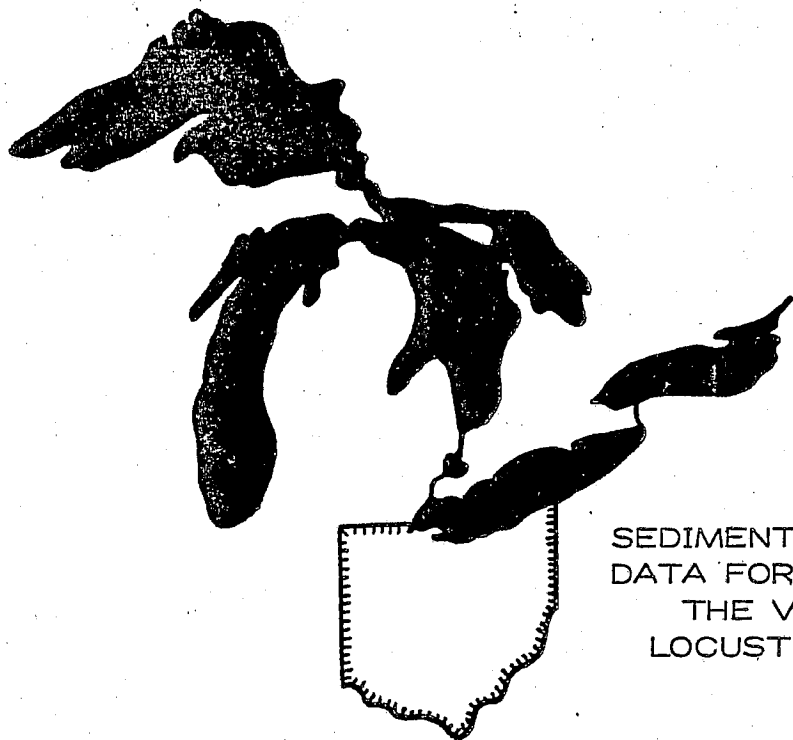




SEDIMENT AND CURRENT
DATA FOR LAKE ERIE IN
THE VICINITY OF
LOCUST POINT, OHIO

CLEAR TECHNICAL REPORT NO. 4

by

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Prepared for
The Toledo Edison Company
Toledo, Ohio

CENTER FOR LAKE ERIE AREA RESEARCH
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO

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PROCEDURE USED FOR SEDIMENT ANALYSIS

SEDIMENT SAMPLING AND ANALYSIS

All surface samples and selected core and sediment collector samples were analyzed mechanically for grain size by sieve and hydrometer methods. The sieve grouping used was U.S. nos. 5, 7, 10, 14, 18, 25, 35, 45, 60, 80, 120, 170, and 230, which gives a half-phi unit interval in grain diameter separation on the Wentworth Grade Scale (table 1). Each sample was sieved for 10 minutes on an electric shaking machine (Tyler Ro-Tap). The material retained on each sieve was weighed to the nearest one-hundredth of a gram and saved for mineral identification.

Statistical analyses were performed on the size distribution data from the samples. The percent of sediment passing through each sieve was tabulated and graphed. Three quartiles, corresponding to the 25, 50, and 75 percent lines, were determined from this percent passing curve. From this information median particle diameters in phi units (Md_ϕ) and sorting coefficients (So) were calculated. The median particle diameter of a sediment sample is that diameter size which corresponds with the 50 percent line (second quartile, Q_2) expressed in phi units. The sorting coefficient, developed by Trask (1932), is a measure of the spread of distribution and is defined statistically as the extent to which the grains spread on either side of the average ($So = \sqrt{Q_3/Q_1}$).

The following classification is useful in describing the uniformity of Lake Erie sediment, particularly in the sand and gravel ranges:

So	Classification
1.0-1.5	well sorted
1.5-2.5	medium sorted
> 2.5	poorly sorted

Samples that consisted predominantly of mud were analyzed for grain size by the hydrometer method. This method is based on Stokes' equation for the velocity of a freely falling sphere (Rubey, 1933). The principle of this procedure is that in a dilute suspension of sediment, thoroughly dispersed and allowed to rest, all particles larger than a specific size will settle within a specific period of time and the reduction of the specific gravity of the suspension caused by this settling can be measured by a hydrometer. Calculations based on such readings can yield the weight or percent of sediment with a

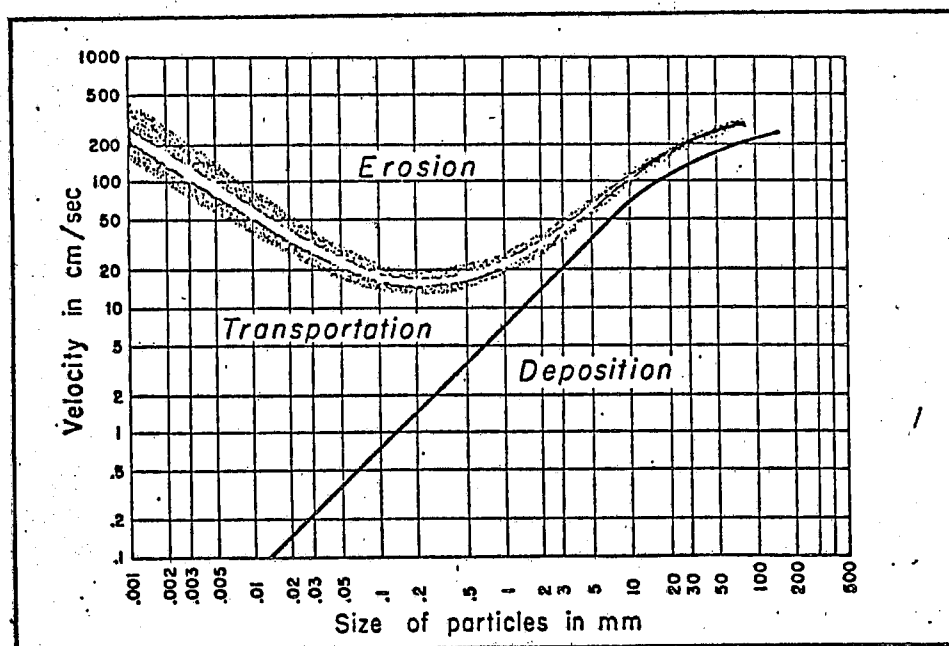
particular size diameter in the sample.

Samples were prepared for hydrometer analysis by hand mixing approximately 50 grams with enough water to make a thin paste. Sodium oxalate (20 ml, 0.1 normal solution) was added as a defloculating agent and the suspension was machine mixed for 10 minutes. The mixture was then placed in a 1-liter graduated cylinder and enough water added to fill the cylinder to the 1,000-ml mark. Normally the hydrometer tests were run in a battery of 11 cylinders. Following a predetermined time schedule, each cylinder was shaken vigorously for about a minute and set to rest. Hydrometer readings were taken at 30 seconds and at 1, 2, 5, 10, 30, 60, and 120 minutes after shaking. A Taylor Instrument Company Bouyoucos-type hydrometer (model H-3863, range 0.995-1.050 specific gravity) was used for these tests. Based on an average specific gravity of 2.70, all of the sand and larger sized particles settle in 30 seconds so that the first reading indicates the combined weight of silt and clay.

