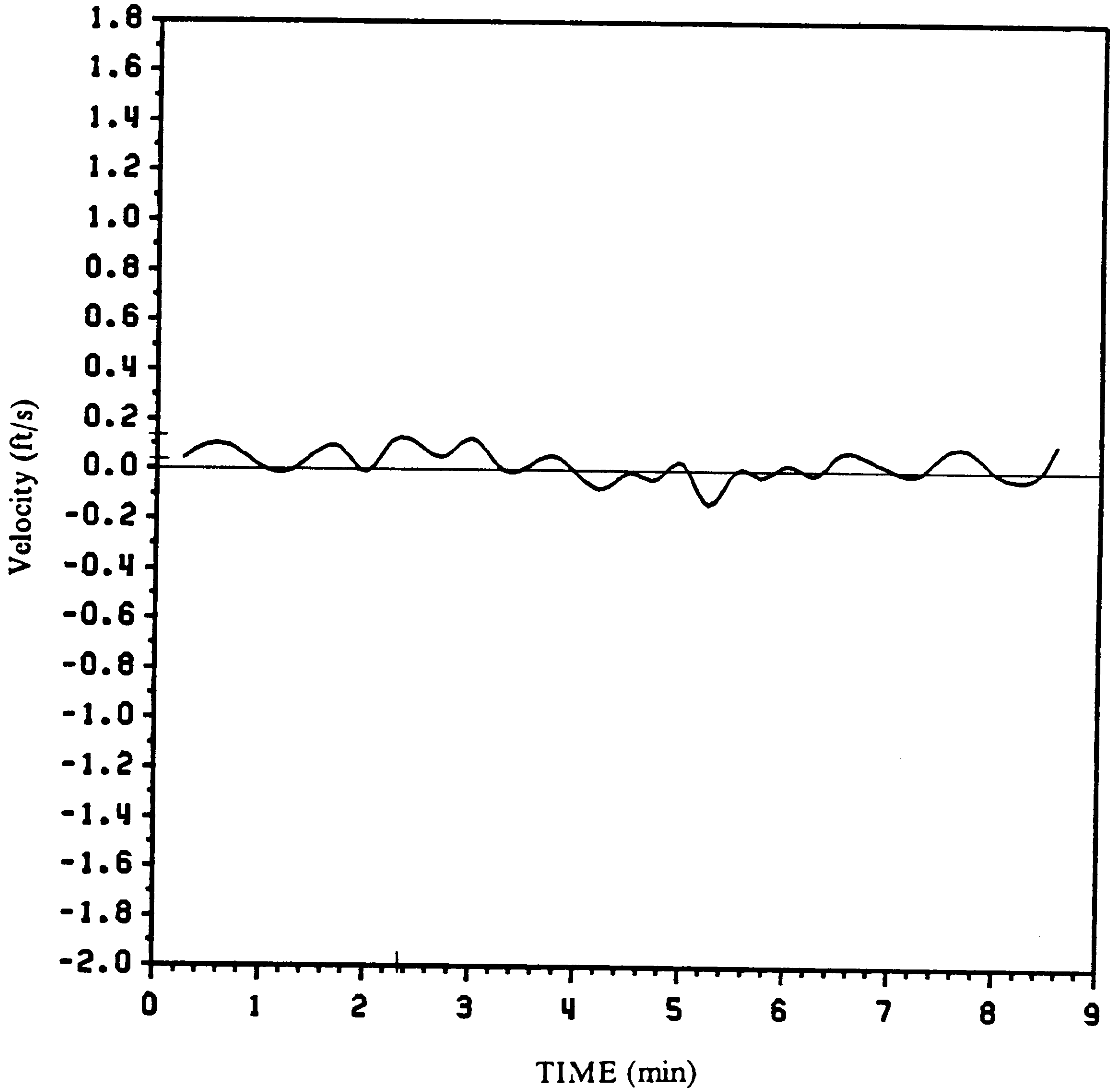


Figure 51. Velocity at Sailing Line Mid-depth for Recreational Boat Traveling near Sailing Line, Representative for All Scenarios

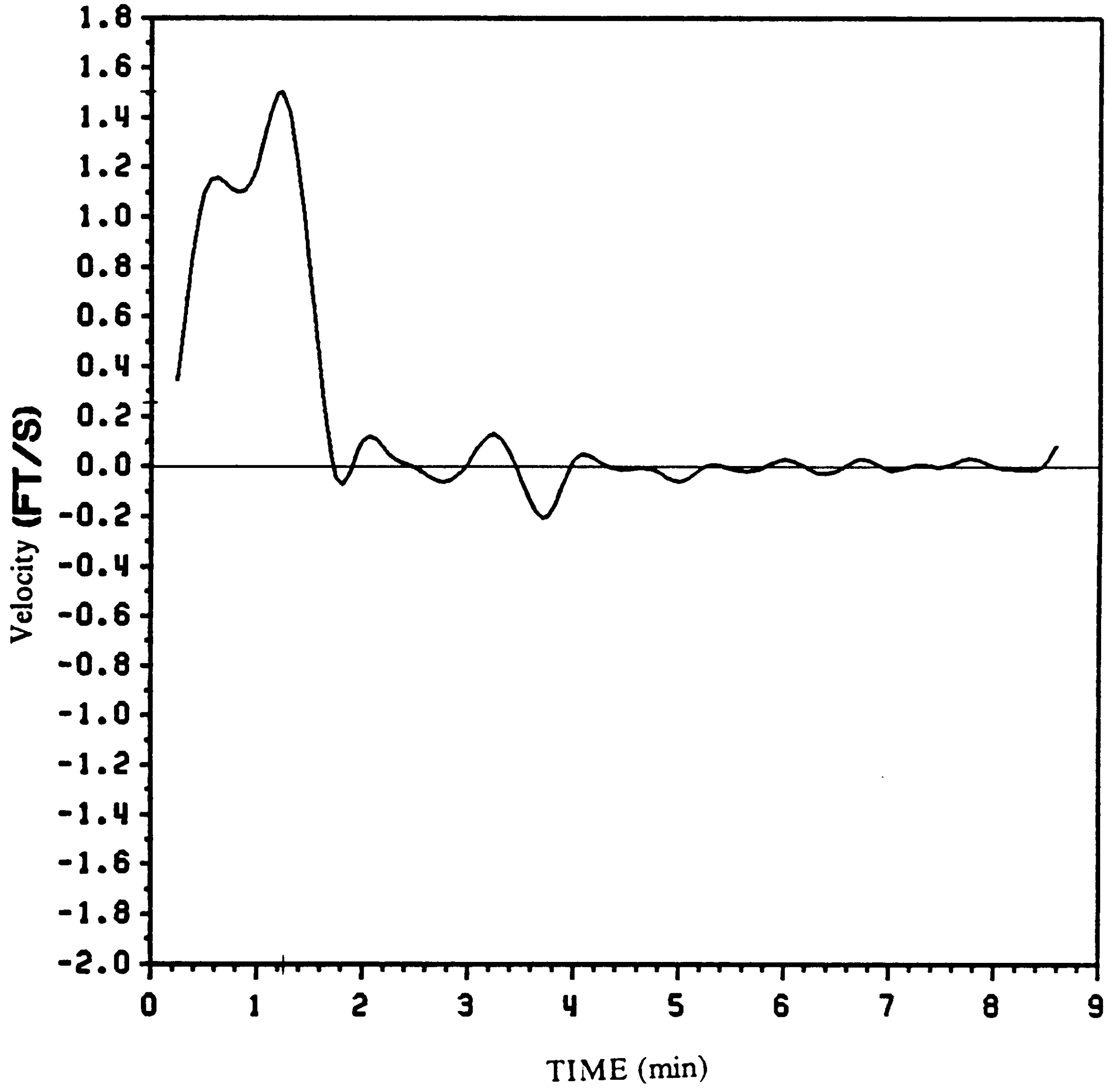


Figure 52. Velocity at Shore for a Series of Near Shore Recreational Boat Passages

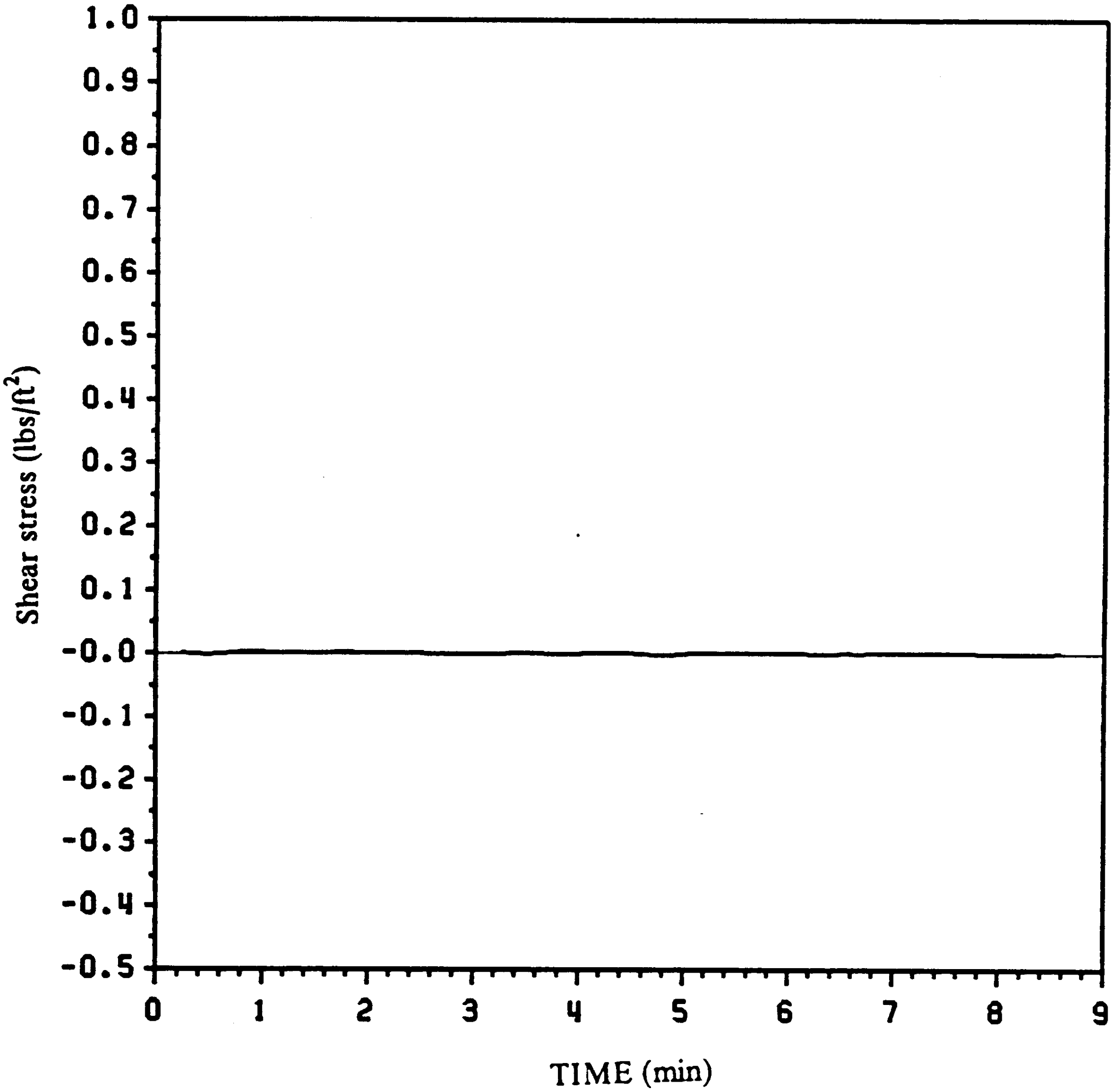


Figure 53. **Shear Stress at Mid-channel for a Series of Near Shore Recreational Boat Passages**

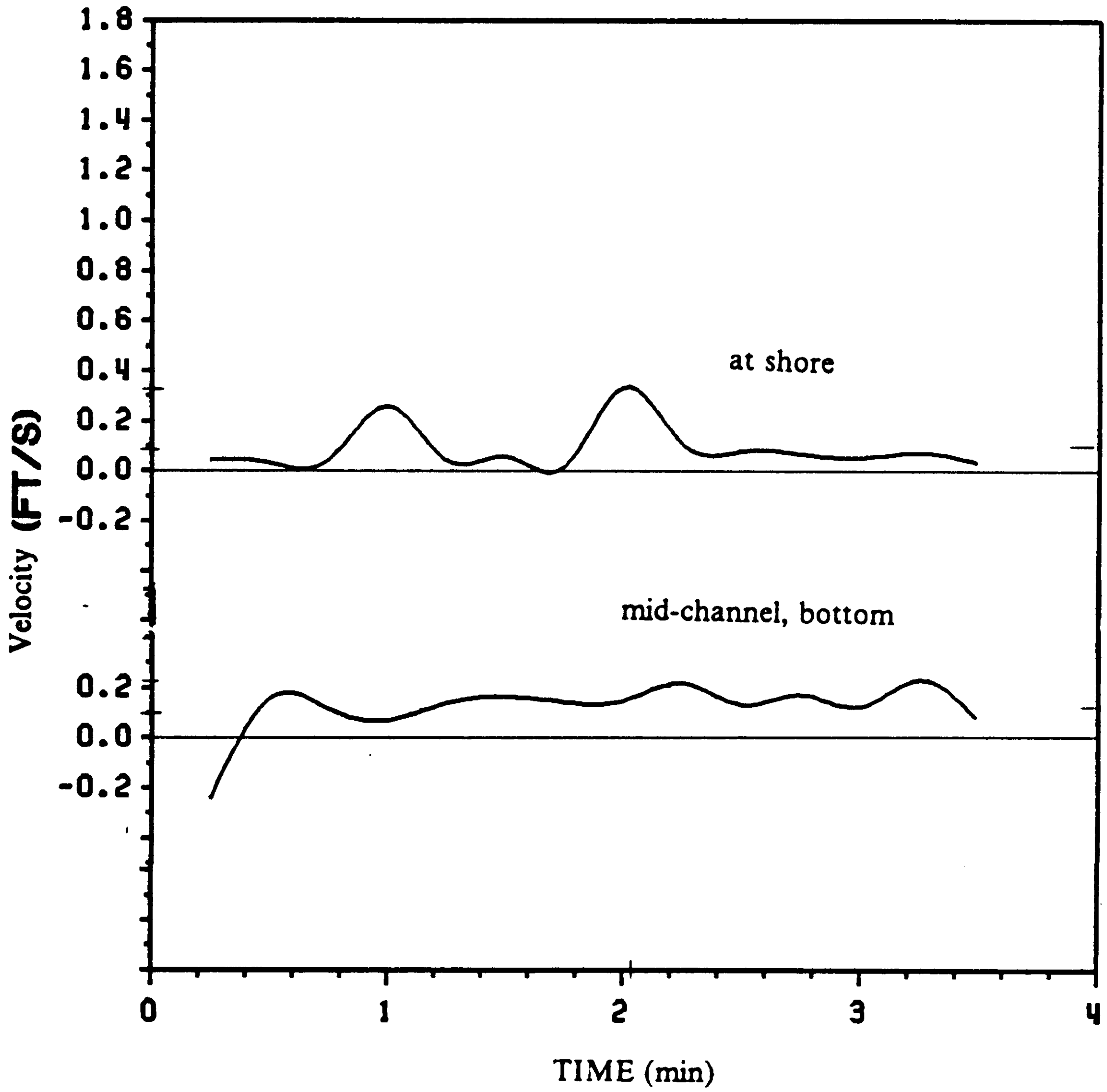


Figure 54. Flow Velocity at Shore due to Recreational Boat Passages along Mid-channel Line

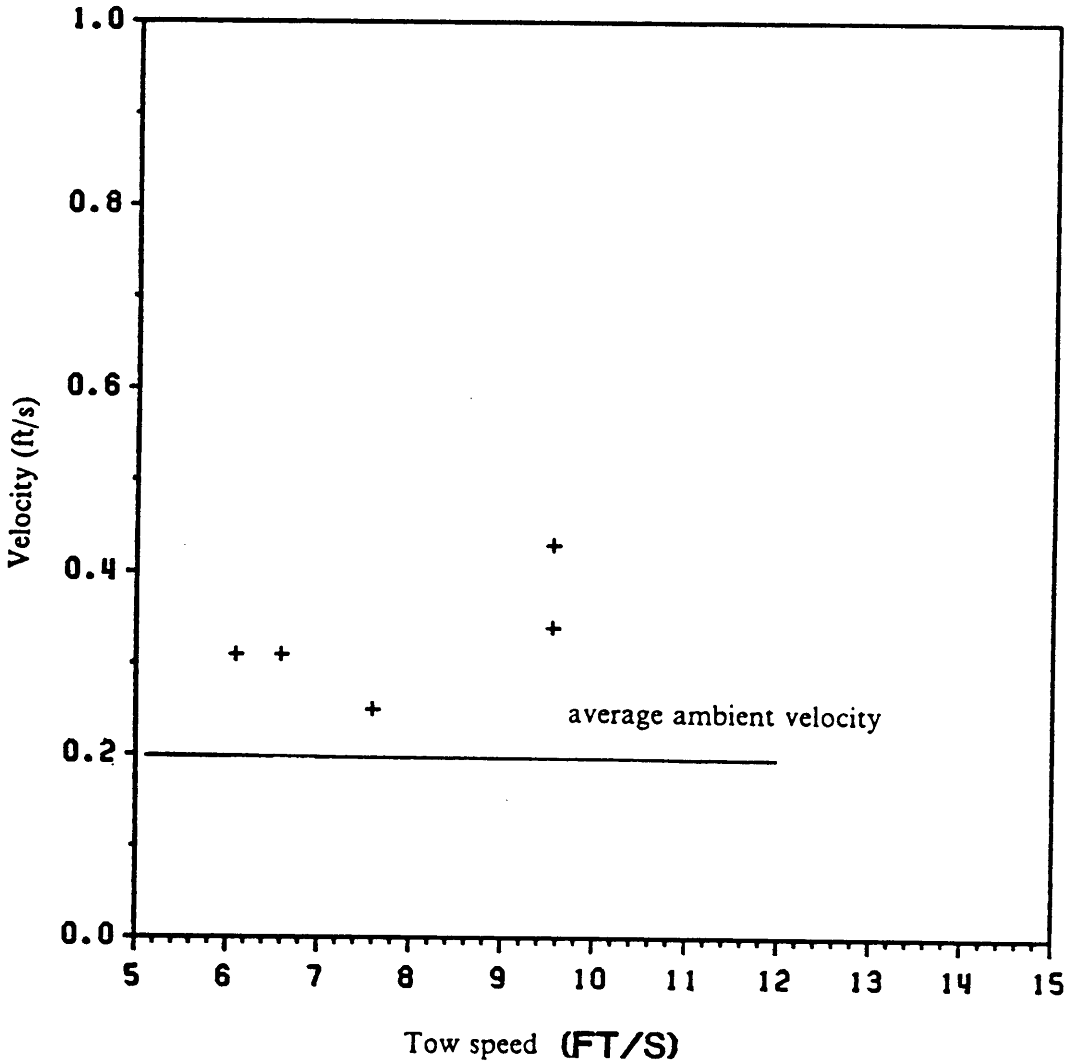


Figure 55. Flow Velocity vs. Tow Speed Measured 500 ft from the Mouth at Center of Back Channel

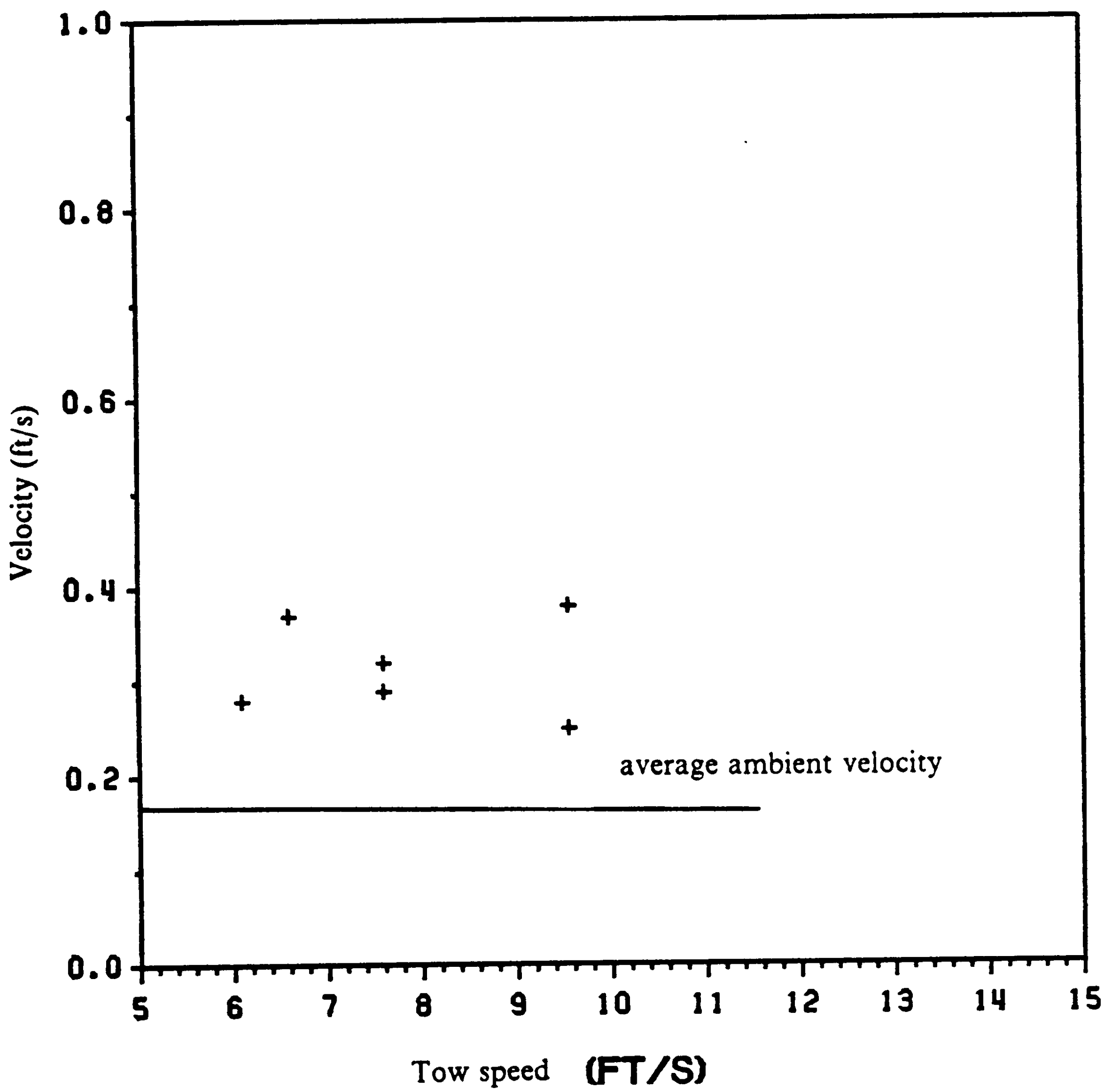


Figure 56. Maximum Flow Velocity vs. Tow Speed for Upbound and Downbound Tows at 500 feet from the Mouth at Shore of Back Channel

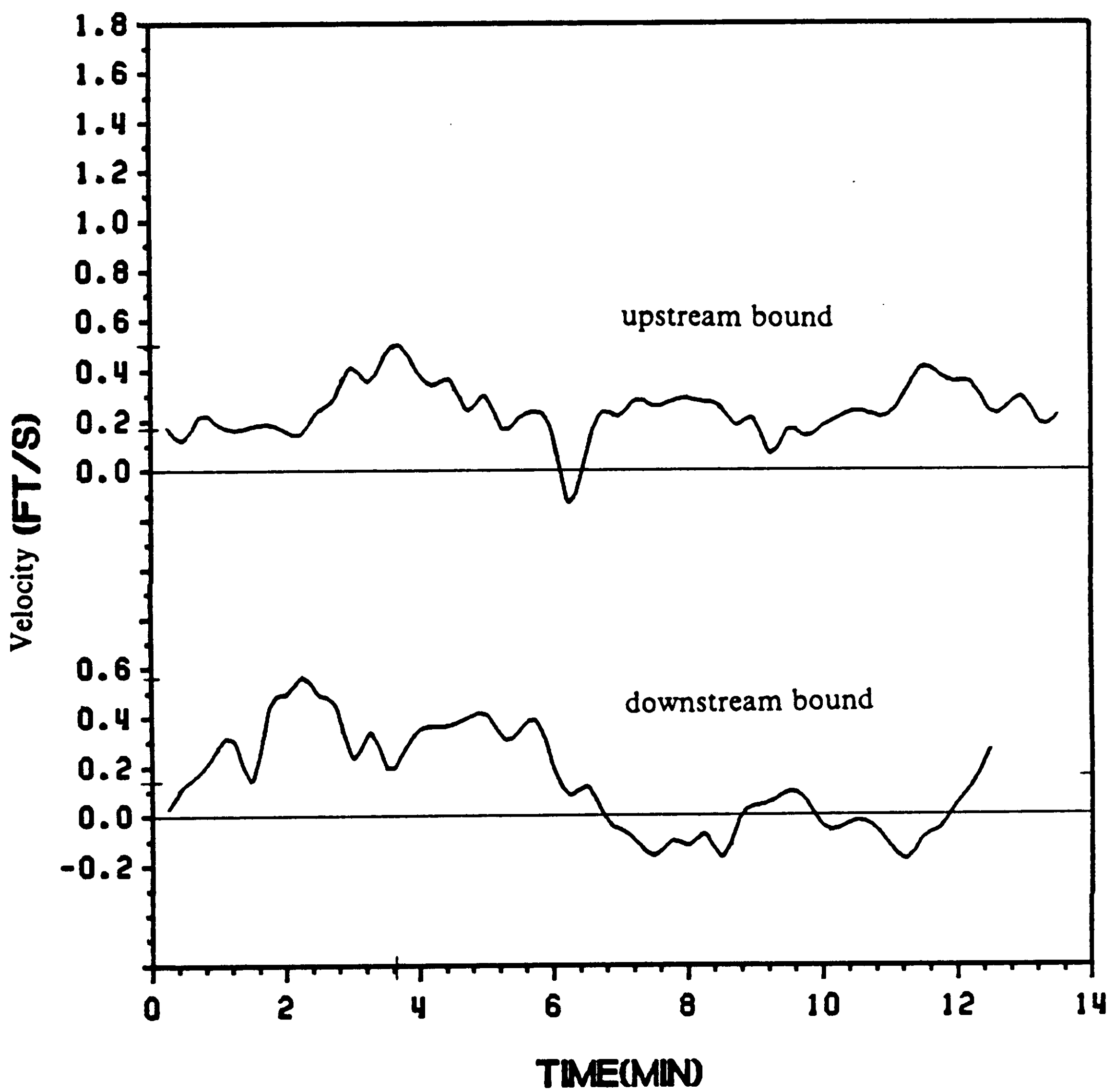


Figure 57. Maximum Flow Velocity vs. Tow Speed for Upbound and Downbound Tows at 500 feet from the Mouth at Shore of Back Channel

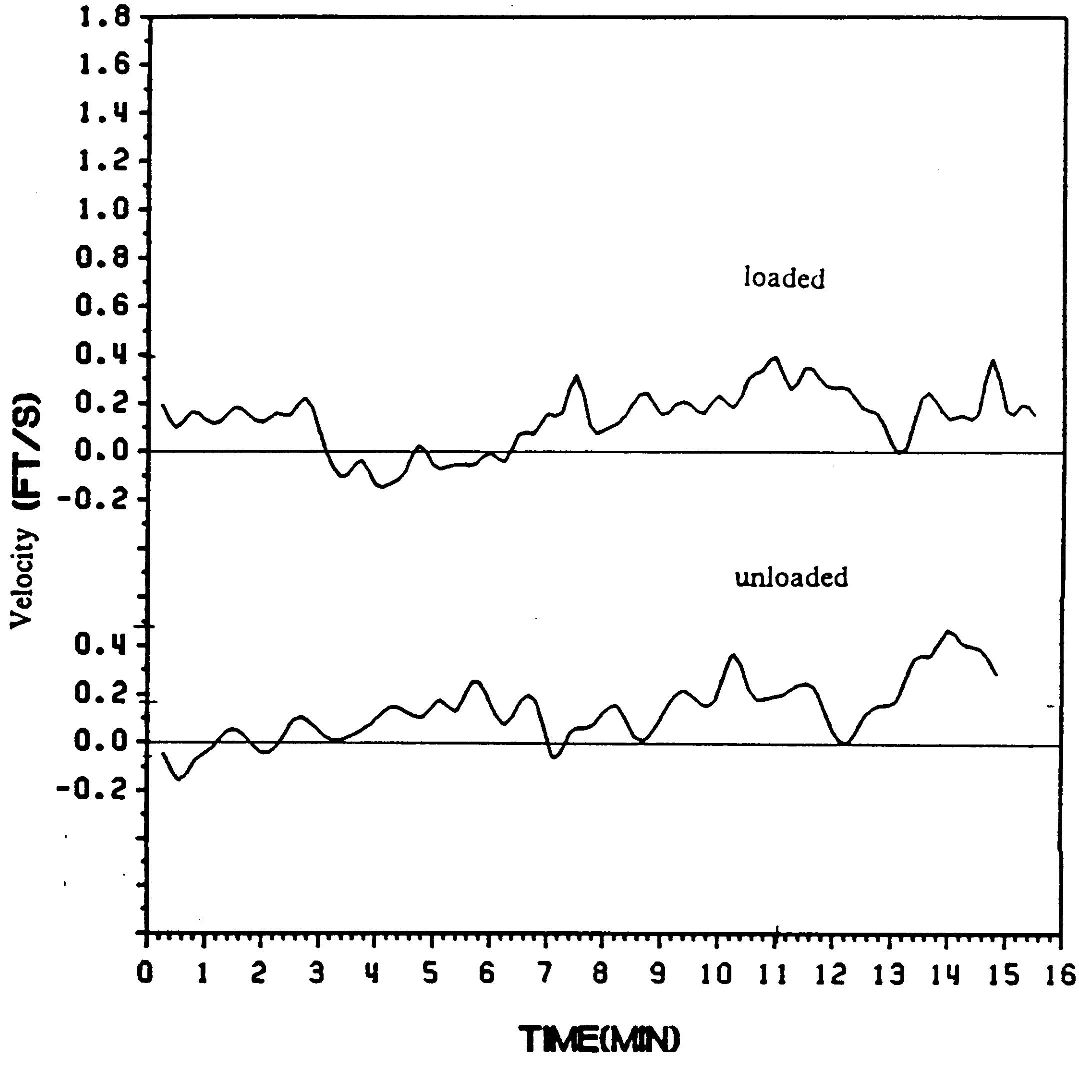


Figure 58. Flow Velocity during Unloaded and Loaded Scenarios in Back Channel Measured at Mid-depth, 500 feet from the Mouth

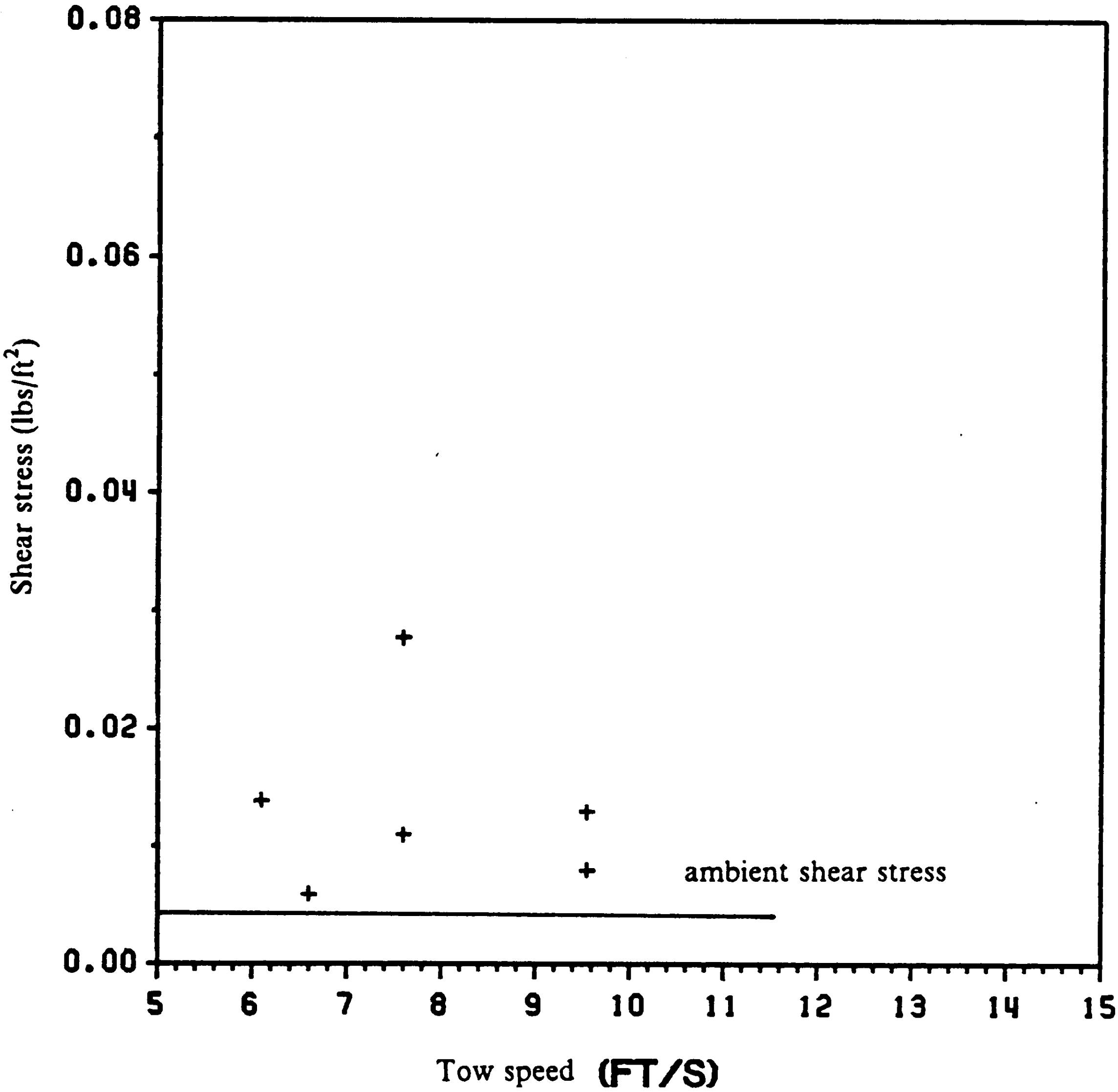


Figure 59. Shear Stress at Back Channel Shore during Controlled Scenarios Measured 500 feet from Mouth

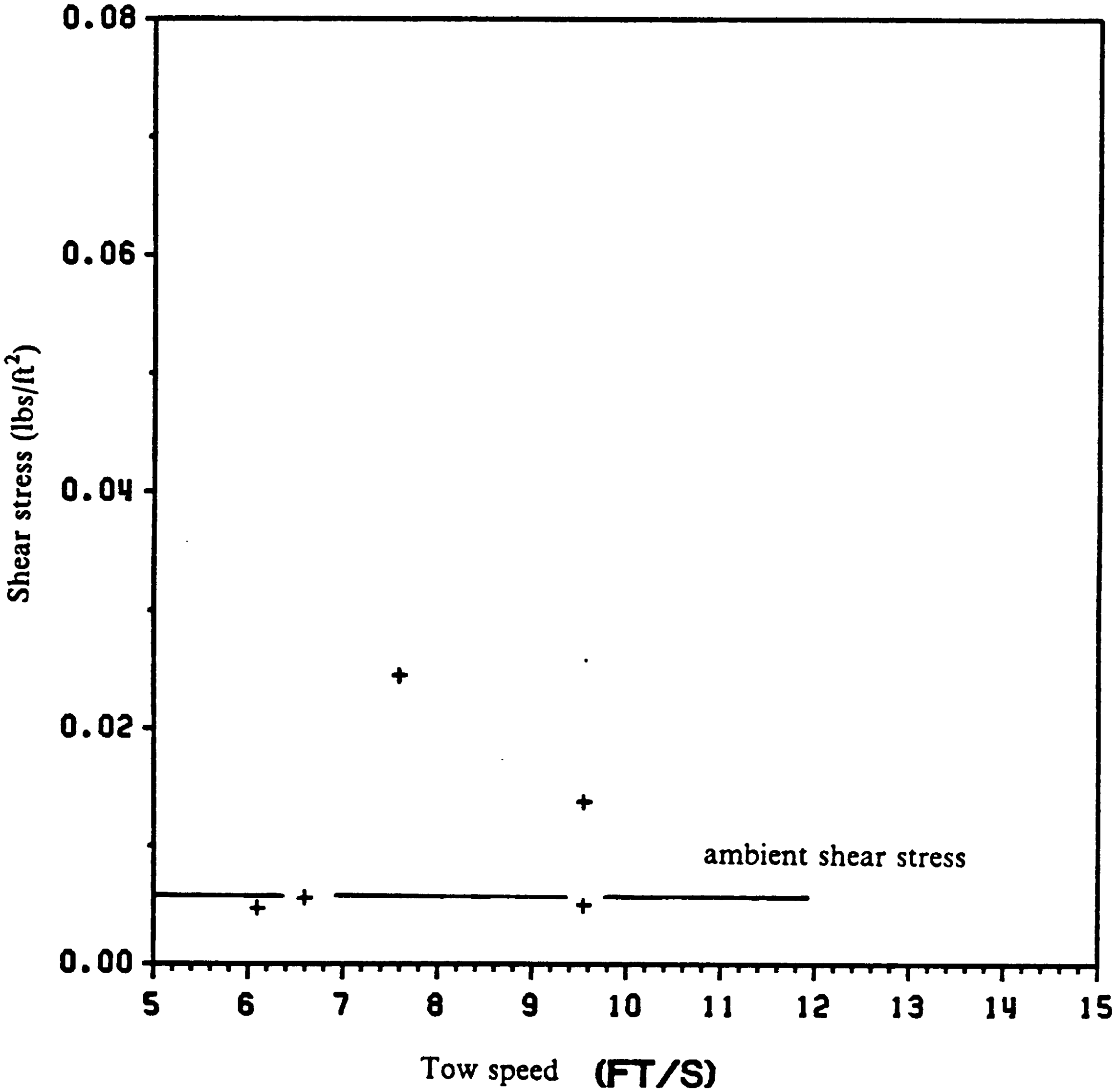


Figure 60. Shear Stress at Back Channel Center during Controlled Scenarios Measured 500 feet from Mouth

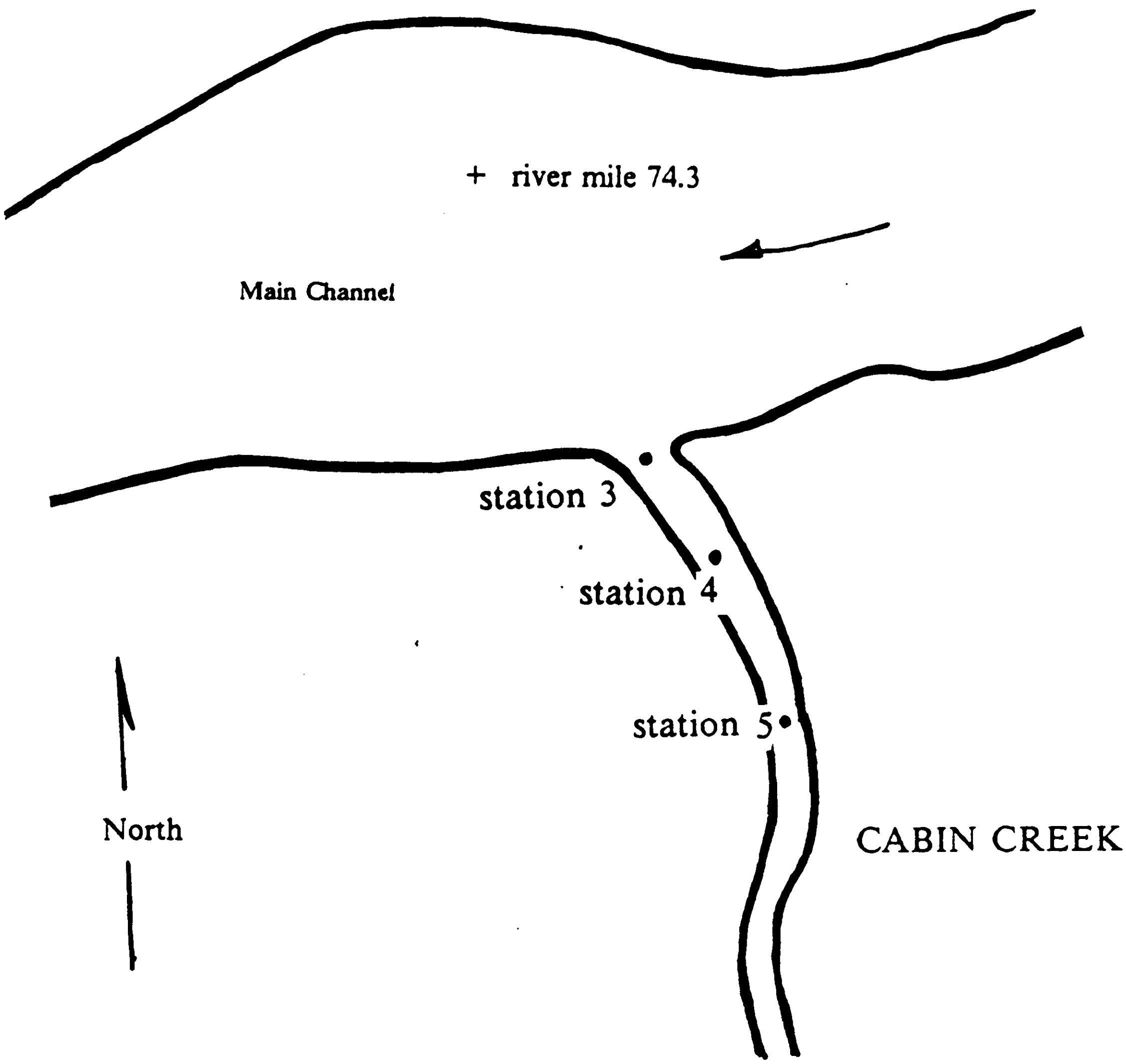


Figure 61. Station Locations for Cabin Creek Scenarios

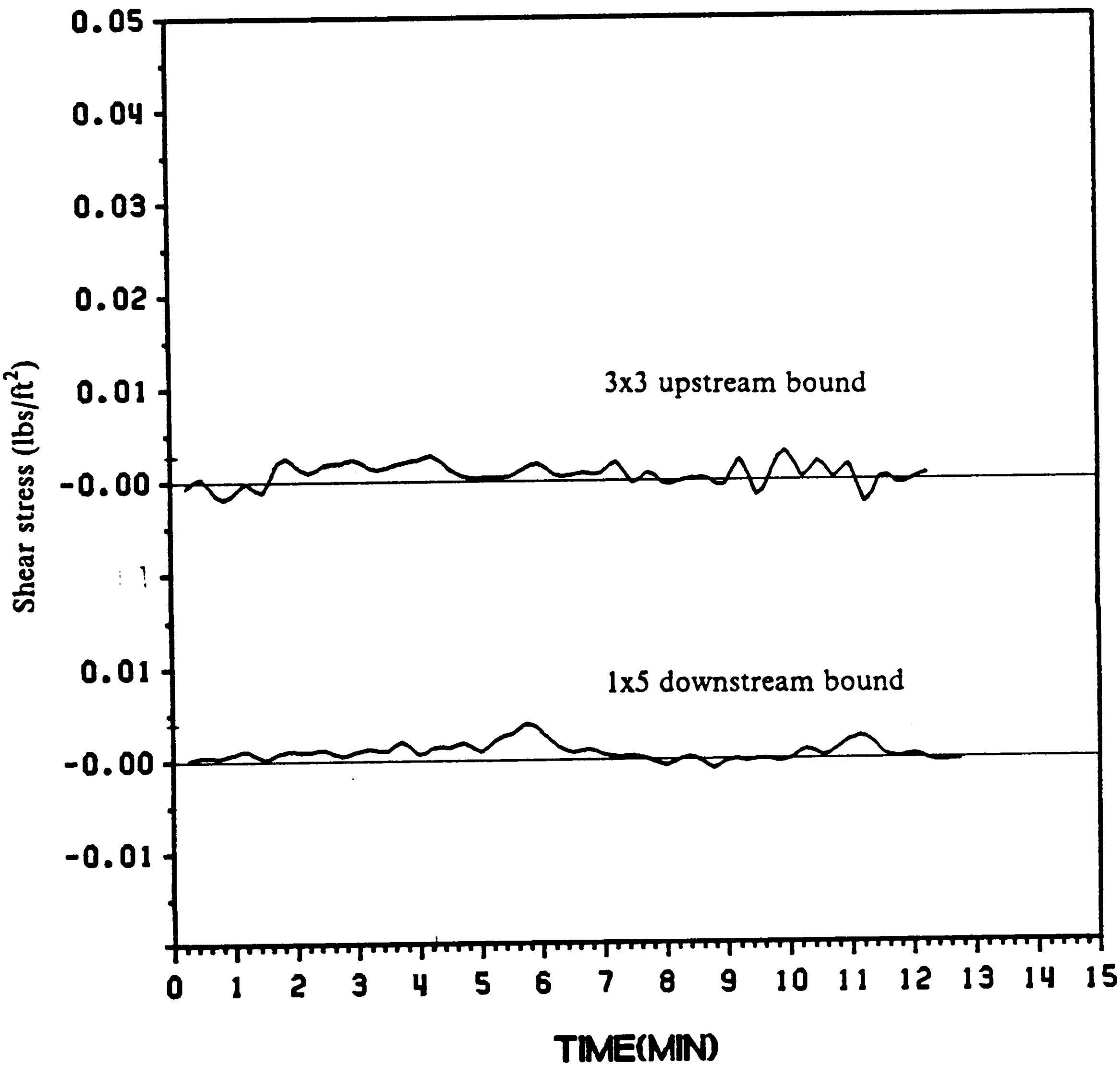


Figure 62. Comparison of Shear Stress at Cabin Creek Mouth due to Two Extremely Different Loaded Barge Scenarios

