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Inland Waters Directorate

Ontario Region

Water Quality Branch

Ontario Region

MAY 1982

Direction générale des eaux intérieures

Région de l'Ontario

Canada

Contaminants in the Bottom Sediments of the Niagara River - May 1981

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Ontario Region

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Introduction:

In June 1980, the Canada-Ontario Review Board released the Environmental Baseline Report of the Niagara River. In November 1981, a further, more detailed report was issued by the same board. This report contained additional analysis of samples collected in 1979 and 1980 studies and some preliminary results of more recent 1981 studies.

In this report, more recent 1981 bottom sediment sample results are reported for both Upper and Lower Niagara River samples for both metals and toxic organic contaminants as collected by WQB-OR in May 1981.

Sampling Methods:

Bottom sediment samples were collected at the station locations given in Figure 1 using a US. BM-54 sampler shown in Figure 2. This is a sampler equipped with tail fins to hold it in the current. When supported by a cable or rope, the sampler is set in the open position for taking a bed sample. When tension on the cable is released by resting the sampler on the stream bed, about the top inch of sediment is collected. The bucket surrounds and encloses the sample so that it is not washed out when the sampler is raised to the water surface.

Descriptions of the proposed sampling stations are given in Tables 1 and 2. Descriptions of the bottom sediments as collected are given in Tables 3 and 4.

PROPOSED

SAMPLING SCHEDULE (DOE)

LOWER NIAGARA RIVER

1981

STATION NO.	RIVER MILEAGE	DESCRIPTION	ANALYSIS BOTTOM SED U.S. BM-54
1	Ni 1.5	Midstream-on line with NOTL station	*
2	Ni 2.8	Cdn. side-above St. Catherines boat club	*
3	Ni 3.7	U.S. side-below SCA discharge pt.	*
4	Ni 4.8	Cdn. side-in area MOE found high PCB 1979	*
5	Ni 5.6	U.S. side-between SCA and Lewiston	*
6	Ni 6.3	Cdn. side-downstream of Queenston	*
7	Ni 6.8	U.S. side-downstream of Lewiston	*
8	Ni 6.8	Midstream	*

TABLE 1

SAMPLING SCHEDULE

UPPER NIAGARA RIVER

(PROPOSED - 1981 - DOE)

STATION NO.	RIVER MILEAGE	DESCRIPTION	ANALYSIS BOTTOM SED U.S. BM-54
9	Ni 37.7	2500 ft. from Cdn. shore	*
10	Ni 38.5	In mouth of Buffalo River	*
11	Ni 36.2 (A)	Above Peace Bridge-Cdn. side	*
12	Ni 36.2 (B)	Above Peace Bridge-U.S. side	*
13	Ni 34.6 (A)	Above International Bridge-Cdn. side	*
14 i	Ni 34.6 (B)	Above International Bridge-U.S. side	*
14 ii	Ni 34.6 (C)	Above International Bridge-in Black Rock Canal	*
15	Ni 32.9 (A)	At mouth of Frenchman's Crk.-Cdn. side	*
16	Ni 32.9 (B)	At mouth of Frenchman's Crk.-U.S. side	*
17	Ni 31.3	Midstream-S. tip of Grand Is.-Chippewa Channel	*
18	Ni 27.2	At mouth of Miller Crk. (Chippewa Channel)	*
19	Ni 24.5	At mouth of Black Crk. (Chippewa Channel)	*
20	Ni 20.5	Midstream-Chippewa Channel above Navy Is.	*
21	Ni 19.4	Downstream of Hooker Res. Lab on Grand Is.	*
22	Ni 18.0	Above Chippewa Power Canal Inlet-Cdn. side	*
23	Ni 31.4	Midstream-S. tip of grand Is.-Tonawanda Channel	*
24	Ni 29.8	U.S. side-Upstream of S. Grand Is. Bridge	*
25	Ni 27.3	U.S. side-At mouth of Two Mile Crk.	*
26	Ni 25.4	Between Tonawanda Is. and U.S. shore- at North end of island	*
27	Ni 23.3	U.S. side	*
28	Ni 21.4	At East entrance behind Cayuga Is.-U.S. side	*
29	Ni 20.1	At West entrance behing Cayuga Is.-U.S. side	*
30	Ni 19.3	Midstream-Just downstream of N. Grand Is. Br.	*
31	Ni 18.9	U.S. side-Off Hooker S. & N. sites	*
32	Ni 17.6	At mouth of Gill Creek-U.S. side	*

TABLE 2

LOWER NIAGARA RIVER BOTTOM SEDIMENTS DESCRIPTION

STATION	DATE	DISTANCE FROM SHORE (FEET)	SEDIMENT DESCRIPTION
6.8 A	May 6	Mid Channel	No Seds (Gravel)
6.8 B	May 6	100'	Sand and Gravel
6.3	May 6	50'	Sand and Gravel
5.6	May 7	50'	No Seds (Rocks)
4.8	May 6	100'	Sandy
3.7	May 6	50'	No Seds
2.8	May 7	100'	Sand and Gravel
1.5	May 8	Mid Channel	No Seds

TABLE 3

UPPER NIAGARA RIVER BOTTOM SEDIMENTS DESCRIPTION

STATION	DATE	DISTANCE FROM SHORE (FEET)	SEDIMENT DESCRIPTION
38.5-Buffalo R.	May 9	Mid Channel	Black Mud
37.7	May 9	Mid Channel	No Seds (Rocks)
36.2 A	May 9	100'	No Seds
36.2 B	May 9	50'	No Seds
34.6 A	May 9	25'	No Seds
34.6 B	May 9	25'	No Seds
34.6 C	May 9	25'	Black Mud, Oily
32.9 A	May 8	50'	Sand and Mud
32.9 B	May 8	50'	Sand and Mud
31.3	May 8	Mid Channel	No Seds
27.2	May 8	50'	Clay, Mud and Sand
24.5	May 8	50'	Clay
20.5	May 8	Mid Channel	No Seds (Rocks)
19.4	May 8	100'	No Seds (Rocks)
18.0	May 8	50'	No Seds (Rocks)
31.4	May 8	Mid Channel	No Seds
29.8	May 8	50'	Sand and Mud
27.3	May 8	50'	Sand and Mud
25.4	May 8	Mid Channel	Sand and Mud
23.3	May 8	50'	Sand and Pepples
21.4	May 8	Mid Channel	Sand and Mud
20.1	May 8	Mid Channel	Black Mud
19.3	May 8	Mid Channel	No Seds (Gravel)
18.9	May 8	50'	No Seds (Rocks)
17.6	May 8	50'	No Seds (Rocks)

TABLE 4

Results and Discussion:

Organic Contaminants:

BHC (α and γ Isomers) (Figures 3 and 4)

Levels of α BHC (a breakdown product of Lindane) were generally at or near the detection limit except for stations in the Black Rock Canal, (32 PPB) near the Love Canal (2269 PPB) and in the Lower Niagara River (151 PPB). Lindane was found in highest concentrations near the Love Canal (21 PPB) and in the Lower Niagara River (87 PPB).

Heptachlor Epoxide: (Figure 5)

Heptachlor epoxide was identified in only four of the sixteen samples collected. Of these highest values were observed in the Buffalo River, (8 PPB) near the Love Canal (10 PPB) and off Two Mile Creek (19 PPB).

α and γ Chlordane (Figure 6 and 7)

α- chlordane was detected in only four of the sixteen stations sampled. All of these except one station in the Black Rock Canal where a value of 49 PPB was measured were relatively low.

γ- chlordane was detected at only two locations. Once again the Black Rock Canal station was high with 94 PPB and the other station located between Tonawanda Island and the U.S. mainland had a value of 20 PPB indicating a source from Ellicot Creek or the Erie Canal.

α and B-Endosulfan (Figure 7 and 8)

Values of α-endosulfan were generally low except for the Buffalo River, the Black Rock Canal and downstream of the Black Rock Canal.

Values of B-endosulfan were low throughout the entire river system except near the Love Canal where a value of 28 PPB was observed.

Heptachlor and Aldrin:

No heptachlor or aldrin was detected at any of the sixteen stations sampled.

DDT and its Metabolites: (Figures 9, 10, 11)

(i) o-p-DDT - This metabolite was not found at any of the sixteen stations sampled.

(ii) p-p-DDT - Parent DDT as this compound is called was found in five of the sixteen stations sampled. Since use of this compound was banned in Canada it is puzzling to see its persistence in sediments off Frenchman's and Miller Creeks on the Canadian side. Either this compound is still being used illegally or it is undegraded in the sediments nearly nine years after its use. Even higher values were observed on the American side downstream of the Black Rock Canal and some p-p-DDT was observed in the Buffalo River.

(iii) p-p-DDE Low levels of this compound were observed at many stations throughout the Niagara River. High values were observed in the Black Rock Canal and downstream of it and between Tonawanda Island and the U.S. mainland indicating a source from Ellicot Creek or the Erie Canal.

(iv) p-p-TDE Generally, values of this compound were quite low throughout the river system. However, somewhat elevated levels were observed along the U.S. mainland side of the river and the Tonawanda Channel particularly off Two Mile Creek.

Dieldrin and Endrin: (Figures 12 and 13)

Dieldrin was detected in only two of the samples collected near the Love Canal and between Tonawanda Island and the U.S. shore.

Endrin was detected at five stations, all along the U.S. mainland from the Buffalo River to Tonawanda Island. Highest values were observed in the Black Rock Canal (181 PPB) and off Two Mile Creek (50 PPB). These areas are probable sources of this compound.

Mirex: (Figure 14)

Mirex values throughout the entire river system were very low except at one station near the Love Canal. At this station a very high mirex value of 890 PPB was observed. This peak was confirmed with G.C.-M.S. analysis. This is not surprising since Hooker Chemical was the sole producer of this compound and large quantities of it are known to have been disposed of in the Love Canal dumpsite.

Methoxychlor: (Figure 15)

Elevated concentrations of this compound were observed downstream of the Black Rock Canal, off Two Mile Creek, off Miller Creek and at one station in the Lower Niagara River.

PCB: (Figure 16)

Elevated values of PCB were observed at every station along the U.S. mainland side of the river and also in the Lower Niagara River indicating sources to the river. Values along the Chippewa Channel, however were relatively low. Very high values were observed in the Black Rock Canal (10200 PPB) and downstream of it (2820 PPB), and between Tonawanda Island and the U.S. Mainland (17900 PPB) indicating a large source probably Ellicot Creek or the Erie Canal. Less elevated values were also observed near the Love Canal (630 PPB) and in the Buffalo River (480 PPB). Values in the Lower Niagara River ranged from 100-300 PPB indicating an increase in concentration from those values observed in the Chippewa Channel of the Upper Niagara.

Dichlorobenzenes: (Figures 17, 18, 19)

Of the three dichloro isomers, the one of widest usage (ie the 1,4-dichloro isomer (Oliver 1981)) also occurs in the highest concentrations and with the widest distribution in the bottom sediments of the Niagara River. The 1,3 isomer occurred at elevated levels in the Black Rock Canal and downstream of it and also at one station in the Lower Niagara. High levels of the 1,4 isomer occurred throughout the river sediments with elevated levels near the Love Canal. The 1,2 isomer also had elevated levels in the Black Rock Canal and downstream of it, near the Love Canal and also at one station in the Lower Niagara.

Trichlorobenzenes: (Figures 20, 21, 22)

The three trichlorobenzene isomers were generally evenly distributed at low concentrations except for somewhat elevated values near the Love Canal, in the Black Rock Canal and in the Buffalo River for the 1,2,3 isomer.

Tetrachlorobenzenes: (Figures 23, 24)

The two tetrachlorobenzene isomers were generally below the detection limit of the analytical method except for high values observed near the Love Canal thereby indicating a source of these compounds.

Pentachlorobenzene: (Figure 25)

This compound showed low values in the Buffalo River and downstream in the Tonawanda Channel. However, of more concern, a very high value was observed near the Love Canal.

Hexachlorobenzene: (Figure 26, 27)

This compound was analysed by standard packed column G.C. and capillary column G.C. Generally distributions were quite similar using both methods. High values were observed near the Love Canal, and between Tonawanda Island and the U.S. mainland in both analysis. A high value was also observed in the Lower Niagara River at one station using capillary column G.C.

Dioxins:

Seven samples of bottom sediments were analysed for 2,3,7,8-TCDD at the following locations (Stations 34.6C, 21.4, 25.4, 6.8B, 38.5, 20.1 and 4.8). This most toxic isomer of the dioxins was not detected at the 5 PPT level in any of these samples.

Metals:

Plots of metal concentrations are given for each of the metals analysed. Methods of analysis were the following:

(i) Total (Arsenic, Selenium and Mercury)

(ii) Extractable using 0.5N HCl (Cadmium, Lead, Cobalt, Copper, Zinc, Nickel and Chromium)

Cadmium: (Figure 28)

Generally, higher values of cadmium were found along the U.S. side of the river from the Buffalo River to the Love Canal area. Especially high values were found in the Black Rock Canal off Scajaquada Creek, in the Buffalo River, off Two Mile Creek, near the Love Canal and at one station in the Lower Niagara. All of these sites except the Lower Niagara one indicate possible sources of cadmium may be present in these areas. Many of these high values were above the MOE objective of 1 PPM.

Chromium: (Figure 29)

Chromium values in the bottom sediments of the Niagara River were generally below the MOE objective of 25 PPM except in the Black Rock Canal and downstream thereof, near the Love Canal and off Two Mile Creek.

Cobalt: (Figure 30)

All cobalt values ranged from 1-5 PPM in the bottom sediments of the Niagara River and were never above the MOE objective of 50 PPM.

Copper: (Figure 31)

Violations to the MOE objective of 25 PPM occurred at several locations, nearly all of which were on the U.S. side of the River. Most elevated values were observed in the Black Rock Canal and downstream thereof, in the Buffalo River, off Two Mile Creek, near the Love Canal and in the Lower Niagara River.

Lead: (Figure 32)

Violations of the MOE objective of 50 PPM occurred at most stations along the U.S. side of the river from the Buffalo River to the Love Canal area. Highest values were observed in the Black Rock Canal off Scajaquada Creek and downstream of the canal.

Nickel: (Figure 33)

Violations of the MOE objective of 25 PPM occurred at only one station in the Black Rock Canal off Scajaquada Creek.

Zinc: (Figure 34)

Violations of the MOE objective of 100 PPM occurred at several stations along the U.S. side of the river from the Buffalo River to the Love Canal area. Highest values occurred in the Black Rock Canal, in the Love Canal area and at one station in the Lower Niagara.

Mercury: (Figure 35)

Very high mercury concentrations (over ten times higher than on the Canadian shore) were observed at nearly every station along the U.S. shore from the Buffalo River to the Love Canal area. Values over 1 PPM were observed in the Black Rock Canal off Scajaquada Creek, downstream of the Black Rock Canal, and near the Love Canal. Elevated values were also observed in the Lower Niagara River as compared to the Chippewa Channel of the Upper Niagara River. Violations of the MOE objective of 0.3 PPM were observed at several stations including the Buffalo River, the Black Rock Canal and downstream thereof and near the Love Canal.

Total Arsenic: (Figure 36)

Levels of total arsenic were generally below the MOE objective of 8 PPM except in the Buffalo River, in the Black Rock Canal and downstream of the Black Rock Canal.

Total Selenium: (Figure 37)

Total selenium values were well distributed at values below about 500 PPB throughout the Niagara River system. Somewhat elevated values appeared near the Love Canal and at one station in the Lower Niagara.

Particulate Organic Carbon: (Figure 38)

Values of P.O.C. ranged from 1-4% in the bottom sediments with a high of 6% observed in the Black Rock Canal off Scajaquada Creek. This value approaches the MOE limit of 6% for % loss on ignition.

Particulate Nitrogen: (Figure 39)

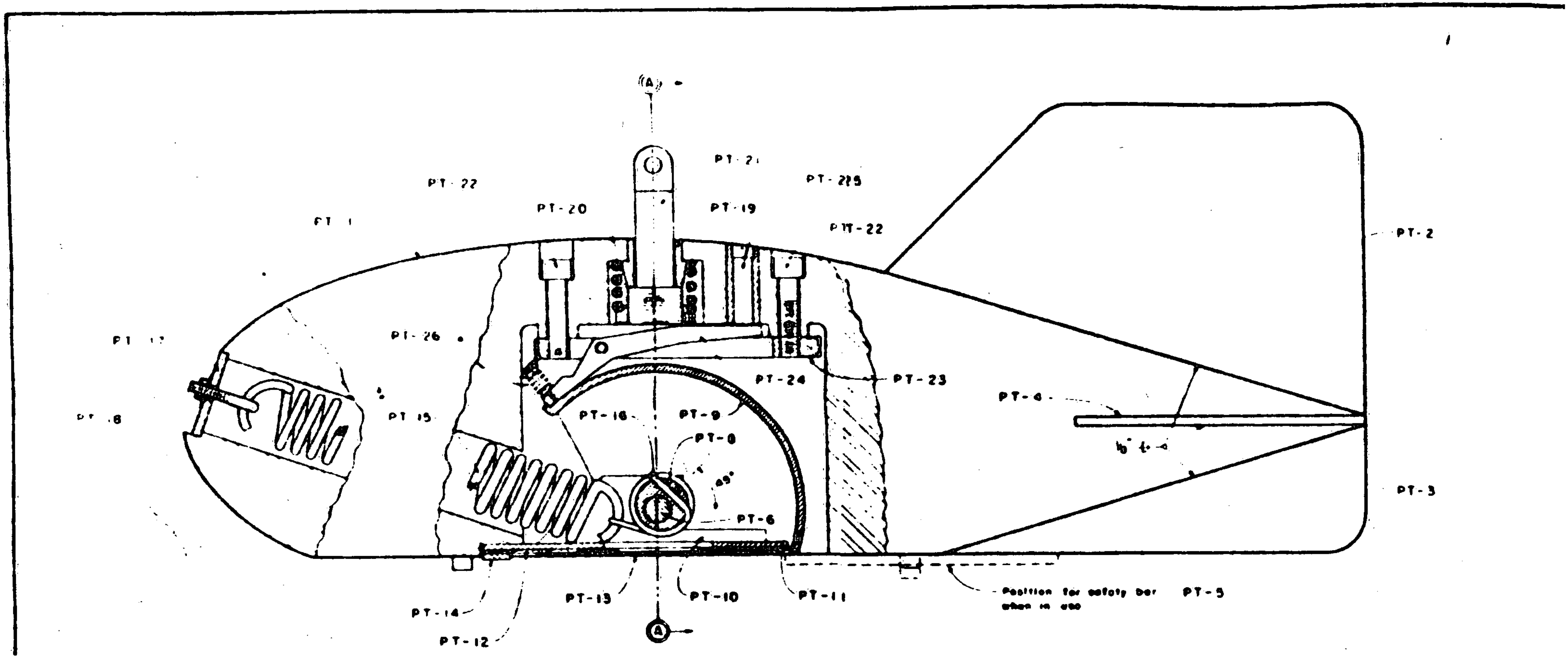
Particulate nitrogen values were usually below 100 PPB except for stations in the Buffalo River, the Black Rock Canal, off Frenchman's Creek and near the Love Canal.