TABLE 1
WENTWORTH SEDIMENT GRADE SCALE^a

Class	Grade limits		Grade name	ϕ units (-log ₁₀ diameters in mm)	U.S. Sieve series
	microns (approx.)	mm			
GRAVEL				-12	
		4096	Very large boulders	-11	
		2048	Large boulders	-10	
		1024	Medium boulders	-9	
		512	Small boulders	-8	
		256	Large cobbles	-7	
		128	Small cobbles	-6	
		64	Very coarse pebbles	-5	
		32	Coarse pebbles	-4	
		16	Medium pebbles	-3	
		8	Fine pebbles	-2	
		4	Very fine pebbles	-1	
		2		0	
		1	Very coarse sand	+1	
	1000	$\frac{1}{2}$	Coarse sand	+2	
	500	$\frac{1}{4}$	Medium sand	+3	
SAND	250	$\frac{1}{8}$	Fine sand	+4	
	125	$\frac{1}{16}$	Very fine sand	+5	
	62	$\frac{1}{32}$	Coarse silt	+6	
	31	$\frac{1}{64}$	Medium silt	+7	
	16	$\frac{1}{128}$	Fine silt	+8	
	8	$\frac{1}{256}$	Very fine silt	+9	
	4	$\frac{1}{512}$	Coarse clay	+10	
	2	$\frac{1}{1024}$	Medium clay	+11	
	1	$\frac{1}{2048}$	Fine clay	+12	
	$\frac{1}{2}$	$\frac{1}{4096}$	Very fine clay		
	$\frac{1}{4}$				
MUD					

^aModified from Dunbar and Rodgers (1957).

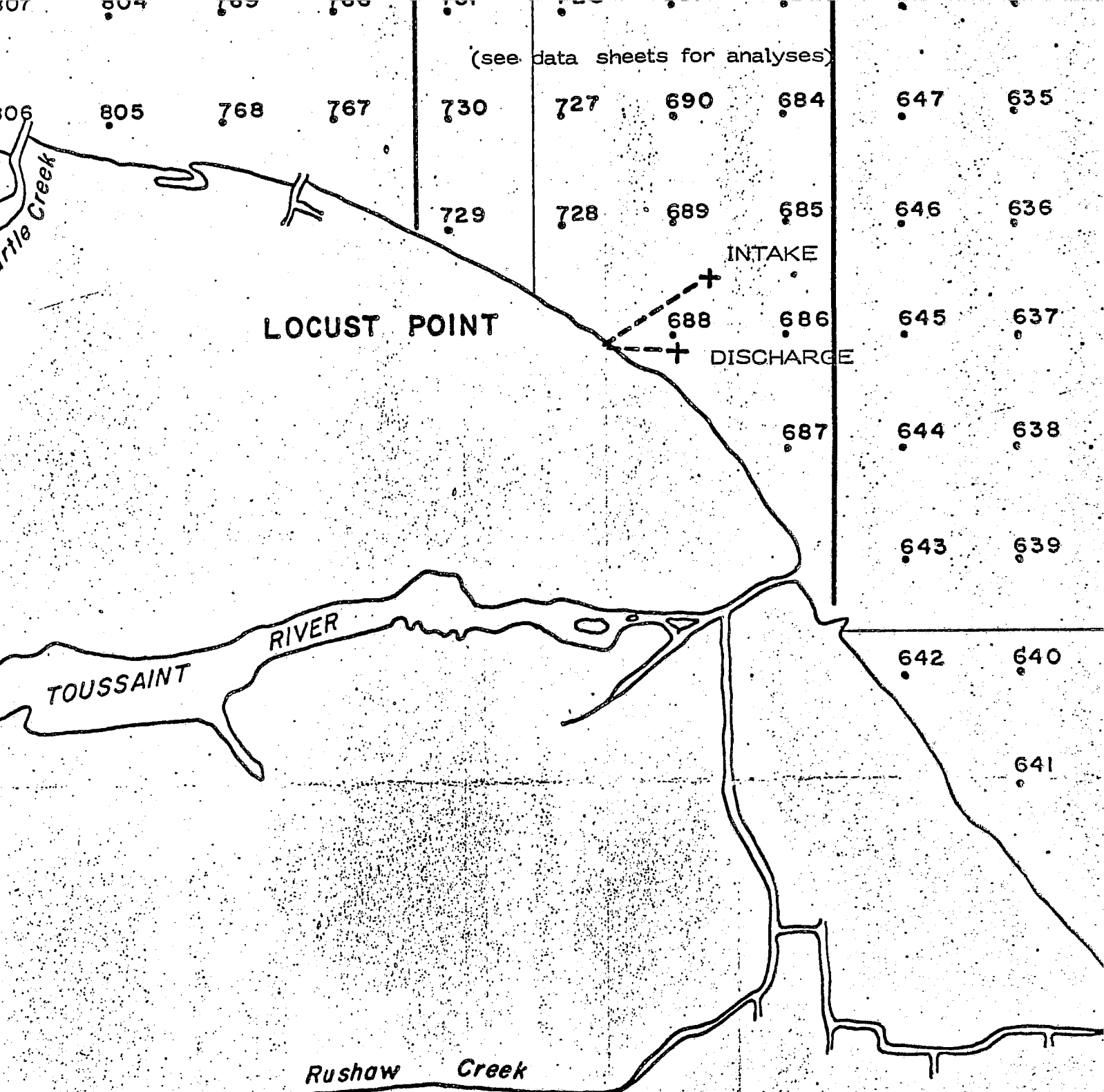


CURRENT VELOCITY CONVERSION TABLE

<u>knots</u>	<u>ft/sec</u>	<u>cm/sec</u>	<u>knots</u>	<u>ft/sec</u>	<u>cm/sec</u>
0.01	0.02	0.52	1.00	1.69	51.48
0.10	0.17	5.15	1.10	1.86	56.63
0.20	0.34	10.30	1.20	2.03	61.78
0.30	0.51	15.45	1.30	2.20	66.96
0.40	0.68	20.60	1.40	2.37	72.09
0.50	0.84	25.76	1.50	2.53	77.24
0.60	1.01	30.88	1.60	2.70	82.36
0.70	1.18	36.02	1.70	2.87	87.51
0.80	1.35	41.18	1.80	3.04	92.66
0.90	1.52	46.33	1.90	3.21	97.81
			2.00	3.38	102.96

FIGURE 27.-CURRENT VELOCITIES AT WHICH VARIOUS SIZE GRADES OF SEDIMENT WILL BE ERODED, TRANSPORTED, OR DEPOSITED (DUNBAR AND RODGERS, 1957; MODIFIED FROM HJULSTRÖM, 1935).