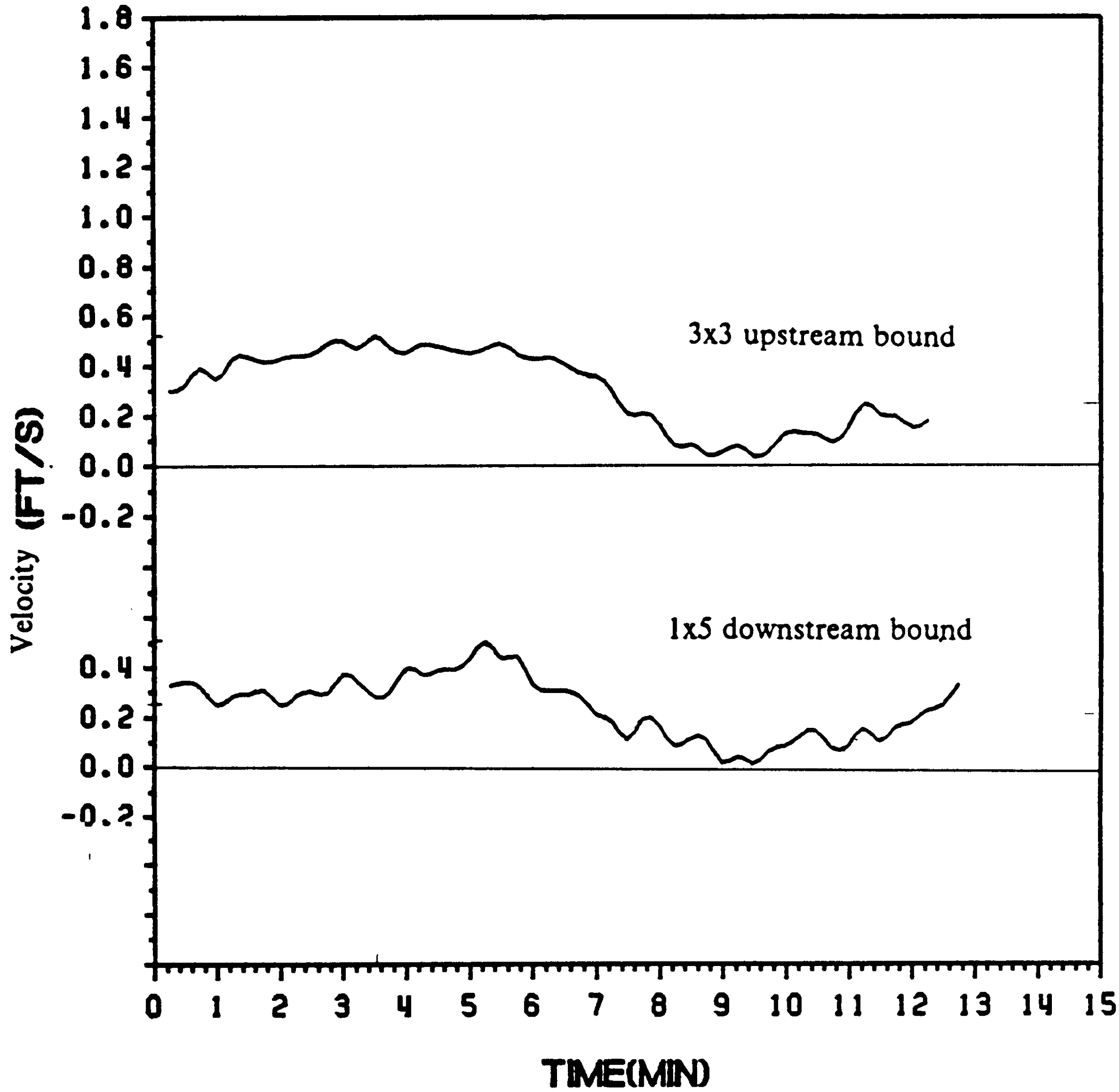


Figure 63. Change in Velocity Measured at 150 ft from the Mouth for Two Extremely Different Loaded Barge Scenarios passing Cabin Creek

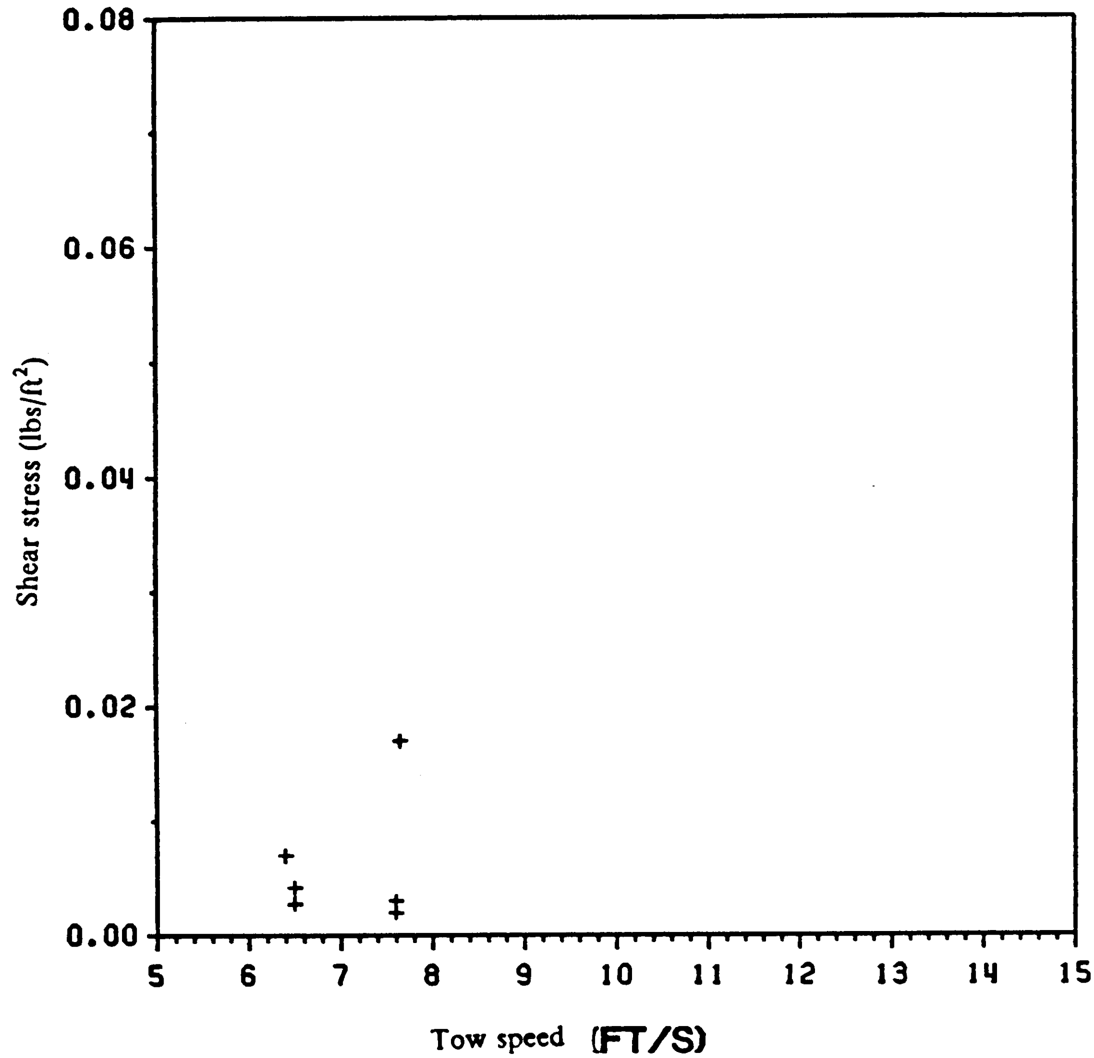


Figure 64. Maximum Shear Stress vs. Tow Speed at Mouth of Cabin Creek

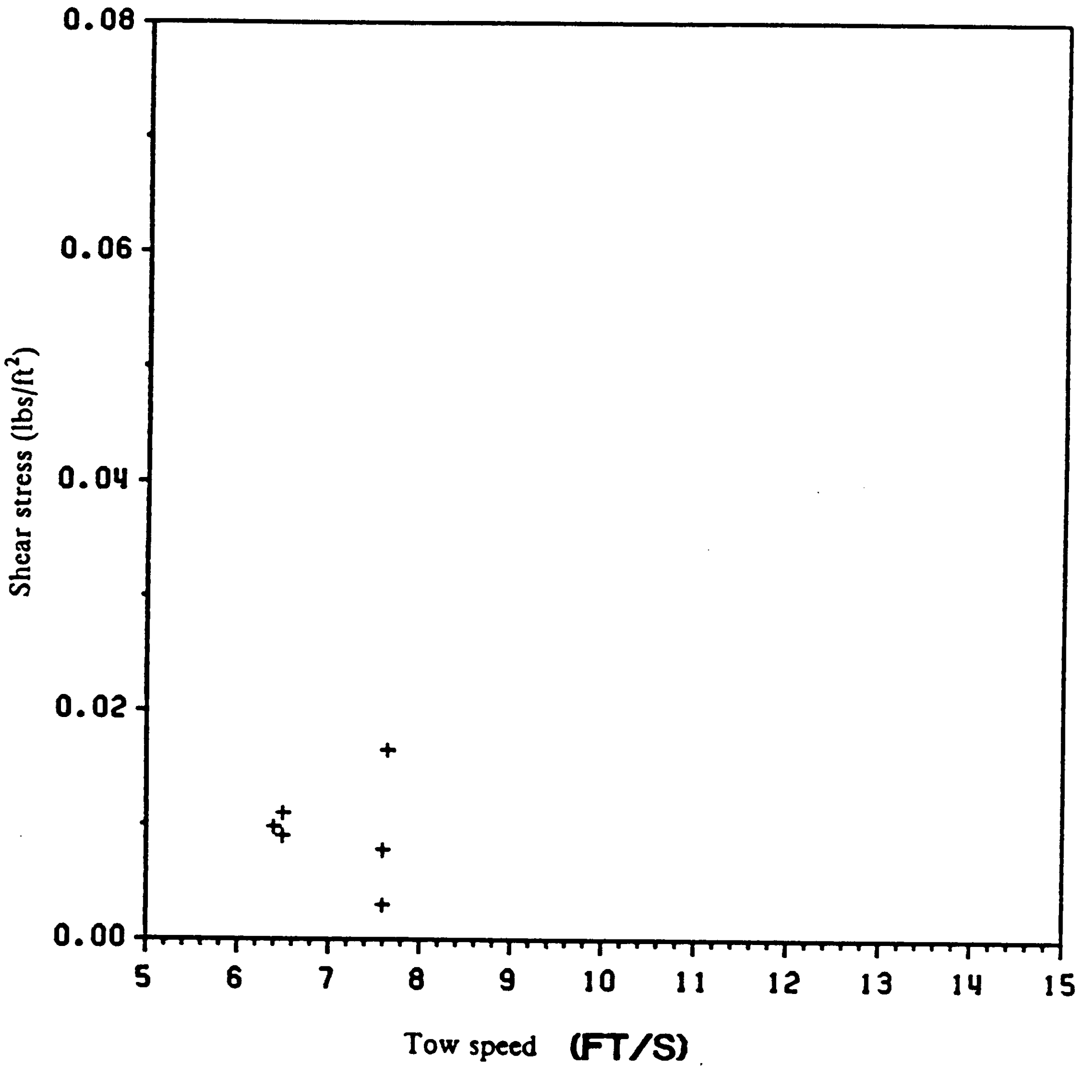


Figure 65. Maximum Shear Stress vs. Tow Speed 150 ft from Mouth of Cabin Creek

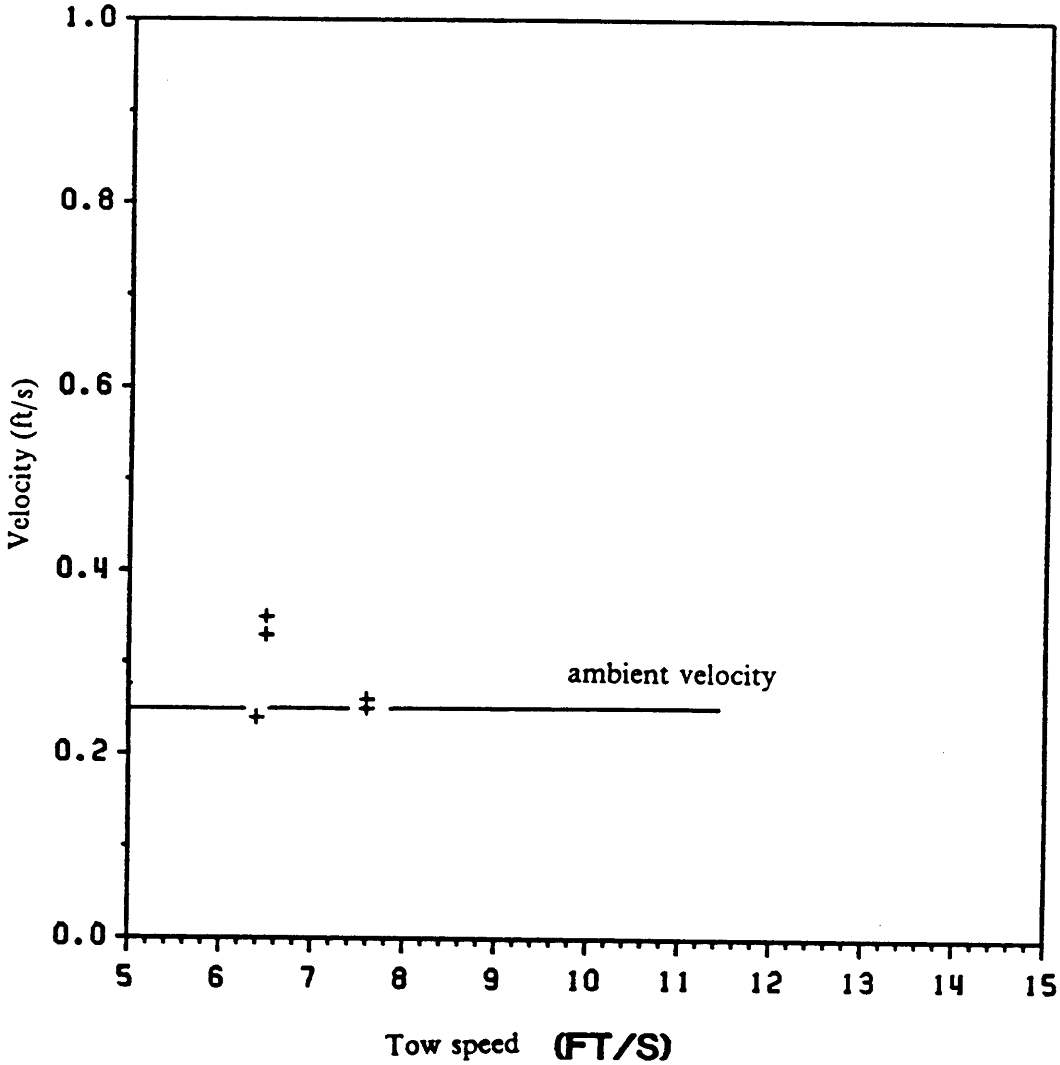


Figure 66. Maximum Velocity vs. Tow Speed at Mouth of Cabin Creek

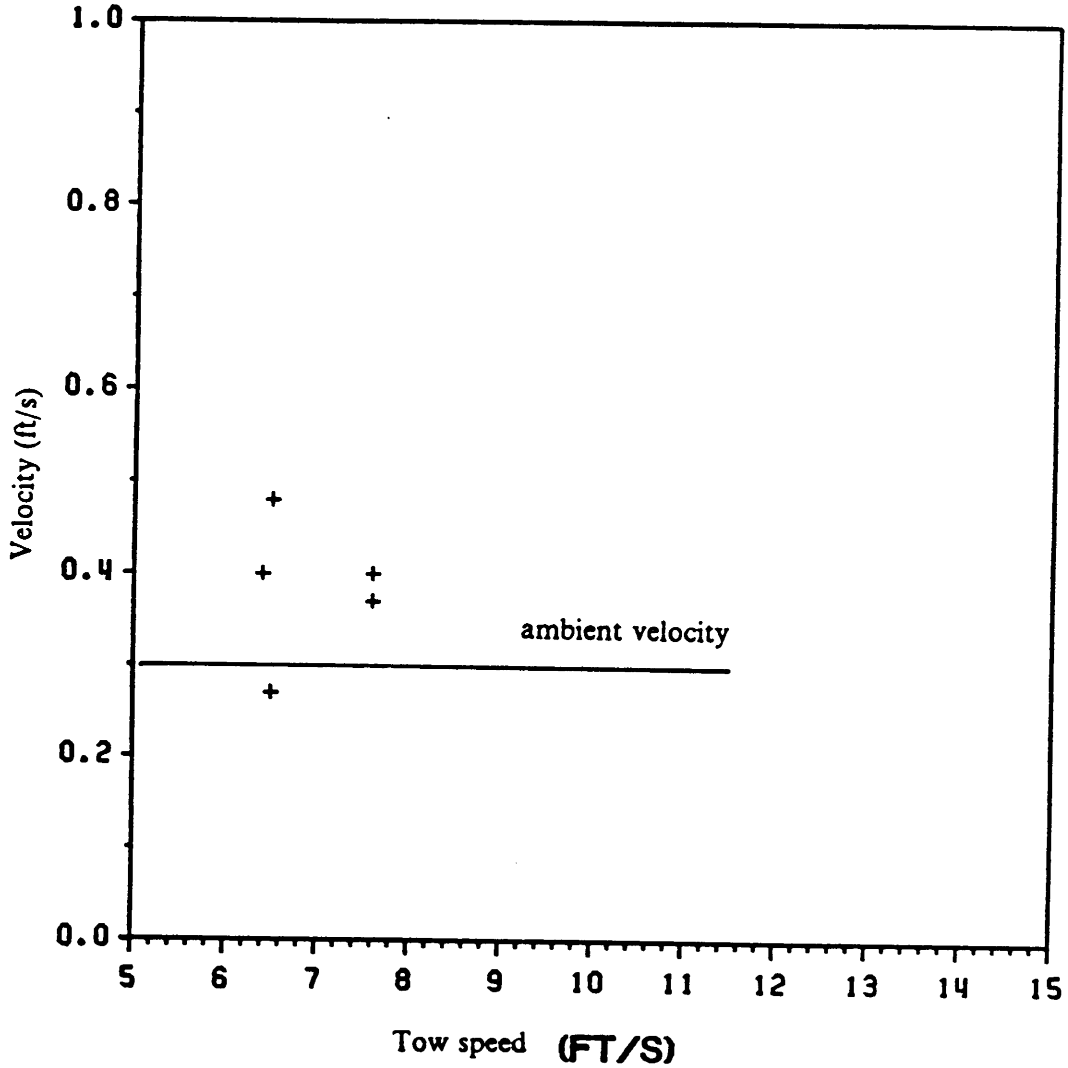


Figure 67. Maximum Velocity vs. Tow Speed 150 ft from Mouth of Cabin Creek

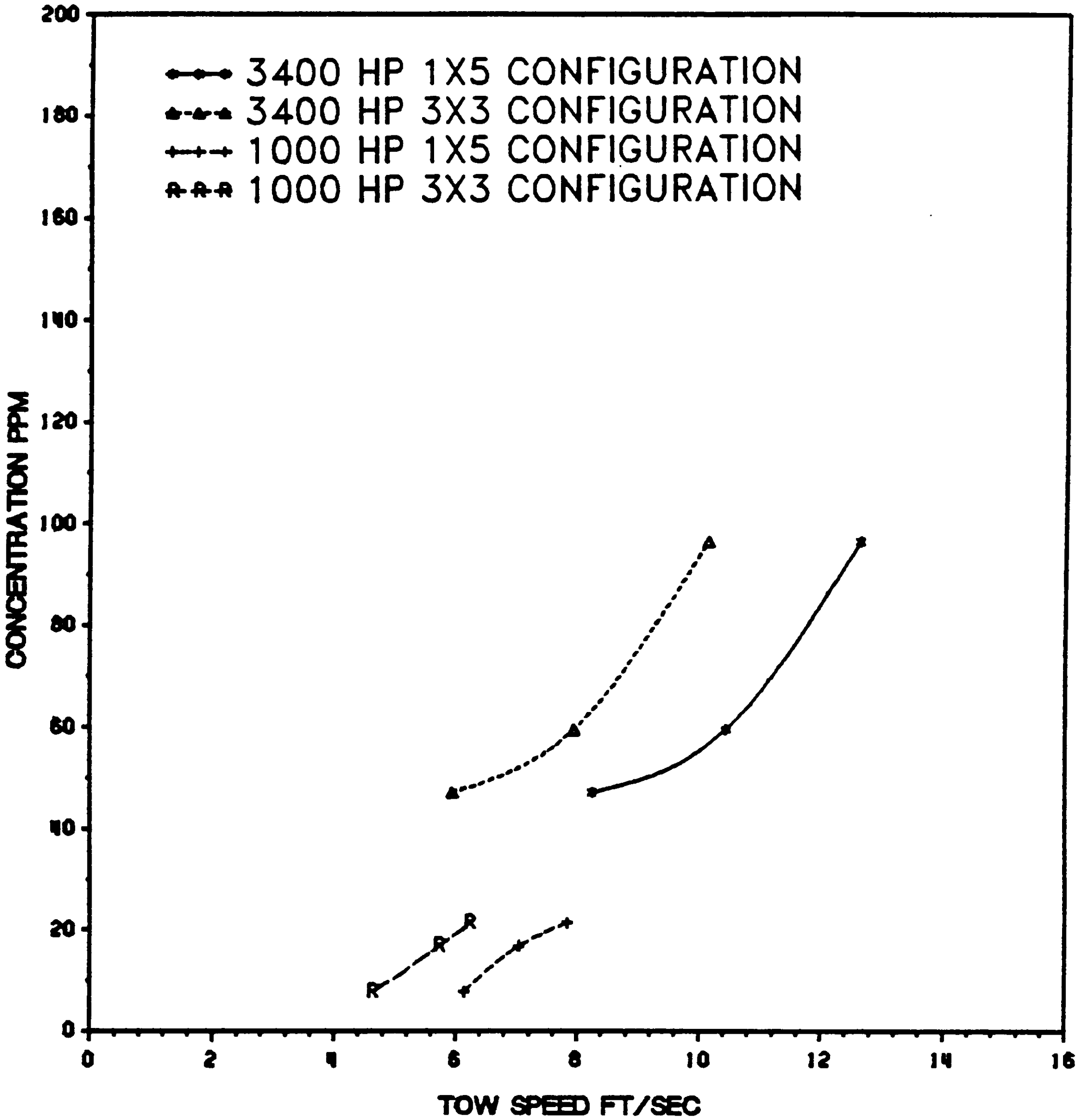


Figure 68. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr. Low Summer Flow, Loaded Downstream Tow, at River Mile 73.1

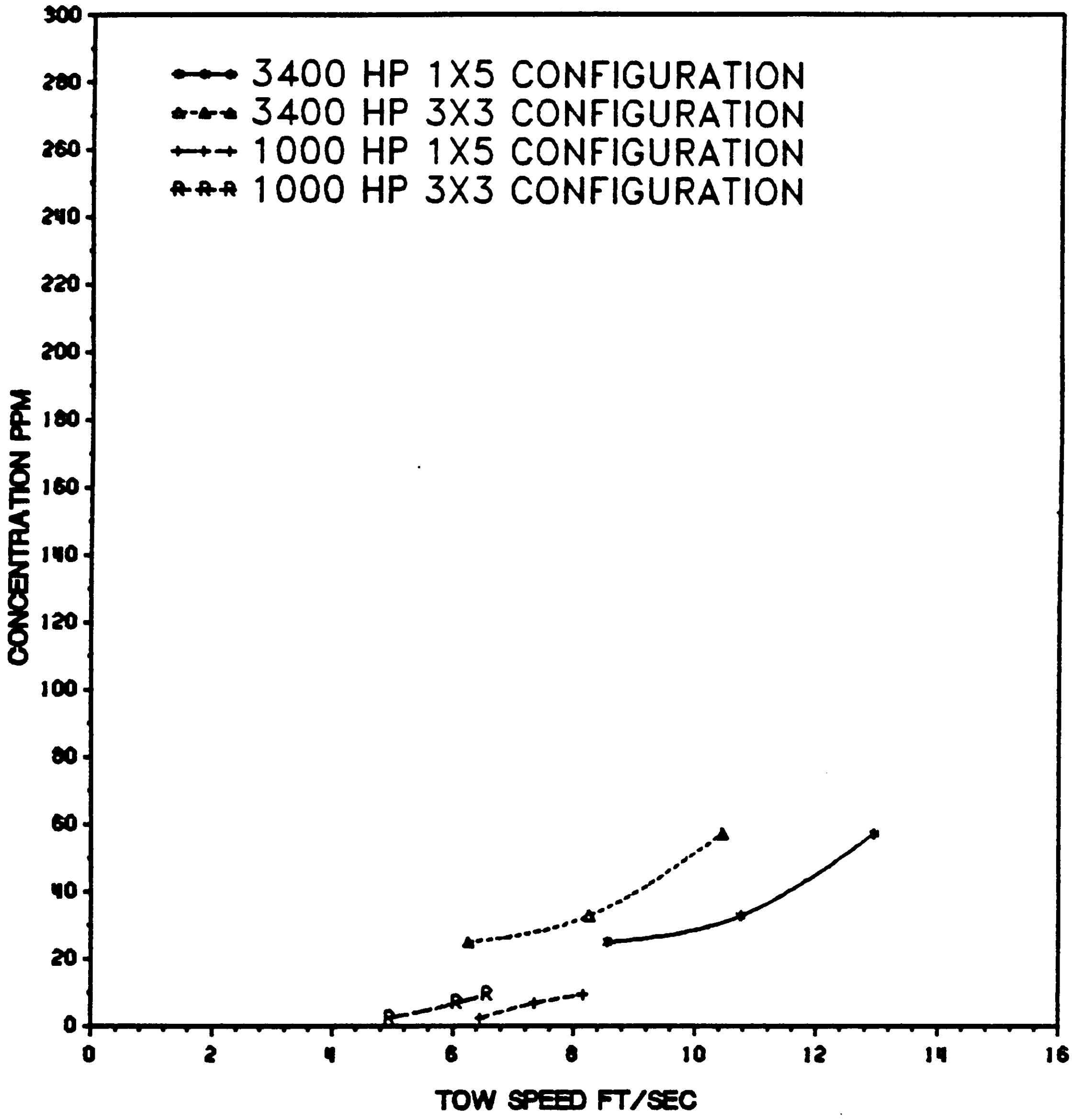


Figure 69. Propeller Induced Sediment Concentration vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 73.1

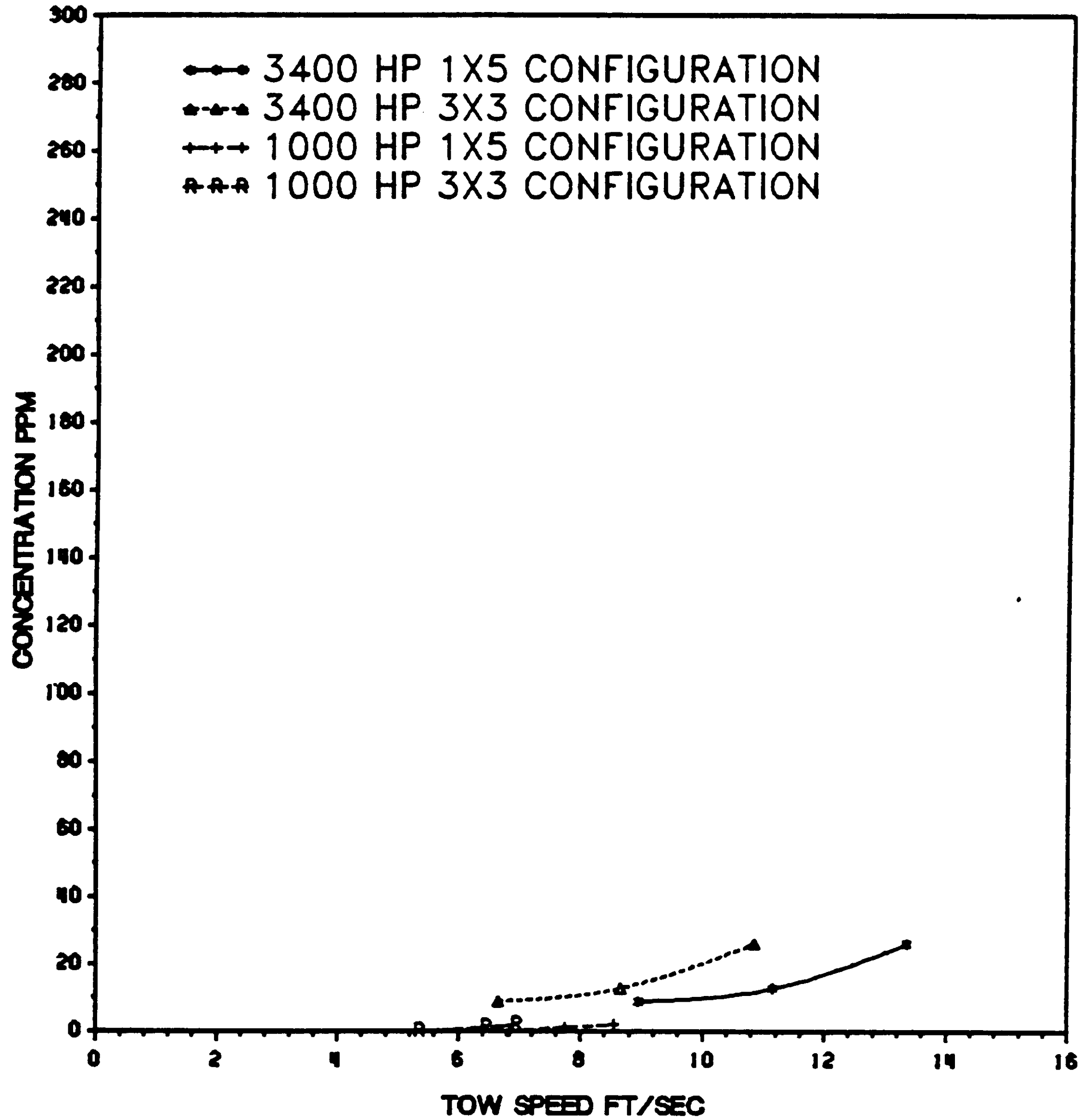


Figure 70. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 73.1

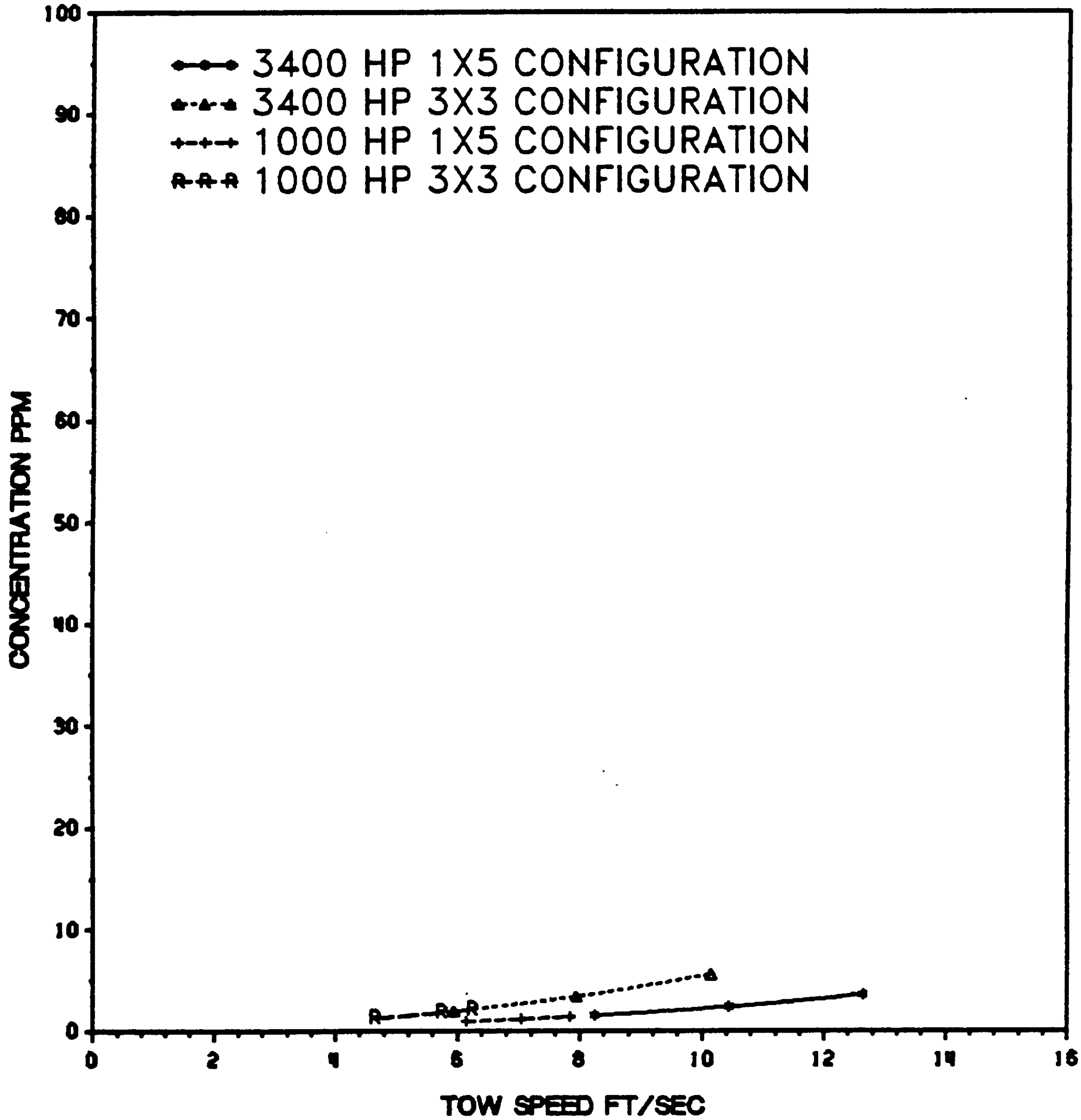


Figure 71. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr.Low Summer Flow, Loaded Downstream Tow, at River Mile 73.1

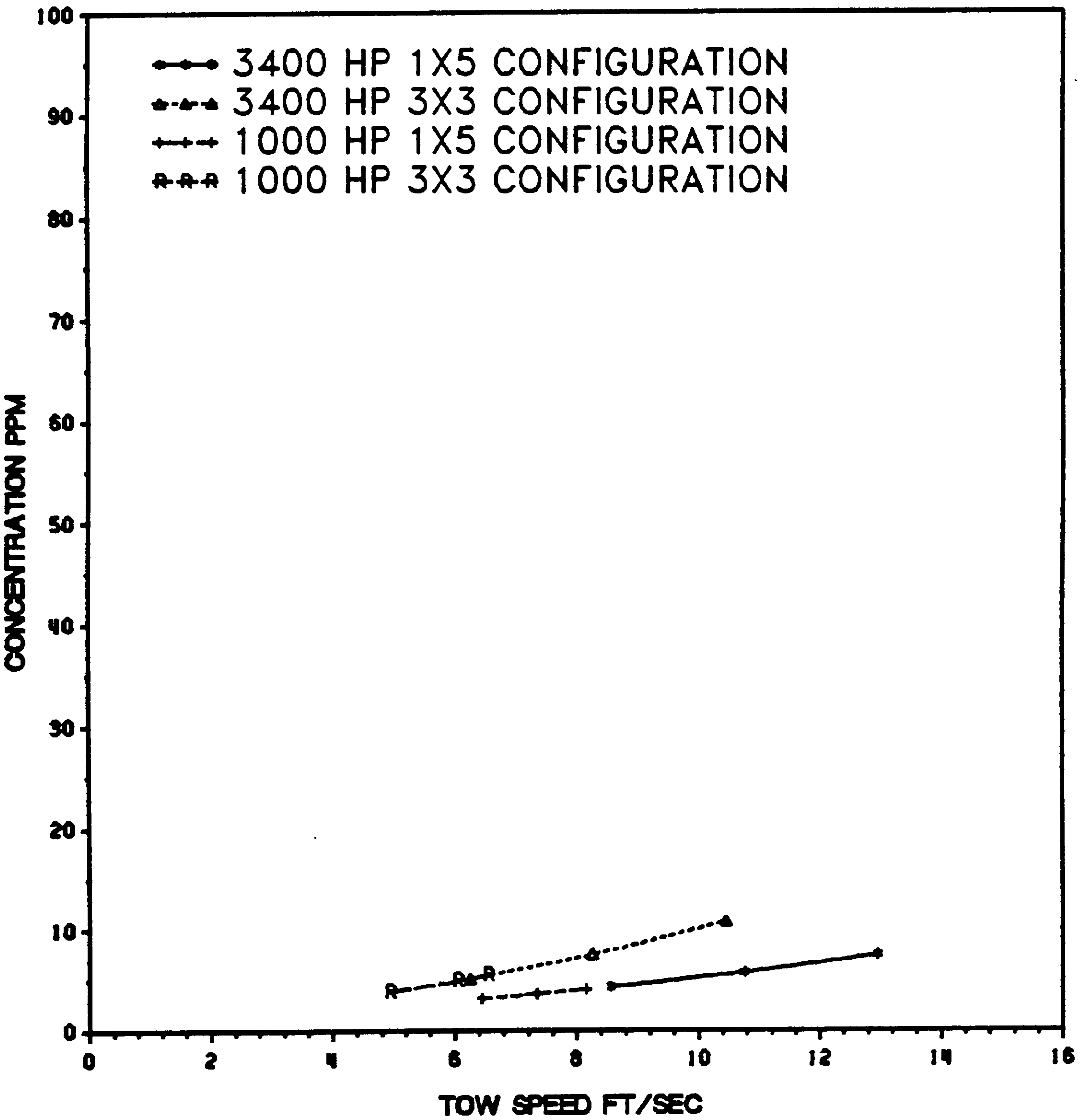


Figure 72. Backwater Induced Sediment Concentration vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 73.1

