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EXHIBITS

MAR 1 9 1981

5EWHME

Ms. Julia Graf
Hydrologist
United States Geological Survey
Champaign County Bank Plaza
102 East Main Street
Urbana, Illinois 61801

Re: Graf Deposition in OMC Case

Dear Julia:

Enclosed is the original transcript of your deposition. You will have to read it for accuracy and sign (notarized) the signature page. I have enclosed an example of how any changes you wish to make should be documented. Please do not make any changes on the transcript itself. If changes do need to be made, please use this basic format. Handwritten is fine. Send any changes to me. I will have them typed and returned to you for your signature. If you have any questions, don't hesitate to call. Thanks again.

Very truly yours,

George Phelus
Enforcement Attorney

Enclosure

bcc: Jacobs

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

THE UNITED STATES OF AMERICA,
Plaintiff,

vs.

OUTBOARD MARINE CORPORATION
AND MONSANTO COMPANY,
Defendants.

No. 78 C 1004

ENFORCEMENT SENSITIVE

AFFIDAVIT OF JULIA B. GRAF

Julia B. Graf, on oath, makes the following changes to the transcript of her deposition in this litigation:

Page	Line	Reads	Should Read
6	15	"Property?"	"Problem ?"
6	17	"in and out"	"in the ditch and out"
8	1	"Q"	"A"
8	3	"gauging"	"gaging"
9	3	"runoff methods"	"runoff models"
9	4	"gauging"	"gaging"
9	6	"flow, data"	"flow, and data"
11	1	"gauging"	"gaging"
11	3	"the professional staff"	"staff"
11	3	"all who would"	"all the professional staff would"
12	8	"Larry Balding"	"Gary Balding"
12	23	"or some district"	"or subdistrict"
13	24	"Larry Balding"	"Gary Balding"

16-5V28.0/066

Page	Line	Reads	Should Read
15	20	"date of reduction"	"data reduction"
16	17	"which we were"	"which were"
21	24	"implying"	"applying"
22	9	"relates to"	"relates two"
22	9-10	"dimensional"	"dimensionless"
22	10-11	"parameters, that contain"	"parameters that control"
22	11	"grains and"	"grains, and"
22	16	"dimensional"	"dimensionless"
22	19	"velocity of grain"	"velocity, of grain"
22	23	"dimensional"	"dimensionless"
23	2	"initial"	"inertial"
23	12	"mearsure"	"calculate"
23	13	"out of"	"at"
30	16	"time. I"	"time, I"
30	17	"failure"	"failure,"
32	2	"in filtration"	"impervious"
32	15	"in any discharge"	"at any discharge using the"
34	10	"a whole"	"a whole sampling period,"
35	24	"with me"	- omit -
38	14	"average pounds"	"average of the points"
39	19	"measure"	"measurement"
39	23	"vanes with"	"vanes parallel with"
40	14	"times the square"	"times the area of the square"

Page	Line	Reads	Should Read
41	11	"sampling"	"samples"
42	15	"to determine"	"determined"
44	20	"pulled"	"put"
46	4	"geology"	"geodetic"
47	18	"status"	"basis"
57	9	"on days so"	"on days when the recorder malfunctioned so"
57	22	", load,"	", suspended load,"
61	7	"discharges."	"discharges would be different from what was estimated."
61	14	"marging"	"margin"
75	20	"house"	"whole"
75	21	"the measure of"	"the amount of"
76	3	"completion"	"construction"
76	22	"beyond with"	"with"
81	16	"the ultimate."	"the ultimate goal."
84	14	"rainfall and time density"	"quantity and time distribution of the runoff"
84	16	"in density"	"intensity"
87	7	"will become"	"will be covered"
87	10	"covered out"	"covered up"
95	22	"axis"	"basis"
103	12	"orally"	"normally"
104	4	"hydrologic, the"	"hydrologic part of the"
104	6	"Mr. Toler"	"Mr. Noehre"

Page	Line	Reads	Should Read
104	14	"Mr. Toler"	"Mr. Noehre"
106	21	"study by"	"by"
106	23	"based only on"	"based on no"
107	1	"beds predicted"	"predicted"
112	1	"bank"	"bankfull"
113	14	"measures that"	"measures the discharge"
115	11	"collecting in"	"checking"
117	18	"knowledge"	"likely"
118	10	"temperature"	"specific gravity"
118	15	"reliability"	"reality"
122	17	"large"	"like"
122	17	"a very significant"	"significant."
122	18	"chance for transport."	- omit -
123	23	"unusual terms"	"usual cases"
132	10	"and the range"	"in the range"
133	2	"letter, the curve"	"curve"
133	8	"than water"	"water"
133	16	"was read"	"was calculated"
134	12	"presented"	"calculated"
135	12	"not melt"	"melt"
137	6	"draining"	"drainage"
137	23	"in the"	"in a"
137	24	"model or"	"model are"
140	3	"data"	"daily"

Page	Line	Reads	Should Read
145	3	"qualifications"	"calculations"
146	9	"degradation"	"vegetation"
146	10	"flowing"	"growing"
148	11	"graphs"	"photographs"
148	13	"80"	"40"
148	12	"preliminary"	"preliminary visits"
150	4	"flow or"	"for"
159	3	"relationship change so often during the study and"	- omit line -
164	5	"yes, which would"	"no, but it would"
165	5	"data"	"days"
166	2	"stream discharge added"	"sediment"
182	4	"relating to"	"relating the"
196	9	"US EPA"	"USGS"
210	15	"graph in"	"Graf and"
211	11	"graph in"	"Graf and"
211	16-17	"graph in the"	"Graf and"
212	9	"graph in"	"Graf and"
235	8	"in our"	"in other"

Julia B. Graf
Julia B. Graf

SUBSCRIBED AND SWORN to
before me this 14 day
of May, 1981.

Notary Public
Expires May 12, 1985

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

THE UNITED STATES OF AMERICA,
Plaintiff,
Vs.
OUTBOARD MARINE CORPORATION
AND MONSANTO COMPANY,
Defendants.

No. 78 C 1004

I hereby certify that I have read the foregoing transcript of my deposition given at the time and place aforesaid, consisting of Pages 1 to 247, inclusive and the attached correction sheets, and I do again subscribe and make oath that the same is a true, correct and complete transcript of my deposition so given as aforesaid, as it now appears.

Julia B. Graf
Julia B. Graf

Subscribed and sworn to
before me this 14 day
of May, A.D. 1981.

Muriel Wetherd
Notary Public
Expires May 12, 1985

(P)

FOI EXEMPT

Interagency Agreement
Between
U. S. Geological Survey
and the
U. S. Environmental Protection Agency

1. Purpose

The U. S. Environmental Protection Agency (U.S. EPA), located at 230 South Dearborn Street, Chicago, Illinois 60604, needs assistance from the U.S. Geological Survey (U.S.G.S.), at Champaign, Illinois 61820, in developing hydrologic and transport information for the North Ditch, a small tributary to Lake Michigan located in Waukegan, Illinois. This information would be used in helping to determine the transport of polychlorinated biphenyl (PCB) contaminated sediment from the Ditch to the Lake. This information will be used to support the Government's position in a lawsuit, filed against the Outboard Marine Corporation (OMC) in Waukegan, whose discharges allegedly caused the contamination problem.

2. Scope of Work

A. The U.S.G.S. shall develop theoretical stage-discharge and velocity-discharge relationships at eight sites along the North Ditch during three rainfall/runoff events, involving at least the following:

1) four (or five) of the eight sites will have staff gauges installed by U.S.G.S.

2) the site furthest downstream will have stage and rainfall recorders installed by U.S.G.S. to obtain continuous stage hydrographs and rainfall data.

3) U.S.G.S. shall use rainfall and runoff data collected by them from the downstream site to calibrate a mathematical model which should yield long term, annual-peak discharges and a magnitude-frequency relationship.

4) U.S.G.S. shall obtain cross section measurements of all eight sites with the resultant water surface profiles and shall compute velocity-discharge relationships at each of the eight sites.

5) U.S.G.S. shall place marked poles or poles with washers at the eight sites to determine degree of sediment deposition or scour.

6) U.S.G.S. shall deploy equipment and instruments as necessary to accomplish the above before the first major snow-melt of the spring. If snow-melt occurs before a major rainfall event, an attempt shall be made to describe or measure quantitatively the flow conditions associated with this melt.

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B. The U.S.G.S. shall quantitatively assess the potential for movement of the PCB-contaminated sediments from the North Ditch, involving the following:

1) an initial estimate of bottom stability shall be provided by U.S.G.S. by obtaining mean or median grain size and specific gravity of bed material at no-flow conditions and applying appropriate mathematical models. Surface sediment samples will be collected by U.S.G.S. using hand samplers. Samples shall be split for analysis by U.S. EPA for total PCB.

2) during each of the three rainfall events to be analyzed, U.S.G.S. shall measure water temperature and water depth and shall collect suspended sediments samples from the downstream station (with assistance from U.S. EPA) frequently during each event for determination by U.S.G.S. of particle size distribution if sample size is sufficient. U.S. EPA will determine suspended sediment concentrations on duplicate samples collected from each vertical.

3) U.S.G.S. shall then plot rating curves for suspended sediment and total sediment discharge which shall then be used to determine sediment discharge expected at a given water discharge (using information gathered in above).

4) Using sediment total PCB data, suspended sediment data, and total and particulate PCB data, an estimate of the rate of transport of contaminated sediments into Lake Michigan shall be made by U.S.G.S.

U.S. EPA personnel shall collect water samples at three of the sites for analysis by U.S. EPA for total PCB, aqueous PCB, and total suspended solids. Measurement and sample collection frequencies for A and B above shall be based on the intensity and duration of each of the three events to be observed, and shall be frequent enough to accomplish the goals set out above.

The U.S.G.S. shall be on site as soon as possible when an event is to occur, and is responsible for coordinating with U.S. EPA field personnel when an event is to be observed. U.S.G.S. personnel shall acquaint U.S. EPA personnel before the fact with specific details of what they must do for U.S.G.S. in the event EPA personnel arrive at the Ditch first and must begin work immediately.

3. Provisions

The U.S.G.S. shall provide all personnel and equipment necessary to accomplish the above tasks, except for the following:

A. U.S. EPA will provide personnel and equipment necessary to collect and analyze water samples at three of the eight Ditch sites for total PCB, dissolved PCB, and total suspended solids.

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B. U.S. EPA will provide personnel to assist in the collection of the surface sediment samples referred to above and will provide sampling devices and containers for the splitting of those samples for analysis for total PCB by U.S. EPA.

C. U.S. EPA will provide personnel necessary to assist in collection of the suspended sediment samples referred to above.

D. U.S. EPA will provide personnel necessary to assist in collection of samples and taking of measurements should they arrive at the site first.

U.S.G.S. personnel shall acquaint U.S. EPA personnel with procedures and use of equipment on those items above for which EPA assistance will be provided, and shall specify sampling frequencies and locations and all other required information needed to accomplish these tasks at the site. Access to the OMC plant site shall be arranged only through the U.S. EPA unless otherwise instructed by U.S. EPA. The U.S.G.S. shall follow EPA-approved chain of custody procedures when handling all samples.

4. Duration of Agreement

This Agreement will begin on the date of execution or on March 1, 1979, whichever occurs first, and will continue through September 30, 1979. This Agreement may be terminated by either party with a 30-day advance written notice. If the Agreement is terminated, the U.S. EPA will provide only those funds necessary to cover actual expenses incurred prior to termination.

5. Reports

Summary reports including data, observations, and interpretation shall be submitted to the Project Officer as soon as possible following the first and second events observed, and before May 15, 1979. Availability for testimony as to procedures and any results obtained may be necessary by U.S.G.S. personnel beginning May 15, 1979, and availability for witness preparation and depositions may be needed prior to that date if data from an event have been collected by then.

A final report shall be submitted as soon as possible after the third event is observed. It is important that as much of the study results as possible be prepared and submitted by May 15, 1979. Due to the litigation, it is mandatory that all information gathered in this study be kept strictly confidential and discussed only among those directly involved in the work. In no event may the results of the PCB levels be discussed with or divulged to anyone other than a U.S. employee directly involved in this study. Information is releasable only through the case attorney, Kaye Jacobs, at (312) 353-2094.

6. Project Officers

For U.S.G.S., Al Noehre, DeKalb District
815-753-1162

For U.S. EPA, Edward DiDomenico, Enforcement Division
FTS-353-2110

7. Funds

The total cost of the work to be performed is estimated not to exceed $40,000. Payment to U.S.G.S. will be on a quarterly basis on Form 1081 (6 copies) to U.S. EPA, Region V, Financial Management Division, 230 South Dearborn Street, Chicago, Illinois 60604. Billings will itemize all costs incurred during the billing period and cite the number of this agreement together with Appropriation No. 689010S, Account No. 968105N000, Object Class No. 2570, and Document Control No. N10172.

8. Authority

The basic authority for Interagency Agreements is the Economy Act of 1932.

Environmental Protection Agency	U.S. Geological Survey
John McGuire Regional Administrator Region V	Thomas J. Buchanan Assistant Chief Hydrologist for Operations Reston, Virginia
Date ______________	Date ______________

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Supporting Information - EPA Order 1610-A

This Interagency Agreement between U.S. Environmental Protection Agency (U.S. EPA) and the U.S. Geological Survey (U.S.G.S.) provides that the U.S.G.S. develop, with U.S. EPA participation, a hydrologic profile of the North Ditch in Waukegan, Illinois beginning on the date of execution of this Agreement or on March 1, 1979, whichever occurs first. The effort should be completed by September 30, 1979.

The U.S.G.S. has done extensive hydrologic work recently on small tributaries in Northern Illinois under the 208 planning program, and has the specific expertise and resources, including specialized sampling and analysis equipment and instruments, necessary to accomplish these complex tasks. Their vast experience and predictive skills in the area of rainfall event analysis would tend to reduce the number of needless and expensive "dry runs" associated with this kind of effort. Therefore, the work cannot be done more efficiently and economically by another source. Considering the above factors, it is in the best interest of the Government to enter into this Agreement.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

PENGAD-Bayonne, N.J.
DEPOSITION
EXHIBIT
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PROGRESS REPORT OF
POTENTIAL FOR MOVEMENT OF SEDIMENTS, NORTH DITCH, WAUKEGAN, ILLINOIS

Administrative Report

Prepared in cooperation with

U.S. Environmental Protection Agency

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PROGRESS REPORT OF
POTENTIAL FOR MOVEMENT OF SEDIMENTS, NORTH DITCH, WAUKEGAN, ILLINOIS

By Julia B. Graf

Administrative Report

Prepared in cooperation with

U.S. Environmental Protection Agency

August 1979

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

Multiply Inch-pound unit	By	To obtain SI (metric) unit
mile (mi)	1.609	kilometer (km).
foot (ft)	0.3048	meter (m).
inch (in)	25.40	millimeter (mm).
foot per second (ft/s)	0.3048	meter per second (m/s).
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s).
pound (lb)	0.4536	kilogram (kg).
pound per cubic foot (lb/ft^3)	0.01602	grams per cubic centimeter (gm/cm^3).

Temperature

degrees Fahrenheit (°F)	-32 x 0.556	degrees Celcius (°C).

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PROGRESS REPORT OF
POTENTIAL FOR MOVEMENT OF SEDIMENTS, NORTH DITCH, WAUKEGAN, ILLINOIS

By Julia B. Graf

ABSTRACT

Stage-discharge and sediment-discharge relationships for North Ditch, Waukegan, Illinois, have been determined from measured cross sections of the channel and grain-size distribution of bed material samples, for a water temperature of 20°C. Average bed material has a mean grain size of 0.156 mm and contains grains in size fractions from 0.0014 mm to 11.2 mm. Minimum discharge required to move this bed material was estimated with an initial-motion criterion applied independently to each size fraction of the bed material. According to that estimate, grains in the 0.708 mm fraction and finer are mobile at low discharges in the ditch, those in the 5.66 mm fraction and coarser are stable for discharges at bankfull stages, and intermediate size fractions will be set in motion as discharge increases from 0.4 ft^3/s to that at bankfull stage. Sediment loads of each size fraction were calculated for discharges ranging up to the bankfull stage discharge of 58.5 ft^3/s, by three different methods. Total sediment load at bankfull discharge calculated by the three methods ranged from 0.036 lb/s to 6.75 lb/s. In the absence of any measured sediment loads, 6.75 lb/s can be taken as an estimate of the maximum load of sediment coarser than 0.089 mm expected in the ditch.

INTRODUCTION

The U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency has determined the potential for movement of bed sediments in North Ditch, Waukegan, Illinois (figure 1). North Ditch is a small tributary (drainage area about 0.11 mi^2) to Lake Michigan which drains property belonging to the Outboard Marine Corporation and the North Shore Sanitary District. The project, directed by Allen W. Noehre, is aimed at development of discharge and velocity-frequency relationships for the ditch, calibration of a rainfall-runoff model for the drainage basin, and development of sediment load-discharge relationships for both measured and unmeasured sediment discharges. Initial results of the project presented here give a preliminary estimate of the hydraulic properties and sediment discharge characteristics of the ditch based upon measured channel cross sections and grain-size distribution of bed sediment samples for a single, assumed water temperature.

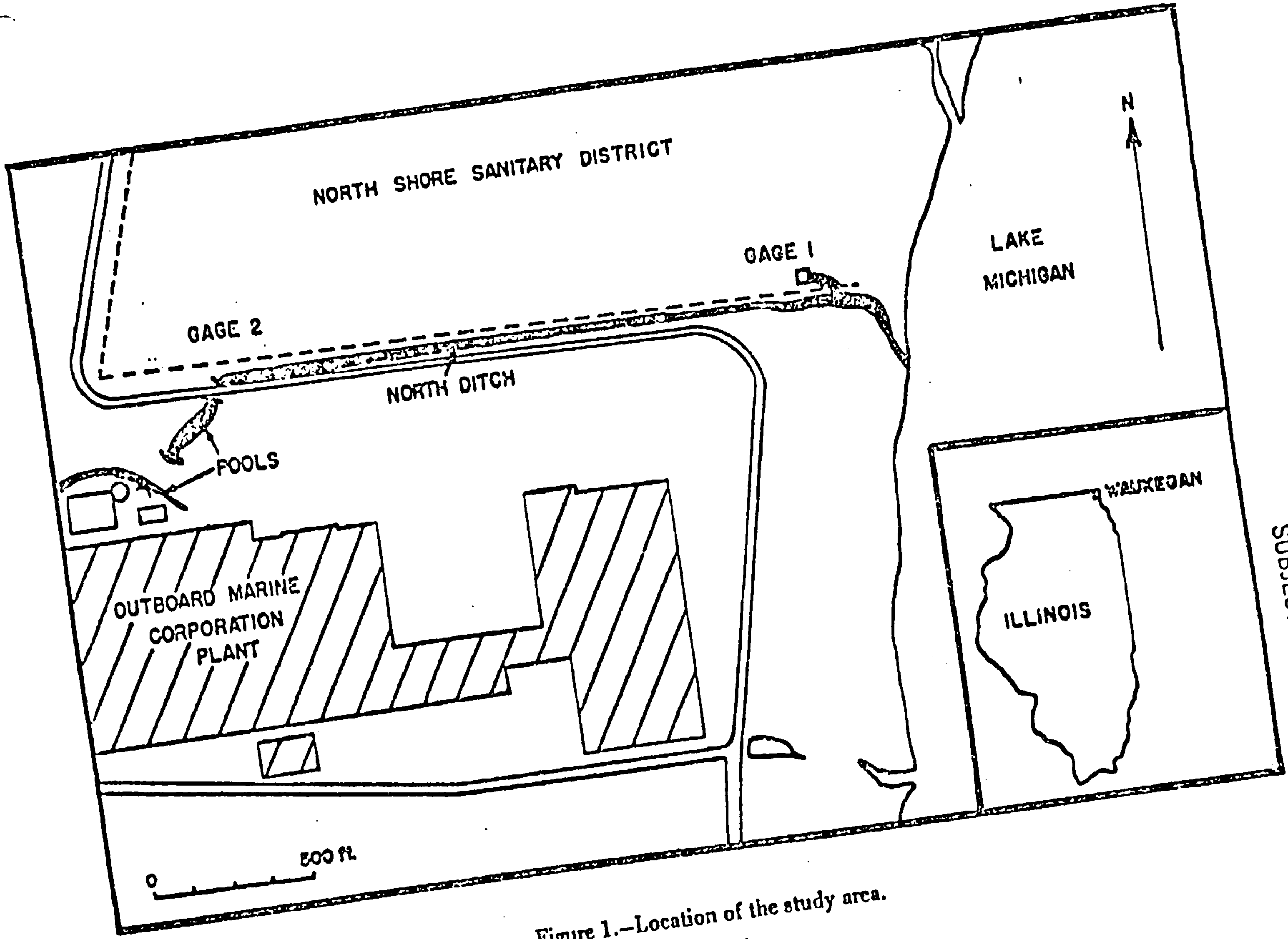

Figure 1.–Location of the study area.

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The methods used for the sediment load calculations are based upon the assumption that sediment is transported by steady, uniform flow. The reach used for the calculations should be as straight and as uniform in slope and cross section as possible. Field inspection showed the lower channel section, from gage 1 to gage 2 (fig. 1) to be the most suitable for the calculations. Inspection at low stage revealed that the channel bed consisted of riffles and pools. Riffles were shallow, disclosing clean, moderately well sorted, gravelly sand (fig. 2). Ripples, an indication of bed-load transport, were visible in the thalweg. In the pools the bed was not visible because of the turbid water but was found to be composed of material much finer than that of the riffles (fig. 2). Pool sediments were black, had a soupy consistency, and were very similar in character to those found in two pools at and just downstream from the plant outfall (figs. 1 and 2). Average bed material, determined from nine samples taken in the reach between gages 1 and 2, was found to have a geometric mean size of 0.156 mm and a geometric standard deviation of 2.25 mm. Other characteristics besides nonuniformity in channel shape and sediments were found that could affect the transport of sediment. Cattails and refuse (cans, bricks, grease clumps) were present on the bed, and a steel retaining wall forms the north bank along most of the downstream section. Cobble gravel was found at the culvert outlet but did not form a significant portion of the channel area.

HYDRAULIC CALCULATIONS

The hydraulic characteristics of an average cross section in the downstream reach of North Ditch were calculated using the method of Einstein (1950) because measurements of hydraulic variables were not available. Cross-sectional area, A, and wetted perimeter, P, were measured graphically from five measured channel cross-sections for a range of water depths, and hydraulic radius, R, was determined for an average section from the relationship R = A/P (fig. 3). Mean velocity was calculated using the above values in the logarithmic velocity equation:

$$\frac{\bar{u}}{u_*} = 5.75 \log \left(12.27 \frac{R'x}{k_s} \right) ,$$

where $\bar{u}$ is mean velocity, u_* shear velocity or $\sqrt{SgR'}$, S channel slope, g the gravitational constant, R′ hydraulic radius with respect to the grains, k_s bed roughness, and x an empirically-determined correction factor which accounts for the change in pressure during the transition between smooth and rough flow. Channel slope was determined from measured cross sections to be 0.000399, omitting the section at gage 1 because backwater conditions that exist much of the time probably influence channel slope at that section. A stage-discharge relationship was calculated for the average section from the area-stage plot and the mean velocity (Q = A$\bar{u}$) (fig. 4).

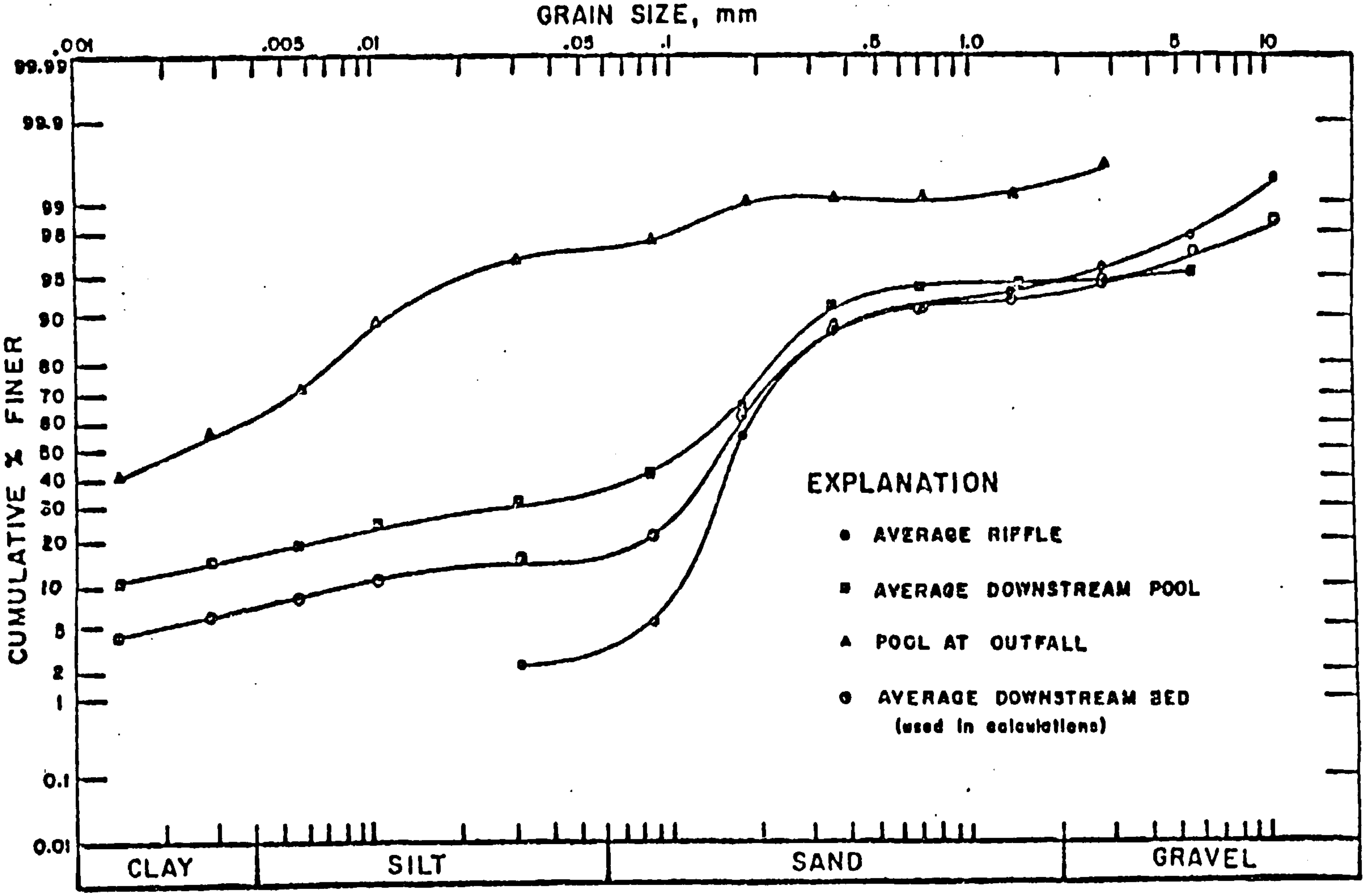

Figure 2.—Grain-size distribution of bed materials of North Ditch.

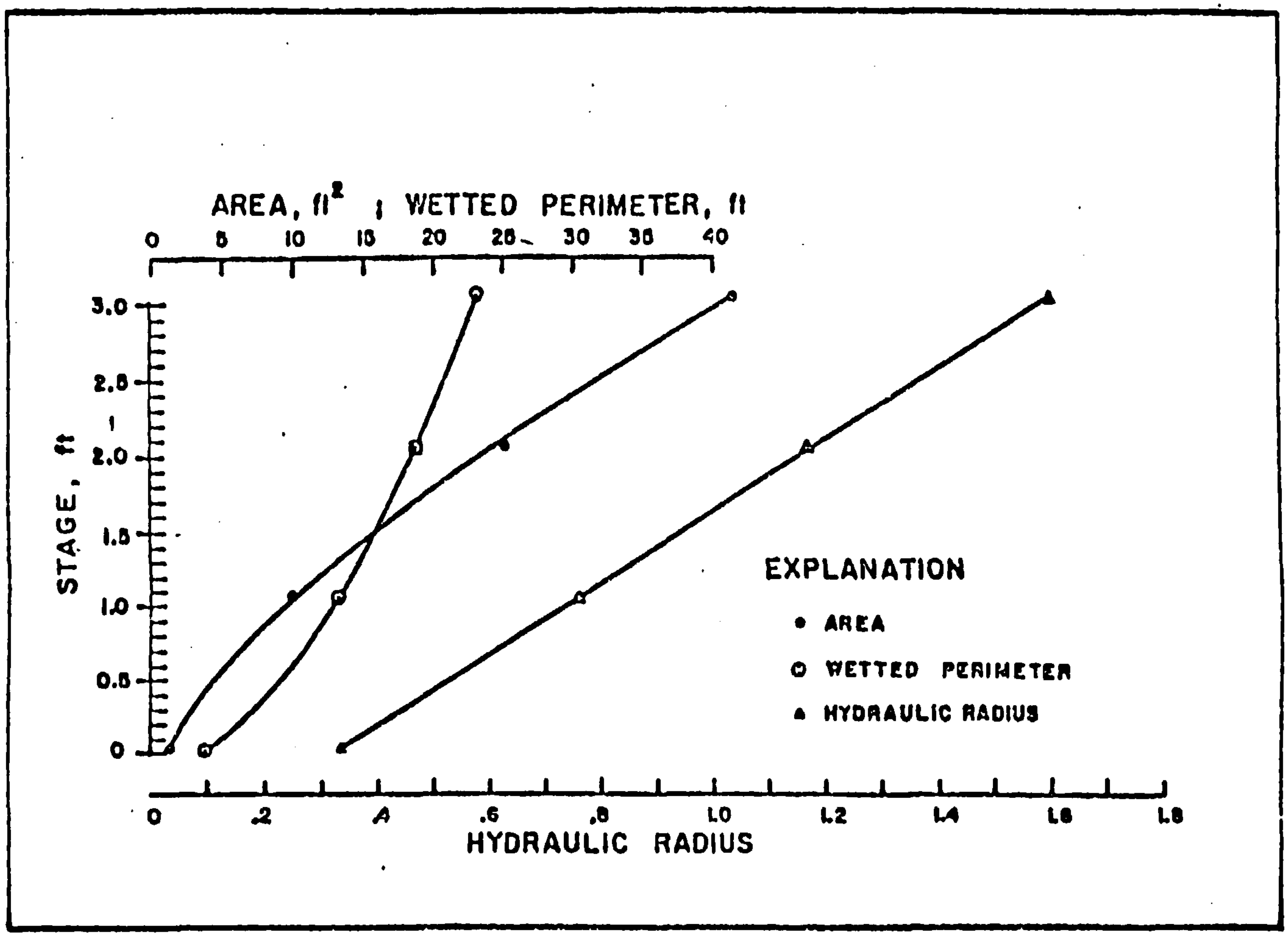

Figure 3.–Hydraulic properties of the average cross section of North Ditch.

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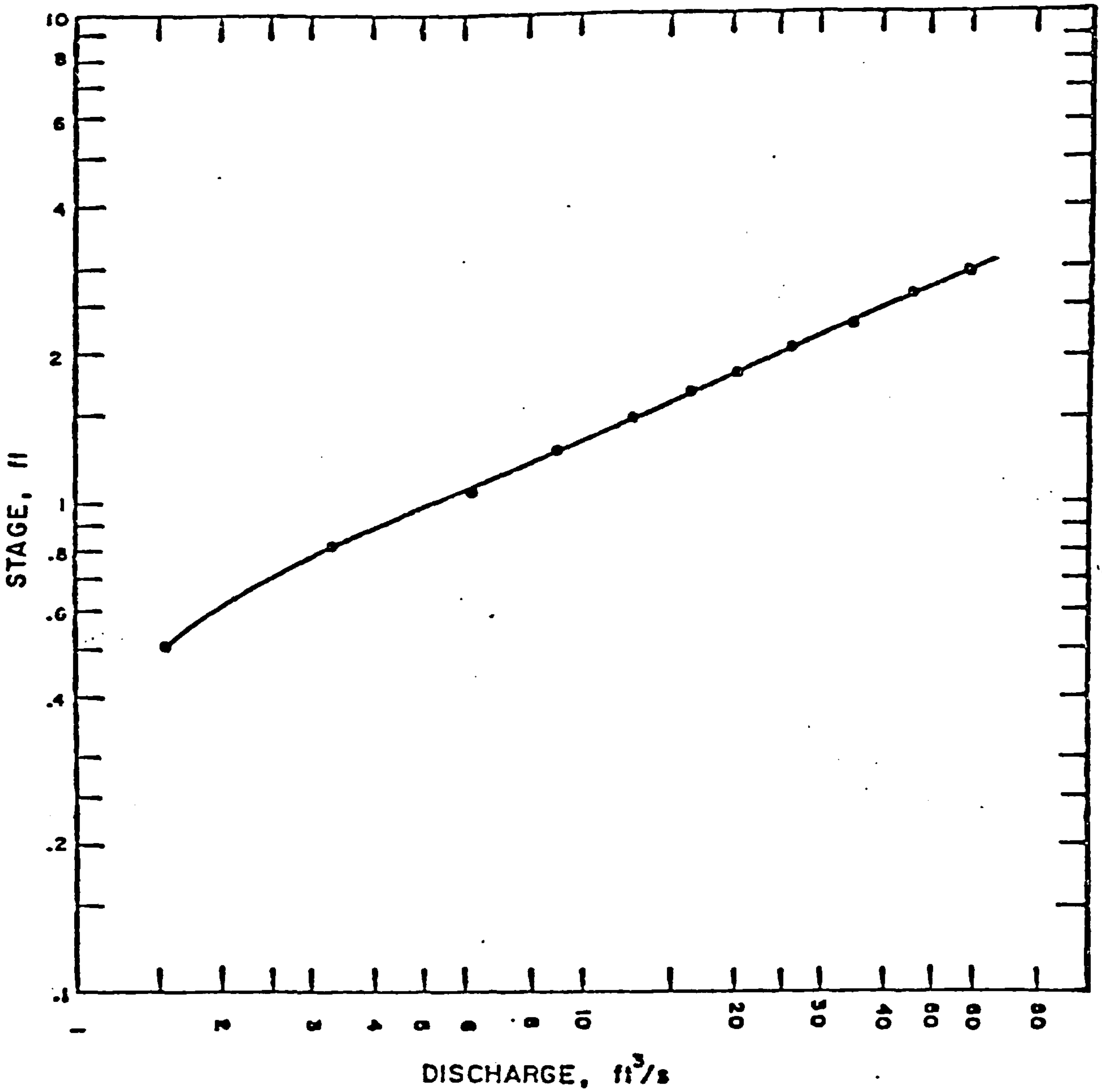

Figure 4.—Calculated stage-discharge relationship for North Ditch.

STABILITY OF THE BED MATERIAL

An estimate of the mobility of the bed material was made by applying an initial-motion criterion to each size fraction of the bed material. This criterion, which gives the flow conditions at which particles of a given size and density first begin to move, is based on measurements made under steady, uniform flows in laboratory flumes.

Threshold shear velocities for size fractions of the bed material of North Ditch were taken from a refined version of the Shields curve (Miller et al., 1977, p. 511, 513) for quartz-density grains at 20°C. The shear velocities were converted to hydraulic radius using the relationship $u_* = \sqrt{gSR}$, and corresponding discharges were read from figure 4. The results (table 1) indicate that particles of the 0.708 mm fraction and finer would be mobile even at low flow. Intermediate size fractions, those with mean diameters of 1.41 and 2.83 mm, should be set in motion as discharge increases from 0.4 ft³/s to that at bankfull stage. The largest grains, those in the 5.66 fraction and larger, should be stable even at bankfull discharge.

Table 1.–Initial motion condition

Grain Size (mm)	u_* (ft/s)	R	Q (ft³/s)
11.2	0.285	6.30	above bankfull stage
5.66	0.190	2.80	
2.83	0.131	1.33	27.2
1.41	0.0886	0.609	2.6
0.708	0.0623	0.301	0.4
0.354	0.0492	0.188	
0.177	0.0426	0.141	below low flow condition
0.089	0.0328	0.0834	
0.032	0.0259	0.0520	

SEDIMENT LOAD CALCULATIONS

Methods

Sediment load calculations estimate the transport capacity of the stream, i.e., the maximum amount of sediment that a stream in equilibrium can possibly carry at the given hydraulic and bed conditions. Methods for sediment load calculation differ in the amount of data required for their use. Suspended sediment samples, corresponding water temperature, and water-surface slope are required for calculation of sediment discharge by the modified Einstein method (Colby and Hembree, 1955). Development of sediment rating curves requires suspended sediment samples and corresponding discharge. Because those data were not available, the method, as originally introduced by Einstein (1950), and relationships of Graf and Acaroglu (1968) and Laursen (1958) have been used to arrive at a preliminary estimate of sediment discharge for an assumed water temperature of 20°C.

Einstein's bedload function estimates the capacity for transport of bedload and suspended load for a steady, uniform flow. It does not consider sediment transported as washload, defined as material finer than normally occurs in the bed. The function consists of a bedload equation, a suspended load equation and assumptions which permit a link between the two. The equations have an analytical basis, but require the use of a number of empirical coefficients and correction factors.

Unlike most of the other bedload functions, Einstein's method considers beds which are composed of a mixture of grain sizes. The presence of grains of different sizes on the bed is partially accounted for by the use of d_{65} (grain size at which 65 percent of the bed material is finer) as a measure of bed roughness. That size was chosen on the basis of laboratory flume experiments using six different sediment mixtures. Also, transport capacity is calculated separately for each size fraction of the bed material. The grain size used in the calculations, d, is taken to be equal to the mean size of the fraction, and particle settling velocity is determined for that same size. In addition, an empirical correction factor is applied to the final bedload equation to account for the shielding of smaller grains by larger ones and by the laminar sublayer.

The basic bedload equation expresses an equilibrium between the rate of erosion of particles from the bed and the rate of deposition. The probability of erosion of a particle is assumed to depend upon the hydrodynamic lift on that particle and its weight. The equation reduces to a relationship between two dimensionless parameters,

$$\Psi = \frac{\rho_s - \rho}{\rho} \; \frac{d}{S R'} \qquad \text{and} \qquad \Phi = \frac{g_b}{\rho_s g} \sqrt{\frac{\rho}{\rho_s - \rho} \; \frac{1}{g d^3}} \; ,$$

where ρ_s is the density of sediment grains, ρ the density of fluid, d the grain size for which load is being calculated, S the slope of the bed, g the gravitational constant, g_b the bedload transport rate, and R′ the hydraulic radius with respect to the grains. Einstein called the first parameter flow intensity and the second intensity of bedload transport. To find the bedload for a size fraction, Ψ is calculated from measured variables, Φ is found from an empirical relation between Ψ and Φ, and several correction factors are applied to Φ to given the bedload rate.

The basis of the suspended load calculation is a well-accepted analytical relationship introduced by Rouse (1937), which gives the concentration of suspended sediment, C, at a chosen level, y, in relation to a known concentration, C_a, at a reference level a:

$$\frac{C}{C_a} = \left(\frac{D - y}{y} \; \frac{a}{D - a} \right)^z ,$$

where D is the total depth of flow, $z = v_s / \kappa u_*$, v_s is particle settling velocity, κ is the Karman constant (approximately 0.4), and u_* is shear velocity. The transport rate of suspended sediment is given by:

$$g_s = \int_a^D C \bar{u} dy ,$$

where $\bar{u}$ is mean flow velocity.

Einstein uses the above relationships with the logarithm velocity equation in the form

$$\frac{\bar{u}}{u_*} = 5.75 \log \left(30.2 \frac{yx}{k_s} \right) ,$$

where x is a correction factor and k_s is bed roughness, to determine the suspended sediment load. To obtain a reference concentration, Einstein assumes that the suspended load is derived from a bed layer, defined as a zone 2 grain diameters thick, in which bedload transport takes place. The known concentration C_a is taken to be the average concentration in the bed layer as determined from the bedload calculation, and the reference level a is taken to be 2d.