Conclusions:

From these data the Buffalo River, the Black Rock Canal or Scajaquada Creek, Two Mile Creek, Ellicot Creek (or the Erie Canal) and the Love Canal area are or have been sources of many of these contaminants to the Niagara River.

Lake Erie does not appear to be a significant source of any of these compounds since concentrations measured in the Chippewa Channel, where 56% of the flow from Lake Erie is channelled, are generally much lower than on the U.S. mainland side of the river in the Tonawanda Channel.

Most of the areas of concern mentioned above contain sediments which violate the MOE dredge spoil criteria for disposal of these sediments. These sediments also fall into the U.S.E.P.A. Region V classification of heavily polluted sediments for most of these contaminant parameters. Therefore disposal of these dredge spoils must be contained and not dumped into Lake Erie.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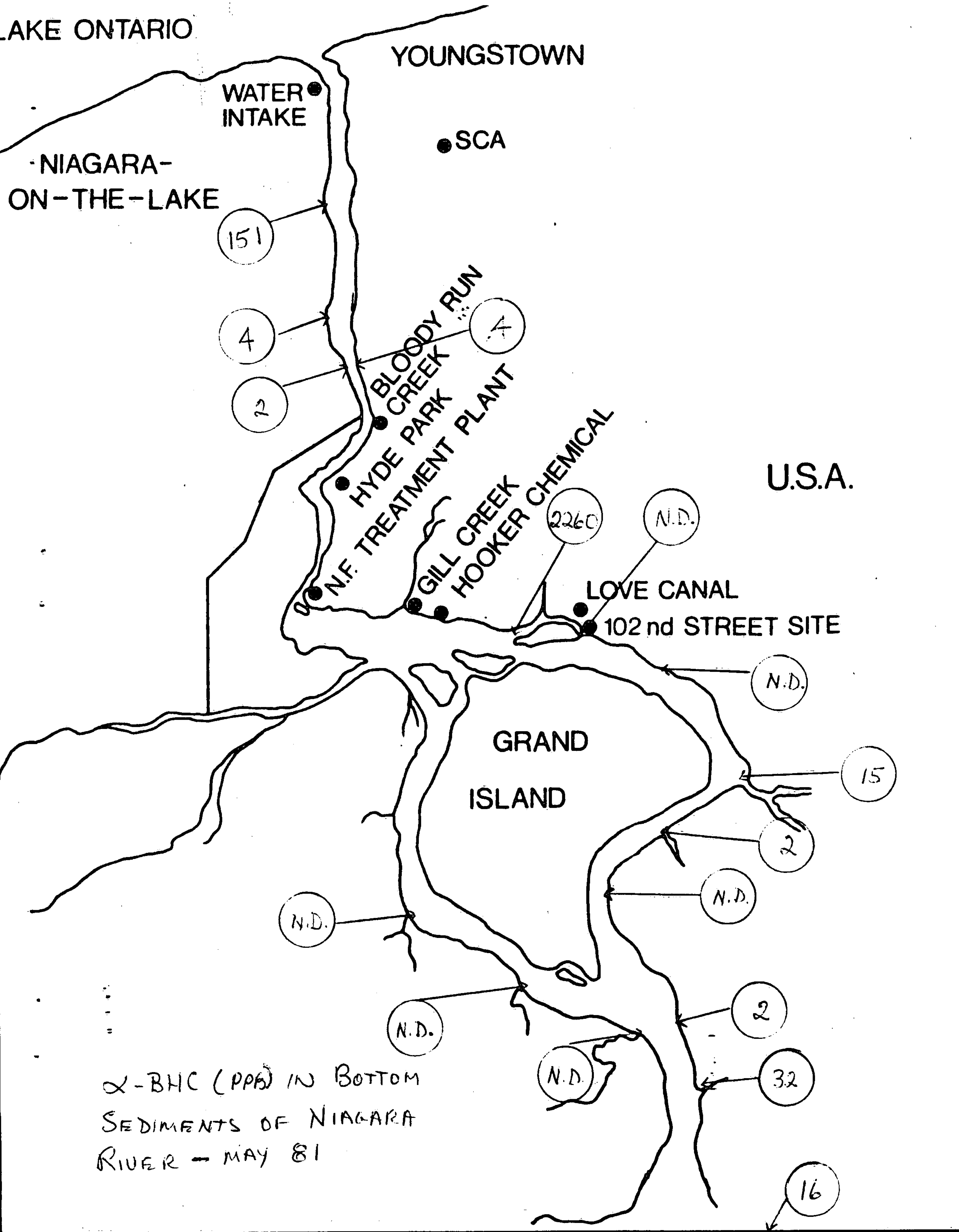
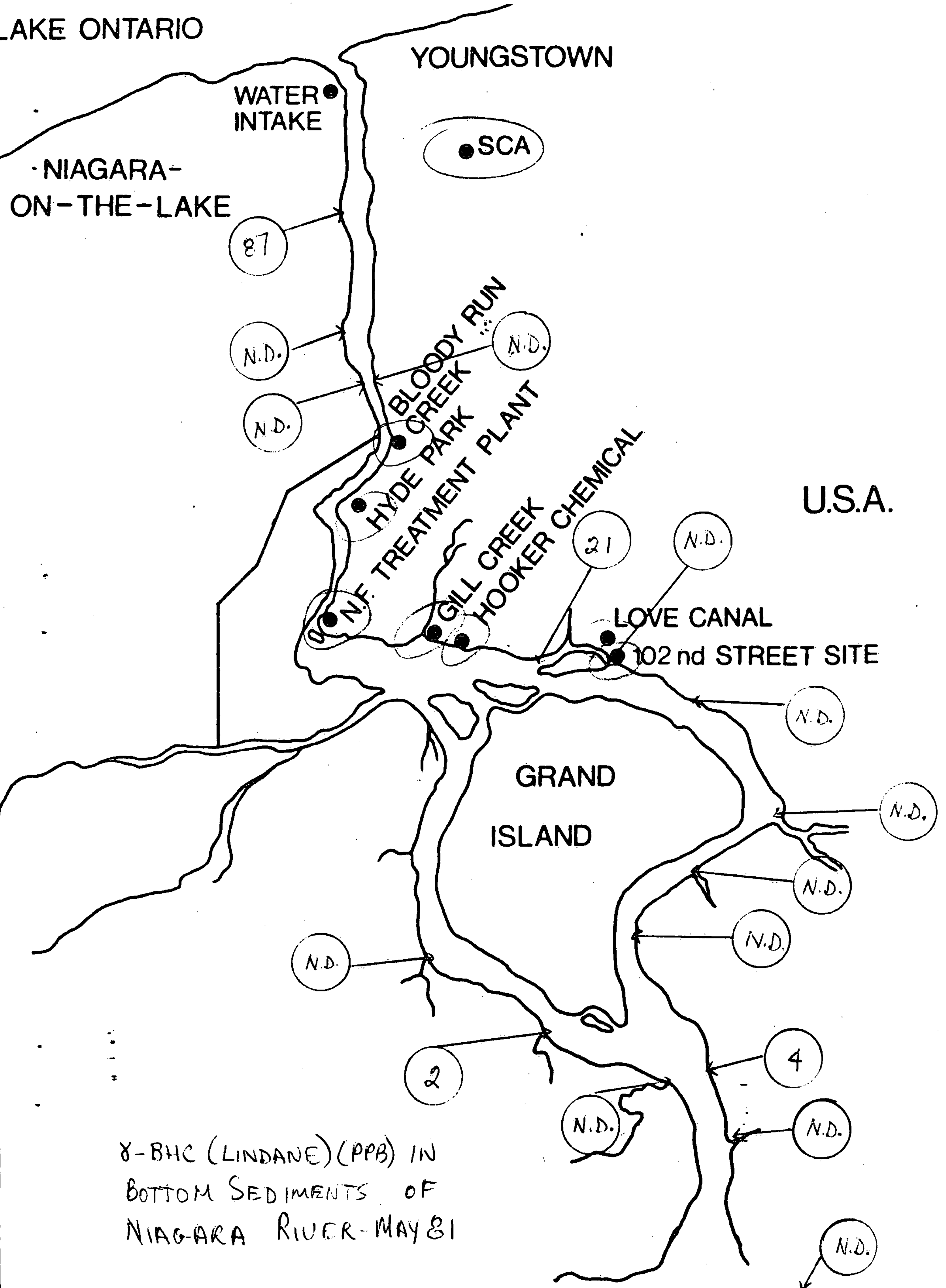
Position for safety bar when in use
PT-5
A