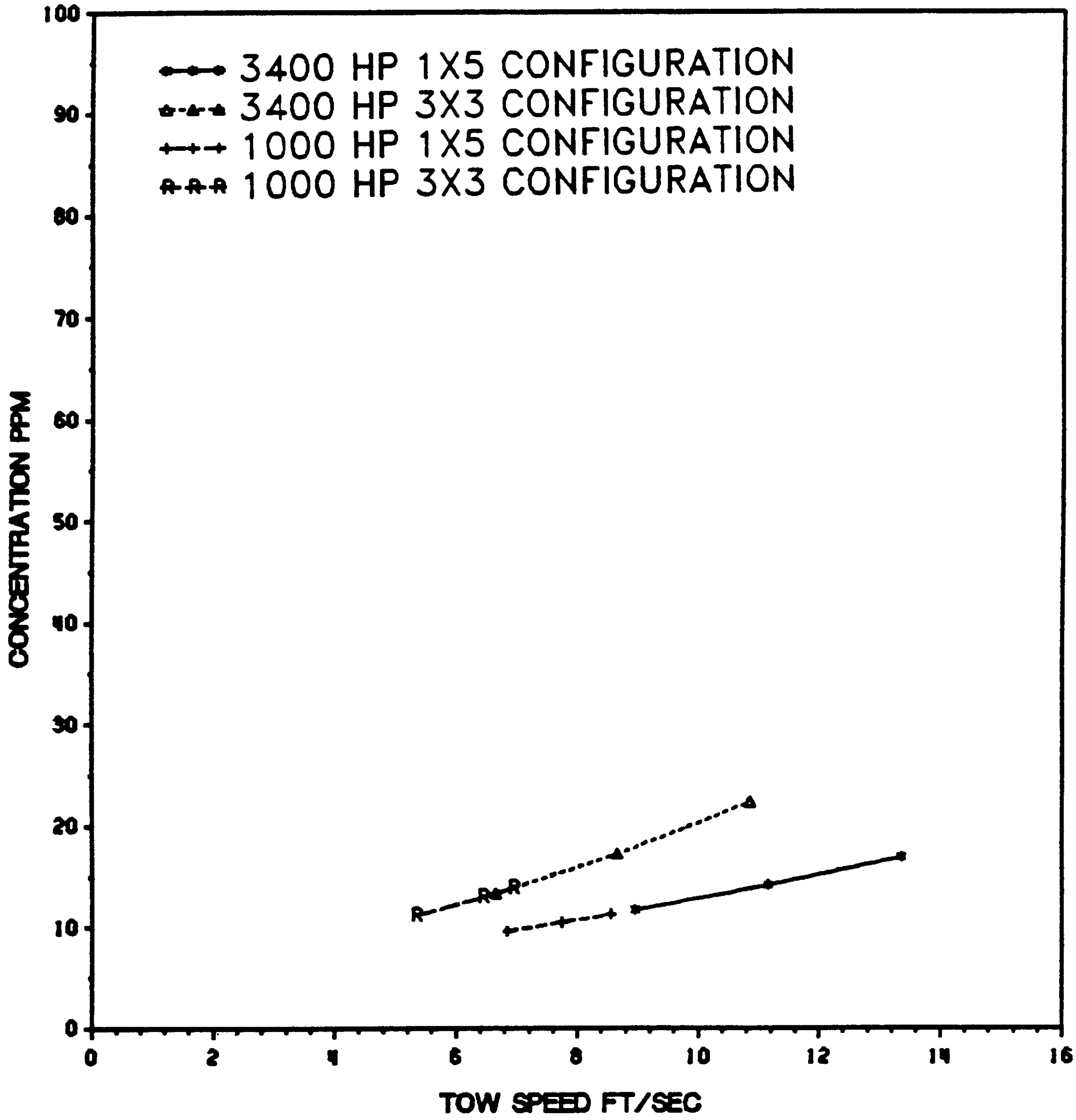


Figure 73. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 73.1

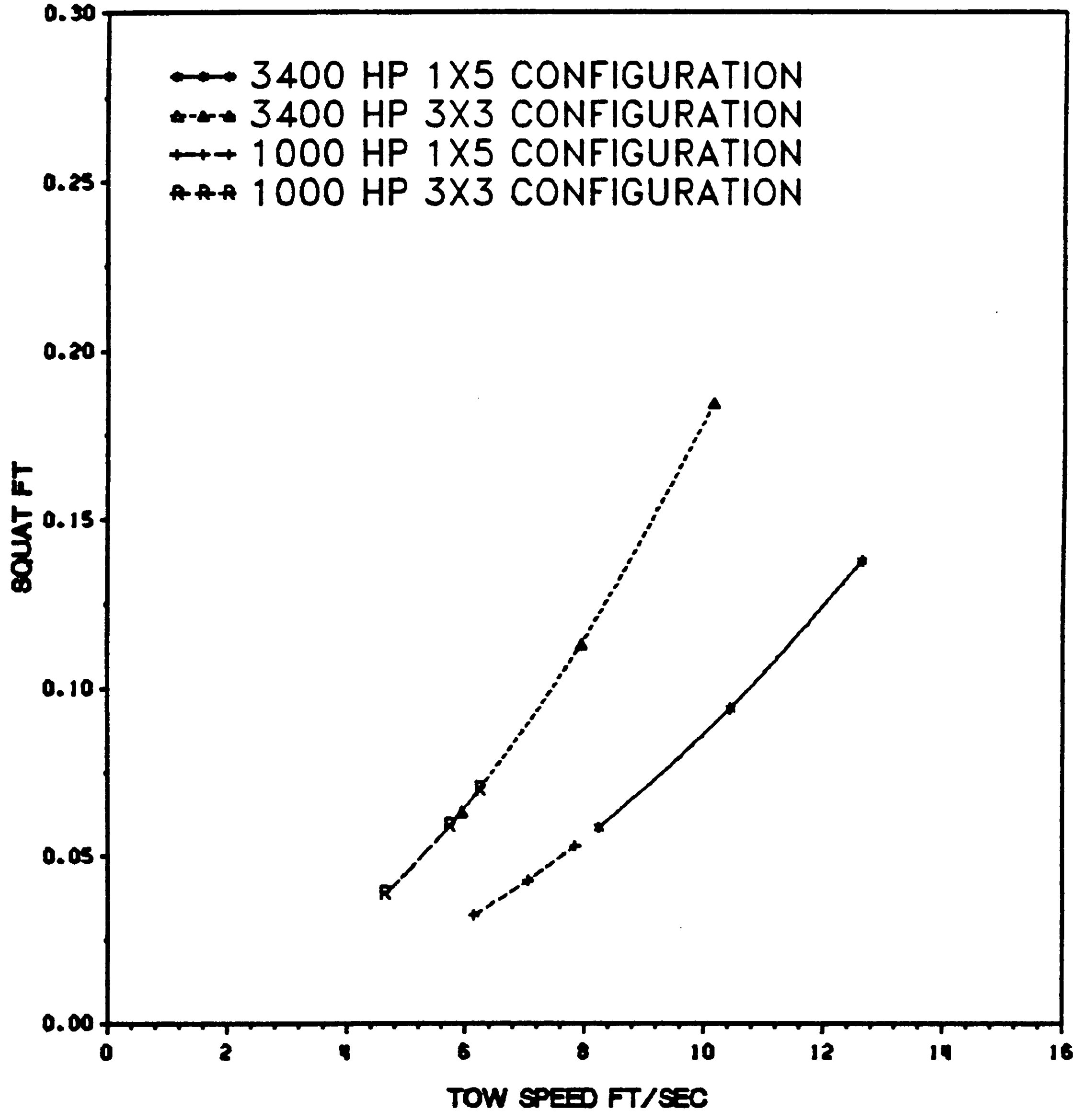


Figure 74. Squat vs. Tow Speed for 5-yr. Low Summer Flow, Loaded Downstream Tow, at River Mile 73.1

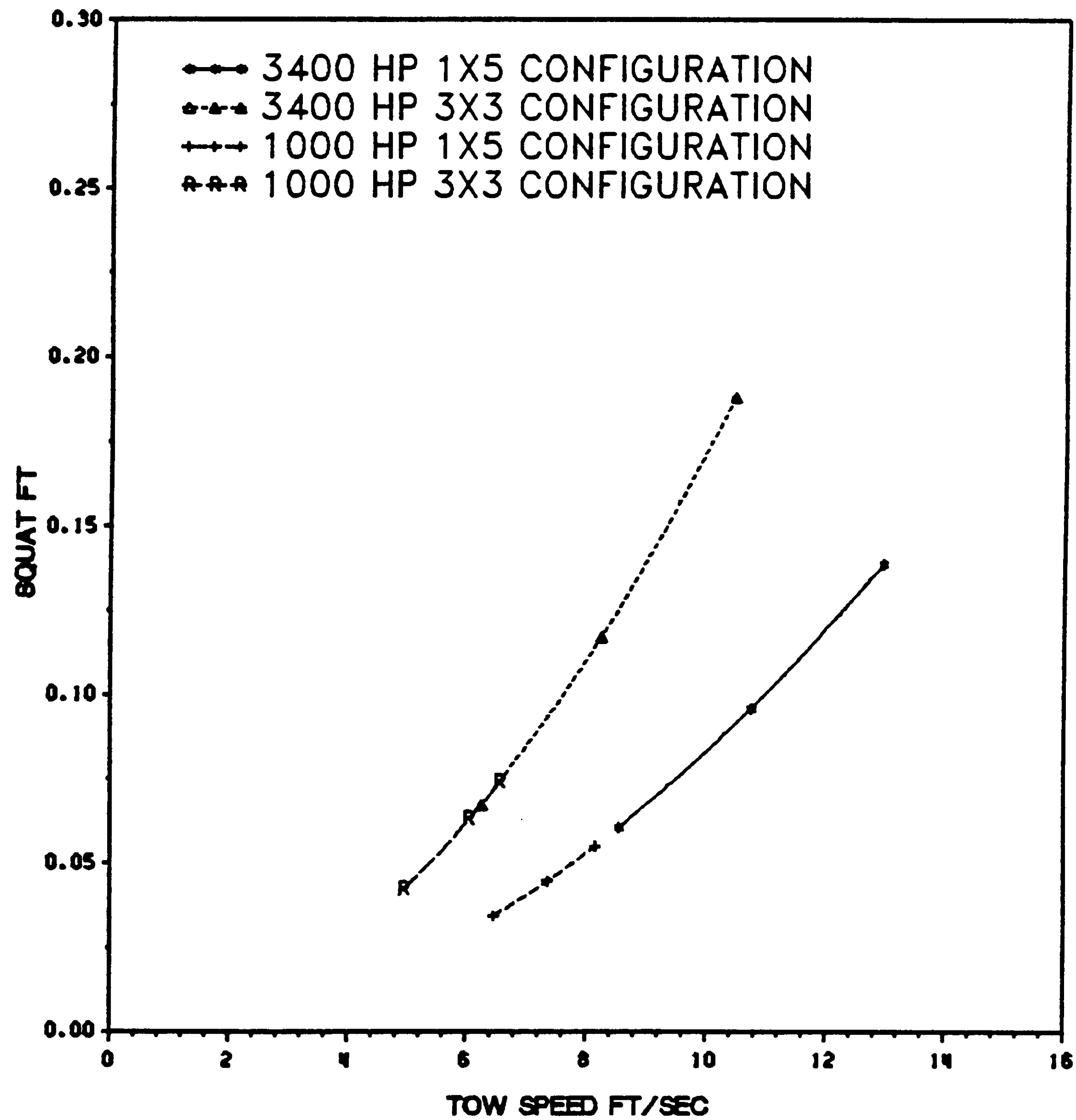


Figure 75. Squat vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 73.1

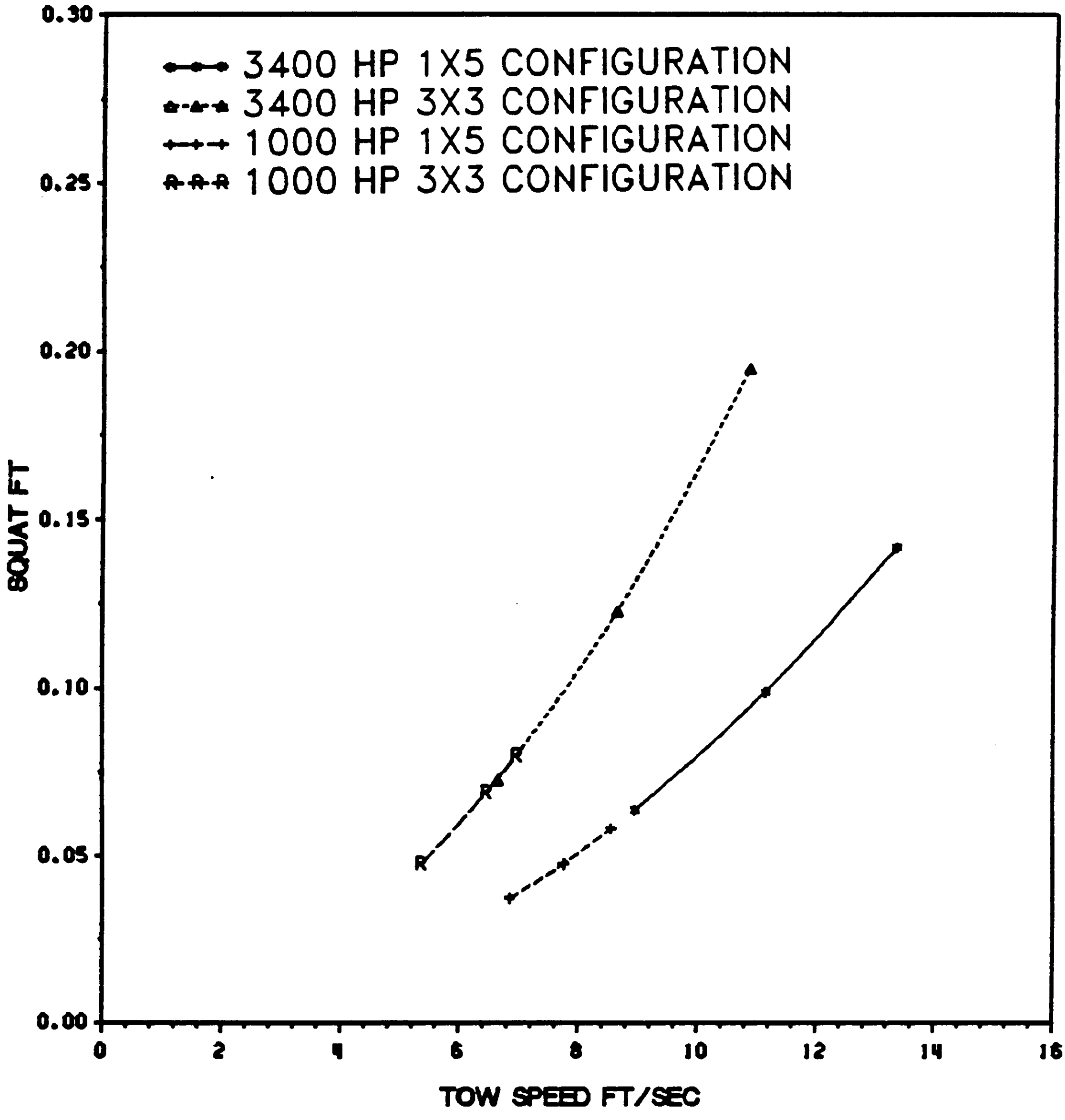


Figure 76. Squat vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 73.1

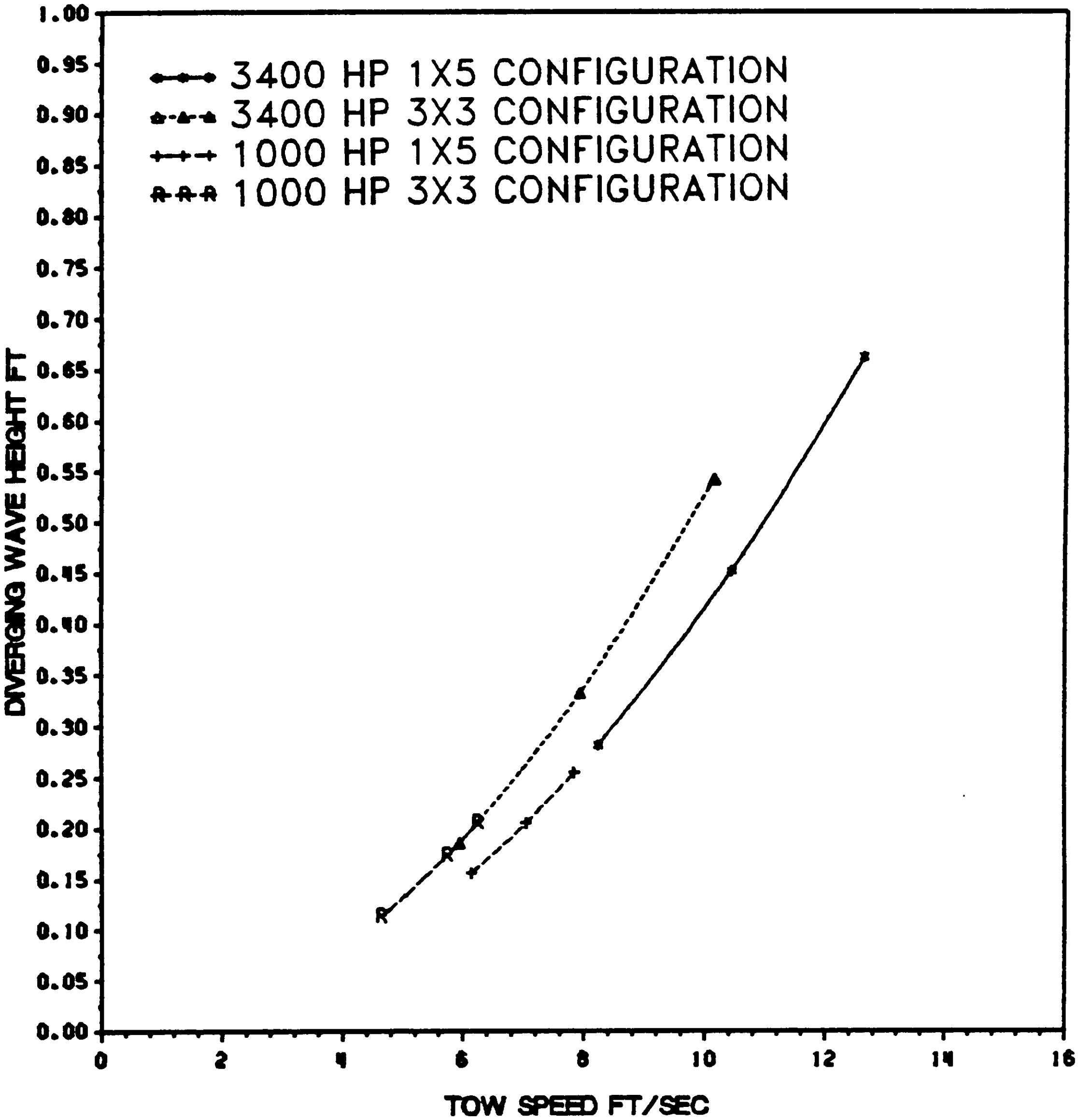


Figure 77. Diverging Wave Height vs. Tow Speed for 5-yr. Low Summer Flow, Loaded Downstream Tow, at River Mile 73.1

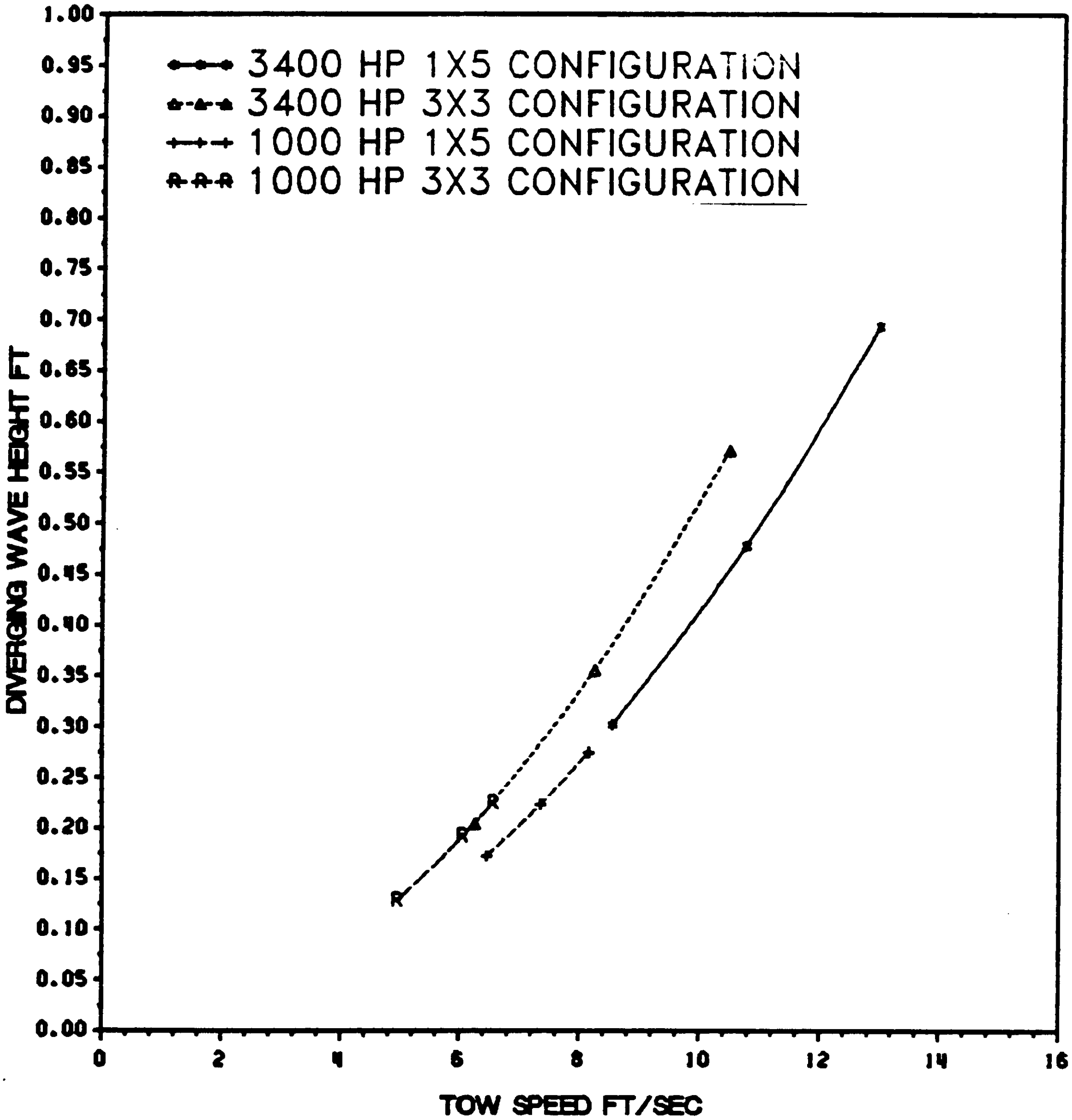


Figure 78. Diverging Wave Height vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 73.1

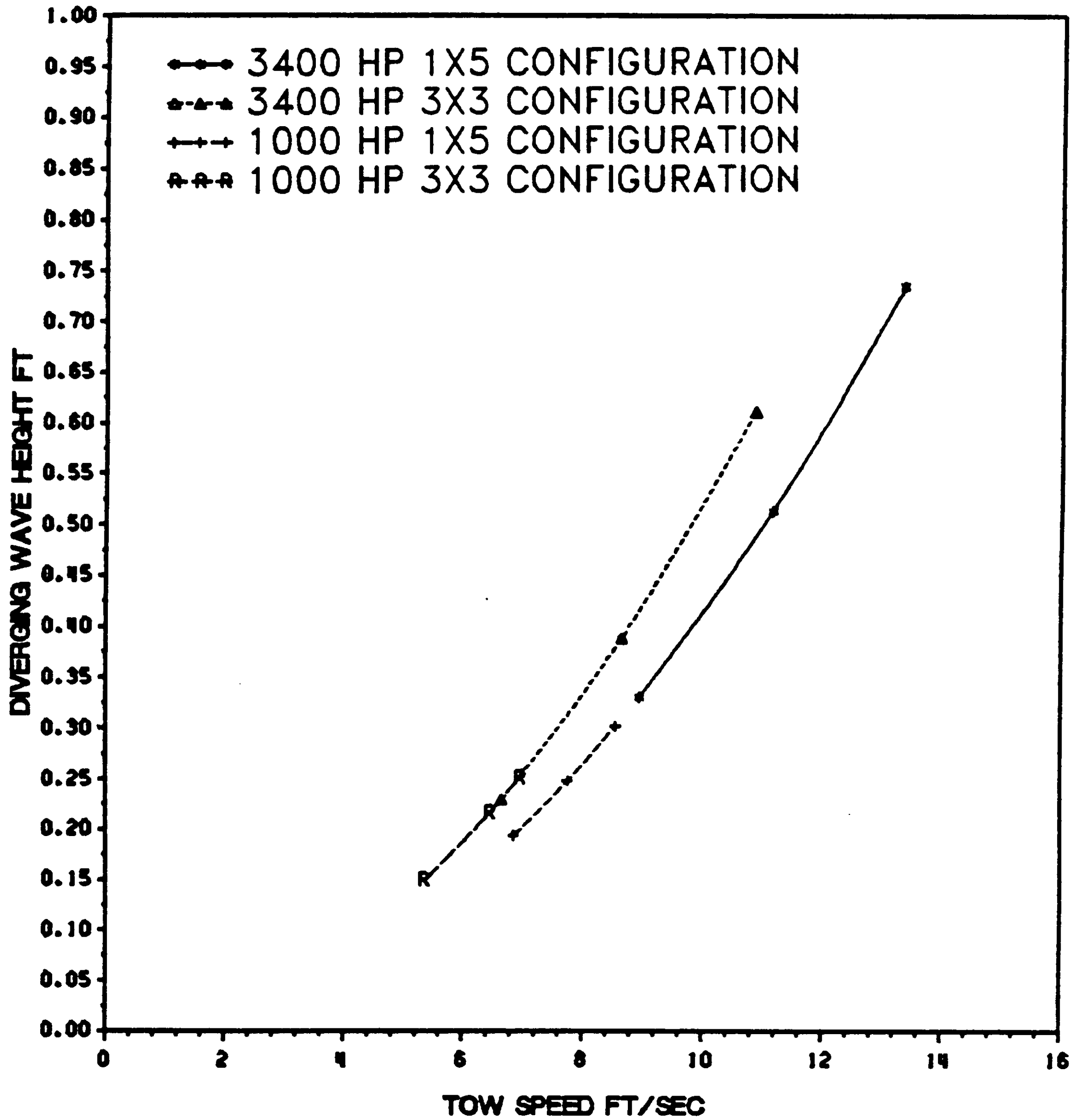


Figure 79. Diverging Wave Height vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 73.1

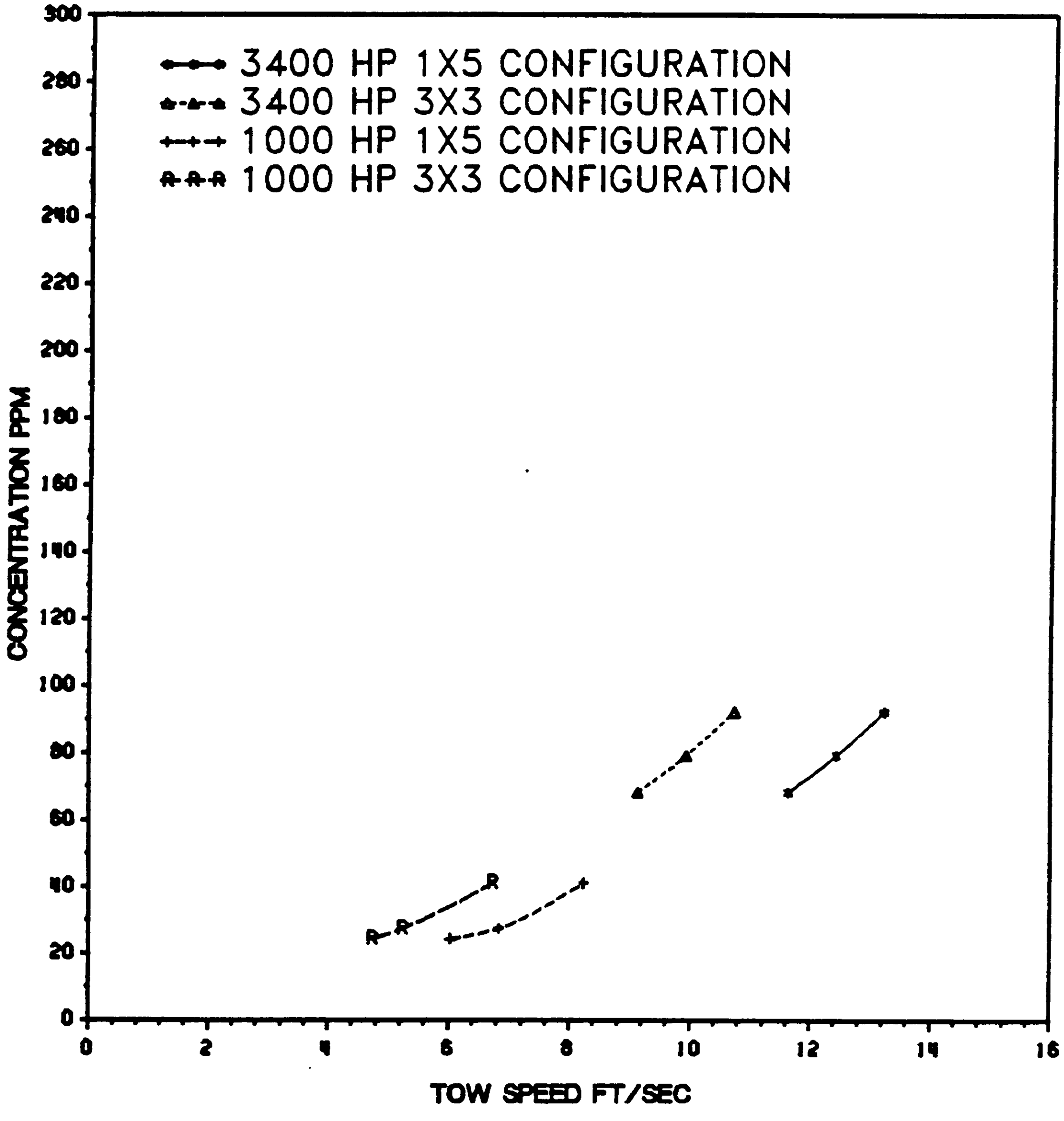


Figure 80. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr. Low Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

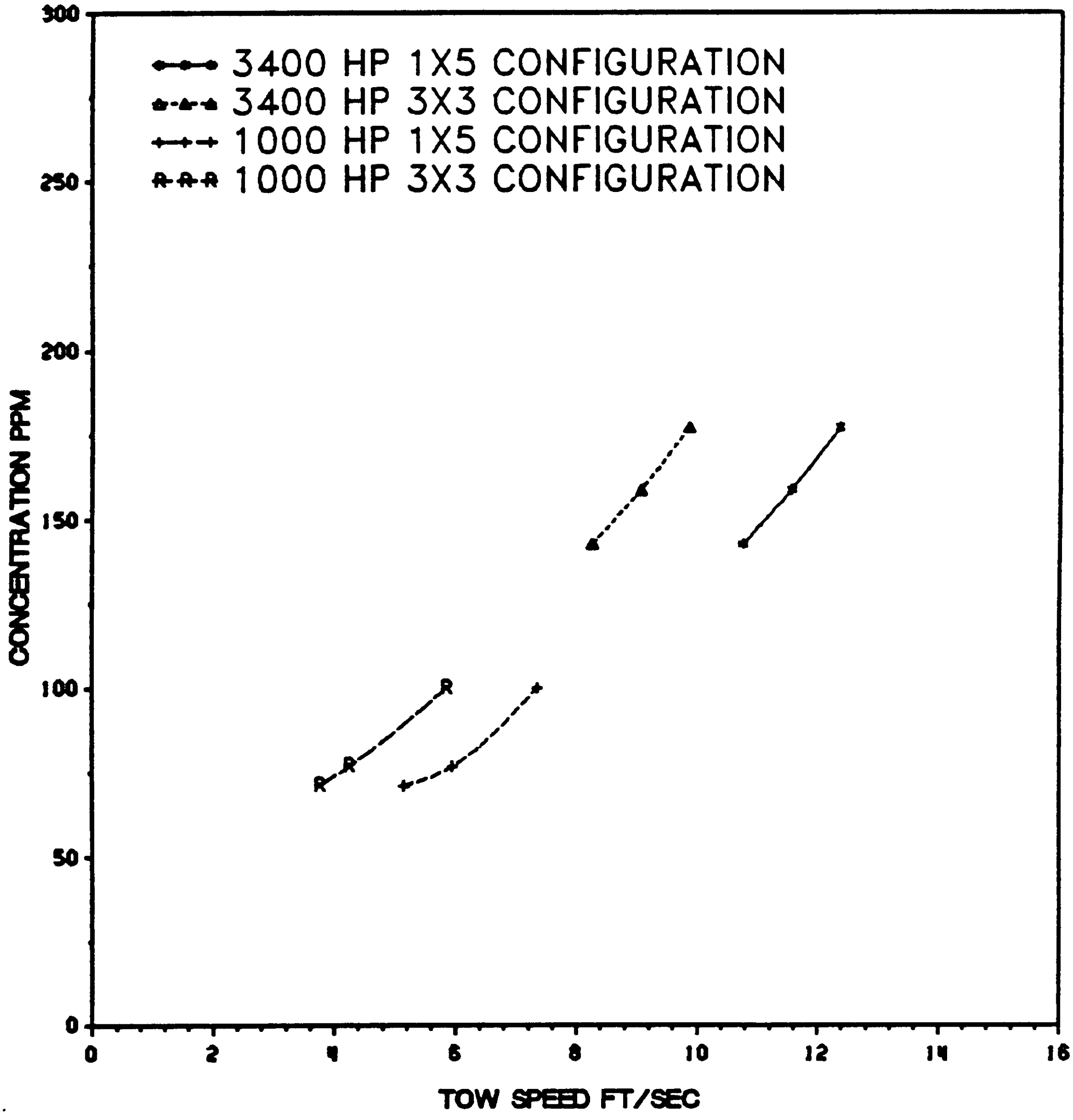


Figure 81. Propeller Induced Sediment Concentration vs. Tow Speed for Mean Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

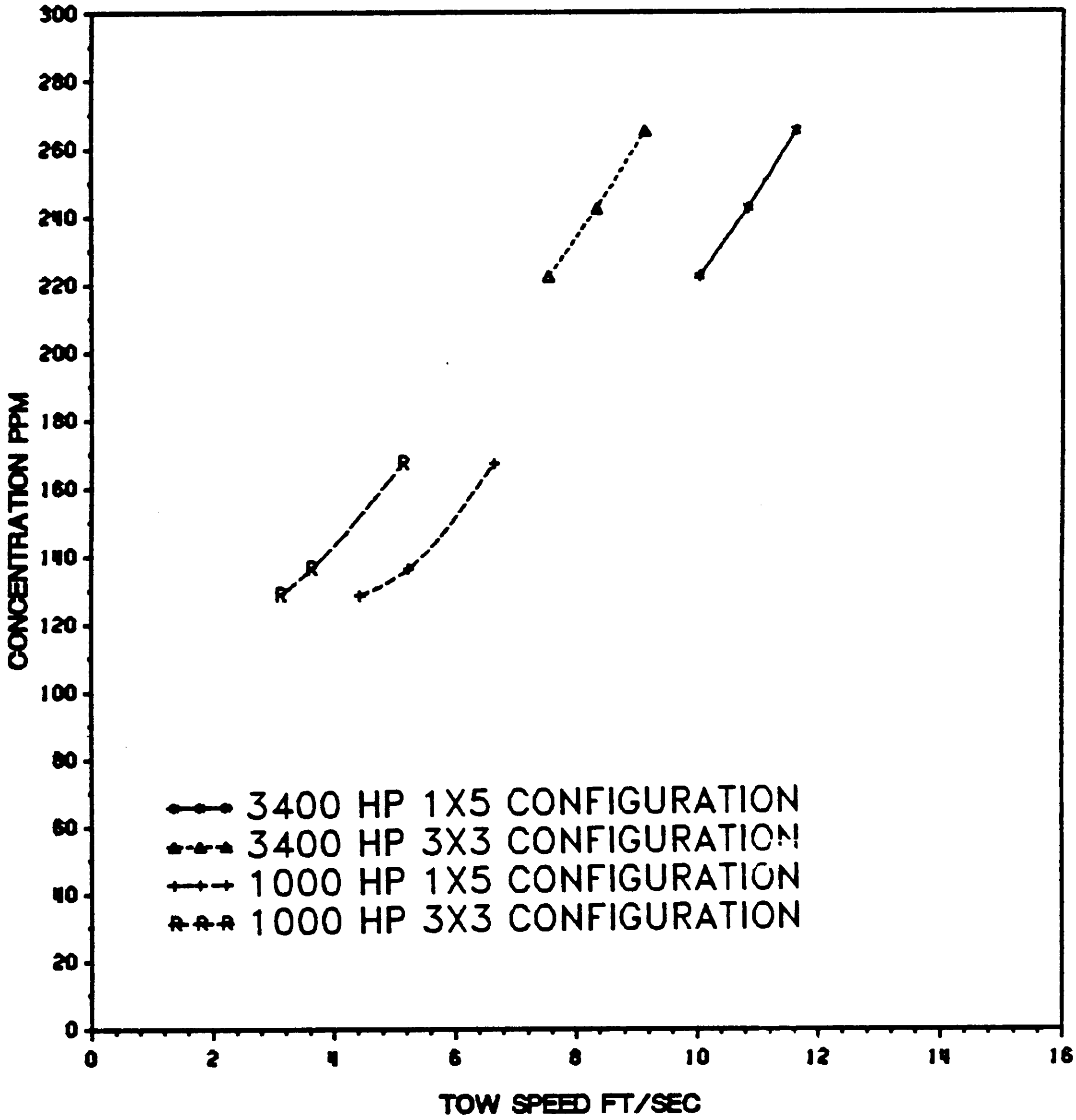


Figure 82. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr High Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

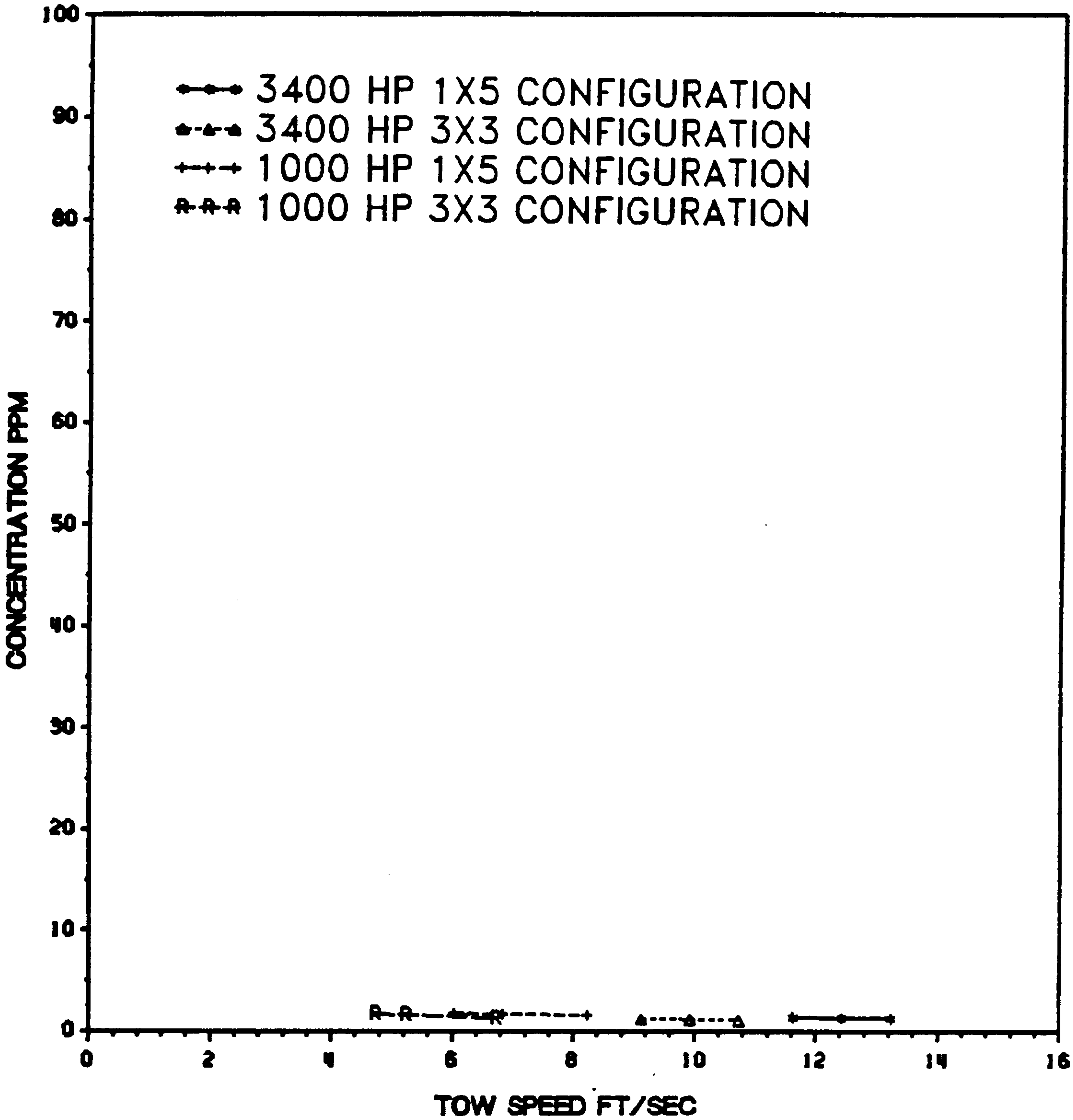


Figure 83. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr. Low Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