(see data sheets for analyses)



LOCUST POINT

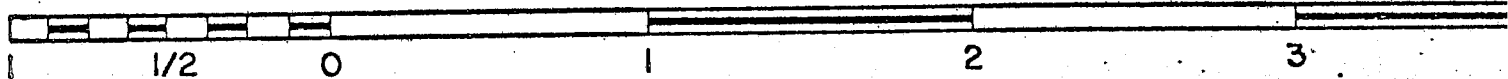
INTAKE

DISCHARGE

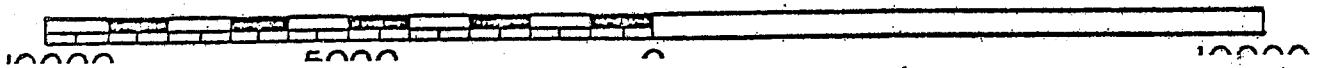
TOUSSAINT
RIVER

Rushaw
Creek

STATUTE MILES



SCALE OF FEET



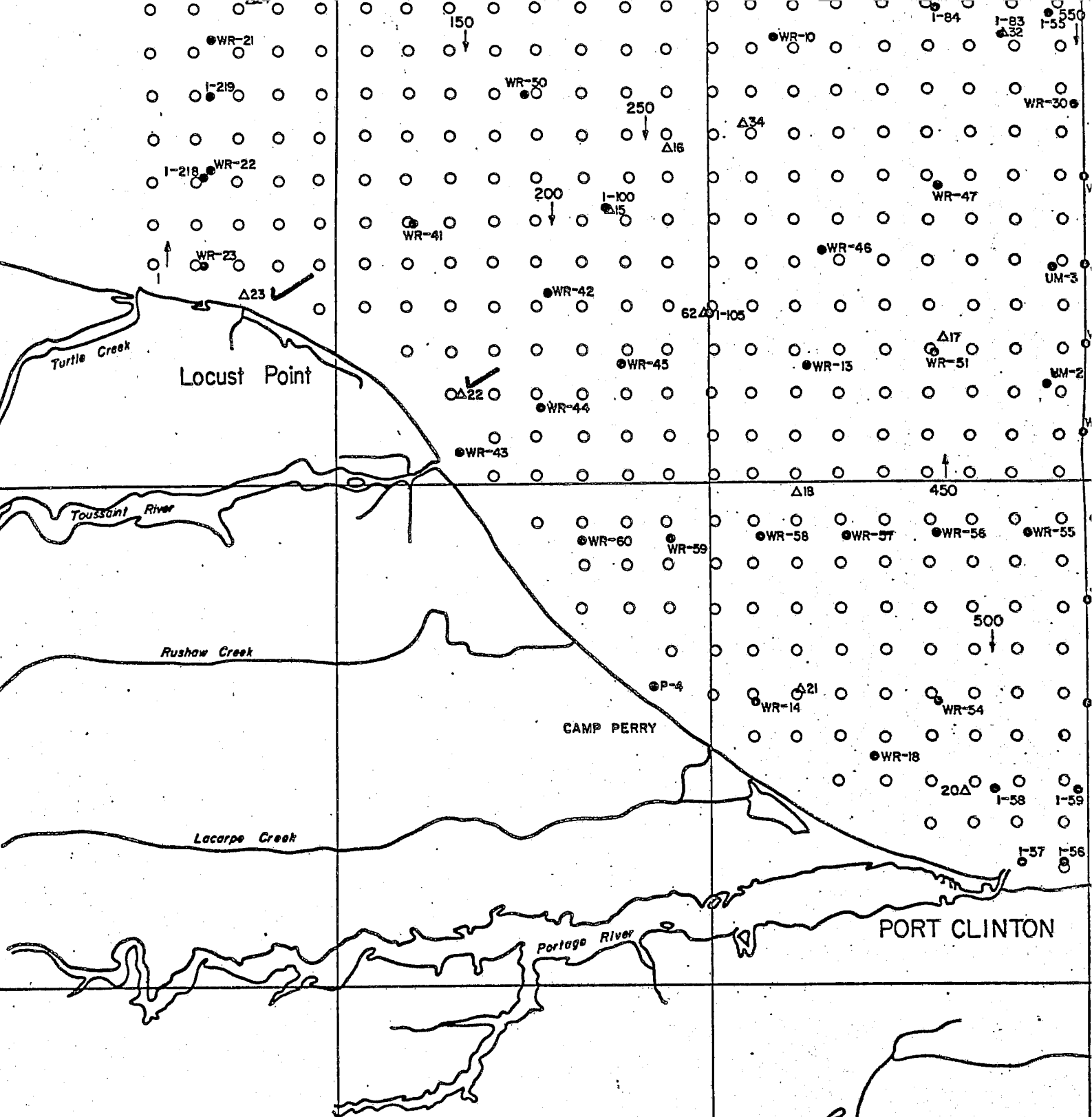
LAKE ERIE SURFACE SEDIMENT SAMPLES
OFFSHORE FROM LOCUST POINT

<u>Station No.</u>	<u>Percent Particle Size</u>			<u>Field Description</u>
	<u>Gravel</u>	<u>Sand</u>	<u>Silt and Clay</u>	
683	54.9	43.5	1.6	Sand and gravel - fine- to medium-grained sand; pea-sized to 1/2" diameter, angular and rounded gravel
684	1.2	98.6	0.2	Sand - brown, medium- to coarse-grained
685	42.5	55.8	1.7	Sand - medium- to fine-grained with 1/2" diameter gravel
686	9.4	87.9	2.7	Sand - brown, medium- to coarse-grained
687	2.1	86.6	11.3	Sand - light brown, fine-grained, silty
188	1.0	19.6	79.4	Sand - coarse-grained, underlain by light gray clay with red zones
689	0.0	0.0	100.0	Clay - light gray, hard with red zones
690	88.9	12.6	1.5	Sand and gravel - fine- to coarse-grained sand, 1/8" diameter gravel, shells
691	16.9	82.4	0.7	Sand and gravel - very fine-grained sand, 1/4" to 3" diameter, subangular
726	68.7	29.6	1.7	Sand and gravel - medium- to coarse-grained sand; 1/8" to 3/8" diameter gravel