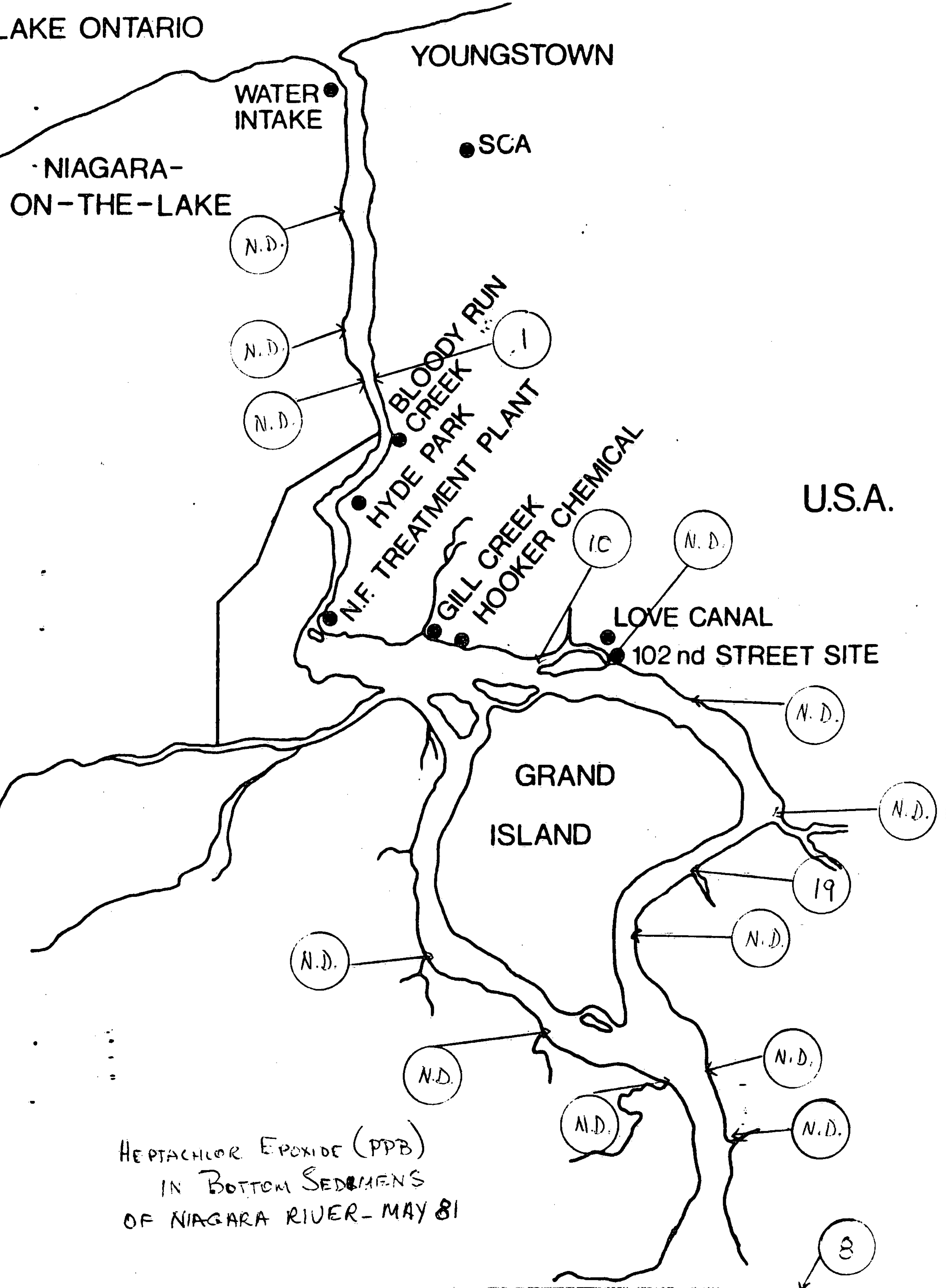
FIGURE 2



α-BHC (ppb) in Bottom Sediments of Niagara River – May 81



γ-BHC (LINDANE) (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81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SCA
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N.D.
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N.D.
BLOODY RUN CREEK
HYDE PARK
N.F. TREATMENT PLANT
GILL CREEK
HOOKER CHEMICAL
1C
N.D.
U.S.A.
LOVE CANAL
102 nd STREET SITE
N.D.
GRAND ISLAND
N.D.
19
N.D.
N.D.
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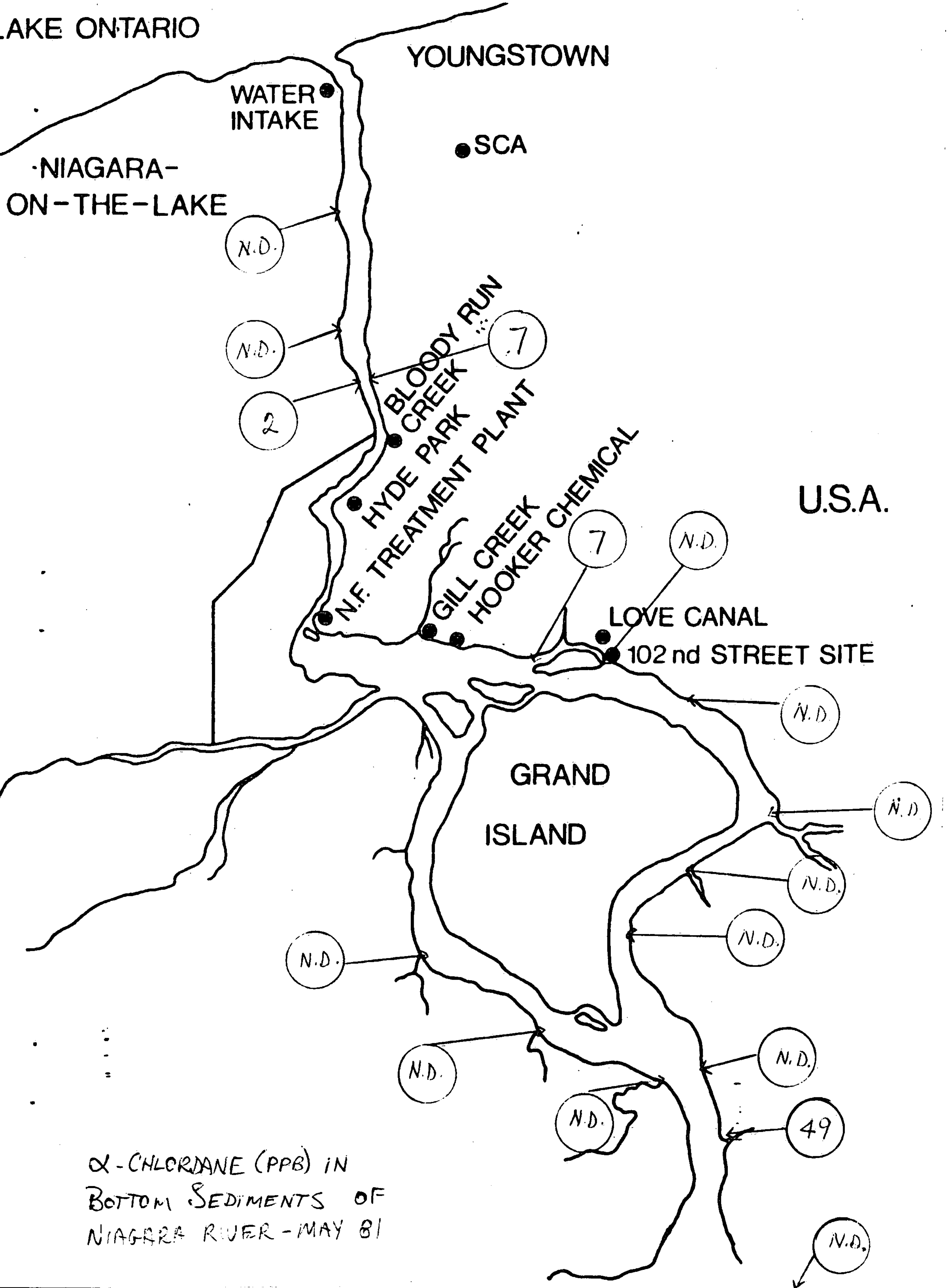
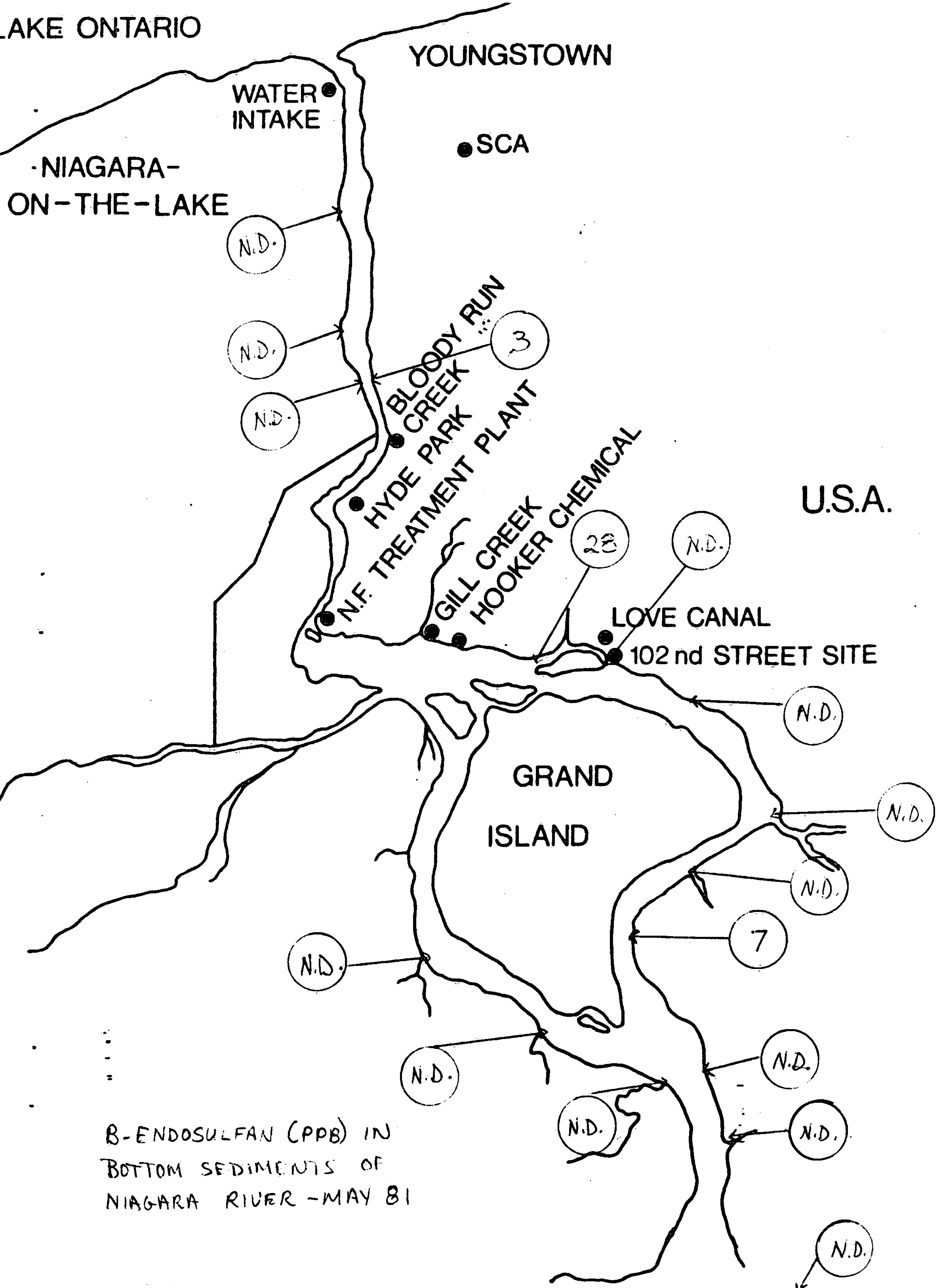
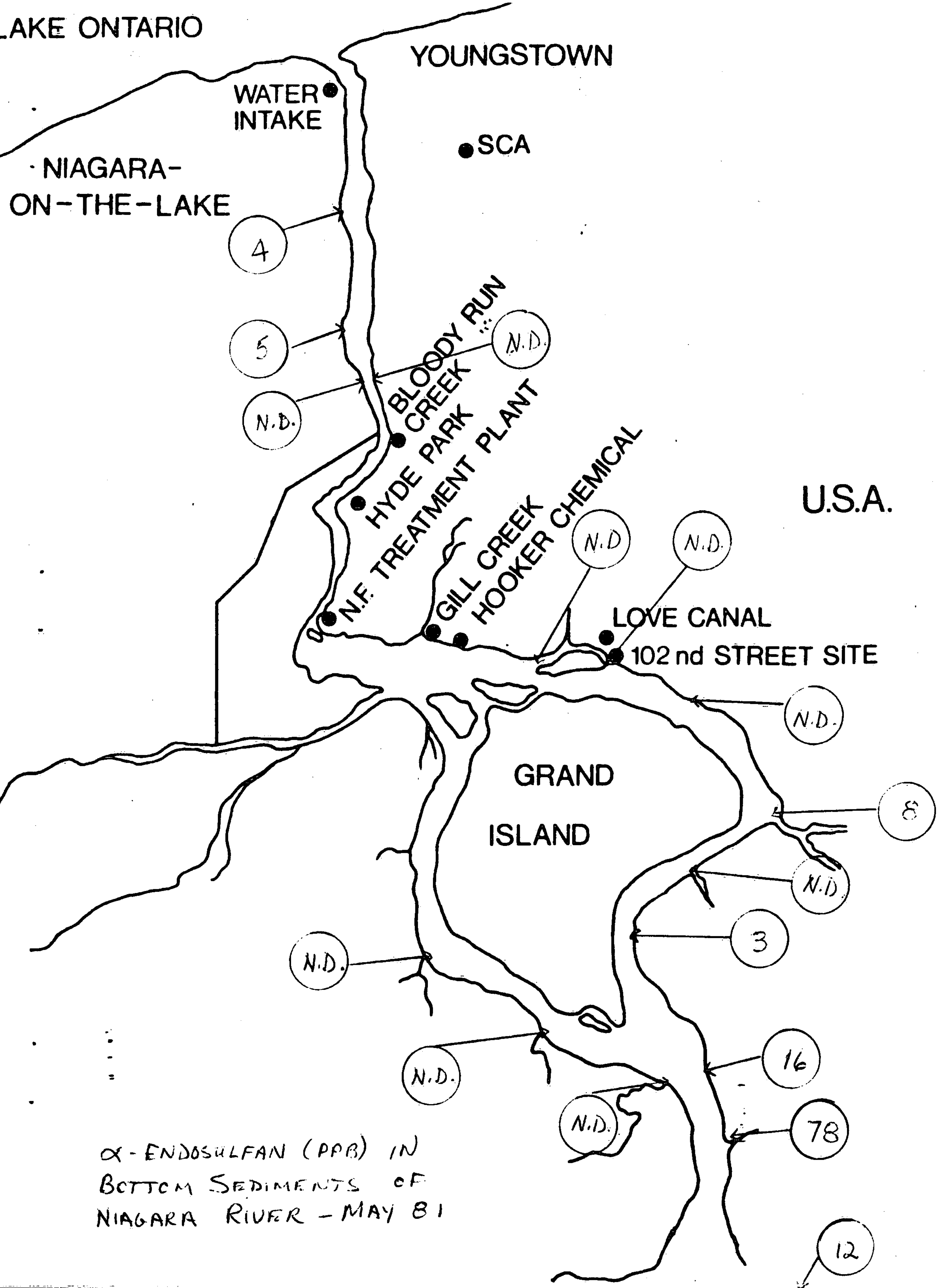
HEPTACHLOR EPOXIDE (PPB) IN BOTTOM SEDIMENS OF NIAGARA RIVER - MAY 81



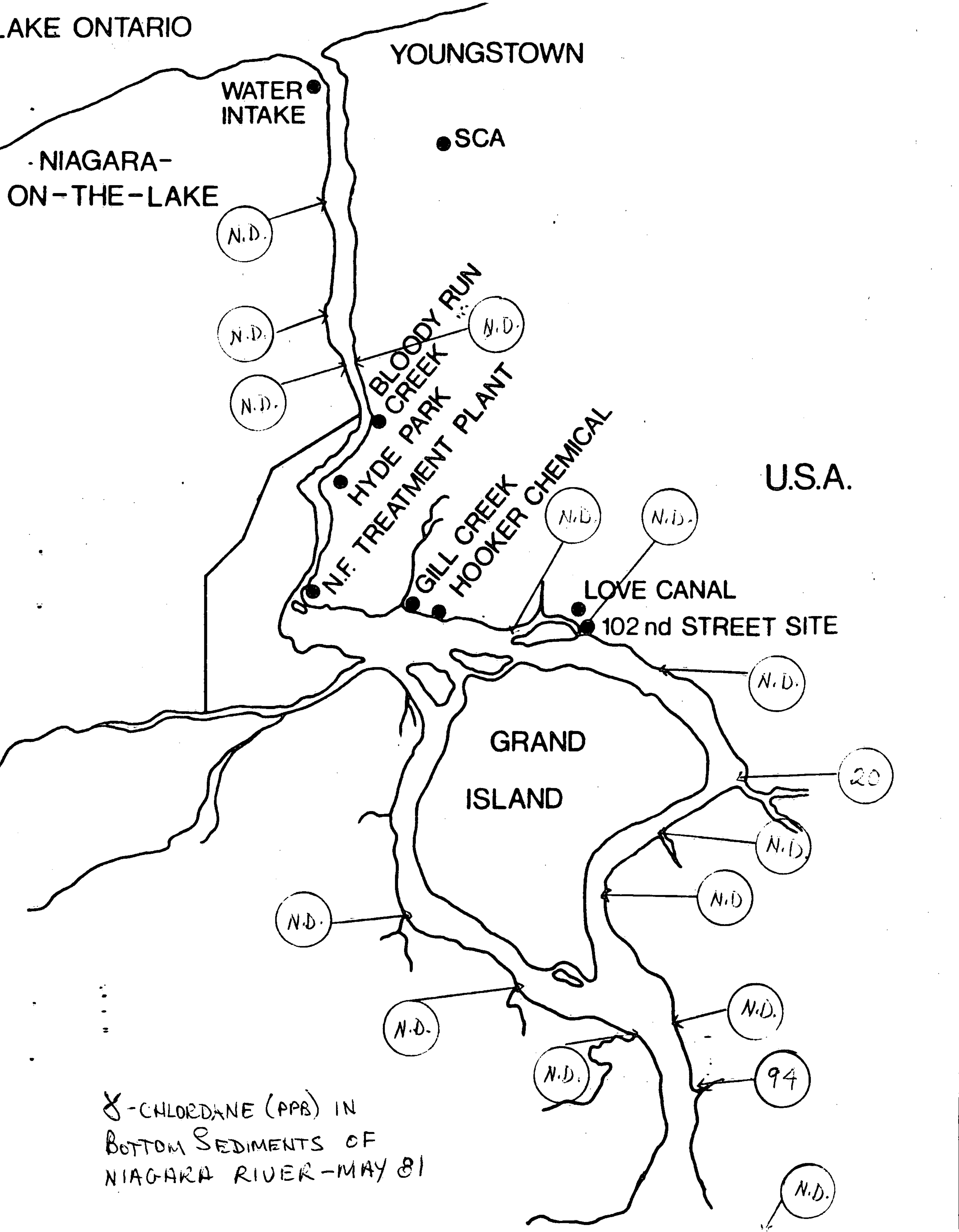
α-CHLORDANE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



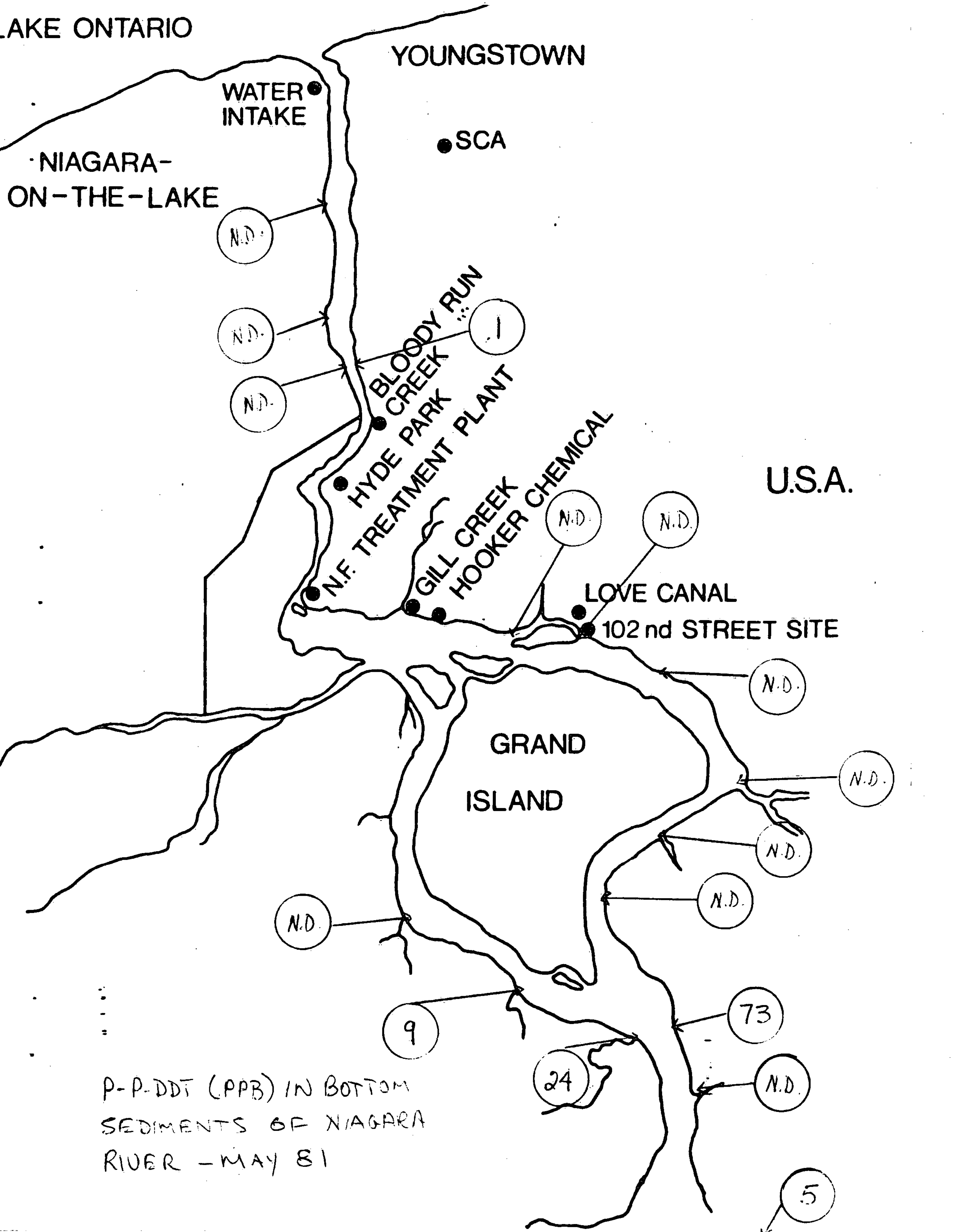
B-ENDOSULFAN (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