A unique feature of Einstein's method is the division of the total hydraulic radius into two parts, that with respect to the grains, R', and that with respect to larger-scale bed irregularities, R". The second is assumed to represent that part of the flow which is ineffective in sediment transport because of separation of flow from the bed caused by bedforms (ripples and dunes). Graf and Acaroglu (1968) have devised a total load function which depends on an empirical relation between two dimensionless parameters which are very similar to those of Einstein (1950):

$$\Psi_A = \frac{[(\rho_s-\rho)/\rho]\,d}{SR} \quad \text{and} \quad \Phi_A = \frac{\bar{C}\bar{u}R}{\sqrt{[(\rho_s-\rho)/\rho]\,gd^3}} ,$$

where $\bar{C}$ is the volume concentration of particle transport, R is the total hydraulic radius (R' + R") and other variables are as previously defined. The relationship between the two was found empirically to be $\Phi_A = 10.39\ \Psi_A^{-2.52}$. In order to make their relationship applicable to both open channel and closed-conduit flow, Graf and Acaroglu (1968) have used the total hydraulic radius rather than R' of Einstein. In addition, they make no distinction between bedload and suspended load but instead obtain the total concentration of transported sediment.

Laursen (1958) used qualitative arguments to develop three factors which he related to sediment load. The ratio u_*/v_s is used to express the effectiveness of the mixing action of the turbulence. A measure of the effective tractive force on a particle is given by τ_0'/τ_c, where τ_0' is the shear stress exerted by the flow on a particle, and τ_c is the shear stress necessary to initiate motion of that particle. The ratio of particle size to total flow depth, d/y_0, was also found to be useful in the relationship. The factors are related by:

$$\frac{\bar{c}}{\left(\frac{d}{y_0}\right)^{7/6}\left(\frac{\tau_0'}{\tau_c}-1\right)} = f\left(\frac{u_*}{v_s}\right),$$

where $\bar{c}$ is the mean concentration of sediment, in weight percent. To find $\bar{c}$, τ_0' is evaluated according to

$$\tau_0' = \frac{\bar{u}^2\ d_m^{1/3}}{30\,y_0} ,$$

where d_m is the mean size of the total bed material sample and $\bar{u}$ is the mean velocity. The critical shear stress, τ_c , and settling velocity, v_s, are found from empirical curves for each size fraction, and $f(u_*/v_s)$ from an empirical relation developed by Laursen. The volume rate of transport, q_s, in ft³/s, is found from the discharge, Q, and $\bar{c}$,

$$q_s = (\bar{c}Q)/265.$$

Sediment load, G_s, in the lb/s is then fround from q_s by the relation $G_s = 165\ q_s$.

Results

Calculations of sediment discharge were made by the three methods described above for each grain-size fraction of the bed material of the ditch for a range of discharges (table 2). The total sediment discharge at a given discharge was determined as the sum of the size fractions for which calculations were made. A water temperature of 20°C was used for the calculations, grain density was taken to be 165 lb/ft^3 (quartz density), and channel slope was 0.000399. Hydraulic characteristics used were those shown in figures 3 and 4, and average bed material was assumed to have the distribution given in figure 2. Figures 5 and 6 are plots of sediment discharge versus discharge for each size fraction and for the sum of the size fractions (total sediment discharge), as calculated by the Graf and Acaroglu (1968) method and the Laursen (1958) and Einstein (1950) methods, respectively.

DISCUSSION

The discharge given by the initial-motion condition for a given sized grain is the minimum flow intensity required to move a particle of that size. The conditions under which that criterion was determined in the laboratory are quite different from those in any natural situation, and the effect that those differences have on the beginning of motion is not well understood. Though the relatively weak cohesive forces that exist among very fine quartz grains are reflected in the initial-motion criterion, no attempt is made to consider the stronger cohesive forces that clay minerals may develop. The presence of clay minerals, oil, or plants would tend to increase the flow intensity required for motion. Also, the laboratory measurements have been made on size-homogeneous beds. The presence of a range of bed-particle sizes affects the beginning of motion, and the effect appears to be different for each size fraction. In a grain-size mixture, the flow intensity required for motion initiation may be increased for small grains which become trapped between larger grains, and may be decreased for large grains which can roll over beds of finer grains.

The methods used above for calculation of sediment discharge differ in the way in which physical principles are applied to the transport problem, and each method makes use of different empirically determined relationships among derived parameters. The results of the Einstein (1950) and Graf and Acaroglu (1968) methods differ largely because of the difference in definition of hydraulic radius. The difference will be greater at lower flow stages.

Table 2.—Calculated sediment discharges

Grain Size (mm)	Discharge (ft^3/s)	Sediment Discharge (lb/s)		
		Graf and Acaroglu	Einstein	Laursen
0.089	6.16	0.274	–	–
	26.5	1.51	–	0.170
	34.8	1.98	–	0.290
	45.6	2.66	–	0.452
	58.5	3.47	–	0.724
0.177	6.16	0.136	–	–
	26.5	0.744	–	0.0155
	34.8	0.977	–	0.0380
	45.6	1.32	–	0.0866
	58.5	1.72	–	0.155
0.353	6.16	0.0680	–	–
	26.5	0.371	–	–
	34.8	0.488	–	0.00815
	45.6	0.652	–	0.0232
	58.5	0.853	0.00417	0.0477
0.708	6.16	0.0335	–	–
	26.5	0.182	–	–
	34.8	0.238	–	–
	45.6	0.319	0.00340	–
	58.5	0.418	0.0259	0.00667
1.41	6.16	0.0165	–	–
	26.5	0.0896	–	–
	34.8	0.118	–	–
	45.6	0.153	–	–
	58.5	0.260	–	–
2.83	6.16	0.00812	–	–
	26.5	0.0442	–	–
	34.8	0.0586	–	–
	45.6	0.0776	–	–
	58.5	0.102	–	–
Total load	6.16	0.536	–	–
	26.5	2.94	–	0.186
	34.8	3.86	–	0.336
	45.6	5.18	0.00417	0.562
	58.5	6.75	0.0301	0.934

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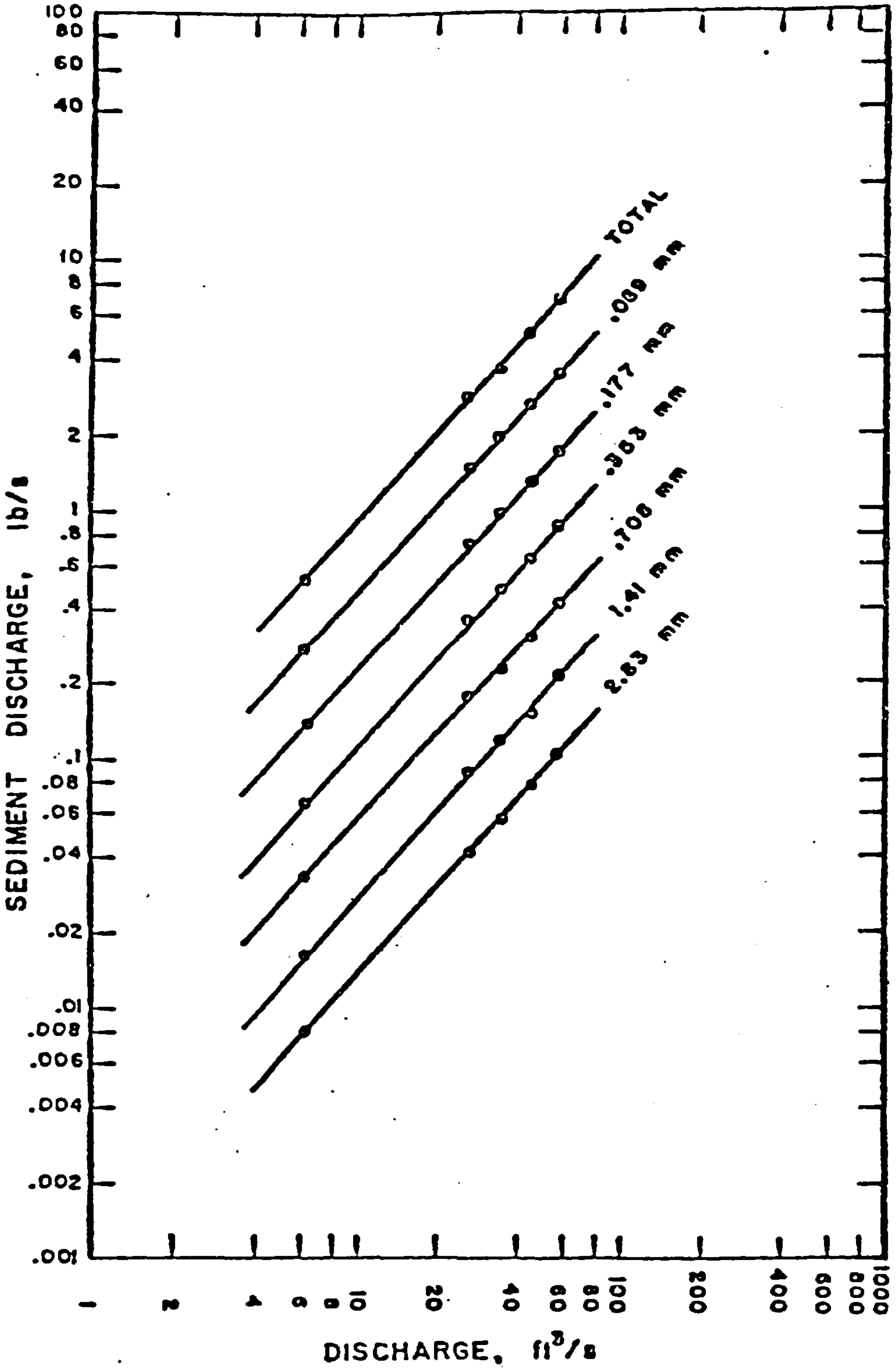

Figure 5.—Sediment discharge through an average cross section as calculated by the method of Graf and Acaroglu (1968).

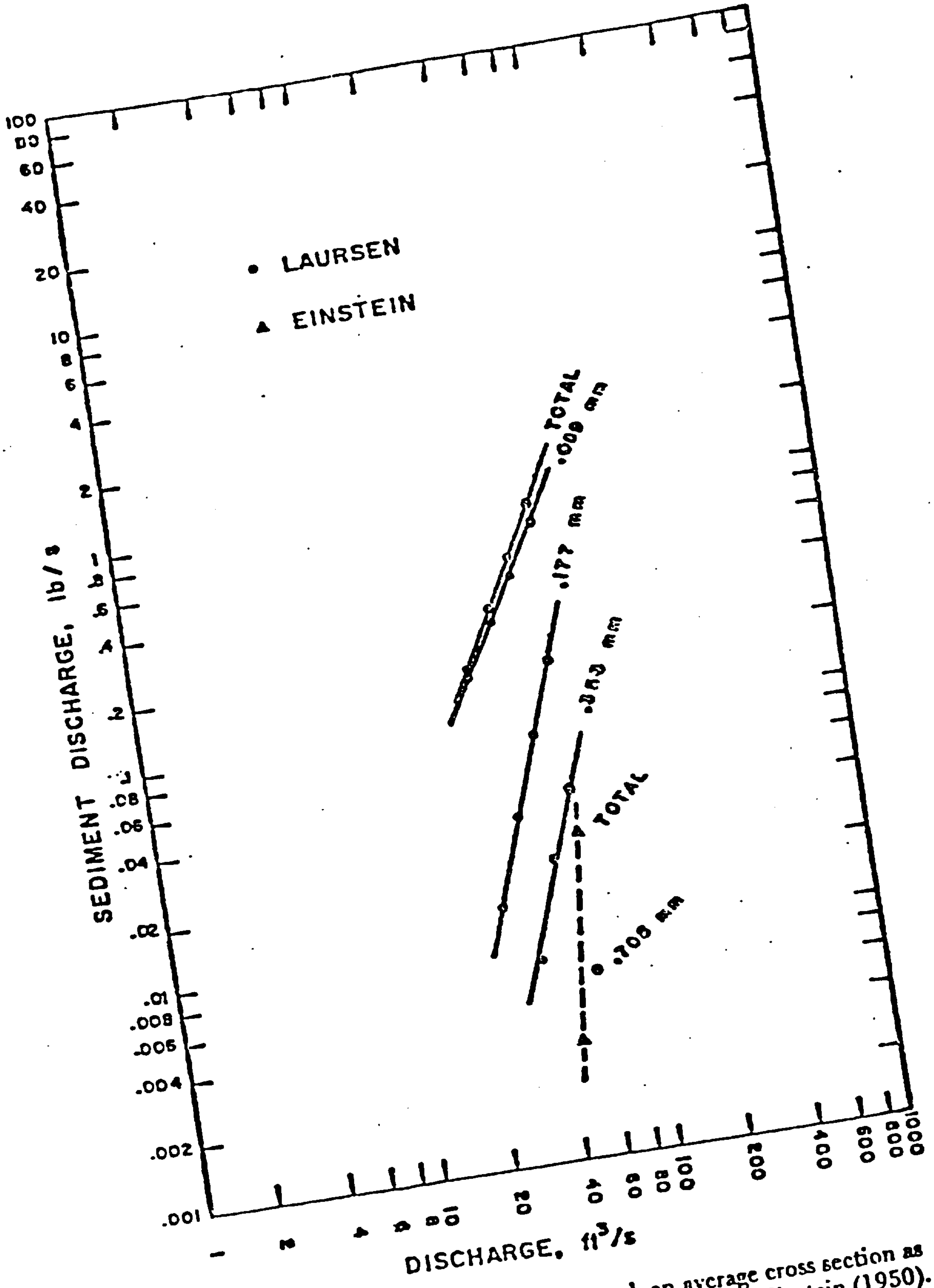

Figure 6.–Sediment discharge through an average cross section as calculated by the methods of Laursen (1958) and Einstein (1950).

Although all three methods can be used for channels with beds having a mixture of grain sizes, only Einstein (1950) explicitly considers the interaction of the different sized grains in the bed and the effect of that interaction on the probability of movement. If each size fraction is treated separately, the probability of a given grain being set in motion and remaining in motion increases as the grain size decreases. Einstein (1950) reasoned that on a bed composed of grains with a range of sizes, the probability of erosion of the finer fractions would be decreased because of shielding by larger grains and the laminar sublayer. Because Einstein includes a factor to account for this effect, his method predicts that the largest loads will be in the intermediate size fractions rather than in the finest size fractions predicted by the other two methods.

The method which best models transport in a given situation can be determined only by comparison of calculated sediment discharge with sediment discharge measured in the reach for which calculations were made. In the case of North Ditch no measured sediment discharges are available, and it is possible to specify only a range of possible sediment discharges. The results of application of the method of Graf and Acaroglu (1968) can be taken as maximum sediment discharges expected for North Ditch, and total sediment discharge in the ditch at bankfull stage most likely lies within the range between the value calculated by that method (6.75 lb/s) and the value determined by the method of Einstein (1950) (0.0301 lb/s).

CONCLUSIONS

The lack of measurements of sediment discharge makes it impossible to know at this time which of the estimates presented above most closely approximates the actual sediment discharge relationship for North Ditch. In the absence of any additional hydraulic or sediment discharge measurements, the results of the Graf and Acaroglu (1968) method can be assumed to give an estimate of the upper limit of sediment transport capacity of North Ditch at the present bed slope. A sediment discharge of 6.75 lb/s is predicted by that method for discharge at bankfull stage. Application of an initial-motion criterion to each size fraction of the bed material of the ditch indicates that all fractions with mean sizes of 2.83 mm and finer will be set in motion as stage increases to bankfull. All of the methods used predict that fractions with mean sizes larger than 2.83 mm will not be transported in significant quantities in the ditch.

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AN ESTIMATE OF SEDIMENT MOVEMENT IN NORTH DITCH, WAUKEGAN, ILLINOIS

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AN ESTIMATE OF SEDIMENT MOVEMENT IN NORTH DITCH, WAUKEGAN, ILLINOIS

By

Allen W. Noehre and Julia B. Graf

Administrative Report

Prepared in cooperation with the
U.S. Environmental Protection Agency

1980

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ILLUSTRATIONS

TABLES

CONVERSION FACTORS

Multiply Inch-pound unit	By	To obtain SI (metric) unit
mile (mi)	1.609	kilometer (km).
foot (ft)	0.3048	meter (m).
inch (in)	25.40	millimeter (mm).
foot per second (ft/s)	0.3048	meter per second (m/s).
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s).
pound (lb)	0.4536	kilogram (kg).
pound per cubic foot (lb/ft^3)	0.01602	grams per cubic centimeter (g/cm^3).
pound per hour (lb/h)	0.4536	kilogram per hour (kg/h).

Temperature

degrees Fahrenheit (°F)	-32 x 0.555	degrees Celsius (°C).

AN ESTIMATE OF SEDIMENT MOVEMENT IN NORTH DITCH, WAUKEGAN, ILLINOIS

By

Allen W. Noehre and Julia B. Graf

ABSTRACT

Stage-discharge and sediment-discharge to stream-discharge relations have been developed for North Ditch, Waukegan, Ill., a small tributary to Lake Michigan. Indirect methods were used to obtain a stream-discharge rating curve, and discharge and stage measurements were used to adjust that relation. Transport curves for discharge of both measured sediment and bed material were developed from measured sediment concentrations and by calculation from three indirect methods. The stream- and sediment-discharge relations were used with stage record to estimate daily sediment load in the ditch for the study period March 13 to September 30, 1979. Maximum daily sediment load during that period, as estimated from the measured-sediment transport curve, was 450 lb. Mean daily sediment load for the 202-day period was 25 lb; the sediment load for the study period was 5,100 lb. Peak stream discharges estimated by empirical equations for floods of 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals were used with a bed material transport curve to estimate sediment discharge for these floods. Total bed material discharge for the same floods is estimated to be 220 lb/h for the 2-year flood peak and 1,600 lb/h for the 100-year flood peak.

INTRODUCTION

A short-term study of the flow and sediment-transport characteristics of North Ditch, a small tributary to Lake Michigan, was undertaken because of a need for the determination of the rate of movement of streambed materials into Lake Michigan. North Ditch drains property belonging to the Outboard Marine Corporation and the North Shore Sanitary District at Waukegan, Ill. (fig. 1). Data collection necessary for the study included bed-material samples, channel geometry and slope data, continuous precipitation and stage measurements, discharge measurements, and sediment-concentration information. These data were collected from March 13 through September 30, 1979.

Channel characteristics, stage record, and stream-discharge measurements were used to develop a stage-discharge relation for the ditch and to estimate hourly and mean daily discharges for periods of flow. Corresponding daily loads of sediment were estimated using a transport curve computed from measured sediment concentrations. Flood-peak stream and bed-material discharges were also estimated.

The 0.11 mi^2 drainage area includes plant buildings, parking lots, roads, railroads, and an expressway, for a total of about 40 percent impervious surface. The area between gages 4 and 5 (fig. 1) is wooded and grassy and it serves as a disposal site for urban debris. Downstream, cattails

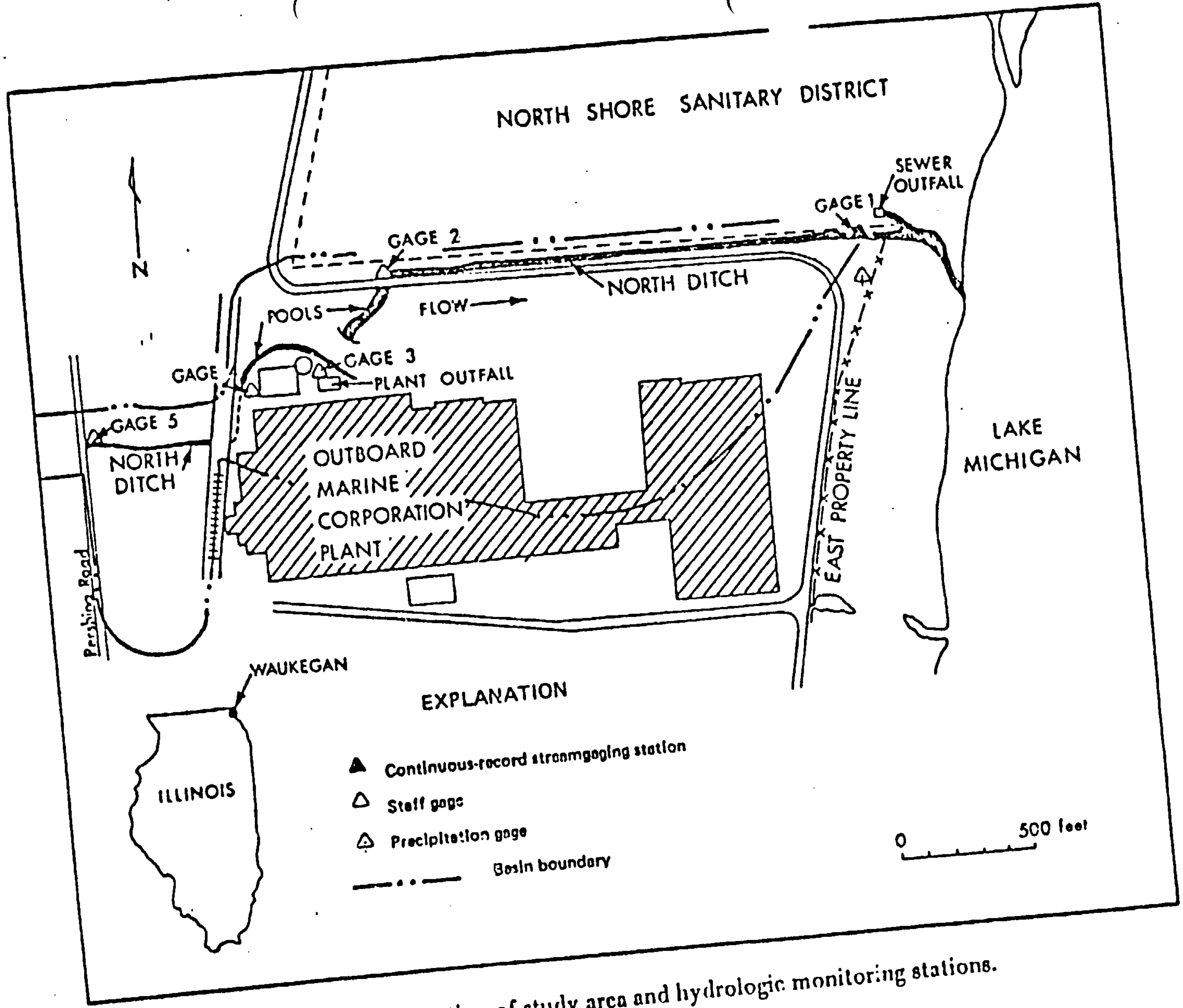

Figure 1.—Location of study area and hydrologic monitoring stations.

and other vegetation grow along the ditch. The ditch drains an area of land fill which is composed of sandy material (Willman, 1971). The ditch itself is small, 3 to 5 feet deep and 20 to 40 feet wide across the top and is unlined except for a steel retaining wall which makes up much of the north bank between gages 1 and 2. A channel profile (fig. 2) shows that the steeper upper reach, between gages 4 and 5, is separated from the lower reach by three culverts and two pools.

Streambed material is composed of sand with some gravel; organic debris and finer sediments are found in the pools. Because of the large impervious surface area and the permeability of much of the remaining area, it is believed that a large proportion of the sediment load of the stream at gage 1 is derived from the channel itself.

The work was performed in cooperation with the U.S. Environmental Protection Agency whose personnel collected some of the sediment samples and analyzed sediment concentration for those samples.

SURFACE WATER RUNOFF

Field Data Collected

A stream-stage recorder gage (No. 1), four staff gages (Nos. 2-5), and a precipitation recorder were installed along a 3,329-foot reach of North Ditch from gage 1 to Pershing Road (figs. 1, 2). Figure 3 illustrates daily precipitation, stage, and mean discharge for the study period at gage 1 (gaps in stage record due to recorder malfunction). Elevation and cross-sectional geometry at 13 locations were obtained by level survey; roughness values (Manning's *n*) were selected during the survey.

Stream discharge was measured at gage 1 during several storm and low flow periods. Maximum discharge measured during the study at gage 1 was 5.3 ft^3/s. In addition, discharge measurements, gage heights, and some maximum stages were obtained at gages 2 through 5.

Stage-discharge Relation

Due to the short study period and lack of available data, indirect methods were used to develop the stage-discharge relation (rating curve). Field data were used to verify the computed relation in the range of the discharge measurements. Water-surface elevations (stage) were computed by the step-backwater computer program (Shearman, 1976) which is based on Chow's step method (1964). That method uses the energy equation with Manning's formula to estimate energy losses between consecutive cross sections. Required computer input data include discharge, stage, cross-section geometry, and Manning's *n* values.

Input values of discharge at gage 1 were estimated using empirical equations developed by Allen and Bejcek (1979) from multiple regression analyses of regional data from gaged sites in northern Illinois:

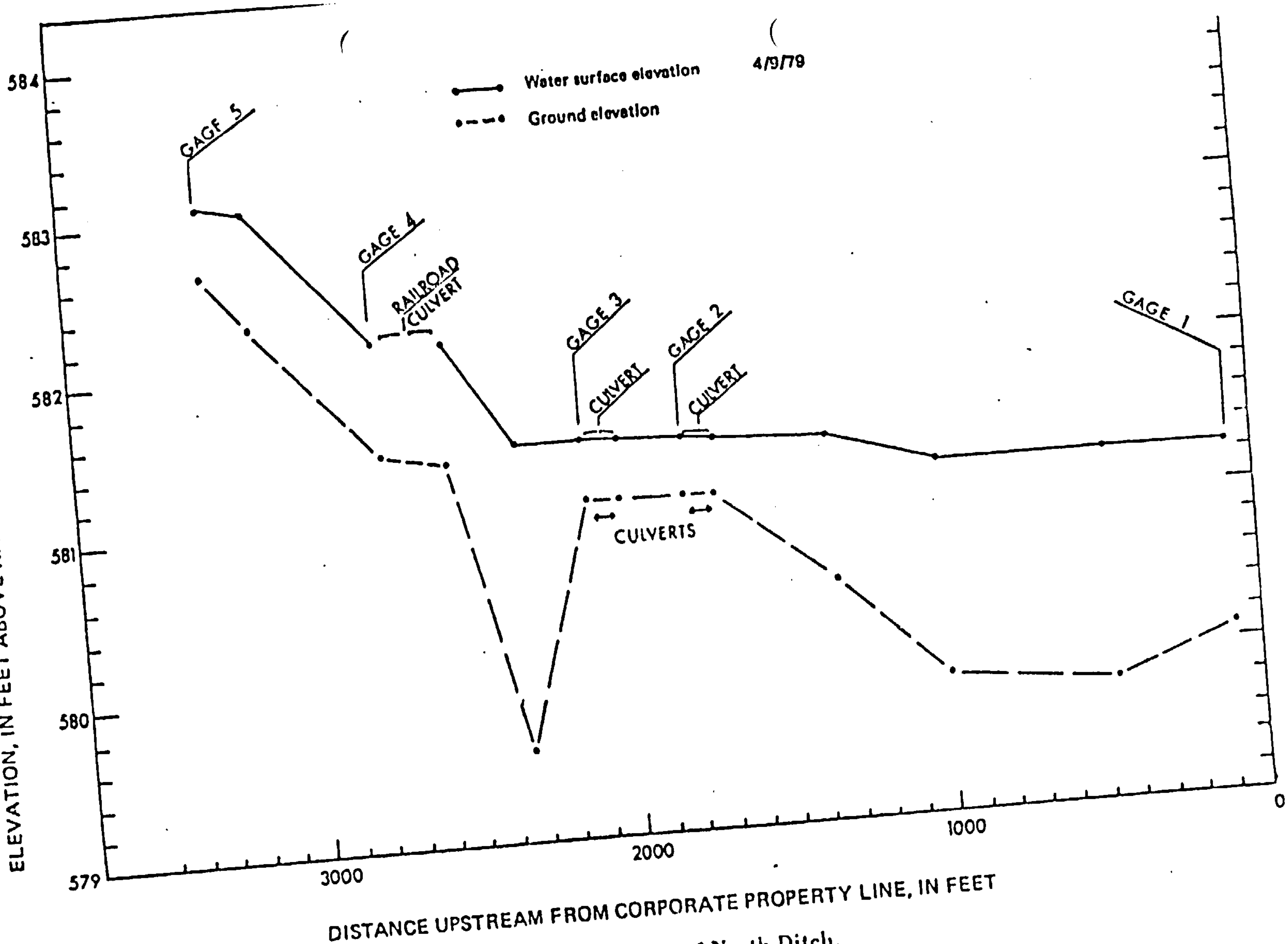

Figure 2.—Profile of North Ditch.

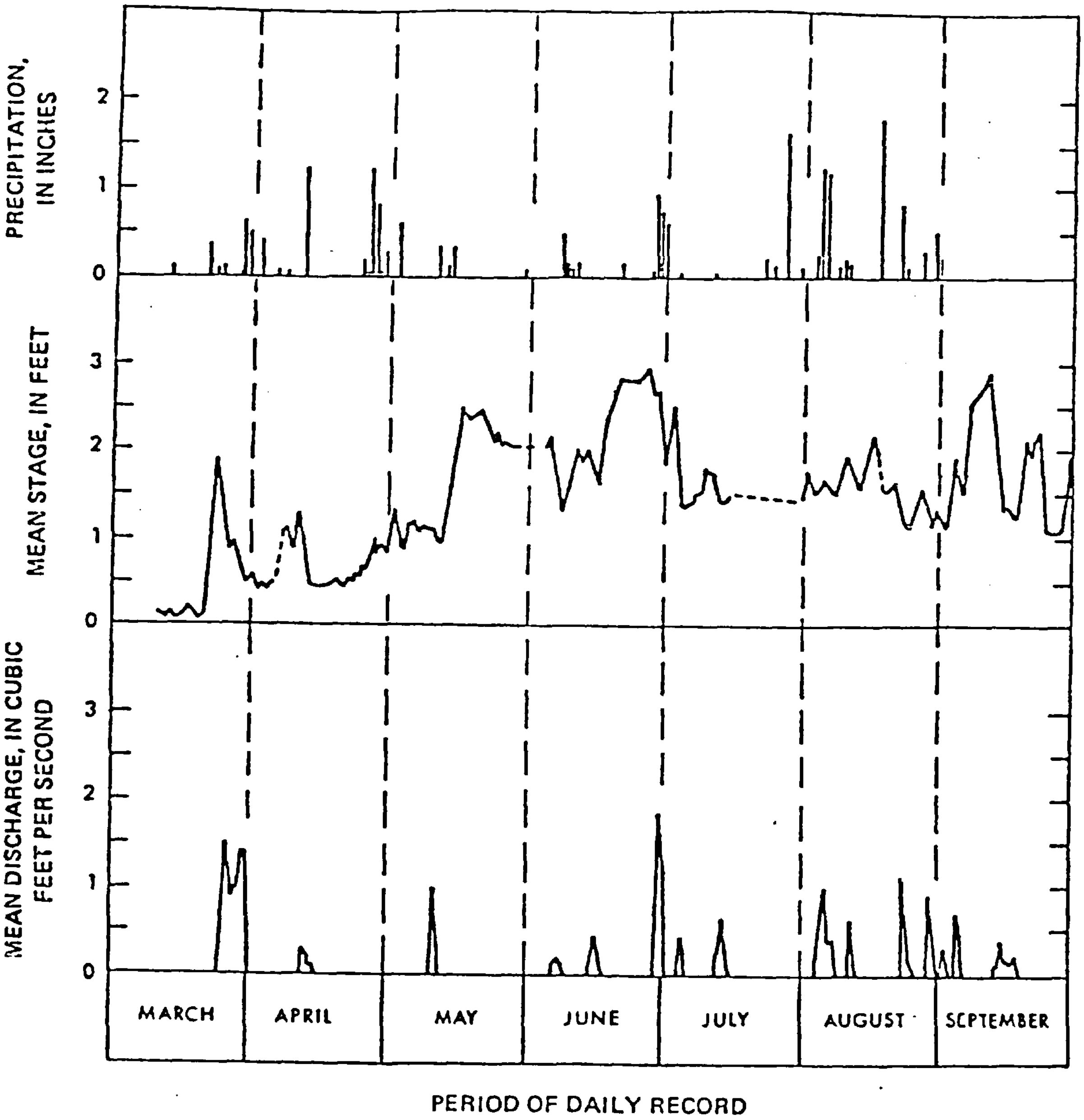

Figure 3.–Daily values of precipitation, mean stage, and mean discharge for the study period at gage 1.

$$Q_{2} = 14.7\,A^{0.698}\,S^{0.241}\,If^{0.313}$$

$$Q_{5} = 23.8\,A^{0.682}\,S^{0.284}\,If^{0.255}$$

$$Q_{10} = 29.8\,A^{0.675}\,S^{0.305}\,If^{0.228}$$

$$Q_{25} = 37.2\,A^{0.668}\,S^{0.325}\,If^{0.202}$$

$$Q_{50} = 42.7\,A^{0.664}\,S^{0.338}\,If^{0.186}$$

$$Q_{100} = 48.0\,A^{0.660}\,S^{0.349}\,If^{0.172}$$

where Q is stream discharge and the numbered subscript denotes the flood recurrence interval, A is drainage area, S is main channel slope, and If is percent imperviousness. The North Ditch drainage area, slope, and percent imperviousness were 0.11 mi^2, 6.29 ft/mi, and 40 percent, respectively.

Starting water-surface elevations at gage 1 were developed by the slope-conveyance method (Dalrymple and Benson, 1967) which makes use of Manning's equation. The energy slope used in Manning's equation was assumed to be equal to the general slope of the ditch.

Cross-section geometry and Manning's *n*, additional input values, were determined from field surveys. The range in Manning's *n* along the ditch was from 0.030 to 0.055 for the main channel with no overbank flow.

A culvert rating computer program based on methods described by Bodhaine (1968) was used to obtain a stage-discharge relation at gages 2, 3, and 4. Program input consists of approach section and culvert geometry, roadway elevation, and roughness coefficients. The culvert rating program calculates discharge from the continuity and energy equations. Discharge measurements made at gages 2, 3, and 4 were used to define the low end of the rating curve at each culvert. The stage-discharge relations at these gages were used to verify or to calibrate the stage computed by the step-backwater method.

Stage was not a reliable indicator of flow at gage 1. A barrier sand bar, built to various heights by wave action along the west shoreline of Lake Michigan (Visocky, 1977), often blocked flow from a sewage-plant outfall downstream from gage 1 and direct wave action from Lake Michigan were all observed to cause backwater in North Ditch and thus affect the stage-discharge relation during the study period. The barrier bar was breached and eroded during periods of rainfall when the water surface rose in the ditch causing the bar to become unstable.

The described backwater conditions caused the stage-discharge relation for gage 1 to shift to a lower discharge for any given stage. During those periods flow conditions were defined by use of a discharge measurement and the highest and lowest recorded elevation before and after the breaching of the barrier bar. Flow into Lake Michigan was observed on days during rapid drops in recorded stage at gage 1.

Hourly discharges were computed using the recorded stage with the rating curve. The hourly discharges were then averaged to determine mean daily discharges (fig. 3). Discharge could not be computed for 25 other periods because discharge measurements were not available to define the changing control conditions. During these periods and the periods of missing stage record, 2.81 inches of rainfall occurred or 14 percent of the total precipitation recorded during the study.

SEDIMENT MOVEMENT

Bed material of North Ditch was described, and initial estimates of sediment discharge were presented in a progress report (Graf, 1979). The three bed-material discharge relations presented in the progress report were calculated using indirect methods with measured bed slope, grain-size distribution of bed material, and an assumed water temperature. In this report, data from sediment concentration samples collected between March 13 and September 30, 1979, are presented, and a transport curve derived from those data is compared to the bed material transport curves given in the progress report.

Sediment Concentration Measurements

Samples for determination of sediment concentration were collected at gage 1 throughout two storm runoff periods (March 30 and April 11-12) and once during each of three miscellaneous periods of flow. The samples were collected using the equal width increment (EWI) method (Guy and Norman, 1970) which yields a representative sample of sediment carried above a level 0.3 ft from the streambed. Stream discharges during the two runoff periods were determined from staff gage readings made at the time of sampling, whereas measurements of stream discharge were made at the time of sediment sampling for the three miscellaneous samples.

The variation of sediment concentration and stream discharge with time for March 30 (fig. 4) typical of the response of small streams with low base flows to a high intensity rainfall. The data for April 11-12 (fig. 4) show a situation which may be more typical for this ditch. During that period, streamflow at gage 1 was affected by strong onshore (upstream) winds which created waves and at times caused backwater conditions in the ditch.

Sediment Discharge Relations

Measured sediment discharge at gage 1 was computed for each sediment concentration sample and plotted against its corresponding stream discharge (fig. 5). A straight line fitted to the data using the least squares technique for regression of logarithms of the data is also shown. For comparison, the bed material transport relations calculated in the progress report have been replotted on figure 6 with the regression line.

Comparison of sediment discharges estimated from each of the four transport curves (fig. 6) reveals that the method of Graf and Acaroglu (1968) significantly overestimates sediment discharge through the ditch. The difference between the measured-sediment discharge data and the estimates

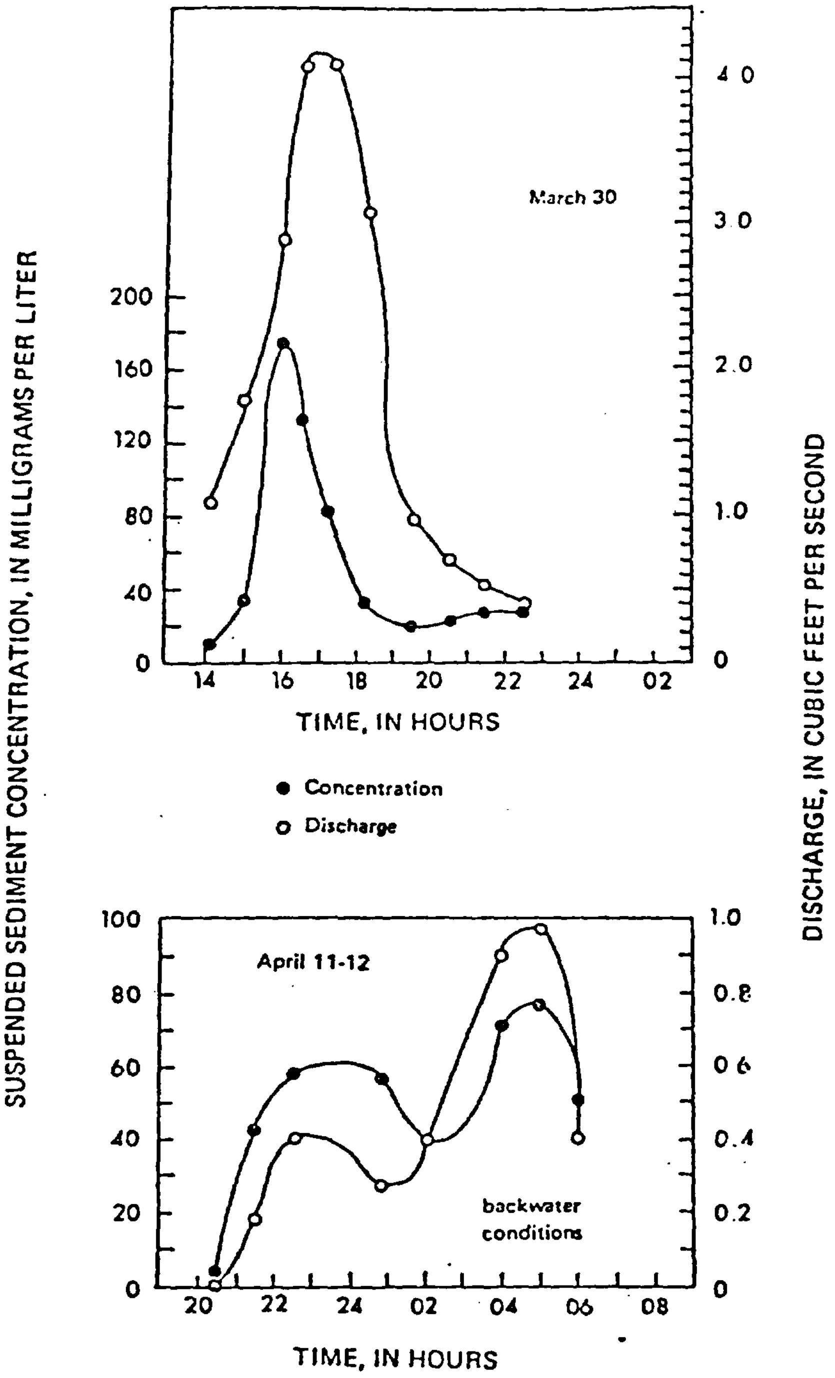

Figure 4.—Sediment concentration and stream discharge at gage 1 during two runoff periods.