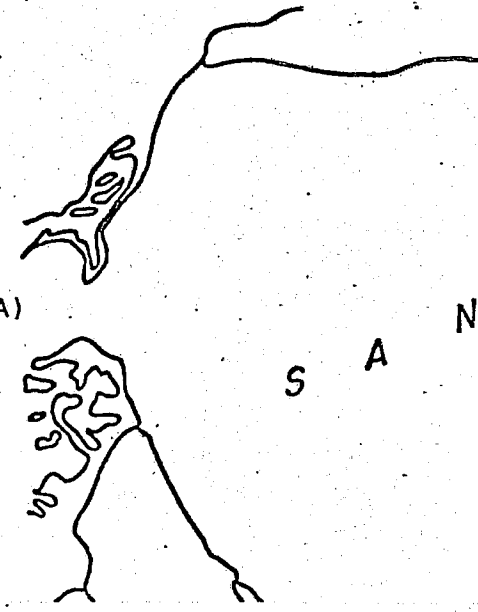
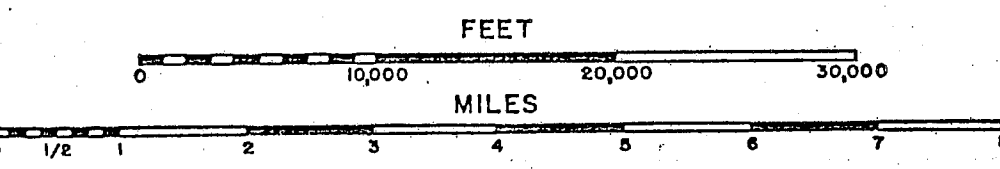
<u>Station No.</u>	<u>Percent Particle Size</u>			<u>Field Description</u>
	<u>Gravel</u>	<u>Sand</u>	<u>Silt and Clay</u>	
727	3.4	93.8	2.8	Sand - brown, medium- to fine-grained, very densely packed
728	16.5	50.7	32.8	Sand and gravel - medium- to coarse-grained sand; 1/8" to 3/8" diameter gravel underlain by light yellow-brown till clay
729	0.0	86.7	13.3	Sand - light brown, fine-grained, over till clay
730	74.9	25.1	0.0	Sand and gravel - brown, medium-grained; fine-grained to 1" diameter gravel
731	37.8	58.7	3.5	Sand and gravel - brown, medium-grained; fine-grained to 1" diameter gravel

SIEVE ANALYSIS OF WASHED SAND AND GRAVEL SAMPLES

Sample Number	WENTWORTH SIEVE SERIES AND PERCENT PASSING													Øm	s
	4	8	10	14	18	25	35	45	60	80	120	170	230		
WR-642	94.60	90.32	89.38	89.15	89.13	89.05	88.77	87.67	82.00	55.12	16.50	3.26	0.71	2.6	1.
WR-643	100.0	100.0	99.91	96.84	92.86	89.11	84.22	77.55	64.48	39.03	17.89	6.84	2.57	2.3	1.
WR-644	100.0	100.0	100.0	99.99	99.95	99.88	99.75	99.36	94.58	31.70	4.90	0.65	0.10	2.4	1.
WR-645	100.0	100.0	100.0	100.0	99.99	99.97	99.71	97.05	77.21	32.13	3.36	0.21	0.02	2.3	1.
WR-646	100.0	99.08	98.64	97.27	94.26	89.48	80.56	63.93	35.99	10.60	1.59	0.17	0.01	1.8	1.
WR-647	94.62	90.24	89.49	87.68	85.43	82.22	76.06	64.60	40.91	19.32	2.36	0.20	0.10	1.9	1.
WR-651	99.78	93.86	92.75	90.81	88.46	85.18	78.98	66.67	44.87	23.87	5.26	0.74	0.06	1.7	1.
WR-681	36.17	35.67	44.76	41.97	37.53	32.91	29.28	26.29	20.22	12.65	2.27	0.37	0.12	<-2.25	3.
WR-683	48.57	45.65	44.76	41.97	37.53	32.91	29.28	26.29	20.22	12.65	2.27	0.37	0.12	<-2.25	3.
WR-684	99.90	99.42	99.18	98.38	96.34	92.79	85.36	67.19	17.12	8.35	1.20	0.24	0.02	1.7	1.
WR-685	63.28	60.11	59.27	57.88	55.99	53.58	48.61	35.40	23.43	11.87	2.10	0.26	0.01	0.8	1.
WR-686	96.42	92.46	91.22	88.13	84.29	79.96	73.06	61.49	40.80	17.67	4.11	0.76	0.16	1.8	1.
WR-687	100.0	98.51	97.95	96.83	95.15	91.98	85.74	72.61	45.69	21.66	6.99	1.87	0.14	1.9	1.
WR-688	100.0	97.90	96.25	93.17	88.01	80.35	69.12	55.39	38.32	24.42	12.79	4.95	0.49	1.7	1.
WR-690	20.05	14.16	13.61	12.93	12.16	11.40	10.20	8.28	5.52	2.77	0.48	0.10	0.06	<-2.25	1.
WR-691	88.09	84.73	83.76	81.51	78.04	73.57	66.35	54.14	34.96	10.86	1.83	0.31	0.13	1.6	1.
WR-692	3.82	3.77	3.76	3.69	3.57	3.44	3.21	2.75	1.98	0.64	0.06	0.06	0.02	<-2.25	1.
WR-693	12.00	11.48	11.35	11.05	10.60	9.97	8.93	7.41	5.27	2.62	0.42	0.06	0.02	<-2.25	1.
WR-694	4.79	2.88	2.55	2.08	1.42	0.97	0.58	0.31	0.14	0.05	0.01	0.10	0.05	<-2.25	1.
WR-695	7.96	7.60	7.53	7.46	7.34	7.20	6.84	5.95	4.16	2.32	0.39	0.95	0.55	<-2.25	3.
WR-696	84.40	76.66	75.16	73.06	70.64	68.00	63.17	53.85	38.50	23.97	6.39	1.95	0.55	<-2.25	1.
WR-697	18.86	17.25	16.64	15.74	14.64	13.40	11.61	9.25	6.04	4.37	1.64	0.22	0.05	<-2.25	1.
WR-700	100.0	100.0	100.0	99.90	99.48	98.85	97.81	95.62	91.97	87.59	79.61	30.24	3.55	3.3	1.
WR-717	100.0	100.0	100.0	100.0	99.93	99.76	99.26	98.17	96.11	93.49	87.79	30.22	3.70	3.3	1.
WR-720	4.34	4.17	4.13	4.04	3.79	3.44	2.99	2.31	1.47	0.90	0.12	0.14		<-2.25	1.
WR-722	74.90	68.60	68.04	66.96	65.44	63.66	60.32	52.91	36.15	15.27	2.48	0.33	0.07	1.6	4.
WR-723	19.75	15.41	14.53	13.59	12.12	10.33	8.40	6.54	3.95	1.67	0.27			<-2.25	1.
WR-724	80.66	59.24	55.39	49.38	43.99	39.37	33.98	27.20	17.18	7.01	1.08			<-2.25	3.
WR-725	64.88	58.53	57.28	54.43	50.32	45.58	38.78	30.03	18.43	8.38	1.79	0.33	0.07	-0.6	3.
WR-726	35.72	31.40	30.80	29.71	28.29	26.63	23.88	19.83	13.58	7.97	1.50	0.22	0.02	0.0	>2.
WR-727	96.59	94.61	93.86	92.35	90.00	86.76	80.75	71.36	52.86	20.13	10.29	1.82	0.11	2.1	1.
WR-728	88.42	78.40	75.30	70.90	65.11	58.85	51.76	43.70	33.46	22.34	9.13	3.20		1.1	3.
WR-729	100.0	100.0	100.0	100.0	99.95	99.84	99.64	99.16	97.18	69.94	13.52	3.27	0.81	2.7	1.
WR-730	36.42	26.43	25.16	23.42	21.90	20.67	18.91	15.88	11.06	5.38	1.07	0.12		<-2.25	>2.
WR-731	19.22	17.53	17.13	16.34	15.25	14.01	12.39	10.11	6.57	2.72	0.44	0.04		<-2.25	1.