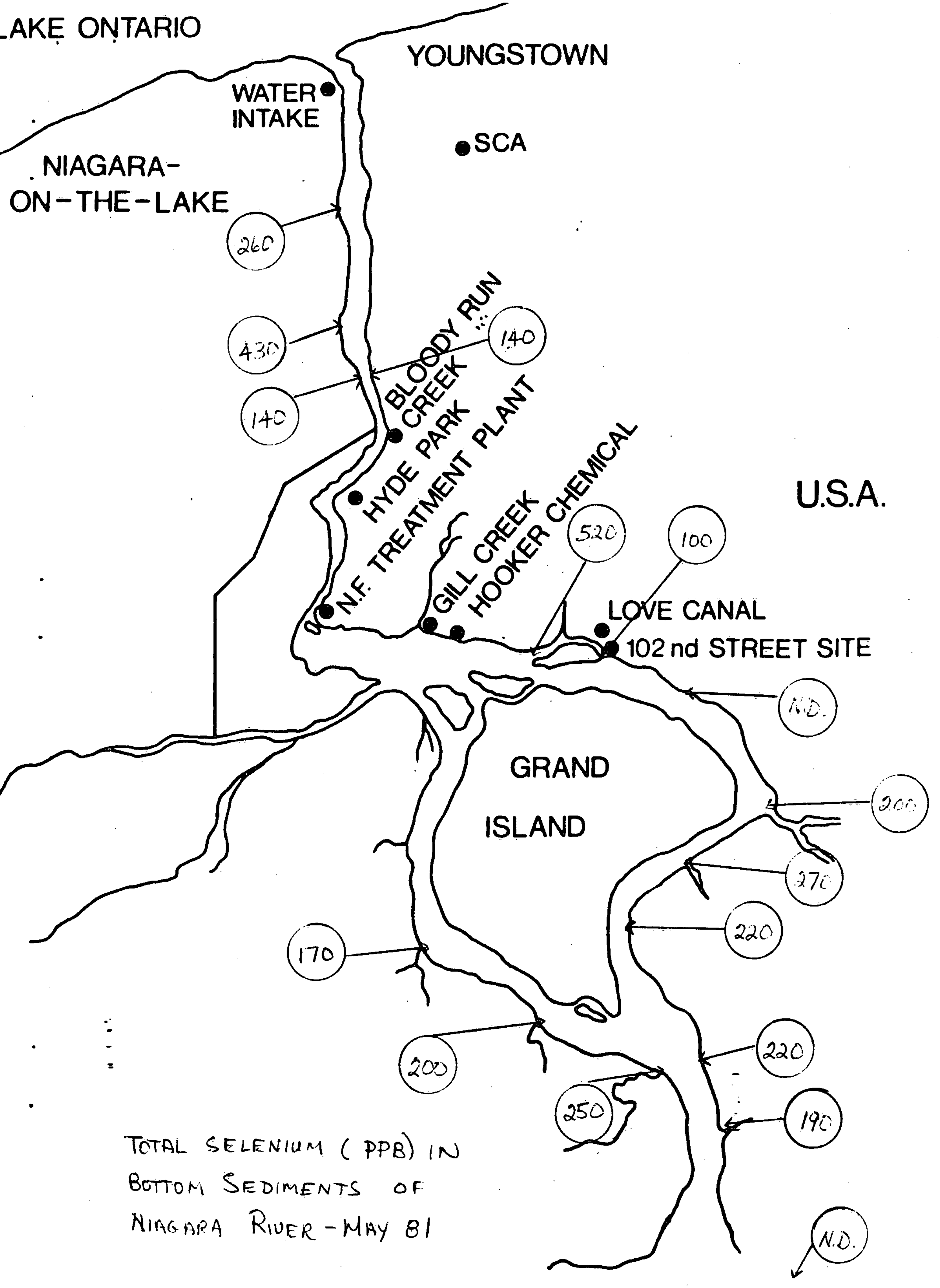
α-ENDOSULFAN (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER – MAY 81



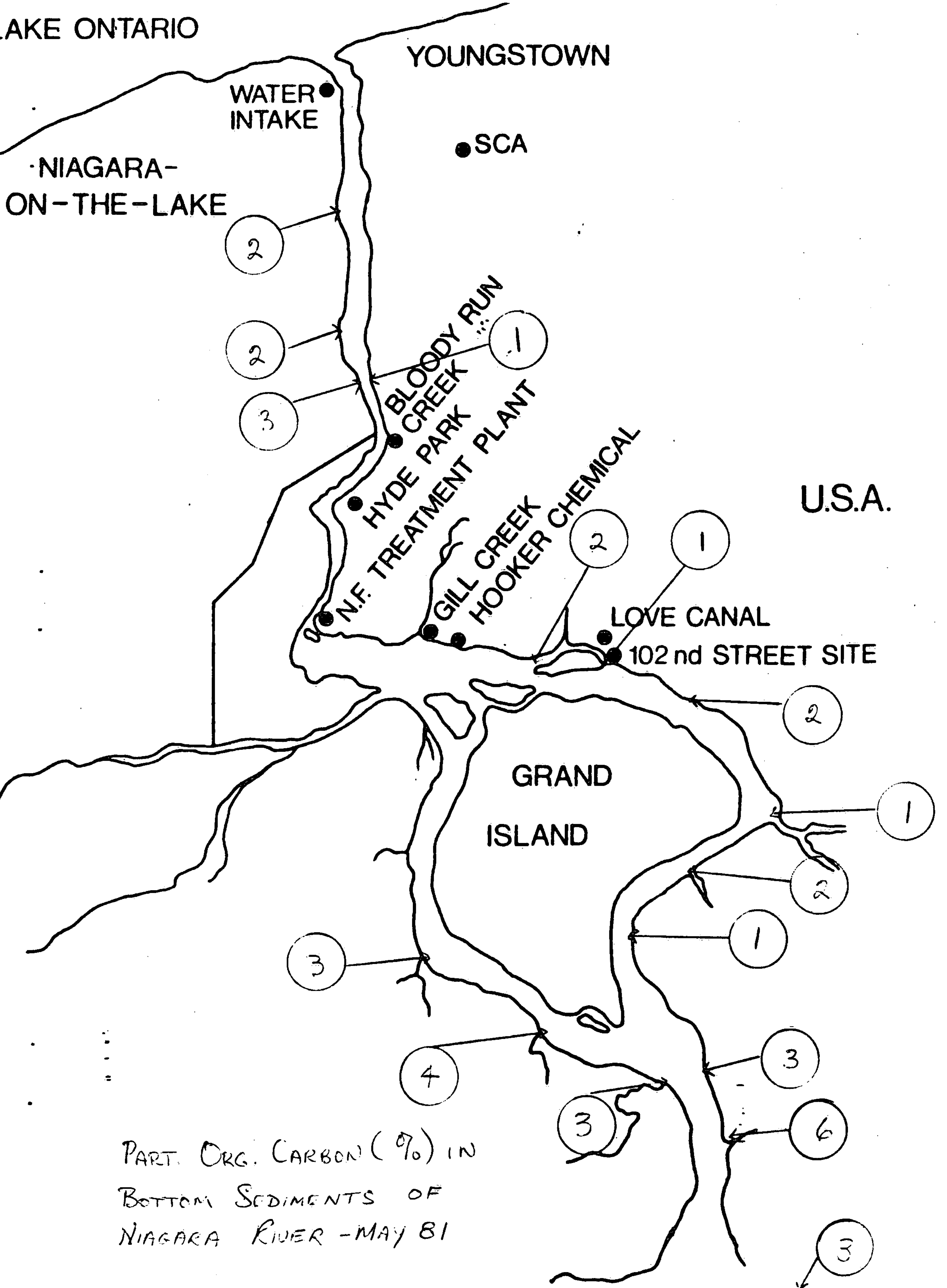
γ-CHLORDANE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER-MAY 81



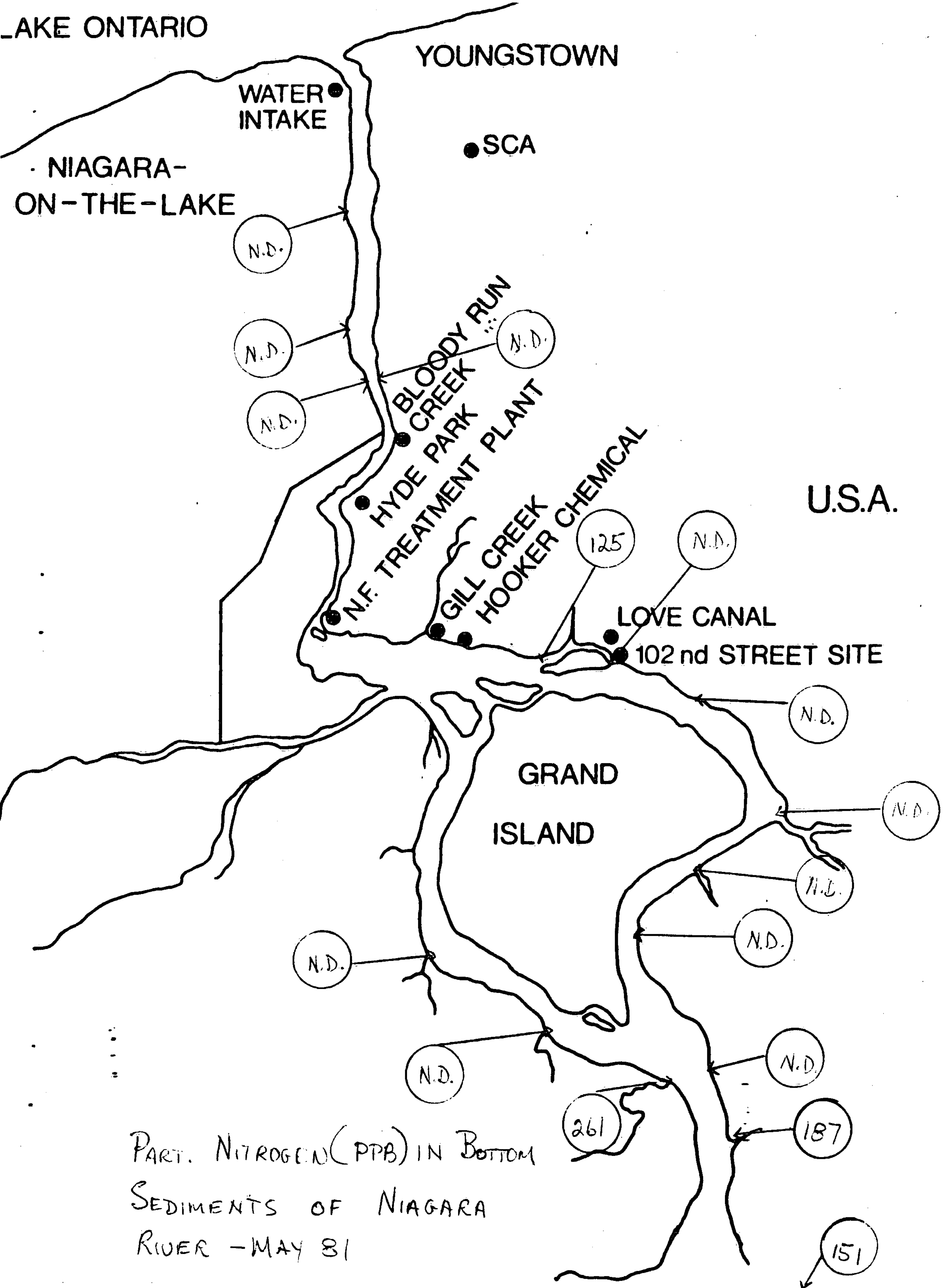
P-P-DDT (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



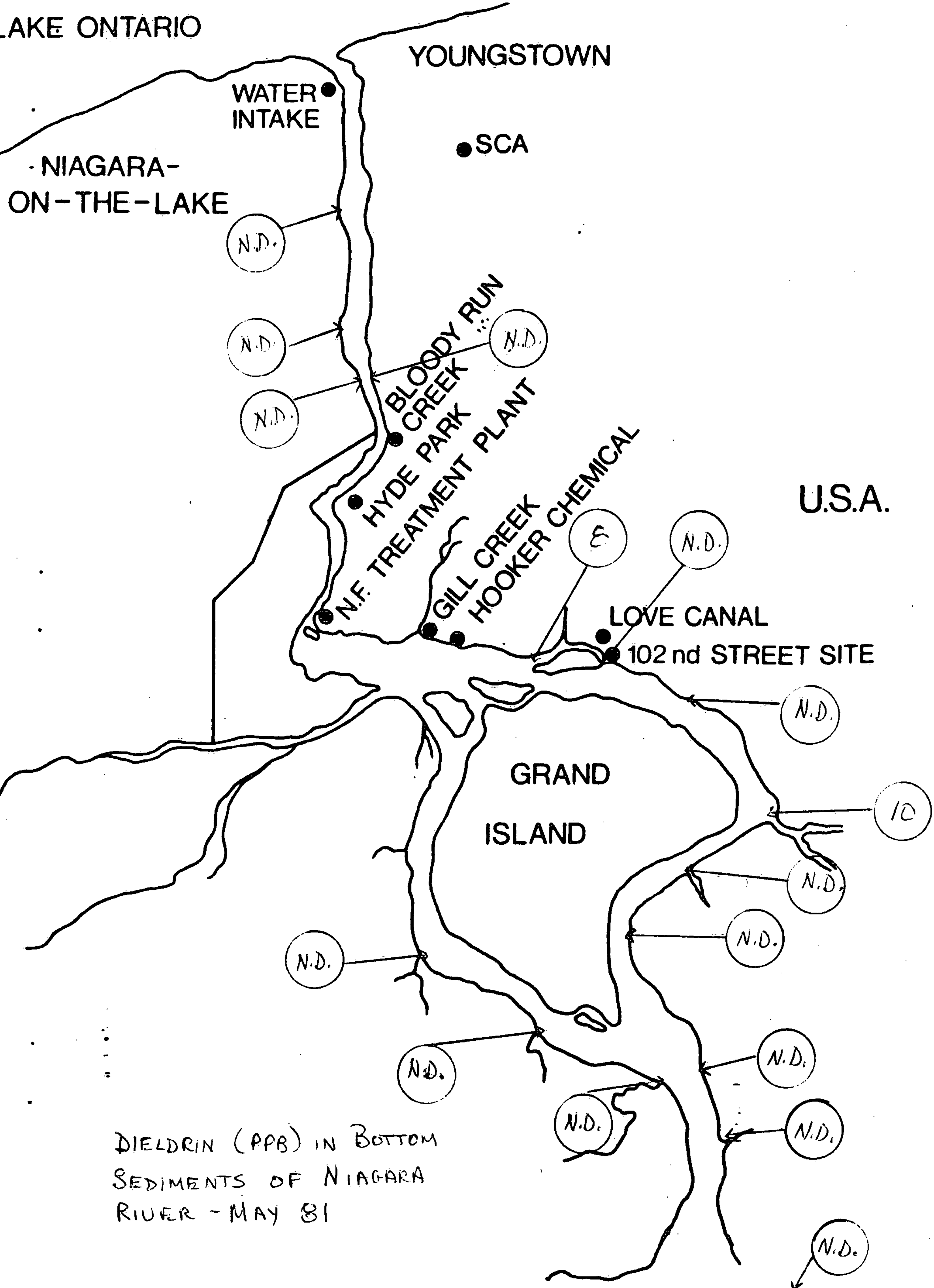
TOTAL SELENIUM (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



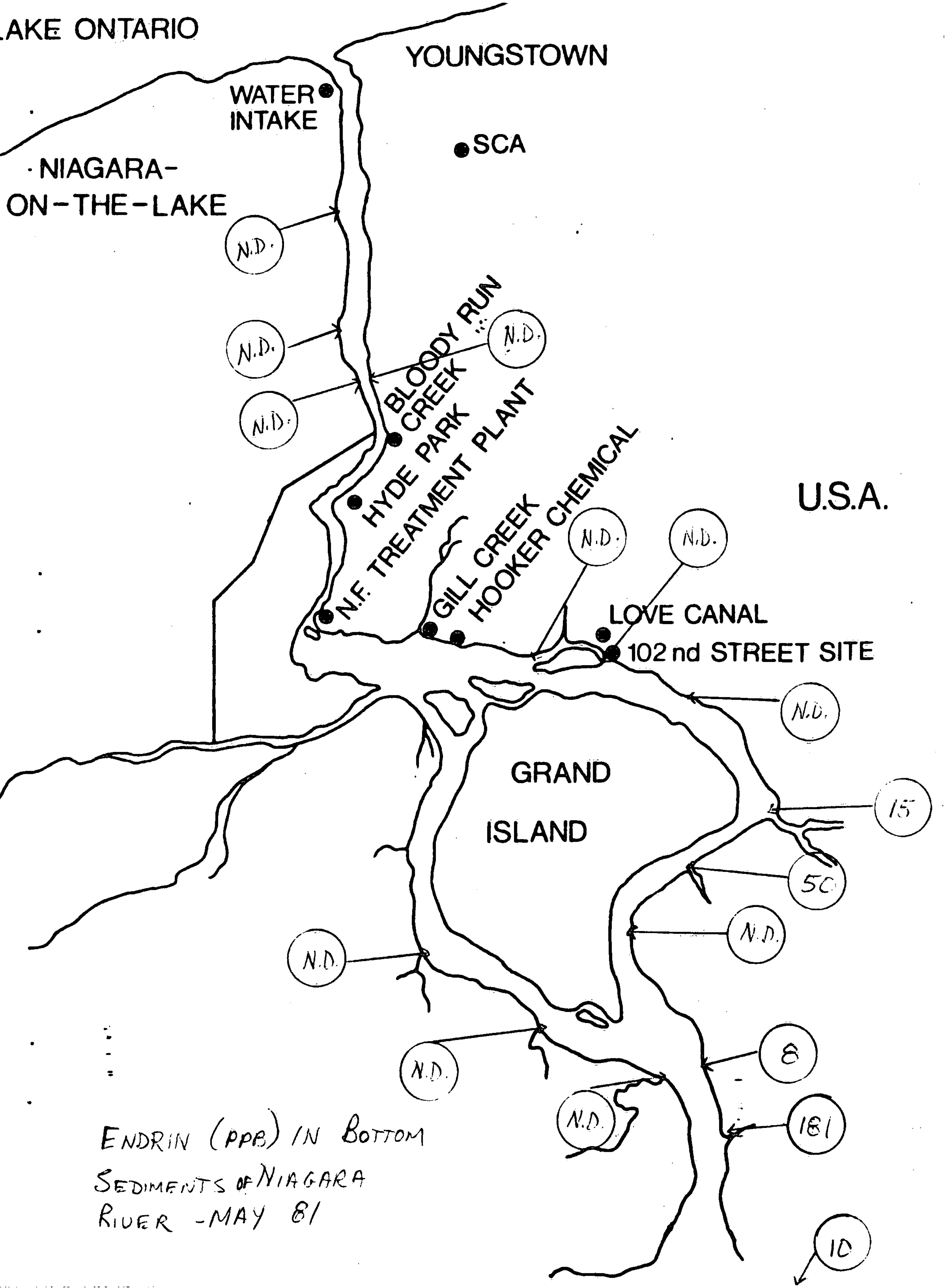
Part. Org. Carbon (%) in Bottom Sediments of Niagara River - May 81