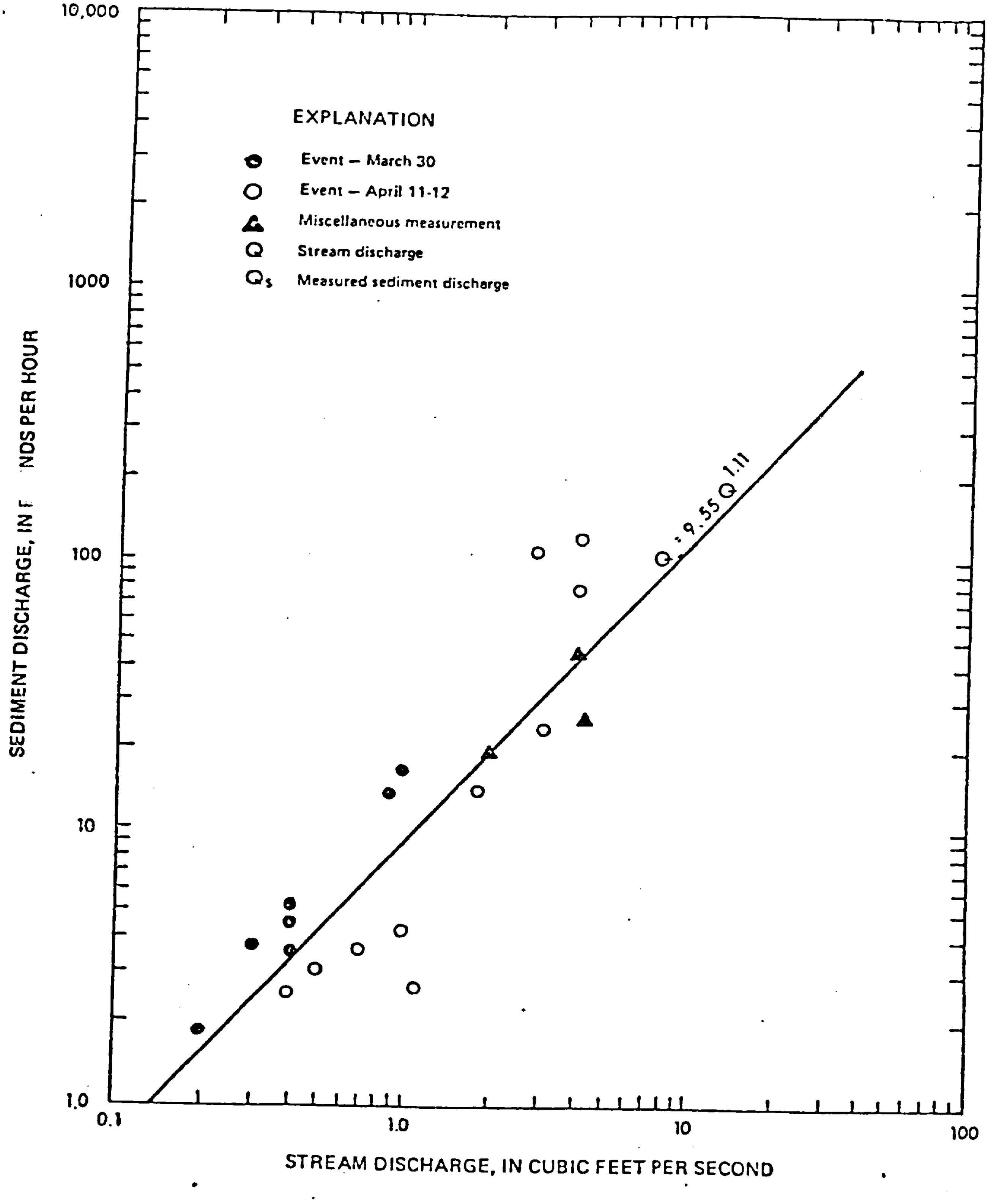

Figure 5.—Measured sediment discharge data and calculated regression line for North Ditch.

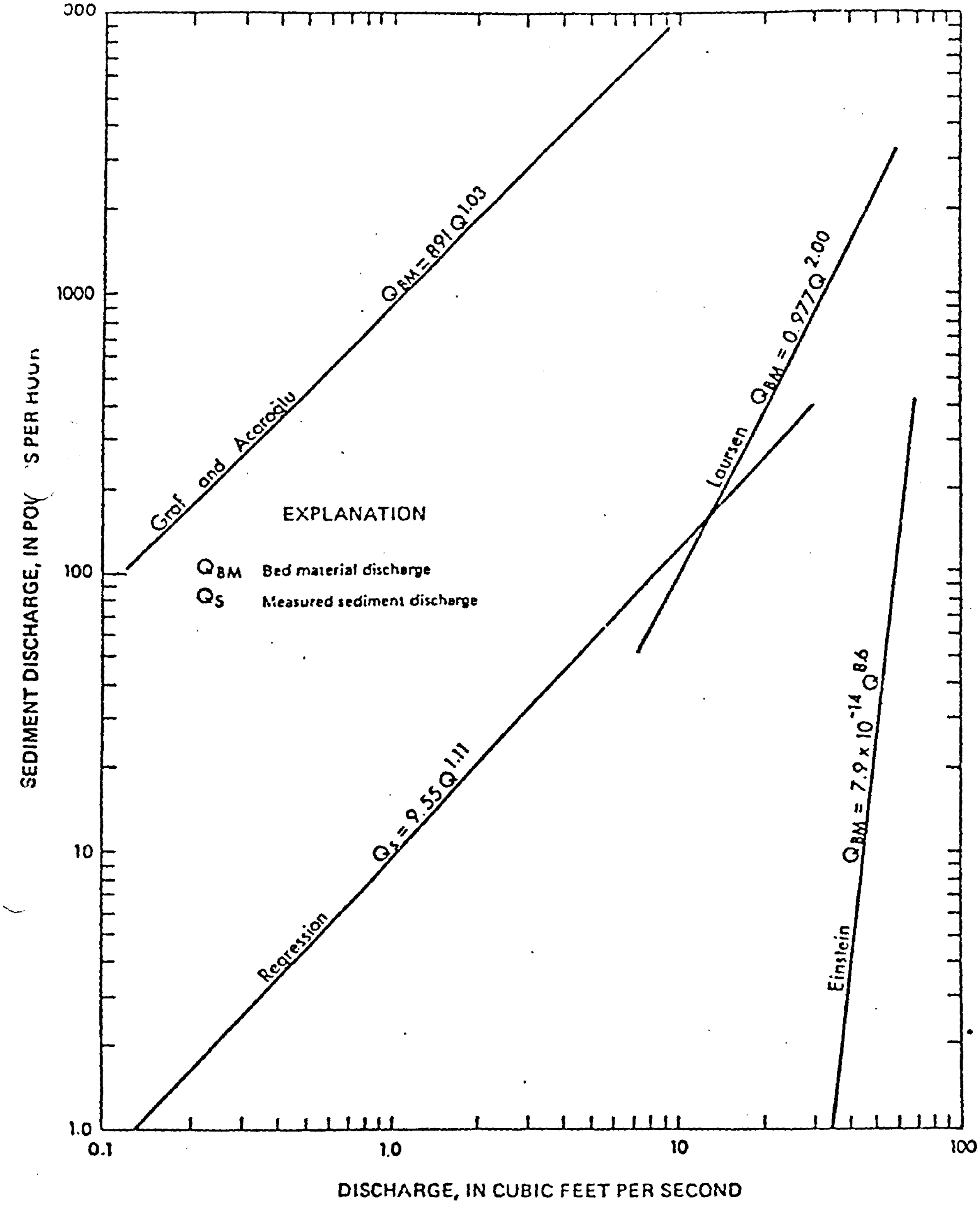

Figure 6.—Predicitive equations and transport curves for sediment discharge in North Ditch.

of bed material discharge by the Graf and Acaroglu method is assumed too large to be caused only by the unmeasured-sediment discharge, which is that portion carried between the bed surface and the lower limit of the suspended-sediment samples – 0.3 ft above the bed. Einstein's (1950) indirect method estimates bed material discharge orders of magnitude lower than any of the measured-sediment data over the entire discharge range.

The regression equation calculated for the measured-sediment data compares most closely with estimates made by Laursen's (1958) method. At low stream discharges, measured-sediment discharges are higher than those estimated with the Laursen method. The difference may be caused by the inclusion of silt and clay sized sediment in sediment samples. That very fine fraction is not accounted for in bed material transport calculations. At discharges higher than about 13 ft^3/s the Laursen method estimates greater sediment discharge than does the regression line. The difference between the two estimates (15 percent at a discharge of 15 ft^3/s and 66 percent at a discharge of 40 ft^3/s) is of the order of magnitude that can be expected for the difference between bed material discharge and measured-sediment discharge. Therefore, at discharges between 13 and 40 ft^3/s, the Laursen equation probably gives better estimates of the amount of sediment in transport than does the regression line.

A transport curve which is a composite of the lower section of the regression line and the upper portion of the transport curve calculated by Laursen's indirect method is given in figure 7. That curve can be used to estimate sediment discharge over the range of stream discharge expected in the ditch. Neither portion of the composite curve gives total sediment discharge. The lower section does not include the unmeasured-sediment discharge, and the upper does not include the silt and clay sized sediment that is considered not to be bed material. Because the highest discharge measured during the study period was about 5 ft^3/s, no verification of the upper portion of the transport curve was possible.

Flood peak discharges for six recurrence intervals, estimated from equations by Allen and Bejcek (1979), were used to estimate sediment discharge at gage 1 (table 1). Because all of the estimated discharges are above 13 ft^3/s, the transport curve obtained by Laursen's method was used to estimate sediment discharge.

Table 1.–Sediment discharges at gage 1 for flood peak stream discharges

Flood recurrence interval (year)	Estimated peak discharge (ft^3/s)	Sediment discharge (lb/h)
2	16	250
5	23	520
10	27	710
25	33	1,100
50	36	1,300
100	40	1,600

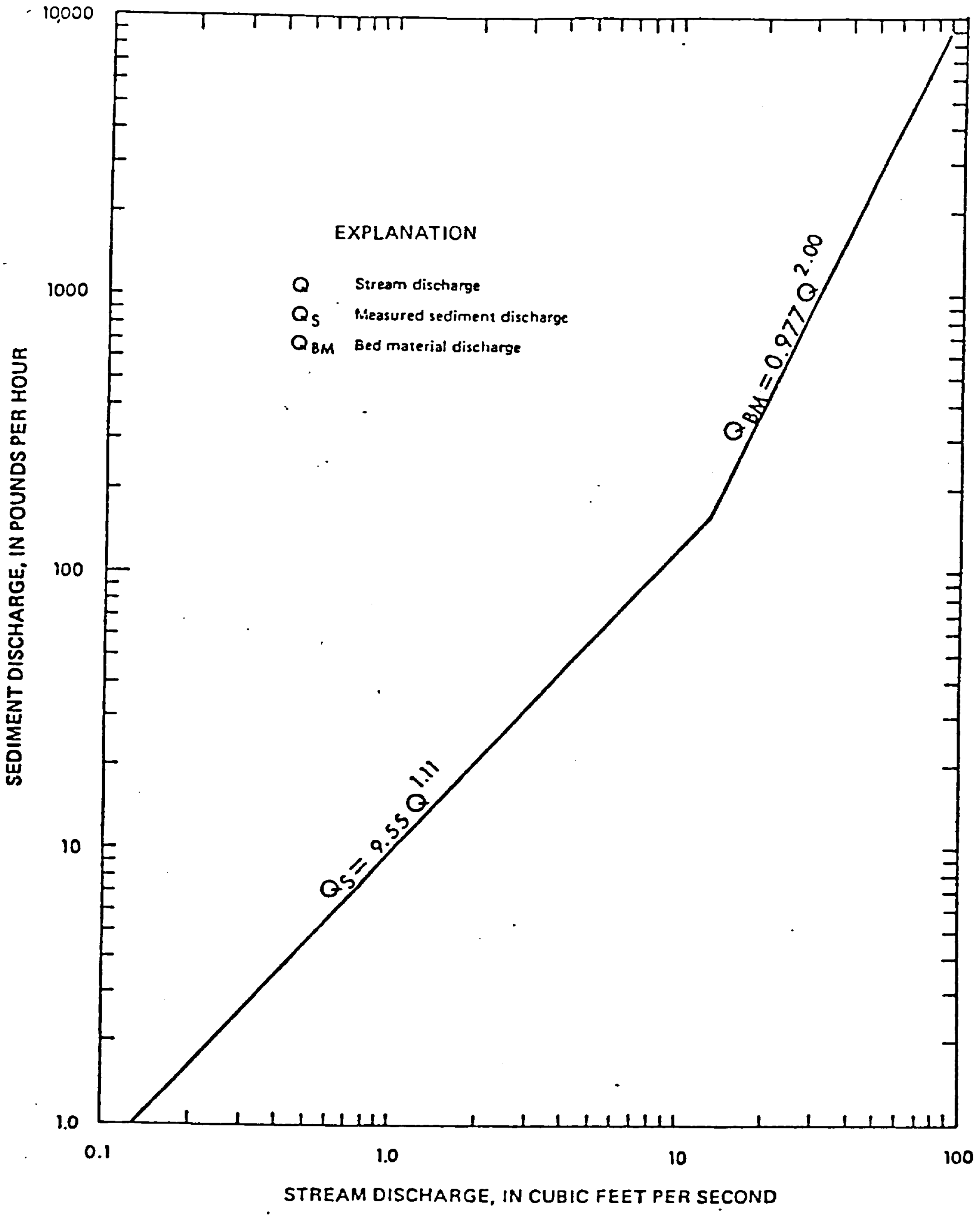

Figure 7.—Composite sediment transport curve.

Sediment Load Estimates

The regression line calculated from the measured sediment discharge was used to estimate diment load for each day for which hourly stream discharge values were determined (table 2).

SUMMARY AND CONCLUSIONS

Stage-discharge and sediment-discharge to stream-discharge relations were developed by idirect methods and direct measurements and used to estimate daily sediment loads in North itch for the period March 13 to September 30, 1979. A barrier sand bar at the mouth of the ditch ffected the stage-discharge relation. The maximum measured discharge and the mean daily discharge ere 5.3 and 1.8 ft³/s, respectively. The transport curve derived from measured sediment concenrations, used with hourly discharge values for days of known flow, gives an estimate of 5,100 lb for ediment transported through the ditch during the study period. Of that total, almost one-third was ransported in the month of March. The maximum daily load was about 450 lb and the average a [illegible] oad for the study period was about 25 lb. Sediment discharges corresponding to flood peak tream discharges were estimated using a bed material transport curve developed by indirect methods. ed material discharge is estimated to be 250 lb/h at the peak discharge of the 2-year flood and ,600 lb/h at the peak discharge of the 100-year flood.

Stream discharge and sediment loads estimated from measured sediment data are considered o be low. The amount of sediment not included in the estimate may be significant because 14 perent of the total rainfall occurred on days for which discharge could not be computed. During lowlow periods unmeasured sediment discharge is probably insignificant and the measured-sediment ransport curve (the regression line) probably approximates total sediment discharge. During higher low periods, the difference between estimates made from the measured-sediment data and the total ediment discharge will be greater because unmeasured discharge will be significant. At discharges igher than about 13 ft³/s, the bed material transport curve calculated by Laursen's indirect method an be used to obtain estimates of sediment discharge. Because that method does not account for h [illegible] lt and clay sized fraction, it will also yield a value which is less than the actual total sediment lischarge.

Table 2.—Daily sediment load, mean daily discharge for selected days during the study period, and hourly peak discharge

Date	Sediment load (lb)	Discharge (ft^3/s)	
		Mean daily	Peak
Mar. 25	56	0.3	—
Mar. 26	370	1.5	4.0
Mar. 27	220	0.9	—
Mar. 28	260	1.0	—
Mar. 29	360	1.4	4.1
Mar. 30	340	1.4	4.3
Mar. 31	12	0.1	—
Apr. 12	66	0.3	1.1
Apr. 13	27	0.1	—
May 11	230	1.0	2.3
June 6	13	0.1	—
June 7	42	0.2	1.1
June 8	21	0.1	—
June 14	22	0.1	—
June 15	84	0.4	1.6
June 29	450	1.8	3.7
June 30	290	1.2	—
July 4	99	0.4	2.1
July 12	51	0.2	—
July 13	140	0.6	2.1
Aug. 3	72	0.3	—
Aug. 4	170	0.7	—
Aug. 5	250	1.0	4.5
Aug. 6	97	0.4	—
Aug. 7	96	0.4	—
Aug. 11	140	0.6	1.9
Aug. 23	280	1.1	5.2
Aug. 24	30	0.2	—
Aug. 25	15	0.1	—
Aug. 29	210	0.9	3.4
Aug. 30	24	0.1	—
Sept. 1	71	0.3	—
Sept. 4	180	0.7	4.7
Sept. 5	130	0.5	—
Sept. 13	28	0.1	—
Sept. 14	100	0.4	5.3
Sept. 15	45	0.2	—
Sept. 16	20	0.1	—
Sept. 17	34	0.2	—
Total	5,100		

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Protocol for Obtaining Rainfall Event Water Samples
from
North Ditch at OMC Waukegan, Illinois

Upon notification that a rainfall is imminent in Waukegan, the EPA team leader who is on duty (call) will alert the following:

a. The OMC contact (see attached Record of Communication dated 3/7/79).

b. The USGS contacts -

Al Noehre
through FTS operator at 353-4401
815/753-1162 (work)
815/758-5054 (home)

or

Tom Fisk
through FTS operator at 353-4401
815/753-1162 (work)
815/758-3304 (home)

DEPOSITION
EXHIBIT
GRAF 4-1D
OMC
7·16·81

c. Other member(s) of the EPA team.

The team will proceed to Waukegan and OMC and begin sampling from the catwalk at the U.S. Geological Survey (USGS) flow gaging station on North Ditch. Sampling will be performed at a second sampling station just east of Pershing Road on North Ditch. If possible, samples will be obtained from a third sampling point located on North Ditch as it crosses the beach toward Lake Michigan.

Samples obtained at the catwalk sampling point will be taken, using an ISCO automatic sampler. The intake of the sampler will consist of a stainless steel strainer connected to teflon tubing leading to the intake of the pump ı the sampler. The stainless steel intake should be suspended at midstream and mid-depth, on the upstream side of the catwalk, in such a way that it does not contact the bottom of the stream. The discharge of the sampler pump, consisting of teflon tubing, will be used to fill three 1 liter glass bottles in rapid succession every half hour. The half hour sampling frequency may vary depending on the anticipated rainfall event duration. Ten samples per station spaced over the whole rainfall event is the goal.

To ensure the integrity of the samples taken by the ISCO sampler method, the sampler should be run for at least one minute discharging to the downstream side of the catwalk, prior to filling the bottles each time. Secondly, a duplicate of each of the three bottles should be taken on the fifth sampling of each event (i.e.: two bottles for PCB's, followed by two bottles for total suspended solids, followed by two bottles for suspended PCB's) at each station. Finally, an empty bottle blank should be sent to the CRL with the samples taken from all three stations during any one event.

Samples collected from North Ditch at the point nearest Pershing Road and at the beach location should be dipped with a stainless steel container of such a size and in such a way that bottom sediments are not resuspended in the sample. The sampling container should be agitated thoroughly and constantly as the sample is poured immediately into three 1 liter bottles. This sampling should be repeated every half hour. The sampling frequency may vary with the anticipated duration of the rainfall event, as mentioned above. Again, a duplicate set of samples should be taken during the fifth sampling of each event.

Sampling should continue until after the rainfall has ceased and until pre-rain stream stage is reached. Temperature and time should be recorded on the field sheets at each station as each set of samples is collected.

With the collection of the first set of samples at each station, a field sheet will be started. This sheet can be used through the fifth set of samples including the set of duplicate samples. Both the samples and the field sheet sheet should be annoted to show that one general chemistry sample (white label/01 preservative code) and two PCB samples (pink label/03 preservative code) were collected. One of the two PCB samples should have the word "Sediment" added to the label under "PCB's" in the middle of the right side of the label. Additional field sheets can be added as necessary and all pertinent descriptive information should be completed on each sheet. The last sheet for the sampling station at the U.S.G.S. flow gaging station should include the description of an empty bottle blank for each event.

Chain of custody sheets should be initiated at the same time that the first field sheets are prepared. All sample bottles, whether filled or empty, should be stored in a locked vehicle until they are delivered to the CRL. As bottles are filled, they should be recapped and a piece of custody tape placed over the cap-bottle connection such that the cap cannot be removed from the bottle without breaking the seal. As usual, all field activities will be performed according to strict custody procedures. Any unusual circumstances or changes in routine procedures should be noted in detail on the field sheets or on attachments to the field sheets.

It may also be necessary to take suspended sediment samples from the catwalk at the USGS gaging station for analysis by the USGS. These samples should be taken using the suspended sediment sampler provided by the USGS. The first set of samples should be taken when there is enough flow (depth) to sample at least three points on the cross-section. This depth would be about 0.3 foot on the staff gage. The relative turbidity of the stream water should be observed and noted on the field sheet. The greater the turbidity the more necessary it is to begin sampling.

When sampling is to start, the resuspended sampler should be taken to the deepest, fastest moving point on the ditch cross-section. The sampler should be lowered and raised, experimentally, at a constant rate such that the bottle fills to 2/3 full. When the rate has been determined, a clean bottle should be placed in the sampler. The sampler should be lowered and raised at the same rate at each of the 3, 4, 5 or 6 vertical locations marked on the catwalk, wherever there is enough depth. A separate bottle may be used at each location. Caution: the sampler should be lowered such that it just contacts the bottom and should not be pushed or angled. As the sample bottles are removed from the sampler, they should be capped and the appropriate information should be recorded on the cap. At a minimum, the following should be recorded: date, time, staff gage level, temperature, depth on the sampler staff, sampling site number from the catwalk and type of sample TSS (total suspended solids) or SIZE. The SIZE samples should be taken only every other time that the TSS samples are taken. Then, a custody seal should be placed across the top of the cap and secured to the bottle.

The sampling should be repated at 6 inch intervals (staff gage readings) as the stream rises to peak flow and then falls again to the pre-sampling level. Also, each time samples are taken at the catwalk, a staff gage reading should be taken at the downstream end of the culvert which passes under the parking lot access road (the first staff gage upstream of the catwalk).

If problems or questions arise regarding any of the activities listed above, the team leader should immediately call:

Mr. Roscoe Libby at 312/353-9772 (FTS) - work
or 312/323-3615 (Com) - home

or

Mr. John Helvig at 612/725-3272 (FTS) - work
or 612/786-3516 (Com) - home

OFFICE	FILE NO.
SUBJECT OMC- NORTH DITCH (FOOT BRIDGE) SAMPLING BM-1	What is this!
COMPUTATION (see USGS report for sample locations map)	

COMPUTED BY	CHECKED BY	DATE	PAGE 1 OF 2 PAGES

DEPOSITION EXHIBIT
GRAF 51D
OMC
2-16-81

(1) Sample #	(2) Date	(3) Time	(4) Temp	(5) (Gage height+) Depth	(6) S.S. mg/l	(7) Chloride mg/l	(8) * ug/l ** mg/kg Aroclor 1248/1242	(9) Lead ug/l	(10)
79CL53									
S01	5-11-79	1207	19.0	1.13					
S02	5-11-79	1207	19.0	1.13					
S03	5-11-79	1207	19.0	1.13					
S04	5-11-79	1207	19.0	1.13					
S05	5 11-79	1207	A.0	1.13					
S06	5-11-79	1207	19.0	1.13					
79CL54									
S01	5-17-79	1315	13.6	1.19			4.02		
S02	5-17-79	1315	13.6	1.19			4.14		
R03	5-17-79	1315	~~[illegible]~~	~~[illegible]~~			< 0.2		
79CL55									
S01	5-23-79	1105	17.5	0.3			4.00		
S02	5-23-79	1105	17.5	0.3			3.68		
R03	5-23-79	1110	~~[illegible]~~	—			< 0.1		
79CL56									
S01	5-30-79	1411	19.	2.07	6	59	4.19		
S02	5-30-79	1411	19	2.07			3.82		
R03	5-30-79	1411	—	—			<0.1		
79CL57									
S01	6-6-79	1030	19.	2.24	7	54	3.60		
S02	6-6-79	1030	19.	2.24			3.50		
R03	6-6-79	1030	—	—			<0.1		
79CL58									
S01	6-13-79	1345	22.0	1.	K5	51	3.52 *	K 2	
S02	6-13-79	1345	22.0	1.			229 **		
R03	6-13-79	1345	—	—			<0.19 *	K 2	
79CL59									
S01	6-20-79	1355	23.	2.72	K5	33	4.53 *	K 2	
S02	6-20-79	1355	23.	2.72			214 **	[illegible]	
R03	6-20-79	1355	—	—			<0.10 *	K 2	
79CL60									
S01	6-27-79	1015	20.	2.56	K5	34	7.93 *	K 2	
S02	6-27-79	1015	20	2.56			505 **		
R03	6-27-79	1015	—	—			<0.12 *	K 2	
79CL61									
S01					K5	65	5.98 *	K 2	
S02							117 **		
R03							<0.16 *	K 2	

OFFICE

SUBJECT OMC NORTH DITCH (FOOTBRIDGE) SAMPLING

COMPUTATION

COMPUTED BY | CHECKED BY | DATE | PAGE 2 OF 2 PAGES

(1) Sample #	(2) Date	(3) Time	(4) Temp	(5) Gage Height	(6) Suspended Solids mg/l	(7) Chloride mg/l	(8) * µg/l ** mg/kg Arcclor 1248	(9) Lead µg/l	(10)
79CL62									
S01	7-11-79	1505	25	1.74	K5	48	6.2 *		
S02	7-11-79	1505	25	1.74			210 **		
R03	7-11-79	1505	—	—			K0.1 *		
79CL63									
S01	7-20-79	1134	19.	1.32	6	38	7.4 *		
S02	7-20-79	1134	19.	1.32			116.0 **		
R03	7-20-79	1134	—	—			K0.1 *		
7 L64									
S01	7-25-79	0940	24.	1.64	6	27	5.1 *		
S02	7-25-79	0940	24.	1.64			58 **		
R03	7-25-79	0940	—	—			K0.1 *		
79CL65									
	8-1-79	1049	20	1.76	14	49	5.33 *		
	8-1-79	1049	20	1.76			117 **		
	8-1-79	1049	—	—			K0.1 *		
79CL88									
S01	8-18-79	1407	25	1.46			5.3 *	4.9	
S02	8-8-79	1407	25	1.46			146 **		
R03	8-8-79	1407	—	—			K0.05 *	K 2	
79CL89									
S01	8-16-79	1030	17	2.00	K5	48	3.8 *	6.3	
S02	8-16-79	1030	17	2.00			312 **		
R03	8-16-79	1030	—	—			K0.08 *	K 2.0	
79CL90									
S01	8-23-79	1017	21	1.40	10	39	5.3 *	8.0	
S02	8-23-79	1017	21	1.40			123.7 **		
* R03	8-23-79	1017	—	—			K0.06 *	K 2	
79CL92									
S01	9-5-79	1310	23.5	1.49	K5	64	6.7 *	K 2	
S02	9-5-79	1310	23.5	1.49			249 **		
R03	9-5-79	1310	—	—			K0.1 *	K 2	
79CL98									
S01	9-11-79	1125	21	2.82	K5	38	3.4 *	K 2	
S02	9-11-79	1125	21	2.82			197.5 **	[illegible]	
R03	9-11-79	1125	—	—			0.4 *	K 2	
79CL99									
S01	9-20-79	1225	17	2.16	K5	39	4.1 *	K 2	
S02	9-20-79	1225	17	2.16			248.3 **		
R03	9-20-79	1225	—	—			K0.1 *	K 2	

OFFICE

FILE NO.

SUBJECT OMC - NORTH DITCH (FOOTBRIDGE) SAMPLING

COMPUTATION

COMPUTED BY

CHECKED BY

DATE

PAGE OF PAGES

(1) SAMPLE #	(2) DATE	(3) TIME	(4) TEMP	(5) GAGE HEIGHT	(6) SUSPENDED SOLIDS mg/l	(7) CHLORIDE mg/l	(8) * mg/l ** mg/Kg Aroclor 1248	(9) Lead mg/l	(10)
79CR01									
S01	9-25-79	1145	18	1.08	K 5	44	7.6 *	K 2	
S02	9-25-79	1145	18	1.08			205 **		
R03	9-25-79	1145	—	—			K=.1 *	K 2	
80CL01									
S01	10-2-79	1530	15	2.50	7	18	7.45 *	11	
S02	10-2-79	1530	15	2.50			108 **		
R03	10-2-79	1530	—	—			K=.1 *	K2	
80CL02									
S01	10-11-79	1022	12	1.20	6	50	8.2 *	K 2	
S02	10-11-79	1022	12	1.20			142 **		
R03	10-11-79	1022	—	—			K=.15 *	K 2	
80CL03									
S01	10-18-79				K5	28	6.94 *	14	
S02	10-18-79						153 **		
R03	10-18-79						K=.1*	K 2	
0CL22									
S01	10-24-79	1000	8	2.14	K 5	20	5.25 *	2.7	
S02	10-24-79	1000	8	2.14			146 **		
R03	10-24-79	1000	—	—			K=.1 *	K 2	
0CL23									
S01	11-1-79	935	9	2.54	8	24	6.3 *	5.1	
2	11-1-79	935	9	2.54			143 **		
R03	11-1-79	935	—	—			K=.1 *	K 2	
0CL24									
S01	11-8-79	1005	6	2.54	K5	16		259	
S02	11-8-79	1005	6	2.54					
R03	11-8-79	1005	—	—				K 2	
0CL25									
S01	11-15-79				5	38		K 2	
S02	11-15-79								
B03	11-15-79							K 2	
79CL91									
S01	9-30-79				13	83	5.7 *	< 2	
S02	9-30-79						48.7 **		
S03	9-30-79						<0.1 *	< 2	

FILE NO.

SUBJECT OMC - NORTH DITCH - (FOOTBRIDGE) WAUKEGAN

COMPUTATION

COMPUTED BY

CHECKED BY

DATE

PAGE OF PAGES

(1) SAMPLE #	(2) DATE	(3) TIME	(4) TEMP	(5) GAGE HEIGHT	(6) mg/l SUSPENDED SOLIDS	(7) CHLORIDE mg/l	(8) µg/l * mg/kg ** Aroklor 1248	(9) LEAD µg/l	(10)
BNCL26									
S01	11-21-79							9.3	
S02	11-21-79								
R03	11-21-79							K2	
BNCL27									
S01	11-29-79	945	0	1.00					
S02	11-29-79	945	0	1.00					
R03	11-29-79	945	—	—					
SCCL31									
S01	12-27-79						12.4 *		
S02	12-27-79						48.1 **		
R03	12-27-79						K .1		
SCCL32									
S01	1-3-80						15.6 *		
02	1-3-80						104.4 *		
R03	1-3-80						K .1		
8 .33									
S01	1-9-80						16.3 *		
S02	1-9-80						228.0 **		
R03	1-9-80						K .1		
SCCL34									
S01	1-15-80						17.9 *	2.0	
S02	1-15-80						304.8 **		
R03	1-15-80						K .1	K2	
SCCL35								—	
S01	1-25-80				10	51	8.0	<2	
S02	1-25-80						66.0		
R03	1-25-80						K .3	<2	

SUBJECT NORTH DITCH AT OMC [illegible] P.A. 9.

COMPUTATION 79CL4D- (See USGS report for sample locations map)

COMPUTED BY G.W.R. | CHECKED BY | DATE 79 04 11 | PAGE OF PAGES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				WATER SAMPLES				SEDIMENT	
SAMPLE	TIME	(°C) TEMP	DEPTH	AROCLOR 1242 PCB	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	AROCLOR 1242 mg/kg	SC [illegible]
S01	2015	5	0.45	<0.10	0.72	<0.10	<0.10		[illegible]
S02	2015	5	0.45					5.5	
S03	[illegible]	3	[illegible]	<0.10	0.28	<0.10	<0.10		121
S04	[illegible]	3	1.22					0.8	
S05	[illegible]	2.5	1.25	<0.10	0.22	<0.10	<0.10		141
S06	[illegible]	2.6	1.25					2.3	
S07	120	3	1.08	<0.10	0.19	<0.10	<0.10		122
S08	120	3	1.08					2.5	
S09	220	2	1.00	<0.10	0.10	<0.10	<0.10		85
S10	220	2	1.00					<3.5	
S11	425	4	0.9	<0.10	0.11	<0.10	<0.10		59
S12	425	4	0.9					<2.0	
S13	520	4	0.75	<0.10	0.10	<0.10	<0.10		52
S14	520	4	0.75					<2.0	
S15	625	4	0.64	<0.10	<0.10	<0.10	<0.10		29
S16	625	4	0.64					<7.0	
S17	730	4	0.59	<0.10	<0.10	<0.10	<0.10		32
S18	730	4	0.59					<3.5	
S19	1018	8	0.53	<0.10	<0.10	<0.10	<0.10		19
S20	1018	8	0.53					<55	
R21				<0.10	<0.05	<0.10	<0.10		
B09				<0.10	0.15	<0.10	<0.10		
D19				<0.10	<0.10	<0.10	<0.10		31
A20								<5.5	

CDU

SUBJECT: NORTH DITCH AT OMC WAUKEGAN, ILL. BM 1.

COMPUTATION 79C1 39 –

COMPUTED BY [illegible] | CHECKED BY | DATE 79 04 11 412 | PAGE OF PAGES

(1)	(2)	(3)	(4)	(5) WATER SAMPLES	(6)	(7)	(8)	(9) [illegible]	(10)
SAMPLE #	TIME	TEMP	FLOW	AROCLOR 1242	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	[illegible]	SS [illegible]
S01	2030	4	1.72	<1.0	3.02	<0.1	<0.1	[illegible]	[illegible]
S02	2030	4	1.72					201	
S03	2130	4	1.79	<1.0	165	<0.1	<0.1		43
S04	2130	4	1.79					236	
S05	2240	4	1.58	<1.0	49.7	<0.1	<0.1		[illegible]
S06	2240	4	1.58					115	
S07	0045	3	1.7	<1.0	35.0	<0.1	<0.1		57
S08	0045	3	1.7					255	
S09	0200	3	1.6	<1.0	21.2	<0.1	<0.1		[illegible]
S10	0200	3	1.6					48.5	
S11	0400	4	1.42	<1.0	11.7	<0.1	<0.1		71
S12	0400	4	1.42					130	
S13	0500	3	1.4	<1.0	[illegible]	<0.1	<0.1		77
S14	0500	3	1.4					95	
S15	0600	4	1.5-1.7	<1.0	20.0	<0.1	<0.1		51
S16	0600	4	1.5-1.7					325	
S17	0715	4.5	1.45	<1.0	6.60	<0.1	<0.1		
S18	0715	4.5	1.45						
S19	1020	7	0.99			<0.1	<0.1		
S20	1020	7	0.99						
R21				<0.1	<0.1	<0.1	<0.1		
D03				<1.0	21.6	<0.1	<0.1		
D19						<0.1	<0.1		

FILE NO.

OFFICE CDO

LAB [illegible]

SUBJECT NORTH DITCH AT OMC WAUKEGAN, IL

Pt 7 Where North Ditch Comes out east of Petroleum [illegible]

COMPUTATION 79C138-

CHECKED BY

DATE 790330

PROJ

COMPUTED BY STREAM-INFLUENT

(1) Sample#	(2) TIME	(3) (°C) TEMP	(4) DEPTH	(5) WATER [illegible] Aroclor 1242 PCB	(6) Aroclor 1248 PCB	(7) Aroclor 1254 PCB	(8) Aroclor [illegible]	(9) [illegible] Aroclor 1248	(10) SS mg/l
S01	1430		0.39	<0.1	0.3	<0.1	<0.1	20	10
S02	1430		0.39			[illegible]	<0.1		20
S03	1530	12.2	0.60	<0.1	0.5			25	
S04	1530	12.2	0.60			<0.1	<0.1		30
S05	1615	11.7	0.84	<0.1	0.5			<10	
S06	1615	11.7	0.54			<0.1	<0.1		45
S07	1650	11.4	0.85	<0.1	0.2			13	
S08	1650	11.4	0.85			<0.1	<0.1		55
S09	1730	11.4	0.83	<0.1	0.5			10	
S10	1730	114	0.93			<0.1	<0.1		70
S11	1835	110	0.74	<0.1	0.3			10	
S12	1835	11.0	0.73			<0.1	<0.1		70
S13	1945	10.2	0.72	<0.1	0.4			<1	
S14	1945	10.2	0.72			<0.1	<0.1		50
S15	2055	9.2	0.64	<0.1				<4	
S16	2055	9.2	0.64			<0.1	<0.1		[illegible]
S17	2205	8.5	0.56	<0.1	0.4			4.8	
S18	2205	8.5	0.55			<0.1	<0.1		[illegible]
S19	2255	7.6	0.56	<0.1	0.3			3.2	
S20	2255	7.6	0.56			<0.1	<0.1		<5
R21				<0.1	<0.1				

CDO

SUBJECT NORTH DITCH AT OMC WAUKEGAN, Il.

COMPUTATION 79 CL 37 - BM-1 at Footbridge

COMPUTED BY [illegible] Gill | CHECKED BY | DATE 79 03 20 | PAGE OF PAGES

(1) Smpl #	(2) TIME	(3) °C Temp	(4) Depth	(5) Aroclor 1242 PCB	(6) Aroclor 1248 PCB	(7) Aroclor 1254 PCB	(8) Aroclor 1260 PCB	(9) Sediment Aroclor 12?? PCB	(10) SS mg/l
S01	1410		0.71	<1	6.5	<0.1	<0.1		11
S02	1410		0.71					4100	
S03	1500	13	0.80	<1	12.2	<0.1	<0.1		34
S04	1500	13	0.80					160	
S05	1600	13.2	0.89	<1	70.0	<0.1	<0.1		175
S06	1600	13.2	0.89					77	
S07	1630	12.0	0.96	<1	30.0	<0.1	<0.1		134
S08	1630	12.0	0.96					290	
S09	1715	12.0	0.97	<1	94	<0.1	<0.1		84
S10	1715	12.0	0.97					915	
S11	1815	11.8	0.92	<1	40.2	<0.1	<0.1		34
S12	1815	11.8	0.92					340	
S13	1930	11.0	0.70	<1	10.8	<0.1	<0.1		20
S14	1930	11.0	0.70					130	
S15	2030	10.4	0.65	<1	9.2	<0.1	<0.1		24
S16	2030	10.4	0.65					1750	
S17	2130	9.6	0.60	<1	13.3	<0.1	<0.1		28
S18	2130	9.6	0.60					275	
S19	2225	9.5	0.56	<1	11.2	<0.1	<0.1		24
S20	2225	9.5	0.56					185	
R01				<0.1	<0.1	<0.1	<0.1		
D09				<1	100.6	<0.1	<0.1		101
D19				<1	8.8			240	26
D10								225	
D20									

SUBJECT OMC NORT. DITCH (FOOTBRIDGE) SAMPLING

COMPUTATION

COMPUTED BY | CHECKED BY | DATE | PAGE 2 OF 2 PAGES

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(1) Sample #	(2) Date	(3) Time	(4) Temp	(5) Gage Height	(6) Suspended Solids mg/l	(7) Chloride mg/l	(8) * μg/L ** mg/kg Aroclor 1248	(9) Lead μg/L	(10)
79CL62									
S01	7-11-79	1505	25	1.74	K5	48	6.2 *	10	
S02	7-11-79	1505	25	1.74			210 **		
R03	7-11-79	1505	—	—			<0.1 *	K2	
79CL63									
S01	7-20-79	1134	19.	1.32	6	38	7.4 *	K2	
S02	7-20-79	1134	19.	1.32			116.0 **		
R03	7-20-79	1124	—	—			<0.1 *	K2	
79CL64									
S01	7-25-79	0940	24.	1.64	6	27	5.1 *	K2	
S02	7-25-79	0940	24.	1.64			58 **		
R03	7-25-79	0940	—	—			<0.1 *	K2	
79CL65									
	8-1-79	1049	20	1.76	14	49		4.3	
	8-1-79	1049	20	1.76					
	8-1-79	1049	—	—				K2	
79CL88									
S01	8-18-79	1407	25	1.46				4.9	
S02	8-8-79	1407	25	1.46					
R03	8-8-79	1407	—	—				<2	
79CL89									
S01	8-16-79	1030	17	2.00	K5	48			
S02	8-16-79	1030	17	2.00					
R03	8-16-79	1030	—	—					
79CL90									
S01	8-23-79	1017	21	1.40	10	39		8.0	
S02	8-23-79	1017	21	1.40					
R03	8-23-79	1017	—	—				<2	
79CL92									
S01	9-5-79	1310	23.5	1.49					
S02	9-5-79	1310	23.5	1.49					
R03	9-5-79	1310	—	—					
79CL98									
S01	9-11-79	1125	21	2.82				<2	
S02	9-11-79	1125	21	2.82				[illegible]	
R03	9-11-79	1125	—	—				<2	
79CL99									
S01	9-20-79	1225	17	2.16					
S02	9-20-79	1225	17	2.16					
R03	9-20-79	1225	—	—					

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DEPOSITION
EXHIBIT
GRAF 6-LD
OMC
2.16.81

OFFICE CDO

SUBJECT TO REVISION

SUBJECT NORTH DITCH AT OMC WAUKEGAN, IL.