- SURFACE SEDIMENT SAMPLING STATION, NUMBERED CONSECUTIVELY BEGINNING IN SOUTHWEST CORNER OF STUDY AREA
- SEDIMENT CORE BORING STATION (STATION I-82 NORTH OF MAP AREA)
- △✓ CURRENT MEASUREMENT STATION
- A-A' LINE OF CROSS SECTION SHOWN IN FIGURE 5



REEF AREA OF WESTERN LAKE ERIE

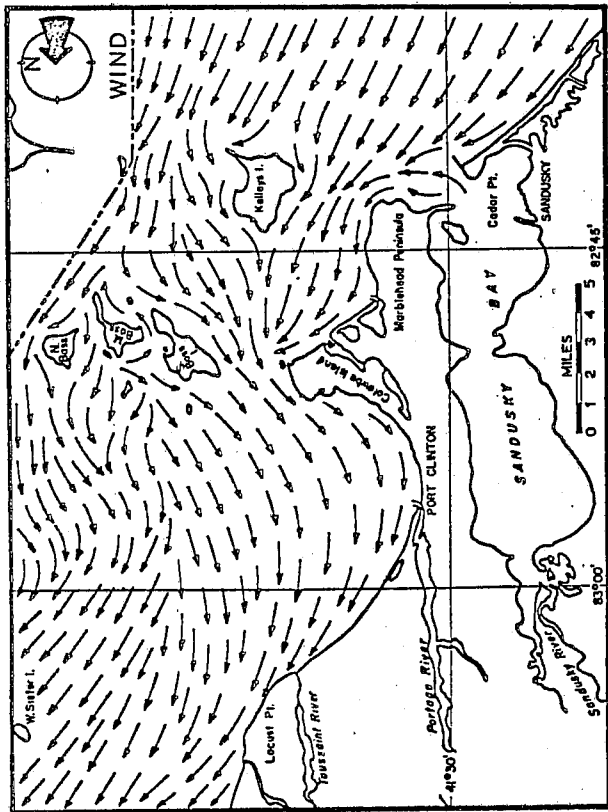
TABLE J.—

Station number	Average current direction and velocity (tenths of knots)															
	North				Northeast				East				Southeast			
	0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30
1 Surface													NE 1			
Bottom													N 1			
2 Surface													NE 3			
Bottom													SW 1			
3 Surface						SW 3				SW 3				NW 1		
Bottom						E 1				E 1				SE 1		
4 Surface		S 3				S 3	S 3	SW 3			SW 1	SW 3			NW 1	
Bottom		SE 1				SE 1	SE 3	E 3			SE 1	E 3			S 1	
5 Surface		S 3				E 3			NE 1							
Bottom		E 3				E 3			NE 1							
6 Surface		S 3				SW 3	SW 3				S 1	SW 3	SW 3		NE 1	
Bottom		E 1				NE 1	E 3				S 1	SE 1	E 1		SE 1	
7 Surface	SW 5										N 1					
Bottom	SW 1	SW 1	SW 1		SW 1	SW 1	W 1				NE 1	W 1		NW 1		
8 Surface	SW 1	S 1	S 1		SW 1	SW 3	S 1	W 3			W 1	W 3		W 1	W 1	
Bottom								N 1			W 1	NW 3		W 1	W 1	
9 Surface									SE 1							
Bottom									E 1							
10 Surface																
Bottom																
11 Surface									S 3							
Bottom									N 1							
12 Surface						NW 3										
Bottom						NE 1										
13 Surface						W 3										
Bottom						NE 1										
14 Surface						SW 3										
Bottom						NE 1										
15 Surface						W 3	W 3				NW 3	NW 5			NW 3	NW 5
Bottom						W 3	W 3				NW 3	N 3			N 3	N 3
16 Surface						W 1	SW 3				NW 3			S 1		
Bottom						S 1	SE 3				NW 3			N 1		
17 Surface											SW 3					
Bottom											NE 3					
18 Surface						W 3					W 3			N 3		
Bottom						NE 3					NE 3			N 1		
19 Surface		SW 3				SW 3										
Bottom		E 3				E 3										
20 Surface						W 5								N 3		
Bottom						NE 1								N 15		
21 Surface											W 3					
Bottom											NE 1					