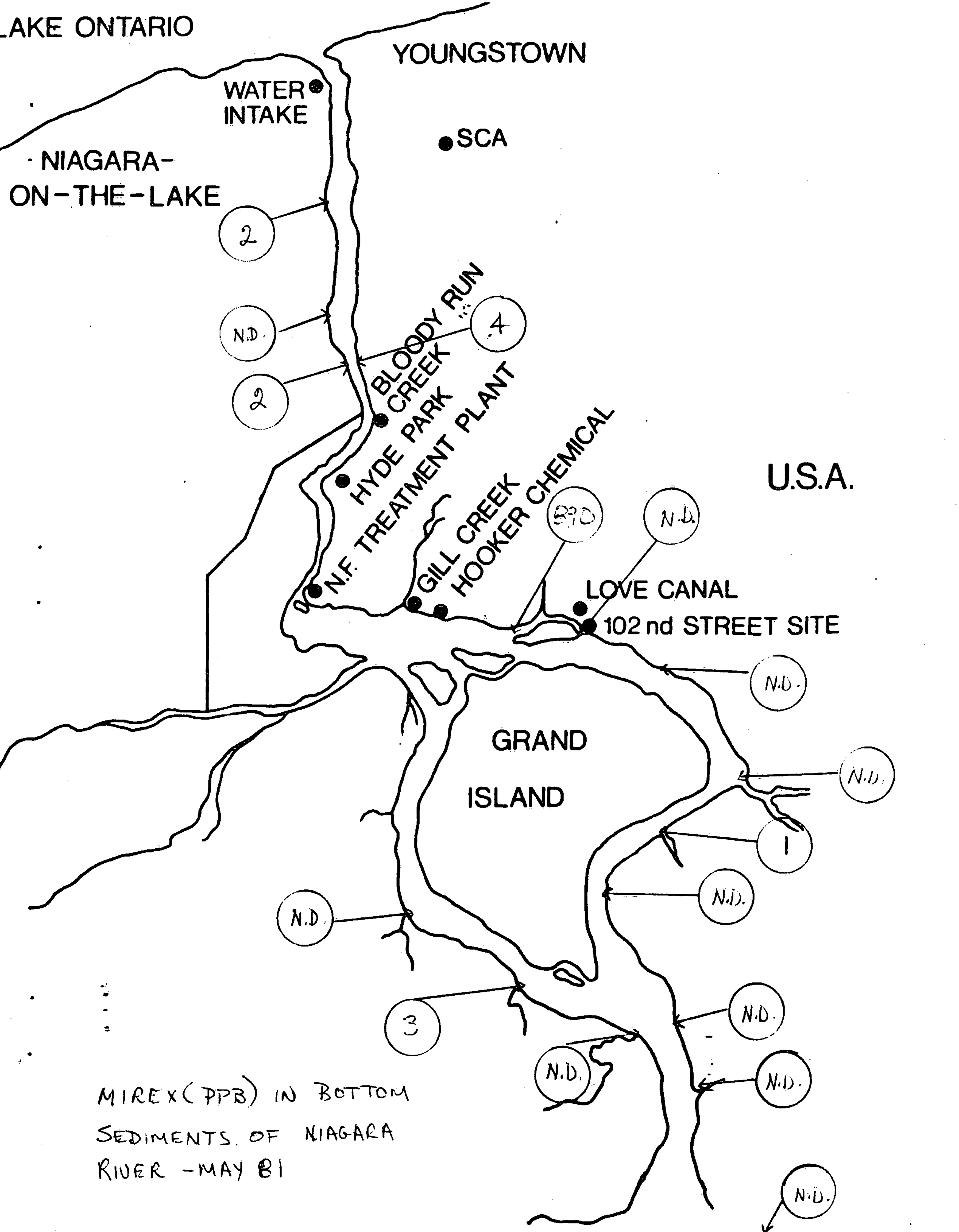
PART. NITROGEN (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER – MAY 81



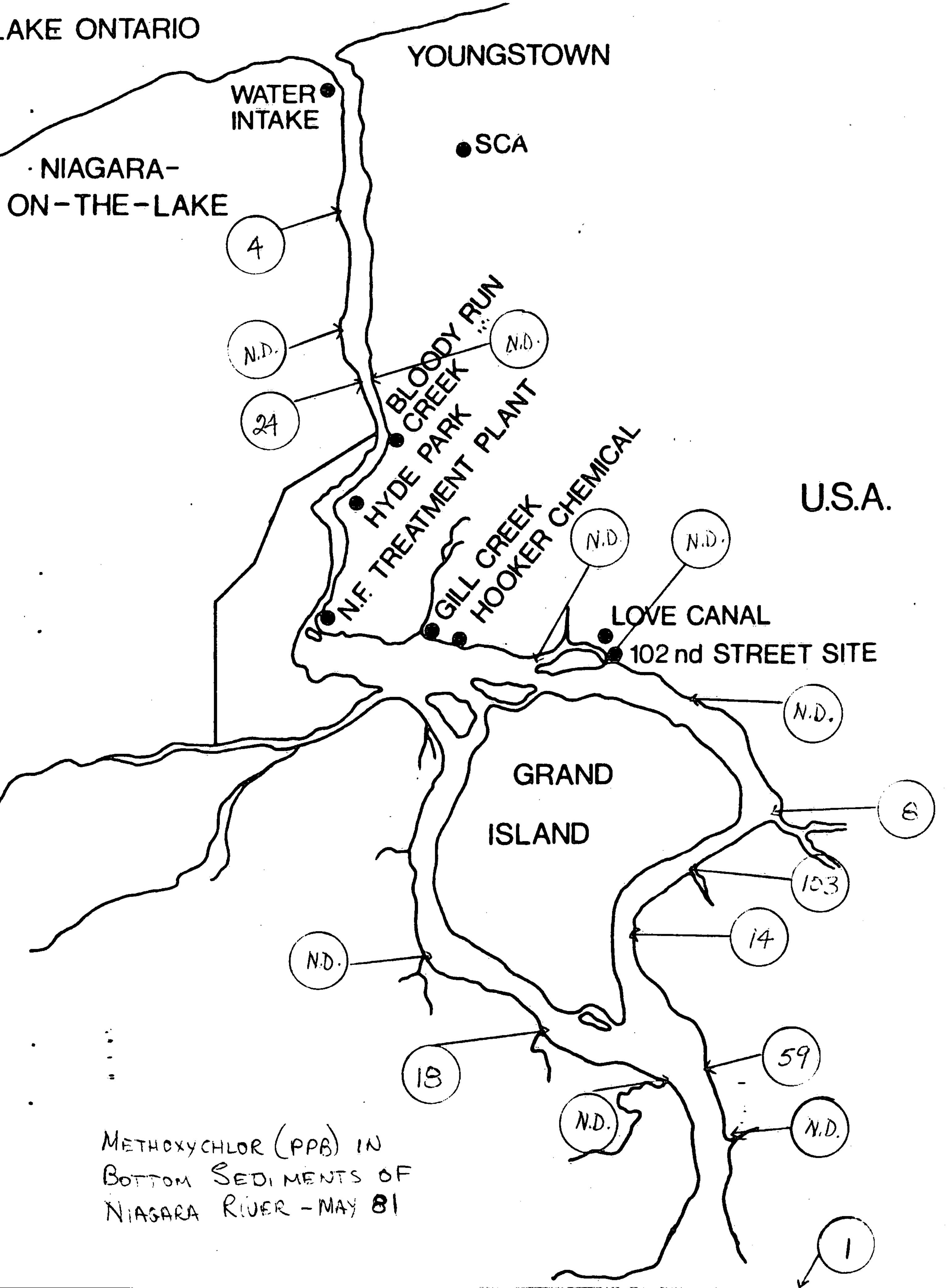
DIELDRIN (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



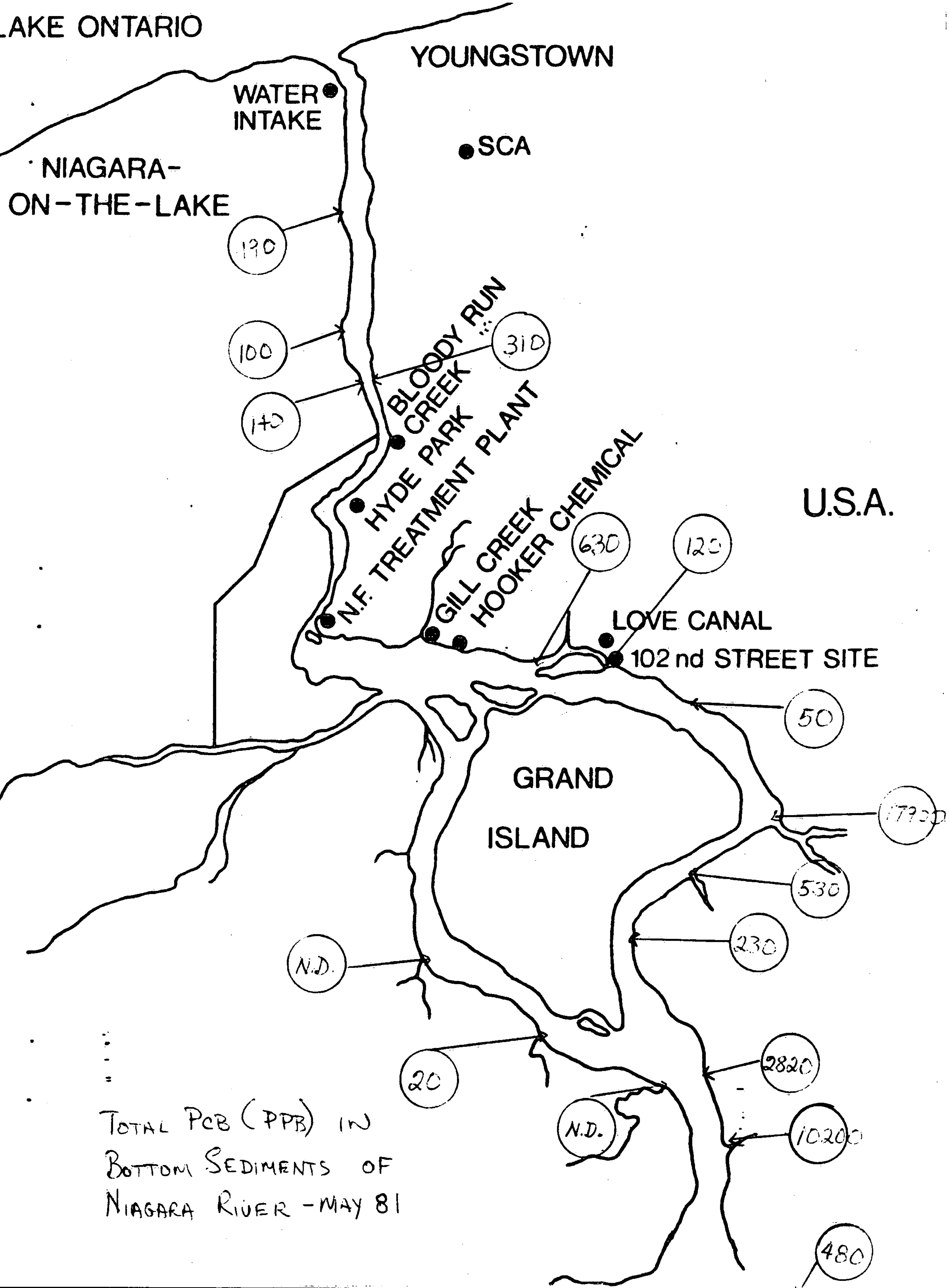
ENDRIN (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



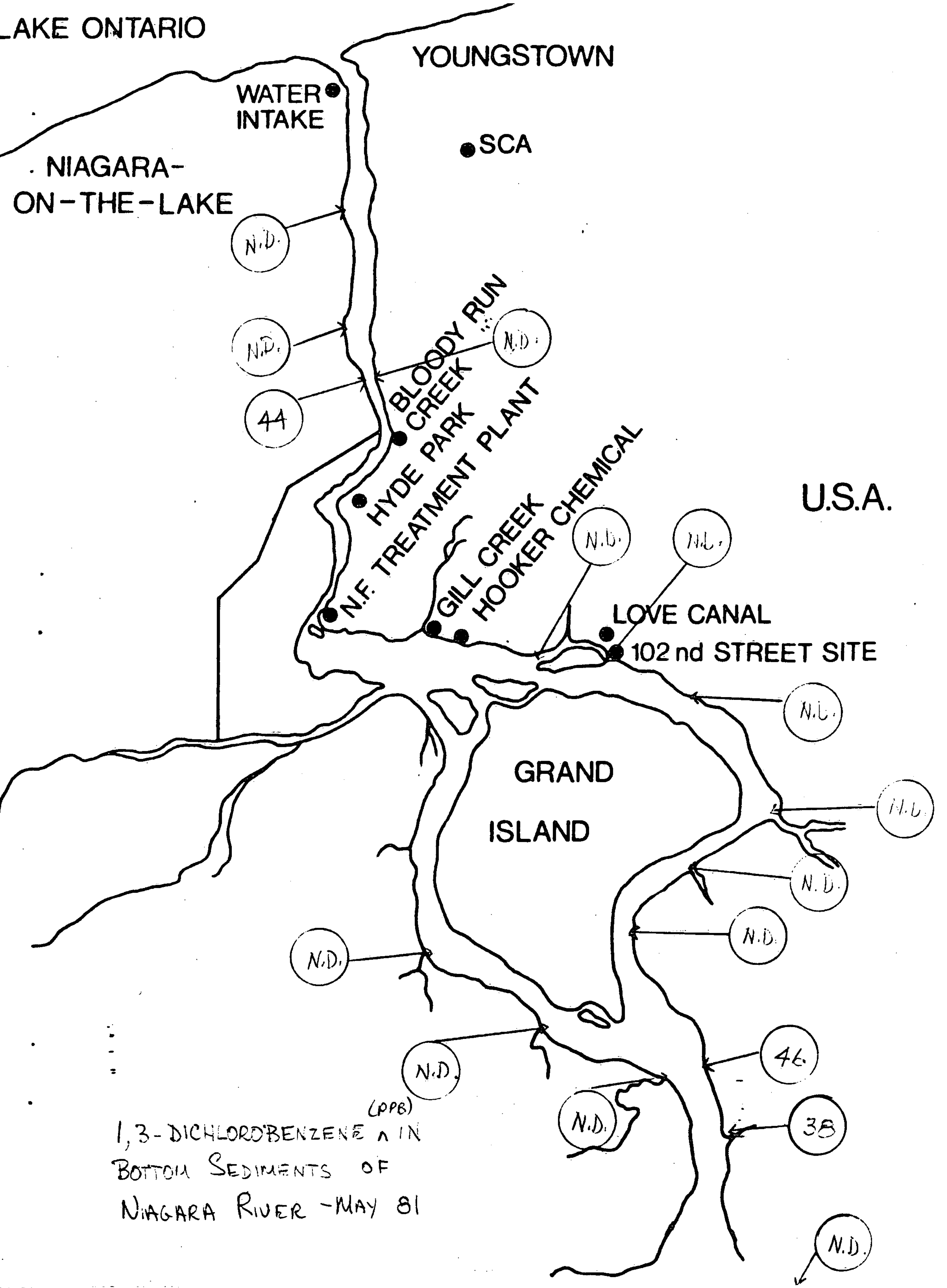
MIREX (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



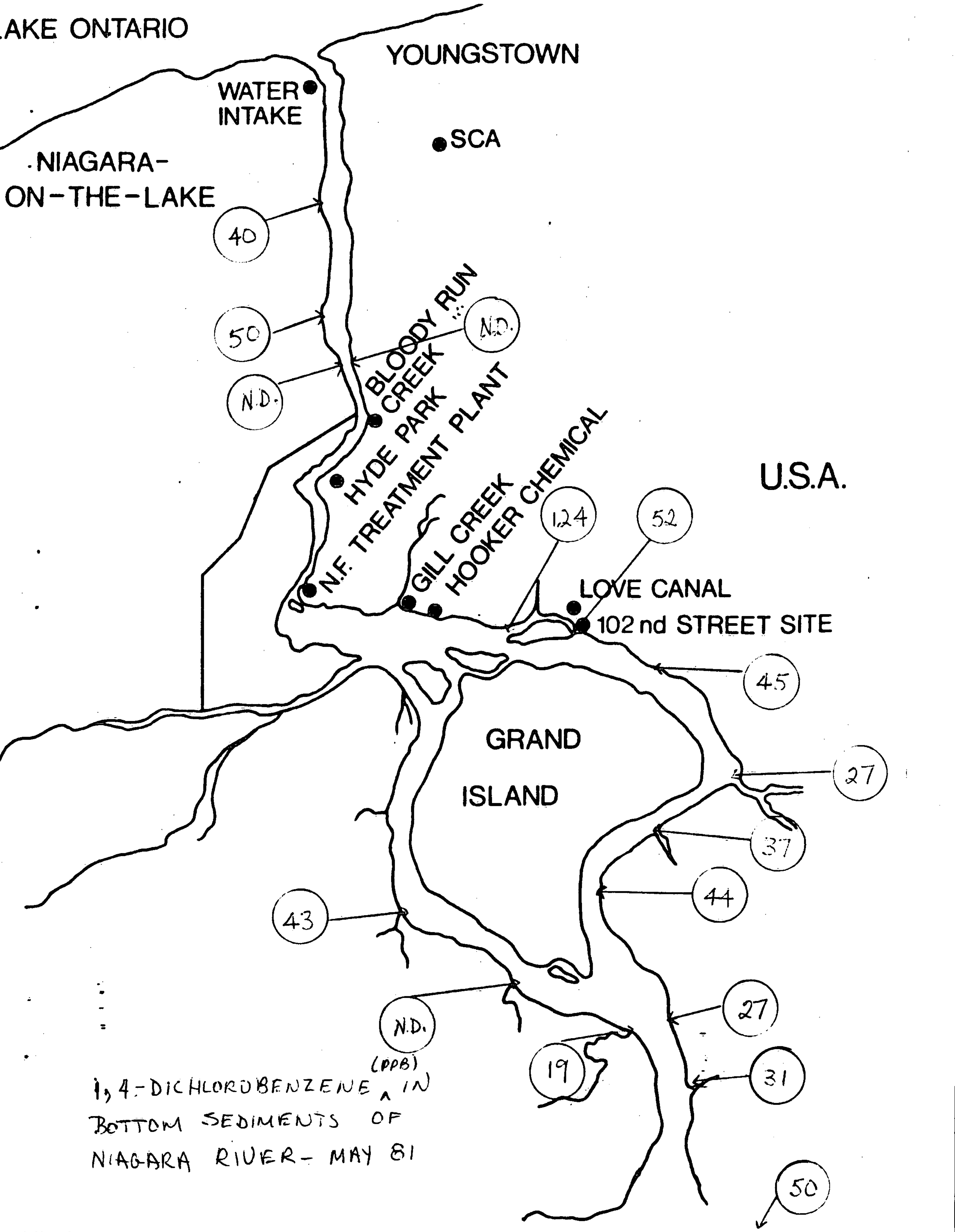
METHOXYCHLOR (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