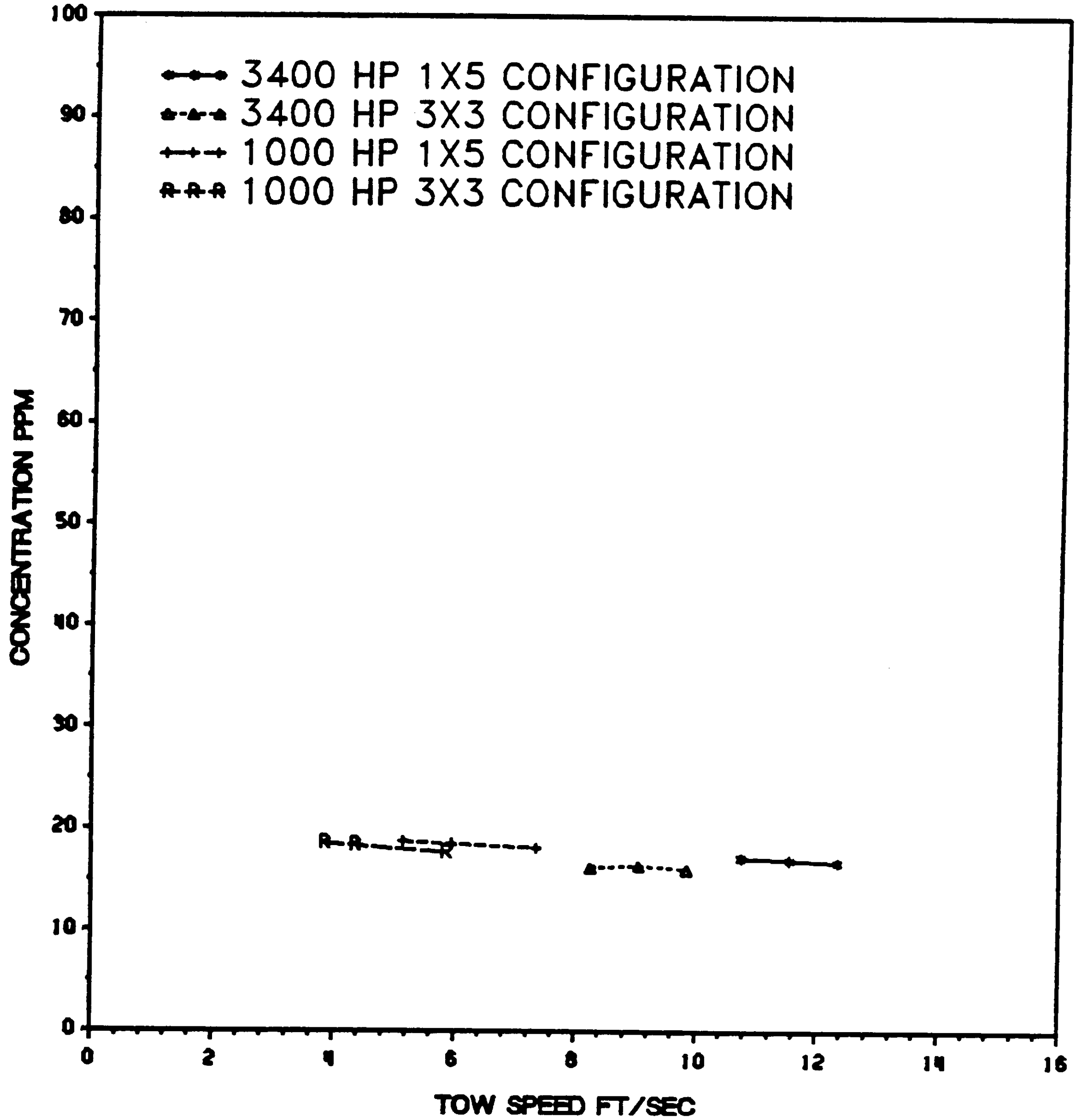


Figure 84. Backwater Induced Sediment Concentration vs. Tow Speed for Mean Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

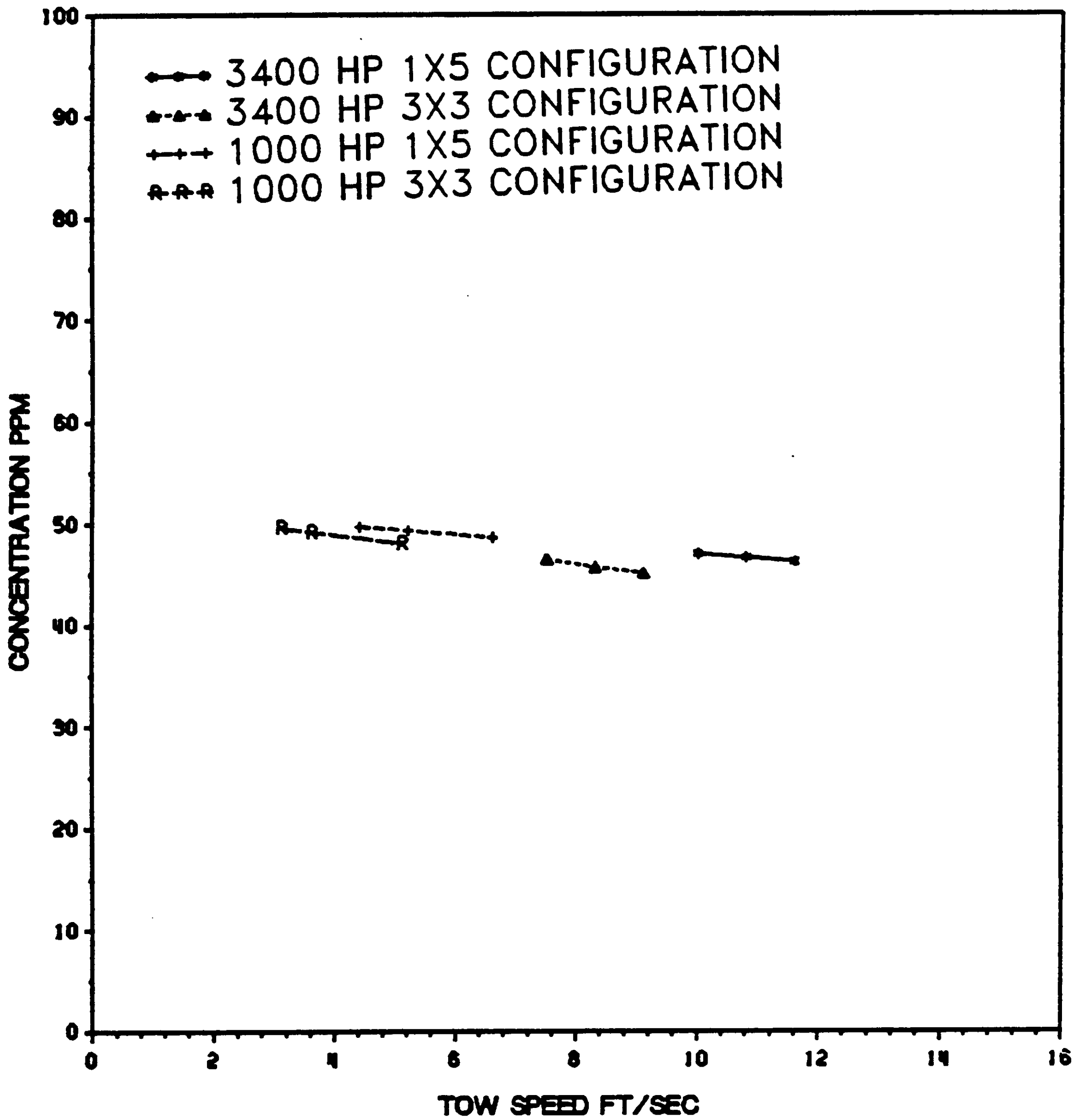


Figure 85. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr High Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

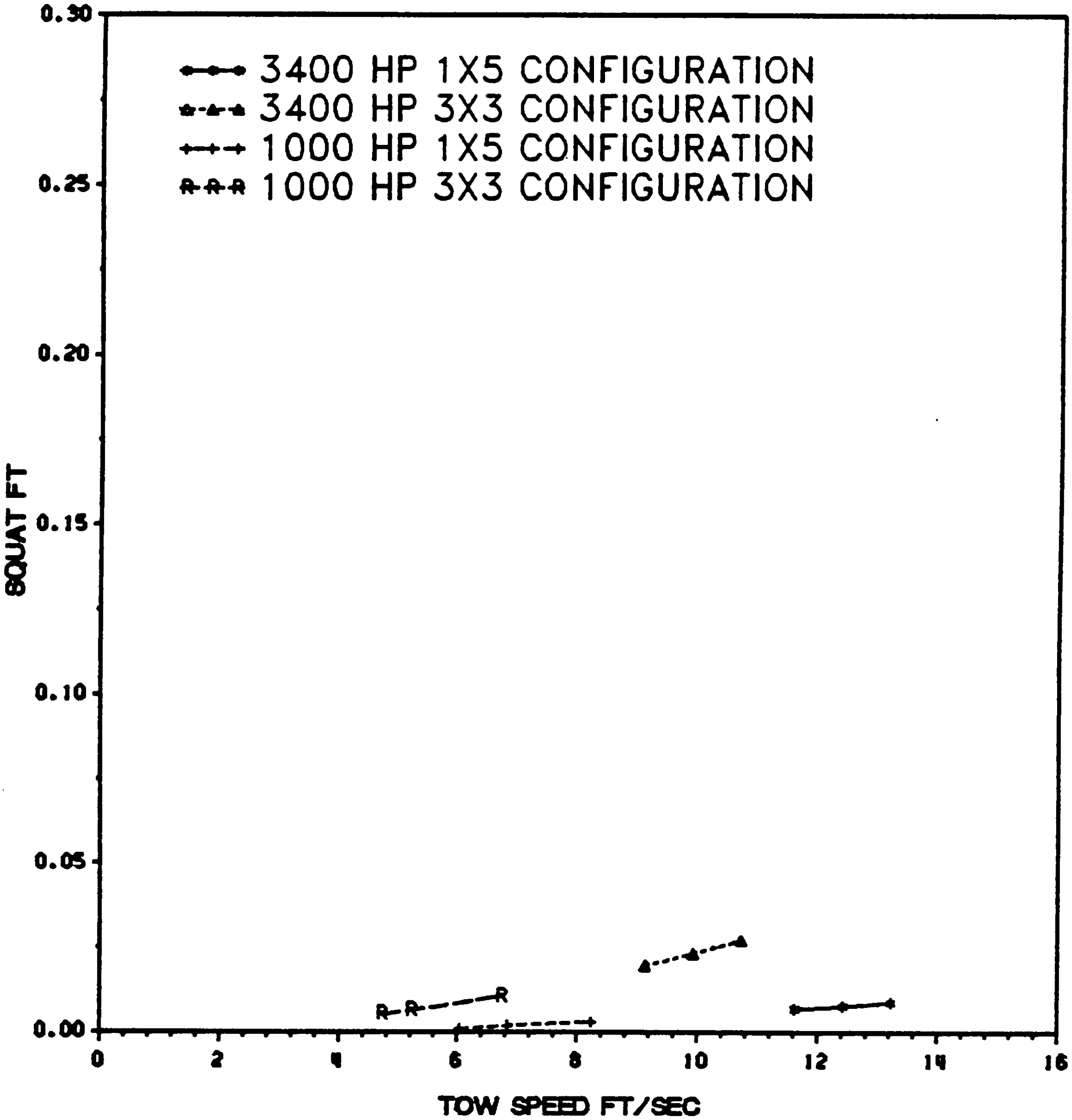


Figure 86. Squat vs. Tow Speed for 5-yr. Low Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

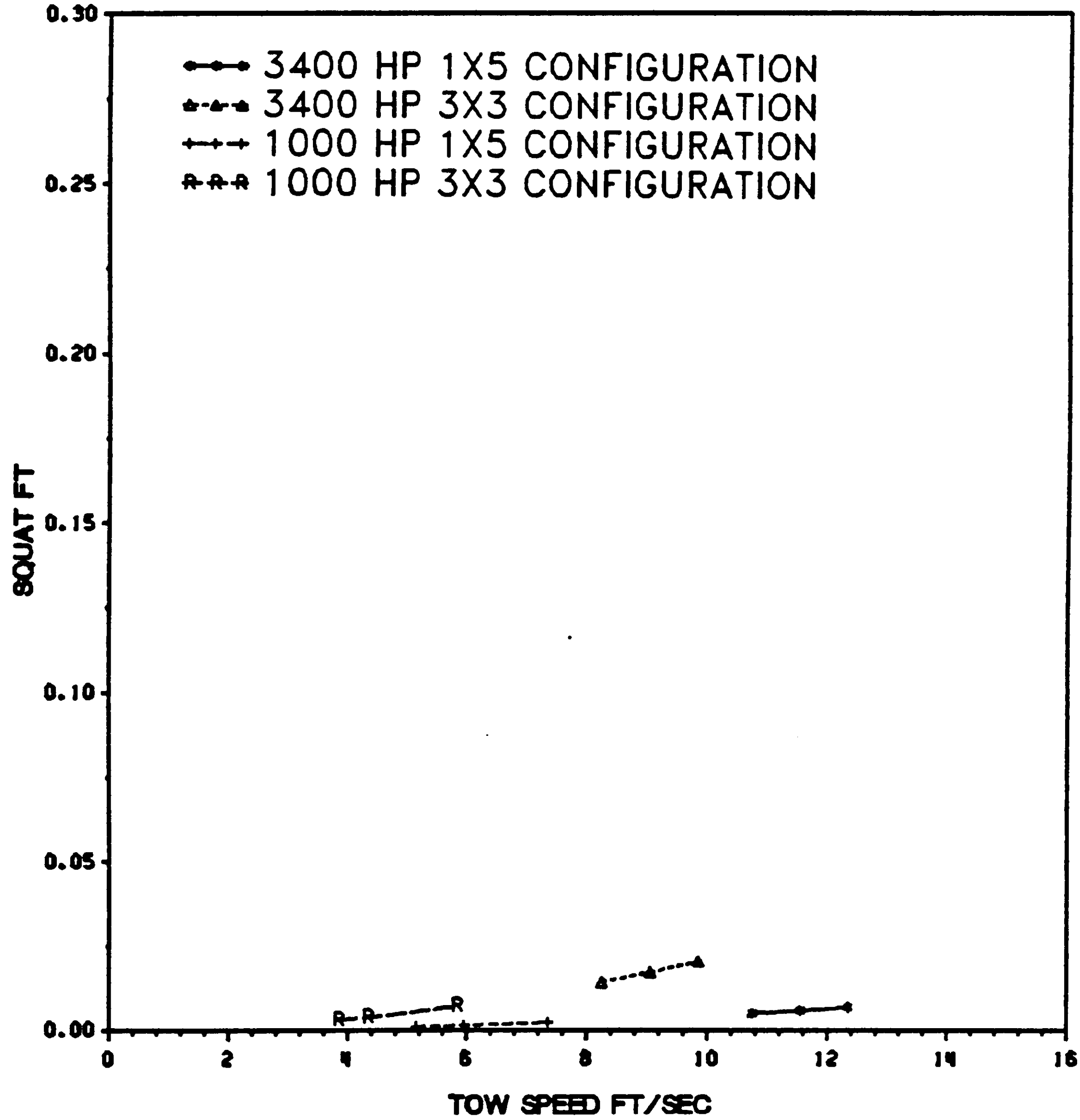


Figure 87. Squat vs. Tow Speed for Mean Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

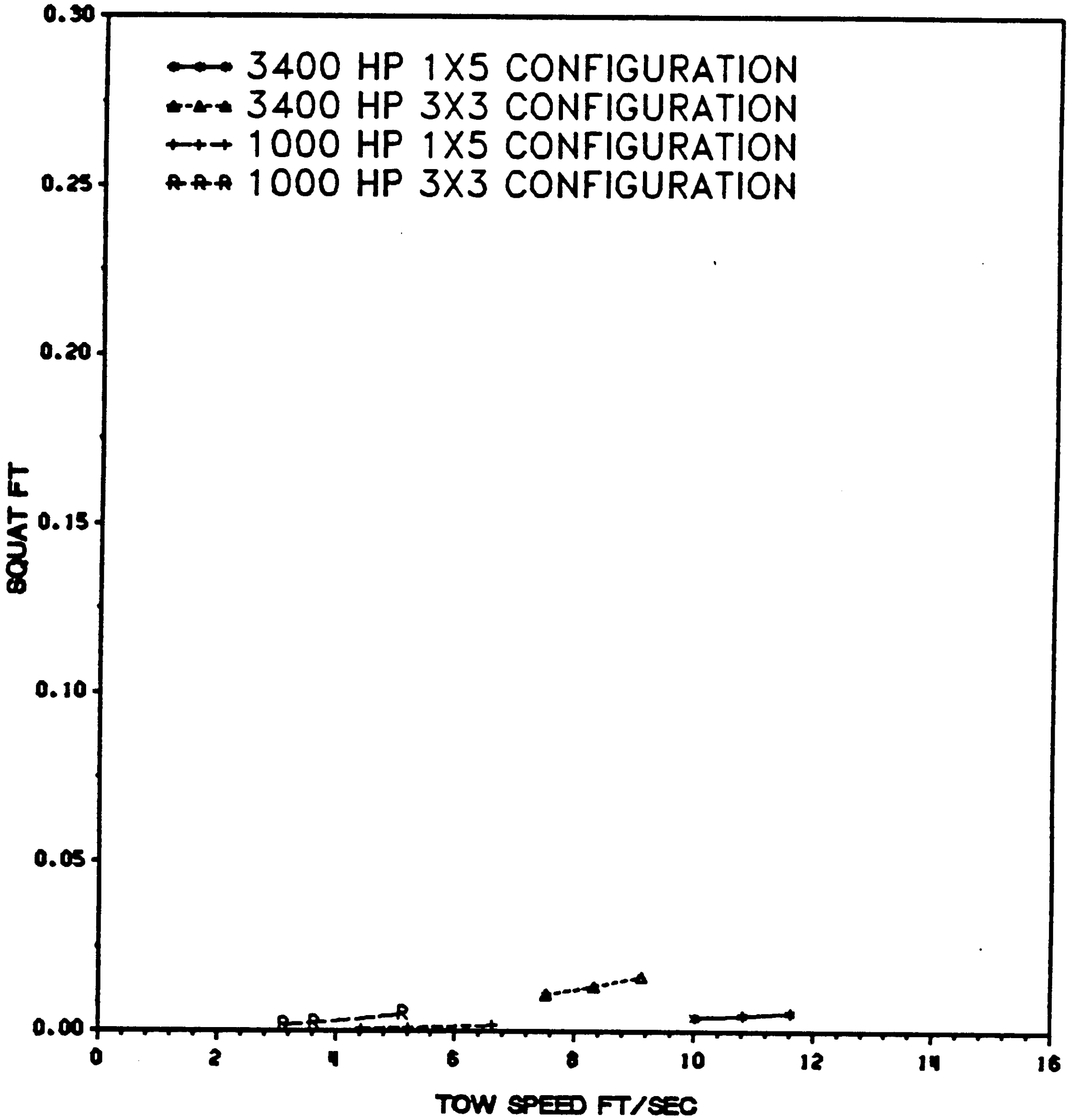


Figure 88. Squat vs. Tow Speed for 5-yr. High Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

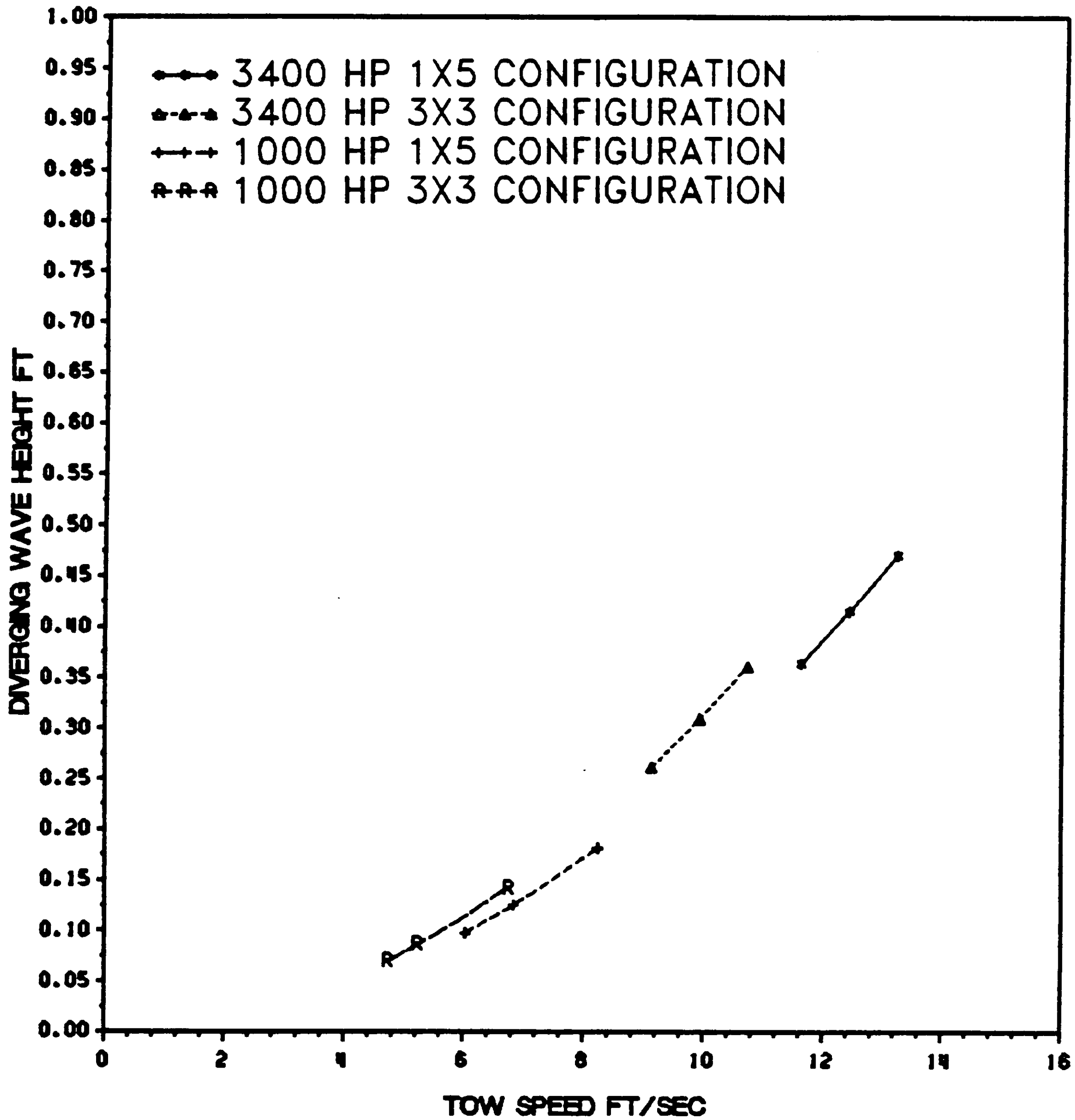


Figure 89. Diverging Wave Height vs. Tow Speed for 5-yr. Low Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

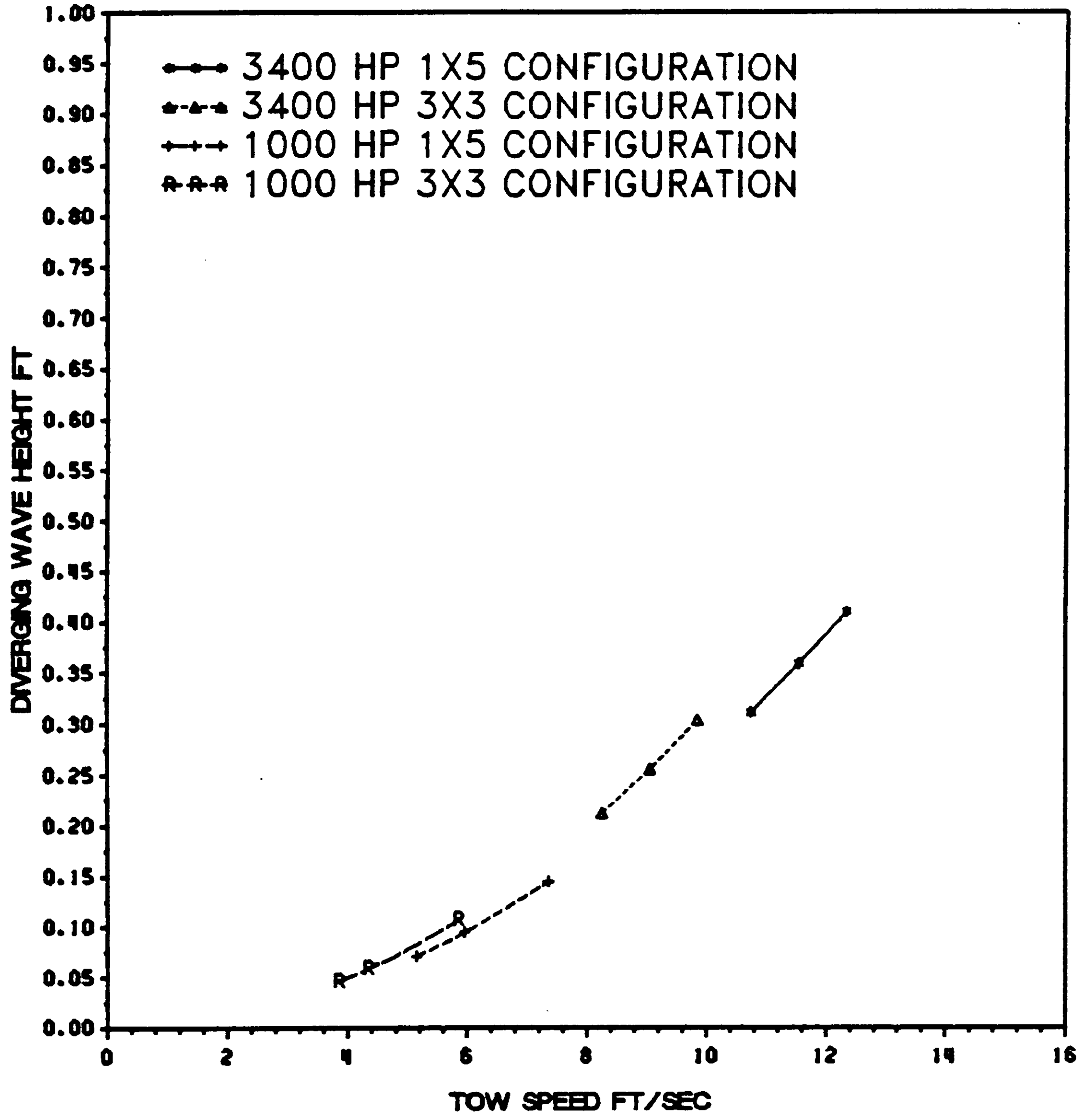


Figure 90. Diverging Wave Height vs. Tow Speed for Mean Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

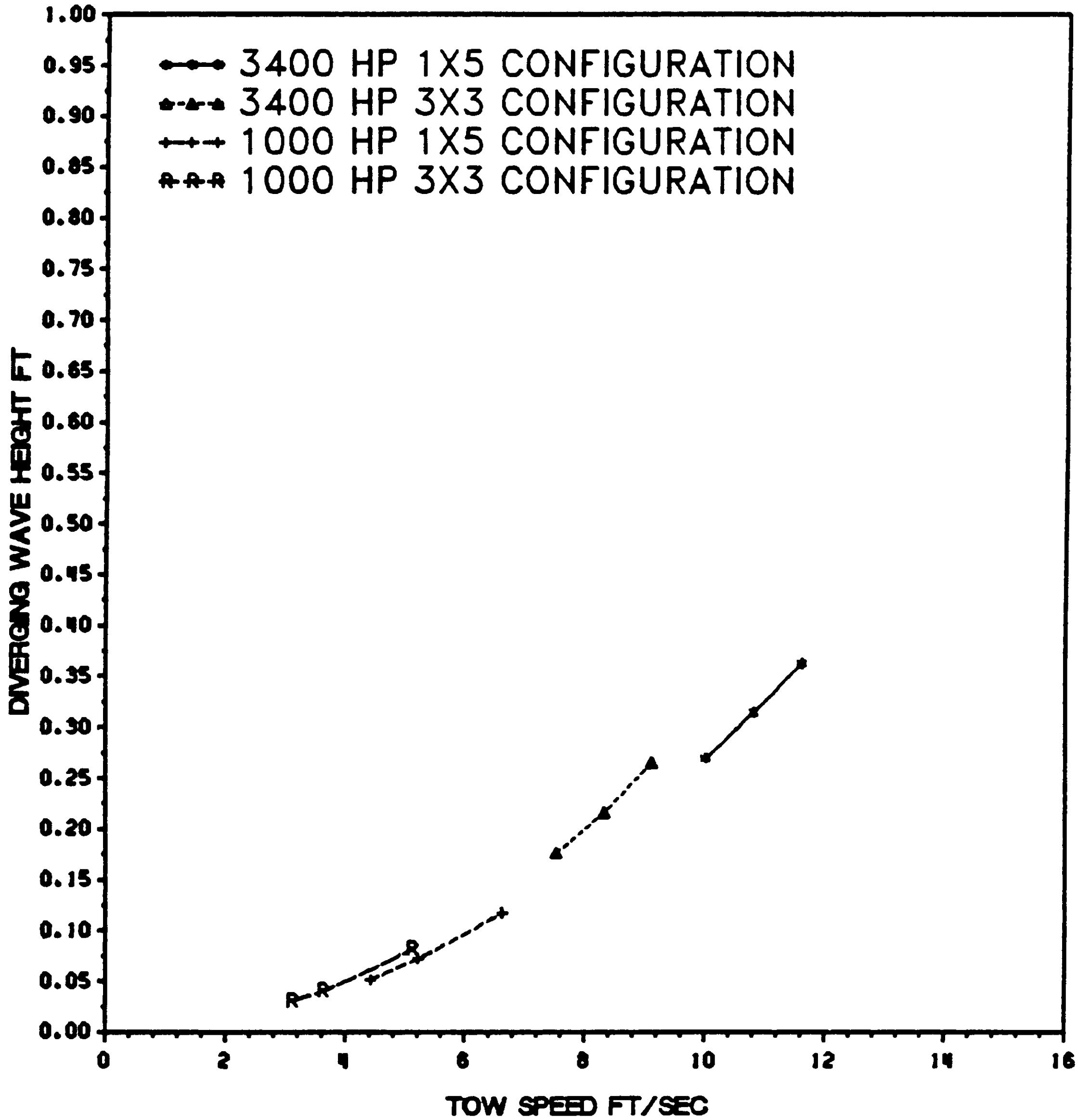


Figure 91. Diverging Wave Height vs. Tow Speed for 5-yr. High Winter Flow, Unloaded Upstream Tow, at River Mile 73.1

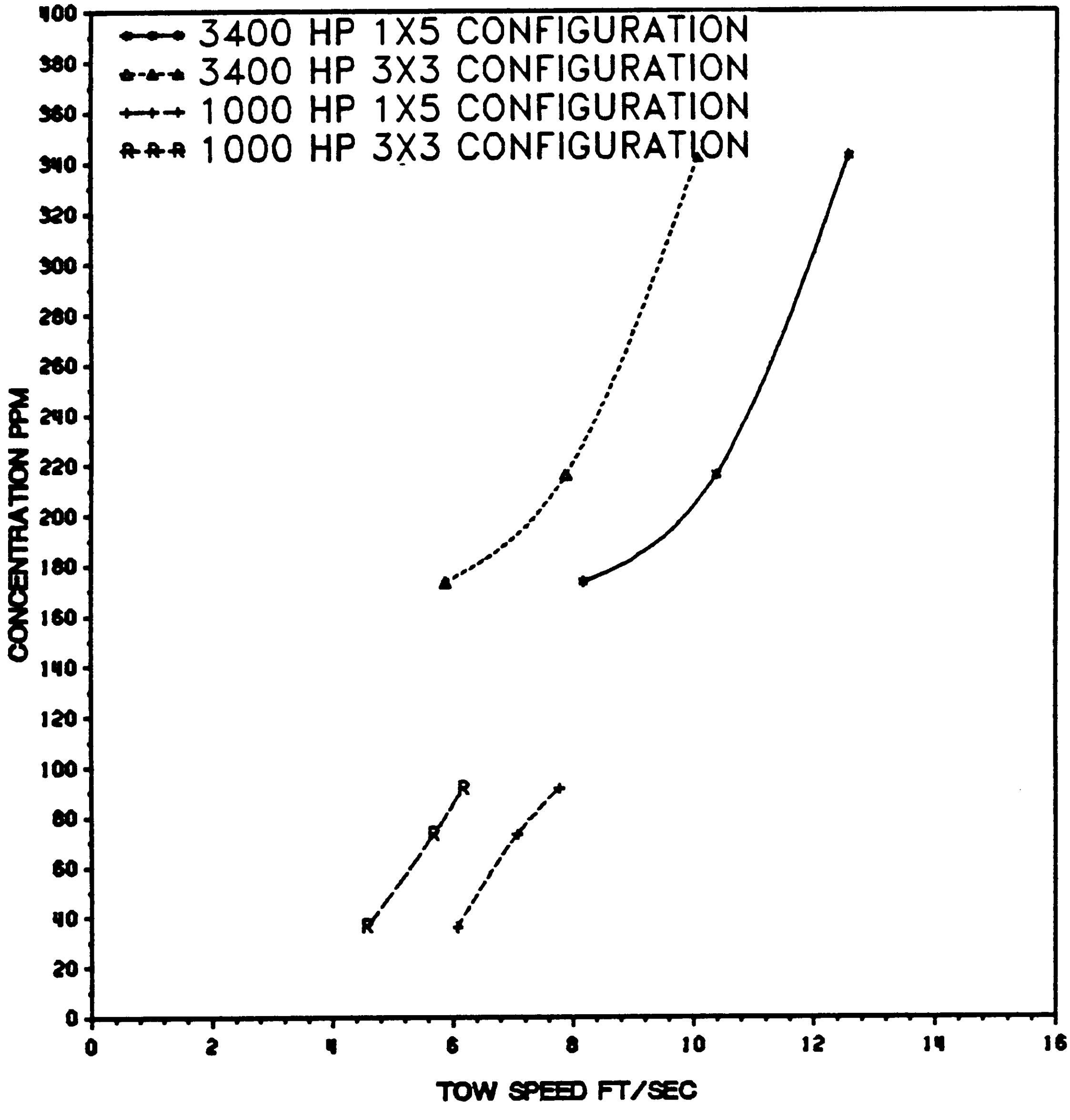


Figure 92. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr. Low Summer Flow, Loaded Downstream Tow, at River Mile 74.3

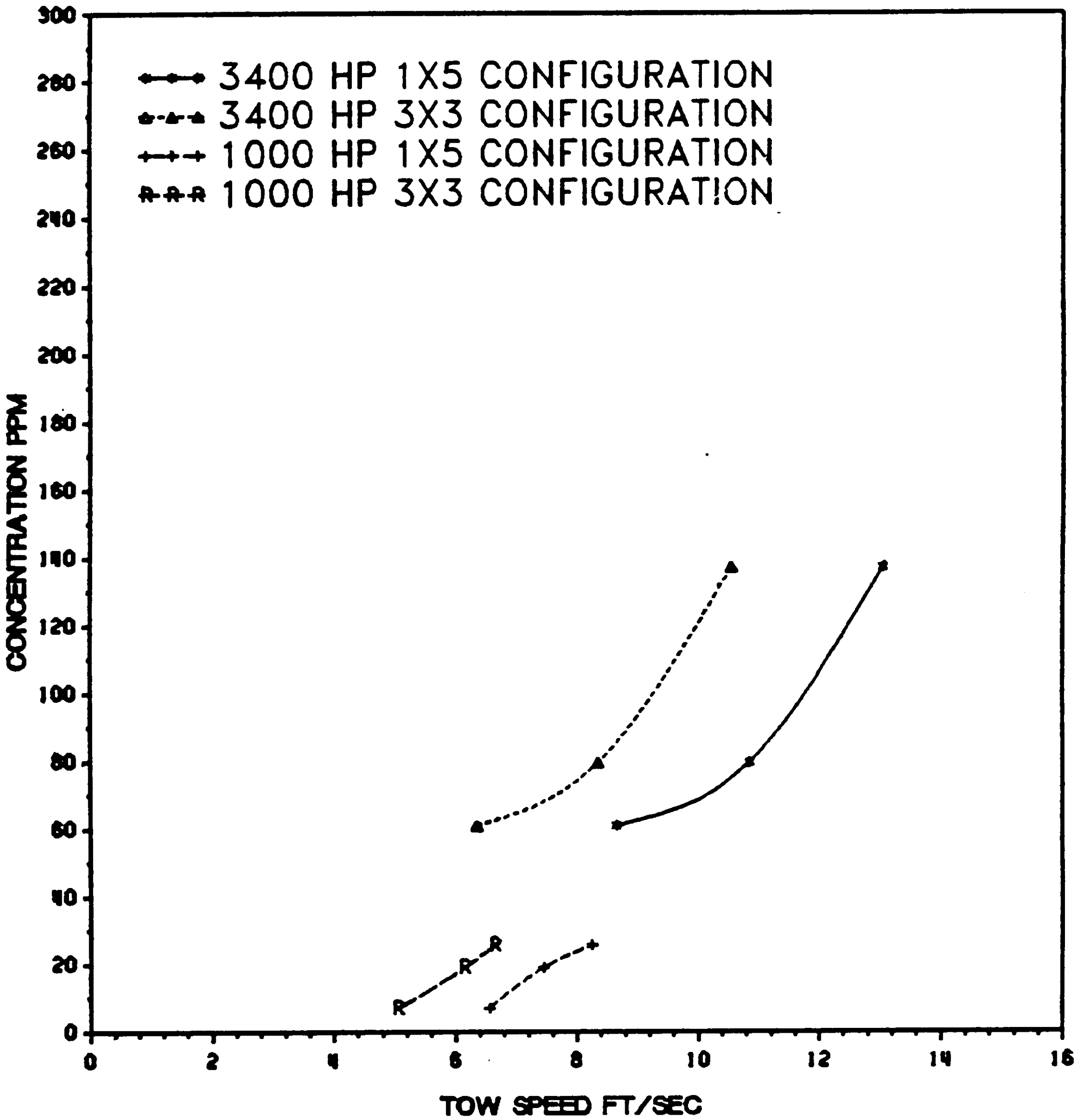


Figure 93. Propeller Induced Sediment Concentration vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 74.3

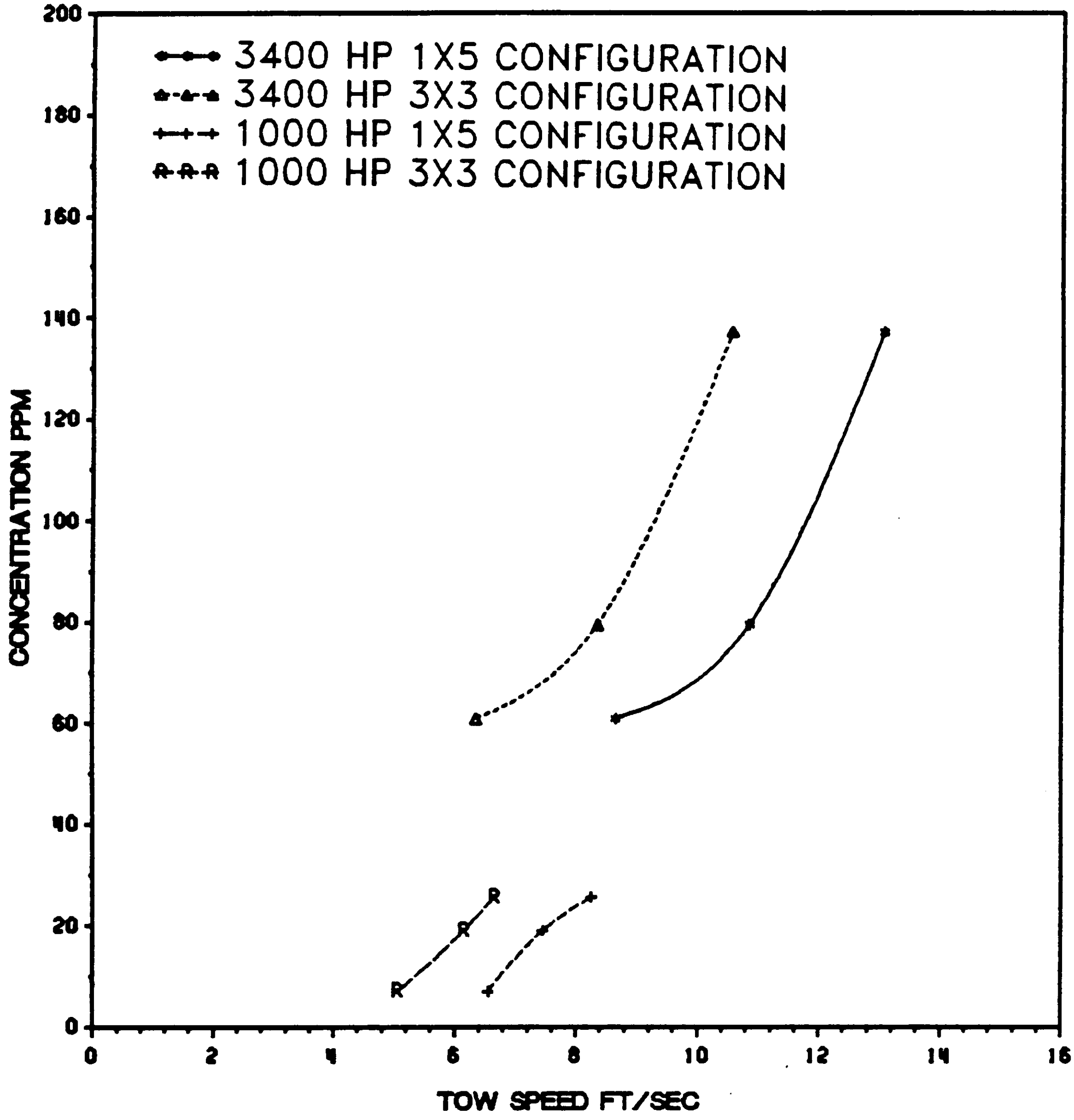


Figure 94. Propeller Induced Sediment Concentration vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 74.3