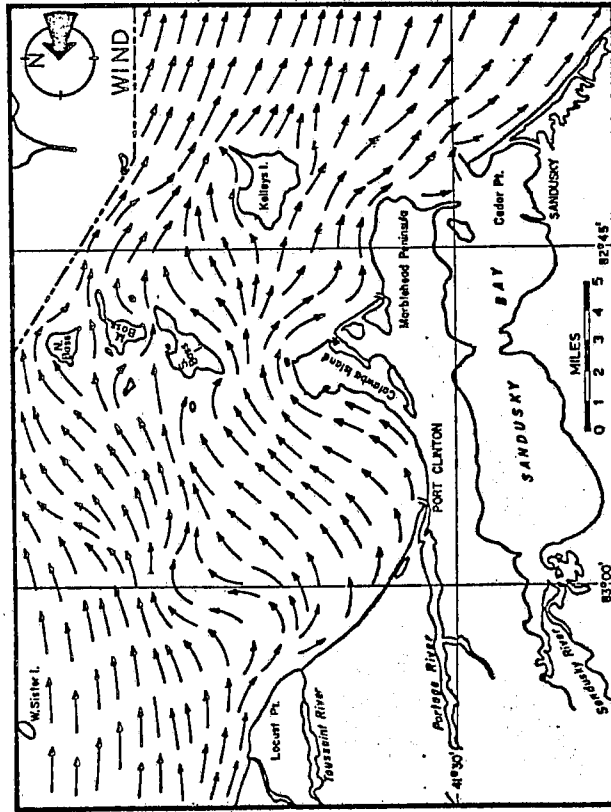
APPENDIX

Current measurements

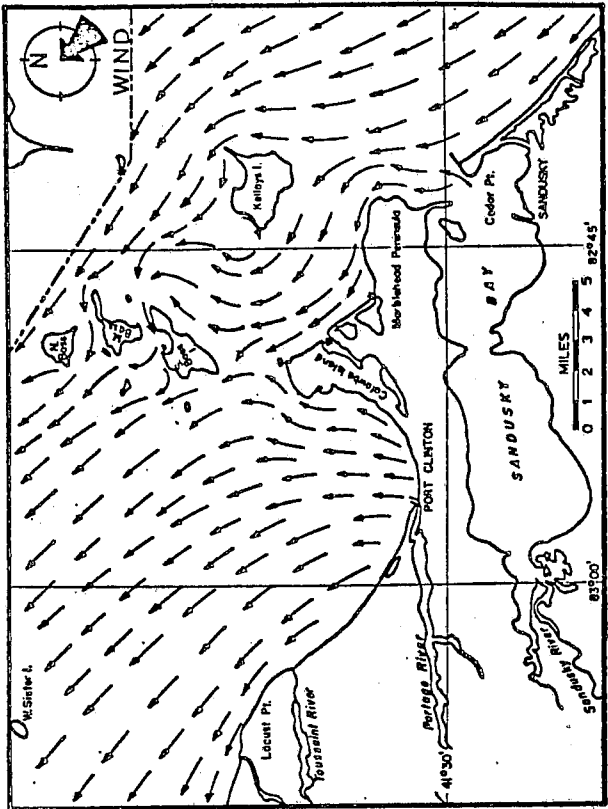
in relation to wind direction and velocity (mph)															
South				Southwest				West				Northwest			
0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30	0-7.5	7.5-15	15-22.5	22.5-30
NE 1 N 1		NE 7 SW 1		SW 1	NE 1 NE 1	NE 7 SW 1									
SW 7	NE 3			SW 7	NE 3 NW 1										
E 3 E 1	E 3 E 3			SE 3 E 1	NE 3 NE 3				E 5 NE 1				SE 3 SE 1		
E 3 W 1	1 S 1			E 3 W 1	NE 1 S 1				E 3 S 1						
NE 3 SW 1	NE 1 NE 1			E 1 W 1	NE 1 W 1	NE 3 S 1		SE 3 W 1	SE 3 NW 1			E 3 S 1	SE 3 N 1	SW 3 W 1	
E 3 SW 5	NE 1 SE 1	NE 3 NE 3		E 3 SW 5	E 3 N 1	SE 5 NE 3		SE 1 NE 1							
N 1				N 1	E 1 E 1			SW 1 N 1	E 1 E 1			E 1 NE 1	E 3 NE 3	E 3 NW 1	
N 1	N 1			NE 1	E 1 NE 1			SE 1 NW 1	E 1 NE 1				SE 3 SE 3	S 3	
					NW 1	N 1 NE 3 S 3		NE 1 S 1	NW 1	N 1					
				NE 3	E 3 N 1			NE 3	E 3 N 1						
					E 1 N 1				E 1 N 1						
					E 1 NE 1				E 1 NE 1						
N 5 NW 1				N 5 NW 1	E 1			N 1	E 1						
					E 3 NW 1				E 3 NW 1						
E 3 E 1	E 3 E 3			E 3 NE 1	E 3 E 1		E 5	N 5	E 3 E 3		E 5				
				NE 3 N 1	NE 1 NW 1	E 3 SE 1		SE 1 S 1		E 3 SE 1		SE 3 SE 1	SE 3 NE 1		
								SE 3 SW 1							
N 3 N 1						SE 3 SW 1				SE 3 SW 1					
						NE 3 SW 1				S 3 SW 1					
N 3 NW 1				NE 3	E 3	SE 1 N 1				SE 1 N 1					
				SW 1		NE 3 NE 1	E 3	SW 1		E 1 SW 1	E 3				
					W 3 W 1	W 1 S 1		S 1	E 3	SE 1 SW 3		S 1 E 1	SE 3 SE 3		
NE 3 W 3				NE 3 W 3	W 1 SE 1	SE 1 NE 1				SE 1 NE 1					
N 5 N 3				N 5 N 3		E 3 E 1		W 1 SW 1	W 1 SW 1	E 3 E 1					
N 3 E 1	N 1 NW 1	N 1 NW 1			N 1	E 3 S 1	N 1 NE 1	E 3 NE 1	SE 3 E 1	E 3 S 1		E 3 N 1	SE 3 E 1		
E 3 W 1	E 3 NW 3			NE 1 S 1	E 3 NW 1			E 3 NE 1	SE 3 NW 1						
N 3 NE 1				NW 1 NW 1	NE 1 NW 1			E 3 N 3				SE 3 E 3			
	E 5 W 3				E 5 W 3										
					SE 1 W 1										



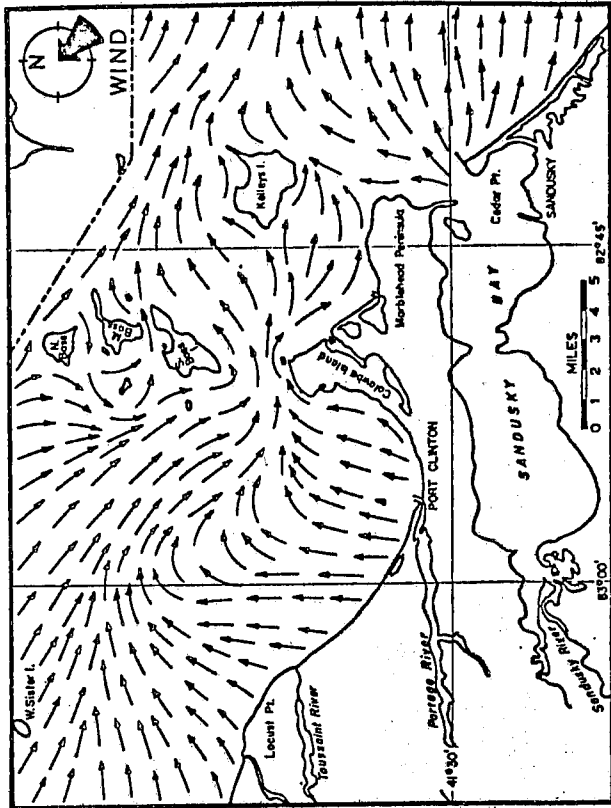
E, Generalized surface currents, moderate east wind