Total PCB (PPB) in Bottom Sediments of Niagara River - May 81



1,3-DICHLOROBENZENE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81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YOUNGSTOWN
WATER INTAKE
SCA
NIAGARA-ON-THE-LAKE
40
50
N.D.
N.D.
BLOODY RUN CREEK
HYDE PARK
N.F. TREATMENT PLANT
GILL CREEK
HOOKER CHEMICAL
U.S.A.
124
52
LOVE CANAL
102 nd STREET SITE
45
GRAND ISLAND
27
37
44
43
N.D.
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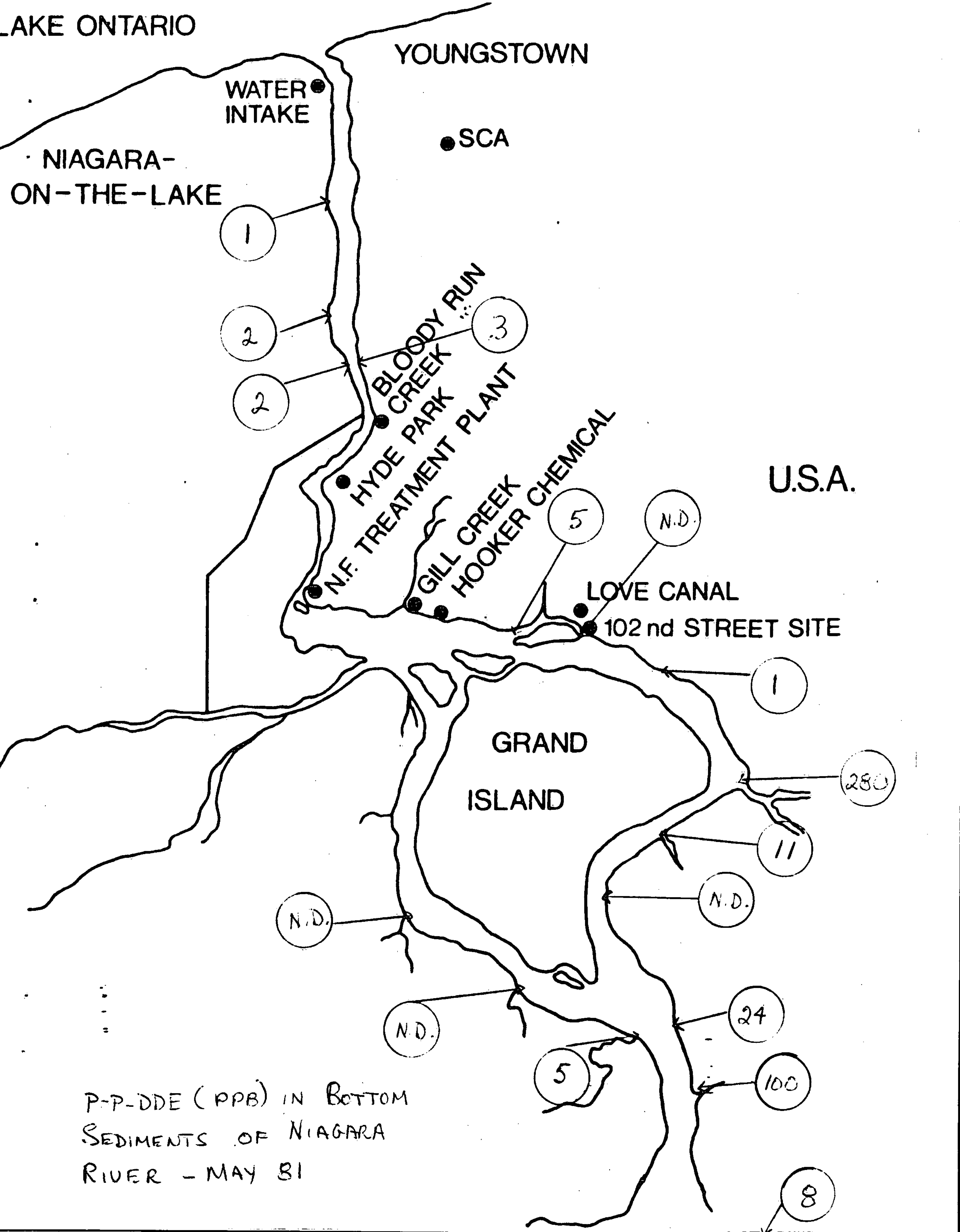
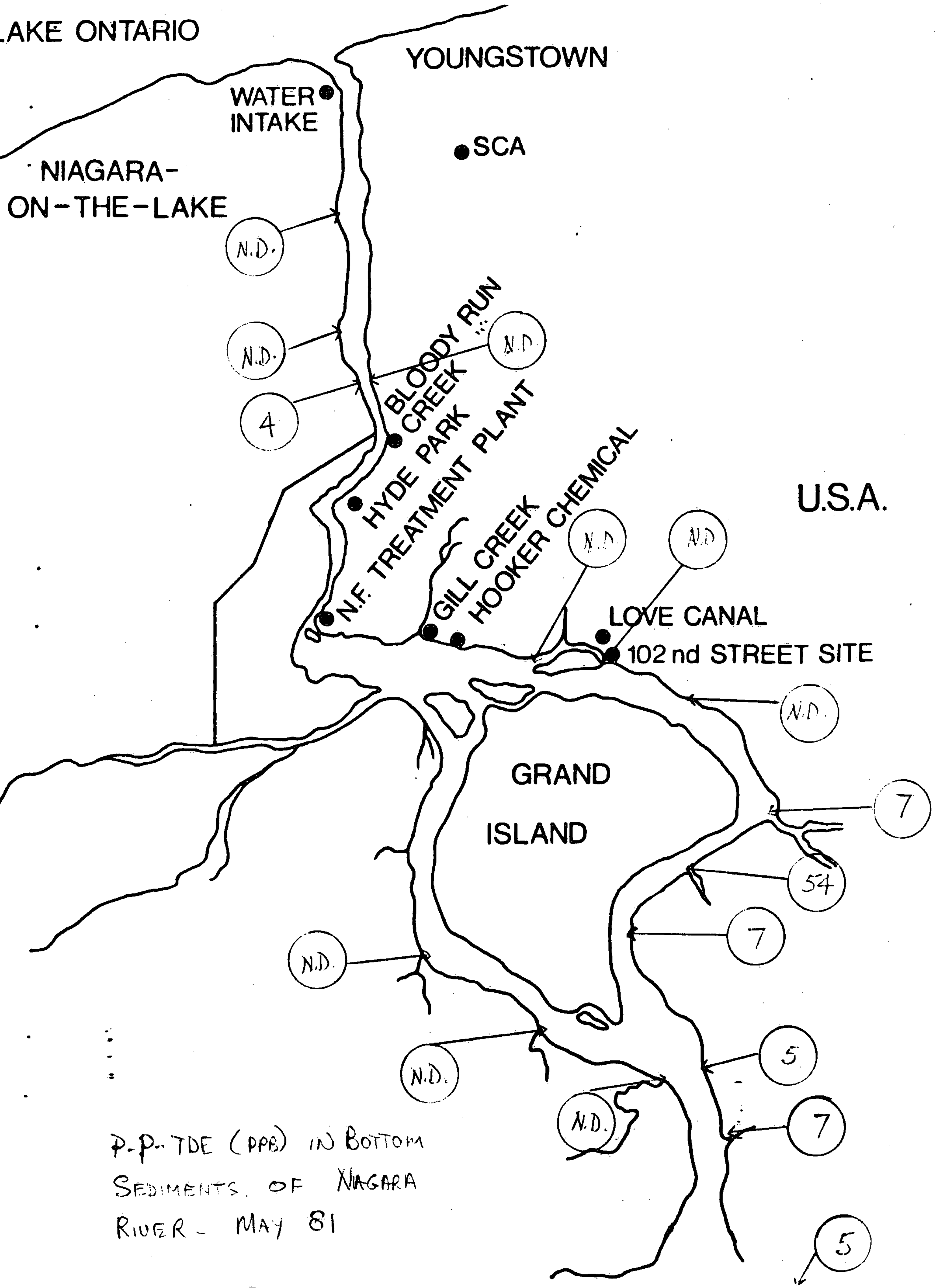
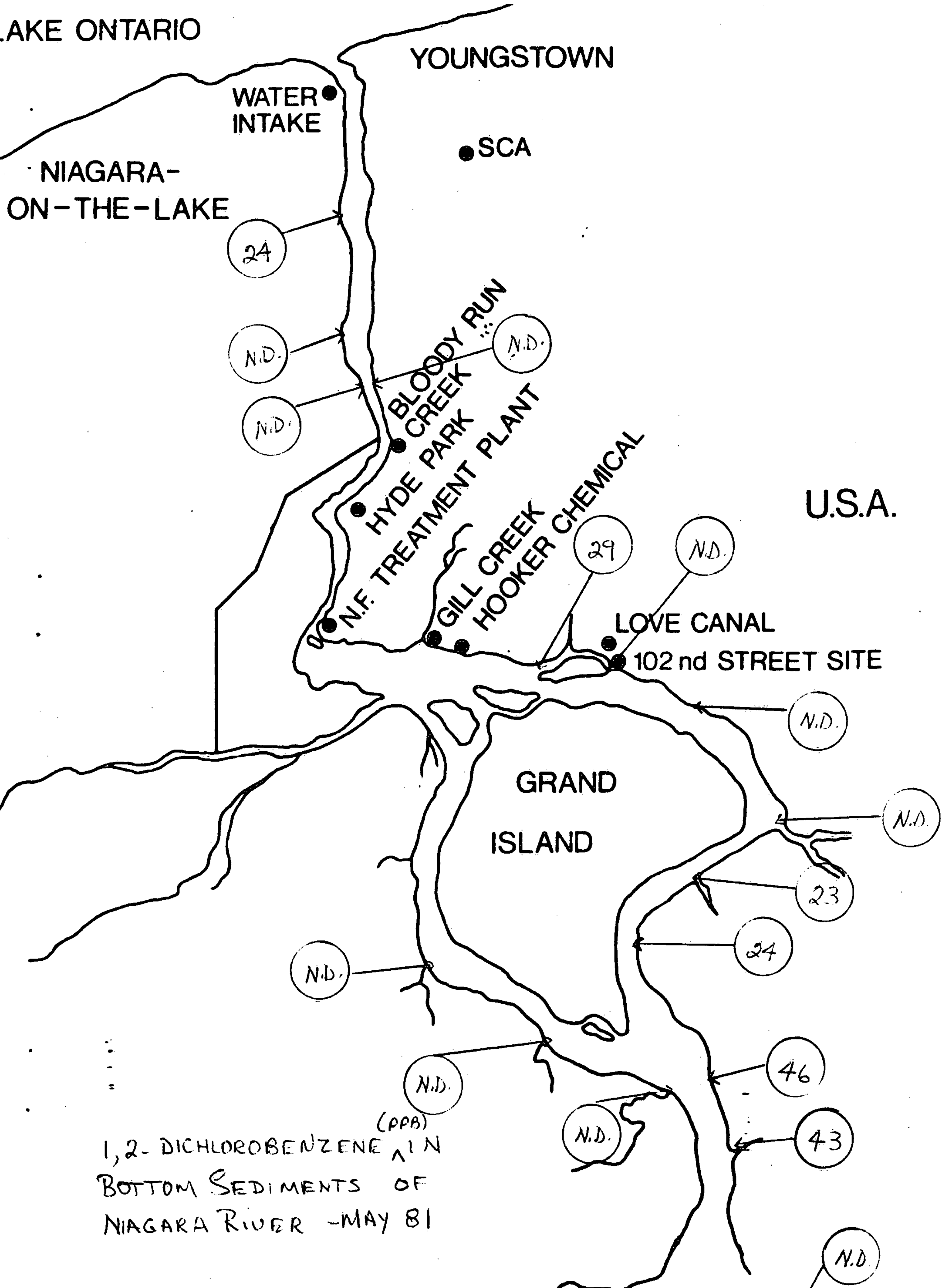
31
50
1,4-DICHLORDBENZENE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81