COMPUTATION 79 CL 37 - BM-2 at Footbridge

~~COMPUTED BY~~ EFFLUENT Grid

CHECKED BY

DATE 79 03 30

PAGE OF PAGES

(1)	(2)	(3)	(4)	(5) WATER - [illegible]	(6)	(7)	(8)	Suspended Sediment	(10)
Sample	TIME	°C Temp	Depth	Aroclor 1242 PCB	Aroclor 1248 PCB	Aroclor 1254 PCB	Aroclor 1260 PCB	Aroclor 12[illegible] PCB mg/kg	SS (105°C) mg/l
S01	1410		0.71	<1	6.5	<0.1	<0.1		11
S02	1410		0.71					400	
S03	1500	12	0.80	<1	12.2	<0.1	<0.1		34
S04	1500	13	0.80					160	
S05	1600	13.2	0.89	<1	70.0	<0.1	<0.1		175
S06	1600	13.3	0.89					77	
S07	1630	12.0	0.96	<1	30.0	<0.1	<0.1		134
S08	1630	12.0	0.96					290	
S09	1715	12.0	0.97	<1	94	<0.1	<0.1		84
S10	1715	12.0	0.97					915	
S11	1815	11.8	0.92	<1	40.2	<0.1	<0.1		34
S12	1815	11.8	0.92					390	
S13	1930	11.0	0.70	<1	10.8	<0.1	<0.1		20
S14	1930	11.0	0.70					130	
S15	2025	10.4	0.65	<1	9.2	<0.1	<0.1		24
S16	2025	10.4	0.65					1750	
S17	2130	9.6	0.60	<1	13.3	<0.1	<0.1		28
S18	2130	9.6	0.60					225	
S19	2225	9.5	0.56	<1	11.8	<0.1	<0.1		29
S20	2225	9.5	0.56					185	
R21				<0.1	<0.1	<0.1	<0.1		
D09				<1	100.6	<0.1	<0.1		101
D19				<1	8.8			290	26
D10								205	
D20									

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FILE NO.

OFFICE CDO

SUBJECT NORTH DITCH AT OMC WAUKEGAN - IL. LAKE MICHIGAN

BM 7 where North Ditch Comes out east of Pershing Road

COMPUTATION 79C138 -

DATE 790330

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PAGE PAGES

~~COMPUTED BY~~ STREAM-INFLUENT

(1)	(2)	(3)	(4)	(5) WATER SAMPLES	(6)	(7)	(8)	(9) SEDIMENT suspended	(10)
Sample#	TIME	(°C) TEMP	DEPTH	Aroclor 1242 PCB	Aroclor 1242 PCE	Aroclor 1254	Aroclor [illegible]	Aroclor 1242	SS (1054) mg/l
									10
S01	1430		0.39	<0.1	0.3	<0.1	<0.1	20	
S02	1430		0.39						26
S03	1530	12.2	0.60	<0.1	0.5	<0.1	<0.1	23	
S04	1530	12.2	0.60						30
S05	1615	11.7	0.84	<0.1	0.5	<0.1	<0.1	<10	
S06	1615	11.7	0.84						48
S07	1650	11.4	0.85	<0.1	0.2	<0.1	<0.1	13	
S08	1650	11.4	0.85						58
S09	1730	11.4	0.82	<0.1	0.4	<0.1	<0.1	10	
S10	1730	114	0.82						70
S11	1835	110	0.76	<0.1	0.2	<0.1	<0.1	10	
S12	1835	11.0	0.76						70
S13	1945	10.2	0.72	<0.1	0.4	<0.1	<0.1	<1	
S14	1945	10.2	0.72						59
S15	2055	9.2	0.64	<0.1		<0.1	<0.1	<4	
S16	2055	9.2	0.64						78
S17	2205	8.5	0.55	<0.1	0.6	<0.1	<0.1	4.8	
S18	2205	8.5	0.58						81
S19	2255	7.6	0.56	<0.1	0.3	<0.1	<0.1	2.2	
S20	2255	7.6	0.56						<5
R21				<0.1	<0.1	<0.1	<0.1		

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SUBJECT: NORTH DITCH AT OMC [illegible] [illegible]

COMPUTATION: 79CL40- Upstream Location

~~COMPUTED BY~~ GARE

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DATE: 79 04 11

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				WATER SAMPLES				SEDIMENT	
SAMPLE #	TIME	°C TEMP	DEPTH	AROCLOR 1242 PCB	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	AROCLOR 1248 mg/kg	SS (105°C) mg/l
S01	2045	[illegible]	[illegible]	<0.10	0.72	<0,10	<0,10		[illegible]
S02	2045	5	[illegible]					5.5	
S03	[illegible]	[illegible]	[illegible]	<0.10	0.28	<0.10	<0.10		121
S04	[illegible]	[illegible]	[illegible]					0.6	
S05	[illegible]	3.5	1.35	<0.10	0.23	<0.10	<0.10		141
S06	[illegible]	[illegible]	1.35					2.3	
S07	120	3	1.08	<0.10	0.19	<0.10	<0.10		122
S08	120	3	1.08					2.5	
S09	230	2	1.00	<0.10	0.10	<0.10	<0.10		85
S10	230	2	1.00					<3.5	
S11	425	4	0.9	<0.10	0.11	<0.10	<0.10		57
S12	425	4	0.9					<2.0	
S13	520	4	0.75	<0.10	0.10	<0,10	<0,10		50
S14	520	4	0.75					<2.0	
S15	625	4	0.64	<0.10	<0.10	<0.10	<0.10		29
S16	625	4	0.64					<7.0	
S17	730	4	0.59	<0.10	<0.10	<0.10	<0.10		20
S18	730	4	0.59					<3.5	
S19	1019	8	0.53	<0.10	<0.10	<0.10	<0.10		19
S20	1018	8	0.53					<55	
R21				<0.10	<0.05	<0.10	<0.10		
B09				<0.10	0.15	<0.10	<0.10		
D19				<0.10	<0.10	<0.10	<0.10		21
D20								<5.5	

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OFFICE	CDO
FILE NO.	
SUBJECT	NORTH DITCH AT OMC WAUKEGAN, IL. BM 1 (Foot Bridge)
COMPUTATION	79C1 39 –
~~COMPUTED BY~~	GPR
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DATE	79 04 11 & 12
PAGE	OF PAGES

1/11/79

1/12/79

(1)	(2)	(3)	(4)	(5) WATER SAMPLES	(6)	(7)	(8)	(9) SEDIMENT	(10) mg/l
SAMPLE #	TIME	TEMP	FLOW	AROCLOR 1242	AROCLOR 1248	AROCLOR 1254	AROCLOR 1260	AROCLOR 1248	SS (105°C)
S01	2030	4	1.72	<1.0	303	<0.1	<0.1	mg/kg	<5
S02	2030	4	1.72					201	
S03	2130	4	1.79	<1.0	16.5	<0.1	<0.1		43
S04	2130	4	1.79					236	
S05	2240	4	1.58	<1.0	49.7	<0.1	<0.1		59
S06	2240	4	1.58					115	
S07	0045	3	1.7	<1.0	35.0	<0.1	<0.1		57
S08	0045	3	1.7					255	
S09	0200	3	1.6	<1.0	21.2	<0.1	<0.1		40
S10	0200	3	1.6					48.5	
S11	0400	4	1.42	<1.0	11.7	<0.1	<0.1		71
S12	0400	4	1.42					130	
S13	0500	3	1.4	<1.0	9.45	<0.1	<0.1		77
S14	0500	3	1.4					95	
S15	0600	4	1.5-1.7	<1.0	20.0	<0.1	<0.1		51
S16	0600	4	1.5-1.7					325	
S17	0715	4.5	1.45	<1.0	6.64	<0.1	<0.1		
S18	0715	4.5	1.45						
S19	1030	7	0.99			<0.1	<0.1		
S20	1030	7	0.99						
R21				<0.1	<0.1	<0.1	<0.1		
D09				<1.0	21.6	<0.1	<0.1		
D19						<0.1	<0.1		

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[illegible] 8

United States Department of the Interior

GEOLOGICAL SURVEY

P.O. Box 1026
Champaign, IL 61820

November 21, 1978

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DEPOSITION EXHIBIT
GRAF 8-ID
2.16.81

Mr. Howard Zar
U.S. Environmental Protection Agency
Great Lakes National Program Office
230 S. Dearborn Street
Chicago, IL 60604

Dear Howard:

Attached is a supplement to our proposal of October 24, 1978, concerning transport of sediment in North Ditch, Waukegan. I have discussed this with Ed DiDomenico and he is expecting it.

Also enclosed is a manual on laboratory analysis of sediment. Ed has indicated your laboratory is receptive to doing the analyses. We will be pleased to work with you on proper sampling equipment and procedures.

We will be pleased to discuss this with Ed when he has reviewed it.

Sincerely yours,

L G Toler

L. G. Toler
Acting District Chief

LT:mg

cy to:
C. Ross
E. DiDomenico
K. Jacobs | Ginsberg | McPhee
G. Milburn
G. Veith

RECEIVED
NOV 22 1978
GREAT LAKES NATIONAL PROGRAM OFFICE
USEPA, REGION V, CHICAGO, IL 60604

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POTENTIAL FOR MOVEMENT OF BOTTOM SEDIMENTS IN THE NORTH DITCH, WAUKEGAN, ILLINOIS - SEDIMENT SAMPLING PROGRAM

FOR OFFICIAL USE ONLY WORKING DRAFT

APPROACH:

An initial estimate of the stability of bottom sediments of North Ditch can be made using a Shield's type curve (Miller, et al, 1977) giving flow conditions at the initial-motion condition for beds of cohesionless grains of uniform size. In order to use such a relationship, mean or median grain size and specific gravity of the bed material must be determined from samples taken at no-flow conditions, and a suitable value for water viscosity at the time of transport must be chosen. Application of this type of relationship will yield the lowest flow conditions at which transport of cohesionless grains can be expected and will make possible a prediction as to whether or not transport could take place at flows expected to occur in the Ditch.

WORKING DRAFT

Additional measurements of channel characteristics and sediment discharge will be used as a check on the estimate described above and will permit the determination of the amount of sediment transport expected for a given runoff event. Measurements of bed material grain-size distributions and discharge and size-distribution of suspended sediment will be used with measured water discharge, channel morphology, water depth, and water temperature data to plot rating curves for suspended sediment discharge and total sediment discharge. These curves can then be used to determine sediment discharge expected at a given water discharge. Used in conjunction with the discharge and velocity frequency relationship established for the Ditch from the hydrologic phase of the planned program, the rating curves will make possible the assessment of the potential for transport of contaminated sediments into Lake Michigan.

Bed material can be sampled under no-flow conditions with hand-operated samplers, and the sampling program will include 1) measurement of channel longitudinal profile by sounding along the thalweg, 2) measurement of cross-section profiles at each of the eight sections where staff gages are planned, 3) determination of the areas of the bed, if any, composed of non-erodible material (hard clay, gravel, etc.) or stabilizing material (aquatic plants, etc.), and 4) collection of bed material samples of the erodible parts of the bed. The number of bed material samples needed depends on the variability of the bed both areally and with depth, and the sampling density will be determined on site. Bed material size distributions, channel cross-section profiles, and water surface slope measured during flow events can be used in the Einstein bed-load function (Einstein, 1950) to estimate the sediment discharge for a given water discharge.

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Depth-integrated ETR suspended sediment samples will be taken at the downstream station at which water discharge is to be measured during runoff events. When possible, samples for determination of suspended sediment concentration will be taken at a 1 to 3 foot spacing across the channel and at frequent intervals during the rising and falling stages. At the time of sampling, depth at the sampling point, water temperature, and water discharge will also be measured. Suspended sediment concentrations and water discharge taken at a number of times during each runoff event for several events will provide the data needed to construct a sediment rating curve for the suspended sediment discharge of North Ditch. If sufficient material is collected at a given discharge, the grain-size distribution of suspended sediment will be determined. That size distribution can be used with bed material size distribution, water temperature, water velocity, and depth to calculate sediment discharge using the Modified Einstein Procedure (Colby and Hembree, 1955). The Modified Einstein Procedure provides a more reliable estimate of sediment discharge than does the Einstein bed load function, and so would yield a more reliable sediment rating curve for the total sediment discharge.

References:

Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge, Niobrara River near Cody, Nebraska: U.S. Geological Survey, Water-Supply Paper 1357, 187 p.

Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U.S. Department of Agriculture, Technical Bulletin 1026, 70 p.

Miller, M. C., McCave, I. N., and Komar, P. D., 1977, Threshold of sediment motion under unidirectional currents: Sedimentology 24, p. 507-528.

8

United States Department of the Interior

GEOLOGICAL SURVEY

P.O. Box 1026
Champaign, IL 61820
October 24, 1978

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PENGAD-Bayonne, N.J.
GRAF 7-1D
7.16.81 Jh

Mr. Howard Zar
U.S. Environmental Protection Agency
Great Lakes National Program Office
230 S. Dearborn Street
Chicago, IL 60604

Dear Howard:

The attached proposal for obtaining hydrologic information on North Ditch is forwarded as per our meeting on September 27, 1978. A lot will depend, of course, on climatic conditions, but with luck, we should get the data we need in a reasonable time.

1 We have not been specific about the collection of bottom samples for size and total carbon analyses and did not include funding specifically for this. I am not sure if your requirement for chain of custody of samples applies or if our routine procedures are adequate. We would be pleased to assist your samplers, if necessary, and perhaps could suggest an analyst.

If this meets with your approval, and all necessary permission can be obtained, we would like to begin collecting data yet this fall. Please call if there are any questions.

Sincerely yours,

Lawrence A. Martens
Lawrence A. Martens
District Chief

LT:mv
Enclosure

10/26/78 Copies to Cantabelor -E
Kizlauskas
✓ DiDomenico -E (1 original)
Jacobs -E
Rennon -E
Zar

RECEIVED
OCT 26 1978
GREAT LAKES NATIONAL PROGRAM OFFICE
USEPA, REGION V, CHICAGO, IL 60604

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WORKING DRAFT

WORKING DRAFT

PROJECT PROPOSAL

POTENTIAL FOR MOVEMENT OF BOTTOM SEDIMENTS IN NORTH DITCH

WAUKEGAN, ILLINOIS

PROBLEM: Polychlorinated Biphenols (PCB's) from industrial sources have accumulated in the bottom sediments of North Ditch, a small (D.A. = about 0.01 mi^2) tributary to Lake Michigan in Waukegan, Illinois. PCB's have a low solubility in water but are known to adhere to organics, clays and sand, in that order of preference. Resuspension of the bottom sediments and downstream movement are a potential threat to the waters of Lake Michigan. The U.S. Environmental Protection Agency has asked for assistance in providing the hydrologic information necessary to assess the potential for resuspension and movement of the bottom materials.

OBJECTIVE: To establish for North Ditch a discharge and velocity frequency relationship to provide information for assessing the potential for sediment transport.

APPROACH: Eight sites along North Ditch have been tentatively selected for data collection. At all eight sites, a theoretical stage - discharge relationship will be developed, samples of bottom materials will be collected for size analyses, and total organic carbon will be determined for the sediment samples. At four of the eight sites staff gages will be installed and samples will be collected by USEPA for water quality determinations.

At the downstream site, stage and rainfall recorders will be installed to obtain continuous stage hydrographs and rainfall. Discharge measurements will be made at the recording site to establish a stage-discharge relation and verify or adjust the theoretical rating.

Stream channel cross-sections obtained at all eight sites will be used to compute water surface-profiles by step-backwater or other indirect method. These profiles will be used to develop the theoretical stage-discharge relationship at each site. The stage-discharge relationships at all eight sights will be adjusted to the downstream site using measured discharges at the downstream site.

Rainfall and runoff data at downstream site will be used to calibrate a USGS rainfall-runoff model. The calibrated model, along with long-term rainfall data from the U.S. Weather Service, will be used to synthesize long-term annual-peak discharges. A magnitude-frequency relationship will be developed for the site using the synthesized discharges and the latest U.S. Water Resources Council Techniques. Discharges for the various frequencies will be compared to results obtained by regional estimating equations (Curtis, 1977, Allen, In review) for consistency of results.

Cross section properties obtained to determine water surface profiles will be used to compute velocity-discharge relationships at each of the eight sites.

F O I EXEMPT

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not until

Project Duration: Project would be completed during 1979 fiscal year.

Reports: Open file release of about 30 pages of data and interpretation would be requested.

Personnel: Al Noehre (GS-13) would be project chief. Field personnel are available for assistance in the De Kalb Subdistrict. James Culbertson and Herman Feltz have been consulted. Culbertson suggests C. F. Nordin be consultant on potential transport of bed material.

Take, whoa, now wait

COSTS:

Equipment - Purchase and install		$5,000
Operation, maintenance and surveying cross sections		6,000
Analytical including computer time and report writing		9,000
	Subtotal	20,000
	WOTSC	4,800
	District Costs	10,500
	TOTAL	$35,400

F O I EXEMPT

REFERENCES:

Allen, Howard E., Jr., and Bejcek, Richard M. (In review) Effects of urbanization on the magnitude and frequency of floods in northeastern Illinois

Curtis, G.W., (1977) Technique for estimating magnitude and frequency of floods in Illinois, U.S. Geol. Survey Water-Resources Inv. 77-117, 70p.

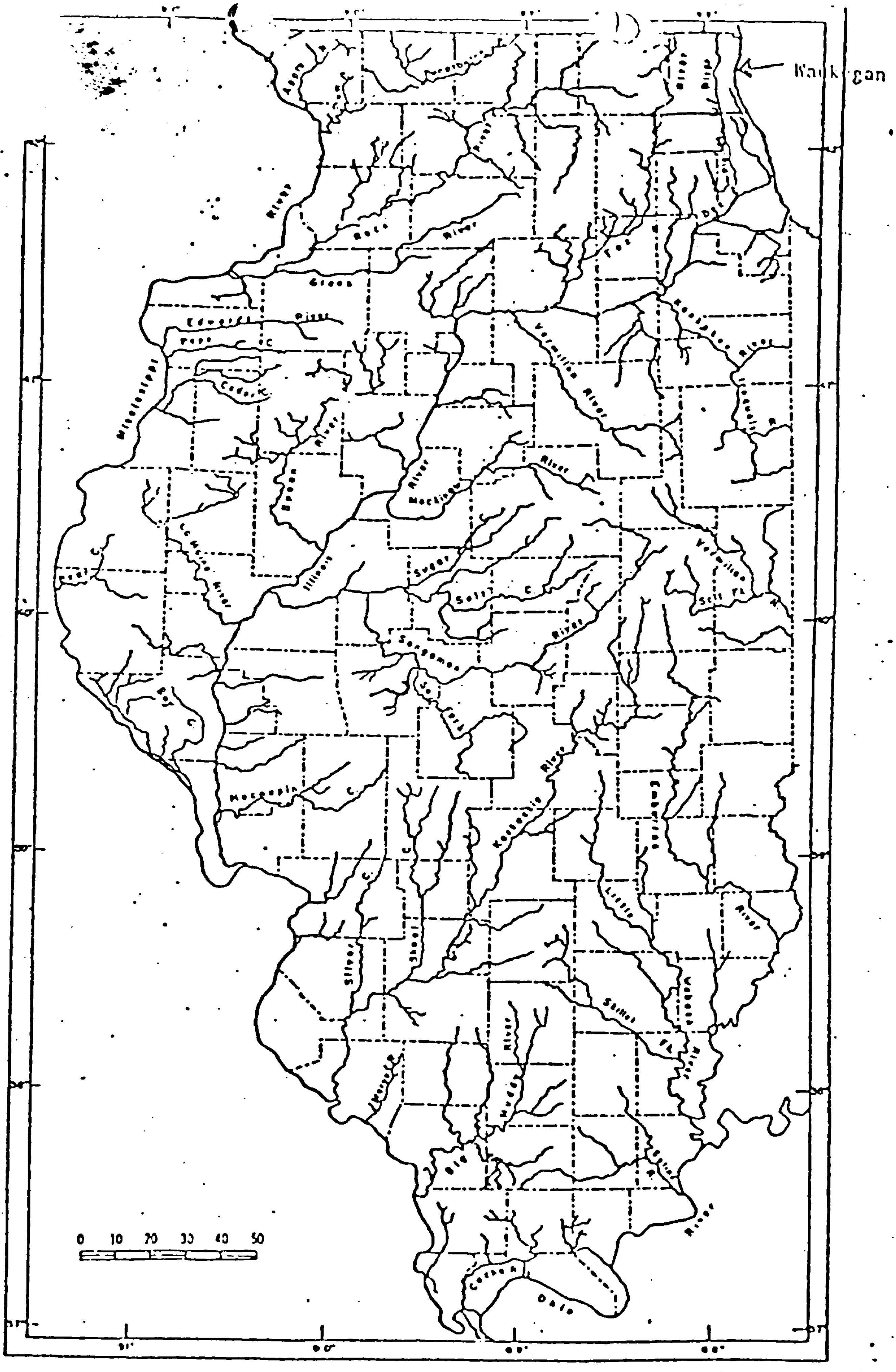

FIGURE 2--Map Showing Stream Systems in Illinois

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

THE UNITED STATES OF AMERICA,)
)
Plaintiff,)
)
vs.) No. 78 C 1004
)
OUTBOARD MARINE CORPORATION)
AND MONSANTO COMPANY,)
)
Defendants.)

The deposition of JULIA B. GRAF, called by Outboard Marine Corporation for examination, pursuant to agreement and pursuant to the Rules of Civil Procedure for the United States District Courts pertaining to the taking of depositions, taken before Thea L. Urban, a Notary Public in and for the County of Cook, State of Illinois, and a Certified Shorthand Reporter of said State, at 30 North LaSalle Street, Chicago, Illinois 60602, on the 16th day of February, A.D. 1981, commencing at 10:00 o'clock a.m.

PRESENT:

MR. JAMES T. HYNES,
(Deputy Chief, Civil Division
United States Attorney's Office
219 South Dearborn Street
Chicago, Illinois 60604),

and

16-5V28.0/066

3-11-81

KAYE,

ORIGINALS TO BE SENT TO GRAF AND BRYSON FOR SIGNATURE.

LINDA

P.S. - WE DID NOT MAKE COPIES OF THESE DEPOSITIONS FOR YOU. IF YOU NEED A COPY, YOU CAN MAKE ONE WHILE YOU HAVE THEM IN YOUR POSSESSION. ALSO, THESE ARE THE ORIGINALS SO WE NEED THEM BACK, AS THEY ARE OUR ONLY COPY.

PRESENT: (Continued)

MR. GEORGE PHELUS,
(Water Enforcement Division
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604),

appeared on behalf of the United States of America;

MS. ROSEANN OLIVER,
(Phelan, Pope & John, Ltd.
30 North LaSalle Street
Chicago, Illinois 60603),

and

MR. JEFFREY C. FORT,
(Martin, Craig, Chester & Sonnenschein
115 South LaSalle Street
Chicago, Illinois 60603),

appeared on behalf of Outboard Marine Corporation;

MR. JAMES H. SCHINK,
MR. ROBERT SHAPIRO,
(Kirkland & Ellis
200 East Randolph Drive
Chicago, Illinois 60601),

appeared on behalf of Monsanto Company.

(Witness sworn.)

JULIA B. GRAF,

called as a witness herein, having been first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MS. OLIVER:

Q What is your name, please?

A Julia B. Graf.

Q How do you spell your last name?

A G-r-a-f.

MS. OLIVER: Let the record show this deposition of Julia B. Graf is being taken pursuant to the Federal Rules of Civil Procedure and by agreement of the parties.

BY MS. OLIVER:

Q What is your residence address?

A 603 South Cleveland Street, Philo, P-h-i-l-o, Illinois.

Q What is your present occupation?

A Hydrologist with the U.S. Geological Survey.

Q How long have you worked for the USGS?

A Two years and two months, three months.

Q Do you have a business address?

A Yes. It is Champaign County Bank Plaza, 102

East Main Street, Urbana.

Q Is that the office of the USGS?

A Yes.

Q Were you asked to do some work for the US EPA or the United States relating to a lawsuit that is entitled United States vs. Outboard Marine?

A Yes, we were.

Q When were you asked to do work?

A It was first brought up to me very shortly after I started working for the Survey in November or December of '78.

Q Who brought the subject up to you?

A My supervisor, Larry Toler.

Q What did you and Mr. Toler discuss doing in 1978?

A He asked me to write a proposal for a project to estimate the movement of sediment in the North Ditch.

Q Did he tell you there was a lawsuit pending?

A I don't remember.

Q Did he tell you what the North Ditch was or anything about what you were supposed to be writing a proposal on?

A There was at that time already large parts of a proposal written that described the area and the problem and what he needed in addition to that was a more detailed plan for field work and laboratory work specifically relating to the sediment.

So I read the materials that had been collected to write that first part of the proposal.

Q Do you know who wrote the parts that were already written?

A No.

Q What did those parts that were written comprise?

A It was a general statement of the problem and the description of the area, and more specifics concerning the hydrologic part of the project.

Q What was the general statement of the property?

A That there was need to know the rate of movement of sediment in and out of the mouth of the Ditch and the total amount in a given time and to predict future movement.

Q Do you know if the portion which had been written before you became involved in the project was done pursuant to the US EPA request for support in this lawsuit?

A Yes, I'm sure that it was.

Q And Mr. Toler was supervisor of this project?

A He was Chief of the Investigation Section, which is the section in our organization that handles project work, so he often does the initial work on the project proposals and acts as title supervisor until the people actually begin working on it.

Q Did you have any contact in November or December of 1978 with anyone at US EPA about this project?

A I don't remember the exact dates, but I began communicating with Ed De Dominico sometime in that time period.

Whether it was December, January, November of 1978, I don't remember. '78 was mentioned after the time and then November, December, January. I don't remember.

Q How is the USGS set up, what departments are there or divisions?

A We are in the Water Resources Division. There is a Geologic Division, a Topographic Division. There is the Conservation Division.

Q What does the Water Resources Division do, what does that division do?

A We do all things relating to water resources.

Q We study stream flow. One of the main areas of our concern is maintaining a nationwide system of stream flow gauging system to collect basic stream flow data and analyze it to do statistical work on it to make predictions.

We do some work with ground water, some more in some States than other States, ground water movement, composition, resources.

Q Since joining the USGS in 1978, 1977?

A '78.

Q In '78, what projects have you worked on other than this project?

A I have two current projects, both basic hydrologic studies. One involves measuring average velocity for long lengths of streams and dispersion characteristics by injecting a dye and following it downstream, seeing how long it takes to move downstream and how the dye spreads out as it moves.

Q Are these related to specific streams?

A I am examining specific streams, 10 or 15 different streams at several different flow conditions, but the goal is to develop, be able to predict how these things would behave on the streams we have not specifically measured to so develop regional relationships

Q What other projects?

A The other one I am working on right at the moment is calibrating rainfall runoff methods for a large number of gauging stations, something on the order of 100 or 120, using computer modeling, using the data that we measure in our stream flow, data on rainfall runoff as input.

Q Other than the two current projects that you are working on now, have you worked with USGS on any other projects besides the Outboard Marine projects?

A A part of my job is writing proposals, just generating ideas for projects and writing them up.

And I did write up a proposal for a project to study the erosion at a low level nuclear waste disposal site at Sheffield. And that has been funded and will be directed by someone else and I am consulting on that.

We consult with other people in the office on their projects quite frequently.

Q But you have not been directly involved in any other project?

A I have not been directing another project, right.

Q Since Outboard Marine. What I am asking is if you have had any active participation other than consulting in the office with your co-workers and other people on any other projects other than the current ones you are working on and the Outboard Marine project.

A No long term active participation, no continuing active participation.

Q I suppose before we really get into this, you should tell me what a hydrologist is.

A A hydrologist is someone who studies the water, its movement, its behavior.

That is a very general term that encompasses a great deal.

Q In the Champaign office, how many hydrologists are employed?

A 30, an estimate.

Q Do they all work within the Water Resources Division?

A Yes, we are the Illinois District Office of Water Resources Division.

Q What other types of positions are there in the Water Resources Division?

A Technicians collect most of the basic stream flow data. They are the ones who are actively involved in maintaining the gauging stations and then the administrative staff. Those are the main categories of the professional staff, all who would have hydrologist titles.

Q In the Water Resources Division, there is an Investigative Section?

A In our office.

Q In your office?

A It is divided into operations and investigations. Operation Section takes care of maintaining the data network statewide, data collection network and any statewide resources projects.

The Investigation Section deals with specific problem-oriented projects.

Q Since you have been at the USGS, how many specific problems or projects has the Investigation Section undertaken?

A This would be a guess. I would say at any one time we would probably have something on the order of 10 projects.

Q Going on at one time?

A Going on, yes.

Q Are you in the Investigation Section?

A Yes.

Q And Mr. Toler was at the time in November, December, January; November, December of '78 and January of '79, Chief of that section?

A Yes.

Q Is he still Chief of that section?

A No, he is now District Chief.

Q Who is now the Chief?

A Larry Balding.

Q When did he become Chief of the Investigation Division?

A Last spring, March, I believe.

Q March of 1980?

A Yes.

Q Do you report directly to the Chief of the Investigation Section?

A Yes, Investigation Section.

Q Do technicians who work with you on specific projects?

A Sometimes. Most of the technicians report directly to either the Chief of the Operation Section or Chief of their office.

Most of the technicians work in our field office or some district office in DeKalb or/and they would report to either the Chief of that Subdistrict

Office or the field office.

There is sometimes a need for them to work on a project in which case they are assigned by their supervisor.

Q To work for someone in the Investigation Section?

A Yes.

Q For example, in the Outboard Marine project, technicians worked under the supervision of the Investigations Section?

A That is a little different project in that Al Noehre is Chief of our Subdistrict Office in DeKalb and he was actually the project chief, so the technicians worked under his direction.

Q Let us put aside for the moment this specific project and talk about the general, the usual customary project that would be undertaken by the Investigations Section.

I take it that you or somebody in your section would write a proposal for the project.

A Yes.

Q Then what happens to the proposal?

A I would give it to my supervisor who now would be Larry Balding and he would review it and decide whether it had merit, whether it had any chance of funding at the higher levels.

He would then give it to Larry Toler who is now District Chief and he would make the same kind of decisions as well as deciding where the best chance of funding would be.

It would then be given a final writing after the office review and submitted to the USGS through the USGS process.

Q Once it is funded and you have an office okay to go ahead with it, what happens to the proposal?

A Work is begun on it.

Q Someone is appointed to be a supervisor of the project?

A Yes. And it certainly doesn't have to be the person that wrote the proposal.

Q A hydrologist in the Water Resources Division is appointed the project officer?

A Yes.

Q What does a project officer do with the proposal after it is funded?

A That has been funded, you say?

Q Yes.

A The first stage would be planning the project, making the final, more detailed field plan. Most of our work is field work, although not all; ordering the equipment, getting it in position, finalizing the budget.

Q Arranging for technicians to work on the project?

A Where they are needed.

Q To do field work, you would require the technicians?

A Not necessarily.

Q Who would do sampling if sampling is needed for the project?

A It depends on the scope of the sampling, really. In some cases, the hydrologist who was chief of the project would do a great deal of it, sometimes a technician would be available to do it.

Q Once the field work was done on the project, what happens next?

A There is usually a phase of laboratory work and date of reduction and analysis and writing reports.

Q Who writes the report?

A The project chief.

Q Do interim or summary project reports have to be submitted to someone in the USGS?

A It depends on the length of the project and the needs of the individual project. There is no general policy.

Q Is there any estimate you can give me as to how long a project usually takes or the duration?

A Usually five years would be about the maximum. Most projects run two years.

Q In November and December of 1978 when you received the information from Mr. Toler and he asked you to write a proposal, you reviewed the parts of the proposal that had already been written?

A Yes.

Q Could you describe for me what those parts consisted of, specifically as you can.

A I am not sure I can be any more detailed than I have been already. It was a fairly general statement, giving location, the goals which we were to develop on rainfall runoff relationship for the Ditch and to tie that in with sediment movement in order to predict how much sediment might move out of the Ditch in the future.

Q Anything else you can recall?

A No.

Q Was there any other material or document that you reviewed other than the parts that were already written?

A Not that I remember.

Q Did you know about this proposal or the draft proposal that was already written by someone with the USGS?

A What I read was written by someone at the USGS, yes.

Q Did Mr. Toler maintain a file on this project that you were aware of?

A I don't know that he did, but I'm sure he did. It would have been procedure to do so.

MS. OLIVER: We would like to review Mr. Toler's file, any preliminary proposals or drafts that were written.

MR. HYNES: Yes.

BY MS. OLIVER:

Q Were you asked to draft a more detailed proposal?

A More detailed in the sediment aspect of it, yes.

Q Could you describe for me what specifically you were asked to draft. What do you mean by the sediment aspects of it?

A I was asked to define a field program to specify the kinds of data that were needed and the kinds of analyses that would be done on those data in order to come up with an estimate of movement of sediment in that Ditch.

Q Did you do that?

A Yes, I did.

Q Did you submit your proposal to Mr. Toler?

A Yes.

Q What happened with the proposal?

A It went through the usual channels and was approved by USGS.

Q Do you know when that was?

A Not specifically, no.

Q Approximately?

A It would have been the winter of '78, '79, yes.

Q Would it have been in November or December of '78 and then January and February of '79, somewhere in that period?

A Yes.

Q Did Mr. Toler or anyone else review your draft proposal with you and make any recommendations or provisions?

A I don't remember specifically; probably. I discussed the proposal with the specifics of the field plan with other USGS personnel, specifically Carl Nordin, who is sediment specialist in the Survey.

Q Mr. Nordin?

A Yes.

Q How do you spell that?

A N-o-r-d-i-n.

Q Is he with USGS?

A Yes.

Q What is his position?

A I assume his title is also hydrologist.

Q Is he also at the Champaign office?

A No, at the Federal Center at Lakewqod, Colorado.

Q Had you done any project like that prior to your proposal that you had done?

A My thesis work in graduate school also involved field sampling of sediment and prediction of motion.

Q What type of water, body of water, did you do your thesis on?

A Lake Michigan.

Q Is that thesis printed somewhere?

A It is in existence in the library at the University of Illinois where a degree was awarded and two papers, largely redrawn from that work, were published in journals and available in the library.

Q They are listed on your bibliography, I think.

A They are, yes.

Q Once your proposal was approved by the USGS, what happened to it next?

A We discussed with the US EPA problems concerning the initiation of work on the proposal, problems like who would actually collect the samples and working out how the samples would be collected, when we could begin work.

Q You said your proposal included the design for field program for the data needed. What type of data did you feel was needed?

A We needed samples of the bed material of the Ditch. We needed measurements of the channel geometry, slope. We needed measured values of sediment that was carried during the flow event.

Q Did your proposal include how many samples or how often the sampling should be done?

A I'm sure that it did.

Q What type of analysis did you design to come up with your conclusion of sediment discharge transport?

A First, there was the laboratory analysis. We needed to do grain size distribution of bed size materials and come up with some general description of bed materials, in terms of specific grain sizes and distributions of those grain sizes and the concentration, values of concentration for the measured samples, samples taken during flow events.

Q Am I correct so far that the first aspect was the data to be accumulated or gathered and the second aspect was the laboratory analysis of that data?

A Yes.

Q Are there any other analyses that were required in the laboratory other than the grain size of materials in the bed and the concentration of materials in the bed?

A No.

Q What was the next part of the proposal?

A I don't remember the original proposal in great detail, but I believe I suggested that with the data from the bed material samples, one could get an additional estimate of the mobility of the bed by implying some incipient-motion criteria.

Q What is incipient-motion criteria?

A It is just a laboratory-generated curve that marks the boundary between motion and no motion for a given grain size and given flow conditions.

Q Is it a formula that is used once you have grain size?

A It is a graph. It doesn't, it is too complicated in relation really to put it in an equation, so it is used in graphical form. It relates to dimensional variables that contain all the physical parameters, that contain the movements of the grains and the points on the graph are determined in the laboratory with grains of a given size and flow conditions carefully controlled.

Q What are the two axes of the graph?

A One is the dimensional number which is called the Reynolds number, which is a measure of the flow, to describe the flow around the particle, and it is made up of shear velocity of grain diameter and kinematic viscosity, contains those parameters which control the kind of flow around the particle.

It is a measure of turbulence, really. And the other axis is the other dimensional parameter called the Shield's parameter, which is really a ratio of the shearing forces on the particle to the gravitational forces, the initial forces.

Q This graph is developed from the measurements of grain size that are taken from the bed?

A It is developed in the laboratory in model stream channels with beds made up of grains of a given very uniform size and the flow conditions carefully controlled and measured.

You set a flow condition. For example, you might increase the velocity of the flow until the grains first begin to move. You measure the flow slope at that point and you measure the parameters out of that point and that would give you the point of that motion for that given particle.

Q That determination is not based on actual analyses or the grain samples that you take from the project you are working on?

A No.

Q That is sort of a theoretical model?

A It is empirical.

Q Empirical?

A Yes.

Q When you were hired by USGS, were you hired to work on this particular project?

A No.

Q It was the first project you worked on?

A Yes, it was.

Q Once you do your graph or your graph of mobility of particles, do you recall what the next step in the original proposal was?

A The next step would be to try and make calculations of bed material load and how the bed material that you sample would move under a given flow in a ditch.

Q How did you propose going about doing that in your original proposal?

A I believe I outlined several levels at which they could be done. The first level is using the Shield's criterion to get an initial motion state.

The second level which would be one which you could do with the next amount of data which would be the channel geometry and the bed material would be to use any one of several bed material load equations or systems of equations to estimate bed material load for that and then the next level would be if you actually had some measure, sediment samples measured during the flow, you could apply different techniques.

Q Did you propose to have measured sediment flow samples taken?

A Yes.

Q Did you make a recommendation as to which of the three calculations should be used in determining the sediment transport?

A I'm sure that I intended that they all be used.

Q Was there any other part of your proposal that you haven't told us about?

A Not that I remember.

Q You mentioned earlier that this was your original proposal. Was that proposal modified or revised in any way later on?