F, Generalized bottom currents, moderate east wind

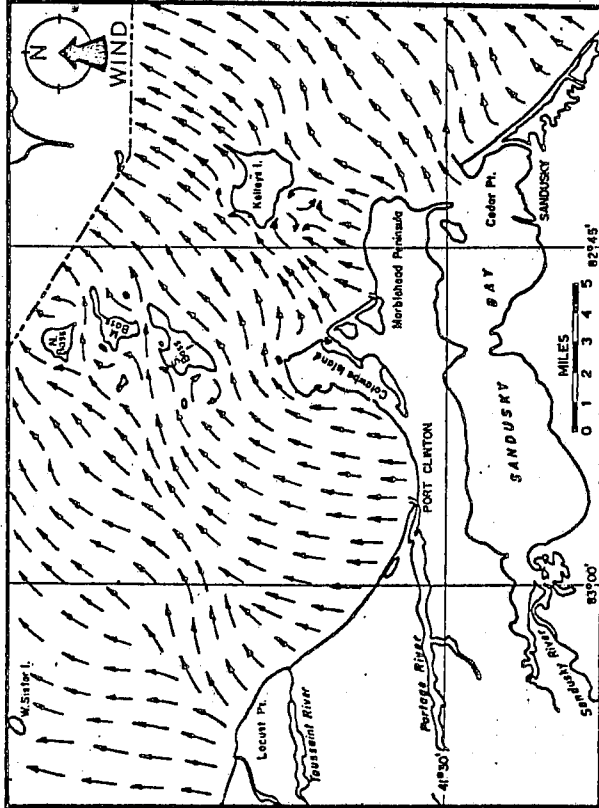


G, Generalized surface currents, moderate southeast wind

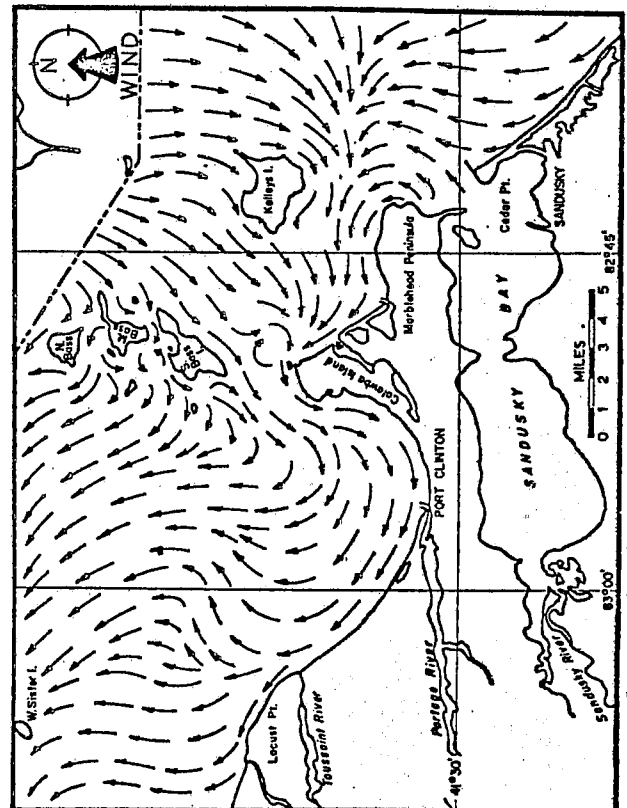


H, Generalized bottom currents, moderate southeast wind

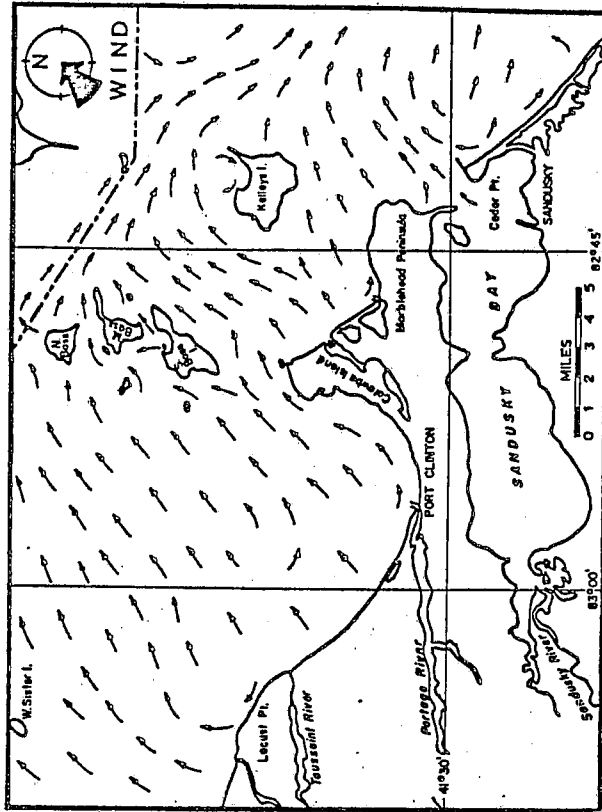
FIGURE 11.—Generalized current diagrams for western basin of Lake Erie—Continued



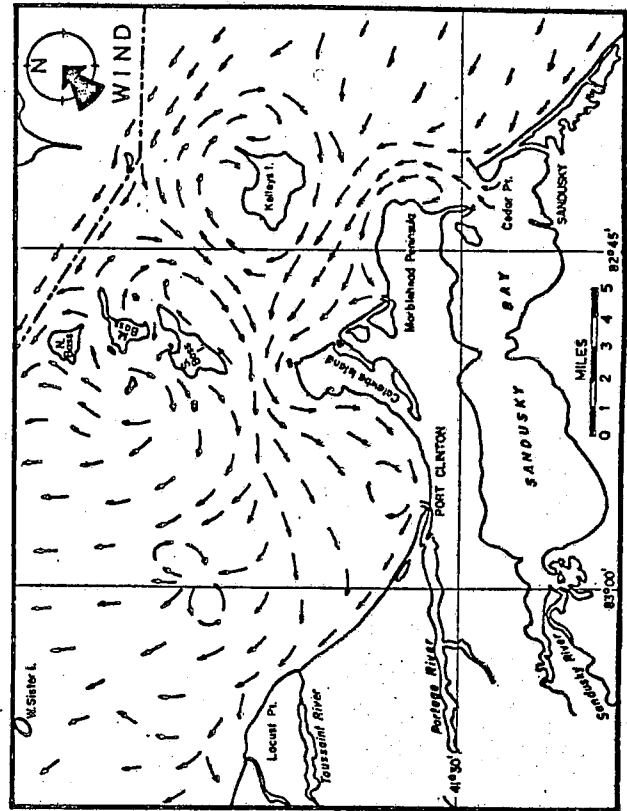
I, Generalized surface currents, moderate south wind