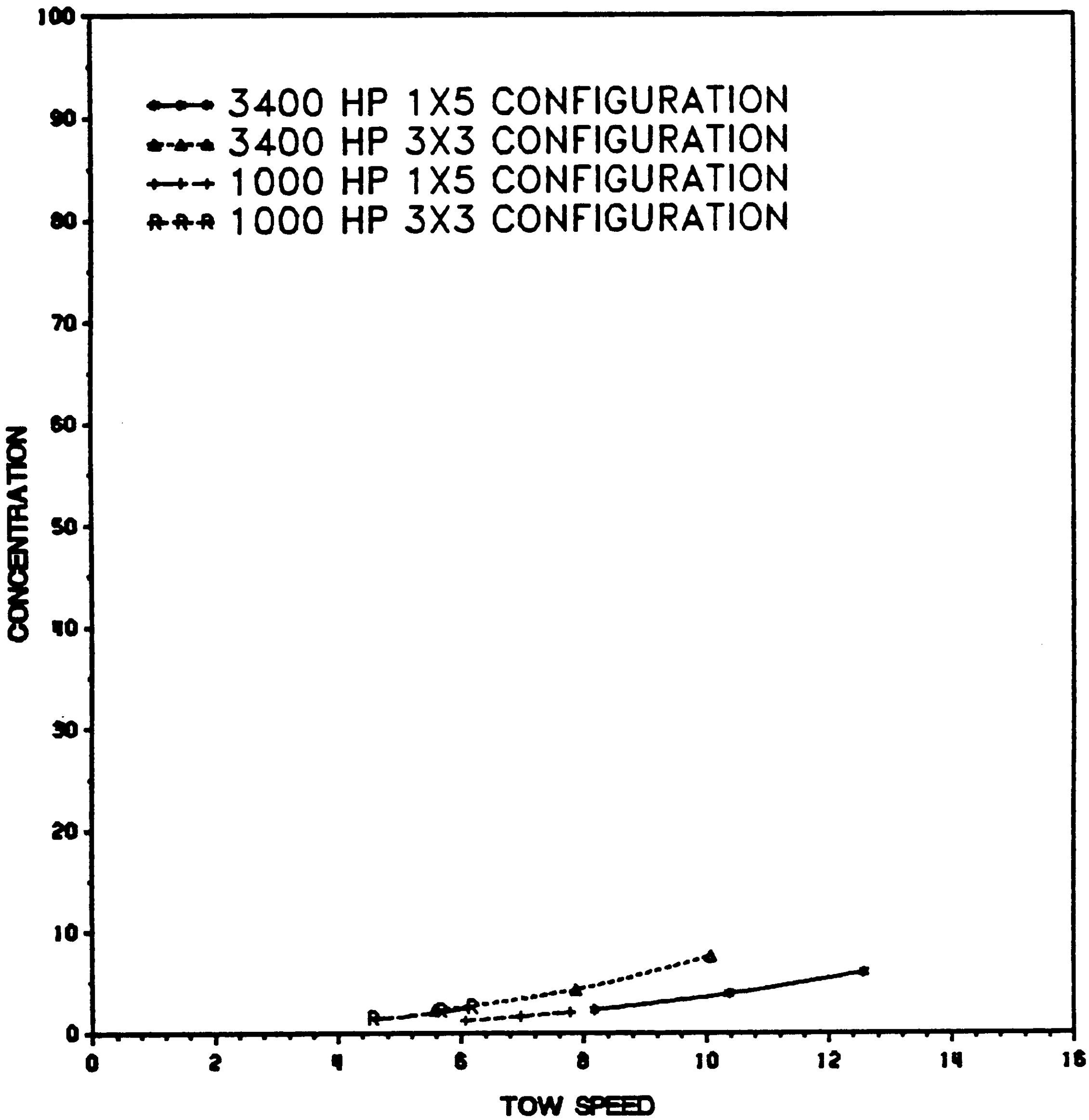


Figure 95. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr. Low Summer Flow, Loaded Downstream Tow, at River Mile 74.3

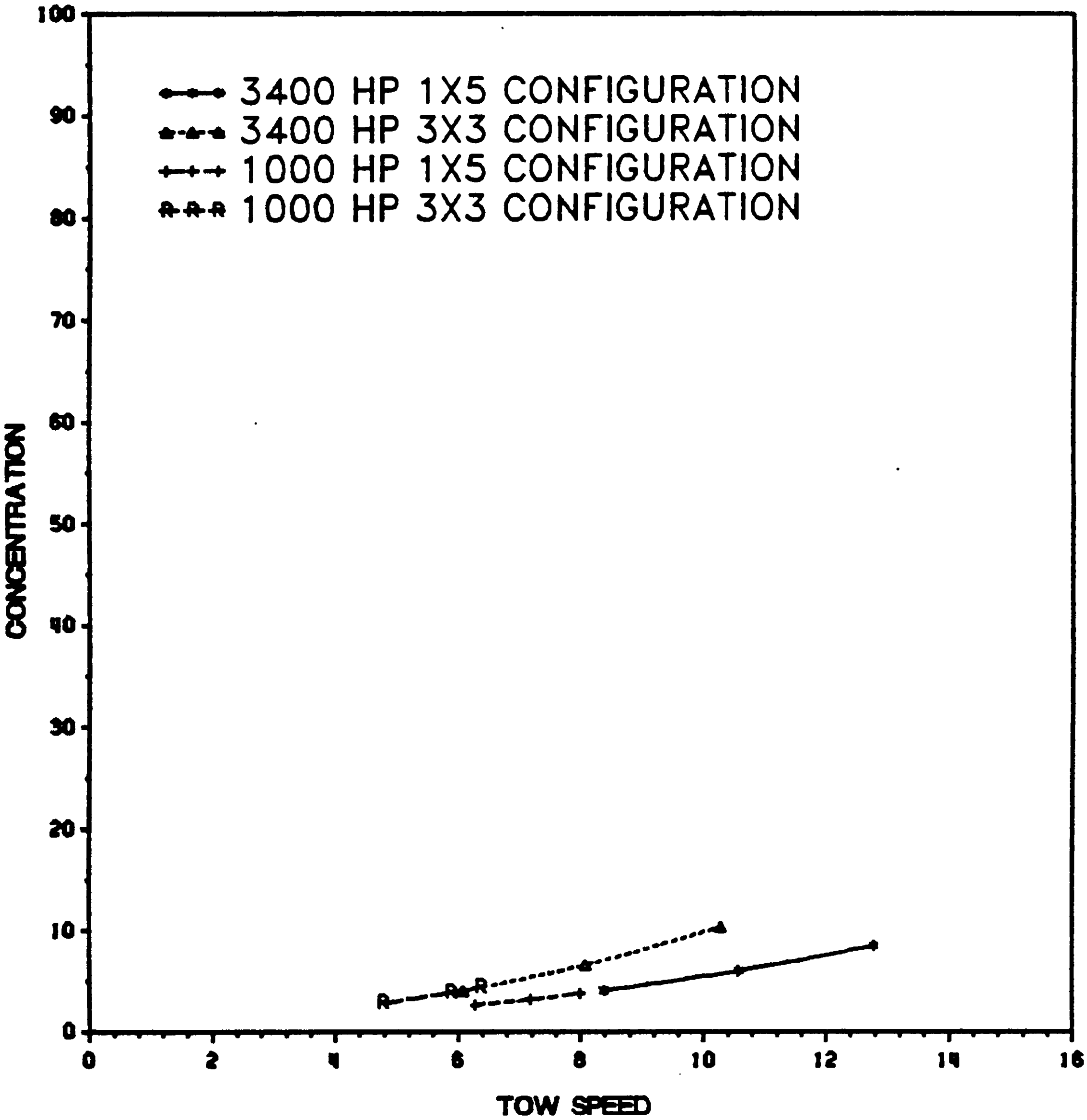


Figure 96. Backwater Induced Sediment Concentration vs. Tow Speed for Mean Summer Flow, Loaded Downstream Tow, at River Mile 74.3

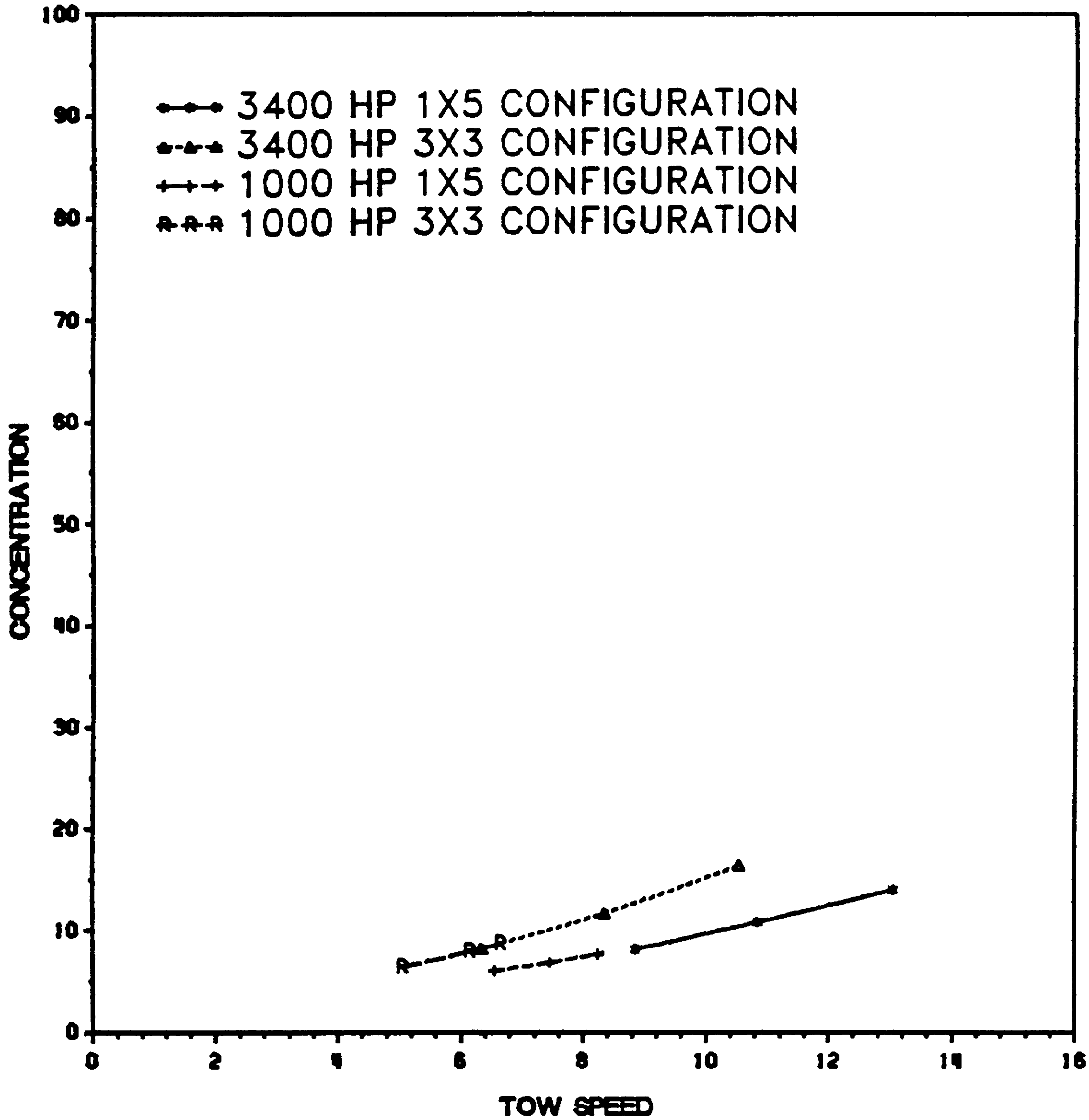


Figure 97. Backwater Induced Sediment Concentration vs. Tow Speed for 5-yr. High Summer Flow, Loaded Downstream Tow, at River Mile 74.

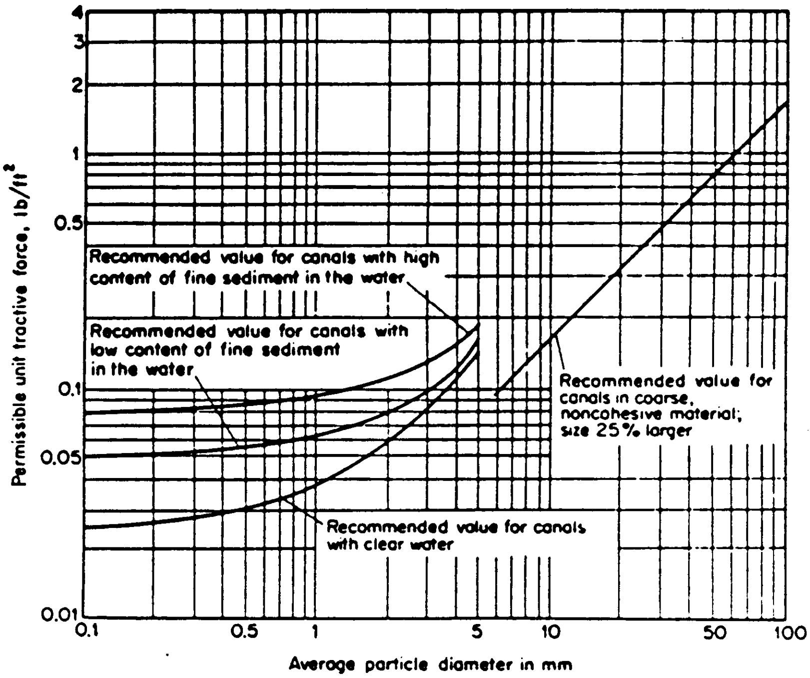


Figure 99. Recommended Permissible Unit Tractive Forces for Canals in Noncohesive Material (Chow, 1965)

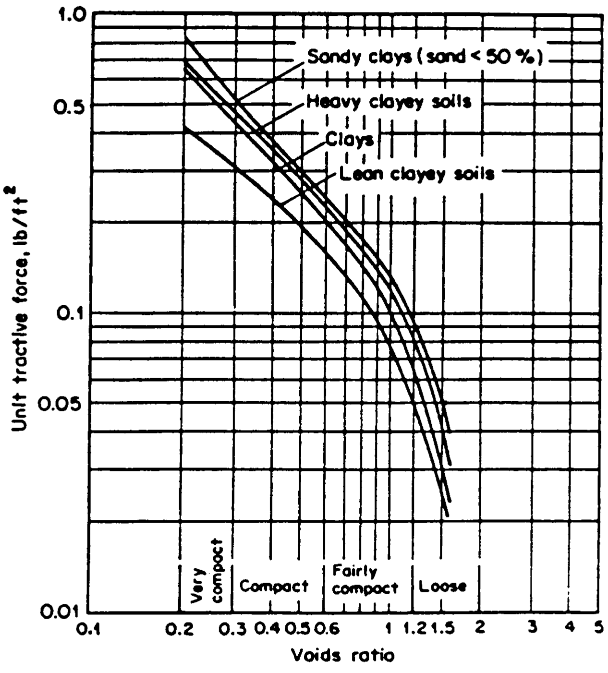


Figure 100. Permissible Unit Tractive Forces for Canals in Cohesive Material (Chow, 1965)

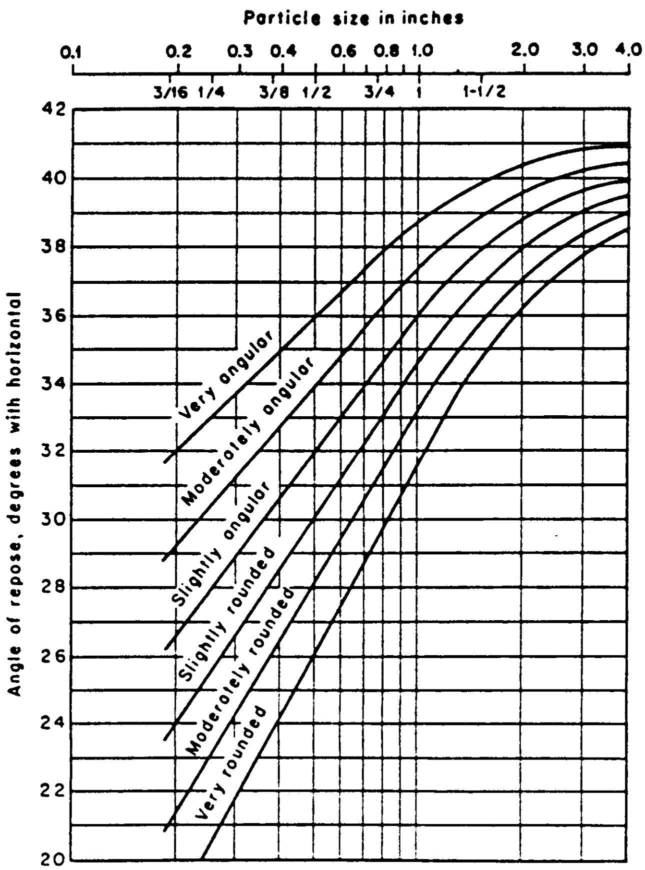


Figure 101. Angles of Repose of Noncohesive Material (Chow, 1965)

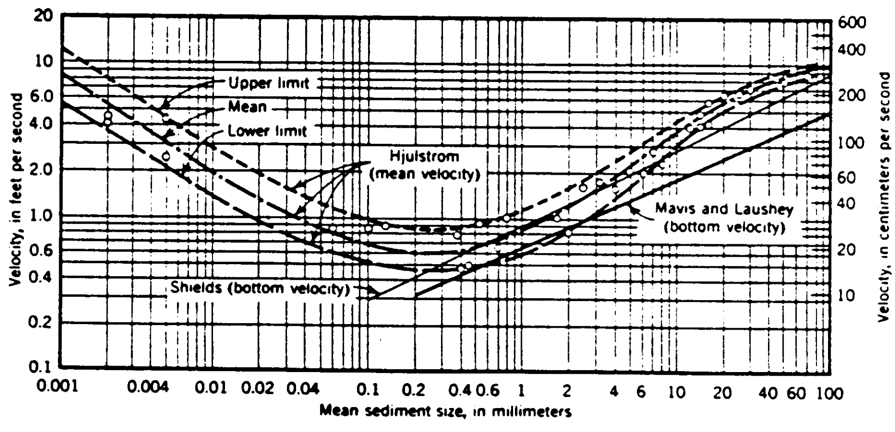


Figure 98. Critical Water Velocities for Quartz Sediment as a Function of Mean Grain Size (ASCE, 1975)

Appendix A. Channel Cross Sections

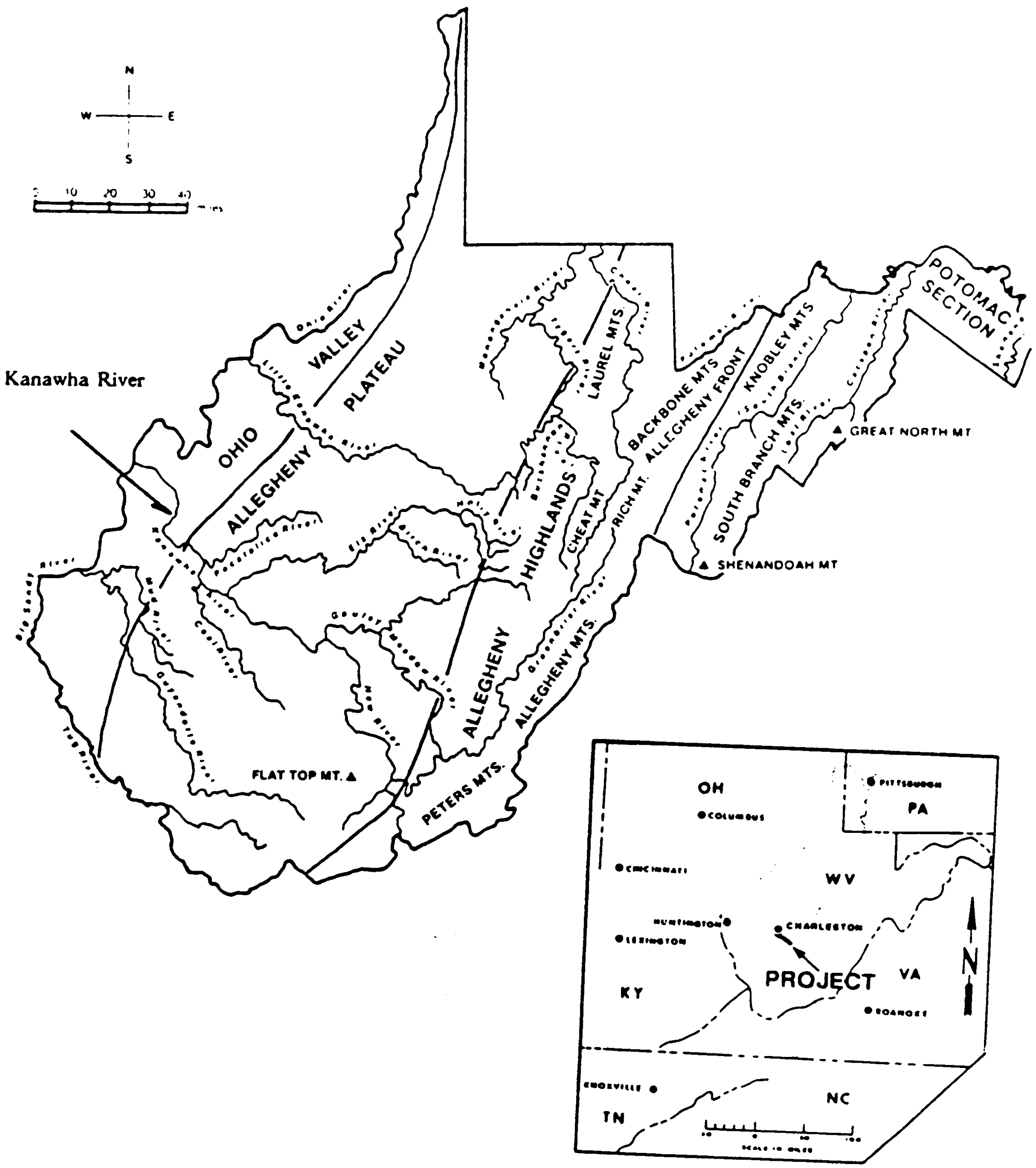


Figure A-1 Topographic Map of West Virginia

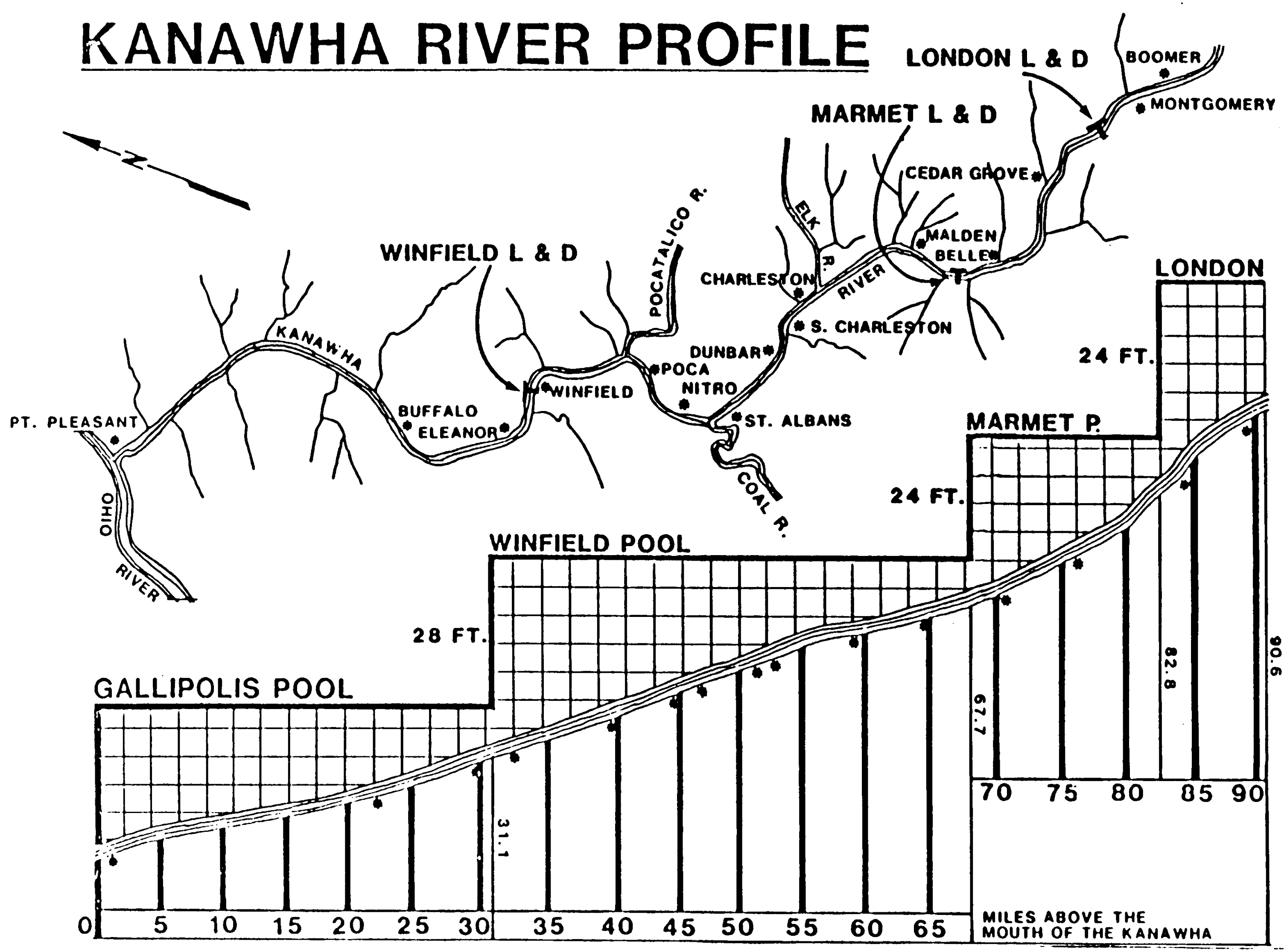


Figure A-2 Kanawha River Profile

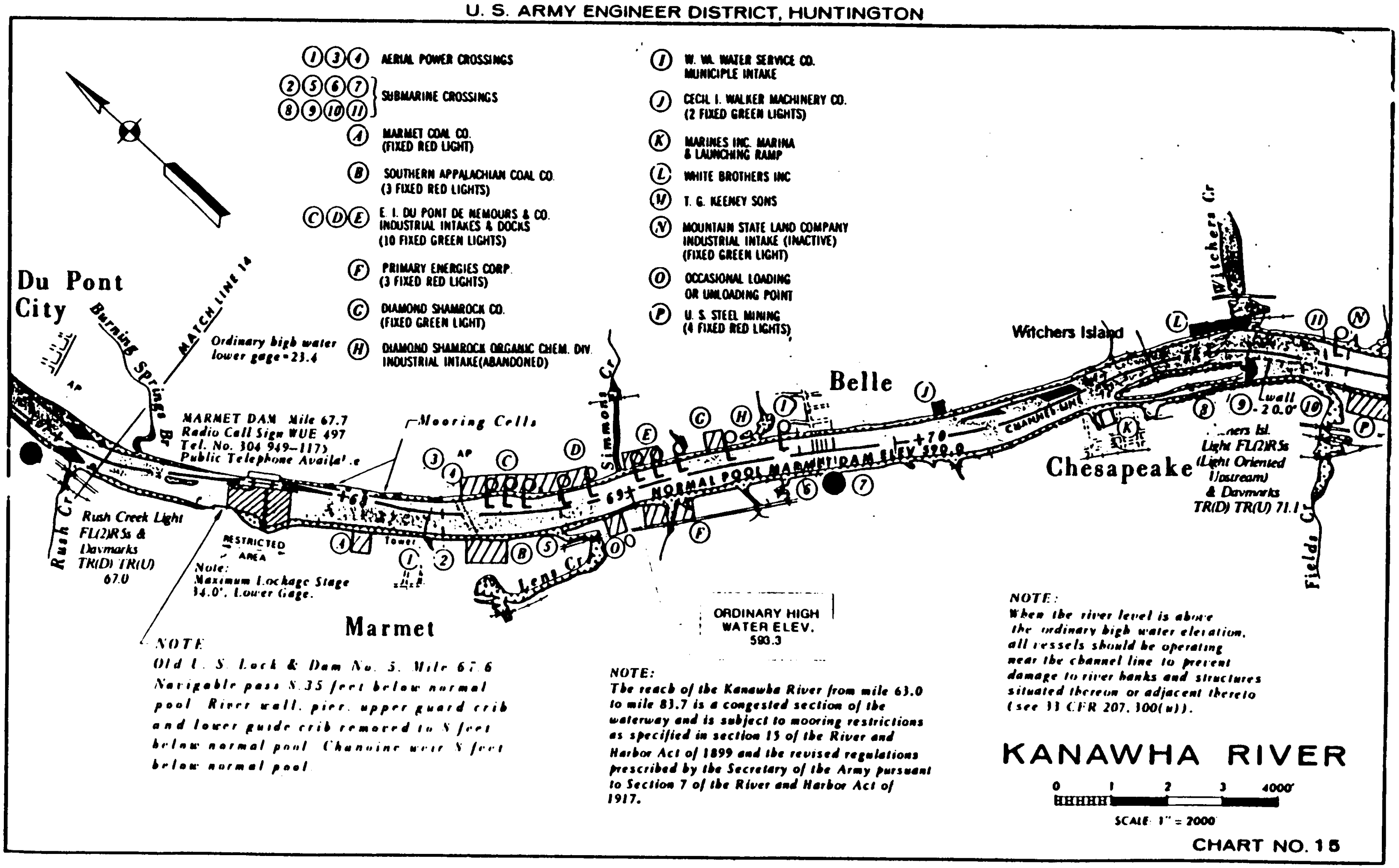


Figure A-3 Kanawha River Navigation Chart

River Miles 67.0 - 71.6

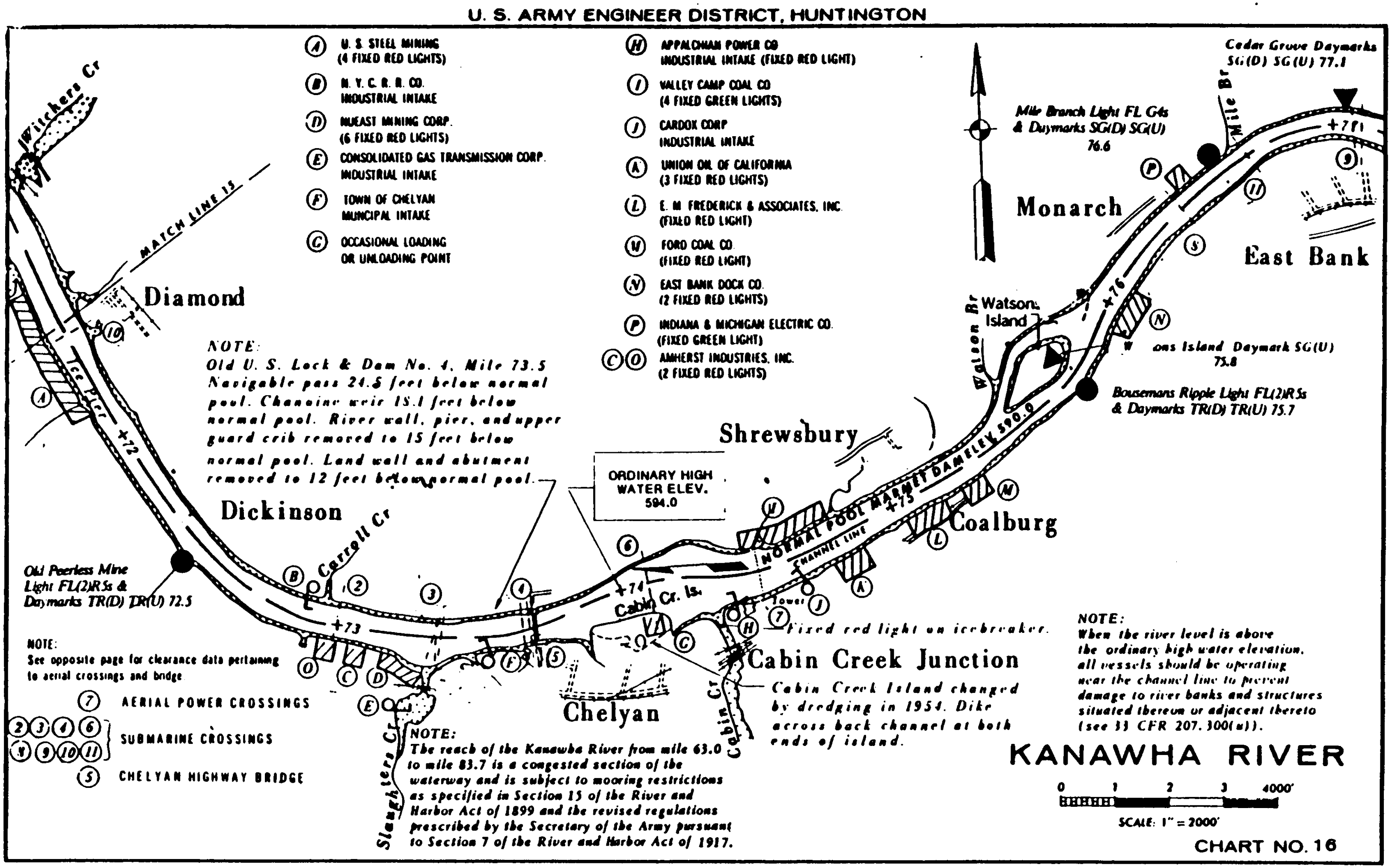


Figure A-4 Kanawha River Navigation Chart

River Miles 71.6 - 77.0

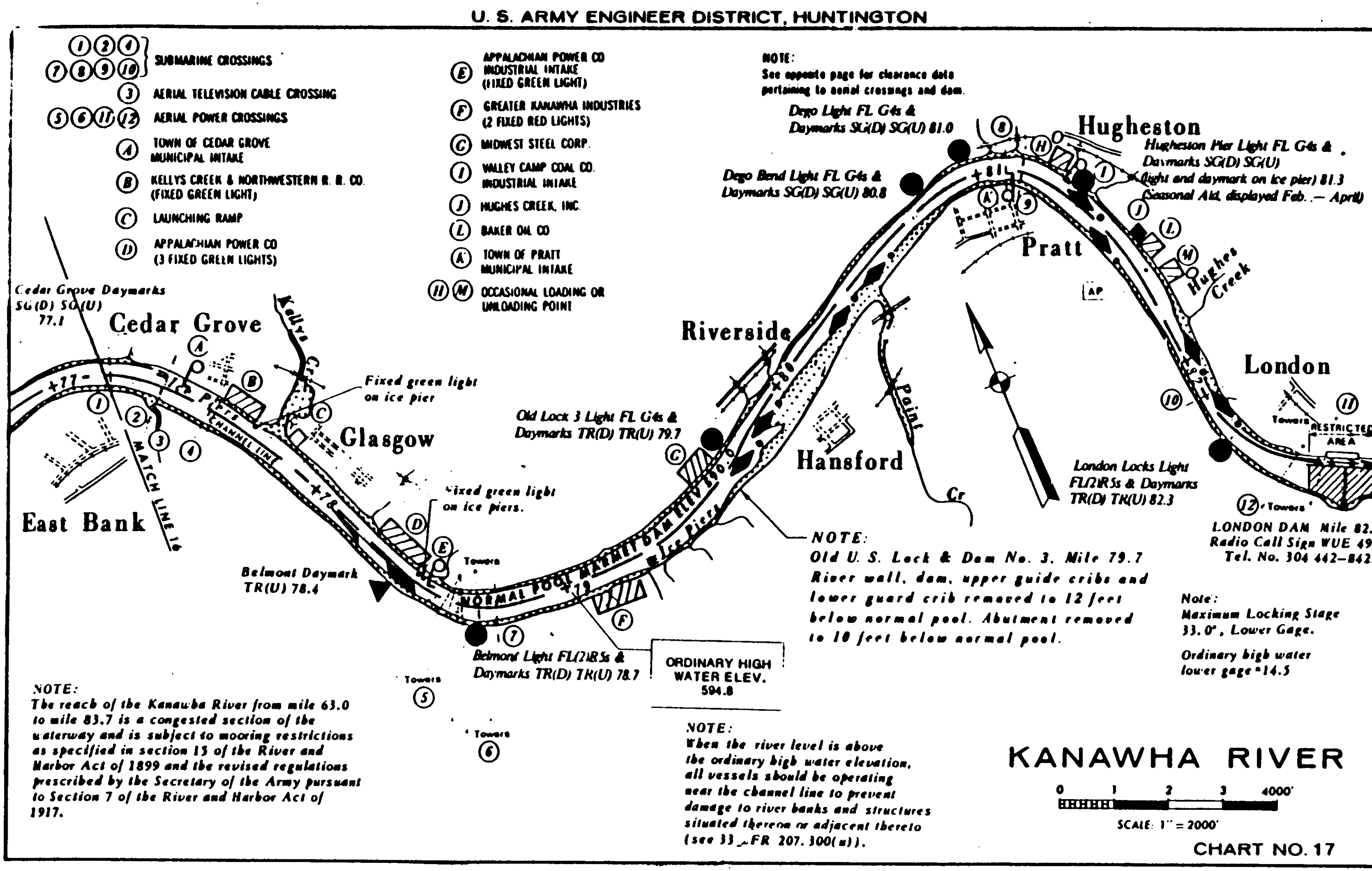
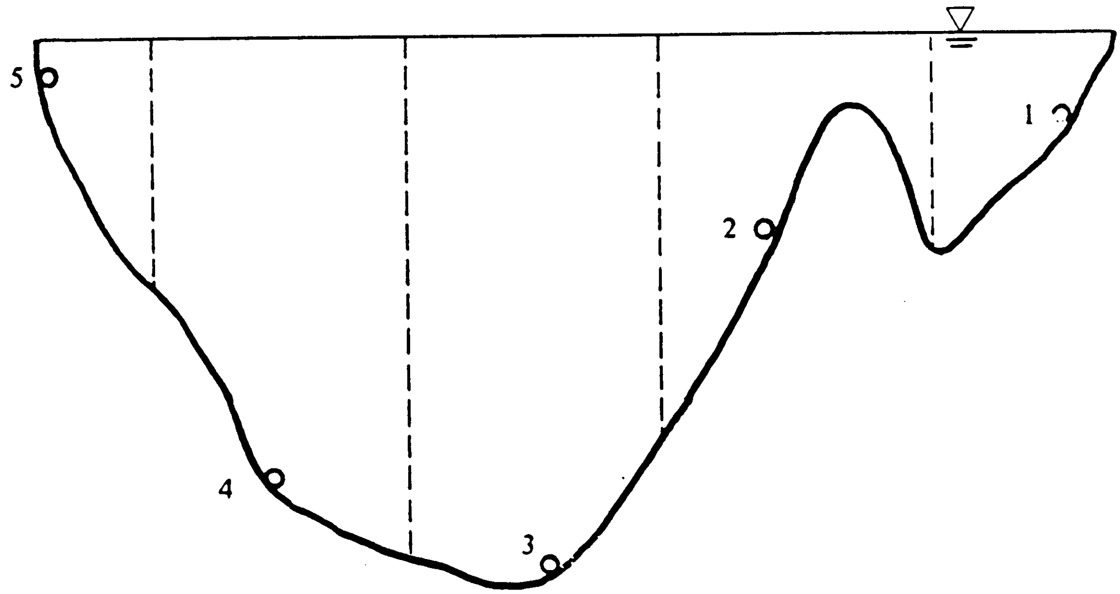