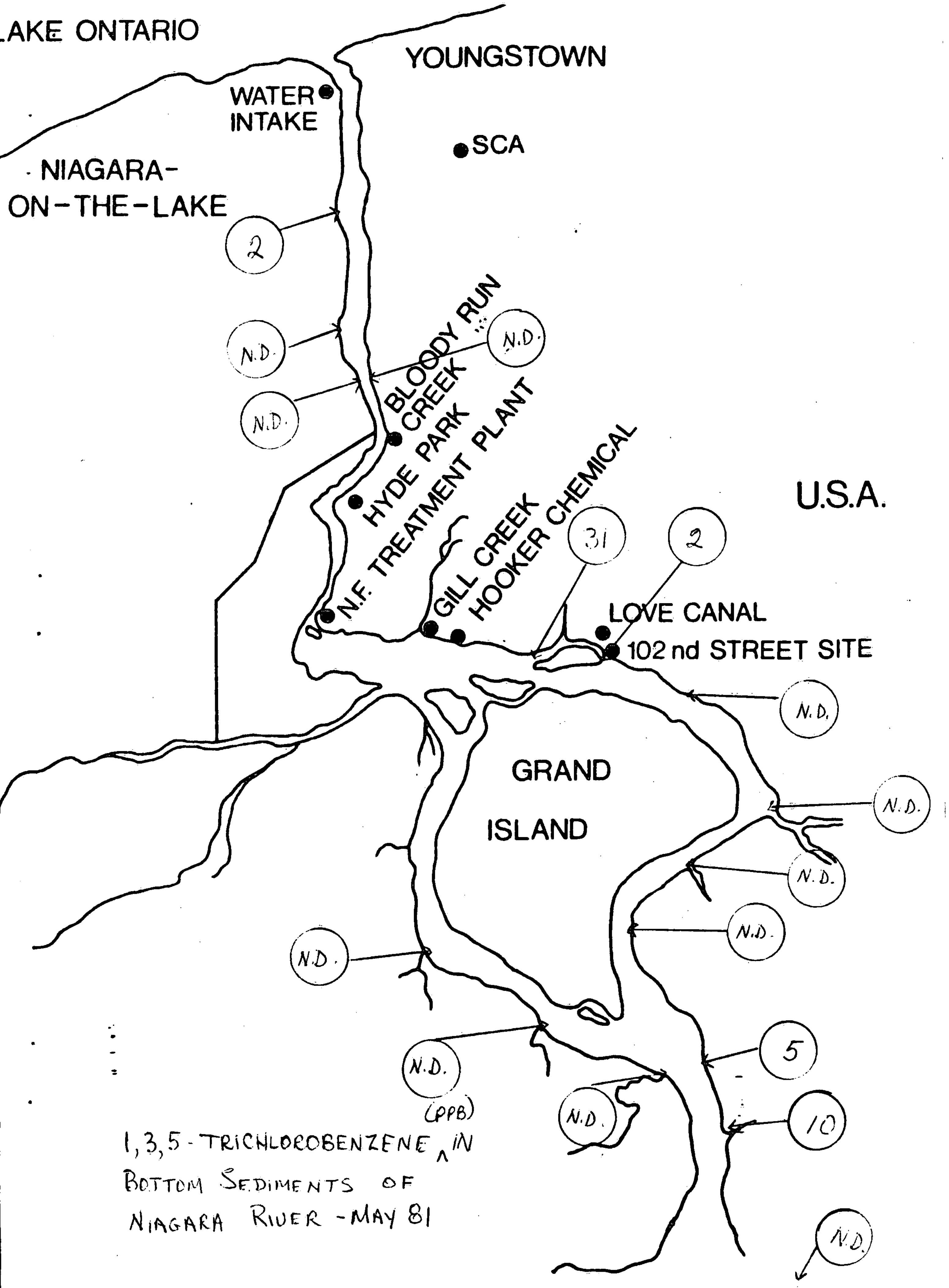


P-P-DDE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81

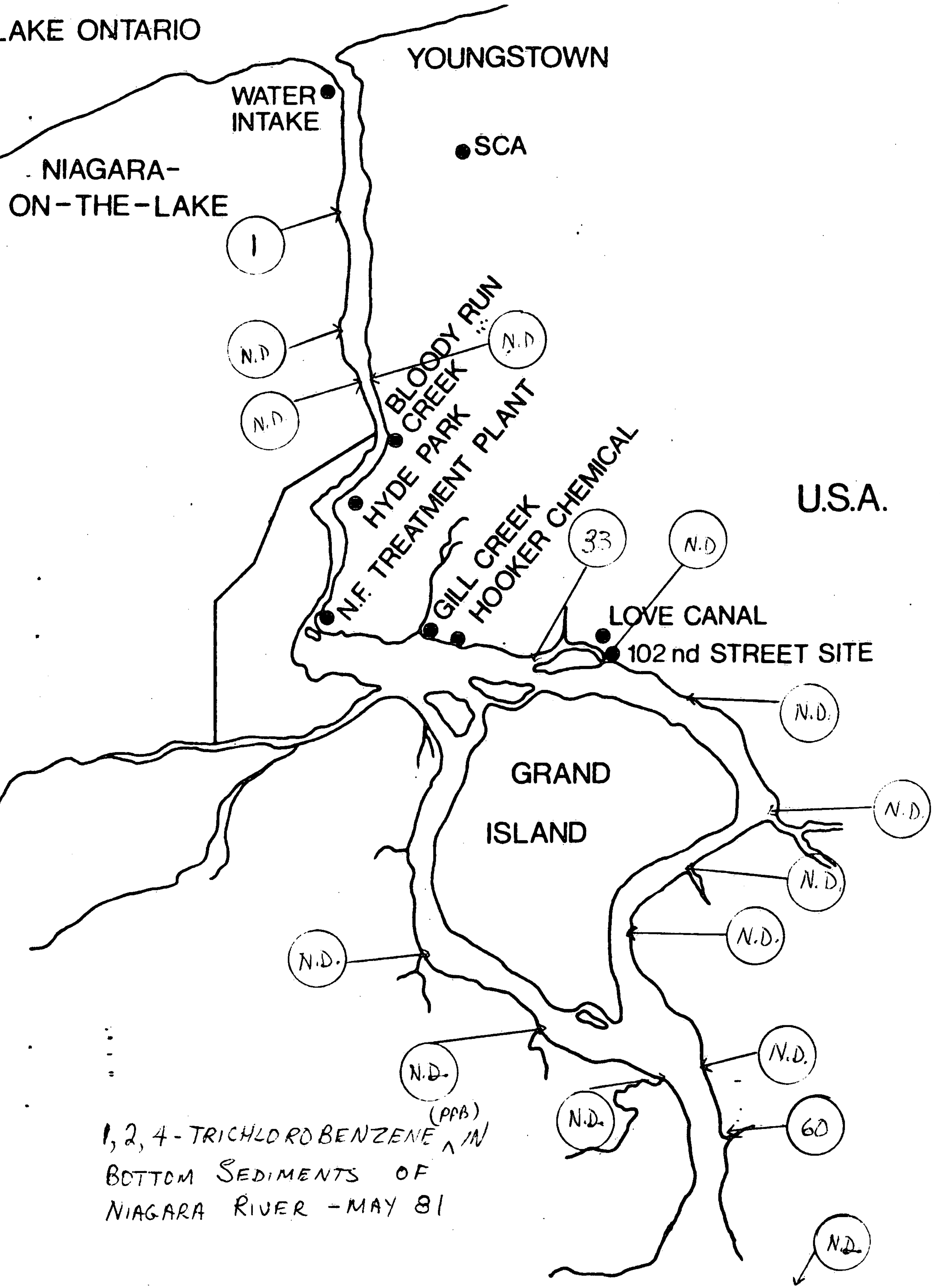


P-P-TDE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81

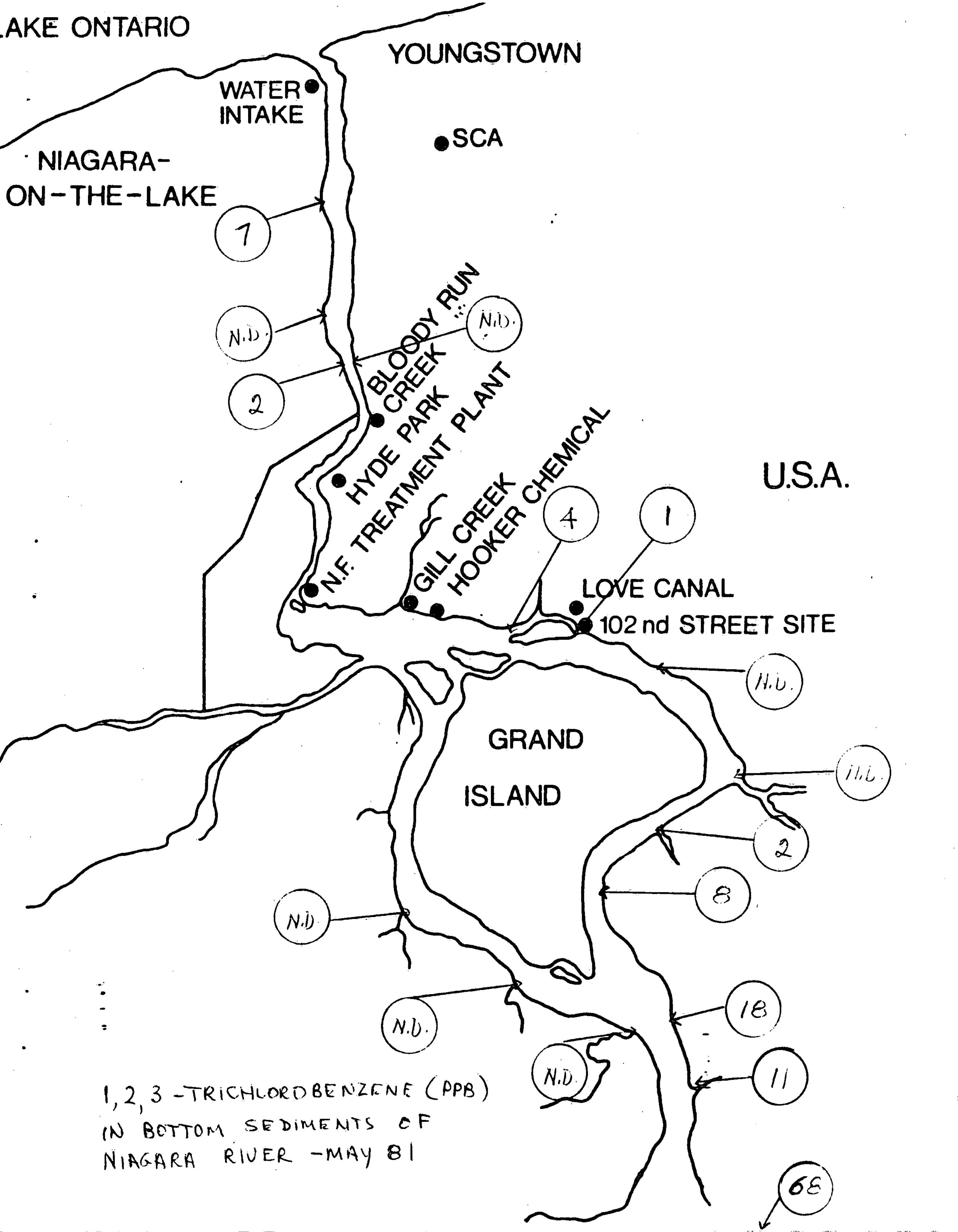

LAKE ONTARIO
YOUNGSTOWN
WATER INTAKE
SCA
NIAGARA-ON-THE-LAKE
24
BLOODY RUN CREEK
N.D.
N.D.
N.D.
HYDE PARK
N.F. TREATMENT PLANT
GILL CREEK
HOOKER CHEMICAL
29
N.D.
U.S.A.
LOVE CANAL
102 nd STREET SITE
N.D.
GRAND ISLAND
N.D.
23
24
N.D.
N.D.
46
N.D.
43
N.D.
1,2- DICHLOROBENZENE (PPB) IN
BOTTOM SEDIMENTS OF
NIAGARA RIVER - MAY 81



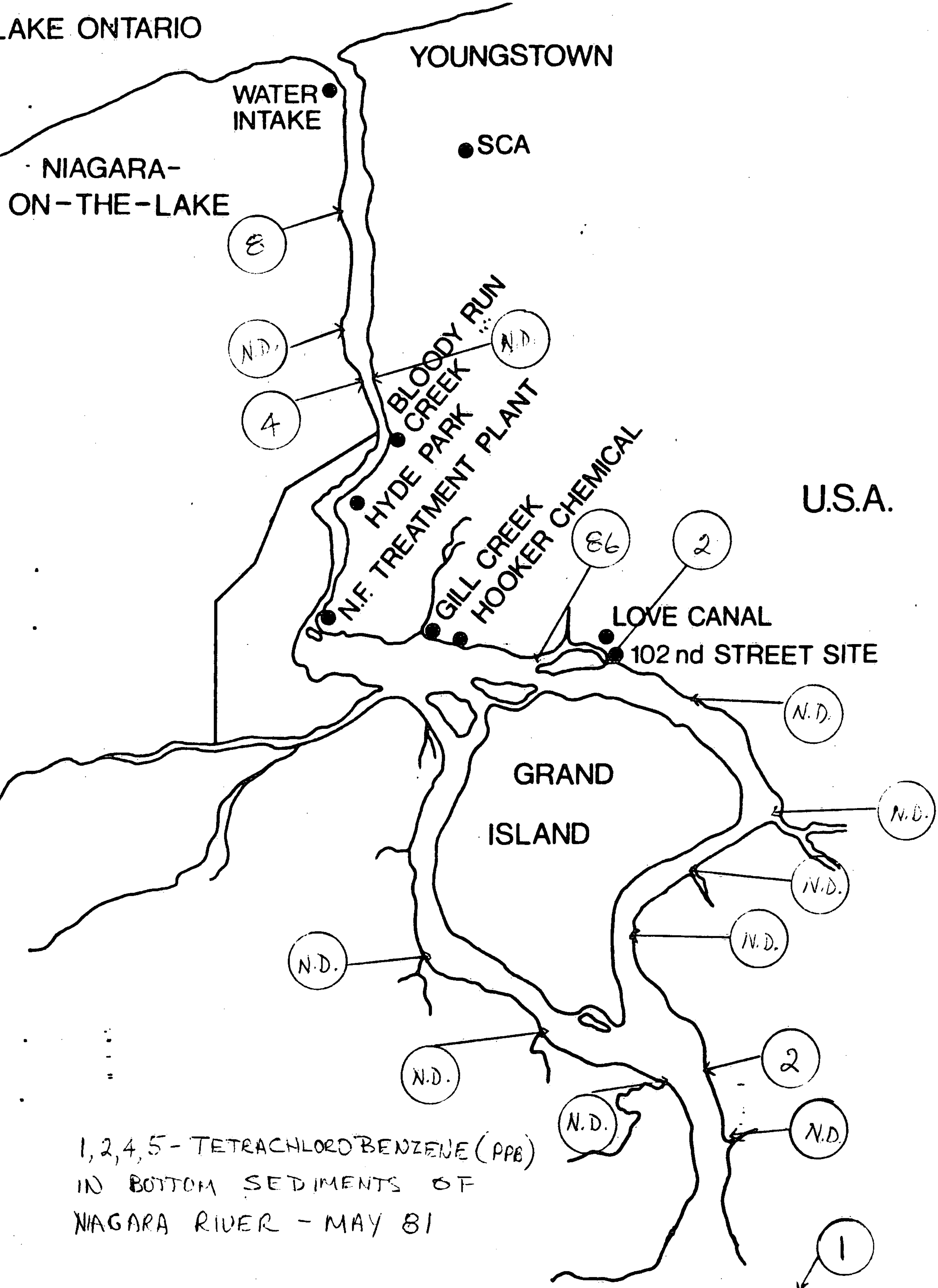
1,3,5-TRICHLOROBENZENE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



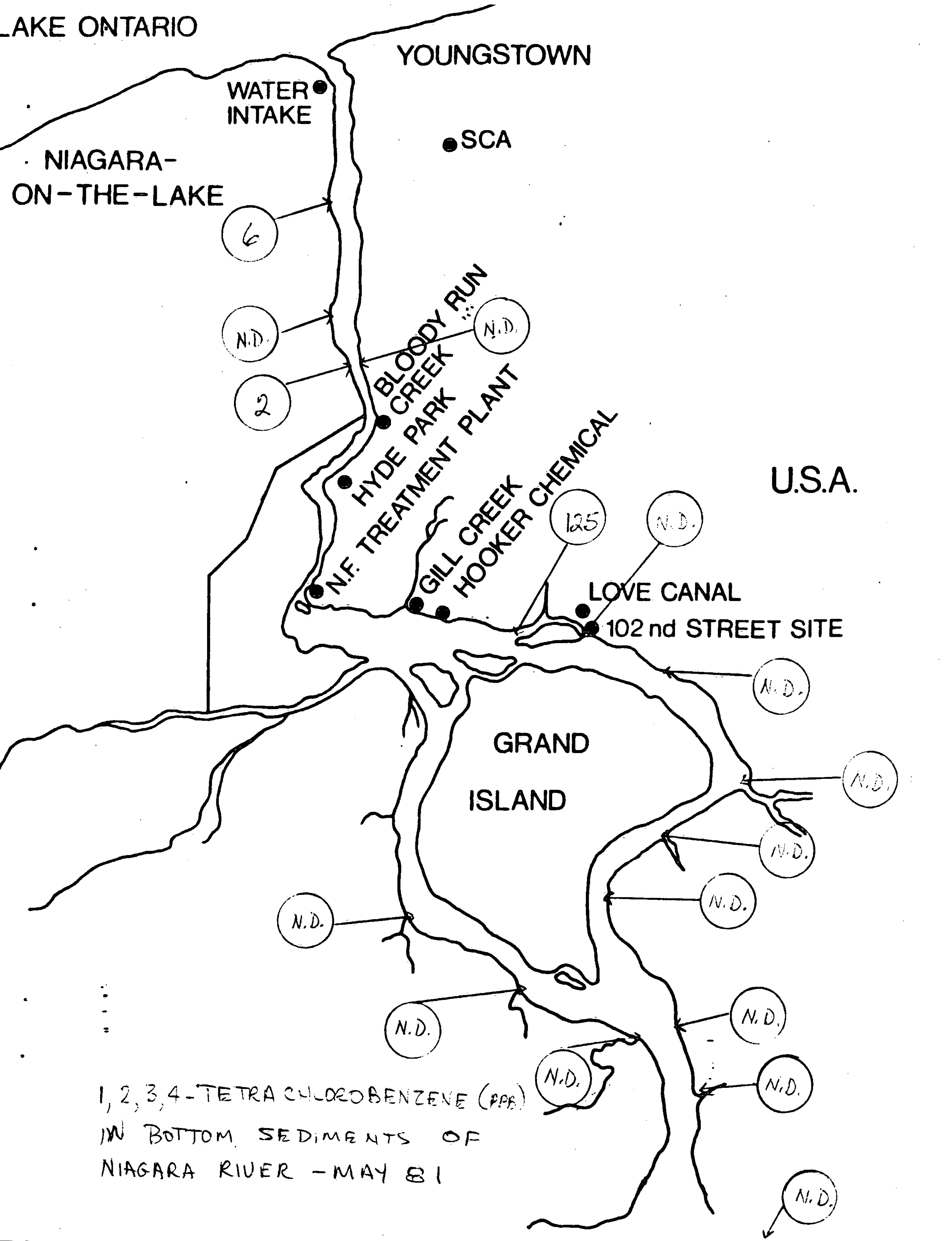
1, 2, 4-TRICHLOROBENZENE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81