J, Generalized bottom currents, moderate south wind



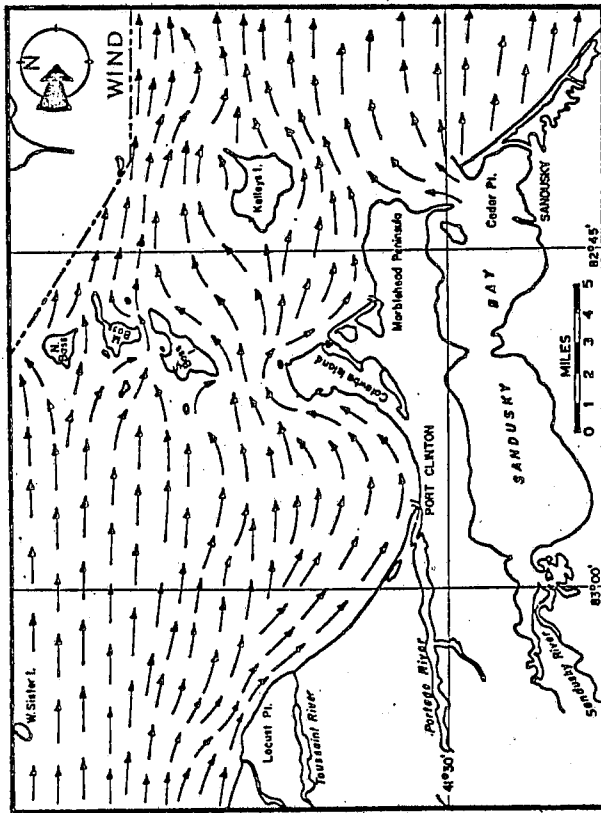
K, Generalized surface currents, moderate southwest wind



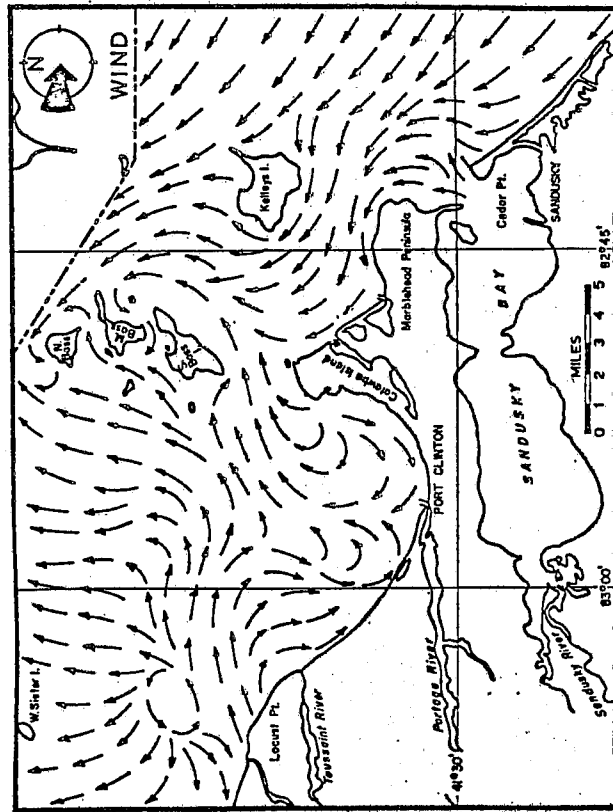
L, Generalized bottom currents, moderate southwest wind

FIGURE 11.—Generalized current diagrams for western basin of Lake Erie—Continued

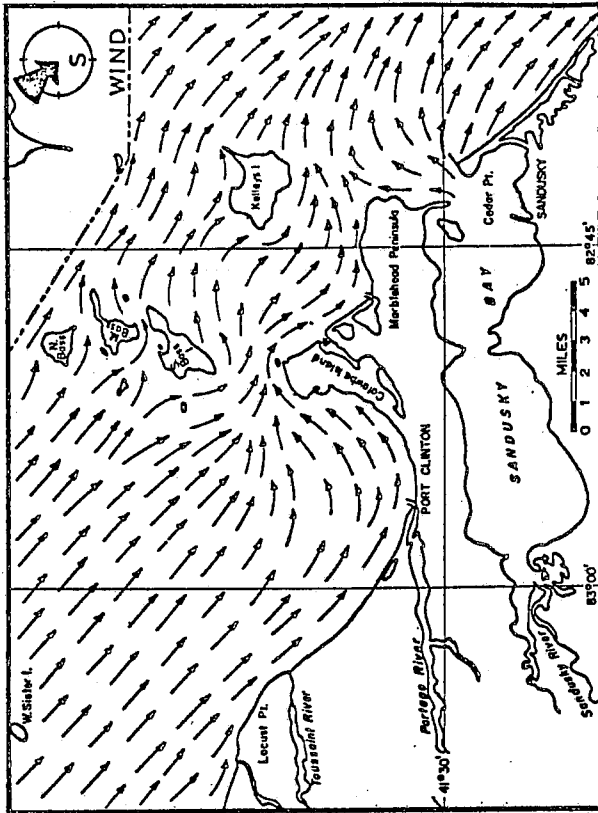
REEF AREA OF WESTERN LAKE ERIE



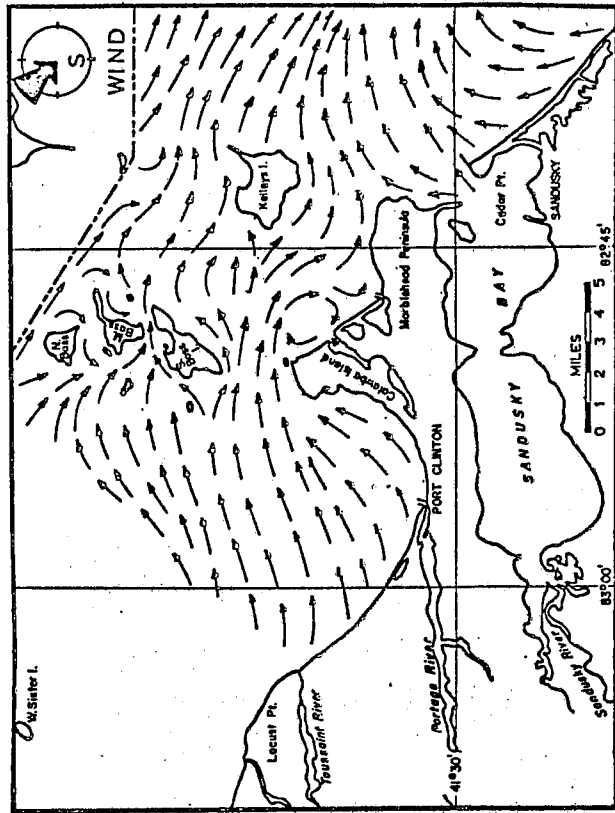
M₁ Generalized surface currents, moderate west wind



N, Generalized bottom currents, moderate west wind



O, Generalized surface currents, moderate northwest wind



P, Generalized bottom currents, moderate northwest wind

FIGURE 11.—Generalized current diagrams for western basin of Lake Erie—Continued