Figure A-5 Kanawha River Navigation Chart

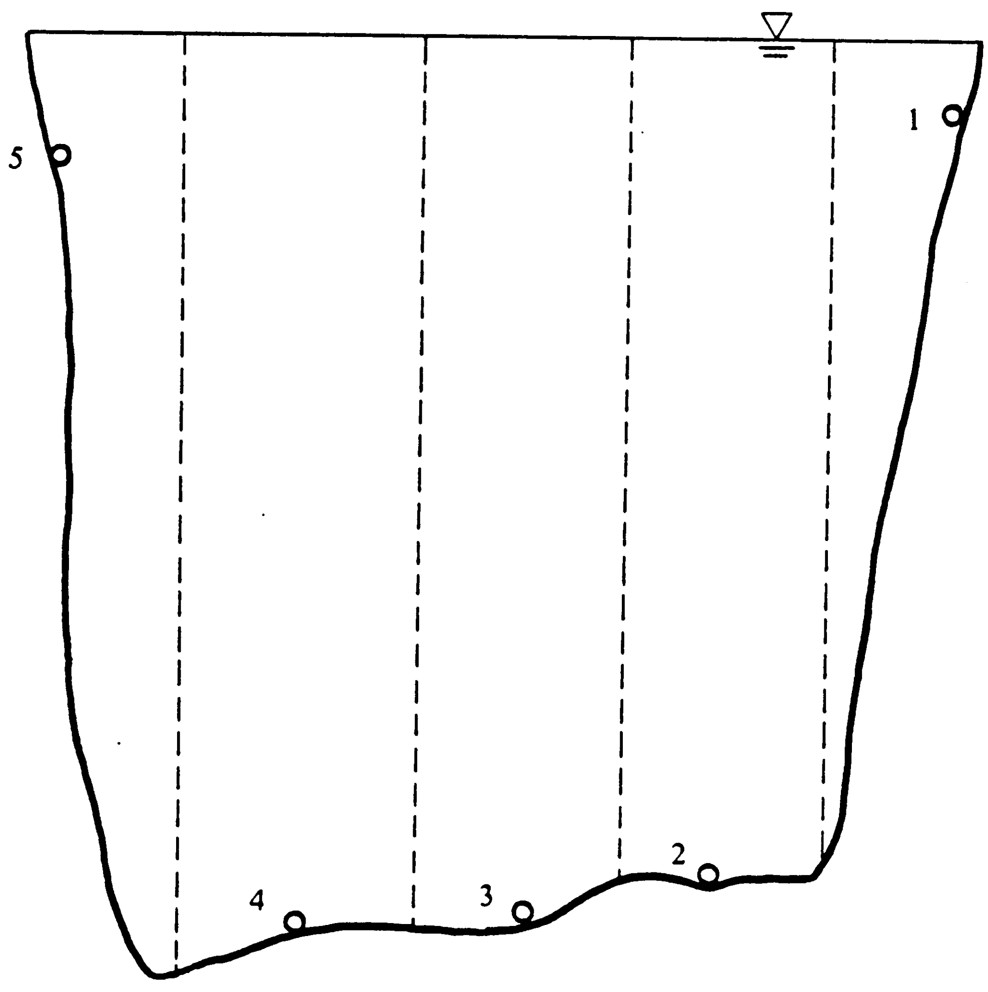
River Miles 77.0 - 83.0



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

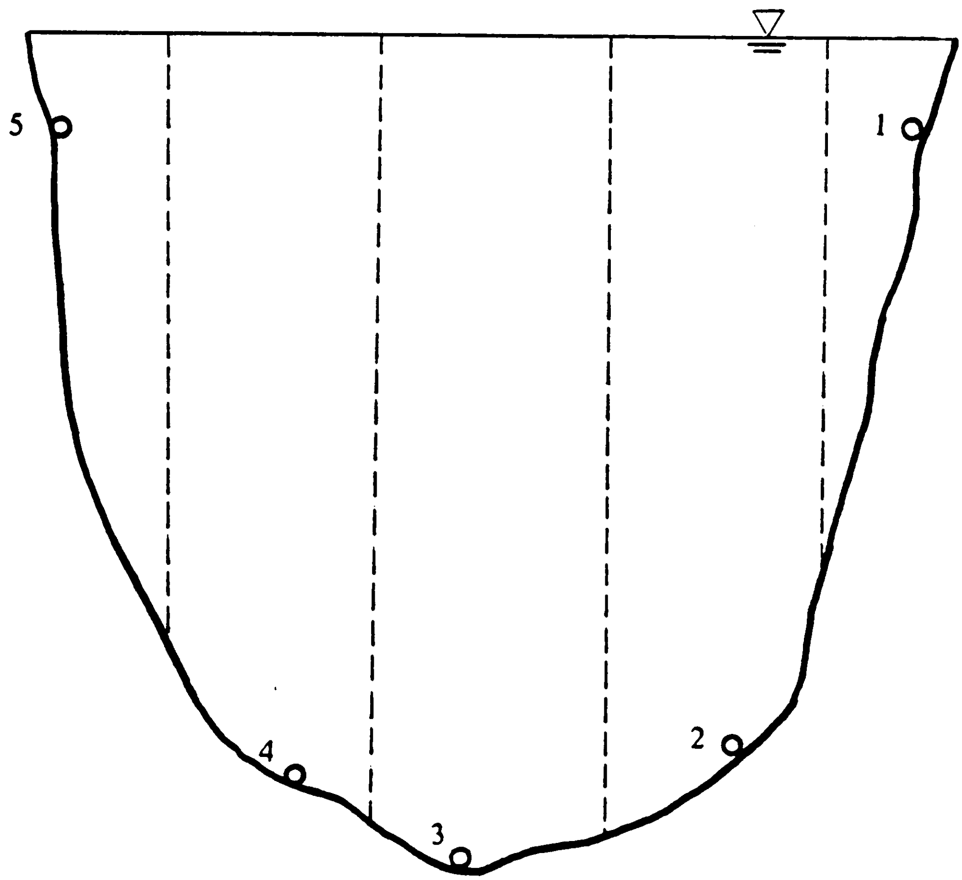
Figure A-6 River Mile 67.0



Horizontal 0.75 inches = 100 feet

Vertical 0.75 inches = 5 feet

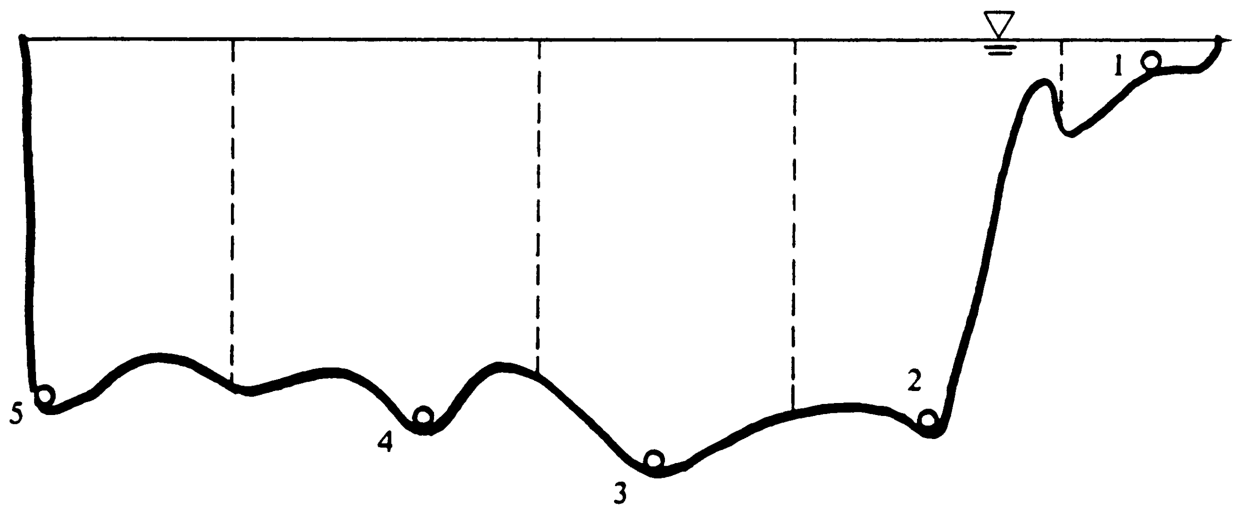
Figure A-7 River Mile 68.1



Horizontal 0.75 inches = 100 feet

Vertical 0.75 inches = 5 feet

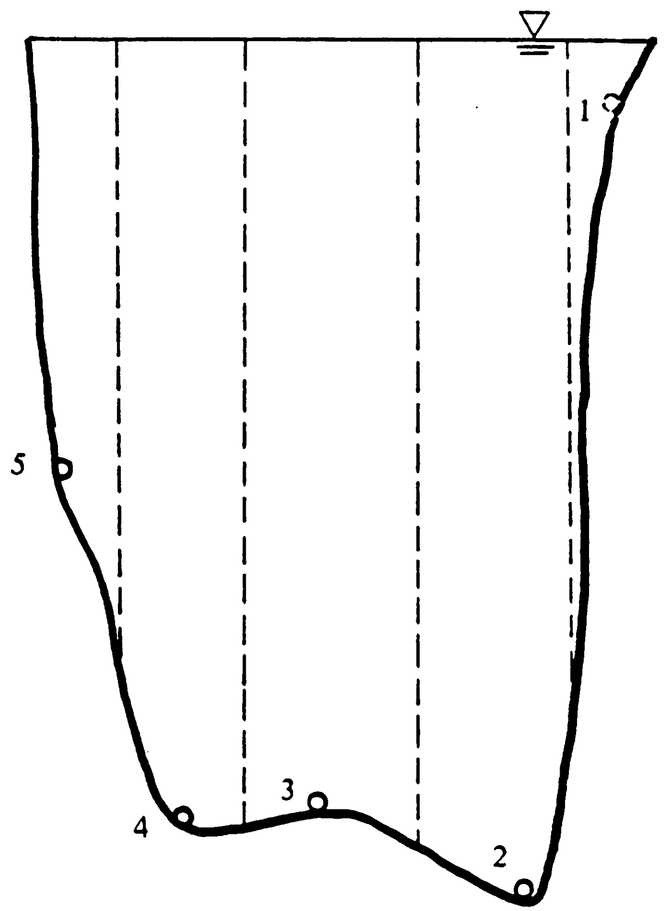
Figure A-8 River Mile 73.1



Horizontal 0.56 inches = 100 feet

Vertical 0.56 inches = 5 feet

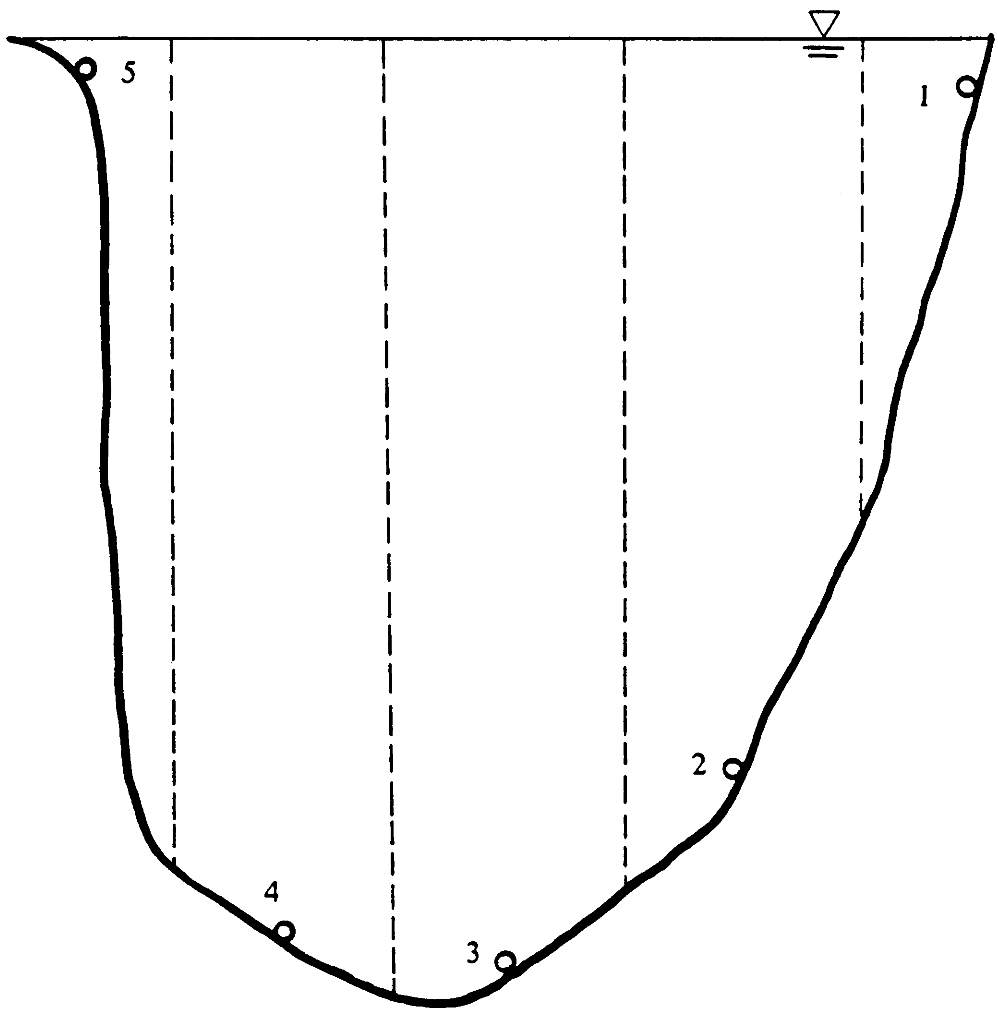
Figure A-9 River Mile 74.3



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

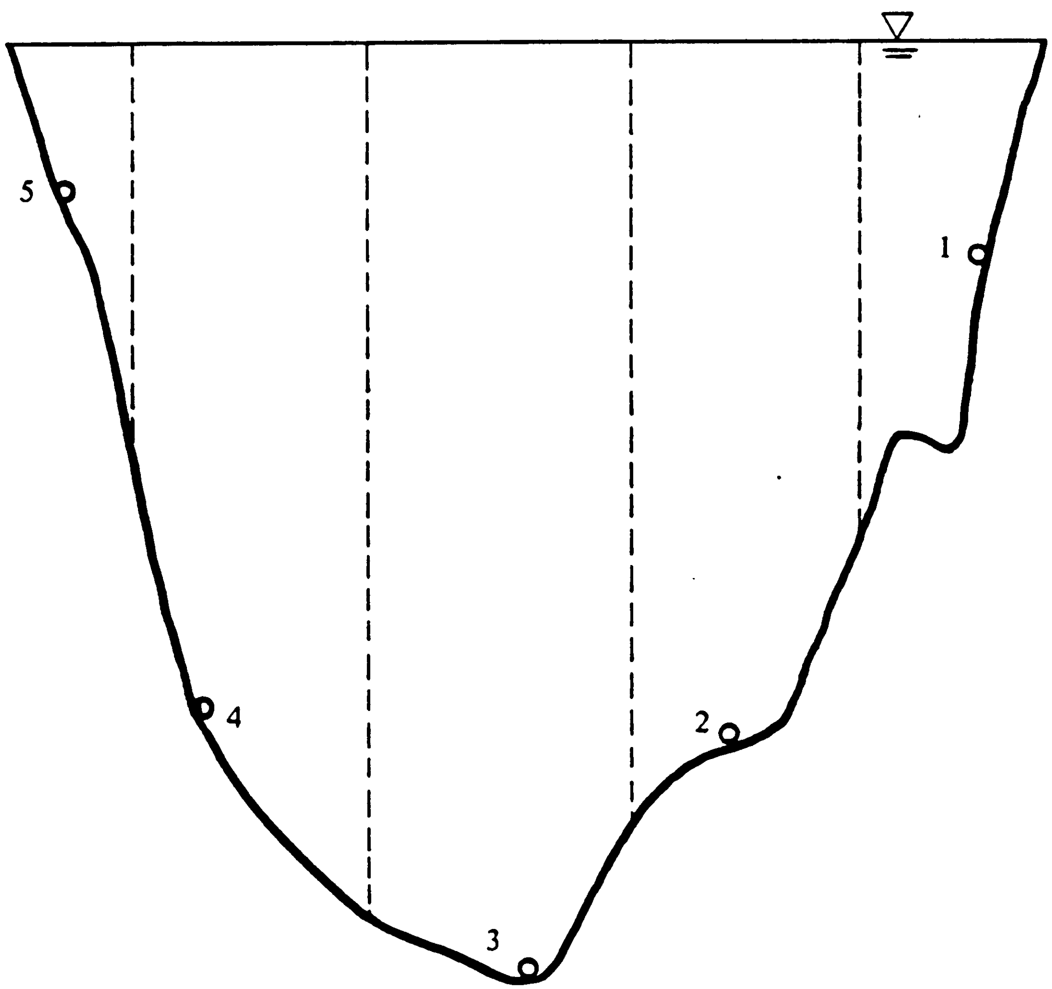
Figure A-10 River Mile 75.6



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

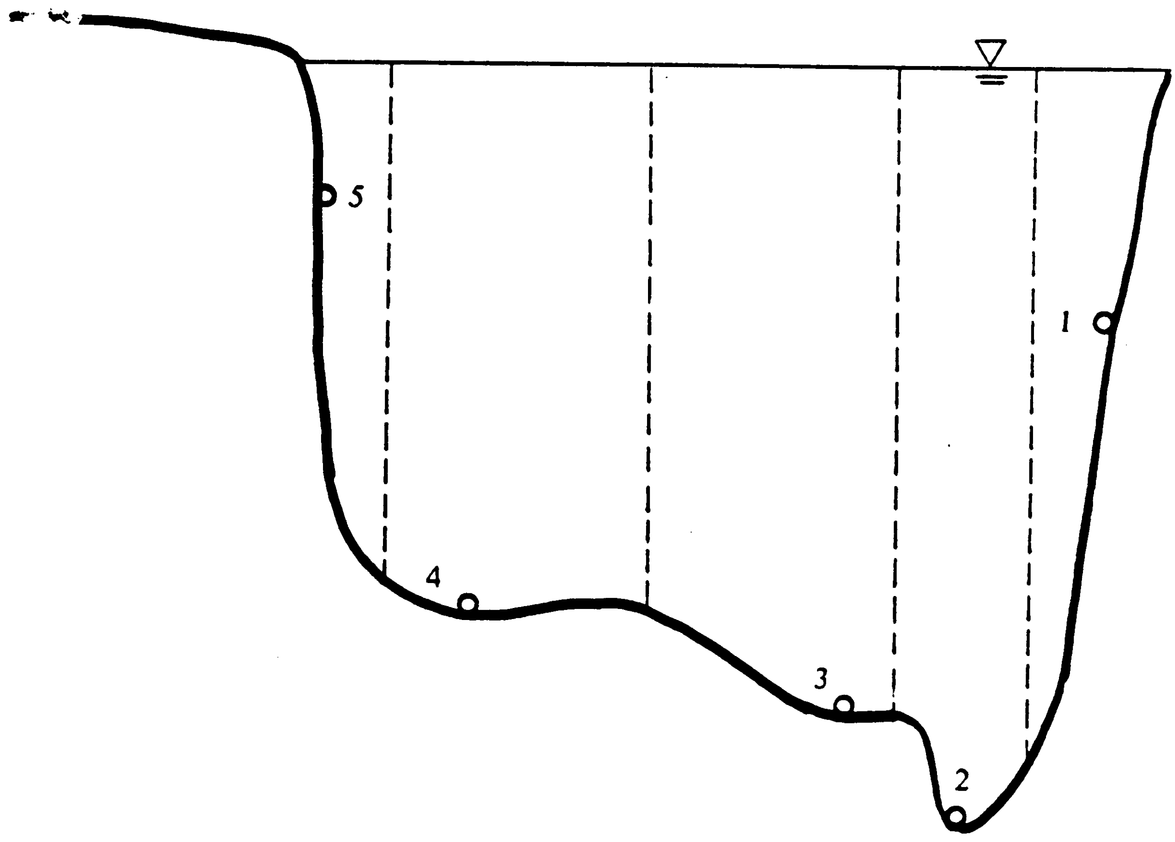
Figure A-11 River Mile 75.7



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

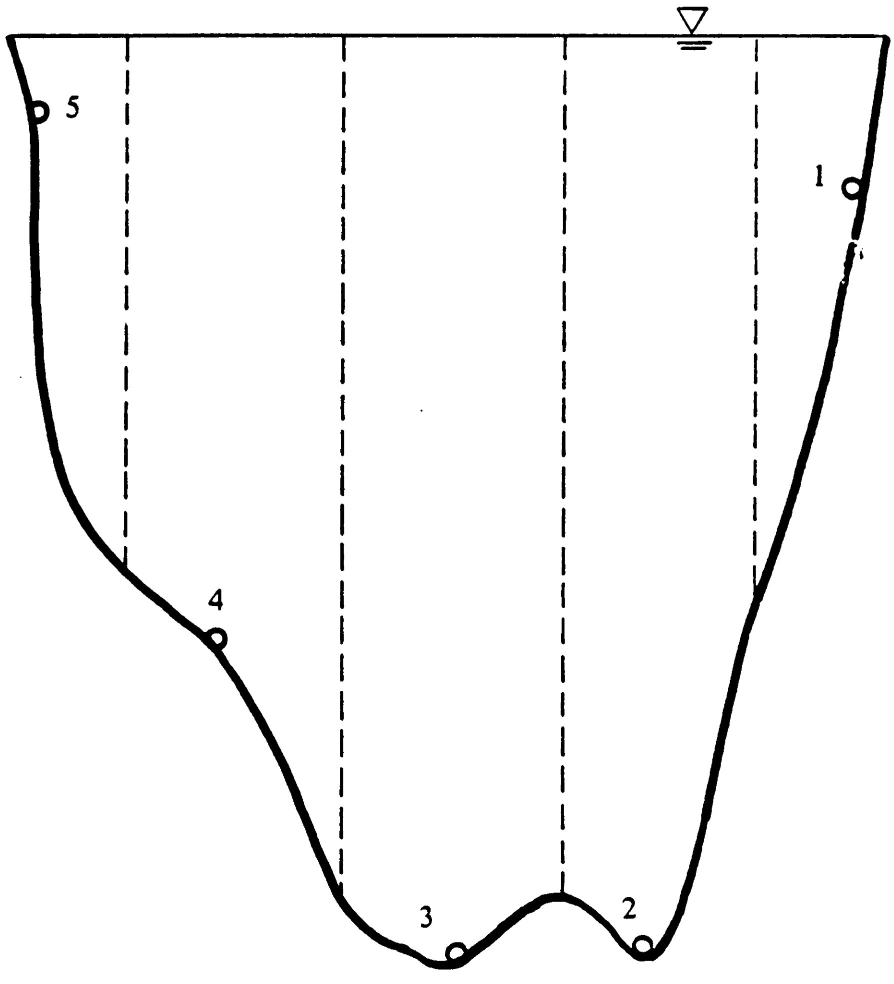
Figure A-12 River Mile 78.7



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

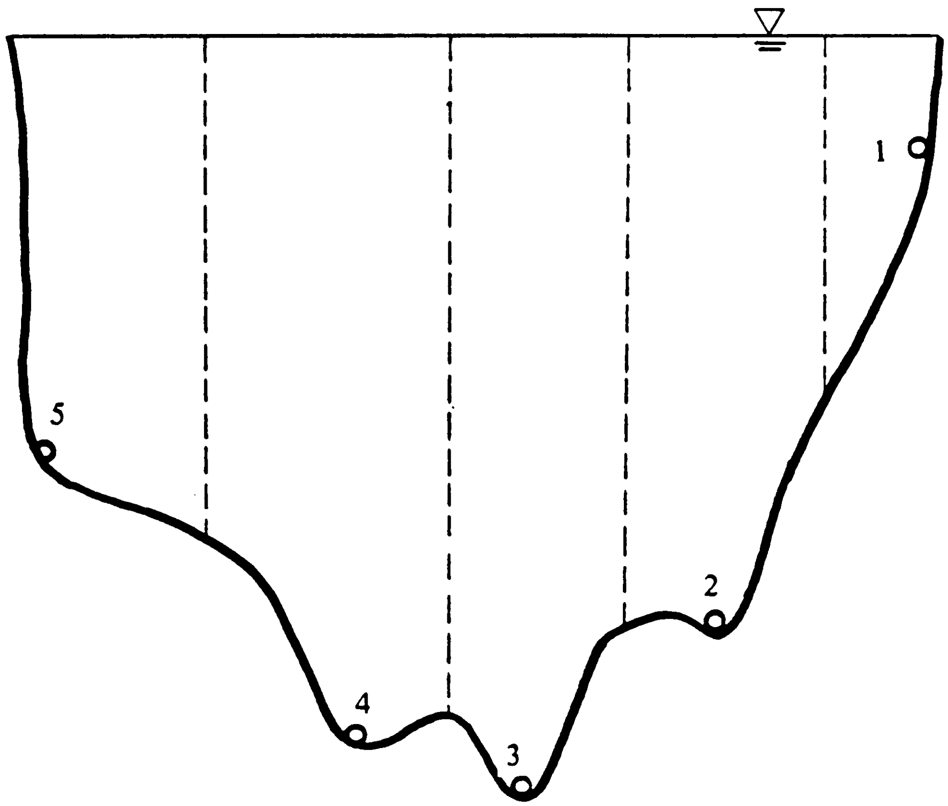
Figure A-13 River Mile 80.2



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

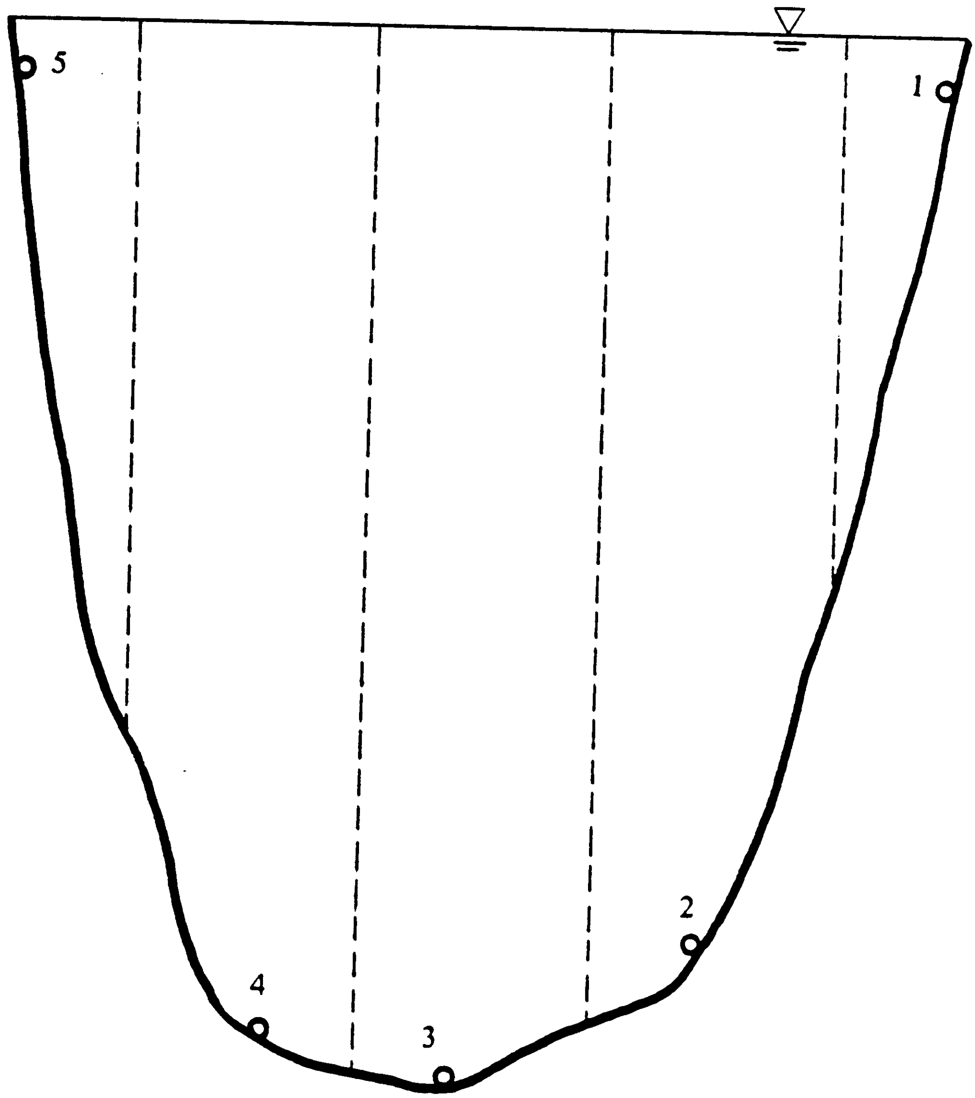
Figure A-14 River Mile 81.1



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

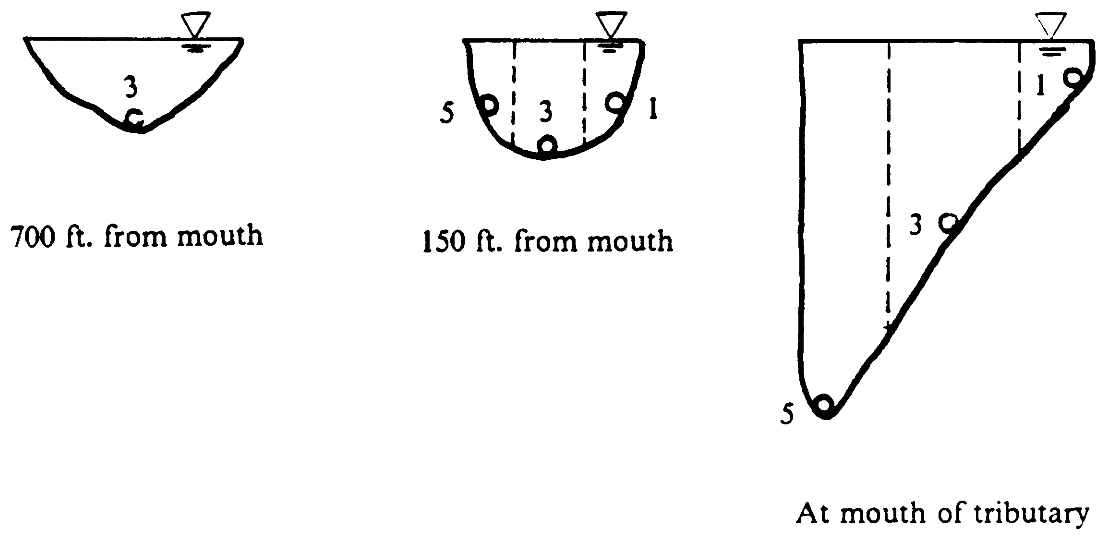
Figure A-15 River Mile 81.6



Horizontal 0.75 inches = 100 feet

Vertical 0.75 inches = 5 feet

Figure A-16 River Mile 83.6



Horizontal 1 inch = 100 feet

Vertical 1 inch = 5 feet

Figure A-17 Cabin Creek

Appendix B. Streamflow Analysis

Streamflow Analysis

This appendix includes:

Cross-sections

Summer, Fall, Winter, and Spring flows

Mean, 5-year high, and 5-year low flows for each season

Water level changes at each cross-section for various seasons and flows indicated by ΔH in feet. The changes are referred to the water level at the date of surveying for the cross sections.

Each cross-section has five subsections. The discharges Q_i in each subsection are indicated by Q_i/Q where Q is the total flow for the entire cross-section.

The mean velocities for each subsections

1. SECTION No.67-0

	Fall		Winter		Spring		Summer	
Low Q	2854.0		9074.0		5593.0		2611.0	
DH	.06		2.28		1.17		-.07	
	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.21	.33	6.33	.98	5.34	.63	4.07	.30
2	12.01	.41	14.71	1.14	13.49	.75	11.82	.38
3	48.33	.69	44.12	1.74	46.04	1.20	48.61	.64
4	33.05	.56	31.49	1.44	32.23	.98	33.16	.52
5	2.40	.23	3.35	.67	2.90	.44	2.33	.21
Mean Q	10765.0		22838.0		15823.0		6351.0	

DH 2.71 5.01 3.80 1.44

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	6.68	1.14	8.29	2.16	7.50	1.59	5.59	.71
2	15.12	1.32	16.93	2.46	16.06	1.82	13.81	.84
3	43.46	1.98	40.50	3.43	41.94	2.63	45.54	1.32
4	31.23	1.64	30.03	2.89	30.62	2.20	32.04	1.09
5	3.50	.78	4.24	1.48	3.88	1.09	3.02	.49

High Q 24317.0 36443.0 29177.0 11870.0

DH 5.26 7.12 6.07 2.98

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	8.44	2.27	9.46	3.11	8.91	2.62	6.90	1.24
2	17.09	2.58	18.13	3.51	17.58	2.97	15.37	1.44

3	40.24	3.59	38.46	4.68	39.42	4.04	43.06	2.12
4	29.92	3.02	29.15	3.97	29.57	3.42	31.07	1.77
5	4.31	1.55	4.79	2.12	4.53	1.79	3.60	.85

2. SECTION No.68-1

	Fall	Winter	Spring	Summer
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Low Q	2854.0	9074.0	5593.0	2611.0
DH	.06	2.28	1.17	-.07

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.90	.11	5.51	.33	5.21	.21	4.86	.10
2	24.51	.17	24.44	.49	24.48	.32	24.51	.15

3	26.25	.17	26.04	.50	26.14	.32	26.26	.16
4	30.88	.17	30.53	.50	30.70	.32	30.90	.16
5	13.47	.16	13.48	.46	13.47	.29	13.47	.14

Mean Q	10765.0	22838.0	15823.0	6351.0
DH	2.71	5.01	3.80	1.44

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.62	.38	6.19	.77	5.89	.55	5.28	.23
2	24.43	.58	24.34	1.14	24.39	.82	24.47	.36
3	26.00	.59	25.80	1.16	25.91	.84	26.12	.36
4	30.47	.59	30.14	1.16	30.31	.83	30.66	.36
5	13.48	.53	13.53	1.04	13.50	.75	13.47	.33

High Q	24317.0	36443.0	29177.0	11870.0

DH	5.26	7.12	6.07	2.98

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	6.25	.82	6.68	1.18	6.44	.96	5.69	.42
2	24.33	1.20	24.26	1.70	24.30	1.41	24.42	.63
3	25.78	1.23	25.62	1.74	25.71	1.44	25.98	.64
4	30.11	1.22	29.86	1.73	30.00	1.43	30.43	.64
5	13.53	1.09	13.58	1.54	13.55	1.27	13.49	.58

3. SECTION No.73-1

	Fall	Winter	Spring	Summer
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Low Q	2820.0	8859.0	5517.0	2581.0
DH	.05	2.24	1.15	-.08

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.01	.17	5.59	.49	5.31	.32	4.97	.16
2	24.28	.17	26.87	.49	25.65	.32	24.11	.16
3	41.91	.28	39.39	.76	40.58	.50	42.07	.25
4	22.79	.18	21.84	.49	22.29	.32	22.85	.16
5	6.01	.13	6.31	.36	6.17	.24	5.99	.12
Mean Q	10563.0		22390.0		15530.0		6247.0	
DH	2.67		4.95		3.76		1.41	

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.70	.58	6.21	1.11	5.95	.81	5.38	.36
2	27.31	.58	29.41	1.13	28.37	.82	25.96	.36

3	38.95	.88	36.88	1.64	37.91	1.22	40.28	.56
4	21.68	.57	20.88	1.07	21.28	.79	22.18	.36
5	6.36	.42	6.62	.81	6.49	.59	6.20	.26

High Q	23855.0	35914.0	28583.0	11660.0
DH	5.19	7.05	5.98	2.94

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	6.26	1.17	6.63	1.65	6.43	1.36	5.76	.63
2	29.61	1.20	30.99	1.70	30.22	1.40	27.59	.63
3	36.68	1.73	35.29	2.37	36.07	1.99	38.68	.96
4	20.80	1.13	20.25	1.56	20.56	1.30	21.57	.62
5	6.65	.85	6.84	1.18	6.73	.98	6.40	.46

4. SECTION No.74-3

	Fall		Winter		Spring		Summer	
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Low Q	2814.0		8818.0		5502.0		2575.0	
DH	.05		2.23		1.15		-.08	
	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	1.24	.08	2.45	.29	1.86	.17	1.17	.07
2	34.09	.20	33.74	.53	33.91	.35	34.11	.18
3	35.12	.19	34.69	.53	34.90	.35	35.14	.18
4	20.49	.18	20.21	.48	20.34	.32	20.50	.16
5	9.07	.16	8.92	.42	8.99	.28	9.08	.15
Mean Q	10524.0		22303.0		15474.0		6228.0	
DH	2.66		4.94		3.75		1.41	

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	2.68	.34	3.82	.72	3.24	.51	2.00	.20
2	33.67	.62	33.31	1.15	33.50	.85	33.87	.39
3	34.60	.61	34.18	1.14	34.40	.84	34.85	.39
4	20.15	.56	19.89	1.05	20.02	.78	20.31	.36
5	8.90	.49	8.80	.90	8.84	.67	8.97	.31

High Q	23766.0	35812.0	28470.0	11619.0
DH	5.18	7.04	5.96	2.93

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.94	.77	4.76	1.12	4.29	.91	2.82	.38
2	33.28	1.20	33.01	1.65	33.16	1.38	33.62	.67

3	34.14	1.20	33.83	1.64	34.01	1.37	34.55	.66
4	19.86	1.10	19.67	1.50	19.78	1.26	20.12	.61
5	8.79	.94	8.74	1.28	8.76	1.08	8.88	.53

5. SECTION No.75-6

	Fall	Winter	Spring	Summer
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Low Q	1104.8	3394.4	2154.0	1011.6
DH	.03	1.41	.77	-.06

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	1.95	.10	2.53	.31	2.27	.20	1.92	.09
2	39.66	.27	38.98	.76	39.29	.50	39.71	.25
3	31.39	.19	31.13	.54	31.25	.35	31.41	.17

4	19.31	.16	19.25	.47	19.28	.31	19.31	.15
5	7.68	.16	8.10	.46	7.91	.30	7.65	.15

Mean Q	4085.2	8644.4	6008.8	2426.8
DH	1.70	3.26	2.41	.92

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	2.65	.37	3.29	.77	2.94	.54	2.33	.22
2	38.84	.90	38.13	1.75	38.51	1.27	39.21	.56
3	31.08	.64	30.78	1.25	30.94	.91	31.22	.40
4	19.24	.56	19.15	1.09	19.20	.79	19.27	.34
5	8.19	.54	8.65	1.06	8.40	.77	7.96	.33

High Q	9221.6	13998.0	11021.6	4518.0
DH	3.41	4.53	3.86	1.86

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.35	.82	3.79	1.22	3.52	.97	2.72	.41
2	38.06	1.86	37.59	2.66	37.87	2.17	38.76	.99
3	30.76	1.32	30.55	1.90	30.67	1.55	31.05	.70
4	19.15	1.15	19.08	1.66	19.12	1.35	19.23	.61
5	8.69	1.13	9.00	1.62	8.81	1.32	8.24	.59

6. SECTION No.75-7

	Fall	Winter	Spring	Summer
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Low Q	1657.2	5091.6	3231.0	1517.4
DH	-.45	1.18	.44	-.54

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.18	.12	3.93	.37	3.59	.24	3.14	.11
2	20.57	.15	20.83	.43	20.72	.28	20.55	.14
3	45.56	.26	44.53	.73	44.99	.48	45.63	.24
4	26.39	.18	25.87	.50	26.10	.33	26.43	.16
5	4.29	.09	4.84	.27	4.60	.18	4.26	.09
Mean Q	6127.8		12966.6		9013.2		3640.2	
DH	1.56		3.43		2.46		.62	

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.09	.44	4.88	.89	4.48	.64	3.68	.27
2	20.88	.51	21.10	1.00	21.00	.73	20.75	.32
3	44.31	.86	43.28	1.66	43.79	1.21	44.88	.54

4	25.75	.59	25.22	1.14	25.49	.83	26.04	.37
5	4.96	.33	5.52	.65	5.24	.47	4.66	.20

High Q	13832.4	20997.0	16532.4	6777.0
DH	3.60	4.90	4.14	1.78

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.95	.95	5.45	1.40	5.16	1.12	4.19	.48
2	21.12	1.06	21.23	1.53	21.17	1.24	20.91	.56
3	43.19	1.76	42.54	2.51	42.91	2.05	44.18	.94
4	25.18	1.20	24.85	1.72	25.04	1.40	25.69	.64
5	5.57	.69	5.93	1.01	5.72	.81	5.03	.36

7. SECTION No.75-8

	Fall		Winter		Spring		Summer	
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Low Q	1104.8		3394.4		2154.0		1011.6	
DH	.03		1.41		.77		-.06	
	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	56.77	.34	55.37	.92	55.99	.61	56.86	.31
2	26.81	.20	26.43	.55	26.61	.36	26.84	.18
3	14.81	.18	15.67	.53	15.29	.34	14.75	.17
4	1.61	.09	2.53	.28	2.11	.18	1.56	.08

Mean Q	4085.2		8644.4		6008.8		2426.8	
DH	1.70		3.26		2.41		.92	
	Qi/Q	Vi	Qi/Q	Vi	Qi/Q	Vi	Qi/Q	Vi

	(%)	(ft/s)	(%)	(ft/s)	(%)	(ft/s)	(%)	(ft/s)
1	55.10	1.08	53.77	2.04	54.47	1.51	55.84	.68
2	26.35	.65	25.93	1.24	26.16	.91	26.56	.41
3	15.83	.62	16.58	1.22	16.20	.88	15.39	.39
4	2.72	.34	3.71	.74	3.18	.51	2.21	.20

High Q	9221.6	13998.0	11021.6	4518.0
DH	3.41	4.53	3.86	1.86

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	53.65	2.16	52.83	3.03	53.31	2.50	54.95	1.18
2	25.90	1.31	25.61	1.86	25.78	1.53	26.30	.71
3	16.65	1.29	17.08	1.86	16.83	1.51	15.92	.68
4	3.80	.78	4.47	1.18	4.08	.93	2.83	.38

8. SECTION No.78-7

	Fall	Winter	Spring	Summer
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Low Q	2749.0	8398.0	5354.0	2517.0
DH	.04	2.13	1.12	-.09

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.40	.12	4.12	.36	3.78	.24	3.35	.11
2	23.77	.31	23.92	.86	23.86	.58	23.76	.29
3	43.32	.37	41.63	1.01	42.41	.68	43.42	.35
4	27.13	.33	26.92	.90	27.02	.60	27.15	.30
5	2.38	.18	3.41	.56	2.92	.36	2.32	.17

	Fall	Winter	Spring	Summer
Mean Q	10130.0	21429.0	14902.0	6024.0

DH 2.58 4.81 3.65 1.36

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.27	.43	4.93	.86	4.60	.62	3.87	.26
2	23.94	1.01	24.00	1.93	23.97	1.42	23.88	.64
3	41.31	1.19	39.85	2.22	40.57	1.64	42.22	.76
4	26.87	1.06	26.62	2.00	26.75	1.47	27.00	.67
5	3.62	.67	4.61	1.36	4.11	.97	3.04	.40

High Q 22866.0 34780.0 27313.0 11209.0

DH 5.05 6.91 5.79 2.85

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.00	.91	5.48	1.31	5.20	1.06	4.35	.47

2	24.00	2.04	24.00	2.86	24.00	2.35	23.95	1.11
3	39.70	2.35	38.67	3.26	39.28	2.70	41.12	1.29
4	26.59	2.11	26.39	2.96	26.51	2.44	26.84	1.15
5	4.71	1.44	5.45	2.10	5.01	1.70	3.74	.74

9. SECTION No.80-2

	Fall	Winter	Spring	Summer
Low Q	2749.0	8398.0	5354.0	2517.0
DH	.04	2.13	1.12	-.09

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	9.97	.44	10.85	1.19	10.44	.81	9.92	.41
2	19.74	.42	19.00	1.09	19.34	.75	19.79	.38

3	29.01	.39	28.44	1.04	28.70	.71	29.05	.36
4	36.38	.52	36.36	1.39	36.38	.94	36.38	.48
5	4.90	.28	5.35	.74	5.14	.50	4.87	.26

Mean Q	10130.0	21429.0	14902.0	6024.0
DH	2.58	4.81	3.65	1.36

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	11.02	1.40	11.78	2.62	11.40	1.94	10.54	.90
2	18.86	1.28	18.26	2.36	18.56	1.76	19.25	.83
3	28.33	1.21	27.84	2.25	28.09	1.67	28.64	.78
4	36.35	1.63	36.25	3.03	36.31	2.25	36.38	1.05
5	5.44	.87	5.86	1.64	5.65	1.21	5.19	.56

High Q	22866.0	34780.0	27313.0	11209.0

DH	5.05	6.91	5.79	2.85

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	11.86	2.76	12.42	3.82	12.09	3.17	11.12	1.53
2	18.21	2.48	17.80	3.41	18.04	2.85	18.78	1.39
3	27.80	2.37	27.45	3.27	27.65	2.72	28.27	1.32
4	36.24	3.19	36.12	4.41	36.20	3.66	36.34	1.77
5	5.90	1.72	6.22	2.39	6.03	1.98	5.49	.95

10. SECTION No.81-1

	Fall	Winter	Spring	Summer
Low Q	2661.0	7832.0	5154.0	2439.0

DH	.02		2.00		1.07		-.10	

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.35	.20	5.00	.54	4.70	.37	4.31	.18
2	27.15	.34	26.66	.91	26.88	.63	27.18	.32
3	43.57	.44	42.31	1.16	42.88	.80	43.65	.41
4	19.47	.27	19.81	.73	19.66	.50	19.45	.25
5	5.46	.26	6.22	.71	5.88	.48	5.42	.24

Mean Q	9599.0		20248.0		14131.0		5750.0	
DH	2.47		4.64		3.53		1.29	

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.15	.66	5.78	1.28	5.46	.93	4.77	.41
2	26.54	1.08	26.07	2.06	26.31	1.52	26.83	.69

3	42.03	1.38	40.88	2.61	41.45	1.93	42.74	.88
4	19.88	.87	20.14	1.67	20.02	1.22	19.70	.55
5	6.39	.86	7.13	1.66	6.76	1.21	5.96	.54

High Q	21651.0	33387.0	25751.0	10655.0
DH	4.88	6.74	5.56	2.74

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.84	1.36	6.33	1.97	6.03	1.58	5.23	.72
2	26.03	2.18	25.66	3.09	25.89	2.51	26.48	1.19
3	40.77	2.76	39.90	3.91	40.44	3.18	41.88	1.51
4	20.16	1.77	20.32	2.54	20.23	2.05	19.92	.95
5	7.20	1.76	7.77	2.54	7.42	2.05	6.49	.94

11. SECTION No.81-6

	Fall	Winter	Spring	Summer
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Low Q	2661.0	7832.0	5154.0	2439.0
DH	.02	2.00	1.07	-.10

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	4.54	.33	5.65	.89	5.15	.61	4.47	.30
2	17.28	.32	17.41	.84	17.36	.58	17.27	.30
3	26.45	.43	25.38	1.10	25.85	.78	26.52	.40
4	33.13	.42	32.23	1.07	32.63	.75	33.19	.39
5	18.60	.44	19.33	1.14	19.01	.80	18.55	.41

	Fall	Winter	Spring	Summer
Mean Q	9599.0	20248.0	14131.0	5750.0

DH 2.47 4.64 3.53 1.29

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	5.89	1.07	6.89	2.05	6.39	1.50	5.27	.67
2	17.43	1.00	17.50	1.86	17.47	1.38	17.37	.64
3	25.16	1.31	24.27	2.40	24.70	1.80	25.74	.85
4	32.04	1.26	31.25	2.33	31.64	1.74	32.54	.82
5	19.48	1.35	20.09	2.51	19.79	1.87	19.08	.88

High Q 21651.0 33387.0 25751.0 10655.0

DH 4.88 6.74 5.56 2.74

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	6.99	2.17	7.73	3.10	7.27	2.51	6.02	1.17
2	17.50	1.96	17.52	2.76	17.51	2.25	17.44	1.09

3	24.18	2.53	23.55	3.51	23.94	2.89	25.04	1.43
4	31.18	2.46	30.60	3.42	30.96	2.81	31.94	1.38
5	20.15	2.65	20.59	3.69	20.32	3.03	19.56	1.48

12. SECTION No.83-6

	Fall	Winter	Spring	Summer
	----	------	------	------
Low Q	2653.0	7781.0	5136.0	2432.0
DH	.01	1.98	1.07	-.10

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	2.48	.08	2.91	.22	2.71	.14	2.46	.07
2	29.31	.16	29.35	.44	29.33	.30	29.30	.15

3	37.81	.18	37.26	.49	37.51	.34	37.84	.17
4	27.00	.13	26.78	.37	26.88	.25	27.02	.12
5	3.40	.07	3.71	.20	3.56	.14	3.38	.07

Mean Q	9550.0	20141.0	14062.0	5725.0
DH	2.47	4.63	3.52	1.28

	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.01	.27	3.45	.54	3.22	.38	2.76	.16
2	29.36	.53	29.37	1.06	29.37	.76	29.34	.33
3	37.13	.59	36.59	1.17	36.86	.85	37.45	.37
4	26.72	.45	26.49	.88	26.61	.64	26.86	.28
5	3.78	.24	4.10	.49	3.93	.35	3.60	.15

High Q	21541.0	33261.0	25610.0	10605.0

DH	4.86		6.73		5.54		2.73	
	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)	Qi/Q (%)	Vi (ft/s)
1	3.49	.58	3.86	.87	3.63	.68	3.06	.29
2	29.37	1.12	29.37	1.64	29.37	1.31	29.36	.59
3	36.53	1.24	36.10	1.81	36.37	1.44	37.06	.65
4	26.47	.93	26.28	1.36	26.40	1.09	26.69	.49
5	4.13	.52	4.39	.77	4.22	.61	3.82	.27

Appendix C. Prediction Results

```
*****************************************************
*******                                     ********
*******  RIVER MILE  73.1                   ********
*******                                     ********
*****************************************************
*****************************************************
*******                 FALL                 *******
*******               LOW  FLOW              *******
*****************************************************
```

```
###################################################
##########1x5 JUMBO TOW CONFIGURATION #############
##########      TOW LENGTH    1025.00FT.############
##########      TOW WIDTH      35.00FT.#############
###################################################
```

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.28
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.865	-1.440	-0.864	-0.651
BACKWATER	0.033	0.095	0.326	0.092	0.033
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.493	-0.744	-1.217	-0.719	-0.526
MAX. VELOCITY	0.191	0.216	0.548	0.238	0.158
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.155	0.126	1.716	0.164	0.093
DUE TO MINIMUM VELOCITY	1.866	4.048	16.155	3.678	2.219
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.05887 FT.