A The basic outline of the work, the data requirements and analyses and computations remained the same throughout. It was reworded and put into contract form, mainly.

Q Did you do the rewording of the proposal?

A No.

Q Who did that?

A I don't know.

Q After you submitted your original proposal, did you make any modifications or revisions to it?

A We reviewed the contract which was in effect a reworded proposal and didn't make any substantial changes.

I believe there were a few details of who would be taking the samples and that sort of thing.

Q Was your original proposal in substance the same agreement that was reached with US EPA with the project?

A Yes, it was.

Q When you wrote your proposal, did you recommend the duration of sampling field work?

A I don't remember.

Q Did you recommend the duration of the project from beginning to final report?

A I don't remember, but I think it was imposed upon us.

Q Imposed by the US EPA and the USGS?

A I don't remember. It could have been by the USGS, and they wanted to end it by the end of the fiscal year.

Q You did your thesis work on the transport of Lake Michigan sediment, is that right?

A Yes.

Q How long did that study take?

A I did field work on the project for three years.

Q Are you familiar with any other projects on sediment transport of any tributaries other than the North Ditch tributary waters?

A Lake Michigan tributaries?

Q Yes.

A No.

Q Are you familiar with any similar projects in any other waters in the United States?

A Well, measuring sediment loads and doing bed material calculations is something that the Survey does as a part of its routine work. There has been in the past less of it done in Illinois than other States by the USGS.

Q I don't think I exactly understand.

Are or were there other projects involving studies made of sediment transport from other tributaries in the United States similar to the project undertaken here?

MR. HYNES: You mean done by USGS or by her or just in the general body of knowledge?

MS. OLIVER: Yes.

BY THE WITNESS:

A You mean any river, any sediment study on any river in the United States?

BY MS. OLIVER:

Q Any river or stream or tributary or whatever?

A A great many, yes.

Q Are you aware of any done by the USGS?

A I couldn't give specific titles, but that is part of our work, yes. There would be quite a number at any time.

Q Would these projects that are done for the studies of sediment movement in the waters fall in the general length of time that you mentioned for any project, for two to five years?

A I would imagine so.

Q What was the duration of this project that you worked on concerning the North Ditch?

A The field data they collected from the middle of March until September 30.

Q When was the final report written?

A It was written that fall, beginning in October and completed in December, and I can't remember specifically what month it was finally printed.

Q Now we are talking about 1979, is that correct?

A Yes.

Q The field sampling data was done from the middle of March 1979 through September 30, 1979?

A Yes.

Q The final report was prepared in October of 1979 and completed in December of 1979?

A Yes.

Q Did you prepare the final report?

A With my co-author, Al Noehre.

Q Did you reach some conclusions concerning sediment transport in the North Ditch?

A We gave an estimate of the amount of sediment that had moved out of the Ditch during the study period, total amount and an amount for each date which we determined flow to have been present in the Ditch.

Q So you came up with a conclusion of, first, the amount of sediment that had been moved from the North Ditch for the entire period of the study?

A Yes.

Q And also came up with a figure for daily movement of sediment for any period in which there was flow in the Ditch?

A Yes.

Q Were there any other conclusions?

A We presented the opinion that that estimate was probably low and gave our reasons for that opinion.

Q Do you recall what the total amount of sediment from the Ditch was during the period?

A I believe it was 5100 pounds.

Q How about the daily flow or movement?

A We gave a daily mean. I'm not sure of that. I think it was 25 pounds.

Q Your conclusion was that the measured amount of movement was low, is that correct?

A Yes.

Q What was that conclusion based on?

A The fact that we did not sample, we were not able to estimate the flow for about 14 percent of the period of the study because a stage recorder failed to operate for that period of time. I believe it was three separate periods of equipment failure and because we were only able to make the estimates for days on which we determined that flow existed and because the equipment couldn't allow us to estimate any for those days, we just could do nothing for that period of time.

(Mr. Schink left the deposition room.)

BY THE WITNESS:

A (Continuing.) That was one reason.

BY MR. OLIVER:

Q What was the other?

A Another reason was that all the methods we used to either calculate or measure the sediment transport, none of those methods actually measured or calculated the total flow of sediment.

MS. OLIVER: Could you read that answer?

(Answer read.)

BY MS. OLIVER:

Q Are there any other reasons?

A Those were the primary ones, the ones that I remember.

Q Are there any secondary reasons that you can recall?

A No.

Q Were you able to predict what the future flow from the North Ditch would be?

A The only prediction that we could give about future conditions were to make an estimate of the movement of sediment at flood peak discharges.

Q And that was not based on any of the measurements that were actually taken?

A The estimates of flood peak discharges were based on the drainage area, the percent in filtration and slope that were actually measured at the site. And then I used those estimated flood peak discharges with the sediment transport curve which we developed on the basis of measured sediment samples and calculations to make the estimate of the sediment movement at those discharges.

Q Is there a reason why you could only predict what the movement of sediment would have been at flood peak periods?

A Rather than other?

Q Rather than in other periods?

A We could use the relationships we developed to estimate sediment in any discharge transport curve we developed relating discharge to transport. The problem is having some way of estimating what the discharge will be in any time in the future.

In order to do that, you have to develop a water rainfall runoff relationship and use a statistical projection of rainfall into the future and use your rainfall runoff relationship to get the discharge at any time in response to a rainfall. We were not able to come up with a satisfactory rainfall runoff relationship that we felt we could reliably base that prediction on.

Q If I understand this correctly, you did not feel that you could reliably predict the sediment movement from the North Ditch in Lake Michigan for any one period of time?

A Any specific future time, right.

Q But you did estimate the sediment movement from the North Ditch into Lake Michigan at flood peak periods?

A Yes, at flood peak discharge.

Q Let us go back a minute here.

The conclusion of the amount of sediment that had moved from the Ditch from the beginning of the study to the end of the study was actually measured, is that right?

A No. We didn't actually, to say it had been measured would mean we had actually been there every time there was flow and sampled the whole quantity of sample and I know we did not do that.

Q How did you determine the 5100 pounds figure?

A We measured the sediment moving through the Ditch during two flow events and at three other times when there was flow in the Ditch for a total of 20 samples of sediment concentration related to discharge of water through the Ditch.

We used those samples to develop a relation, in this case it was just a regression equation based least squares criterion.

Q So you measured 20 events?

A We measured 20 samples.

Q 20 samples?

A We would call an event, an event would include a whole, I would say we measured 5 events.

Q 5 events but 20 samples?

A 20 samples.

Q When you say a flow event, is that a rainfall or a storm?

A When I say flow event, I would mean the discharge resulting from a rainstorm, but I would be speaking of water moving through the Ditch rather than the rain, if I said flow.

Q What are the other three times that there was flow in the North Ditch? How would you know which were the three times?

Do you understand my question?

A No.

Q You said you measured two flow events and three other times there was flow in the North Ditch.

A   Okay. They were times when either Al Noehre or one of the technicians from the office went to the Ditch to measure the discharge. They also took samples of sediment for sediment analysis.

Q   Was that during a rainfall?

A   No.

Q   Would there be flow in the Ditch?

A   Yes.

MR. HYNES: I am not sure we are talking about different events. Those five events that were measured, was that sediment measurement and not flow measurement? Are you just talking about the two rainfall events and three other occurrences, were those five events at which there were 20 samples that were taken and were those 20 samples of sediment?

MS. OLIVER: I think so.

THE WITNESS: Yes, there were 20 samples of sediment. There must be 17 samples that were taken during the two flow events.

There were readings made of the staff gage at the site. Three measurements that Al Noehre or his technicians took were actual discharge measurements made by the technicians with me and sediment samples.

MR. SHAPIRO: Off the record for a minute.

(Discussion off the record.)

MS. OLIVER: Back on the record.

BY MS. OLIVER:

Q What did these 20 samples consist of?

A In each case they were samples taken by the most commonly used survey method within the USGS for taking what can be called suspended samples.

You take a bottle on the end of a rope or stick and lower it through the flow to the bed until the sample touches the bed and pull it back up. And you do it at selected points across the stream, a composite sample.

Q During the two rainfall events, 17 of those types of samples were taken?

A Yes.

Q During the other three sample periods that sampling was done?

A Yes.

Q Was it just a grab sample, those other three times?

A The same type of sample.

Q But it was just done once?

A One sample consists of a number of different grab samples with a bottle throughout the stream. How many depends upon the size of the stream, the depth of the flow and a composite sample which would be one point on a plot of paper would be made up of perhaps 8 or 10 or 20 bottles of sediment that you put together.

Q Do you know how many were taken each time that bottle was lowered into the North Ditch?

MR. HYNES: Are you specifically talking about those three?

MS. OLIVER: For the three, yes.

BY THE WITNESS:

A No, I don't know.

BY MS. OLIVER:

Q How about for the 17 samples that were taken during the flow events in rainfall?

A Are you saying row how many bottles were put into the composite sample?

Q Right.

A No, I don't know.

Q Once all these bottles are removed, how are they developed into a composite sample?

A With the method that Survey uses and was used in that case, you just put them all together, just dump them together into another container.

Q You make one sample?

A And that becomes the sample.

Q Once you did the sampling, how did you determine from that sampling that the 5100 pounds you concluded had moved from the Ditch?

A I used those 20 samples, did a calculated regression line.

Q What is a regression line?

A It means you use the least squares technique and minimize the square of differences at any point and predicted line. It is a standard statistical technique for coming up with a line which is in a sense an average pounds.

Q What you did is you averaged the samples?

A No.

Q What did the regression line do?

A What you have when you have the measured data is a plot that contains 20 points, each associated with a value of discharge and sediment discharge, stream discharge and sediment discharge, and all the regression line does is draw a straight line through those points which are scattered. The points themselves are scattered around the line and you want some way of predicting in a sense the average discharge, the average value of sediment discharge.

So in that sense you can think of it as a value, so it just gives me a line on a graph that would allow me to take any given discharge value going up to the line and read off the sediment discharge corresponding to that or use the equation of the line to do it with a calculator rather than reading it off the graph.

Q When you say you had discharge measurements, is that correct?

A Yes.

Q What does that measure?

A The amount of water passing across a section in a given period of time.

Q That measures the amount of water of that one end of the bottle that was lowered into the North Ditch?

A No. A discharge measure would give you the total amount of water passing through a cross section of a ditch in a given period of time.

Q How were those measurements taken?

A We used a meter, which is a series of vanes with the flow. It is a circular plate on a pivot that has a lot of little vanes to catch the flow. And the flow turns it around and as vanes are oriented into a flow, every time the cup turns around once, it makes an electrical connection inside the meter and that electrical current is passed through to some headphones and you use a stop watch and time how many clicks there are in a certain period of time.

That gives you the velocity of the water at that point.

If you measure the velocity of water at a great number of points across the stream, you assume that the velocity that you measured at any point is the velocity in the small area around that point. You add up all of those velocity times square and it gives the discharges, velocity times the square over which that velocity --

Q That gives you the discharge measurement?

A Yes.

Q You are talking about water discharge?

A Water discharge.

Q From that measurement, how do you get to sediment discharge or can you get to that measurement, to sediment discharge?

A If you get sediment concentration measurements at that discharge, it is just multiplying the concentration times the water discharge times the factor that accounts for the changing units. That would give you sediment discharge.

Q When you are talking about sediment, are you talking about the material at the bottom of the North Ditch or are you talking about any material that might wash into the North Ditch and flow through?

A The measured samples would not discriminate between those two. You would be sampling what was moving. You would be getting sampling of everything that was moving between the surface of the water and .3 feet from the bed.

Q So your study and your report does not differentiate between discharge or movement of bed materials and discharge or movement of materials upstream or that are washed into the North Ditch and moving along and are discharged into Lake Michigan?

A The calculations we made by indirect methods are based on movement, are trying to predict movement of the bed materials in the Ditch.

The measured samples would not be able to discriminate.

Q The last step you told us about was the regression line and the regression line plots the discharge measurements and the other axis of that is the sediment discharge?

A Yes.

Q For the sediment discharge, that was calculated on the basis of what?

A That would have been the measured values.

Q The discharge measurements?

A Would have been the measured values of sediment concentration and in the case of the three samples that were taken by Al Noehre and his technicians, it would have been based on measured discharge values.

In the case of other samples, it would have been the measured sediment concentration and a discharge to determine from readings of our staff gage at the site.

MR. SHAPIRO: Could I have that answer?

(Answer read.)

BY MS. OLIVER:

Q To measure two flow events, you had a staff gage mechanism or some type of equipment set up?

A Yes. There were staff gages put in at a number of locations along the Ditch.

Q Those were used during rainfall events?

A Yes.

Q For the other three miscellaneous sampling periods, those were not used?

A They were read as well.

Q Why weren't they used as when you had a rainfall event?

A Because the purpose of the visit of Al Noehre and his technicians to the site was to collect data that they needed in order to determine the relationship between the reading on the staff gage and the discharge going through the Ditch, so they had to go about it, they had to measure the discharge and read all the gages in order to tie the two together.

Q Once you have your regression line, how do you come up with the 5100 pound figure?

A We determined the days on which there was flow in the Ditch and discharge for each hour of the day in which there was flow in the Ditch.

Q How did you do that?

A From the stage record. We had a gage with a recorder attached to it that gave continuous record of stage in the Ditch.

Q And stage means level of the Ditch?

A Level of water in the Ditch, and Al Noehre from his discharge measurements was able to develop a relationship between that stage and the amount of water that was going through the Ditch.

Q How many stage recorders did you have?

A One.

Q One in the Ditch and that would give an accurate reading of the stage level in the Ditch?

A Yes.

Q Do you recall where that was located in the Ditch?

A It was located near the mouth, I would think very near the property line.

Q Were there days when this recorder showed no flow in the Ditch?

A Oh, yes.

Q Is there a record kept of how many days there were no flow?

A Yes, in the sense it would be all the days that were not listed as days of flow that we pulled in, except in those in which the record was missing.

Q And the record was missing because the recorder malfunctioned?

A Yes.

Q Was somebody out there from the USGS or the US EPA to check the equipment, make sure it was functioning properly?

A I don't believe so.

Q So it could have recorded for a day, not worked for a day, and then worked again when somebody showed up and saw it working?

A I can't imagine a situation in which a recorder would do that.

Q On the days when nobody was there to check the recorder, you would not know for sure whether there was a day with no flow or a day with flow, that just was not recorded?

A The recorder keeps recording whether there is flow or not.

Q But it shows no flow?

A It shows the level of water in the Ditch and the flow has to be, the flow is not necessarily given directly by the level of water in the Ditch.

Q I take it that the stage recorder and the gages are sensitive instruments?

A Yes.

Q Are they calibrated in some way or reset in some way?

A Yes, the levels that the gages read are usually tied in with some standard Survey level, like a benchmark, something that relates the elevation at that point to national geology vertical datum.

Q How was the equipment, the gages and the recorder in the North Ditch checked for accuracy?

A There are two things in measuring. One is the level of water, the stage, and you survey the gage very carefully when it is installed. If there is any indication at all that anything is changing, you resurvey it. In any case, it is very well implanted in the ground so unless you have some reason to believe the ground is shifting or an earthquake or somebody comes, and it would take more than a push to change it.

Q It malfunctioned in this case?

A Yes.

Q I'm sorry, go ahead.

A I don't know exactly what that malfunction was. It could have been something as simple as a dead battery. It could have been the tape getting jammed. It is recorded on a paper tape, just punches holes at given preset periods of time to indicate the given stage. It is a mechanical system and there is always room for some mechanical failure.

Q Does someone have the responsibility or did someone have the responsibility of going out to the site periodically and checking the equipment that was there to determine whether it was calibrated properly or it functioned properly?

A It would have been actually Al Noehre's responsibility.

Q Do you know what he did with respect to that responsibility?

A In terms of how often he checked the instrument, no, I don't know.

Q In your opinion, should there be a period when somebody should go out and regularly periodically observe the instrumentation or check it?

A Yes, there should be and there is.

Q What is the standard period of time?

A The standard period for normally our gages are on the status of six weeks.

Q Every six weeks?

A Checked every six weeks.

Q Is that a standard period for checking a stage recorder, too?

A That is what I mean.

Q Stage gage and stage recorder are the same thing?

A The gage is the thing that actually senses the water level and the recorder is the thing that records it, but -- so they are two different things, but they are used together.

Q How about the other gages that were located along the North Ditch?

A The other gages were staff gages. That means they are just a graduated stick, essentially, and they are placed securely enough so they won't move and tie it in with the recording gage in terms of level, so you know how the levels read at those gages.

Q So the stick is placed into the ground?

A Yes.

Q And determined by the water passing through it at one point on the stick, it is somehow recorded on paper?

A No.

Q For that one point?

A No. The recorded stage, it is only the stage right at the gage that has the recorder attached to it.

Q What about these other staff gages?

A They are gages that a technician would read while at the site.

Q How often were those gages read?

A They were read at each time a discharge measurement was made, and I believe that was five or six times.

Q Could you say the amount of sediment that you found had moved during the period of the project was accurate to a reasonable degree of geological certainty?

A Do you want me to put a number on the end?

Q Accuracy, first of all generally.

A For the period of record, it is an estimate, but it is a reasonably good estimate for the period of record.

Q Are you satisfied as a hydrologist that the time that was recorded was adequate to come up with an estimate of the amount of sediment that moved?

MR. HYNES: You mean for the period of time it was actually measured?

MS. OLIVER: Yes, that is all I am talking about right now.

THE WITNESS: Could you say that again?

MS. OLIVER: Read the question, please.

(Question read.)

BY THE WITNESS:

A Yes.

BY MS. OLIVER:

Q When you say the estimate that you came up with was reasonably accurate, could you put a certain percentage on that?

A I wouldn't like to.

Q I realize you wouldn't like to, but can you?

Is it 50 percent accurate, would you say?

A I would say better than 50 percent.

Q 60 percent?

MR. HYNES: You are getting into something here -- are you talking about a specific statistical significant standard decision or just kind of a ball park guess?

MS. OLIVER: No, I am asking in her opinion as a hydrologist whether she could tell me a percentage that she would attribute to this estimate of the amount of sediment that moved.

You can answer.

BY THE WITNESS:

A I am just trying to figure out what kind of error to express it as.

BY MS. OLIVER:

Q If it would help to just repeat it, I guess my question was can you say that your estimate of sediment moved during the period of time was 50 to 60 percent accurate, somewhere in that range?

A I would rephrase that to say if you mean that do I think that the amount of sediment we estimated as having moved through the Ditch during the study period was within, has a greater than 50 percent chance of having been what actually moved through, yes, I would say in that range.

Q In order to arrive at the amount of sediment as an estimate, of the amount of sediment that had actually moved through the Ditch during the study priod, were there any measurements or any analyses that were not done that you believe should have been done or could have been done?

MR. HYNES: Could have been done or would have been done for what purpose, to improve the accuracy of it?

MS. OLIVER: To improve the accuracy.

BY THE WITNESS:

A Under the circumstances, no.

BY MS. OLIVER:

Q Under what circumstances?

A If you had someone who could live by the mouth of the Ditch and never sleep, who was actually there and able to do a sample every 15 minutes for the period of our study.

Q Would you have had a more accurate estimate?

A You would have had a more accurate estimate because you would have measured everything, but in fact that is not practical in any case to measure everything.

Q So if you had a longer time in which to do the study, you would have had a higher degree of accuracy?

A That would not have affected the accuracy of the study of the estimate we made based on the method we used.

Q What would have affected it?

A It might have allowed us to develop a rainfall runoff relationship and therefore predict what might move out under future conditions.

Q Do you know whether it is the ordinary practice or the customary practice in making determinations of the amount of sediment that actually moves during a study period to make that estimate based on the number of samples that were done in this case?

A Do you mean is it common practice to estimate the amount of sediment that moved based on the amount of samples measured during any study period or on this number of samples?

Q On this number of samples.

A It is common practice to make an estimate based on however many samples you happen to have when that estimate is needed.

Q Isn't there a threshold level of the minimum number of samples which you as a scientist, hydrologist, would require before attempting to make an estimate?

A No. If you have one sample, it is better than no samples.

Q Would you feel confident that your estimate of the movement based on one sample would be reasonably accurate?

A No.

Q How many samples?

A My estimate of how much moved in that sample would be reasonable. I would have confidence in estimating that.

Q To determine how much movement there is during a study period of six months, how many samples would you feel in your professional opinion was needed to make a reasonable accurate prediction?

A In sediment work, in anything in which you take samples, the confidence increases with the number of samples, but in sediment work, the natural scatter of the data is very large so that even in many cases when you have a very large number of samples, the error measured in terms of that prediction of data around the line may or may not be significantly reduced.

Q So what you are saying is when you are doing sediment analyses, it is very difficult to come up with an accurate estimate?

A Yes.

Q And in this case you would attribute the 50 to 60 percent range of accuracy to your measuring of sediment movement during the period?

A I really don't think it is possible to put a number on the accuracy of that estimate.

Q Do you think it is somewhere above 50 percent but you cannot say where?

A Yes.

Q Then the next conclusion you reached was an estimate of the daily sediment movement out of the North Ditch, is that right?

A The estimate of total sediment movement was based on the daily sediment so that came first.

Q In your opinion is the estimate of the daily sediment movement from the North Ditch reasonably accurate?

MR. SHAPIRO: Are you talking about daily sediment or mean daily sediment?

BY MS. OLIVER:

Q The figure of 25 pounds as you have given me as a mean daily sediment, is that correct?

A Yes.

Q That is what I was referring to.

A It is accurate as any of the other estimates. Mean, of course, means may never get a value of 25, but --

Q Sure.

Your conclusion is the measured sediment movement was low. Is that right?

A Yes.

Q Compared to what, compared to future movement or compared to what you could expect? What does that mean?

A We felt that if somehow you could know what had actually moved out of the Ditch during that period of time, it probably would be more than we estimated.

Q Is there any way you could know what actually moved out of the Ditch during that period of time?

A No.

Q Would it be just as likely that what had actually moved out of the Ditch would be less?

A In our opinion, no. It would be more likely that it would be high.

Q Is that opinion based upon a reasonable degree of geological certainty?

A Yes.

Q Can you attribute a flow accuracy to that prediction or that conclusion?

A I feel very sure that our estimate was low. To try to put a number on an opinion, 80 percent sure that it is low, 90 percent.

Q When you say your estimate was low, you are talking about your estimate on the total amount of sediment that moved?

A Yes.

Q Do you know how low that estimate is or that was?

A No.

Q You did not make any calculations or do any work to determine whether it was just a little low or very low?

A It really is not possible.

Q I think you told me the reasons that you believe the estimate was low was because the machines malfunctioned for 14 days. Is that one of the reasons?

A I don't remember that it was exactly 14 days; for some period of time. I believe the way we expressed it in the report is that 14 percent of rainfall occurred on days so that we felt if you were to assume that the same percentage of flow would have come from the same percentage of rainfall, then perhaps you were missing 14 percent of the flow.

Q And the second reason that you based your opinion that the estimate of sediment movement was low was because you had not measured or calculated total flow of sediment?

A Yes.

Q What is total flow of sediment?

A The total sediment load would be just all the sediment being carried from a stationary part of the bed to the surface of the flow. In the sediment samples measured, load, you can't sample the levels that are below .3 feet from the bed and the bed so that they only give you a sample of what is above that level of .3 feet from the bed and the surface and the calculations by indirect methods give movement of bed material load, that is movement of grains of sizes that are actually contained in the bed in significant quantities and they did not include what is sometimes called the wash load, the very fine fraction which does not get deposited in significant quantities in the bed but it is just washed right through from upstream sources.

The measured sediment samples would include that because there is no way for the sampler to discriminate between those two.

Q So what you are saying is the total sediment flow would be some portion of particles in the bed itself that moved through the Ditch which cannot be measured by your instrumentation?

A The total load would just be everything that is moving through.

Q And that is not what your instrumentation measured?

A It is not what the samples measured, no.

Q Did any of the equipment measure that?

A No.

Q That measurement would be required to get an accurate number or prediction on the amount of sediment that actually has flowed through the Ditch?

A Yes, but in fact it is not possible to measure that.

Q Were there any other facts or reasons on which your opinion that the estimated amount of sediment that moved through the Ditch was low?

A Not that I can remember.

Q Other than determining an estimate of the amount of sediment that moved through the Ditch, the estimate of the mean daily movement of sediment through the Ditch and your conclusion that the estimate was low, did you make any other findings or opinions as a result of this project?

A No.

Q Is your conclusion that the amount of sediment that moved through the Ditch was low based on empirical data?

A In a sense that the equipment problems contributed to that, that is a feel, the finding which would be empirical.

The other is just knowledge of what you are measuring and what you are calculating.

Q When we talk about empirical data or estimates, what do you mean by empirical?

A Measuring, essentially.

Q I think you also told us that you made a prediction of the estimate of the sediment movement at flood peak discharges.

A Yes.

Q And for that prediction, you prepared a sediment transport curve?

A Yes, it was the same sediment transport curve that we developed in order to estimate the daily loads.

Q Is that prediction that you made a prediction that you would give with a reasonable degree of geological certainty?

A I would have less confidence in that prediction than in the estimate of sediment that moved out of the Ditch because I am using the same transport curve and there is a certain error involved in applying that. In addition, I am using the equations that predict flood peak discharges and there is a certain error involved in that, so you have more error.

Q So your confidence in that prediction would be it is less than 50 percent?

MR. HYNES: Objection, you put the words in her mouth. Why don't you ask her what percentage that would be?

BY MS. OLIVER:

Q Is it less than 50 percent?

A I think there is probably a greater than a 50-50 chance that that amount of sediment would carry these discharges.

Q Greater than 50-50 chance?

A If you want to think about it in that term.

Q Well, can you tell me?

A Again, it would be less.

Q What would the margin of error be?

A Hmm?

Q Would you tell me what the marging of error would be for the prediction that you made?

MR. HYNES: I think you are asking her again what percentage and she is having a very big problem coming up with a percentage. It is just a guess, just less confidence than on her other opinions.

MS. OLIVER: All I am asking is if she can't give it to me, it's fine.

THE WITNESS: No, I would not like to put a number on that.

MS. OLIVER: All right.

BY MS. OLIVER:

Q Have you done any work on this project since completing the final report?

A No.

Q Do you plan on doing any further calculations or work on this project?

A No.

Q Other than the final report you drafted a progress report, is that correct?

A Yes.

Q And you drafted a preliminary report, preliminary final report?

A There would only be two reports: Progress report and final report.

Q Progress report and final report?

A Yes.

Q Were you given any field reports or summary information during the course of the project?

A I don't know exactly what you mean by that, but if I am interpreting it correctly, no.

Q What was your involvement during the March 1st to middle of September 30, 1979 work period?

A I visited the site once and took bed material samples, made a description of the area for my own use.

Q When was that visit?

A In March. I don't remember the exact date.

Q Did you make notes from that visit?

A Yes, I did.

Q Did you bring those with you?

A No.

Q Do you have those?

A Yes.

MS. OLIVER: I would like to see those notes.

MR. HYNES: Visit notes.

BY MS. OLIVER:

Q Did you make any other notes on this project during the course of the project and your preparation of the final report?

A Just the calculations, anything relating to the calculations themselves.

Q Do you have those calculations along with the notes all in a file for this project that you keep?

A Yes.

MS. OLIVER: I would like those as well.

BY MS. OLIVER:

Q Did you have meetings with anyone from the US EPA during the course of this study or the preparation of the final report?

A After the project actually beginning, you mean?

Q Or before the project began.

A Al and I met with Ed De Dominico and a number of other people from the US EPA during the planning stage once.

Q What was discussed at that meeting?

A Who would take samples, how would they be taken. We wanted them taken with the Survey methods so they would all be compatible with the work we collected, so there was a certain -- we drafted up instructions and that was on the site. US EPA people were there as well, and then techniques were demonstrated.

Q After that initial meeting, what other meetings did you have with US EPA?

A I believe that was all.

Q Who was your project officer, Al --

A Noehre was chief of the project.

Q What is Mr. Noehre's background?

A He is now Chief of our Subdistrict Office in DeKalb. He is a hydrologist also. He has been at that office for many years directing the basic data collection network in the northern part of the State.

Q He was responsible for the actual collection of the data?

A Yes.

Q Was he responsible for anything else besides the collection of the data?

A He did the hydrologic analysis involved in the report as separate from the sediment.

Q Did he do anything else?

A We wrote the report together.

Q He agreed with the conclusions of the report?

A Yes.

Q Did Mr. Nordin --

MR. SHAPIRO: He is the sediment expert?

THE WITNESS: Yes.

BY MS. OLIVER:

Q Did you meet with Mr. Nordin?

A No, I talked with him on the telephone.

Q How many times did you talk to Mr. Nordin?

A Once or twice.

Q Do you recall whether those conversations were at the beginning of the project or at the end of the project?

A The one that I remember specifically while I was drafting the proposal, we were discussing the field

Q Did he recommend any revisions?

A No.

Q Did you send it to him?

A Yes.

Q As part of --

A My supervisor sent it to him.

Q Do you know if he talked to your supervisor about the report?

A I am sure he did not.

Q Do you know why he would send the report?

A Because he has a great deal of experience in sediment work and we wanted an outside opinion, outside the office opinion.

Q But he did not give you any approval or criticism?

A He gave approval.

Q How did he give his approval?

A On a note attached to the paper.

Q What did he say?

A He said that he felt it was suitable for publication at that time we were discussing in what form it would be, could be published. And he said he thought it would be suitable for an open file report which is just a category for reports.

Q What type of things were in the open file category?

A Short term studies or preliminary studies, many times additional work may be published as a water resources investigation. They are often internal survey projects that are of primary interest to people working in the Survey on techniques or data reports, that sort of thing.

MS. OLIVER: Could we take a break for lunch?

(At 12:15 p.m., a luncheon
recess was taken to 1:00 p.m.
this same day.)

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

THE UNITED STATES OF AMERICA,)
)
Plaintiff,)
)
vs.) No. 78 C 1004
)
OUTBOARD MARINE CORPORATION)
AND MONSANTO COMPANY,)
)
Defendants.)

February 16, 1981,

1:00 o'clock p.m.

The deposition of JULIA B. GRAF resumed pursuant to noon recess at 30 North LaSalle Street, Chicago, Illinois 60602, before Thea L. Urban.

PRESENT:

MR. JAMES T. HYNES,

MR. GEORGE PHELUS,

MS. ROSEANN OLIVER,

MR. JEFFREY C. FORT,

MR. JAMES H. SCHINK,

MR. ROBERT SHAPIRO.

JULIA B. GRAF,

called as a witness herein, having been previously duly sworn, was examined and testified further as follows:

(Graf-OMC Deposition Exhibits Nos. 1 through 6, inclusive, were marked for identification, 2/16/81, TLU.)

DIRECT EXAMINATION

BY MS. OLIVER:

Q You mentioned at the beginning of the morning session when you were first involved in the project, a partial proposal had been written.

A Yes.

Q Do you know if any work had been done by the USGS on a project involving the Outboard Marine Corporation other than the writing of a partial proposal?

A I am quite sure there had not been any work.

Q There had been no sampling done?

A No.

Q You also mentioned this morning that the findings which you made in your final report were in your opinion at least 50 percent accurate or had a degree of accuracy of at least 50 percent.

Could you tell me what factors or facts you base your opinion on that the findings made are at least 50 percent accurate?

A The fact that at every stage we sampled what was possible to sample. We had good stage record for most of the period. I felt I took enough bed material samples to characterize the Ditch and that they were properly analyzed; the sources of error were for periods we could not sample; the fact that the stage discharge relationship is fairly complicated, one, and therefore, it could not be, there are limits on the accuracy with which it could be obtained.

Q Are there any limits that are recognized in your field of study on the accuracy of obtaining estimates of sediment transport?

MR. HYNES: You mean in terms of percentage?

MS. OLIVER: Any type of margin of error or numerical or quantified limits.

BY THE WITNESS:

A I don't think I can answer that.

BY MS. OLIVER:

Q I guess what I am asking is in the field of sedimentology, is there a recognized margin of error for determining sediment transport?

A It would vary with each individual case. In the case of making a discharge measurement, the person who makes a measurement makes notes on the measurement and makes an estimate as to the error, whether it is less than 5 percent, less than 1 percent, less than 10 percent error.

Q Were these made on this project?

A Yes.

Q Who would make those?

A Each person who made the discharge measurement would make this judgment.

Q The field people?

A The field people. In the case of sediment, it is not really possible at the time of the individual measurement to make a specific type of quantitative variable.

In the case of discharge measurements, individual discharge measurements, usually there is an error of less than 10 percent, usually 5 percent. There are very few that the technician would rate as less than 1 percent.

Q And that is for each discharge measurement?

A Each individual measurement.

Q Are you familiar with any other projects done by USGS or anybody other than the USGS which involved a study of a small tributary such as the North Ditch for the purpose of determining sediment transport?

A I can't name specific projects. I feel very sure there are some, that is the type of things that we are going to be trying to do in the other project that I mentioned that I worked the proposal for.

It is not a tributary in the sense that in this case there is no perennial stream on the site, so we are trying to determine the sediment runoff from overland flow and intermittent streams. But it is similar.

Q Did you undertake in this project, did you check with the USGS to see if there were any similar projects?

A In the techniques that were used in the field plan, there are so many similar projects that you wouldn't. There are standard techniques that are used all the time in a lot of very similar projects.

Q But those projects do not involve the same types of conclusions or predictions that you are asked to make in this project.

MR. HYNES: Is that a question?

MS. OLIVER: Yes.

BY THE WITNESS:

A They would entail making the same kinds of measurements and analyzing the data in a similar way and making the same kinds of conclusions, yes.

BY MS. OLIVER:

Q So in other projects that you are familiar with, an estimate of the amount of sediment moving during the period of time has been done?

A Again, I can't name a specific project in which that was being done, but that is the kind of thing we do routinely.

Q How does that come up routinely?

A Part of our job in addition to collecting and analyzing the stream flow data is in order to form a data base for predictions is collecting and analyzing sediment data in any form.

Q Other than collecting and analyzing sediment data, are you aware of any other projects which make predictions that sediment data was a high or low estimate of the actual sediment transport?

A There are certain tributary studies in which they make an estimate, sediment loads and some statement as to the error and the direction of error which would be a standard thing to make.

Q Are you aware of any projects which make a prediction based on the analysis and gathering of sediment data in discharge measurements of the estimated sediment movement at flood peak discharges?

A I don't know of any specific.

Q In your experience in the geological field, is the project that was done in the case of the Outboard Marine Company, a unique project in terms of what the USGS was asked to do and the findings and predictions it was asked to make?

A No.

Q Can you tell me of any specific projects that were similar?

A Well, we have another project that is currently being carried out by our DeKalb office to study the effect of urbanization on transport.

In that project, they have taken an area of farmland which is going to be turned into residential housing and they have set up a house sampling system designed to measure the measure of sediment carried to the outlet of the stream by transport within the stream, by transport off the slopes and they will continue to make the sampling on that site and measure the process during the process of urbanization to make a conclusion of how much sediment load is caused to the process of completion as compared to the base load of the stream and presumed to predict what might happen to that sediment load as the property will become stabilized and so on.

To me, that is a very similar project.

Q Was that project under way at the time this project was begun?

A I don't remember exactly when that project started. I was not directly involved with it, but I think they were begun about the same time.

Q Is that still ongoing?

A That is a five-year project which I believe is in the third year.

Q Are you aware of any similar type projects done on a short term basis such as this one?

A This is certainly much shorter than most of the projects the Survey engages in.

Q You are not aware of any others?

A I cannot think of any specific projects beyond with this short term.

Q Is the reason it is shorter than most of the other projects that the USGS engages in because of the time limitations placed on your Agency by the US EPA?

A Yes.

Q I would like you to look at what we have marked as Exhibit No. 1.

Can you identify Exhibit No. 1?

A I have seen it before, certainly. I reviewed it, made some suggestions as to changes.

Q It is called Interagency Agreement between U.S. Geological Survey and the U.S. Environmental Protection Agency, is that right?

A Yes.

Q This is the contract that was entered into between the USGS and the US EPA for the project involving Outboard Marine Corporation?

A I don't know that this is the final version of the contract.

Q Does this version encompass your proposal that you submitted and was approved?

A Largely, yes.

MS. OLIVER: If there is another draft of this floating around or signed, final proposal, we would like to see it.

MR. HYNES: I don't know if there is another one, but if there is one. You got that from us, is that right?

MS. OLIVER: Yes.

MR. HYNES: I assume that is the only one we have, but I will just double check.

BY MS. OLIVER:

Q Did you prepare the statement in the Purpose in Paragraph 1?

A No.

Q You understood the purpose to be as stated in Paragraph 1?

A Yes.

Q Part of Paragraph 1 states:

"This information would be used in helping to determine the transport of polychlorinated biphenyl (PCB) contaminated sediment from the Ditch to the Lake. This information will be used to support the Government's position in a lawsuit, filed against the Outboard Marine Corporation (OMC) in Waukegan, whose discharges allegedly caused the contamination problem."

Was that information you were given by your superior, Mr. Toler?

A I assume that at some point in the process he said that to me. At what point I got it from him and what point I got it from documents like this that I was given to read, I cannot say.

Q Paragraph 2 is entitled Scope of Work.

Are the items that appear in Paragraph 2 items that you prepared and were in your proposal?

A It is a combination of things that were in part of the proposal that I wrote, the part that was written by someone else and some things that were discussed at the meeting we were talking about, field techniques.

Q The items listed under A, first of all under Scope of Work, was what? Can you briefly tell me what the theoretical stage-discharge and velocity-discharge relationships are?

A That is the process of rating a stream, determining relationship between water level and the amount of water that passes through this stream.

Q That was done by measurements or data collection at eight sites along the North Ditch?

A The intention was to be able to rate this stream along its entire length; that is, to be able to predict the water level at any point along the stream.

Q Was that done, in fact?

A It was done to a lesser degree than we would have liked to. That was the reason for the staff gages all along the length. We didn't need those specifically to get the stage-discharge relationship at the recording site. We needed those to develop that relationship at other points along the gage and to collect the theoretical calculations.

Q When you say it was done to a lesser extreme than what you had hoped or what you wanted, to what degree was it done?

A Al did obtain the stage-discharge relationship there, but I think he would have less confidence in that discharge-stage relationship than the one developed at the recording gage.

Q Where did he obtain the one you would think he would have had less confidence in? Are you talking about at this gaging station?

A Those would be the points of control. The problem is, well, the channel varies considerably along its length, including the culverts and the way you pass the water through the culverts is different than the way it passes through an open channel. It adds an extra complicating factor.

Q I guess what I am asking is one of the intentions of the project was to develop theoretical stage-discharge and velocity-discharge relationships at eight sites along the North Ditch.

I am asking if that was done in fact.

A I think there were only five sites that were finally instrumented. We finally had staff gages. Why that decision was made, I don't know.

Q You would have wanted eight, that was in your proposal?

A Me in the sense of USGS?

Q Right.

A I personally needed only one.

Q Why would you have eight instead of one?

A One reason to be able to check the theoretical water surface profile developed from the step-backwater analysis that is discussed in the report, the ultimate.

Q The eight sites were initially contemplated to give you a better idea of what the relationships were that you wanted to find, is that right?

A Yes.

Q For some reason, the eight sites was changed to five?

A Yes.

Q And you do not know who made that decision or why it was made?

A I'm sure it was Al Noehre who made the decision. I don't know why.

Q You don't know why?

A No. I'm not sure -- I am fairly sure this is not the final agreement, but, and I say that because of Point 5, which I believe we objected to and was deleted.

Q We will get to Point 5.

A There may be other things later on.

Q Under the intention to develop theoretical stage-discharge and velocity-discharge relationships at eight sites, there are a number of subparagraphs, and I take it those subparagraphs were specific things to be done to each degree of the relationship?

A Yes.

Q No. 1 is Installing 4 or 5 Staff Gages at the 8 Sites.

Do you know if 4 or 5 staff gages were installed?

A Yes, that is what I was thinking of when I said I think there were only five. I don't know what the other three were.

Q There were no staff gages at the other three sites?

A I don't know that the other three sites ever existed. I don't know what they were.

Q Paragraph 2 is the site further downstream will have stage and rainfall recorders installed by USGS.

Was that done?