DIVERGING WAVE HEIGHT = 0.2839 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.48
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.002	0.000	0.000	0.000	0.002
PROPELLER	-0.701	-0.932	-2.131	-0.931	-0.701
BACKWATER	0.042	0.120	0.412	0.117	0.042
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.545	-0.811	-1.908	-0.786	-0.579
MAX. VELOCITY	0.202	0.241	0.635	0.262	0.168
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.179	0.171	2.590	0.216	0.111
DUE TO MINIMUM VELOCITY	2.431	5.155	57.174	4.720	2.845
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.09430 FT.

DIVERGING WAVE HEIGHT = 0.4548 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	12.68
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.033	0.000	0.000	0.000	0.033
PROPELLER	-0.820	-1.090	-2.492	-1.089	-0.820
BACKWATER	0.051	0.145	0.499	0.141	0.051
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.695	-0.969	-2.269	-0.944	-0.728
MAX. VELOCITY	0.242	0.267	0.721	0.287	0.208
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.286	0.226	3.710	0.277	0.193
DUE TO MINIMUM VELOCITY	4.605	8.504	93.032	7.898	5.214
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.13805 FT.

DIVERGING WAVE HEIGHT = 0.6657 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.18
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.466	-1.137	-0.466	-0.351
BACKWATER	0.025	0.071	0.243	0.069	0.025
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.192	-0.345	-0.915	-0.320	-0.226
MAX. VELOCITY	0.183	0.192	0.465	0.214	0.149
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.138	0.090	1.084	0.123	0.081
DUE TO MINIMUM VELOCITY	0.157	0.466	7.239	0.378	0.240
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.03279 FT.

DIVERGING WAVE HEIGHT = 0.1581 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.08
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.432	-0.587	-0.442
BACKWATER	0.028	0.081	0.278	0.079	0.028
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.284	-0.466	-1.210	-0.441	-0.317
MAX. VELOCITY	0.186	0.202	0.501	0.224	0.153

CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.145	0.105	1.332	0.139	0.086
DUE TO MINIMUM VELOCITY	0.436	1.086	15.887	0.932	0.586
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.04304 FT.

DIVERGING WAVE HEIGHT = 0.2076 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.88
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.543	-0.632	-0.476
BACKWATER	0.032	0.090	0.310	0.088	0.032
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.318	-0.511	-1.320	-0.486	-0.351
MAX. VELOCITY	0.190	0.212	0.532	0.233	0.156
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.151	0.118	1.581	0.155	0.091
DUE TO MINIMUM VELOCITY	0.588	1.410	20.308	1.227	0.766
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.05332 FT.

DIVERGING WAVE HEIGHT = 0.2571 FT.

##

###########3x3 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 615.00FT.#############

########### TOW WIDTH 105.00FT.#############

##

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	5.98
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.865	-1.978	-0.864	-0.651
BACKWATER	0.222	0.261	0.371	0.254	0.222
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.493	-0.744	-1.756	-0.719	-0.526
MAX. VELOCITY	0.380	0.382	0.594	0.399	0.347
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.943	0.625	2.149	0.704	0.739
DUE TO MINIMUM VELOCITY	1.866	4.048	45.238	3.678	2.219
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.06381 FT.

DIVERGING WAVE HEIGHT = 0.1882 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	7.98
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.932	-2.131	-0.931	-0.701
BACKWATER	0.296	0.348	0.496	0.338	0.296
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.543	-0.811	-1.908	-0.786	-0.577
MAX. VELOCITY	0.455	0.470	0.718	0.484	0.421
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.509	1.113	3.665	1.210	1.233
DUE TO MINIMUM VELOCITY	2.410	5.155	57.174	4.720	2.822
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.11363 FT.

DIVERGING WAVE HEIGHT = 0.3351 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.18
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.008	0.000	0.000	0.000	0.008
PROPELLER	-0.820	-1.090	-2.492	-1.089	-0.820
BACKWATER	0.378	0.444	0.632	0.432	0.378
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.670	-0.969	-2.269	-0.944	-0.704
MAX. VELOCITY	0.544	0.566	0.855	0.577	0.511
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.426	1.877	5.979	1.986	2.052
DUE TO MINIMUM VELOCITY	4.191	8.504	93.032	7.898	4.766
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.18493 FT.

DIVERGING WAVE HEIGHT = 0.5454 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	4.68
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.466	-1.137	-0.466	-0.351
BACKWATER	0.174	0.204	0.291	0.199	0.174
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.192	-0.345	-0.915	-0.320	-0.226
MAX. VELOCITY	0.332	0.326	0.513	0.344	0.298

CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.660	0.398	1.425	0.464	0.498
DUE TO MINIMUM VELOCITY	0.157	0.466	7.239	0.378	0.240
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.03908 FT.

DIVERGING WAVE HEIGHT = 0.1153 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	5.78
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.432	-0.587	-0.442
BACKWATER	0.215	0.252	0.359	0.245	0.215
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.284	-0.466	-1.210	-0.441	-0.317
MAX. VELOCITY	0.373	0.374	0.581	0.391	0.339
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.895	0.585	2.025	0.663	0.698
DUE TO MINIMUM VELOCITY	0.436	1.086	15.887	0.932	0.586
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.05962 FT.

DIVERGING WAVE HEIGHT = 0.1758 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.28
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.543	-0.632	-0.476
BACKWATER	0.233	0.274	0.390	0.266	0.233
AMB. VELOCITY	0.158	0.121	0.222	0.146	0.124
MIN. VELOCITY	-0.318	-0.511	-1.320	-0.486	-0.351
MAX. VELOCITY	0.391	0.396	0.612	0.412	0.358
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.017	0.687	2.344	0.769	0.804
DUE TO MINIMUM VELOCITY	0.588	1.410	20.308	1.227	0.766
DUE TO AMBIENT VELOCITY	0.094	0.025	0.136	0.041	0.050

SQUAT = 0.07038 FT.

DIVERGING WAVE HEIGHT = 0.2075 FT.

****

******* FALL *******

******* MEAN FLOW *******

****

##

###########1x5 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 1025.00FT.#############

########### TOW WIDTH 35.00FT.#############

##

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00

RUNNING HORSEPOWER 1600.00

PROP. DIAMETER(FT) 8.00

TOW SPEED (FT/SEC) 8.88

STILL WATER SPEED 8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.784	-0.862	-0.651
BACKWATER	0.033	0.090	0.310	0.087	0.033
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.077	-0.443	-1.077	-0.393	-0.212
MAX. VELOCITY	0.607	0.509	1.016	0.557	0.472
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.221	1.395	9.730	1.792	1.663
DUE TO MINIMUM VELOCITY	0.014	0.946	11.467	0.672	0.202
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.06313 FT.

DIVERGING WAVE HEIGHT = 0.3251 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00

RUNNING HORSEPOWER 2000.00

PROP. DIAMETER(FT) 8.00

TOW SPEED (FT/SEC) 11.08

STILL WATER SPEED 10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.930	-1.921	-0.929	-0.701
BACKWATER	0.041	0.112	0.386	0.109	0.041
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.127	-0.510	-1.215	-0.459	-0.262
MAX. VELOCITY	0.615	0.531	1.093	0.578	0.480
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.336	1.573	11.938	1.994	1.739
DUE TO MINIMUM VELOCITY	0.053	1.402	16.074	1.044	0.354
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.09829 FT.

DIVERGING WAVE HEIGHT = 0.5061 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00

RUNNING HORSEPOWER 3200.00

PROP. DIAMETER(FT) 8.00

TOW SPEED (FT/SEC) 13.28

STILL WATER SPEED 12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.820	-1.087	-2.247	-1.086	-0.820

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
BACKWATER	0.049	0.134	0.463	0.130	0.049
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.247	-0.668	-1.541	-0.617	-0.381
MAX. VELOCITY	0.623	0.554	1.170	0.600	0.488
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.461	1.765	14.445	2.211	1.823
DUE TO MINIMUM VELOCITY	0.302	2.989	31.322	2.391	0.951
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.14119 FT.

DIVERGING WAVE HEIGHT = 0.7271 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.78
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.351	-0.465	-1.019	-0.464	-0.351
BACKWATER	0.025	0.068	0.236	0.067	0.025
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.223	-0.045	-0.312	0.005	0.088
MAX. VELOCITY	0.599	0.488	0.943	0.536	0.465
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.123	1.238	7.885	1.612	1.598
DUE TO MINIMUM VELOCITY	0.231	0.002	0.353	0.000	0.020
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.03680 FT.

DIVERGING WAVE HEIGHT = 0.1895 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.68
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.283	-0.585	-0.442
BACKWATER	0.028	0.077	0.268	0.075	0.028
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.132	-0.166	-0.577	-0.116	-0.003
MAX. VELOCITY	0.602	0.497	0.974	0.545	0.467
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.160	1.304	8.645	1.687	1.622
DUE TO MINIMUM VELOCITY	0.059	0.060	1.980	0.022	0.000
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.04722 FT.

DIVERGING WAVE HEIGHT = 0.2432 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 8.48
STILL WATER SPEED 7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.382	-0.630	-0.476
BACKWATER	0.031	0.086	0.296	0.083	0.031
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.098	-0.211	-0.676	-0.161	-0.037
MAX. VELOCITY	0.605	0.505	1.002	0.553	0.470
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.201	1.365	9.359	1.757	1.649
DUE TO MINIMUM VELOCITY	0.027	0.118	3.091	0.055	0.002
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.05757 FT.
DIVERGING WAVE HEIGHT = 0.2965 FT.

##
##########3x3 JUMBO TOW CONFIGURATION #############
########## TOW LENGTH 615.00FT.#############
########## TOW WIDTH 105.00FT.#############
##

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 6.58
STILL WATER SPEED 5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.784	-0.862	-0.651
BACKWATER	0.223	0.252	0.361	0.246	0.223
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.077	-0.443	-1.077	-0.393	-0.212
MAX. VELOCITY	0.797	0.672	1.068	0.715	0.662
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.606	3.042	11.177	3.622	4.058
DUE TO MINIMUM VELOCITY	0.014	0.946	11.467	0.672	0.202
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.07204 FT.
DIVERGING WAVE HEIGHT = 0.2248 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 8.58
STILL WATER SPEED 7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.930	-1.921	-0.929	-0.701

BACKWATER	0.291	0.329	0.471	0.320	0.291
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.127	-0.510	-1.215	-0.459	-0.262
MAX. VELOCITY	0.865	0.749	1.177	0.790	0.730
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.188	4.122	14.714	4.787	5.243
DUE TO MINIMUM VELOCITY	0.053	1.402	16.074	1.044	0.354
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.12249 FT.

DIVERGING WAVE HEIGHT = 0.3822 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.78
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.087	-2.247	-1.086	-0.820
BACKWATER	0.365	0.413	0.592	0.402	0.365
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	-0.246	-0.668	-1.541	-0.617	-0.381
MAX. VELOCITY	0.939	0.833	1.298	0.872	0.805
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	10.180	5.564	19.359	6.321	6.773
DUE TO MINIMUM VELOCITY	0.300	2.989	31.322	2.391	0.948
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.19335 FT.

DIVERGING WAVE HEIGHT = 0.6034 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	5.28
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.465	-1.019	-0.464	-0.351
BACKWATER	0.179	0.202	0.290	0.197	0.179
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.223	-0.045	-0.312	0.005	0.089
MAX. VELOCITY	0.753	0.622	0.996	0.666	0.618
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	5.690	2.450	9.203	2.973	3.386
DUE TO MINIMUM VELOCITY	0.233	0.002	0.353	0.000	0.020
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.04639 FT.

DIVERGING WAVE HEIGHT = 0.1447 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.38
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.283	-0.585	-0.442
BACKWATER	0.216	0.245	0.350	0.238	0.216
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.132	-0.166	-0.577	-0.116	-0.003
MAX. VELOCITY	0.790	0.664	1.057	0.707	0.655
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.459	2.946	10.857	3.516	3.949
DUE TO MINIMUM VELOCITY	0.059	0.060	1.980	0.022	0.000
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.06773 FT.
DIVERGING WAVE HEIGHT = 0.2113 FT.

******** BOAT INFORMATION *********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.88
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.382	-0.630	-0.476
BACKWATER	0.233	0.264	0.378	0.257	0.233
AMB. VELOCITY	0.574	0.420	0.707	0.469	0.439
MIN. VELOCITY	0.098	-0.211	-0.676	-0.161	-0.037
MAX. VELOCITY	0.807	0.683	1.084	0.726	0.672
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.830	3.191	11.668	3.783	4.223
DUE TO MINIMUM VELOCITY	0.027	0.118	3.091	0.055	0.002
DUE TO AMBIENT VELOCITY	2.786	0.810	3.503	1.110	1.378

SQUAT = 0.07876 FT.
DIVERGING WAVE HEIGHT = 0.2458 FT.

****
******* FALL *******
******* HIGH FLOW *******
****

##
##########1x5 JUMBO TOW CONFIGURATION #############
########## TOW LENGTH 1025.00FT.#############
########## TOW WIDTH 35.00FT.#############
##

******** BOAT INFORMATION *********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	9.73
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.861	-1.630	-0.860	-0.651
BACKWATER	0.033	0.088	0.306	0.086	0.033
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.344	-0.019	-0.271	0.047	0.127
MAX. VELOCITY	1.027	0.929	1.665	0.992	0.811
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.886	7.570	38.939	9.096	6.909
DUE TO MINIMUM VELOCITY	0.724	0.000	0.237	0.002	0.053
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.07123 FT.

DIVERGING WAVE HEIGHT = 0.3889 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.93
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.927	-1.756	-0.926	-0.701
BACKWATER	0.041	0.108	0.375	0.105	0.041
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.294	-0.086	-0.397	-0.019	0.077
MAX. VELOCITY	1.035	0.949	1.734	1.012	0.818
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	13.134	8.034	43.652	9.604	7.077
DUE TO MINIMUM VELOCITY	0.478	0.009	0.691	0.000	0.014
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.10709 FT.

DIVERGING WAVE HEIGHT = 0.5847 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	14.13
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.084	-2.053	-1.083	-0.820
BACKWATER	0.048	0.128	0.444	0.124	0.048
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.175	-0.243	-0.694	-0.176	-0.042
MAX. VELOCITY	1.042	0.969	1.803	1.031	0.826
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	13.386	8.516	48.718	10.129	7.250
DUE TO MINIMUM VELOCITY	0.122	0.174	3.331	0.071	0.003
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.15023 FT.

DIVERGING WAVE HEIGHT = 0.8202 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.63
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.926	-0.463	-0.350
BACKWATER	0.026	0.069	0.240	0.067	0.026
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.644	0.378	0.433	0.444	0.427
MAX. VELOCITY	1.020	0.910	1.599	0.974	0.804
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.654	7.144	34.758	8.628	6.751
DUE TO MINIMUM VELOCITY	3.771	0.604	0.886	0.947	1.281
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.04380 FT.

DIVERGING WAVE HEIGHT = 0.2392 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.53
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.584	-1.166	-0.583	-0.442
BACKWATER	0.029	0.077	0.268	0.075	0.029
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.553	0.258	0.193	0.323	0.336
MAX. VELOCITY	1.023	0.919	1.627	0.982	0.807
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.752	7.325	36.512	8.827	6.818
DUE TO MINIMUM VELOCITY	2.525	0.205	0.091	0.389	0.682
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.05475 FT.

DIVERGING WAVE HEIGHT = 0.2989 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	9.33
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.629	-1.256	-0.628	-0.476
BACKWATER	0.032	0.084	0.293	0.082	0.032

AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.519	0.212	0.103	0.278	0.302
MAX. VELOCITY	1.026	0.926	1.652	0.989	0.809
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.842	7.488	38.119	9.006	6.878
DUE TO MINIMUM VELOCITY	2.136	0.120	0.016	0.255	0.515
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.06550 FT.

DIVERGING WAVE HEIGHT = 0.3576 FT.

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##########3x3 JUMBO TOW CONFIGURATION #############

########## TOW LENGTH 615.00FT.#############

########## TOW WIDTH 105.00FT.#############

##

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	7.43
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.861	-1.630	-0.860	-0.651
BACKWATER	0.232	0.254	0.366	0.248	0.232
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.344	-0.019	-0.271	0.047	0.127
MAX. VELOCITY	1.227	1.096	1.725	1.154	1.010
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	20.541	12.031	43.052	13.923	12.316
DUE TO MINIMUM VELOCITY	0.724	0.000	0.237	0.002	0.053
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.08632 FT.

DIVERGING WAVE HEIGHT = 0.2835 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	9.43
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.927	-1.756	-0.926	-0.701
BACKWATER	0.295	0.323	0.465	0.315	0.295
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.294	-0.086	-0.397	-0.019	0.077
MAX. VELOCITY	1.289	1.164	1.824	1.221	1.072
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.410	14.265	50.325	16.304	14.424
DUE TO MINIMUM VELOCITY	0.478	0.009	0.691	0.000	0.014
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.13905 FT.

DIVERGING WAVE HEIGHT = 0.4567 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.63
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.084	-2.053	-1.083	-0.820
BACKWATER	0.364	0.398	0.573	0.388	0.364
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.175	-0.243	-0.694	-0.176	-0.042
MAX. VELOCITY	1.358	1.240	1.932	1.295	1.141
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	26.840	17.014	59.190	19.210	16.987
DUE TO MINIMUM VELOCITY	0.122	0.174	3.331	0.071	0.003
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.21150 FT.

DIVERGING WAVE HEIGHT = 0.6946 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.13
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.926	-0.463	-0.350
BACKWATER	0.192	0.210	0.302	0.205	0.192
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.644	0.378	0.433	0.444	0.427
MAX. VELOCITY	1.186	1.051	1.661	1.111	0.969
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	18.799	10.707	38.710	12.502	11.055
DUE TO MINIMUM VELOCITY	3.771	0.604	0.886	0.947	1.281
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.05876 FT.

DIVERGING WAVE HEIGHT = 0.1930 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.23
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.584	-1.166	-0.583	-0.442
BACKWATER	0.226	0.248	0.356	0.241	0.226

AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.553	0.258	0.193	0.323	0.336
MAX. VELOCITY	1.221	1.089	1.715	1.148	1.004
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	20.267	11.821	42.365	13.698	12.117
DUE TO MINIMUM VELOCITY	2.525	0.205	0.091	0.389	0.682
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.08174 FT.

DIVERGING WAVE HEIGHT = 0.2684 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.73
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.629	-1.256	-0.628	-0.476
BACKWATER	0.242	0.265	0.381	0.258	0.242
AMB. VELOCITY	0.994	0.841	1.359	0.907	0.778
MIN. VELOCITY	0.519	0.212	0.103	0.278	0.302
MAX. VELOCITY	1.236	1.106	1.740	1.164	1.019
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	20.956	12.350	44.097	14.264	12.619
DUE TO MINIMUM VELOCITY	2.136	0.120	0.016	0.255	0.515
DUE TO AMBIENT VELOCITY	11.825	5.726	22.025	7.058	6.193

SQUAT = 0.09344 FT.

DIVERGING WAVE HEIGHT = 0.3069 FT.

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******* WINTER *******

******* LOW FLOW *******

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###########1x5 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 1025.00FT.#############

########### TOW WIDTH 35.00FT.#############

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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.76
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.813	-0.862	-0.651
BACKWATER	0.033	0.090	0.311	0.088	0.033
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.203	-0.514	-1.210	-0.466	-0.303
MAX. VELOCITY	0.480	0.439	0.914	0.484	0.380
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.741	0.923	7.233	1.210	0.945

DUE TO MINIMUM VELOCITY	0.182	1.433	15.891	1.089	0.519
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.06212 FT.

DIVERGING WAVE HEIGHT = 0.3166 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 10.96
STILL WATER SPEED 10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.930	-1.953	-0.929	-0.701
BACKWATER	0.041	0.113	0.390	0.110	0.041
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.254	-0.581	-1.350	-0.533	-0.353
MAX. VELOCITY	0.488	0.462	0.993	0.506	0.389
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.821	1.062	9.108	1.371	0.999
DUE TO MINIMUM VELOCITY	0.325	2.019	21.609	1.585	0.777
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.09724 FT.

DIVERGING WAVE HEIGHT = 0.4956 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 3200.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 13.16
STILL WATER SPEED 12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.820	-1.088	-2.284	-1.087	-0.820
BACKWATER	0.049	0.135	0.468	0.132	0.049
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.374	-0.738	-1.681	-0.690	-0.473
MAX. VELOCITY	0.497	0.485	1.071	0.528	0.398
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.913	1.215	11.271	1.546	1.063
DUE TO MINIMUM VELOCITY	0.901	3.967	40.010	3.282	1.677
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.14020 FT.

DIVERGING WAVE HEIGHT = 0.7145 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 400.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 6.66
STILL WATER SPEED 5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.351	-0.465	-1.036	-0.465	-0.351
BACKWATER	0.025	0.069	0.237	0.067	0.025
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	0.096	-0.116	-0.433	-0.068	-0.004
MAX. VELOCITY	0.473	0.418	0.840	0.463	0.374
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.678	0.801	5.694	1.068	0.901
DUE TO MINIMUM VELOCITY	0.025	0.022	0.887	0.005	0.000
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.03591 FT.

DIVERGING WAVE HEIGHT = 0.1830 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.56
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.305	-0.585	-0.442
BACKWATER	0.028	0.078	0.269	0.076	0.028
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	0.006	-0.237	-0.702	-0.189	-0.094
MAX. VELOCITY	0.476	0.427	0.872	0.472	0.376
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.699	0.852	6.324	1.128	0.916
DUE TO MINIMUM VELOCITY	0.000	0.162	3.447	0.086	0.024
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.04627 FT.

DIVERGING WAVE HEIGHT = 0.2358 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.36
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.406	-0.630	-0.476
BACKWATER	0.031	0.086	0.297	0.084	0.031
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.028	-0.282	-0.803	-0.234	-0.128
MAX. VELOCITY	0.479	0.435	0.900	0.480	0.379
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.727	0.899	6.921	1.182	0.935
DUE TO MINIMUM VELOCITY	0.001	0.265	5.022	0.157	0.054
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.05658 FT.

DIVERGING WAVE HEIGHT = 0.2883 FT.

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###################################################
##########3x3 JUMBO TOW CONFIGURATION #############
##########     TOW LENGTH    615.00FT.#############
##########     TOW WIDTH     105.00FT.#############
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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	6.46
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.813	-0.862	-0.651
BACKWATER	0.222	0.253	0.361	0.246	0.222
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.203	-0.514	-1.210	-0.466	-0.303
MAX. VELOCITY	0.670	0.602	0.965	0.642	0.570
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.179	2.236	8.403	2.680	2.736
DUE TO MINIMUM VELOCITY	0.182	1.433	15.891	1.089	0.519
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.07021 FT.

DIVERGING WAVE HEIGHT = 0.2171 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.46
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.930	-1.953	-0.929	-0.701
BACKWATER	0.291	0.331	0.473	0.322	0.291
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.254	-0.581	-1.350	-0.533	-0.353
MAX. VELOCITY	0.738	0.680	1.076	0.718	0.639
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	5.404	3.152	11.439	3.671	3.691
DUE TO MINIMUM VELOCITY	0.325	2.019	21.609	1.585	0.777
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.12041 FT.

DIVERGING WAVE HEIGHT = 0.3724 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.66
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.088	-2.284	-1.087	-0.820
BACKWATER	0.367	0.417	0.596	0.406	0.367
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.373	-0.738	-1.681	-0.690	-0.472
MAX. VELOCITY	0.814	0.766	1.200	0.802	0.715
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.988	4.405	15.508	5.005	4.958
DUE TO MINIMUM VELOCITY	0.895	3.967	40.010	3.282	1.669
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.19118 FT.

DIVERGING WAVE HEIGHT = 0.5912 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	5.16
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.465	-1.036	-0.465	-0.351
BACKWATER	0.177	0.202	0.289	0.196	0.177
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	0.097	-0.116	-0.433	-0.068	-0.003
MAX. VELOCITY	0.625	0.551	0.892	0.593	0.525
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.486	1.744	6.741	2.139	2.208
DUE TO MINIMUM VELOCITY	0.026	0.022	0.887	0.005	0.000
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.04479 FT.

DIVERGING WAVE HEIGHT = 0.1385 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.26
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.305	-0.585	-0.442
BACKWATER	0.215	0.245	0.350	0.238	0.215
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	0.006	-0.237	-0.702	-0.189	-0.094
MAX. VELOCITY	0.663	0.594	0.953	0.635	0.563
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.067	2.155	8.132	2.591	2.650
DUE TO MINIMUM VELOCITY	0.000	0.162	3.447	0.086	0.024
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.06593 FT.

DIVERGING WAVE HEIGHT = 0.2039 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.76
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.406	-0.630	-0.476
BACKWATER	0.232	0.265	0.378	0.257	0.232
AMB. VELOCITY	0.447	0.349	0.603	0.396	0.348
MIN. VELOCITY	-0.028	-0.282	-0.803	-0.234	-0.128
MAX. VELOCITY	0.680	0.614	0.981	0.654	0.580
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.350	2.360	8.821	2.816	2.868
DUE TO MINIMUM VELOCITY	0.001	0.265	5.022	0.157	0.054
DUE TO AMBIENT VELOCITY	1.447	0.484	2.246	0.690	0.746

SQUAT = 0.07688 FT.

DIVERGING WAVE HEIGHT = 0.2378 FT.

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******* WINTER *******

******* MEAN FLOW *******

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###########1x5 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 1025.00FT.#############

########### TOW WIDTH 35.00FT.#############

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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	9.64
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.861	-1.643	-0.860	-0.651
BACKWATER	0.033	0.088	0.306	0.086	0.033
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.411	-0.044	-0.323	0.023	0.179
MAX. VELOCITY	1.095	0.905	1.626	0.968	0.863
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	15.232	7.020	36.450	8.492	8.134
DUE TO MINIMUM VELOCITY	1.160	0.001	0.389	0.000	0.130
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.07032 FT.

DIVERGING WAVE HEIGHT = 0.3819 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00

PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.84
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.927	-1.770	-0.926	-0.701
BACKWATER	0.040	0.108	0.375	0.105	0.040
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.361	-0.110	-0.450	-0.044	0.129
MAX. VELOCITY	1.102	0.925	1.696	0.988	0.870
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	15.509	7.467	41.017	8.983	8.322
DUE TO MINIMUM VELOCITY	0.823	0.019	0.985	0.001	0.055
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.10608 FT.

DIVERGING WAVE HEIGHT = 0.5761 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	14.04
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.085	-2.070	-1.083	-0.820
BACKWATER	0.048	0.128	0.445	0.125	0.048
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.242	-0.268	-0.750	-0.201	0.010
MAX. VELOCITY	1.110	0.945	1.765	1.007	0.878
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	15.791	7.931	45.936	9.492	8.514
DUE TO MINIMUM VELOCITY	0.288	0.229	4.140	0.102	0.000
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.14917 FT.

DIVERGING WAVE HEIGHT = 0.8101 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.54
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.934	-0.463	-0.350
BACKWATER	0.026	0.069	0.239	0.067	0.026
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.711	0.353	0.386	0.419	0.479
MAX. VELOCITY	1.088	0.886	1.559	0.950	0.855
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	14.973	6.610	32.410	8.040	7.959
DUE TO MINIMUM VELOCITY	4.902	0.499	0.642	0.809	1.733

DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.04302 FT.
DIVERGING WAVE HEIGHT = 0.2336 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.44
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.584	-1.177	-0.583	-0.442
BACKWATER	0.029	0.077	0.268	0.075	0.029
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.620	0.233	0.144	0.299	0.388
MAX. VELOCITY	1.091	0.894	1.588	0.958	0.858
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	15.083	6.784	34.104	8.232	8.033
DUE TO MINIMUM VELOCITY	3.419	0.154	0.040	0.313	0.995
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.05390 FT.
DIVERGING WAVE HEIGHT = 0.2927 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	9.24
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.629	-1.267	-0.629	-0.476
BACKWATER	0.032	0.084	0.293	0.082	0.032
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.586	0.188	0.053	0.254	0.354
MAX. VELOCITY	1.094	0.901	1.613	0.965	0.861
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	15.182	6.941	35.657	8.405	8.100
DUE TO MINIMUM VELOCITY	2.947	0.084	0.002	0.198	0.782
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.06461 FT.
DIVERGING WAVE HEIGHT = 0.3509 FT.

###
###########3x3 JUMBO TOW CONFIGURATION #############
########### TOW LENGTH 615.00FT.#############
########### TOW WIDTH 105.00FT.#############
###

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00

PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	7.34
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.861	-1.643	-0.860	-0.651
BACKWATER	0.231	0.254	0.365	0.247	0.231
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.411	-0.044	-0.323	0.023	0.179
MAX. VELOCITY	1.293	1.071	1.686	1.130	1.061
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.597	11.270	40.332	13.108	14.016
DUE TO MINIMUM VELOCITY	1.160	0.001	0.389	0.000	0.130
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.08473 FT.

DIVERGING WAVE HEIGHT = 0.2769 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	9.34
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.927	-1.770	-0.926	-0.701
BACKWATER	0.294	0.323	0.465	0.315	0.294
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.361	-0.110	-0.450	-0.044	0.129
MAX. VELOCITY	1.356	1.140	1.785	1.197	1.124
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	26.741	13.439	47.387	15.426	16.312
DUE TO MINIMUM VELOCITY	0.823	0.019	0.985	0.001	0.055
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.13719 FT.

DIVERGING WAVE HEIGHT = 0.4484 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.54
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.085	-2.070	-1.083	-0.820
BACKWATER	0.364	0.399	0.574	0.389	0.364
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.242	-0.268	-0.750	-0.201	0.010
MAX. VELOCITY	1.425	1.216	1.895	1.271	1.193
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	30.487	16.116	56.013	18.264	19.093
DUE TO MINIMUM VELOCITY	0.288	0.229	4.140	0.102	0.000

DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.20943 FT.
DIVERGING WAVE HEIGHT = 0.6846 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.04
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.934	-0.463	-0.350
BACKWATER	0.190	0.209	0.301	0.204	0.190
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.712	0.353	0.386	0.419	0.479
MAX. VELOCITY	1.252	1.026	1.621	1.086	1.020
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	21.682	9.990	36.132	11.729	12.638
DUE TO MINIMUM VELOCITY	4.902	0.499	0.642	0.809	1.733
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.05737 FT.
DIVERGING WAVE HEIGHT = 0.1875 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.14
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.584	-1.177	-0.583	-0.442
BACKWATER	0.225	0.247	0.355	0.241	0.225
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.620	0.233	0.144	0.299	0.388
MAX. VELOCITY	1.287	1.064	1.676	1.123	1.055
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.296	11.067	39.667	12.889	13.798
DUE TO MINIMUM VELOCITY	3.419	0.154	0.040	0.313	0.995
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.08017 FT.
DIVERGING WAVE HEIGHT = 0.2621 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.64
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE

DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.629	-1.267	-0.629	-0.476
BACKWATER	0.241	0.264	0.380	0.258	0.241
AMB. VELOCITY	1.062	0.817	1.320	0.882	0.830
MIN. VELOCITY	0.586	0.188	0.053	0.254	0.354
MAX. VELOCITY	1.303	1.081	1.701	1.140	1.070
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	24.053	11.580	41.344	13.440	14.347
DUE TO MINIMUM VELOCITY	2.947	0.084	0.002	0.198	0.782
DUE TO AMBIENT VELOCITY	14.056	5.266	20.305	6.545	7.342

SQUAT = 0.09180 FT.
DIVERGING WAVE HEIGHT = 0.3000 FT.

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*********************************************************
*******              WINTER                      *******
*******              HIGH FLOW                   *******
*********************************************************
###################################################
###########1x5 JUMBO TOW CONFIGURATION #############
###########      TOW LENGTH    1025.00FT.#############
###########      TOW WIDTH       35.00FT.#############
###################################################
********     BOAT INFORMATION     **********************
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RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 10.37
STILL WATER SPEED 8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.859	-1.532	-0.858	-0.651
BACKWATER	0.033	0.087	0.303	0.085	0.033
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.694	0.320	0.313	0.382	0.393
MAX. VELOCITY	1.378	1.265	2.148	1.324	1.076
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	27.886	18.009	79.706	20.465	14.566
DUE TO MINIMUM VELOCITY	4.593	0.377	0.355	0.621	1.026
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.07751 FT.
DIVERGING WAVE HEIGHT = 0.4408 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 12.57
STILL WATER SPEED 10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.925	-1.650	-0.924	-0.701
BACKWATER	0.040	0.105	0.367	0.103	0.040
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.644	0.253	0.194	0.315	0.342

MAX. VELOCITY	1.385	1.284	2.212	1.342	1.084
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	28.264	18.756	86.593	21.256	14.819
DUE TO MINIMUM VELOCITY	3.769	0.196	0.093	0.364	0.716
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.11389 FT.
DIVERGING WAVE HEIGHT = 0.6476 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	14.77
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.082	-1.930	-1.081	-0.820
BACKWATER	0.048	0.124	0.432	0.121	0.048
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.525	0.096	-0.085	0.159	0.223
MAX. VELOCITY	1.392	1.302	2.277	1.360	1.091
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	28.646	19.523	93.852	22.065	15.075
DUE TO MINIMUM VELOCITY	2.204	0.013	0.009	0.053	0.233
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.15724 FT.
DIVERGING WAVE HEIGHT = 0.8941 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.27
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.462	-0.868	-0.462	-0.350
BACKWATER	0.027	0.069	0.242	0.068	0.027
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.994	0.716	0.977	0.777	0.693
MAX. VELOCITY	1.371	1.248	2.087	1.307	1.070
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	27.528	17.314	73.471	19.729	14.327
DUE TO MINIMUM VELOCITY	11.818	3.634	8.717	4.584	4.569
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.04930 FT.
DIVERGING WAVE HEIGHT = 0.2803 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00

TOW SPEED (FT/SEC) 9.17
STILL WATER SPEED 6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.441	-0.583	-1.093	-0.582	-0.441
BACKWATER	0.030	0.077	0.268	0.075	0.030
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.903	0.596	0.752	0.657	0.602
MAX. VELOCITY	1.374	1.255	2.113	1.314	1.073
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	27.682	17.610	76.103	20.042	14.429
DUE TO MINIMUM VELOCITY	9.180	2.168	4.174	2.861	3.154
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.06061 FT.
DIVERGING WAVE HEIGHT = 0.3447 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 9.97
STILL WATER SPEED 7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.628	-1.177	-0.627	-0.476
BACKWATER	0.032	0.084	0.291	0.081	0.032
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.869	0.551	0.668	0.612	0.568
MAX. VELOCITY	1.377	1.262	2.136	1.321	1.075
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	27.818	17.875	78.493	20.324	14.520
DUE TO MINIMUM VELOCITY	8.296	1.738	2.988	2.345	2.705
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.07165 FT.
DIVERGING WAVE HEIGHT = 0.4074 FT.

##
##########3x3 JUMBO TOW CONFIGURATION #############
########## TOW LENGTH 615.00FT.#############
########## TOW WIDTH 105.00FT.#############
##

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 8.07
STILL WATER SPEED 5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.859	-1.532	-0.858	-0.651
BACKWATER	0.239	0.256	0.369	0.249	0.239
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.694	0.320	0.313	0.382	0.393

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
MAX. VELOCITY	1.583	1.434	2.214	1.489	1.282
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	40.182	25.615	86.820	28.454	23.053
DUE TO MINIMUM VELOCITY	4.593	0.377	0.355	0.621	1.026
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.09755 FT.
DIVERGING WAVE HEIGHT = 0.3321 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 10.07
STILL WATER SPEED 7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.925	-1.650	-0.924	-0.701
BACKWATER	0.298	0.319	0.461	0.311	0.298
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.644	0.253	0.194	0.315	0.342
MAX. VELOCITY	1.642	1.498	2.306	1.551	1.341
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	44.251	28.926	97.288	31.901	25.957
DUE TO MINIMUM VELOCITY	3.769	0.196	0.093	0.364	0.716
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.15190 FT.
DIVERGING WAVE HEIGHT = 0.5171 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 3200.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 12.27
STILL WATER SPEED 9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.082	-1.930	-1.081	-0.820
BACKWATER	0.363	0.389	0.562	0.379	0.363
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.525	0.096	-0.085	0.159	0.223
MAX. VELOCITY	1.708	1.567	2.407	1.619	1.406
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	49.012	32.874	109.705	35.991	29.402
DUE TO MINIMUM VELOCITY	2.204	0.013	0.009	0.053	0.233
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.22552 FT.
DIVERGING WAVE HEIGHT = 0.7677 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 400.00
PROP. DIAMETER(FT) 5.00

TOW SPEED (FT/SEC) 6.77
STILL WATER SPEED 4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.462	-0.868	-0.462	-0.350
BACKWATER	0.200	0.215	0.310	0.209	0.200
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.994	0.716	0.977	0.777	0.693
MAX. VELOCITY	1.545	1.393	2.155	1.449	1.243
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	37.666	23.599	80.421	26.348	21.278
DUE TO MINIMUM VELOCITY	11.819	3.634	8.717	4.584	4.569
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.06866 FT.
DIVERGING WAVE HEIGHT = 0.2337 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 800.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 7.87
STILL WATER SPEED 5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.441	-0.583	-1.093	-0.582	-0.441
BACKWATER	0.233	0.250	0.360	0.243	0.233
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.903	0.596	0.752	0.657	0.602
MAX. VELOCITY	1.577	1.428	2.205	1.483	1.276
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	39.788	25.298	85.815	28.124	22.774
DUE TO MINIMUM VELOCITY	9.180	2.168	4.174	2.861	3.154
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.09278 FT.
DIVERGING WAVE HEIGHT = 0.3158 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 8.37
STILL WATER SPEED 6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.628	-1.177	-0.627	-0.476
BACKWATER	0.248	0.265	0.383	0.259	0.248
AMB. VELOCITY	1.345	1.178	1.845	1.239	1.043
MIN. VELOCITY	0.869	0.551	0.668	0.612	0.568
MAX. VELOCITY	1.592	1.444	2.228	1.498	1.291
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	40.777	26.095	88.341	28.955	23.475
DUE TO MINIMUM VELOCITY	8.296	1.738	2.988	2.345	2.705
DUE TO AMBIENT VELOCITY	26.145	14.746	51.985	16.995	13.408

SQUAT = 0.10494 FT.
DIVERGING WAVE HEIGHT = 0.3572 FT.