A Yes.

Q Was one stage and rainfall recorder installed or more than one recorders installed?

A There was one of each installed.

Q It was done at the mouth of the North Ditch?

A Not right at the Lake, but as close to the mouth as they could come to be sure it wouldn't be washed away by the waves.

Q No. 3 is to collect data to determine the mathematical model.

Was No. 3 done?

A No.

Q Do you know why it was not done?

A We felt we didn't collect enough data to do that.

Q Could you have extended the project to take additional data or gather additional data to do that?

A That option never came up from our point of view. We could have.

Q Could it have been done if you had longer time to do it?

A And more money.

Q What was the purpose or the significance of collecting rainfall and runoff data to calibrate a mathematical model? What would that do?

A If the flow events in a stream, runoff events are caused most commonly storms, rainfall events, and you can develop reliable relationship between the two in terms of intensity and time distribution and relate the intensity and time distribution of the rainfall to the rainfall and time density of the results, you can then use that model to predict what kind of discharge in density and time distribution you would get in times of future rains.

Q And you did not make any calculation of what effect future rainfall would have in the Ditch?

A No, we did not.

Q Paragraph 4 involved obtaining cross section measurements of all eight sites with the resultant water surface profiles and then computing velocity-discharge relationships at each of the eight sites.

Do you know if that was done?

A We measured cross sectional profiles at more than eight sites. I think it was 13 sites and water surface profiles on that data and every time someone read the staff gages which would have been at least as often as the discharge measurements were made, that would have been a water profile to the Ditch, related to that discharge.

Q Why was that important to do?

A In a short term study like this, those data would just serve to check the predictions you made on the basis of theoretical models. In a longer term study, those measurements would be the relationship between themselves.

Q You came up with a theoretical model prediction in the studies, is that right?

A Yes.

Q Did the cross section measurements that you made in fact check that theoretical model?

A The cross section measurements are just a basis of input for the model. It is the water surface profile that is the result of them.

Q Did you use the water surface profiles to correct the mechanical model?

A To adjust it, to calibrate it, in a sense.

Q Are you saying that on a short term study, it is not possible to obtain enough data to make accurate predictions based on data itself, but you use a theoretical model?

A Yes.

Q And you use the data that you are able to gather in the short time as you state to check to see if your theoretical model is in the ball park?

A You examine it and you adjust it.

Q Paragraph No. 5 involved placement of marked poles or poles with washers at the eight sites to determine degree of sediment deposition or scour. That was not done, you testified earlier?

A Yes.

Q Why was that not done?

A We felt it would not add anything significantly and it would be difficult to do because it would mean someone would have to visit the site very frequently.

I believe we felt at that point the personnel was just not available to do that.

Q What would the marked poles or poles with washers, what purpose would they serve?

A In some cases, they can be used to tell how the sediment is moving within an area.

If you put a pole, just slip a washer loosely over it, if the flow scours around the pole, the washer will just slip down. If further flow develops, the washer will become with sediment around it, the washer will become covered up. If you have the original level of the washer very carefully surveyed and can tell in fact it has been moved down and covered out, you can tell something by the scour and fill and how it has been pulled up. And it becomes a closely spaced network, you know how the scour and fill is behaving over the whole stream bed. You can get a better idea of the bed and how the bed material is moving.

Q How can you get an idea how the bed material was moving without the pole and pole washers and --

A We didn't, in that sense.

Q You didn't feel it was necessary to the project?

A We felt it wasn't possible to do it in the way that would add substantially to the project.

Q Did you believe that it was an important or significant step in reaching the conclusions that you reached?

A I think the conclusions I reached would not have been affected.

Q Were there other conclusions you could have made based on the poles and poles with washers?

MR. HYNES: Objection, could have made?

I object to the form of the question, but you can answer.

BY THE WITNESS:

A It is possible.

BY MS. OLIVER:

Q What types of conclusions would those measurements or that determination help make?

A We could have, if it had given us good data which we felt it would not, would have been able to help us to be able to say whether sediment was continually being eroded from the lower part of the Ditch, apart from the samples and calculations, and whether they were made for --

Q Excuse me a minute.

Could you read that back?

(Answer read.)

BY MS. OLIVER:

Q Did you measure in any way how much if any sediment was being eroded from the bottom of the Ditch?

A No.

Q Is that a significant factor in determining the movement of sediment from the Ditch into Lake Michigan?

A Was what?

Q Was the amount of sediment being eroded in the bottom of the Ditch a factor to consider in determining sediment transport from the Ditch?

A Not the amount but where it's coming from.

Q Where what is coming from?

A Sediment.

Q Did you consider where it was coming from?

A No.

Q Do you know who proposed that Paragraph 5 be added into the contract?

A We had a meeting with the US EPA at which we were talking about our field plan and that was one of the ideas that was brought up and they wrote this agreement up as a result of our proposal and the result of that meeting and it was included here.

Q Then you and your supervisor reviewed this and decided what should stay in and what should not stay in?

A Yes.

Q No. 6 states that the USGS shall deploy equipment and instruments as necessary to accomplish the above before the first major snow-melt of the spring.

Was that done?

A Yes, I believe it was. I think we got most of the snow-melt.

Q Did the snow-melt occur before a rainfall event?

A I don't remember.

Q The second sentence in Paragraph 6 states if snow-melt occurs before a major rainfall event, an attempt shall be made to describe or measure quantitatively the flow conditions associated with this melt.

Do you know if this was done?

A I know there was nothing specifically done on snow-melt runoff as separate from rainfall. That was the year of the big snow. There was a lot of snow around. It took a long, long time to get rid of it, so my memory was there was no one significant snow-melt event. It took place over a long period of time.

Q Do you recall if the flow conditions were measured quantitatively during the snow-melt or was --

A The recorder started on whatever date was in the report, the 13th of March, which certainly should have gotten most of the snow-melt and the stage recorder would record the runoff, whether it was due to rainfall or snow-melt.

Q Based on the fact that there was a lot of snow that year, do you know whether the fact of a lot of snow melting increased the flow in the Ditch?

A Over a normal year?

Q Over a normal year.

A We can't say because we don't know what a normal year would have been. It certainly would not have been a necessary result for the higher than usual snow.

Q Could it result in a higher flow in the Ditch?

A It could.

Q Did you take that into consideration in making your conclusions in your report onthe amount of flow and transport of sediment?

MR. HYNES: You mean in terms of 2, 5, 10, 15, that peak year?

MS. OLIVER: No, in terms of movement of sediment during that period of time and then the conclusion that it was probably lower.

MR. HYNES: All right.

BY THE WITNESS:

A Yes, we did.

BY MS. OLIVER:

Q How did you do that?

A Just intuitively, just basing judgment as to what effect it had.

Q Is that in the report somewhere?

A No.

Q Is there any way you can explain to us how you took that into account other than intuitively?

A I cannot. Al Noehre probably could.

Q Out of the six steps that are outlined in Subparagraph A of Exhibit No. 1, which of those steps were in your original proposal?

A They are more specific than what was discussed in the proposal in terms of the number of sites. I'd say 1, 2, 3, 4 would have been included in the original proposal. The sixth one is merely, considers timing which was not specific at the time of writing of the proposal.

Q Were there any steps in your proposal that you felt necessary to be taken that are not listed in Paragraph A here?

A No.

Q Paragraph B of the Scope of Work states that USGS shall quantitatively assess the potential for movement of the PCB-contaminated sediments from the North Ditch.

Was that part of your initial proposal?

A My proposal concerned movement of sediment. It didn't --

Q Did not involve the quantitative assessment of PCB as sediment?

A Didn't specify PCB-contaminated sediment in my memory.

Q Did the final agreement between US EPA and USGS include Part B of the Scope of Work in Exhibit No. 1?

A I'm sure it did. Not necessarily in this form here.

Q Do you recall what form it did?

A Well, my memory is that we objected to Part 4 under Part B in that we felt that anything having to do with PCBs themselves was not in the scope of our expertise. And we stressed the point that we would be dealing with just the sediment itself and not with what was on the sediment in the sense --

Q Do you know who included Part B into this draft?

A Who wrote this? No, I don't.

Q You did not do any quantitative analysis or assessment of the movement of PCB-contaminated sediment from the North Ditch?

A We did a quantitative assessment for the potential of movement of sediment from the Ditch. If they are contaminated sediments, it in no way affected our study.

Q But you did not determine how much of the sediment was PCB-contaminated or how much of the sediment that was moving was PCB-contaminated?

A Correct, we did not.

Q There are four subparagraphs under B detailing the steps to be taken to accomplish the quantitative assessment of PCB-contaminated sediment movement from the North Ditch.

Were any of those four steps undertaken by USGS?

A No. 1 was. No. 2 was for two rainfall events. No. 3 was. No. 4 was not.

Q No. 1 briefly was what?

A That was the gathering of bed material samples, having them analyzed for grain size and applying the Shield's criterion that I talked about earlier.

Q Were those the bed samples that you personally went out and took?

A Yes.

Q How many of those samples did you take?

A 16.

Q Are you talking about 16 composite samples or 16 samples?

A These were samples of bed material at very low flow conditions, so actually I walked into the stream bed and used a grab sampler, just grabbed a chunk of sediment at 16 locations.

Q Those are the only bed samples that were taken during the project?

A For our use, yes.

Q What purpose or what significance did the bed samples have in your study?

A That is a major source of material which is to be transported and so it serves as an axis for all of the indirect calculations and direct methods of calculating load.

Q Because you can't measure, in fact, the amount of moved sediment that is actually moving. You take a sample and calculate or analyze the grain size and specific gravity and then indirectly come up with a theoretical model on how much the bed is being transported?

A At very low or zero low flow, most of the sediment will just lie still on the bed so it is bed material. When you get a flow event, a certain amount of that has been carried up into the flow so that you will sample with your sampler and you can measure. Some of it is always carried very close to the bed and you cannot measure it so the indirect methods actually are used to calculate both loads, but yes, it is to get at a layer that is very close to the bed that you cannot measure.

Q Did you make field notes when you went out to obtain these bed samples?

A Yes.

Q Are those included in the file that you keep on this project?

A Yes.

MS. OLIVER: We have asked for the file, Jim, so we include the field notes.

MS. HYNES: No. 6.

BY MS. OLIVER:

Q The surface sediment samples that are mentioned in Paragraph 1 were taken by field personnel?

A Yes, those are the same. Those are the ones I took, same ones that we were talking about.

Q Are surface sediment samples the same as bed samples?

A Bed sediment samples, yes.

Q Paragraph 1 provides that samples shall be split for analysis by US EPA for total PCB. Do you know if that was done?

A Yes, it was. I know that they were split.

Q Your split of the sample was used for your calculation of grain size and specific gravity?

A Yes, it was sent to our Iowa Lab for size analysis.

Q It was not used for any other purpose?

A Yes, it was not.

Q Paragraph 2 provides that during each of the three rainfall events to be analyzed, USGS shall measure water temperature and water depth and shall collect suspended sediments samples from the downstream station.

That was done, we talked about that earlier today?

A Those are the samples we talked about earlier today, yes.

Q The 20 samples?

A 17, not 20, during the two rainfall events.

Q Paragraph 3 provides for three rainfall events and only two rainfall events were actually used?

A Yes.

Q Why was that?

A It was just a question of getting the personnel there to catch the rainfall events. We only managed to hit on two. A difficulty in sampling problems, streams like that have a very, very rapid response to rainfall. If you are not sitting right at the site, your chances of missing it are very good.

Q Again, if the project had been extended for a longer period of time, you would have gotten another rainfall event, perhaps?

A Possibly.

Q Who determined three rainfall events would be the number to be used?

A I don't remember.

Q In your proposal, did you determine how many rainfall events were necessary for this particular project?

A I don't remember.

Q Do you have an opinion of how many rainfall events are necessary to determine sediment transport?

A No. I think three was probably an arbitrary number picked on the basis of judging how many might be possible to get in the amount of time.

Q In your opinion were the two rainfall events that actually occurred adequate for purposes of what you wanted to accomplish in this study?

A They were not adequate to develop the rainfall and runoff relationship that would have allowed a prediction of future runoff events.

Q Let me ask this:

When you drafted your proposal, did you contemplate having adequate rainfall runoff data so as to be able to predict future sediment transport?

A That was one of the goals of the study, yes.

Q That was not reachable or attainable because of the inadequacy of your data?

A Yes.

Q Were there any other goals or purposes of the study that you could not accomplish?

A No.

Q Did you substitute the prediction that you made for sediment movement at flood peak discharges for the goal that you weren't able to accomplish because of the inadequate data?

A That would be a fair statement. We added it because we felt it was something we could say. I believe it was not in the original proposal, so we could say that was a substitute.

Q It was the best you could do under the circumstances of the data that you had?

A Yes.

Q Paragraph No. 3 talks about plotting rating curves for suspended sediment and total sediment discharge.

Were those curves plotted?

A Yes, they were what are called in the final report, the sediment transport curve.

Q Paragraph 3 also states that those curves shall be used to determine sediment discharge expected at a given water discharge.

Was that able to be done?

A Yes, that was what we did to come up with the daily sediment loads and the sediment discharge at flood peak discharges.

Q In Paragraph No. 4 which provides for an estimate of the rate of transport of contaminated sediments into Lake Michigan shall be made by USGS, that was not done by USGS, is that right?

A That is correct. We only estimated the rate of transport of sediments into Lake Michigan.

Q You were not concerned with whether they were contaminated or uncontaminated?

A Correct.

Q During the rainfall events, were records kept of intensity and duration of rainfall?

A The rainfall was recorded by the rainfall gage on the site and records kept, yes.

Q And that record would indicate how long the rainfall lasted and how much rain fell?

A Yes.

Q Are those records indicated at all in your report?

A They are given on a figure in the report. I believe it is the figure 2 that shows, that has a time along the bottom axis and several measured variables along the other axes, one of which is rainfall, so it would give daily rainfall.

Q Paragraph No. 3 of Exhibit No. 1 states predictions. Are the predictions that are stated in the manner of operating that which was followed?

A You are talking about the three at the bottom, we are talking about three up above?

Q No, I am sorry.

A That was the procedure that was generally followed, yes.

Q Do you know what funds would have been provided to USGS for this project?

A No, I don't remember.

Q On Page 3 of the exhibit, there is a section called Reports and Paragraph 5, do you see that, the first sentence which talks about summary reports including data, observations and interpretation shall be submitted to the project officer as soon as possible following the first and second events observed and before May 15, 1979.

Do you know if the project officer received summary reports?

A The only reports that are written as a result of the project were the progress report, which I wrote which I believe is dated August of '79, but was in fact, I think, if I am correct in saying this, sent to EPA in draft form somewhat ahead of that. The reason for writing a report at that time was the May deadline.

Q Did the field technicians have observation reports to fill out?

A You mean did they fill out reports on measurements?

Q When they went out to the site, did they have some reported procedure to follow?

A They have standard methods of taking notes for discharge measurements and recording any other samples that they take and these would have been submitted orally.

Q Right.

A Yes.

Q What was your title with respect to this project?

A The only title associated with a project is the Chief. All other personnel are just project personnel.

Al Noehre was the Chief of this project. I was just one of the project, the other project personnel, really.

Q Did Mr. Noehre have an input in the proposal that you drafted and that was finally approved?

A I assume that it was either he or Larry Toler who wrote the original proposal and that I was shown when I arrived at the Survey and who had the major hand in writing the hydrologic, the proposal.

Q Did you submit your reports on this project to Mr. Toler?

A In the case of the final report, we wrote that together so we really wouldn't call that submitting. It was a joint effort.

Q How about your progress report?

A The progress report, I wrote, and keeping him aware of what I was doing and certainly having him review it at each stage.

Q Would it be fair to say that Mr. Toler was in charge of the field aspect of this project and you were in charge of the interpretation and conclusions?

A The first part is certainly true. He was also in charge of and had a major hand in the analysis of data and the conclusions concerning the hydrologic aspects of the study, whereas, I had the major hand in carrying out the work and then forming the conclusions and sediment aspects.

Q I would like to show you Exhibit No. 2 and ask if you can identify that.

A Yes, I can.

Q What is that?

A This is a progress report that I wrote sometime in the spring of 1979.

Q What was the purpose of the project report?

MR. HYNES: Progress.

BY MS. OLIVER:

Q Progress, sorry.

A The purpose was to sum up the data and calculations that we had at that time.

Q Was this written during the course of the sampling and recording on site?

A If the sampling was still going on as this was being written, yes.

Q Was this written because of the requirement in the summary report?

A Yes.

Q It was not written because you felt you had enough data to give tentative conclusions in the report?

A It was written because of the requirement. It also initially fell, the result of the project naturally fell into two parts: That which we could do theoretically and that which came under the field measurements scheme.

Q What part did that report address itself to?

A A description of bed materials, an estimate of mobility of the bed materials through the Shield's criterion; the initial-motion criterion and all the calculation of bed material load through indirect methods.

Q When you say the calculation of bed material load through indirect methods, again, are you talking about calculations, the theoretical calculation of how much bed material would be transported through the Ditch?

A Yes.

Q So when you talk about sediment load and bed material load, you are talking about how much it is moving, being transported?

A Yes.

Q What were your conclusions in this preliminary draft?

A We presented the results of the calculations study by the indirect methods, stated that they gave a wide range for the sediment loads in the Ditch; that at that time, based only on actual measurements of sediment load, we really could not say which of these beds predicted the conditions in the Ditch, so what we made are general statements that you could take the higher one as a maximum end of it and it was a very high maximum.

Q Are you saying based on the size of the bed samples that you took, you made theoretical calculation of the sediment movement?

A Based on the bed material samples that we took and on the cross section measurements that we made and on the slope that was measured.

Q You applied three different theoretical models to that data?

A Right.

Q Are there more than three theoretical models that could be applied?

A There are many more than three methods for attaining sediment loads. Most of them are not theoretical.

Q Could you use, based on the data that you had available to you, any other methods that exist?

A Yes.

Q What were those other methods?

A There are several other equations available. They differ in what data was used to fit the equation and whether you consider the shear stress or you consider mean velocity as the criterion you want to measure. There is -- I forgot what the question was already.

Q Well, were any of the other methods that were available to be used other than the three that you tried, other than theoretical equations?

A (No response.)

MS. OLIVER: Let me try again.

Let me ask it this way:

BY MS. OLIVER:

Q How did you determine the three models stated were the most appropriate to use?

A One of the methods, the one developed by Einstein is generally considered to be the best well-founded physically. It is also the most complicated one.

The reason it is considered the best well-founded is it is based on a consideration of the forces on the part of the flows.

Q What about the Graf and Acaroglu?

A The same physical variables are involved in all of them in that one has just different assumptions. It was designed to be used in pipe flow as well as open channel flow, so it is a more general equation.

The difference between those two and the Laursen method are that Laursen uses the critical motion criteria. As part of it, he considers the value of the shear stress that exists on the bed at the given flow as compared to the critical motion criterion, whereas, both Einstein and Laursen avoid, Eisntein and Graf avoid the necessity or getting into defining critical motion.

It was partly for that difference that I included that one.

Q Is the Graf that prepared this physical model related to you?

A No.

Q I guess my question was how you limited your application of the data to these three models rather than other models.

A I didn't see any reason for doing an infinite number of calculations. I picked out those three that in my opinion were most well accepted, covered the range of approaches available and included values that we had measurements for.

Q There were other equations that you could have used but you did not have measurements for those?

A Yes.

Q And you got from those three theoretical models a maximum discharge and a minimum discharge?

A Sediment discharge you are referring to now?

Q Yes.

A No. You get only one value related to a given discharge.

Q You came up with three different values using the three indirect methods, is that right?

A Right.

Q We had better define what you mean by indirect methods as used in your report.

A Anything that is not measured, a combination of theoretical and empirical relationships.

Q You wound up with three values for sediment discharge based on the three methods?

A Right.

Q How did you determine which one of those three was more accurate than the others?

A We did not.

MR. HYNES: You mean in terms of progress report?

MS. OLIVER: Yes.

BY MS. OLIVER:

Q You did not?

A No.

Q Did you come up with any judgment as to which would be more valid?

A No.

MR. HYNES: Again, you are talking about just on the progress report?

MS. OLIVER: Yes.

MR. HYNES: Okay.

BY MS. OLIVER:

Q When you completed the progress report, did you yourself have an opinion of which was the more valid approach?

A No.

Q In your progress report, you talk about the total sediment load bankfull discharge. What does bankfull discharge mean?

A That is just the discharge at a stage which the water level is right at the bank, just before it begins to flow over into the flood plain.

Q So that is a very high flow?

A Very high flow, yes.

Q Did you have recordings for the bankfull stage?

A In the period of measurement, we never recorded a stage anywhere near that bank flow, no.

Q You came out with a sediment load at bankfull stage?

A In the progress report, I developed, again, by theoretical methods, the stage-discharge relationship and this was not in any way related to -- well, any flow frequency information that would have allowed me to predict what actually occurred.

Q What was the purpose of doing that calculation?

A Because I needed that as a basis for the sediment calculations. I have to know, I have to have some flow information in order to get the sediment discharge.

Q Flow information that you had wasn't adequate for you to come up with that calculation, the full data that did not permit you to make a calculation based on the data, so you made an indirect calculation?

MR. HYNES: I am not sure I understand that question.

BY MS. OLIVER:

Q Go ahead. Do you understand?

A What I did with my indirect methods in terms of getting stage-discharge relationship are very much, was really the same thing that Al did when talking about the step-backwater analysis. It is using the energy equations with the channel configuration, you essentially, say, give it a stage or a water level.

Q When you give it a water level, you just think up, you make up a water level to use?

A Yes, make up a water level to use.

Q Then what do you do?

A And you calculate the discharge at that water level, theoretical equations other than measuring it.

Out in the field, the stage recorder will record the stage and the technician goes and measures that and plots that on a graph.

In this case, I say if the water level is this, the theoretical relationships give me a discharge of this and I plot that on my curve.

Q And once you get that discharge, what do you use that discharge figure for?

A I use that in the sediment equations.

Q So you then determine the flow?

A As the basic flow that is carrying the sediment.

Q First you are determining theoretically what the discharge is and then you are using that theoretical calculation to make another theoretical calculation of what the sediment flow or discharge will be?

A Yes.

Q First you take the water discharge -- I get it.

You did that for each of the three indirect methods?

A Yes, except that the hydraulic calculations were the same for all three.

Q You assumed flow and calculated discharge and used that discharge to plug into each of the three equations?

A Sediment, yes.

Q Did you check the result of those calculations, the theoretical equation result that you came up with against any data that you had?

A At that time there was no data.

Q So at that time you could make no, even a guess as to which one of those was close to what was happening in the North Ditch?

A Yes, correct.

Q What was the purpose of making the calculations and using the equations in the progress report?

A One was to just give the best estimate we could at that time as to how mobile the sediments were and what might be moving out and what conditions.

Q But they were not based on any real data that you had.

A They were based on channel geometry and bed material samples.

Q But you could not check the accuracy you were getting as a result.

A No. The other reason was to present what we would be collecting in the field data against --

Q Kind of a dry run to find out what the results would be?

A Chapter 1.

Q Was this progress report submitted to US EPA?

A Yes, it was.

Q Before it was submitted to the US EPA, was it revised by Mr. Noehre?

A It went through the standard internal USGS review which would be in this case Al and several other people in our office.

Q Did you get any comments from them on this progress report?

A It was rewritten as a result of their comments.

There was no substantial objections to any material contained. It was merely clarifying the grammar, correcting the grammar, clarifying the statements.

Q If you would look at Page 11 of your progress report, the first paragraph called Results, the third sentence starting with, a water temperature of 20 degrees centigrade was used for the calculations.

How was that temperature determined?

A That was just an arbitrary temperature that was chosen because it was a temperature which many values, variables that are available, and it is one of several standard temperatures considering I didn't have any temperature measurements in the Ditch.

Q Were they taken in the Ditch?

A I don't know.

Q Wouldn't the temperature in the Ditch affect the flow, the discharge in the Ditch to some extent?

A It affected sediment movement.

Q Was that provided or considered in your proposal and the study that was done?

A Not specifically, no.

Q Does 20 degrees centigrade increase or decrease the normal sediment flow in the Ditch?

MR. HYNES: From what, increase or decrease from what?

MS. OLIVER: From the normal temperature.

BY THE WITNESS:

A The temperature is something that changes constantly. You would expect it to be cold in the early spring and in the winter, and then warmer in the summer. When the temperature is cooler, that would tend to increase the sediment load.

BY MS. OLIVER:

Q That is what I meant.

The lower temperature increases the sediment transport?

A Yes, and in the early spring, I would have expected the temperature of the water to be much less than 20 degrees centigrade. It is knowledge that it got higher than that in the summer.

Q Sure. So the temperature of any body of water is a variable for determining the sediment transport in that body of water?

A By indirect methods, yes.

Q Unless you are there to check the temperature?

A Yes.

Q And you don't know if that was done in the North Ditch?

A I don't know.

Q You also say in that sentence, grain density was to be taken to be 165 pounds per cubic foot.

Was that by analysis in a laboratory or was that an assumption that you made?

A That was just another assumption. The temperature was an assumption but based on the fact that the dominant mineral that the grains are made of is quartz and most of the materials that form these grains have densities which are not really different from quartz, so that is a commonly made assumption and one that is usually very close to reliability.

Q Do you know if analytical work was done to determine whether the density was in fact 165 pounds per cubic foot?

A It was not done.

Q And you state channel slope was .000399. How was that calculated?

A That was measured from the survey that was made at the beginning of the project that provided the channel configuration and the surveying end of the gages. They were tied into some absolute elevation by surveying techniques to see that the level of each cross section as you move up the stream was given relative to the same survey point, and you just get the slope by the difference in elevation.

MS. OLIVER: Off the record.

(Brief recess had.)

BY MS. OLIVER:

Q Let me ask this:

Were any of the factors that you put into your equations in your progress report based on the actual data that you had obtained, other than the channel slope?

A The grain size distribution of the bed material was used in the calculations. You need a grain size that represents the bed roughly and that is based on measured grain size distribution of that material.

Q That was analyzed by the lab in Iowa?

A From the samples that I took.

Q What else?

A The channel configuration of the cross section of the channel and the size of the channel.

That was it.

Q Your calculations or your use of the equations in the progress report were based on assumptions that sediment is transferred by a steady uniform flow, is that correct?

A Yes.

Q That is not always the case, I take it?

A No. Certainly not in nature.

Q But your calculations and indirect methods that you used were based on a steady uniform flow?

A Yes.

Q And that had no relation to what was actually going on in the North Ditch?

A I don't know what you mean by that. You mean did I check that with the field?

Q You assumed a steady uniform flow and determined what that discharge would be?

A Yes.

Q In reality of the North Ditch, it did not have a steady uniform flow?

A Probably not.

Q In fact, that was confirmed by the measurements, isn't that right?

A In a sense, most -- steady means that the flow doesn't vary with time, and uniform means that the slope of the energy grade line is parallel to the bottom at all points of the Ditch.

It is probably safe to say that those conditions are never really strictly met in any channel, but it is the basis for practically every equation that describes flow or sediment transport because there is no way to account, really, for the variations in most cases. So you consider that the flow is in natural channels really usually uniform or usually it is steady for finite periods of time and uniform over certain given areas.

Q Isn't the second variable in addition to temperature the fact that the flow in the channel and the stream or whatever body of water is not steady and uniform at any given time a variable that may make determining the sediment discharge a very difficult thing to do?

A Yes.

Q That is why you use a theoretical equation, and that is why --

A You use a theoretical equation because you want some way of estimating it when you don't have field data.

Q Besides the flow in a body of water and the temperature, what other variables exist which make the determination of sediment discharge a complicated or difficult thing to do?

A The natural variability in size and density and shape of a material that is being transported is one thing. The cohesive forces that exist among certain mineral compositions and grain sizes --

Q What does that mean, the composition of forces?

A There are forces that attract like particles due to unbalanced charges on the surface of the minerals. They exist on any mineral grain, but usually for most minerals they are very weak.

As the grains get smaller and smaller, the surface area increases so the effect of the forces increases. For a very fine quartz, the attractive forces due to large grains becomes a very significant chance for transport. They are most significant in clay minerals, oil or plants just because of the crystal structure of the mineral itself. They have larger unbalanced forces and very, very fine, so they have a much higher surface area, so predicting the movement of cohesive sediment is much harder.

Q Would you classify the sediment to the North

Ditch as cohesive?

A No. It was in the areas of the bed that were exposed to a very clean largely quartz sand in which cohesion would be minimal. In the pool areas that were covered with water, when I took my samples, the sediment was much finer than some of them, it might be significant.

Q Were the pool areas areas that were around the Ditch?

A No, in the Ditch.

Q In the Ditch?

A They are in almost any stream that has a sand bed. There are areas where the stream bed is higher and the stream bed is lower. It is a configuration and is formed by the flow and the areas that are shallower, there are generally coarser sediment than the pools.

Q Did you find the presence of any clay minerals in the North Ditch?

A We didn't analyze the mineralogy but in doing grain size analysis in the pools, there was a significant portion of fine materials and in most unusual terms, much of that fine sediment is made up of clay minerals.

Q And the presence of those pools would indicate to you a stronger cohesive force?

A No.

Q What effect would those pools have?

A As flow passes through the Ditch, the velocity would decrease in the area of the pools because the cross sectional areas is increasing and that would tend to deposit.

Q And reduce the discharge?

A No. The discharge remains constant. What changes is the velocity.

Q Doesn't higher velocity have some effect on the amount of sediment that is being moved through the Ditch?

A Yes.

Q And if the velocity is lowered as it moves through these pools, doesn't that affect the amount of discharge that is being transported?

A Oh, you are talking about sediment discharge?

Q Sediment discharge.

A It would be locally and temporally decreasing at any given flow condition.

Q How is that factor considered in reaching your conclusions as to the amount of sediment that is moved out of the Ditch?

A It didn't affect it.

Q Did you consider it?

A We were not considering where the sediment was being deposited or eroded along its path to the gage. We were only concerned with what was moving past the gage, that was actually getting past the gage. Sediment transport is a statistical phenomenon. Sediment is being deposited. Whether the velocities locally are lower and being eroded somewhere else and the flow may shift, so where it was deposited at one time, it will be eroded in the next instance, so it is really not possible to keep track of where a given particle is going to be deposited or eroded in any given time.

Q What effect did the different grain sizes in the bed system tell you that you have on the qualifications or equations?

A I made the calculations for each grain size separately and calculated the sediment load of each grain size and then added them up to get the total load. I used the grain sizes that were available in the bed for the calculation and I used the fraction of the material in that bed in the calculation.

I don't know what you mean other than that. I don't know what you mean by effect did that have on the calculations.

Q If you would look at Page 15 of your report in the paragraph right above Conclusions, the second part of the last sentence.

You state that the total sediment discharge in the Ditch at bankfull stage most likely lies within the range between the value calculated by that method (6.75 pounds per second) and the value determined by the method of Einstein, (.0301 pounds per second).

How could you make a determination that you state in that sentence or how did you make that determination?

A It was just judgment based on the fact that these are commonly used methods, that the Einstein was very low and it just seemed very unlikely to me based on what I know about sediment transport that you could get anything lower than that and the other one was really very high. It is really a judgment, just a judgment.

Q But as you stated before, I think you had no real basis for comparing any of these three.

A Right.

Q Methods to do the ultimate movement in the North Ditch.

A Right.

Q Did you consider that the actual transport of sediment in the North Ditch could be as low as determined by Einstein's method?

A Yes.

Q But again, you didn't have any basis to say it was that figure or a little above or a little below?

A Yes.

Q The last sentence of your Conclusions states:

"All of the methods used predict that fractions with mean sizes larger than 2.83 millimeters will not be transported in significant quantities in the Ditch."

What does that mean?

A It just means that those grains are too big to be moved in any flows likely to be expected in any ditch.

Q Grain sizes larger than that point wouldn't be moved out?

A They would just stay there.

Q Was there any determination made to determine how much of the bed in the North Ditch consisted of grain sizes larger than 2.83 millimeters?

A Yes, I believe it is Figure 2 here, Page 4, that gives the grain size distributions.

The grain size in millimeters across the top show that 2.83 would be something like 5 percent of most of the bed material.

Q Is that 5 percent of the area of the bed or 5 percent of what?

A It would be about 5 percent by weight of the top few inches of the whole surface.

Q Because only the top few inches are transported?

A Yes.

Q It is 5 percent of the first few inches?

A Yes.

Q I have forgotten if I asked you, but when you sent your report, or when it was sent to the US EPA, did you receive any comments from anyone at the US EPA about it?

A I don't remember any.

Q Who reviewed it at US EPA, do you know?

A I don't know. We sent it to Ed DeDominico, I believe.

Q Did you have any communications with him about this report or what you were doing?

A No.

Q During the course of the project, did you have any communications from US EPA people to do other things or not do things that you were planning on doing?

A No.

Q Would you look at Exhibit No. 3. Will you identify that?

A Yes.

Q What is that?

A This is the final report of the project which gives an estimate of sediment movement in the North Ditch.

Q That is the report that you and Mr. Noehre wrote?

A Yes.

Q Did you prepare a draft of this report?

A There were several drafts.

Q Were they circulated within the USGS?

A Yes.

Q Were they circulated within the US EPA?

A I believe that we sent them a draft report at one stage.

Q Do you have the drafts that you prepared of this final report, did you keep the drafts?

A I don't believe so, other than perhaps the one that was sent. When I use the term draft, loosely, it is just everything from writing up notes, preparing the report, actually getting a copy. I guess there was really only one report, draft report in the strict sense.

Q Included in this final report is a discussion of the actual discharge measurements that were made at the site.

A Yes.

Q Other than the addition of that data in this final report, is there any additional data in this report that did not appear in your progress report?

A There is rainfall data, the stage data that was collected at the recording gage; the discharge, this is the water discharge that was determined from the precipitation at the stage recordings.

Q The daily values of precipitation?

A Yes. That draft has on it the data that I am talking about right now. That is all the data that was added.

Q Let me ask you this:

Other than using the stream discharge data, did you use any other data in making your indirect calculations on sediment transport?

A In this report?

Q Yes.

A The calculations I made in here were direct calculations in that they were based on the measured values of sediment concentration and I used those values with the stream discharge to develop the sediment transport curve.

Q For your prediction of future transport at flood peak discharges?

A Yes.

Q You used the indirect method to come up with the prediction?

A I used the end of the line which was determined from Laursen's method and was unchecked by direct measurements, yes.

Q If we can look for a minute to Figure 7 on Page 12, that is your sediment transport curve, is that correct?

A Yes.

Q From that you make your prediction on the future sediment discharge at flood peak discharges, is that right?

A Yes.

Q First of all, why did you use the Laursen method?

A Why did I choose one out of, from the other two that I used?

Q Yes.

A Because it was closest to the measured values and the range where they overlapped.

Q Is there a way to quantify how closely they were to the actual data that you had, to how close it was to the actual data you had?

A I don't think there would be one that would mean very much.

Q Let us go back for a minute to the previous figure, Figure 6 on Page 10, which has a regression line and then three other equations plotted out, is that right?

A Yes.

Q Is Figure 7 a composite of the regression line in the Laursen line?

A Yes.

Q Why is that composite used?

A Because we wanted to be able to extend the letter, the curve to discharges higher than those for which we had measured values.

Q You wanted to extend the curve to discharges that were higher than the measured values?

A Yes, that is correct.

Q You assumed there would be higher discharges?

A Yes, higher than water discharges.

Q What were the bases for your assumptions there?

A The conditions that existed during the period of the measurement were really fairly low water conditions. There was no flow for a lot of the period. There were some storm events but we felt, well, the highest measured discharge was something like 5.3 cubic feet per second. The discharge that was read for the two years flood recurrence was 15 cubic feet per second.

We did not calculate an annual flood peak for recurrence, but higher; you might expect that once a year you would get over 10 cubic feet per second.

Q Why would you expect that?

A Well, the flood peak discharges were estimated from equations that were developed from a large number, something over 100 gage stations, and in Northeastern Illinois, that varied considerably in drainage area, size and slope and covered the range, all those variables represented in North Ditch.

So we feel that the predictions of flood peak discharges, particularly for the two-year flood recurrence, are as good as you could get for North Ditch and probably pretty close to reality.

Q Based on what?

A Based on the data set from which the equations were presented.

Q And the data set was what?

A The data set was stream flow data collected over a great many years from a large number of stations within Northeastern Illinois.

Q What you are saying is based on the data you had collected is why you assumed what you had found in the North Ditch couldn't be accurate?

A I don't think that is what I said.

Q But you said it wouldn't be realistic or it would be higher.

A I am saying that because of the natural variability of the rainfall and runoff from a particular set of conditions that we measured were probably on the low side. I don't think we sampled the annual flood peak, the statistical one-year recurrence. I think it either didn't happen that year or it happened on the date that the recorder wasn't working.

Q Excuse me.

The time period that you sampled out there was during the time of the big snow-melt which could cause a lot of water, I take it?

A Not necessarily.

Q Why not?

A It could not melt very slowly and trickle out.

Q But it would nevertheless melt and wind up in North Ditch?

A Or percolate through the ground.

Q And over the summer periods when you would expect rainfall events, is that right?

A Was that a question?

Q Yes, it was.

A The study was done over a period in which you would expect most of the flow to occur, yes.

Q What information do you have that shows that the flow did not occur, that the average or the expected flow in the North Ditch did not occur?

A Only that the values that we measured were so much lower than we predict for a flood of the two-year recurrence interval.

Q And your prediction is based on the other data base that you had?

A Yes.

Q What data base is this?

A USGS data.

Q It is for Illinois?

A For Northeastern Illinois.

Q How many bodies of water are included in this data base?

A There were, I believe, 103 gaging stations used.

Q Does that indicate there were 103 separate bodies of water?

A Yes.

Q There is one gaging station in each of these 103 bodies of water?

A Probably. It's possible that some of them had two if it was a long stream, but basically, most likely it was 103 different streams.

Q Did any of these 103 streams flow into Lake

Michigan?

A I don't know.

Q Do you know what the breakdown of these 103 streams was in terms of size, compared to the North Ditch?

A They covered a wide range of draining area. North Ditch would have been at the low end of that size.

I don't remember what the cutoff values of that were, but it would have been in the low end of the range.

Q Did you look at just the bodies of water that were comparable to the North Ditch rather than all 103 bodies of water?

MR. HYNES: Could you repeat that?

(Question read.)

BY THE WITNESS:

A I did not, no.

BY MS. OLIVER:

Q Who did?

A The people that developed those equations. I took the equations that were developed by people in our DeKalb office and published in the Survey Report, the things that they were trying to model or statistical phenomena,so the more equations you have, the better estimate you are going to get and if you pick out any one range of variables, there is no reason to believe that you would come out with a better estimate, really.

Q Wouldn't the only reason you would use the statistical values that had been developed from this data base be when you don't have the value available in the project you are working on?

A Yes.

Q And if you are doing a project and you have values and you come up with measurements, aren't those measurements a more accurate measure of what the situation is from that Ditch than the averages from the 103 other streams?

A If we had 100 years of data, that would be.

Q Is that the only way you can accurately tell what the flow in the North Ditch would be over a 100-year period?

A It is the most accurate way.

Q What is the next most accurate way if you don't have 100 years to sample?

A It is to use a data station that does have 100 years to predict it.

Q Let me ask you this:

Why did you undertake a project that was to measure what was in the North Ditch if you weren't going to use that for determining the transport rate?

A I did use it for determining the transport rate. I am just trying to extend the prediction to conditions that we have not measured.

Q Are you saying that in order to predict what the transport rate in the North Ditch would be, you could not rely on the data that you had collected at the North Ditch?

MR. HYNES: I object to the form of the question. I think that data base she is talking about just predicts the peak discharge..

MS. OLIVER: That is the only prediction that has been made of future transport.

MR. HYNES: I just wanted to clarify you were talking about a peak discharge.

BY MS. OLIVER:

Q Do you remember the question?

A No.

MR. HYNES: I'm sorry, could you read it back?

(Question read.)

BY THE WITNESS:

A Over the range of conditions for which values were collected, that is certainly the best estimate and that is what I used to calculate the data flow of sediment,because on those days the discharge that we estimated was within the range of the measured values, but with the flood peak discharges we are extending the range of the estimate so far beyond any of the measured values with that, there is no reason to believe these measured values would be going on with those conditions any better than the indirect methods. In fact, there is good reason to believe the indirect method might give a better estimate.

BY MS. OLIVER:

Q How can you determine which indirect method to use if the values may have no relation to what you are in fact predicting?

A You use just the logical reasoning that the one that best reflects what is happening at high flow conditions should somehow approach the measured values that conditions, at states where you do have measurements. That was the only reason for picking the Laursen method.

Q And they may not be reliable at all?

A It is an extrapolation, goes beyond anything that is measured. There are no checks on it.

Q Did you take into consideration in making the qualifications in your final report the ground water at the North Ditch, around the North Ditch?

A No.

Q Does ground water affect the flow in the North Ditch?

A I don't know what effect it has in that specific location. It is a phenomenon about which very little is known.

Q Are you saying there is little ground water effect to the flow in a body of water or not?

A There is little known about the effect the ground water has on the movement of sediment in streams.

Q So it could be a factor or it could not be a factor and nobody really knows?

A Yes.

Q On Figure 6, just so I understand, the regression line that is in that graph is the actual measurement?

A Yes.

Q And you added to this graph the three theoretical curves?

A Yes.

Q The Figure No. 7, the composite sediment transport curve does not in fact say that this graph is limited to the flood peak discharge, does it?

A No, because it isn't.

Q This is just an extrapolation of the stream discharge or sediment transport in the Ditch?

A The upper end of it is an extrapolation.

Q And the bottom portion of it is the actual measurement?

A Yes.

Q But in fact there is no basis in the data for the extrapolation on the end?

A Right.

MR. HYNES: What do you mean basis in the data? Do you mean the upper end, there is no actual measured data used to get that graph?

MS. OLIVER: There is no data period to get that which verifies that part of the graph.

MR. HYNES: Is that what you understood?

THE WITNESS: Yes.

BY MS. OLIVER:

Q My understanding of the calculations by the indirect method was that they were to be used to predict the flood peak discharges?

A You are talking now about the indirect method or sediment calculations?

Q Yes.

A Were used to calculate the flood peak discharges?

Q Yes.

A Yes, that is in effect what happened.

MS. OLIVER: Let us go off the record.

(Discussion off the record.)

BY MS. OLIVER:

Q Looking at Figure 7 in your final report, the Composite sediment transport curve that we have there is a composite of the actual measurements of sediment, discharge measurements at the North Ditch and theoretical extrapolation or calculations of what the sediment discharge would be for certain flood peak periods, is that right?

A At any discharge higher than that for which we had measurements, yes.

Q Is the combining of actual and theoretical data such as you did in Figure 7 something that is the usual practice in the USGS?

A The use of theoretical relationships to extend the predictions beyond measured values certainly is. That is what is done every time the USGS does a statistical analysis of rainfall runoff data.

They use a statistical method to examine, in effect, theoretical relationships to extend the data.

Q The bottom portion of this curve that is the portion based on the actual sediment discharges at the North Ditch is the data from which you made your findings of the amount of sediment movement through the Ditch?

A Over the period of the study and the mean daily sediment movement.

Q Then the upper portion of this graph is less reliable in terms of actual occurrences or events in the Ditch than the lower portion of this graph?

A Yes.

Q Then you cannot quantify for me how much less reliable or less confident you are in that upper portion?

A I couldn't put a number on it, no.

Q Do you know how the data was reviewed to make sure that it was accurate?

A Well, any of the data that was sent to our laboratory, which was the grain size data, some of the sediment concentration data for concentration and grain size is checked before it is sent out in that the qualifications, measurements are all each individually checked and reviewed.

Any of the discharge measurements have a standard procedure for being checked before they are finally submitted as final measurements.

Q What is that standard procedure?

A The measurement takes, you take the measurements on a standard form and it involves taking large numbers of measurements, velocity and calculating width, calculating areas so there are a lot of little decisions, routine, which have to be added up to check that large measurement.

You have someone different than the person making the measurement just go out and do those calculations all over again to see whether they have come up with the same answer.

Q Would Mr. Noehre have been in charge of making sure that it is done on field data?

A Yes.

Q Do you know if that in fact was done?

A I didn't see the actual checked sheets. It is standard procedure to check discharge measurements.

Q If you would look to Page 3 of your final report, up at the first full paragraph on Page 3, it reads that:

"Streambed material is composed of sand with some gravel; organic debris and finer sediments are found in the pools."

Do you know what organic debris or sediments in the pools consisted of?

A There are various kinds of degradation flowing along the Ditch and just from my personal examination of it, leaves, grasses, things that were in all sorts of states of degradation had been deposited primarily in the pools.

Q You also state in the next section that because of the large impervious surface area and the permeability of much of the remaining area, it is believed that a large proportion of the sediment load of the stream at Gage 1 is derived from the channel itself.

Gage 1 is located near the mouth of the North Ditch, is that right?

A Yes.

Q What impervious surface area are you talking about?

A The parking lots, roofs, roads that are paved, railroad tracks.

Q You would not think there would be runoff, wash from that area?

A There would certainly be runoff, but the only sediment that would be carried by runoff would be carried on by tires or people's feet, certainly would be a lot less than running off a total sediment surface.

Q You state it is believed that a large proportion of the sediment load of the stream at Gage 1 is derived from the channel itself.

Is that your assumption there?

A It was a judgment that both Al and I made and agreed on together.

Q When you talk about a large portion of sediment load, what portion are you talking about?

A 70, 80 percent.

Q How did you determine that number?

A Just my own opinion based on having been there and looked at the situation, and also measurement of the percent of impervious area.

Q Did Mr. Noehre measure the impervious area?

A Yes, he did.

Q And he came to the conclusion that it was about 40 percent impervious?

A Yes.

Q How did he do his measurement?

A From graphs, from his on-site surveillance and inspection.

Q Did he do a specific measurement or survey of the impervious surface area?

A I believe he did not actually survey in the same sense that you survey in the gage, the areas in percent impervious. I think he used some graphs and some preliminary to determine the area.

Q Based on the estimate that 80 percent of the surface area is impervious, how would you wind up with the estimate that 80 percent of sediment transported is from the North Ditch itself?

A In addition to the impervious area, the materials that form the area which is not impervious are sand, they are very permeable, so I suspect, my judgment is that a large portion of flow that falls on that would actually percolate through the ground and if it gets to the stream at all, would come as an interflow through the ground.

Therefore, I would say that most of the

flow in the basin is probably confined to the channel itself and that therefore, most of the sediment and that and the fact there is a retaining wall in one area and there are grasses that further protect some of the area, particularly in the upper part of the Ditch.

Q On Page 6 of your report, you talk about the fact that Stage was not a reliable indicator of flow at Gage 1.

Do you see that reference there?

A Yes.

Q How was flow at Gage 1 measured, if not by the stage recorder?

A There were actual discharge measurements there at times and the stage was used to get flow based on adjustments at the stage to discharge measurements.

And looking at the stage record, to determine when the periods of flow occurred in a normal stream, you would expect that when the discharge increases, the stage increases, and in North Ditch what happens with a flow event is that discharge increases and stage increases until the barrier bar is breached.

Then you suddenly, the stage falls very abruptly because the water can now flow directly into the Lake at much greater force, so you get an increase in discharge flow or a decrease in stage, really, but that happens very abruptly.

Then you get the typical relationship taking over so the problem with interpreting the record was to identify the points at which the bar was breached from the stage record by this rapid fall in the stage.

Q You are talking about a sandbar that was near the mouth of the Ditch and near Lake Michigan, is that right?

A Yes.

Q And that sandbar would block the flow into Lake Michigan from the Ditch?

A The surface flow, yes, probably some passing through the sand.

Q Would it affect the discharge, the sediment discharge?

A Yes. It would stop it.

Q It would stop it.

So until the flow got to an intensity or velocity that would break through that sandbar barrier, there would be no flow in Lake Michigan or sediment transport into Lake Michigan?

A There would be no sediment transport. There might be some flow through the sand.

Q But it would be reduced?

A Or minor flow over.

Q Did you or the technicians determine how often during the rainfall events that sandbar would be eroded if broken through?

A That was determined from a stage record.

Q Was the sandbar at that point nearing the mouth of the North Ditch a continuous phenomenon or permanent phenomenon?

A It is an intermittent phenomenon. It depends on the conditions in the Lake as well as those in the Ditch.

Q Do you know how often technicians found the sand barrier was present?

A It is probably fairly safe to assume that it was present on all of the days other than those that were listed as periods of flow in the table.

Q There is a record that shows how many periods of flow that sand barrier was eroded or broken?

A It was breached on all the days in which we assumed there to have been flow that were then used to characterize sediment loads. We made that judgment on the basis of stage record by rapid sudden decrease in stage during the period of rainfall.

Q Do you know how many days those were over the 8-month period?

A What page are you referring to?

Q Page 14.

A 39 days and then there is the 14 percent of rainfall that occurred on days for which no stage record was present, so we can't -- that is 39 days out of a little bit less than the total period of the record.

Q The total period of record?

A Something like six months.

Q 6 times 30 might be about 180 days?

A About.

Q Are you saying that every time it rained, the sand barrier eroded or broke, was broken through?

A No. There were periods of rainfall when this rapid drop in stage was not found.

Q During those periods of rainfall there would not be a sediment transport into Lake Michigan?

A Nothing significant.

Q Do you know what days those were or how many days would that have been, the rest of the days?

A No. That would certainly have been, probably a large number of days in which there was no rainfall. You would have to look at the rainfall data on Figure 5.

Q Did you take into consideration , the sandbar effect in making determination, an estimate of the daily sediment load?

A You mean in getting the mean daily?

Q Getting the mean daily.

A We just averaged that out of the total number of days in the study period so that if you considered the mean daily discharge for days on which there was flow, it would be higher. I believe that's what I did.

Yes, that is what I did so that is mean daily for all the days in the study period.

Q So that would take into account the days that there was no flow into Lake Michigan and no rainfall?

A Yes.

Q How about in calculating an estimate of the amount of sediment moved in the study period?

A That was based on periods of flow.

Q That was based on daily periods of flow or your daily mean?

A No, not the daily mean, no. What I did to come up with that figure was we had hourly discharges for every day in which there was flow, which is those days that are listed that are in the table. I took that sediment rating curve based on the measured values and for each of the hourly discharges, calculated how much sediment would move at that discharge which existed for the whole hour. I added up the values for the whole 24 hours in that day and those are the values given in the first column showing load in pounds for that day.

I added up all the values in that column to get the total that was moved during the study period.

Q You assumed the discharge or the flow continued at the same rate for the entire hour period?

A Yes.

Q Is that a reasonable assumption to make?

A Yes.

Q Is that in fact what happens?

A It is very close to what happens because for most of the hours, it was fairly low and it was fairly constant over much of the day.

During storm periods, the storm periods happened so fast that --

Q During the heavy rainfall period, the amount of rain that falls is not usually constant for an hour, is it?

A Certainly not.

Q So you are figuring out the sediment load in pounds over the study period based on an assumption that the amount of flow will be uniform for the hour, each hour there is a discharge?

A Yes.

Q When there is a heavier rain or a heavy rainfall that is in fact not the case, is it?

A It is really not a bad estimate in the sense you are just averaging over an hour and if you can picture the discharge in a storm, it would start at some low value and go very quickly, peak, and then drop off and what you are doing is just taking an average.

So by averaging over an hour, at the end of that hour, you will be higher at the beginning, lower at the end, and you are taking an average of what is in the middle, so you are coming up with something that is not too unrealistic.

Q So your sediment load over the study period is based on what you would assume the average would be over that hour period?

A Yes.

Q Are the dates that are listed on Table No. 2 on Page 14 the only dates on which there was flow recorded over the six-month period?

A They are the only dates on which we could be sure there was flow.

Q In which flow was recorded on your instruments?

A Because the flow is not recorded on the instrument. It is only the stage that is recorded in the instrument, but the stage is a reflection of the flow. We have to make the judgment that the bar is breached and in order to do that, we have to have a dropping stage that was sharp enough and significant enough to be sure that the bar had been breached, that that was in fact an indication of breaching of the bar, so in addition to the lost stage record, there were other periods in which we just could not be sure, so we did not include those. And that is, we have mentioned that somewhere in there.

On Page 7, the very top of the page, it states that discharge could not be computed for 25 other periods because discharge measurements were not available to define the changing control conditions.

Q What does that mean?

A That means we couldn't tell if it was flow or not. And because we didn't have a stage-discharge relationship definition for the stream based on measured discharge values, we used the few measured discharge values that we had to rate the stream for the period of time around the time of that discharge measurement and felt we couldn't extrapolate it too far.

MS. OLIVER: Would you read that back?

THE WITNESS: Maybe I could rephrase it.

MS. OLIVER: Let her read it back and then maybe I'll have another question.

(Question read.)

BY MS. OLIVER:

Q What do you mean you rated the stream? What does that mean?

A Rating means developing a stage-discharge relationship.

Q How did you do that in this situation?

A We did not develop a consistent stable stage-discharge relationship because the control conditions, that is the conditions that control the stage at the gage, were not stable and consistent.

Q Why would you need a stage-discharge relationship? What does that do?

A That is what allows us to go from the recorded values of stage to knowing how much water is passing through.

You either measure it or you can use the measured values of stage and a relationship would be determined in some other way to get the discharge.

Q You did not do that in this case because you did not have reliable enough information or enough recording information at the stage area?

A What we would normally do at the gaging station is over a period of many years, develop a graph that includes many measured values of stage and discharge and then interpret a stage record using that graph to predict, to say what the discharge was at any given time.

Because we had no data at the beginning, we had no rating curve like that. That was one of the goals in the study, to develop one, but in fact that rating curve changed so often during the study, that relationship changed so often during the study and we were not able to obtain one that applied for the whole period of the study. It applied only to a period of the study close to the time of each individual discharge measurement.

The next time somebody went to make a discharge measurement, it would have resulted in a different stage-discharge relationship, so it would apply only to the stage record at that time.

Q What significance does that have, if any, to you? What does that mean, that every time you went to measure there was a different relationship?

A It meant that you could not take the stage record developed and measured in March and use a discharge measurement made in August to get the discharge. What you really needed was the discharge measurement made closer to the time of the stage record that you are trying to interpret.

Q Is that why the field people had to go out and make additional measurements?

A Yes.

Q And not rely on the stage recorder?

A They had to go out and make discharge measurements because no matter what the conditions are, the stage recorder only gives you stage. It does not give you the discharge and ultimately, however you do it, you have to get the discharge for measured values.

Q But the stage should somehow be related --

A Yes.

Q -- to the discharge?

A Yes.

Q And in this case it was not?

MR. HYNES: In the 25 that were not reported on Table 2 or whatever it is?

MS. OLIVER: Yes.

BY THE WITNESS:

A Right. They were just periods when we felt we were unable to say what was going on.

BY MS. OLIVER:

Q So in addition to the 39 that appears on Table 2, there were 25 other periods that you could not define, and then in addition to those periods, there were other periods of missing stage records because of malfunction of equipment, is that correct?

A Yes.

Q Do you know how many periods were missed because of that malfunction?

A That would be indicated on the first figure 3 by the dotted line. It shows a period in the beginning of April that looks, a few days, there is a period of overlapping May and June, a period that includes most of the end of July and a shorter period in August.

Q But you don't know how many measuring periods those actually included?

A No, I cannot.

Q If you look at Page 11 on the report, the first paragraph there talks about your regression equation.

Would you explain to me how you reached the limits of 13 cubic feet per second and 40 cubic feet per second that you discuss in your paragraph?

A The 40 was just picked because that is the 100-year flood and there was no use considering anything higher than that. That is sufficient in itself, such an extrapolation.

The 13 came about, that is the point of intersection of the two surveys.

Q The Laursen theoretical and the regression real data one?

A Yes. That is already extending the measured curve beyond measured values.

Q So the 13 cubic feet per second is more than higher, the higher value than it had actually measured?

A Yes, so that is carrying the curve calculated on the measured values beyond the range of the measurements and at the point of intersection, taking the Laursen, the justification for taking the higher one there rather than just continuing the measured line out is that the measured sediment samples do not include the sediment carried below a level .3 feet from the bottom in the bed and at high flow, at low flows, that amount of sediment is less significant than it is at high flow.

What is going to be carried between a level .3 feet from the bed and the bed is going to be the larger size particles that are just being rolled, bounced along the streambed with the flow and can't actually pick up and carry into the center of the flow.

That is not measured, that is not included in the samples that are based on measured samples.

Q I guess my question is why do you conclude at the end of that paragraph that if discharge is between 13 cubic feet and 40 cubic feet, the largest equation probably gives a better estimate for the amount of sediment transport than the regression line?

A We know that the amount of sediment actually carried in the flow is going to be more than given by the regression line because the regression line is based on samples which do not include part of the load. We have not sampled the whole load, so we know that the total amount of the sediment carried is going to be more than that.

We know from experience with other streams that the amount of sediment being carried in that bed layer, in that layer with the sediment samples does not sample, will increase as the flow increases.

That is basically the justification for taking the Laursen estimate there.

(Brief recess had.)

BY MS. OLIVER:

Q The Laursen equation doesn't consider the total sediment load, does it?

A It does not consider the total load, but it does consider that load carried near the bed. What it does not consider is transport of silt and clay-sized material.

Q But the Acaroglu method does?

A Yes, which would be sampled.

Q Going back to something that came up earlier, wasn't your testimony that the reason you used the Laursen equation to tack onto the regression line was because it was closest to the actual data that was measured out of the three theoretical models that you considered?

A Yes.

Q But there is no way of knowing whether that in fact it is closer or has any significance to the actual transport of sediment from the North Ditch?

A Except judgment.

Q But what factors are there that lead you to conclude that the Einstein curve or line would not be the appropriate one?

A It predicts that there would be no movement of sediment over a whole range of flow that in fact we did measure movement. We measured movement of the grain sizes that it predicted. There would be no movement, so we have field measurements that are in direct conflict with what it predicts.

Q Do you have field measurements that conflict with the Laursen calculations?

A We have, if you extend a Laursen prediction down to the range of measured values, it would express lower sediment loads.

Q Predict lower than what you actually --

A Than what we actually measured which is reasonable, because the measured values are not measuring, they are including the transport of fine sediment which the Laursen does not predict and those low flows from the transport in the bed layer, I wouldn't go so far as to say it would not be significant, but it would be a minor portion of the flow.

Q How about the third model you considered? Wouldthe actual data that you got contradict with that model or those calculations?

A The measured values were much, much less than that model predicted would move over that and because I think the movement in the bed layer, I think the movement in the bed layer would not be enough to account for that difference, that is again just a judgment.

Q In the summary conclusion section of your report, the first sentence of the last page, you state that the stream discharge added loads estimated from the measured data are considered to be low.

Low as compared to what, as to what you would expect?

A As to what actually happened.

Q You do not have any knowledge of what actually happened?

MR. HYNES: Objection. That has been asked and answered. She is talking about those 25 days that were not measured or they had stage measurements.

MS. OLIVER: That is not what actually happened though. If this is her opinion, that they were low --

MR. HYNES: Why don't you phrase the question because I think you tacked on a phrase at the end of this. Maybe I misinterpreted what you said.

BY MS. OLIVER:

Q Your statement here that sediment loads estimated from measured sediment data are considered to be low, is that the opinion you talked about earlier when you said you would expect more sediment transport than you were actually able to measure?

A If you are talking about the statement I made about the 5.3 CFS maximum discharge being the low end of the scale, no, that is not what I am talking about.

MR. HYNES: The first sentence in that paragraph.

MS. OLIVER: Yes.

BY THE WITNESS:

A What I am talking about there is I am using the 5100 pounds.

BY MS. OLIVER:

Q That is what I am asking.

A That estimate of 5100 pounds is for sediment transported through the Ditch during that period. It was actually, probably less than that that went through the mouth of the stream during that period.

Q That is based on what you would expect, based on your data base from other places and based on the fact that you missed some sampling days in this project?

A It is based on the fact that we missed some days during the project, and the fact that measured sediment data do not include the bed layer, so we always know there is some fraction of flow, whether it is significant or not, that we are not sampling.

Q Didn't you also take into account the data base that we said you got from the 103 other streams or bodies of water?

A No.

Q Not for this?

A Not for this. The estimates in Table 2 were based entirely on data that there was water in the Ditch. The only time that data base was used was coming up with the equation, coming up to estimate the flood peak discharges.

MS. OLIVER: I don't have anything else right now.

MR. SHAPIRO: Could we take a couple of minutes?

(Brief recess had.)

CROSS EXAMINATION

BY MR. SHAPIRO:

Q Miss Graf, could you fill in for me something from your resume I did not understand.

Can you tell me what you were doing between 1975, when you received your Ph.D., and 1977, when you became Assistant Professor in the Department of Geology at the University of Illinois?

A I was sitting at the University with no job, no title, preparing my thesis for publication, writing project proposals, trying to find a job.

Q Were these project proposals for the USGS?

A No, just my own, trying to decide if I had all the money I could want and all the equipment I could want, what is it I would like to work on, and how would I go about working on it.

Q But you did continue working in the field through that period?

A Yes.

(Graf-Monsanto Deposition Exhibits Nos. 7 and 8 marked for identification, 2/16/81, TLU.)

BY MR. SHAPIRO:

Q I would like to show you what has been marked as Graf Exhibit 7.

Would you read that, please.

Have you seen this before?

A I believe this is a proposal that I was given when I first arrived at the Survey as what had already been worked up on the project.

Q But you did not review this before you came for your deposition today?

A No.

Q Is this the complete proposal that you saw, that you were presented with at the time that you were asked to prepare a proposal on the North Ditch?

A I believe so, but it is quite a long time.

Q This is the proposal from which you prepared your proposal, your subsequent proposal for the studies of the North Ditch that was ultimately sent to US EPA?

A Yes, it is the one to which I added sediment work.

Q Was everything that was proposed in this proposal included in your proposal, as well?

A I would say yes on the basis of the quick reading I just gave it.

Q Looking at the cover letter, you did not participate in the meeting of September 27, 1978 that is referred to in the first paragraph?

A No.

Q Did that occur before you were employed at USGS?

A Yes, it did.

Q Turning to the first page of the proposal under Objective, it states that the objective of the proposal is to establish for North Ditch a discharge and velocity frequency relationship to provide information for assessing the potential for sediment transport.

Does that statement accurately reflect the objective of the study as undertaken by you?

A That would be half of it.

Q What would be the other half?

A The other half would be actually assessing the potential for sediment transport.

Q In the next paragraph under Approach, it describes the development, says that a theoretical stage-discharge relationship will be developed.

Was that theoretical stage-discharge ever developed?

A Yes, that was the relationship that was discussed in the final report as having been determined by step-backwater techniques.

Q It was developed for each of the eight sites or five sites as they ultimately became?

A Yes, it was.

Q It was?

A It is actually one -- well, yes, it was.

Q It is actually one relationship for the entire Ditch?

A I believe it is. Step-backwater would give a water level at any point along the Ditch upstream from the starting point related to a discharge at the downstream point, so yes, it would be.

Q Would that method allow it to be plotted as a single line on a graph or not?

A Yes.

Q Using the information, the theoretical relationship for all eight sites, you would still come out with one single line on a graph that would represent the theoretical stage-discharge relationship for the stream?

A No, you would in that way apparently come up with a different line for each stage station.

Q Turning to the draft report which has been referred to as a draft report, progress report, Exhibit 2, Page 6 of that report, Figure 4, is that the theoretical discharge-stage relationship that was called for in the project proposal?

A That is a stage, a theoretical stage-discharge relationship developed for the lower reach of the channel, so it is not for all eight sites or however many sites, really only one site.

Q For Gage 1?

A Gage 1.

Q Was this stage-discharge relationship that is in Figure 4 developed by the step-backwater method?

A No, it was developed by the same equations that the step-backwater method uses, but the step-backwater method does more than this in that it uses a condition at one cross section which is what this is, to get the conditions at the cross section upstream.

Q So the theoretical stage-discharge relationship mentioned in the project proposal is not this particular stage-discharge relationship but that the two are developed from the same formula, ultimately?

A Actually the project proposal doesn't specify a method for coming up with stage-discharge relationship, so in the sense, because it is a theoretical stage-discharge relationship, it is the same one.

Q And the theoretical stage-discharge relationship in Figure 4, did you use in drafting that any actual stage and discharge measurements down in the Ditch?

A No.

Q So that you used assumed values for developing this relationship?

A I used assumed values of stage and calculated a discharge relating to that stage.

Q Using the other measurements that you had for channel morphology?

A Using channel morphology and bed material to give a roughness value.

Q In the second paragraph under Approach in this project proposal, the proposal says in the second sentence:

"Discharge measurements will be made at the recording site to establish a stage-discharge relation and verify or adjust the theoretical rating."

The stage-discharge relation developed from the discharge measurements, would that be the stage-discharge relations referred to in the Final Report that is based on actual measurements in the North Ditch?

A Yes.

Q Was the comparison ever made or the verification or adjustment of the theoretical stage-discharge relationship found in the progress report, was it ever made with the actual stage-discharge relationship developed in the final report?

A No. The theoretical rating that Al developed was checked and adjusted by comparison with the discharge measurements and it was found to vary with time. The measurement that I made has no time, was a general discharge relationship developed to apply, really, to an average section of the lower reach of the channel.

Q Any channel that resembled this particular channel?

A That had that channel geometry and bed material size, yes.

Q So that this last sentence refers not to any comparison between the stage-discharge relationship in the progress report and the stage-discharge relationship developed in the final report, but rather the verification of the stage-discharge relationship in the final report by actual discharge measurements?

A Yes.

Q And no comparison was ever made of these two stage-discharge relationships, theoretical and the progress report, and the actual as verified in the final report?

A Correct.

Q On Page 2 of this proposal, there is reference to rainfall runoff model. You said earlier that this rainfall runoff model was not developed because it was not reliable, is that correct?

A It was not developed because there was not enough data.

Q There simply wasn't enough data to come up with the model to start with?

A There wasn't enough data to come up with a reliable model. You can take any one runoff and rainfall runoff event and plug those values into the computer and come up with parameters that you would need to reproduce those runoffs given in that input rainfall, but one event just isn't sufficient. You might be able to reproduce that one event, but what good would that do?

Q Please describe to me what a rainfall runoff model is.

A Yes. It is a comparison. You input values of discharge over runoff. You input values of rainfall that produce that runoff. You use some method of reconstructing to the hydrograph from the rainfall and adjust that reconstruction hydrograph until it matches the computed one and you get out of that analysis values of a number of parameters which you can then put back into the model with the rainfall to compute a hydrograph, probably makes no sense.

Q Let me ask --

A When you go from rainfall runoff, not all of the rain that falls on a basin runs off and is found at the gage. There is a certain loss of rain and what runs off is considered the excess rainfall.

So when you talk about rain, the first thing you have to do is figure out how much of it will run off and you just measure the runoff, that measure of runoff which is what we do with a gage and assume that everything that was not picked up at the gage was lost.

Q But would a rainfall runoff model be an alternative way of determining discharge for a stream for any particular period, alternative to a stage-discharge relationship?

A Yes. It is a way of predicting flood hydrographs, with some flood discharges in response to a rain.

Q Flood because there are periods of precipitation which would increase the discharge of the Ditch?

A Of rain, yes.

Q Floods and rain?

A Yes.

Q What data were you looking at in order to make your rainfall runoff model reliable?

A Just enough runoff events. The two that we had for which we had sediment samples had all of the data necessary. Each of them that had rainfall and discharge data, we felt the two in themselves were not enough to form a calibrated rainfall runoff model.

Q Did you take any steps at the beginning of the proposal to ensure that you would be able to develop a rainfall runoff model during the course of the hydrologic phase of the testing?

A We made sure that the instrumentation and the samples that we took, measurements of channel geometry and roughness were what we needed as input to install the runoff model. What we couldn't recall was how many events there had been and whether we could be there to sample them, so there was no way that we could really ensure that we could get the data.

Q If you had been successful in developing a rainfall runoff model, would you be able to predict from that model the discharge for each of the two and five and ten-year flood intervals? I am referring to the --

A Yes, I think I know what you mean.

Q For the record, I am referring to the figures in the first two columns of Table 1 of Page 11 of the final report.

A Determining the statistics of flood frequency is really a separate kind of analysis. What the rainfall runoff model would have allowed us directly to do is to give a known rainfall amount and time distribution, say we had hourly values of rainfall for a 48-hour period over which there was a storm. We could take those data with the calibrated rainfall runoff model and compute the discharge hydrograph. We could compute the discharge at any time in response to the rainfall.

Now, as long as you have the rainfall data, you can use those rain data to predict what the runoff response would be, so if you can use it as it says in this proposal, as long term rainfall data from the U.S. Weather Service to predict what future rain distribution would be, then you could predict what the runoff distribution would be.

Q Just to repeat, it would be another way of establishing what discharge was over an extended period for the North Ditch?

A Yes.

Q And it would allow you to extrapolate beyond to the period of the actual measurement and sediment discharge for the North Ditch?

A Yes.

Q Would it be a more accurate way of predicting discharge than the indirect methods, the other indirect methods that were used?

A Yes, I think so.

Q How many rainfall events would you need in order to make the model reliable?

A I would say if you had three to five years of data, you might be able to get a fairly good model.

Q When you say three to five years of data, do you mean every rainfall event for three to five years?

A I mean sampling all the rainfall and runoff for three to five years in hopes that you would get every year, three or four models that you might be able to use.

When I said earlier that one of my projects is calibrating rainfall runoff models or a large number of gaging stations in the state, we don't look at a station unless it has 10 years of record because we don't believe it will give us enough floods of significance that are good for modeling, that are reasonable models to be worth the effort of looking at them.

Q You testified earlier that many of the projects or most of the projects that USGS runs extend from two to five years. Is one of the reasons for that that it permits the USGS to develop a rainfall runoff model for the particular project?

A We do a lot of things which don't involve rainfall runoff modeling, but because most of our work does involve field work which involves sampling events which are rare and equipment that fails and personnel that come and go, you need several years in order to get a good sampling of whatever it is you are trying to measure.

It takes actually much of the first year often to get the plan, order the equipment, get it put in and takes most of the last year to write the report.

Q But would it be fair to say that in this case, you lack the more reliable method of rainfall runoff model because of the shortness or the brevity of the study period?

A Yes.

Q In the last paragraph on Page 2, there is reference to a velocity-discharge relationship that is to be computed which I believe is also mentioned in Exhibit No. 1.

Was that velocity-discharge relationship ever developed?

A No.

Q Can you tell me what a velocity-discharge relationship is?

A It would be a plot or an equation relating to mean velocity at a given cross section with a discharge at that cross section. When you make a discharge measurement, you are actually measuring the real velocity and you are computing the discharge by multiplying the times of square times the flow.

Q So if you had a velocity-discharge relationship, you could determine from the velocity what the discharge of the stream was?

A You could, but you would never get discharge that way.

Q Why not?

A It is easier to get it from a stage-discharge relationship and a stage is much easier to measure than either of those other things.

Q Would it be an alternative way of determining discharge if the stage-discharge relationship were not reliable?

MR. HYNES: Were not reliable in terms of what? Inherently unreliable or because of malfunctions in equipment or something like that?

BY MR. SHAPIRO:

Q If you could not develop a reliable stage-discharge relationship because of physical conditions in the stream.

A No, because the velocity and discharge, you would have to measure one or the other and the whole point of having a stage recorder and getting stage-discharge relationship is so that there will be something there recording the values when you are not there. So that you wouldn't have to just have somebody there continuously measuring the discharge.

Q And that could not be done for velocity?

A Velocity isn't measured by quantity. You are actually measuring velocity at many points in the stream in order to get the discharge. There is no way you can measure the mean velocity at a cross section with something that could sit there and do it while you were not there.

There are ways you could measure the point velocity, but I don't know of anybody that does that.

Q In other words, it would not be useful to know, in other words, if you had measurement of velocity at, say, Gage 1 in the North Ditch, it would not be possible to predict from that on the basis of velocity-discharge relationship the discharge that is occurring through Gage 1, at Gage 1?

A It would be, but I don't see any reason to do that.

Q Can you tell me why the proposal called for the development of a velocity-discharge relationship?

A No.

Q It would serve no purpose?

A None that I know of.

Q Would you look at what has been marked as Graf Exhibit No. 8.

A Yes.

Q Before I ask you some questions about it, I have a couple more questions about Graf Exhibit 7, the proposal.

That velocity-discharge relationship that is mentioned in Exhibit 7 is also called for in Graf Exhibit 1 in Paragraph 2(a).

A Yes.

Q Do you know who requested that the velocity-discharge relationship be included as part of this agreement?

A I don't know. I would guess that it came from a proposal included in Exhibit 7, which was apparently written by Larry Martens.

Q Do you know if this velocity-discharge relationship was also called for in the final agreement between the USGS and the US EPA?

A I don't know, but I suspect it was.

Q Do you recall in reviewing this agreement whether you ever questioned the reasons for proposing that a velocity-discharge relationship be developed?

A I don't remember questioning it.

Q Do you recall anybody questioning it?

A No.

Q Also in Graf Exhibit 7 in the first paragraph under the Approach, the first page of the project proposal, there is a reference to a statement that total organic carbon will be determined for the sediment samples.

Can you tell me whether that determination was made?

A It was not.

Q It was not.

Was it included in the final agreement between the USGS and the US EPA?

A I don't believe so.

Q So that that determination was not made by anyone?

A Was not made by the USGS.

Q Do you know whether it was made by anyone else?

A I have never heard anyone mention it.

Q Could you tell me why you would want to know the total organic carbon?

A No.

Q Graf Exhibit No. 8, have you ever seen this before?

A I believe this is at least a draft of the proposal that I wrote up.

Q Do you know whether this is the final proposal that you wrote up?

A I think so.

Q If there were another draft or a final edition of this one, it would be in the folder that you have kept on this particular project?

A It isn't in anything that I have.

Q Would it be anyplace else in the USGS?

A If there were another draft, it would be on file in our office someplace.

Q Mr. Noehre's file?

A Probably in the District Office files, Larry Toler.

Q So Mr. Toler would have a file that would contain this?

A Yes.

Q Is that file an OMC file or just a general file of proposals?

A I don't know how he organizes the file.

MR. SHAPIRO: I think we would like to take a look --

MR. HYNES: It has already been asked for here, No. 3, Toler proposal file.

BY MR. SHAPIRO:

Q This is the proposal that you recall drafting as a supplement to the proposal that is marked as Graf Exhibit 7?

A Yes.

Q It adds to the original proposal, a proposal for actual sampling at the site?

A Yes.

Q As well as the means of developing a theoretical prediction of sediment discharge for the North Ditch?

A Yes.

Q On Page 2 of this proposal, the last sentence, you say bed material size distributions, channel cross-section profiles and water surface slope measured during flow events can be used in the Einstein bed-load function (Einstein, 1950) to estimate the sediment discharge for a given water discharge.

Did you select the Einstein bed-load function as the means to estimate sediment discharge?

MR. HYNES: You mean in the final or in this draft proposal?

BY MR. SHAPIRO:

Q In the draft.

A Yes.

Q Was the reason that you chose the Einstein bed-load function that it was the best well-founded bed-load function available?

A It is the one with which I was most familiar. It is the one that attempts to consider the physical processes that are occurring.

Q One of the reasons it is the best well-founded bed-load functions is that it considers the inter-relationship of various grain sizes?

A Yes.

Q Can you describe what you mean by that?

A Most bed-load functions are designed to show, calculated separately for grain sizes considering that each size range acted independently.

His function does that but in addition, it uses, incorporates a factor for roughness of the bed which is taken from the actual grain size distribution and then it considers the hiding of smaller grains by shielding smaller grains by larger grains, by using a laboratory-determined hiding factor, shielding factor.

Q So that in other words, some of the smaller grains would not be taken up into the discharge because they are protected by the larger grains in the streambed?

A Yes.

Q And the other indirect methods of calculating sediment discharge do not take that into consideration?

A They assume that each size has equal probability of meeting the flow.

Q And the Einstein function is actually closer to the actual dynamic of what happens in the streambed?

A We don't know.

Q Is it true that large grains in the sediment bed do protect small grains?

A In some cases, they do. There is really very little known about the transport of grain size mixtures. If you get a grain which is just enough bigger that the flow did move it, the flow could make it roll across the bed and it wouldn't be hiding. And in fact, it might cause more erosions by disturbing little particles underneath it. But if you get a grain that is big enough that the flow cannot move it, it might protect the grains underneath, but it might cause little eddies around it that might erode. It might protect a certain amount, but it would also increase erosions at certain points.

The individual phenomena are identified mostly by flume work, laboratory work, but how they interact and how those interactions depend on the flow state is very poorly understood. This was at a time which is quite a while ago, at a time very innovative because he attempted to consider some of these phenomena.

Q So you are saying not to the phenomena doesn't occur but that the precise relationship, the precise characteristics of the phenomena are not known?

A Yes.

Q So what Einstein attempts to do is factor in those phenomena by choosing some values to reflect that phenomena?

A Yes.

Q And none of the other functions do that?

A Yes. And he may in fact, by factoring them in, have overcorrected.

Q At the time you drafted this proposal, you did not state that it was necessary to consider any other bed-load function, did you?

A I didn't state that I would use any others.

Q Then you were content to stay with the Einstein bed-load function?

A Yes.

Q On the next page, starting at the bottom of this page but going over to the next page, it states:

"If sufficient material is collected at a given discharge, the grain-size distribution of suspended sediment will be determined. That size distribution can be used with bed material size distribution, water temperature, water velocity, and depth to calculate sediment discharge using the Modified Einstein Procedure." There is a citation.

Further, it states:

"The Modified Einstein Procedure provides a more reliable estimate of sediment discharge than does the Einstein bed-load function, and so would yield a more reliable sediment rating curve for the total sediment discharge."

Was the Modified Einstein Procedure used?

A No. We never collected enough data to use it.

Q What data were you lacking?

A We had some suspended samples for which we determined grain size distribution, but not enough to provide a basis for those calculations.

Q Is there anything else that you were lacking?

A No. All the others could be routinely calculated.

Q So the only data that you were lacking were the grain size distribution for the bed, enough samples of grain size to --

A Not of the bed, of the material that was being carried.

Q Of the material that was being carried.

Your data for the material that was being carried were the sediment samples that were taken on the two storm events and the three miscellaneous samples during the course of the six-month period?

A Yes.

Q How many more samples would you have needed in order to have enough data to use the Modified Einstein Procedure?

A It wasn't that those numbers of samples were too few. It was the sample collected at each time was insufficient.

Q You had to use the samples, the bottle sampler more times for each sediment sample?

A It is also that the flow at those times was low enough that the amount of sediment being carried into the stream was at the low end of any of these procedures, really.

Q Even during the storm events?

A Yes.

Q How did you know that?

A By looking at the samples and seeing what the concentrations were and what the mean velocities measured with.

Q Let me ask you this:

Would you conclude that on the basis of the samples that you took that the Modified Einstein Procedure simply could not be used for a ditch of this sort?

A In the flow ranges that were present during the period of record, I would say that was true. It is not recommended for use at mean velocities less than a given value which was much higher than those that we measured at the time of the sampling. Partly the reason for that is the velocities are just, well, too low to put enough sediment to give a reasonable sediment sample.

Q Would you have any reason when you drafted the proposal that you would be able to get flows high enough to use the Modified Einstein Procedure?

A I hoped that we would get flows high enough to use it, yes.

MR. HYNES: Off the record.

(Mr. Hynes conferred with the witness and Mr. Phelus.)

(Brief recess had.)

MR. SHAPIRO: Would you read the last question and answer.

(Record read.)

BY MR. SHAPIRO:

Q But you never did get sediment samples that were sufficient to use the Modified Einstein Procedure?

A Right.

Q This proposal anticipates that it might be true that you would not be able to come up with sufficient material to use the Modified Einstein Procedure, isn't that right?

A Yes.

Q In the absence of such data, the proposal calls for the development of use of the Einstein bed-load function estimated discharge and then the taking of actual sediment samples measured during certain runoff events, those two steps.

MR. HYNES: What are you reading, Rob?