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*****************************************************
*******              SPRING                  *******
*******             LOW  FLOW                *******
*****************************************************
  ##################################################
  ###########1x5 JUMBO TOW CONFIGURATION ############
  ###########     TOW LENGTH    1025.00FT.##########
  ###########     TOW WIDTH       35.00FT.##########
  ##################################################
********      BOAT INFORMATION      ****************
```

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.50
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.864	-1.892	-0.863	-0.651
BACKWATER	0.033	0.092	0.317	0.090	0.033
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.355	-0.636	-1.495	-0.604	-0.419
MAX. VELOCITY	0.328	0.321	0.714	0.349	0.264
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.642	0.381	3.613	0.484	0.362
DUE TO MINIMUM VELOCITY	0.788	2.604	28.776	2.251	1.221
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.06020 FT.
DIVERGING WAVE HEIGHT = 0.2986 FT.

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********      BOAT INFORMATION      ****************
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RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.70
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.931	-2.038	-0.930	-0.701
BACKWATER	0.041	0.116	0.400	0.113	0.041
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.406	-0.702	-1.641	-0.670	-0.470
MAX. VELOCITY	0.337	0.345	0.796	0.373	0.273
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.687	0.466	4.906	0.580	0.394
DUE TO MINIMUM VELOCITY	1.118	3.447	37.385	3.022	1.645
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.09539 FT.
DIVERGING WAVE HEIGHT = 0.4732 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	12.90
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.005	0.000	0.000	0.000	0.005
PROPELLER	-0.820	-1.089	-2.383	-1.088	-0.820
BACKWATER	0.050	0.140	0.482	0.136	0.050
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.530	-0.860	-1.986	-0.828	-0.594
MAX. VELOCITY	0.351	0.368	0.879	0.396	0.287
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.763	0.562	6.464	0.687	0.449
DUE TO MINIMUM VELOCITY	2.256	6.095	63.936	5.473	3.048
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.13865 FT.

DIVERGING WAVE HEIGHT = 0.6877 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.40
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.466	-1.084	-0.465	-0.351
BACKWATER	0.025	0.069	0.239	0.067	0.025
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.055	-0.237	-0.687	-0.205	-0.119
MAX. VELOCITY	0.320	0.298	0.636	0.327	0.256
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.601	0.309	2.606	0.403	0.334
DUE TO MINIMUM VELOCITY	0.006	0.163	3.242	0.109	0.045
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.03413 FT.

DIVERGING WAVE HEIGHT = 0.1693 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.30
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.366	-0.586	-0.442
BACKWATER	0.028	0.079	0.273	0.077	0.028
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.146	-0.358	-0.969	-0.326	-0.210
MAX. VELOCITY	0.324	0.308	0.670	0.337	0.260

CONCENTRATION (ppm)

DUE TO MAXIMUM VELOCITY	0.619	0.339	3.012	0.437	0.346
DUE TO MINIMUM VELOCITY	0.076	0.518	8.506	0.399	0.198
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.04440 FT.

DIVERGING WAVE HEIGHT = 0.2202 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.10
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.471	-0.631	-0.476
BACKWATER	0.031	0.088	0.302	0.085	0.031
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.180	-0.403	-1.074	-0.371	-0.244
MAX. VELOCITY	0.327	0.316	0.699	0.345	0.263
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.634	0.366	3.405	0.468	0.357
DUE TO MINIMUM VELOCITY	0.132	0.725	11.368	0.575	0.295
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.05466 FT.

DIVERGING WAVE HEIGHT = 0.2711 FT.

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###########3x3 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 615.00FT.#############

########### TOW WIDTH 105.00FT.#############

##

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	6.20
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.864	-1.892	-0.863	-0.651
BACKWATER	0.221	0.256	0.365	0.249	0.221
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.355	-0.636	-1.495	-0.604	-0.419
MAX. VELOCITY	0.517	0.484	0.762	0.509	0.453
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.117	1.213	4.331	1.391	1.494
DUE TO MINIMUM VELOCITY	0.788	2.604	28.776	2.251	1.221
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.06656 FT.

DIVERGING WAVE HEIGHT = 0.2011 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.20
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.931	-2.038	-0.930	-0.701
BACKWATER	0.293	0.338	0.483	0.329	0.293
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.405	-0.702	-1.641	-0.670	-0.470
MAX. VELOCITY	0.588	0.567	0.880	0.589	0.524
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.975	1.888	6.486	2.100	2.196
DUE TO MINIMUM VELOCITY	1.117	3.447	37.385	3.022	1.644
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.11643 FT.
DIVERGING WAVE HEIGHT = 0.3518 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.40
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.820	-1.089	-2.383	-1.088	-0.820
BACKWATER	0.371	0.429	0.612	0.417	0.371
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.525	-0.860	-1.986	-0.828	-0.589
MAX. VELOCITY	0.668	0.658	1.009	0.677	0.604
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.152	2.866	9.541	3.109	3.183
DUE TO MINIMUM VELOCITY	2.207	6.095	63.936	5.473	2.989
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.18728 FT.
DIVERGING WAVE HEIGHT = 0.5658 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	4.90
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.351	-0.466	-1.084	-0.465	-0.351
BACKWATER	0.175	0.202	0.288	0.197	0.175
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.056	-0.237	-0.687	-0.205	-0.120
MAX. VELOCITY	0.472	0.431	0.685	0.456	0.407

CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.662	0.872	3.217	1.026	1.131
DUE TO MINIMUM VELOCITY	0.006	0.163	3.242	0.109	0.045
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.04157 FT.

DIVERGING WAVE HEIGHT = 0.1256 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.00
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.366	-0.586	-0.442
BACKWATER	0.214	0.248	0.353	0.241	0.214
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.146	-0.358	-0.969	-0.326	-0.210
MAX. VELOCITY	0.510	0.476	0.750	0.501	0.446
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.041	1.156	4.146	1.330	1.433
DUE TO MINIMUM VELOCITY	0.076	0.518	8.506	0.399	0.198
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.06233 FT.

DIVERGING WAVE HEIGHT = 0.1883 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.50
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.471	-0.631	-0.476
BACKWATER	0.232	0.268	0.383	0.261	0.232
AMB. VELOCITY	0.296	0.229	0.397	0.260	0.231
MIN. VELOCITY	-0.180	-0.403	-1.074	-0.371	-0.244
MAX. VELOCITY	0.528	0.497	0.780	0.521	0.464
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.235	1.303	4.619	1.486	1.589
DUE TO MINIMUM VELOCITY	0.132	0.725	11.368	0.575	0.295
DUE TO AMBIENT VELOCITY	0.487	0.147	0.693	0.211	0.256

SQUAT = 0.07316 FT.

DIVERGING WAVE HEIGHT = 0.2210 FT.

****

******* SPRING *******

******* MEAN FLOW *******

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###########1x5 JUMBO TOW CONFIGURATION ##############
###########   TOW LENGTH   1025.00FT.##############
###########   TOW WIDTH   35.00FT.##############
###

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	9.22
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.862	-1.714	-0.861	-0.651
BACKWATER	0.033	0.089	0.307	0.086	0.033
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.131	-0.270	-0.733	-0.211	-0.046
MAX. VELOCITY	0.814	0.681	1.287	0.736	0.638
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.988	3.155	18.912	3.934	3.676
DUE TO MINIMUM VELOCITY	0.057	0.234	3.891	0.117	0.004
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.06622 FT.
DIVERGING WAVE HEIGHT = 0.3499 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.42
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.928	-1.846	-0.927	-0.701
BACKWATER	0.040	0.110	0.380	0.107	0.040
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.080	-0.336	-0.866	-0.277	-0.096
MAX. VELOCITY	0.822	0.702	1.361	0.757	0.646
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	7.165	3.438	22.093	4.251	3.795
DUE TO MINIMUM VELOCITY	0.016	0.435	6.200	0.253	0.025
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.10159 FT.
DIVERGING WAVE HEIGHT = 0.5368 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	13.62
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.086	-2.159	-1.085	-0.820

BACKWATER	0.048	0.131	0.453	0.127	0.048
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	-0.039	-0.494	-1.178	-0.435	-0.215
MAX. VELOCITY	0.830	0.723	1.434	0.777	0.653
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	7.349	3.737	25.600	4.583	3.920
DUE TO MINIMUM VELOCITY	0.002	1.281	14.750	0.895	0.211
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.14450 FT.

DIVERGING WAVE HEIGHT = 0.7636 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.12
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.976	-0.464	-0.350
BACKWATER	0.025	0.068	0.237	0.067	0.025
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.431	0.128	0.004	0.186	0.254
MAX. VELOCITY	0.807	0.661	1.217	0.717	0.630
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.825	2.900	16.166	3.646	3.567
DUE TO MINIMUM VELOCITY	1.310	0.029	0.000	0.083	0.328
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.03949 FT.

DIVERGING WAVE HEIGHT = 0.2087 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.02
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.585	-1.230	-0.584	-0.442
BACKWATER	0.028	0.077	0.267	0.075	0.028
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.340	0.007	-0.249	0.066	0.163
MAX. VELOCITY	0.810	0.669	1.247	0.725	0.633
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.892	3.008	17.309	3.768	3.612
DUE TO MINIMUM VELOCITY	0.702	0.000	0.188	0.004	0.102
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.05010 FT.

DIVERGING WAVE HEIGHT = 0.2647 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.82
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.630	-1.325	-0.629	-0.476
BACKWATER	0.031	0.085	0.294	0.082	0.031
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.306	-0.038	-0.344	0.021	0.129
MAX. VELOCITY	0.813	0.677	1.274	0.733	0.636
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	6.956	3.106	18.368	3.878	3.655
DUE TO MINIMUM VELOCITY	0.532	0.001	0.465	0.000	0.055
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.06060 FT.

DIVERGING WAVE HEIGHT = 0.3202 FT.

###

##########3x3 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 615.00FT.#############

########### TOW WIDTH 105.00FT.#############

###

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	6.92
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.862	-1.714	-0.861	-0.651
BACKWATER	0.226	0.252	0.362	0.246	0.226
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.131	-0.270	-0.733	-0.211	-0.046
MAX. VELOCITY	1.008	0.844	1.342	0.896	0.831
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.248	5.784	21.276	6.825	7.383
DUE TO MINIMUM VELOCITY	0.057	0.234	3.891	0.117	0.004
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.07752 FT.

DIVERGING WAVE HEIGHT = 0.2474 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.92
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.928	-1.846	-0.927	-0.701

BACKWATER	0.292	0.325	0.467	0.317	0.292
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.080	-0.336	-0.866	-0.277	-0.096
MAX. VELOCITY	1.073	0.917	1.447	0.967	0.897
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	14.450	7.300	26.271	8.457	9.010
DUE TO MINIMUM VELOCITY	0.016	0.435	6.200	0.253	0.025
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.12880 FT.

DIVERGING WAVE HEIGHT = 0.4111 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.12
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.086	-2.159	-1.085	-0.820
BACKWATER	0.364	0.406	0.582	0.395	0.364
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	-0.038	-0.494	-1.178	-0.435	-0.215
MAX. VELOCITY	1.145	0.998	1.562	1.045	0.969
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	17.140	9.239	32.574	10.520	11.039
DUE TO MINIMUM VELOCITY	0.002	1.281	14.750	0.895	0.210
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.20018 FT.

DIVERGING WAVE HEIGHT = 0.6389 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	5.62
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.464	-0.976	-0.464	-0.350
BACKWATER	0.184	0.205	0.294	0.200	0.184
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.431	0.128	0.004	0.186	0.255
MAX. VELOCITY	0.965	0.797	1.274	0.850	0.789
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	10.935	4.917	18.384	5.882	6.431
DUE TO MINIMUM VELOCITY	1.311	0.029	0.000	0.083	0.328
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.05113 FT.

DIVERGING WAVE HEIGHT = 0.1632 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 800.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 6.72
STILL WATER SPEED 5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.585	-1.230	-0.584	-0.442
BACKWATER	0.220	0.245	0.352	0.239	0.220
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.340	0.007	-0.249	0.066	0.163
MAX. VELOCITY	1.001	0.837	1.332	0.889	0.825
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.040	5.644	20.813	6.674	7.232
DUE TO MINIMUM VELOCITY	0.702	0.000	0.188	0.004	0.102
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.07310 FT.
DIVERGING WAVE HEIGHT = 0.2333 FT.

******** BOAT INFORMATION **********************
RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 7.22
STILL WATER SPEED 6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.630	-1.325	-0.629	-0.476
BACKWATER	0.236	0.263	0.378	0.256	0.236
AMB. VELOCITY	0.781	0.592	0.980	0.650	0.605
MIN. VELOCITY	0.306	-0.038	-0.344	0.021	0.129
MAX. VELOCITY	1.018	0.855	1.358	0.906	0.841
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.564	5.997	21.982	7.055	7.614
DUE TO MINIMUM VELOCITY	0.532	0.001	0.465	0.000	0.055
DUE TO AMBIENT VELOCITY	6.274	2.133	8.798	2.772	3.201

SQUAT = 0.08439 FT.
DIVERGING WAVE HEIGHT = 0.2693 FT.

****
******* SPRING *******
******* HIGH FLOW *******
****

##
###########1x5 JUMBO TOW CONFIGURATION #############
########### TOW LENGTH 1025.00FT.#############
########### TOW WIDTH 35.00FT.#############
##

******** BOAT INFORMATION **********************
RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 9.99
STILL WATER SPEED 8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.860	-1.587	-0.859	-0.651
BACKWATER	0.033	0.087	0.304	0.085	0.033
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.617	0.148	0.012	0.211	0.332
MAX. VELOCITY	1.301	1.095	1.903	1.155	1.016
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.970	12.005	56.691	13.927	12.504
DUE TO MINIMUM VELOCITY	3.372	0.043	0.000	0.117	0.660
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.07371 FT.

DIVERGING WAVE HEIGHT = 0.4096 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00

RUNNING HORSEPOWER 2000.00

PROP. DIAMETER(FT) 8.00

TOW SPEED (FT/SEC) 12.19

STILL WATER SPEED 10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.926	-1.709	-0.925	-0.701
BACKWATER	0.040	0.107	0.371	0.104	0.040
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.567	0.082	-0.111	0.144	0.282
MAX. VELOCITY	1.308	1.114	1.970	1.173	1.023
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	24.325	12.607	62.478	14.572	12.742
DUE TO MINIMUM VELOCITY	2.698	0.008	0.019	0.040	0.429
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.10975 FT.

DIVERGING WAVE HEIGHT = 0.6098 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00

RUNNING HORSEPOWER 3200.00

PROP. DIAMETER(FT) 8.00

TOW SPEED (FT/SEC) 14.39

STILL WATER SPEED 12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.083	-1.999	-1.082	-0.820
BACKWATER	0.048	0.126	0.438	0.123	0.048
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.448	-0.075	-0.400	-0.013	0.163
MAX. VELOCITY	1.316	1.134	2.037	1.192	1.030
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	24.684	13.229	68.633	15.235	12.983
DUE TO MINIMUM VELOCITY	1.453	0.007	0.710	0.000	0.102
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.15295 FT.

DIVERGING WAVE HEIGHT = 0.8498 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.89
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.463	-0.900	-0.463	-0.350
BACKWATER	0.026	0.069	0.240	0.067	0.026
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.917	0.545	0.698	0.607	0.632
MAX. VELOCITY	1.294	1.077	1.839	1.137	1.009
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.635	11.448	51.500	13.329	12.281
DUE TO MINIMUM VELOCITY	9.564	1.687	3.390	2.286	3.593
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.04598 FT.

DIVERGING WAVE HEIGHT = 0.2555 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.79
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.583	-1.134	-0.583	-0.442
BACKWATER	0.029	0.077	0.268	0.075	0.029
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.826	0.424	0.465	0.487	0.541
MAX. VELOCITY	1.297	1.085	1.866	1.144	1.012
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.778	11.685	53.685	13.583	12.377
DUE TO MINIMUM VELOCITY	7.264	0.836	1.078	1.229	2.386
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.05707 FT.

DIVERGING WAVE HEIGHT = 0.3171 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	9.59
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.628	-1.222	-0.628	-0.476
BACKWATER	0.032	0.084	0.292	0.082	0.032

AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.792	0.379	0.377	0.442	0.507
MAX. VELOCITY	1.300	1.092	1.891	1.151	1.014
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	23.905	11.898	55.677	13.811	12.462
DUE TO MINIMUM VELOCITY	6.503	0.610	0.600	0.936	2.011
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.06793 FT.
DIVERGING WAVE HEIGHT = 0.3774 FT.

##
###########3x3 JUMBO TOW CONFIGURATION #############
###########   TOW LENGTH   615.00FT.#############
###########   TOW WIDTH   105.00FT.#############
##

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 7.69
STILL WATER SPEED 5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.860	-1.587	-0.859	-0.651
BACKWATER	0.235	0.255	0.367	0.248	0.235
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.617	0.148	0.012	0.211	0.332
MAX. VELOCITY	1.503	1.262	1.966	1.318	1.217
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	35.013	17.903	62.119	20.189	20.131
DUE TO MINIMUM VELOCITY	3.372	0.043	0.000	0.117	0.660
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.09077 FT.
DIVERGING WAVE HEIGHT = 0.3028 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 9.69
STILL WATER SPEED 7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.926	-1.709	-0.925	-0.701
BACKWATER	0.296	0.321	0.462	0.313	0.296
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.567	0.082	-0.111	0.144	0.282
MAX. VELOCITY	1.564	1.329	2.061	1.382	1.278
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	38.880	20.670	70.973	23.094	22.896
DUE TO MINIMUM VELOCITY	2.698	0.008	0.019	0.040	0.429
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.14413 FT.
DIVERGING WAVE HEIGHT = 0.4807 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.89
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.083	-1.999	-1.082	-0.820
BACKWATER	0.363	0.394	0.568	0.384	0.363
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.448	-0.075	-0.400	-0.013	0.163
MAX. VELOCITY	1.631	1.402	2.166	1.453	1.346
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	43.427	24.016	81.609	26.586	26.196
DUE TO MINIMUM VELOCITY	1.453	0.007	0.710	0.000	0.102
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.21701 FT.

DIVERGING WAVE HEIGHT = 0.7238 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.39
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.350	-0.463	-0.900	-0.463	-0.350
BACKWATER	0.195	0.212	0.305	0.206	0.195
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.917	0.545	0.698	0.607	0.632
MAX. VELOCITY	1.463	1.219	1.904	1.276	1.178
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	32.633	16.240	56.765	18.434	18.451
DUE TO MINIMUM VELOCITY	9.564	1.687	3.390	2.286	3.593
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.06268 FT.

DIVERGING WAVE HEIGHT = 0.2090 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.49
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.583	-1.134	-0.583	-0.442
BACKWATER	0.229	0.248	0.357	0.242	0.229

AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.826	0.424	0.465	0.487	0.541
MAX. VELOCITY	1.496	1.256	1.956	1.311	1.211
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	34.640	17.641	61.275	19.912	19.866
DUE TO MINIMUM VELOCITY	7.265	0.836	1.078	1.229	2.387
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.08611 FT.

DIVERGING WAVE HEIGHT = 0.2872 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.99
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.628	-1.222	-0.628	-0.476
BACKWATER	0.244	0.265	0.381	0.258	0.244
AMB. VELOCITY	1.268	1.008	1.599	1.069	0.983
MIN. VELOCITY	0.792	0.379	0.377	0.442	0.507
MAX. VELOCITY	1.512	1.272	1.980	1.327	1.227
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	35.577	18.302	63.399	20.609	20.532
DUE TO MINIMUM VELOCITY	6.503	0.610	0.600	0.936	2.011
DUE TO AMBIENT VELOCITY	22.397	9.504	34.753	11.230	11.460

SQUAT = 0.09800 FT.

DIVERGING WAVE HEIGHT = 0.3268 FT.

****

******* SUMMER *******

******* LOW FLOW *******

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###########1x5 JUMBO TOW CONFIGURATION #############

########### TOW LENGTH 1025.00FT.#############

########### TOW WIDTH 35.00FT.#############

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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.25
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.865	-1.989	-0.864	-0.651
BACKWATER	0.033	0.095	0.327	0.092	0.033
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.430	-0.747	-1.784	-0.730	-0.481
MAX. VELOCITY	0.254	0.213	0.532	0.226	0.203
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.326	0.121	1.577	0.143	0.181

DUE TO MINIMUM VELOCITY	1.306	4.095	47.278	3.846	1.751
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.05865 FT.

DIVERGING WAVE HEIGHT = 0.2819 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.45
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.003	0.000	0.000	0.000	0.003
PROPELLER	-0.701	-0.932	-2.142	-0.931	-0.701
BACKWATER	0.042	0.120	0.414	0.117	0.042
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.483	-0.814	-1.937	-0.797	-0.534
MAX. VELOCITY	0.265	0.239	0.619	0.251	0.214
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.366	0.166	2.415	0.191	0.209
DUE TO MINIMUM VELOCITY	1.770	5.210	59.616	4.918	2.303
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.09411 FT.

DIVERGING WAVE HEIGHT = 0.4523 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	12.65
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.041	0.000	0.000	0.000	0.041
PROPELLER	-0.820	-1.090	-2.505	-1.089	-0.820
BACKWATER	0.051	0.146	0.501	0.142	0.051
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.640	-0.972	-2.300	-0.955	-0.691
MAX. VELOCITY	0.312	0.264	0.706	0.276	0.262
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.563	0.221	3.496	0.249	0.353
DUE TO MINIMUM VELOCITY	3.714	8.581	96.596	8.173	4.540
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.13790 FT.

DIVERGING WAVE HEIGHT = 0.6628 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.15
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.466	-1.144	-0.466	-0.351
BACKWATER	0.025	0.071	0.243	0.069	0.025
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.130	-0.348	-0.938	-0.331	-0.181
MAX. VELOCITY	0.245	0.189	0.449	0.203	0.195
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.298	0.087	0.978	0.105	0.162
DUE TO MINIMUM VELOCITY	0.056	0.477	7.777	0.418	0.133
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.03259 FT.

DIVERGING WAVE HEIGHT = 0.1566 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.05
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.441	-0.587	-0.442
BACKWATER	0.028	0.081	0.279	0.079	0.028
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.221	-0.469	-1.235	-0.453	-0.272
MAX. VELOCITY	0.249	0.200	0.484	0.213	0.198
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.310	0.101	1.213	0.121	0.170
DUE TO MINIMUM VELOCITY	0.227	1.106	16.839	1.002	0.390
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.04283 FT.

DIVERGING WAVE HEIGHT = 0.2058 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.85
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.633	-1.552	-0.632	-0.476
BACKWATER	0.032	0.090	0.311	0.088	0.032
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.255	-0.514	-1.346	-0.498	-0.306
MAX. VELOCITY	0.252	0.209	0.516	0.222	0.201
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.321	0.114	1.449	0.135	0.177
DUE TO MINIMUM VELOCITY	0.330	1.434	21.451	1.310	0.533
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.05310 FT.

DIVERGING WAVE HEIGHT = 0.2552 FT.

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#####################################################
###########3x3 JUMBO TOW CONFIGURATION ##############
###########       TOW LENGTH    615.00FT.##############
###########       TOW WIDTH     105.00FT.##############
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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	5.95
STILL WATER SPEED	5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.865	-1.989	-0.864	-0.651
BACKWATER	0.222	0.261	0.372	0.254	0.222
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.430	-0.747	-1.784	-0.730	-0.481
MAX. VELOCITY	0.443	0.380	0.577	0.388	0.392
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.407	0.613	1.985	0.651	1.021
DUE TO MINIMUM VELOCITY	1.306	4.095	47.278	3.846	1.751
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.06340 FT.

DIVERGING WAVE HEIGHT = 0.1864 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	7.95
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.932	-2.142	-0.931	-0.701
BACKWATER	0.297	0.349	0.497	0.339	0.297
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.481	-0.814	-1.937	-0.797	-0.531
MAX. VELOCITY	0.517	0.468	0.702	0.474	0.467
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.121	1.100	3.444	1.139	1.616
DUE TO MINIMUM VELOCITY	1.747	5.210	59.616	4.918	2.275
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.11319 FT.

DIVERGING WAVE HEIGHT = 0.3329 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.15
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.011	0.000	0.000	0.000	0.011
PROPELLER	-0.820	-1.090	-2.505	-1.089	-0.820
BACKWATER	0.379	0.446	0.634	0.433	0.379
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.610	-0.972	-2.300	-0.955	-0.661
MAX. VELOCITY	0.610	0.565	0.840	0.568	0.559
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.274	1.865	5.693	1.893	2.605
DUE TO MINIMUM VELOCITY	3.274	8.581	96.596	8.173	4.040
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.18451 FT.

DIVERGING WAVE HEIGHT = 0.5426 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	4.65
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.466	-1.144	-0.466	-0.351
BACKWATER	0.174	0.204	0.291	0.199	0.174
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.130	-0.348	-0.938	-0.331	-0.181
MAX. VELOCITY	0.394	0.323	0.496	0.333	0.343
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.037	0.388	1.296	0.422	0.721
DUE TO MINIMUM VELOCITY	0.056	0.477	7.777	0.418	0.133
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.03872 FT.

DIVERGING WAVE HEIGHT = 0.1139 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	5.75
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.587	-1.441	-0.587	-0.442
BACKWATER	0.215	0.253	0.359	0.246	0.215
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.221	-0.469	-1.235	-0.453	-0.272
MAX. VELOCITY	0.435	0.371	0.565	0.380	0.384
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.346	0.574	1.867	0.612	0.971
DUE TO MINIMUM VELOCITY	0.227	1.106	16.839	1.002	0.390
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.05921 FT.

DIVERGING WAVE HEIGHT = 0.1741 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.25
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.633	-1.552	-0.632	-0.476
BACKWATER	0.233	0.275	0.391	0.267	0.233
AMB. VELOCITY	0.221	0.118	0.205	0.134	0.170
MIN. VELOCITY	-0.255	-0.514	-1.346	-0.498	-0.306
MAX. VELOCITY	0.454	0.393	0.596	0.401	0.403
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.503	0.675	2.172	0.713	1.100
DUE TO MINIMUM VELOCITY	0.330	1.434	21.451	1.310	0.533
DUE TO AMBIENT VELOCITY	0.225	0.023	0.109	0.033	0.113

SQUAT = 0.06996 FT.

DIVERGING WAVE HEIGHT = 0.2057 FT.

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******* SUMMER *******

******* MEAN FLOW *******

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##

###########1x5 JUMBO TOW CONFIGURATION ##############

########### TOW LENGTH 1025.00FT.##############

########### TOW WIDTH 35.00FT.##############

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******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.56
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.864	-1.872	-0.863	-0.651
BACKWATER	0.033	0.092	0.316	0.089	0.033
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.297	-0.605	-1.424	-0.568	-0.383
MAX. VELOCITY	0.386	0.350	0.764	0.384	0.301
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.985	0.488	4.365	0.633	0.510
DUE TO MINIMUM VELOCITY	0.493	2.268	25.116	1.898	0.959
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.06063 FT.

DIVERGING WAVE HEIGHT = 0.3027 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00

PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 10.76
STILL WATER SPEED 10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.931	-2.017	-0.930	-0.701
BACKWATER	0.041	0.115	0.397	0.112	0.041
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.347	-0.672	-1.569	-0.635	-0.433
MAX. VELOCITY	0.395	0.374	0.845	0.407	0.309
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.043	0.586	5.797	0.744	0.549
DUE TO MINIMUM VELOCITY	0.744	3.043	32.949	2.592	1.327
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.09579 FT.
DIVERGING WAVE HEIGHT = 0.4783 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 3200.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 12.96
STILL WATER SPEED 12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.004	0.000	0.000	0.000	0.004
PROPELLER	-0.820	-1.089	-2.358	-1.088	-0.820
BACKWATER	0.050	0.139	0.478	0.135	0.050
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.470	-0.830	-1.910	-0.792	-0.555
MAX. VELOCITY	0.407	0.398	0.926	0.430	0.321
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	1.128	0.696	7.501	0.868	0.606
DUE TO MINIMUM VELOCITY	1.646	5.506	57.325	4.836	2.555
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.13897 FT.
DIVERGING WAVE HEIGHT = 0.6938 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 400.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 6.46
STILL WATER SPEED 5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.465	-1.072	-0.465	-0.351
BACKWATER	0.025	0.069	0.238	0.067	0.025
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	0.003	-0.207	-0.624	-0.170	-0.082
MAX. VELOCITY	0.378	0.328	0.687	0.362	0.293
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.932	0.405	3.232	0.537	0.475
DUE TO MINIMUM VELOCITY	0.000	0.111	2.473	0.064	0.017

DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.03453 FT.
DIVERGING WAVE HEIGHT = 0.1724 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	7.36
STILL WATER SPEED	6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.351	-0.586	-0.442
BACKWATER	0.028	0.079	0.272	0.077	0.028
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.088	-0.328	-0.903	-0.291	-0.173
MAX. VELOCITY	0.382	0.338	0.720	0.372	0.296
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.954	0.440	3.691	0.576	0.490
DUE TO MINIMUM VELOCITY	0.020	0.404	6.973	0.289	0.120
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.04482 FT.
DIVERGING WAVE HEIGHT = 0.2238 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	8.16
STILL WATER SPEED	7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.455	-0.631	-0.476
BACKWATER	0.031	0.087	0.301	0.085	0.031
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.122	-0.373	-1.007	-0.336	-0.208
MAX. VELOCITY	0.385	0.346	0.749	0.380	0.299
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	0.974	0.472	4.133	0.613	0.503
DUE TO MINIMUM VELOCITY	0.047	0.581	9.479	0.433	0.192
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.05509 FT.
DIVERGING WAVE HEIGHT = 0.2751 FT.

##
##########3x3 JUMBO TOW CONFIGURATION ##############
########### TOW LENGTH 615.00FT.##############
########### TOW WIDTH 105.00FT.##############
##

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00

PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 6.26
STILL WATER SPEED 5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.864	-1.872	-0.863	-0.651
BACKWATER	0.221	0.255	0.364	0.248	0.221
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.297	-0.605	-1.424	-0.568	-0.383
MAX. VELOCITY	0.575	0.514	0.812	0.543	0.490
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.802	1.432	5.184	1.673	1.835
DUE TO MINIMUM VELOCITY	0.493	2.268	25.116	1.898	0.959
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.06738 FT.
DIVERGING WAVE HEIGHT = 0.2047 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 2000.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 8.26
STILL WATER SPEED 7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.931	-2.017	-0.930	-0.701
BACKWATER	0.292	0.337	0.480	0.327	0.292
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.347	-0.672	-1.569	-0.635	-0.433
MAX. VELOCITY	0.646	0.595	0.929	0.622	0.560
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	3.802	2.166	7.550	2.453	2.617
DUE TO MINIMUM VELOCITY	0.744	3.043	32.949	2.592	1.327
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.11732 FT.
DIVERGING WAVE HEIGHT = 0.3564 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 3200.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 10.46
STILL WATER SPEED 9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.820	-1.089	-2.358	-1.088	-0.820
BACKWATER	0.370	0.426	0.608	0.414	0.370
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.467	-0.830	-1.910	-0.792	-0.552
MAX. VELOCITY	0.724	0.685	1.056	0.710	0.639
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	5.140	3.212	10.851	3.546	3.694
DUE TO MINIMUM VELOCITY	1.619	5.506	57.325	4.836	2.519

DUE TO AMBIENT VELOCITY 0.780 0.209 0.975 0.301 0.377
SQUAT = 0.18813 FT.
DIVERGING WAVE HEIGHT = 0.5716 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	4.96
STILL WATER SPEED	4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.001	0.000	0.000	0.000	0.001
PROPELLER	-0.351	-0.465	-1.072	-0.465	-0.351
BACKWATER	0.175	0.202	0.288	0.197	0.175
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	0.003	-0.207	-0.624	-0.170	-0.083
MAX. VELOCITY	0.530	0.461	0.737	0.492	0.444
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.257	1.055	3.939	1.265	1.421
DUE TO MINIMUM VELOCITY	0.000	0.111	2.473	0.064	0.017
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.04230 FT.
DIVERGING WAVE HEIGHT = 0.1285 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.06
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.586	-1.351	-0.586	-0.442
BACKWATER	0.214	0.247	0.352	0.240	0.214
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.088	-0.328	-0.903	-0.291	-0.173
MAX. VELOCITY	0.568	0.506	0.801	0.535	0.483
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.713	1.369	4.978	1.606	1.766
DUE TO MINIMUM VELOCITY	0.020	0.404	6.973	0.289	0.120
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.06315 FT.
DIVERGING WAVE HEIGHT = 0.1919 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.56
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE

DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.632	-1.455	-0.631	-0.476
BACKWATER	0.232	0.267	0.381	0.260	0.232
AMB. VELOCITY	0.354	0.259	0.448	0.295	0.268
MIN. VELOCITY	-0.122	-0.373	-1.007	-0.336	-0.208
MAX. VELOCITY	0.586	0.526	0.830	0.555	0.500
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	2.941	1.530	5.503	1.778	1.942
DUE TO MINIMUM VELOCITY	0.047	0.581	9.479	0.433	0.192
DUE TO AMBIENT VELOCITY	0.780	0.209	0.975	0.301	0.377

SQUAT = 0.07400 FT.

DIVERGING WAVE HEIGHT = 0.2248 FT.

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*****************************************************
*******              SUMMER                  *******
*******             HIGH FLOW                *******
*****************************************************
##################################################
###########1x5 JUMBO TOW CONFIGURATION #############
###########     TOW LENGTH   1025.00FT.#############
###########     TOW WIDTH      35.00FT.#############
##################################################
********      BOAT INFORMATION     **********************
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RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	1600.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.96
STILL WATER SPEED	8.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.766	-0.862	-0.651
BACKWATER	0.033	0.089	0.309	0.087	0.033
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.002	-0.402	-0.988	-0.347	-0.147
MAX. VELOCITY	0.685	0.550	1.087	0.601	0.536
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.440	1.729	11.757	2.227	2.332
DUE TO MINIMUM VELOCITY	0.000	0.721	8.986	0.477	0.077
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.06383 FT.

DIVERGING WAVE HEIGHT = 0.3308 FT.

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********      BOAT INFORMATION     **********************
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RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	11.16
STILL WATER SPEED	10.20

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.929	-1.902	-0.928	-0.701
BACKWATER	0.041	0.111	0.385	0.108	0.041
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	-0.048	-0.469	-1.124	-0.414	-0.197

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
MAX. VELOCITY	0.693	0.571	1.163	0.623	0.544
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.578	1.930	14.210	2.456	2.424
DUE TO MINIMUM VELOCITY	0.004	1.108	12.919	0.780	0.168
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.09903 FT.

DIVERGING WAVE HEIGHT = 0.5133 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	13.36
STILL WATER SPEED	12.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.087	-2.225	-1.086	-0.820
BACKWATER	0.049	0.133	0.461	0.130	0.049
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	-0.168	-0.627	-1.446	-0.571	-0.317
MAX. VELOCITY	0.702	0.593	1.239	0.644	0.553
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.726	2.145	16.970	2.700	2.524
DUE TO MINIMUM VELOCITY	0.110	2.501	26.234	1.929	0.583
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.14192 FT.

DIVERGING WAVE HEIGHT = 0.7356 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.86
STILL WATER SPEED	5.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.465	-1.008	-0.464	-0.351
BACKWATER	0.025	0.068	0.236	0.067	0.025
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.302	-0.004	-0.230	0.050	0.153
MAX. VELOCITY	0.678	0.529	1.015	0.581	0.529
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.318	1.551	9.687	2.021	2.250
DUE TO MINIMUM VELOCITY	0.513	0.000	0.149	0.002	0.086
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.03742 FT.

DIVERGING WAVE HEIGHT = 0.1939 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00

TOW SPEED (FT/SEC) 7.76
STILL WATER SPEED 6.80

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.585	-1.270	-0.585	-0.442
BACKWATER	0.028	0.077	0.267	0.075	0.028
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.211	-0.125	-0.491	-0.070	0.062
MAX. VELOCITY	0.681	0.538	1.046	0.590	0.532
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.366	1.626	10.543	2.108	2.282
DUE TO MINIMUM VELOCITY	0.200	0.027	1.263	0.005	0.008
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.04788 FT.
DIVERGING WAVE HEIGHT = 0.2482 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 8.56
STILL WATER SPEED 7.60

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.368	-0.630	-0.476
BACKWATER	0.031	0.085	0.295	0.083	0.031
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.177	-0.170	-0.589	-0.116	0.028
MAX. VELOCITY	0.684	0.546	1.073	0.597	0.535
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	4.415	1.694	11.343	2.187	2.315
DUE TO MINIMUM VELOCITY	0.126	0.064	2.105	0.022	0.001
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.05826 FT.
DIVERGING WAVE HEIGHT = 0.3020 FT.

##
##########3x3 JUMBO TOW CONFIGURATION #############
########## TOW LENGTH 615.00FT.#############
########## TOW WIDTH 105.00FT.#############
##

******** BOAT INFORMATION **********************

RATED HORSEPOWER 3400.00
RUNNING HORSEPOWER 1600.00
PROP. DIAMETER(FT) 8.00
TOW SPEED (FT/SEC) 6.66
STILL WATER SPEED 5.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.651	-0.863	-1.766	-0.862	-0.651
BACKWATER	0.224	0.252	0.361	0.245	0.224
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.002	-0.402	-0.988	-0.347	-0.147

MAX. VELOCITY	0.876	0.712	1.139	0.760	0.728
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.480	3.587	13.416	4.298	5.198
DUE TO MINIMUM VELOCITY	0.000	0.721	8.986	0.477	0.077
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.07329 FT.

DIVERGING WAVE HEIGHT = 0.2300 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	2000.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	8.66
STILL WATER SPEED	7.70

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.701	-0.929	-1.902	-0.928	-0.701
BACKWATER	0.291	0.328	0.470	0.319	0.291
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	-0.048	-0.469	-1.124	-0.414	-0.197
MAX. VELOCITY	0.944	0.788	1.248	0.834	0.795
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	10.298	4.764	17.321	5.575	6.557
DUE TO MINIMUM VELOCITY	0.004	1.108	12.919	0.780	0.168
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.12393 FT.

DIVERGING WAVE HEIGHT = 0.3889 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	3400.00
RUNNING HORSEPOWER	3200.00
PROP. DIAMETER(FT)	8.00
TOW SPEED (FT/SEC)	10.86
STILL WATER SPEED	9.90

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.820	-1.087	-2.225	-1.086	-0.820
BACKWATER	0.365	0.411	0.589	0.400	0.365
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	-0.167	-0.627	-1.446	-0.571	-0.316
MAX. VELOCITY	1.017	0.871	1.367	0.915	0.869
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	12.559	6.318	22.387	7.236	8.286
DUE TO MINIMUM VELOCITY	0.109	2.501	26.234	1.929	0.581
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.19489 FT.

DIVERGING WAVE HEIGHT = 0.6116 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	400.00
PROP. DIAMETER(FT)	5.00

TOW SPEED (FT/SEC) 5.36
STILL WATER SPEED 4.40

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.351	-0.465	-1.008	-0.464	-0.351
BACKWATER	0.180	0.203	0.291	0.198	0.180
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.302	-0.004	-0.230	0.050	0.153
MAX. VELOCITY	0.833	0.663	1.069	0.712	0.684
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	7.414	2.933	11.212	3.579	4.418
DUE TO MINIMUM VELOCITY	0.515	0.000	0.149	0.002	0.086
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.04747 FT.
DIVERGING WAVE HEIGHT = 0.1490 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 800.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 6.46
STILL WATER SPEED 5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.585	-1.270	-0.585	-0.442
BACKWATER	0.217	0.245	0.350	0.238	0.217
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.211	-0.125	-0.491	-0.070	0.062
MAX. VELOCITY	0.870	0.705	1.128	0.752	0.721
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.310	3.481	13.060	4.182	5.072
DUE TO MINIMUM VELOCITY	0.200	0.027	1.263	0.005	0.008
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.06896 FT.
DIVERGING WAVE HEIGHT = 0.2164 FT.

******** BOAT INFORMATION **********************

RATED HORSEPOWER 1000.00
RUNNING HORSEPOWER 1000.00
PROP. DIAMETER(FT) 5.00
TOW SPEED (FT/SEC) 6.96
STILL WATER SPEED 6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.368	-0.630	-0.476
BACKWATER	0.234	0.264	0.377	0.256	0.234
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.177	-0.170	-0.589	-0.116	0.028
MAX. VELOCITY	0.886	0.724	1.156	0.771	0.738
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.739	3.750	13.961	4.476	5.389
DUE TO MINIMUM VELOCITY	0.126	0.064	2.105	0.022	0.001
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.08005 FT.
DIVERGING WAVE HEIGHT = 0.2512 FT.

BACKWATER	0.180	0.203	0.291	0.198	0.180
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.302	-0.004	-0.230	0.050	0.153
MAX. VELOCITY	0.833	0.663	1.069	0.712	0.684
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	7.414	2.933	11.212	3.579	4.418
DUE TO MINIMUM VELOCITY	0.515	0.000	0.149	0.002	0.086
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.04747 FT.
DIVERGING WAVE HEIGHT = 0.1490 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	800.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.46
STILL WATER SPEED	5.50

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.442	-0.585	-1.270	-0.585	-0.442
BACKWATER	0.217	0.245	0.350	0.238	0.217
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.211	-0.125	-0.491	-0.070	0.062
MAX. VELOCITY	0.870	0.705	1.128	0.752	0.721
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.310	3.481	13.060	4.182	5.072
DUE TO MINIMUM VELOCITY	0.200	0.027	1.263	0.005	0.008
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

SQUAT = 0.06896 FT.
DIVERGING WAVE HEIGHT = 0.2164 FT.

******** BOAT INFORMATION ***********************

RATED HORSEPOWER	1000.00
RUNNING HORSEPOWER	1000.00
PROP. DIAMETER(FT)	5.00
TOW SPEED (FT/SEC)	6.96
STILL WATER SPEED	6.00

VELOCITIES AT BOTTOM (ft/sec)

	LFT SHORE	LFT CENTER	CENTER	RGT CENTER	RGT SHORE
DIVERGING WAVE	0.000	0.000	0.000	0.000	0.000
PROPELLER	-0.476	-0.631	-1.368	-0.630	-0.476
BACKWATER	0.234	0.264	0.377	0.256	0.234
AMB. VELOCITY	0.653	0.460	0.778	0.514	0.504
MIN. VELOCITY	0.177	-0.170	-0.589	-0.116	0.028
MAX. VELOCITY	0.886	0.724	1.156	0.771	0.738
CONCENTRATION (ppm)					
DUE TO MAXIMUM VELOCITY	8.739	3.750	13.961	4.476	5.389
DUE TO MINIMUM VELOCITY	0.126	0.064	2.105	0.022	0.001
DUE TO AMBIENT VELOCITY	3.906	1.051	4.596	1.436	1.977

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