MR. SHAPIRO: I am referring to the Einstein bed-load function as discussed in the first paragraph on Page 2 and then the actual sampling is referred to in the second paragraph on Page 2.

THE WITNESS: Yes.

BY MR. SHAPIRO:

Q And those were the sole steps called for by this proposal?

A The first step was to just estimate, in the first paragraph, estimate the stability of bottom sediments using the Shield's curve. That was done, and then using bed material size distribution in channel cross section, then have water surface slope with the bed-load function and measured samples.

Q Now, as part of the measured step, it says, and I am reading in the middle of the second paragraph on Page 2:

"At the time of sampling, depth at the sampling point, water temperature and water discharge will also be measured."

Were those three variables measured?

A In the case of the three samples that were taken by US EPA people, the water discharge was also measured, as well as sediment samples taken.

In the case of those that were taken by EPA people during flow events, they did not actually measure the water discharge. They read the gage to get the stage.

The depth at the sampling point is measured as a consequence of taking the sediment samples, that is what you get when you take the samples.

Q But none of the samples was measured for water temperature?

A They may have been. I don't use it.

Q So you have never seen any of the data, any data that might have been collected on water temperature?

A It might have been on some of the data sheets that I was given, but I didn't see it to remember it.

Q You said earlier that as the water temperature decreased, the sediment concentration would increase, is that correct?

A Yes.

Q The sediment carried by the stream would increase, total sediment carried by the stream?

A Yes.

Q Colder water carried more sediment?

A Yes.

Q But you never used any variation in water temperature in various functions that you used or developed?

A No.

Q You just assumed the 20 degree centigrade?

A Yes.

Q What is that, 68 degrees Fahrenheit?

A Something close to that, yes.

Q That is a fairly warm temperature for a stream of that sort, isn't it?

A It certainly would be warmer than I would expect the water to be in the spring when the biggest runoff occurs.

Q Would it reach that temperature through significant portions of the summer?

A I would guess that it would exceed that temperature at low flow in the summertime.

Q So at high flow you would get a drop in temperature?

A In the summer that would not be unusual.

Q So that at high flow the sediment concentration might increase for two different reasons, both the velocity of the stream and the increase in temperature?

A Yes.

Q Does any of the theoretical calculations take that into account?

A No. You would have to just make the calculation separately and for different temperatures.

Q In your observation of the North Ditch, was there anything that would cause the stream to have a higher temperature than streams that you encounter normally?

A Nothing that I could tell in my brief visit there, no.

Q You are aware of the sewer outfall from the North Shore Sanitary District that is at the end of the stream?

A Yes.

Q Is the discharge through an outfall warmer than it would ordinarily be, warmer than the water in the Ditch?

A I don't know.

Q There was also an outfall from the OMC facility, is that correct?

A Yes.

Q Do you know whether the discharge from that outfall was of warm water or cool water?

A No.

Q So no measurements were taken of water temperature from those outfalls?

A Not that I have seen.

Q In the 20 degree centigrade figure, that was a figure that you said was normal to use in equations of this sort?

A It is one of several standard temperatures for which we made calculations of a lot of things.

Q Standard because it reflects the average temperature for streams of this sort?

A No. It is standard in a broader sense of the standard chemical temperature. It is standard in the sense that it is a temperature at which many chemical variables are measured.

Q So that it bears no relationship to the actual temperature in the North Ditch?

A Correct.

Q If the temperature in the North Ditch were considerably higher than you would expect normal for a stream of that sort, would you expect the theoretical relationship to overestimate the amount of sediment transported by this stream?

A If the temperature were significantly higher than 20 degrees C.?

Then it would cause all of those lines to be too high.

Q Substantially overestimating the amount of sediment discharge by the stream?

MR. HYNES: Objection to substantially.

You can answer.

BY THE WITNESS:

Q The amount of the effect would depend on the temperature difference. The effect of temperature, even though it is significant, would certainly be a lot smaller in effect than any change in discharge.

BY MR. SHAPIRO:

Q And stream discharge?

A Yes.

Q Do you know whether the water in the North Ditch ever feezes?

A No, I don't know.

Q Is it possible that it does?

A Yes.

Q Would you expect that it would?

A Yes.

Q During the period when the water in the Ditch freezes, there would be no sediment discharge, is that right?

A There could be if all the water in the Ditch was frozen, certainly there would be no sediment discharge.

Q And if, say, the surface or a certain distance from the surface was frozen, it would lower the level of sediment discharge for the stream as a whole?

A There could in that case still be some flow underneath the ice that would carry sediment, and because the water is colder for the same discharge, it might carry more sediment. But usually under those conditions, the flow is very low and sediment discharge is very low.

Q In other words, it is theoretically possible that the temperature and the decrease in temperature allowing, were there to be greater sediment load, might compensate for the decrease in amount of flow but that that is unlikely to occur?

A Yes.

Q Was the North Ditch frozen at any time during the sampling period?

A No.

Q You would expect it to be frozen, I would assume, during the winter months that were not covered by the sampling period?

A If it froze, it would be during those months. It is possible there was some shore ice about, at the beginning of the sampling period, but there was not any when I was there in March, so I suspect it was not.

Q But you said that you would expect the Ditch to freeze at some time?

A Yes.

Q And during that period of time when the Ditch were likely to freeze, the mean daily sediment discharge could be much lower than it would be over the course of time when there was no freezing?

A Certainly.

Q Wouldn't it then be true that the mean daily discharge predicted by the sampling period that you used would overstate the mean daily discharge for the year as a whole?

A Yes, it might.

Q And if it were a cold winter, perhaps by quite a lot?

A Yes.

Q You mentioned, I believe, in reference to, or we discussed in reference to your Exhibit No. 1 a request to deploy equipment and instruments as necessary to accomplish the above for the first major snow-melt of spring, the above being the taking of data for the three rainfall runoff events or in anticipation of three rainfall runoff events.

You said, I believe, that you thought that the instruments were in place before that first major snow-melt, is that right?

A That's what I said, yes, but I really cannot remember very much about how the data in place went in that, in that snow-melt.

Q Do you recall when the instruments were first put in place on the OMC property?

A They were, when I began recording, I believe it was the 13th of March, the 13th of March.

Q And between the 13th of March and 30th of March, do you recall there was a significant snow-melt, a major snow-melt in the area?

A I don't recall.

Q Do you recall whether there was a major rainfall event between the 13th and the rainfall event that occurred on the 30th?

A I would have to look at the rainfall data.

Figure 3 on Page 5 of the final report shows that the rain at the end of the month was the highest that we recorded for that month, but that there was some rainfall.

Q During a rainfall event, when there is still a considerable amount of snow on the ground, would the discharge for the stream be unusually high for the stream as a whole during the year?

A Yes.

Q Because of the melting snow?

A Because of the melting snow, because it would reduce infiltration and, therefore, increase the runoff to the stream.

Q By infiltration, you mean rain soaking into the ground?

A Yes.

Q So that if there were a substantial amount of snow on the ground at the time of the March 30th rainfall event, that the measurements for that rainfall event might in fact be unusually high for a particular rainfall event?

A Could be.

Q Does melting snow ordinarily carry an unusual amount of sediment?

A Do you mean does it cause a higher sediment discharge within the stream or does it carry an unusual amount of sediment from the basin to the stream?

Q The latter.

A I don't have any experience of my own that discusses that specific thing. Because of the temperature effect, the water/snow meltoff would be colder, I would expect it could carry more sediment than runoff with warmer water. But I don't know. You see, counteracting that would be quite a bit of the basin would be covered by the snow and the ground would be frozen, so how those would interact, I wouldn't want to guess.

Q Is it likely that snow in the area around the North Ditch would be likely to contain a lot of sediment, dirt and other material picked up while sitting on the ground?

MR. HYNES: You say a lot, a lot in comparison to what?

BY MR. SHAPIRO:

Q More than just simple rainfall would contain so that the runoff into the stream could contain more sediment than simple rainfall would contain.

A No. In an urban area, it looks a lot sootier. Whether it is that or it is just a fine layer of soot that would not be considered sediment, or whether that is grain that you could actually measure sediment, I don't know.

Q Is there any reason that you can give to determine what the relationship is between the sediment that is running off into the Ditch and the sediment that is carried by the Ditch into its own discharge?

A There is no good way of doing that. That is one of the really difficult problems of erosion.

Q Looking at the progress report which is marked as Exhibit No. 2, do you see in the upper right-hand where it says draft copy subject to revision?

A Yes.

Q Is this in fact merely a draft copy?

A I think this is in fact a draft copy, but so close to the final as to be almost indistinguishable.

Q What would the differences be?

A We made some modifications to Figure 1. We added, that is the progress report, I am sorry.

MR. HYNES: If I might, Rob:

If you know, did your office, do you know who put that stamp, draft copy, on there?

THE WITNESS: I think our office did. And I cannot remember whether that was because it was a progress report and the revision would be the final report, or I suspect that we sent it to EPA before it had undergone our final approval in Reston. I think that was what was done. 1 think that was in fact the final copy of it.

BY MR. SHAPIRO:

Q Were there no revisions made?

A No.

Q Referring to Figure 6 on Page 14 of the progress report, is the broken line on that graph, the triangular dots which is referred to as the Einstein curve, the same Einstein function that was called for in the proposal that you drafted?

A Yes.

Q And you said that the Einstein curve was the best well-founded bed-load function?

A I said that it was the one which attempted to most closely model the physical processes that were going on.

I would not say it was the most, best well-founded because that would be saying it compared best with measured values and that would not be true.

Q That was the only function called for by your proposal, that is specifically mentioned by your proposal?

A Yes.

Q Referring to the Einstein curve and at the same time to the final report, Page 11 in Table 1, which is sediment discharges at Gage 1 for flood peak stream discharges, can you tell me what the Einstein curve would predict in the way of sediment discharge for the two-year flood recurrence interval?

A It is off the scale of the graph, but it would be very, very low.

Q For the five-year flood recurrence interval?

A Again, off the scale.

Q Would the same be true for the 10 and 25-year floor recurrence interval?

A Yes.

Q So the Einstein curve, which was called for in your proposal, resulted in sediment discharges at Gage 1 of very, very, very low levels for flood recurrence intervals up to the 25-year flood recurrence interval?

A Lower than the estimate made here, certainly.

Q Low enough to not even register on the graph?

A Well, the graph scales just depend on how I did. Yes, you will notice that the scale in this sediment discharge is pounds per second rather than pounds per hour, so there is a factor of 60 given in that scale and the other scales which is one complicating factor.

Q You are referring to?

A It is not -- yes, it is easier to read on Figure 6 in the final report because those are the same scale, at least, so if you look up the 40 cubic feet per second as a one-year flood and it comes out to being a few pounds per hour as opposed to 1600.

Q So that for the estimated peak discharge, that occurrence once every 100 years, that would be a few pounds per hour carried by the Ditch?

A Estimated by that method.

Q Estimated by that method.

A Yes.

Q And for a flood recurrence interval 25 years and less of the estimated peak discharge, that flood recurrence interval of 20 years or less, that method would predict also only a few pounds per hour?

A Yes.

Q Is that correct?

A Yes.

Q So that, again, the proposal specifically called for, the method specifically called for in the proposal that you drafted would result in a prediction of only, well, less than a pound per hour, much less than a pound per hour for any flood recurrence interval 25 years or less?

A That is what that equation would predict.

Q Turning to the graph in Acaroglu function --

MR. HYNES: That is also in Figure 6?

MR. SHAPIRO: In Figure 6.

BY MR. SHAPIRO:

Q (Continuing.) Can you tell me what the predicted sediment discharge is in pounds per hour for the estimated peak discharge for the two-year floor recurrence interval?

A Something over 10,000.

Q 10,000 pounds per hour?

A Yes.

Q You said that the Einstein curve would for the two-year, the estimated peak discharge for the two-year flood recurrence interval predict less than a pound per hour?

A (Nodding.)

MS. OLIVER: Excuse me. What is your answer?

BY THE WITNESS:

A Yes, yes.

BY MR. SHAPIRO:

Q In other words, the graph in Acaroglu curve would predict sediment discharge 10,000 times as great?

A Yes.

Q Is it possible to tell from this figure what the predicted sediment discharge would be on the graph in the Acaroglu method for the 20-year flood recurrence interval, the estimated peak discharge of that?

MS. OLIVER: Which?

MR. SHAPIRO: The 25-year.

BY THE WITNESS:

A It would be possibly -- it is off the graph, so I would have to get out my calculator and use the calculator to calculate that.

BY MR. SHAPIRO:

Q It would be substantially more than 10,000?

A More than that.

Q You said that for that 25-year flood recurrence interval, the estimated peak discharge at that time under the Einstein curve would also be less than a pound per hour?

A Yes.

Q Again, the graph in Acaroglu curve would predict discharges of more than 10,000 times as great?

A Yes.

Q Under the Laursen curve for the estimated peak discharge of the 25-year flood recurrence interval, can you tell me what the predicted sediment discharge would be in pounds per hour?

A For the 25-year?

Q Yes.

A That is in what, is that in Table 1 -- 1100.

Q So that the Laursen curve would predict sediment discharge in pounds per hour of more than 1100 times what the Einstein curve would predict?

A Yes.

Q And you said, I think, that all these curves would overstate the amount of sediment carried by the Ditch if the temperature in the Ditch regularly exceeded the 20 degrees centigrade figure used in the calculation?

MR. HYNES: Objection, that is a mischaracterization.

You may answer.

BY MR. SHAPIRO:

Q You may answer.

A All these calculations if made for a higher temperature would yield lower sediment discharges.

Q So that even the Einstein curve might overstate the sediment load or the sediment discharge of the Ditch?

A In my opinion, the Einstein curve very significantly underestimates the sediment load in the Ditch. There is no way you could make it overstate the sediment load in the Ditch, in my opinion.

Q But if the temperature value that was used there substantially understates the temperature in the North Ditch, even in the Einstein curve, it would overstate or could?

A If you made a calculation at the higher temperature, it would yield a prediction of even lower sediment discharge, even farther from what happens in the Ditch, in my opinion.

Q Referring to Page 11 of the progress report, you discussed earlier with Ms. Oliver the channel slope value of .000399 that was chosen.

Can you tell me what channel slope is?

A It is just the difference in elevation between two points.

Q Elevation of the surface of the water?

A Elevation of the channel bed.

Q Of the channel bed.

I am almost finished.

Turning to the final report, you stated that the first step in this report was to develop a stage-discharge relationship, is that right, or relation, referring to Pages 3 through 7 of the report?

A The stage-discharge relationship was the basis of sediment estimates in the sense it was the first step.

Q It was the first step because you needed it to go on and make the next calculation?

A Yes.

Q And that stage-discharge relationship was developed on the basis of measurements that were made in the North Ditch over the sampling period, is that right?

A Yes.

Q Earlier we talked about in the progress report, Figure 4, which also plots the stage-discharge relationship.

A Yes.

Q You said that the stage-discharge relationship that was developed on the basis of actual measurements was never compared with calculated stage-discharge relationship,is that right?

A That is right.

Q And the stage-discharge relationship in Figure 4 and the calculations are used in the equations or the functions that Einstein, Laursen, Graf and Acaroglu used?

A Yes.

Q Can you tell me how it is used?

A It is probably -- I am trying to think of something simple.

Q Let me ask you this:

Is it the shear velocity that is used in those equations drawn from this relationship?

A No.

Q Maybe you better try to explain that to me.

How is the relationship used?

A In the case of the Laursen method, it is the discharges used to convert a sediment concentration which is calculated by another means to sediment discharge merely by multiplying times the water discharge and then some correction factor for the difference in units.

In the Einstein method, you use it indirectly and if you look on Page 9 of the progress report --

Q I was afraid you were going to direct me to that page.

A I'm not sure this will make it any clearer.

You use the mean velocity which is calculated from the discharge. The discharge is the velocity times the area. You get the area by plotting up your cross section and using some sort of preliminary to get the area relating to any stage.

Q Would the stage-discharge relationship be used to develop the mean velocity figure that goes into these functions?

A Yes.

Q Would these functions be more accurate if you used actual stage-discharge measurements rather than the purely theoretical one that is shown in Figure 4?

A Yes.

Q But that was never done in this case?

A No.

Q Turning once again to the final report, Figure 5, that figure plots the actual 20 samples that were taken in the two storm events and the three miscellaneous periods, is that right?

A Yes.

Q And a regression line is developed from those points?

A Yes.

Q Does the regression line place the same value on each one of those individual points?

A Yes.

Q So that each contributes equally to the final development of the regression line?

A Yes.

Q Turning back to Page 7 under sediment concentration measurements, the second paragraph, it says:

> "The variation of sediment concentration and stream discharge with time for March 30 (fig. 4) is typical of the responses of small streams with low

base flows to a high intensity rainfall. The data for April 11-12 (fig. 4) show a situation which may be more typical for this Ditch. During that period, streamflow at Gage 1 was affected by strong onshore (upstream) winds which created waves and at times caused backwater conditions in the Ditch."

By that description, are you referring to the problem you described earlier with the sandbar building up in front of the Ditch causing the water to back up until it breaks through the sandbar?

A No, this was a little different situation in that there was no flow through the bar into the Lake, but the winds and waves created, did create a counter to that flow in the upstream section and this was only an intermittent phenomenon.

Q So that the water would break up at one point and then flow, would break up a little and flow?

A It wouldn't actually break up in the sense that you would get reverse flow.

Q Water would never flow from Lake Michigan into the Ditch?

A It certainly would at times, but whether it did on that occasion or not, that is not specifically what we meant by that. Backwater doesn't necessarily mean a reverse flow. It just means you get some obstruction of flow causing the stage to rise. You could get that situation and still have flow going in a downstream direction.

Q But you said the way in which the stage-discharge relationship was developed for Gage 1 was to take the stage measurements for those times for which you had actual discharges and compare them in those periods?

A Yes.

Q And would those periods include periods in which there were backwater conditions in the Ditch?

A It could.

Q But would those be reflected in the stage-discharge relationship that you then developed?

A They would be reflected in the stage because it would be a rising stage, so yes, they would.

Q In a case in which there is some backwater, what would happen to the sediment in the water while there is some backwater?

A That would depend on what happened to the discharge. If the backwater, you could still get an increase in flow in a time when there was backwater, backwater condition, in which case if the flow was increasing, you would still get increasing sediment transport.

If the backwater actually obstructed to the point from the velocity-discharge what was discharged, velocity would be decreased so you would get some sediment deposited.

Q So sediment, some of the sediment would drop out of the flow?

A Yes.

Q And that would decrease the amount of sediment discharge into the Lake?

A Yes.

Q So that the results that you obtained for April 11 and 12 show in Figure 4 a generally lower sediment discharge than for March 30 when there were no backwater conditions?

A Yes, they do show that. You can see that the scale of discharges is different even for the two graphs.

Q But even taking that into consideration, the sediment discharge is lower for the April 11 and 12 event?

A Yes, it is. Discharge is lower, yes.

Q And you say in the paragraph I read on Page 7 that that is a situation which may be more typical for this Ditch, isn't that right?

A Yes.

Q Because backwater conditions occur with some regularity?

A Yes.

Q Was any attempt made in the development of the regression line in Figure 5 to account for the more typical character of the April 11 and 12 samples?

A No. What can I say? It was accounted for in the sense that the backwater conditions in addition to producing a lower sediment discharge, also produced a lower stream discharge and therefore the whole plot plotted lower on the graph. Therefore, the whole point, in other words, it doesn't matter whether the backwater conditions exist or not. The water discharge is lower. The sediment discharge is lower.

If water discharge is higher, the sediment discharge will be high.

Q If the regression line were developed solely from the April 11 and April 12 samples, would it look the same as it does here?

A No. It would have a greater sloping and so at higher discharges it would predict a higher sediment discharge.

Q And you said a few moments ago that water sometimes runs from Lake Michigan into the Ditch, is that right?

A I said I think that there was movement of water that countered the movement of water from the Ditch into the Lake. I don't believe I said there was moving water, moving from the Lake into the Ditch, because I have no way of knowing that.

Q Would you expect that in some instances, Lake Michigan water would actually flow into the Ditch rather than the other way around?

A It might be that there could be circumstances in which the Lake level would rise to a point where it was higher than the Ditch level and the bar still in place and water would percolate through the bar into the Ditch because of the difference in levels.

There might be a case in which the waves would be so high they would splash over the bar, but, and water get into the Ditch in that way, but I would expect that that would very quickly erode the bar and the water would rush out.

Q Would the water that rushes over the sandbar carry with it some of the sediment from the bar?

MR. HYNES: You mean the Lake Michigan water flowing into the Ditch?

MR. SHAPIRO: Yes.

BY THE WITNESS:

A I wouldn't consider that a significant source of sediment. I would imagine if it did, it would stay right there in the stream side of the bar.

The bar, the whole purpose of it is a constructional feature built by the waves and long shore currents of the Lake. Therefore, it is made up of sediment moving in that direction.

BY MR. SHAPIRO:

Q But if there were some kind of sustained pressure on the bar in the other direction, it could in fact wash some of that bar into the Ditch?

A I suppose it could.

Q That would be during a heavy storm period in the Lake?

A By storm, you mean the event that produced high waves? It could.

Q Can you tell me how high you think the waves might have to be in order to do that?

A No, I couldn't tell you that.

Q Would a two-foot wave, do you think --

MR. HYNES: Objection. She just said she could not do it.

BY THE WITNESS:

A I have no idea.

BY MR.SHAPIRO:

Q Turning to Table 2, the values that appear in the third full column under mean daily discharge are the values that are developed on the basis of stage-discharge relation, is that correct?

A Yes. I think that -- in fact, I know what Al did to come up with those figures was to take his hourly discharge estimates for the 24 hours for days in which there was flow and add them up and divide by 24.

Q When you say days in which there was flow, are those the days that are represented by values that appear in the fourth column or periods when there was flow, periods when there were values in the fourth column?

A Those are the days which are listed in the first column.

Q I see.

But the values that appear in the fourth column, are they actual discharge measurements?

A No. Those are values determined from the stage-discharge relationship. Those are days which in addition to being flow, there was something that could be considered runoff events in that there was a rise in discharge and a fall in discharge and was able to pick out a peak. Ones for which there is no value given would be days in which the flow was rather steady all day and there was no significant peak.

Q In Column 3, you said that these figures were the hourly discharge figures for the 24-hour day, each hour discharging figure added up and then divided by 24. The values here are then taken and put into the equations that appear on the composite sediment curve to give you the sediment loads in Column 2?

A No. What I did to get the sediment load was to take the hourly values and compute the sediment load for an hour, for that hour, and then add those for the 24 hours.

Q I think that will explain my question.

Does that explain why it is that for several different points one mean daily discharge, there are a variety of different sediment loads that are predicted?

A Yes, exactly.

Q Going back for a moment to Figure 4, the lower of the two graphs there for April 11 and 12, that graph contains measurements of discharge, a sediment discharge?

A Concentration.

Q Concentration.

So from the concentration and the stream discharge, you could develop the sediment discharge for those?

A Yes.

Q That would be the actual sediment discharge for that period?

A Yes.

Q Can you tell me why in Table 2 there is no sediment discharge listed for April 11, which is one of the days in which you had actual figures for sediment discharge?

A Well, part of that is included under April 12.

Q So that the figures for April 12 are actual figures or estimated figures?

A They are estimated figures.

Q That could come from the regression line?

A Yes.

Q Rather than the actual samples?

A Yes, and I believe, I am trying to remember talking about this point, I am trying to remember what the problem there was, and I believe it was just one of timing that looking at the stage record we could not definitively pinpoint the breaching of the bar until what actually became the 12th and yet from the field measurements, we know in fact it was breached before that time.

And since all of the other estimates of load on this were estimates from the stage record and the regression line, we felt it was inconsistent to just stick in a couple of measured values. It wouldn't have made much difference in the whole, just certainly less than 66 pounds which since that is what was called for in the pounds when you made that part of that peak, 66 pounds --

Q But the 66 pounds is a calculated load rather than a measured load?

A Yes.

Q Is the same thing true for the March 30 figure?

A Yes.

Q So that you did not use any actual measurements or no actual samples appearing in this column of the table?

A Right.

Q Turning to Page 3 of the final report, the first full paragraph, you discussed earlier, it says that, "Organic debris and finer sediments are found in the pools."

What are the pools that are referred to there?

A That is any of the lower areas of the stream, both which are indicated as pools on Figure 1.

Q Figure 2.

A I'm sorry, Figure 2, and areas in the stream between Gages 1 and 2 that are deeper than other areas.

Q The deeper area, would there be more organic material?

A There isn't necessarily a 1 to 1 relationship. The gage is merely where the grasses happened to be growing and where they die. My memory is when I was there most of the organic material was in the two deeper pools between Gages 2 and 3 and 3 and 4. That is because that is where most of the vegetation happened to be growing at that time. I imagine it would be something that would depend on what time of year you were there.

Q Is it true generally that material found in the pools is less likely to be taken up by the flow of the stream?

A No.

Q More likely to be taken up?

A Yes.

Q Why is that?

A Because it is finer.

Q Is the organic material itself finer than the other material in the streambed?

A What I meant by organic material was there was dead leaves, bits of grasses, sticks, things that I could see on just a visual inspection of the Ditch looking at the sediment samples and I was putting them in, so these would be coarser than sand but they would also be more likely to be carried because they would be less dense and have a less complex shape like a feather being thrown by the wind, in a sense.

Q Wouldn't that mean it would be more likely to be more material in the downstream bed than in the pools if that were in fact the case?

A There are two situations here we are talking about and I think we are getting confused. One is what the bed looks like when the bed was low and was very low when I made my inspection. The flow was not strong enough when I made it at that time to carry very much sediment. The other is what happens when there is significant flow in the Ditch. When the flow is decreasing, as it decreases it would tend to deposit materials first in the low areas or pools because the velocity is less there. That material would stay at very low flow and be visible in concentrations like those when I made my inspection in the Ditch.

Then as the flow increased again, that material would be picked up rather quickly again because it is finer, in spite of decreased velocity that there is likely to be around the pools. The velocity would be lower in the pools than in the riffles, but in a storm now it would be high enough to pick that material up.

Q So it would be high enough to pick it up but it would at least initially be less likely to pick up the material that was in the pools?

A I think the difference in flow state between the range in flows that you are talking about is too small to have that effect shown. Those pools are not that deep. They are not that different from the rest of the channel.

Q But it is true that a large proportion of the material that is carried as sediment load is sand and inorganic material?

A The part that we measured was because we sifted out the organic material.

Q So you do not know what proportion the organic material would ordinarily constitute?

A That is right.

Q Did anyone keep a record of how much organic material was taken out or sifted out of the samples?

A When I say it was taken out, I mean when we did the particle size analysis, you can't do that with sticks and leaves and things. You pick them out, really, rather than sift them out, and do the particle size analysis on what remains, what are the mineral grains left or if there happens to be shells or something like that, you include those in the particle size because they would act as a particle that was moving along.

In the concentration samples, you get a weight per volume of water and in that case, anything that did not volatilize would be included in that.

Q In that calculation?

A In that measurement.

Q But you would not have any way of determining from that measurement what the actual character of the material was that was being transported?

A Right.

Q So from the actual sediment records of the sediment samples which are taken, there was no way to tell what percentage of organic and inorganic material was in the sediment flow, sediment discharge?

A I believe that is true.

Q So that if you had a material that had an affinity for organic rather than inorganic material, there would be no way of telling from those samples whether the sediment that was carried was likely to have that material attached to it or what the likelihood was that it would be attached to it?

A Yes.

Q And your answer is you could not do that?

A There would be no way from our measurements to know what was attached to the sediment.

Q Do you know whether anyone else ever analyzed those samples for organic and inorganic proportions?

A I don't know. I know that EPA took, I believe, EPA took samples for their own use at the time we took samples for our use.

Q Do you know what was done with those samples?

A No.

Q You have never seen any records or results of those samples?

A No.

MR. SHAPIRO: I have no further questions.

REDIRECT EXAMINATION

BY MS. OLIVER:

Q I will try to make this very quick.

If you look at Figure No. 1 in your final report, do you know what the area upstream of Gage No. 5 was? Do you know what type of area that was?

A No, I don't know. I only saw the Ditch from Pershing Road downstream.

Q When you went to the Ditch, when you say at Pershing Road downstream, were you at one or more of the gages that are reflected on Figure 1?

A I walked all the way from Gage 1 up to Gage 5.

Q Can you tell me what in your opinion caused the discrepancy between actual measurements that you made on discharge from the Ditch and the three theoretical models that you thought you could use?

A What is happening physically that makes one give values closer to what we measure than others, I can't explain. The range in those calculations and the fact that one fit and the other didn't is not unusual compared to sediment calculations from other streams.

Q Is it usual to have the discrepancy that you had in this case?

MR. HYNES: You mean the range discrepancy between the three methods?

MS. OLIVER: Yes.

BY THE WITNESS:

A The methods would give values that were closer to each other at higher flows. Most of them were developed to be used on larger streams at higher flows.

BY MS. OLIVER:

Q We have been talking about the North Ditch as a stream or tributary.

A Yes.

Q Is that an accurate description as you use that word or those words in your profession?

A Yes.

Q Is it typical of streams and tributaries that you sample in your work?

A It is not typical of the ones that I personally sample.

Q What makes it not typical.

A It is a very urbanized area. It has a drainage area that is very much modified by man. In that respect it is like many other streams in the Chicago area or in our urbanized areas.

When I say it is not typical to the ones I measure, it is because I am measuring for different things. I am trying to avoid urban areas. It is certainly small in terms of drainage areas, it is on the small end of the streams that we would measure for our normal stream gaging stations, although we certainly have measured quite a few for specific projects that are on that order, size.

Q Based on your measurements, it is on the low side as far as flow is concerned?

A Yes.

Q I do not want to belabor this point, but is there anything about the North Ditch, the dynamics of it, anything about it which would cause the problems you encountered in coming up with a prediction of what sediment transport would be in the future?

A It is a more difficult problem to deal with because of the interaction of the stream with the Lake. The problems that we had coming up with values were more due to the fact that we just did not have enough time to sample.

Q Do you know what use your findings or your conclusions would be put to by the US EPA?

A I know from talking with Jim and George in the last few days that it was used as a basis for calculating the amount of PCBs that were getting into the Lake.

I have never seen those calculations.

Q That was part of the original scope of your work, at least as indicated in Exhibit No. 1?

A Was --

Q With your Agency, wasn't it, to come up with calculations for the movement of PCBs into the Lake?

A Which part?

Q Part B, Exhibit No. 1, Part 2(b).

A You are talking about (b) for now? I see what you mean.

Q The heading, B.

A Yes. We considered our scope to be merely estimating the potential for movement of sediments.

We never felt we were concerned with the PCBs at all.

Q Did you feel that you could accurately develop conclusions or predictions based on the scope of your work on the project that you undertook and the determination of the project for the conclusions on the movement of PCBs into the Lake?

A I am not -- is your question did USGS feel they were capable of making the calculations or the estimate of PCBs movements or are you asking can someone else make that?

Q No. I am asking whether based on what your project involved and the length of time you had to do it, whether the USGS felt that it could assess quantitatively the potential for movement of PCB-contaminated sediments into Lake Michigan?

A We felt that subject to restrictions stated in the report itself, we could estimate the potential for movement. We could estimate how much sediment had moved out of the Ditch during the study period.

Q Would that have further complicated your study, to have determined PCB-contaminated sediments that moved into the Lake?

A We would have no way of knowing which ones were contaminated and which ones were not.

Q If that information was given to you, for example, Paragraph 4 of Part B, could you have accurately determined or made an estimate of the rate of transport of contaminated sediments into Lake Michigan?

A I am not sure what particular PCB data means, but if we had values of PCB, I don't even know how you talk about it, concentration for the samples that we measured, we could have come up with a curve just using the sediment one or related to the sediment one for transport of PCBs into the Lake and come up with a calculation like that.

I don't know enough about how PCB is, what is attached, the variables to know how accurately that estimate would be.

We felt that was not within our area of expertise and we did not want to do it.

Q But that determination of PCB transport would be based upon your transport curve or at least related to the sediment transport curve that you developed?

A Yes.

Q So the information in your final report was developed and calculated by Mr. Noehre?

A Yes.

Q He did all the stream discharge calculations?

A Yes.

Q In determining the sediment discharge, you relied to some extent on his calculations for stream discharge, is that correct?

A Yes.

Q Are the total sediment discharge figures that you estimated in your final report and mean daily sediment figures that you estimated in your final report low as compared with other streams or tributaries that you investigated?

A Were investigating? I have never made these sort of calculations on a stream of this size before so I have nothing to compare it against. It is certainly lower than most of the values we get for Illinois streams because it is very much smaller and the flows are very low.

Q One final question I think on the report just so I make sure I understand at least part of this.

On Page 3 at the bottom, you talk about regression analyses of regional data from gaged sites in Northern Illinois. Are these gage sites the 103 other places that you talked about earlier?

A Yes.

Q Do you have a list of all of that data that you looked at, is that listed in one place?

A It is in the publication that is referred to, Allen and Bejcek, 1979, which was a USGS publication.

Q You mentioned earlier that about 40 percent of the surface area was impervious.

A Yes.

Q Does that area contribute suspended solids to storm water runoff?

A It certainly could.

Q Did you measure at any point whether suspended solids were entering the Ditch?

A No, we only measured those passing by at Gage 1.

Q I would like you to look at three exhibits we had marked and I did not ask you about previously.

Exhibit No. 4 is called a Protocol for obtaining rainfall event water samples. Do you know if that is the protocol that was used for obtaining the samples on the project at the North Ditch?

A This is the protocol that I saw at one point at the beginning of the study. That should have been followed.

Q You did not have any contact with anyone at

Outboard Marine, did you?

A No.

Q Exhibit No. 5 and Exhibit No. 6 appear to be sample sheets. Could you identify those?

A I couldn't tell without comparing them exactly, what ones I have, but they look like the ones that were sent to me that contain the suspended concentrations that I used for the two events.

Q Do you know if this is a USGS form that is used?

A This was sent to us by the EPA. It doesn't look like, it is not a standard form that we use for any specific thing. It is similar to many Government forms, but I cannot tell if it is a USGS form.

Q Do you recall when you received those forms whether all the information in the columns was completed at the time?

For example, one of the columns, Column 8 says Aroclor 1248 and gives some numerical values underneath it.

A I think they are as they were sent to me.

Q What did you use from these charts in making your calculations and reaching your conclusions in your final report?

A I used the date and the time. Al Noehre used the gage height to get a discharge and suspended solids.

Q Have you maintained all the data sheets that were sent to you?

A Yes.

Q They were in your file?

A Yes.

Q You do not know from just looking at these whether that is a complete set or covers the period of --

A I would assume it is because it seems to be about the right number of sheets and if anything, is more than I have.

Q Some of these, the third page on Exhibit No. 5 refers to dates in November of 1979. Do you know if that was after your project ended?

A Yes.

Q Do you know what these refer to?

A No.

Q Mr. Noehre would know, I take it?

A I don't think he would. Those were taken by the EPA. Our active interest in the project ended September 30. I don't believe we did any more work there except to take out the instruments.

Q In October and November of 1979, the figures given here for gage height and suspended solids were not used by you in computing or making your calculations?

A No.

Q The samples that were taken at the Ditch were sent to the Iowa USGS Laboratory for analysis?

A The bed materials, samples that I took. That was sent to the Iowa Laboratory. In addition, some of the suspended samples were sent to the Iowa Lab.

Q What was done with the suspended solids?

A They were analyzed for concentration and in some cases, for size distribution.

Q For the same types of things your bed samples were analyzed for?

A Well, the concentrations were used to come up with sediment discharge and the size was done, we don't really use those data. We could have used, had we been able to use the Modified Einstein. In fact, there it was so little sample they weren't able to break it down and find size fractions that they could use.

Q Who is the person in charge of analyzing the samples at the Iowa Laboratory?

A Those samples were analyzed by the EPA.

Q The bed samples and suspended solids that were sent to Iowa.

A I don't remember the name of the person offhand.

MS. OLIVER: Jim, if they have any materials relating to the work done on this project, we want to see those, too.

MR. HYNES: The Iowa Lab's?

THE WITNESS: They would have, I'm sure, only the data sheets that were sent back to me. They would be in my file.

MS. OLIVER: We asked for Mr. Noehre's file, too.

MR. HYNES: If Mr. Noehre has one.

MS. OLIVER: Thank you.

MR. SHAPIRO: I have just a couple of clarification questions.

RECROSS EXAMINATION

BY MR. SHAPIRO:

Q These sample sheets that were sent to you, you said they were sent by the EPA?

A Yes.

Q That is because the EPA was in charge of taking the various measurements at the Ditch?

MR. HYNES: In charge is a poor choice of words.

MR. SHAPIRO: Let me withdraw that.

BY MR. SHAPIRO:

Q Was the EPA responsible for analyzing the sediment samples that were taken at the Ditch?

A That were taken by them, yes.

Q Taken by them at the Ditch.

Did those include the March 30 and April 11 and 12 storm periods and the three miscellaneous periods?

A They include the March 30 and April 11 and April 12 periods, but not the three miscellaneous.

Q Not the three miscellaneous.

So you received those a period of time after those events took place?

A Yes.

Q From the EPA?

A Yes.

Q And did you make use of the water temperature calculations on the samples?

A No, I did not, but I am sure it was on there when I got these, so I would have seen them, and contrary to my previous memory, I'm sure I saw them.

Q From the figures that appear on the sample sheets, you could have calculated mean temperature for the Ditch?

A I could have, but I don't think it would have meant very much in terms of sediment transport.

Q Let me ask it this way:

Could you have calculated the three theoretical methods using the various temperature values that appear in these sheets?

A Sure.

Q And could you have then developed a composite curve for each of the three models that would reflect the sediment discharge for the range of temperatures in the Ditch?

A You could. You would have an awful lot of curves by then.

Q But you didn't do that?

A No, I didn't.

What might have been more meaningful would have been to, say, average the temperature for March.

Q For each month?

A For June and something like that. It turns out that the one for March would have been close, pretty close to 20 degrees, in fact the average temperature looks as though it was pretty close to 20 degrees. The difference between 19 and 20, 23 and 20, 17 and 20, wouldn't make a significant difference in sediment transport.

When you get down to the ones that are 6, that or zero, that might begin to make a difference.

MR. SHAPIRO: I have no further questions.

MS. OLIVER: I have none.

MR. HYNES: Fine.

(Witness excused.)

FURTHER DEPONENT SAYETH NOT. . .

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

THE UNITED STATES OF AMERICA,	)	
Plaintiff,	)	
vs.	)	No. 78 C 1004
OUTBOARD MARINE CORPORATION AND MONSANTO COMPANY,	)	
Defendants.	)	

I hereby certify that I have read the foregoing transcript of my deposition given at the time and place aforesaid, consisting of Pages 1 to 247, inclusive, and I do again subscribe and make oath that the same is a true, correct and complete transcript of my deposition sogiven as aforesaid, as it now appears.

____
Julia B. Graf

Subscribed and sworn to
before me this ____ day
of __________, A.D. 1981.

____
Notary Public.

Theo L. Urban
Certified Shorthand Reporter
134 South La Salle Street
Chicago, Illinois 60603
312 - 782-3332

UNITED STATES OF AMERICA)
NORTHERN DISTRICT OF ILLINOIS)
EASTERN DIVISION) SS:
STATE OF ILLINOIS)
COUNTY OF COOK)

I, Thea L. Urban, a notary public in and for the County of Cook and State of Illinois, do hereby certify that JULIA B. GRAF was by me first duly sworn to testify the whole truth and that the above deposition was recorded stenographically by me and was reduced to typewriting under my personal direction, and that the said deposition constitutes a true record of the testimony given by said witness.

I further certify that the reading and signing of said deposition was not waived by the witness and her counsel.

I further certify that I am not a relative or employee or attorney or counsel of any of the parties, or a relative or employee of such attorney or counsel, or financially interested directly or indirectly in this action.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal of office at Chicago, Illinois, this ____ day of ______________, A.D. 1981.

____
Notary Public, Cook County, Illinois.
My commission expires December 15, 1983.

Thea L. Urban
Certified Shorthand Reporter
134 South La Salle Street
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