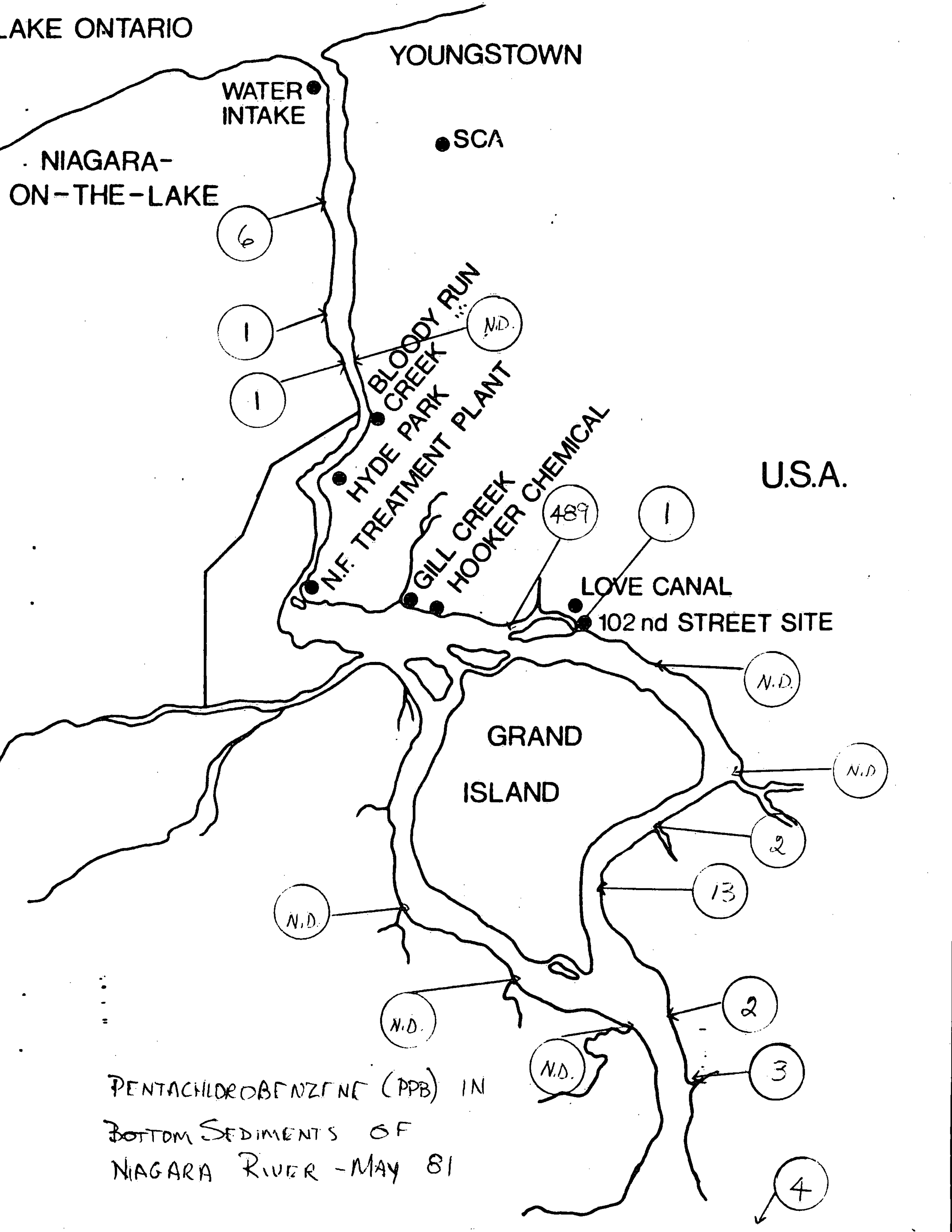


1, 2, 3 -TRICHLORO BENZENE (PPB)
IN BOTTOM SEDIMENTS OF
NIAGARA RIVER -MAY 81

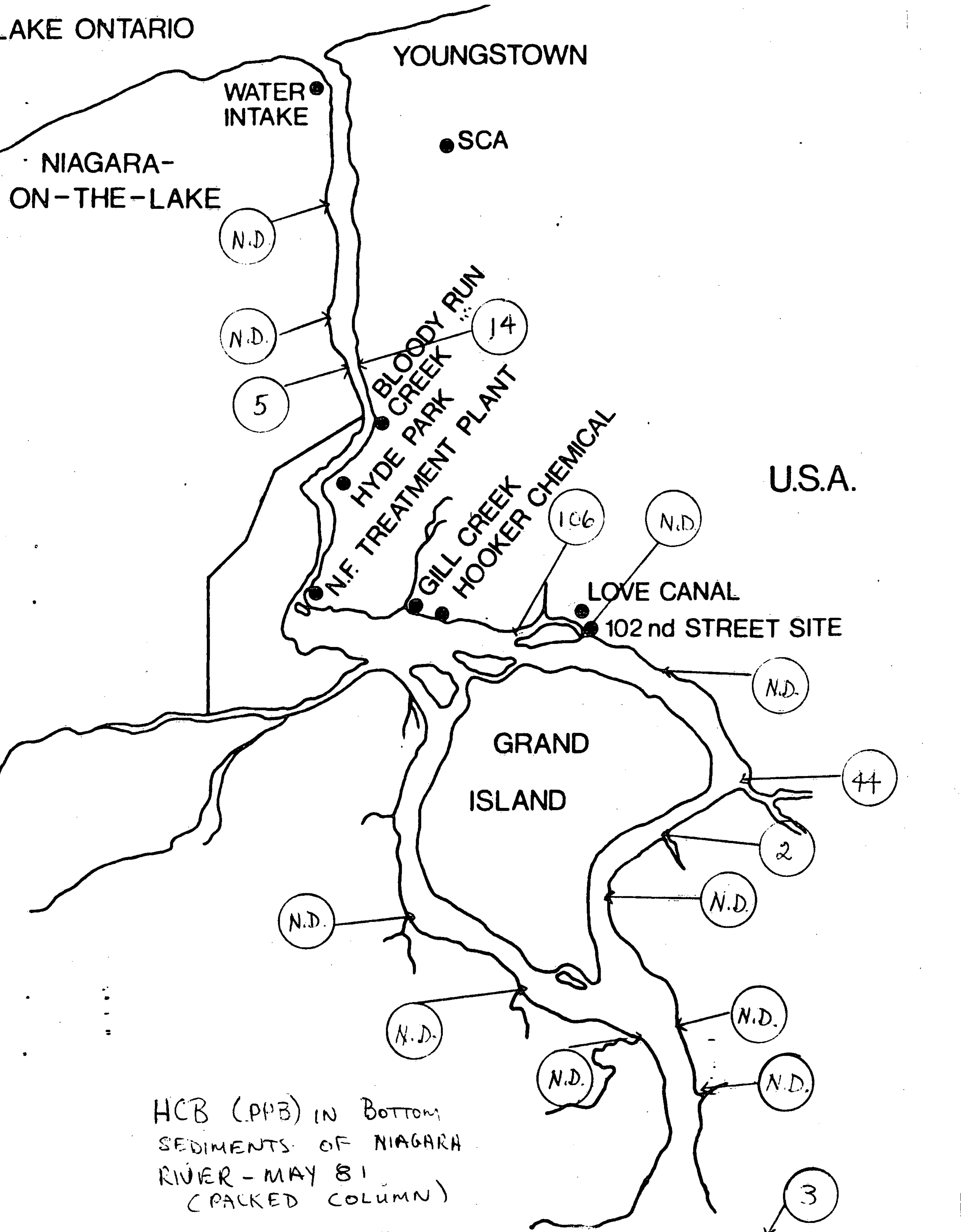


1,2,4,5-TETRACHLOROBENZENE (PPB)
IN BOTTOM SEDIMENTS OF
NIAGARA RIVER - MAY 81

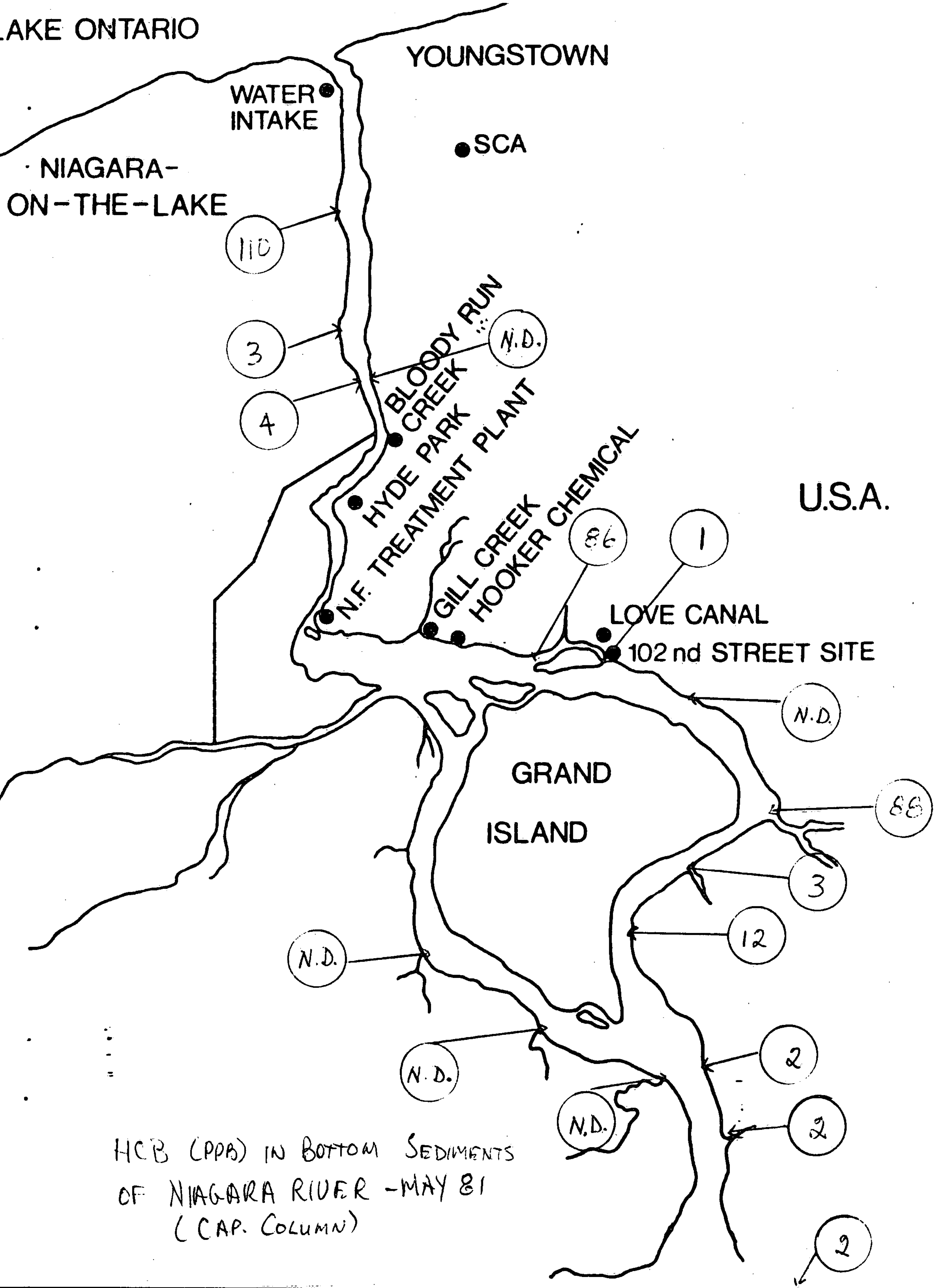

LAKE ONTARIO
YOUNGSTOWN
WATER INTAKE
SCA
NIAGARA-ON-THE-LAKE
6
N.D.
N.D.
2
BLOODY RUN
CREEK
HYDE PARK
N.F. TREATMENT PLANT
GILL CREEK
HOOKER CHEMICAL
125
N.D.
U.S.A.
LOVE CANAL
102 nd STREET SITE
N.D.
GRAND ISLAND
N.D.
N.D.
N.D.
N.D.
N.D.
N.D.
N.D.
N.D.
N.D.
1, 2, 3, 4-TETRA CHLOROBENZENE (PPB)
IN BOTTOM SEDIMENTS OF
NIAGARA RIVER - MAY 81



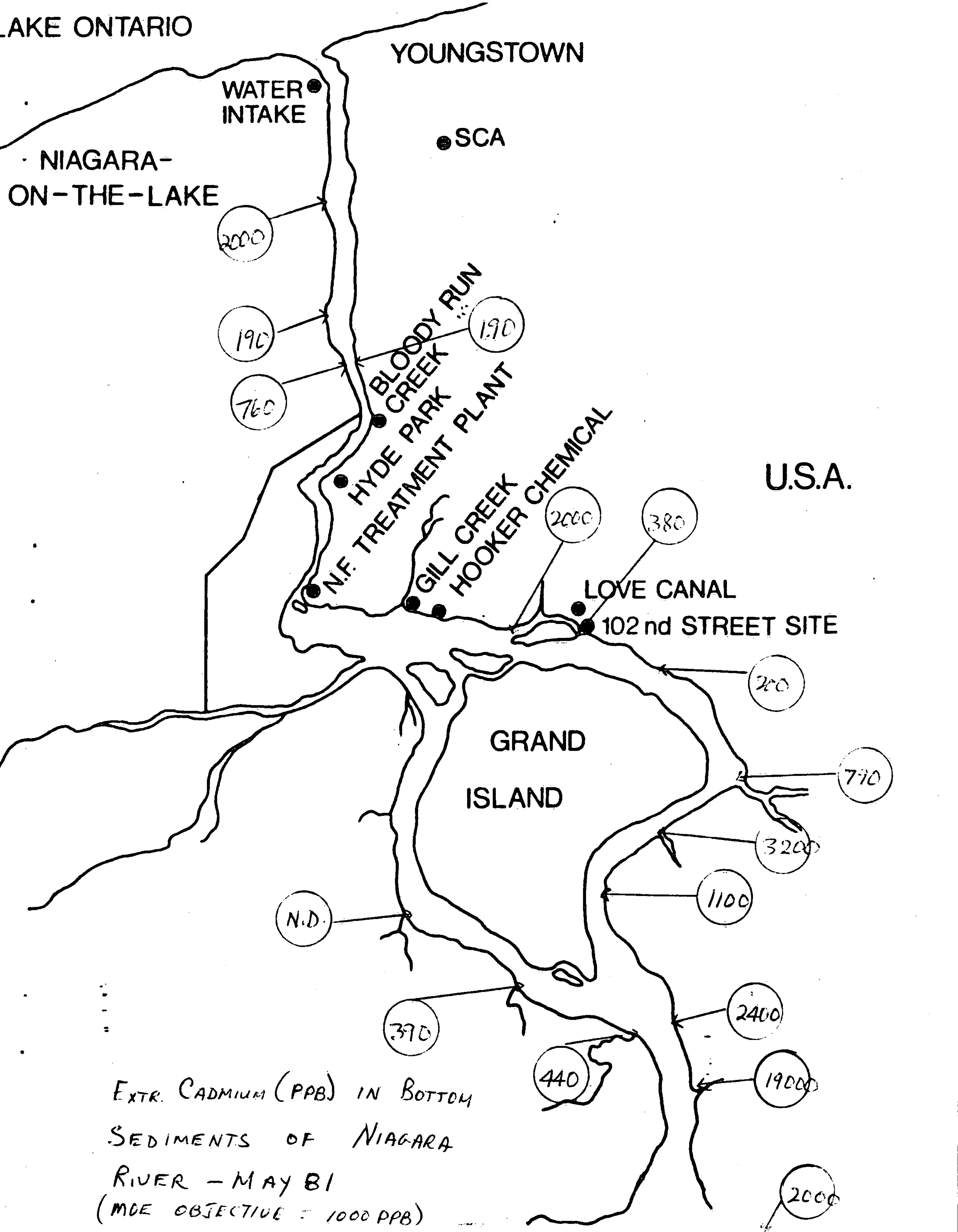
PENTACHLOROBENZENE (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81



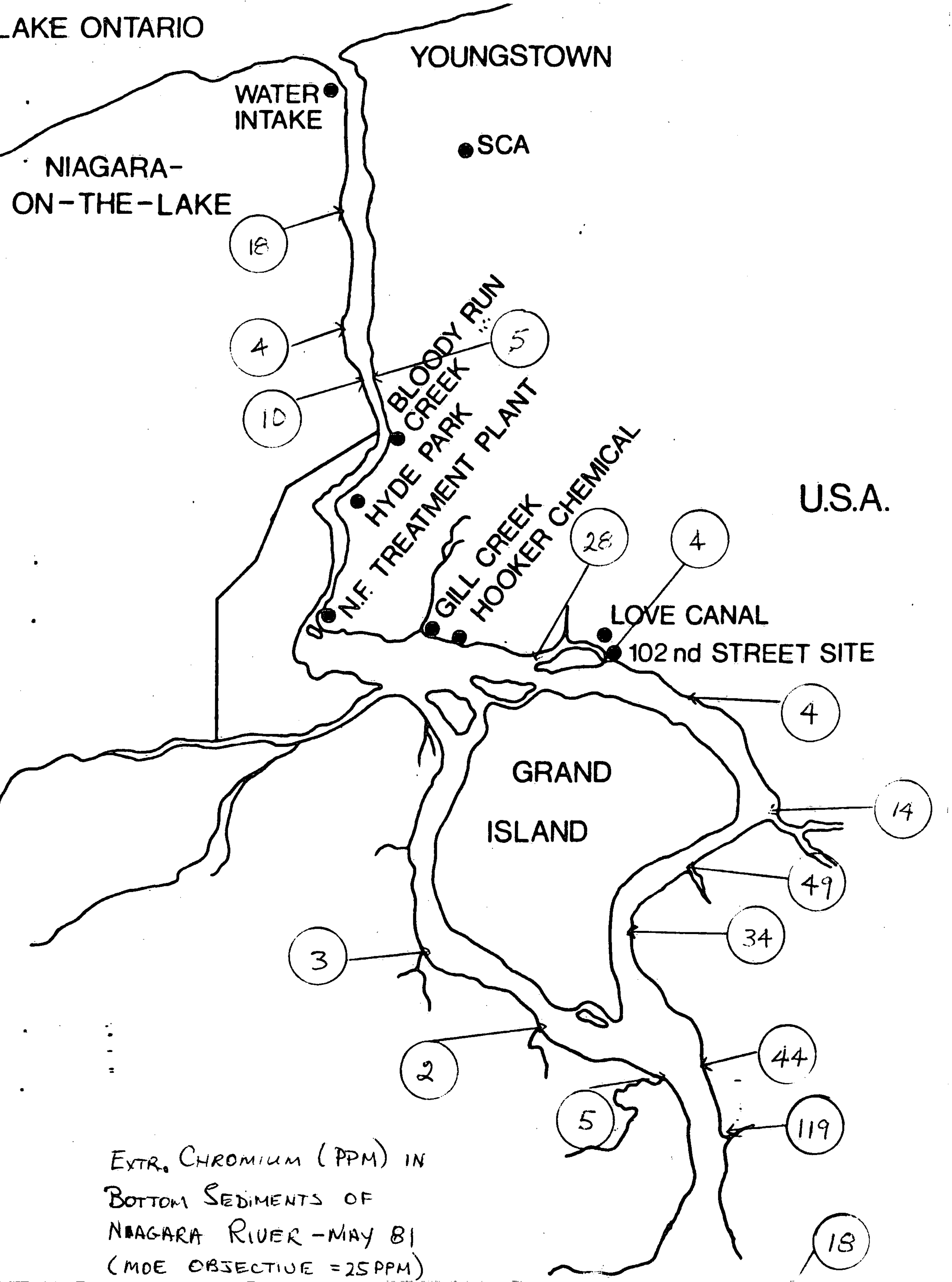
HCB (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (PACKED COLUMN)



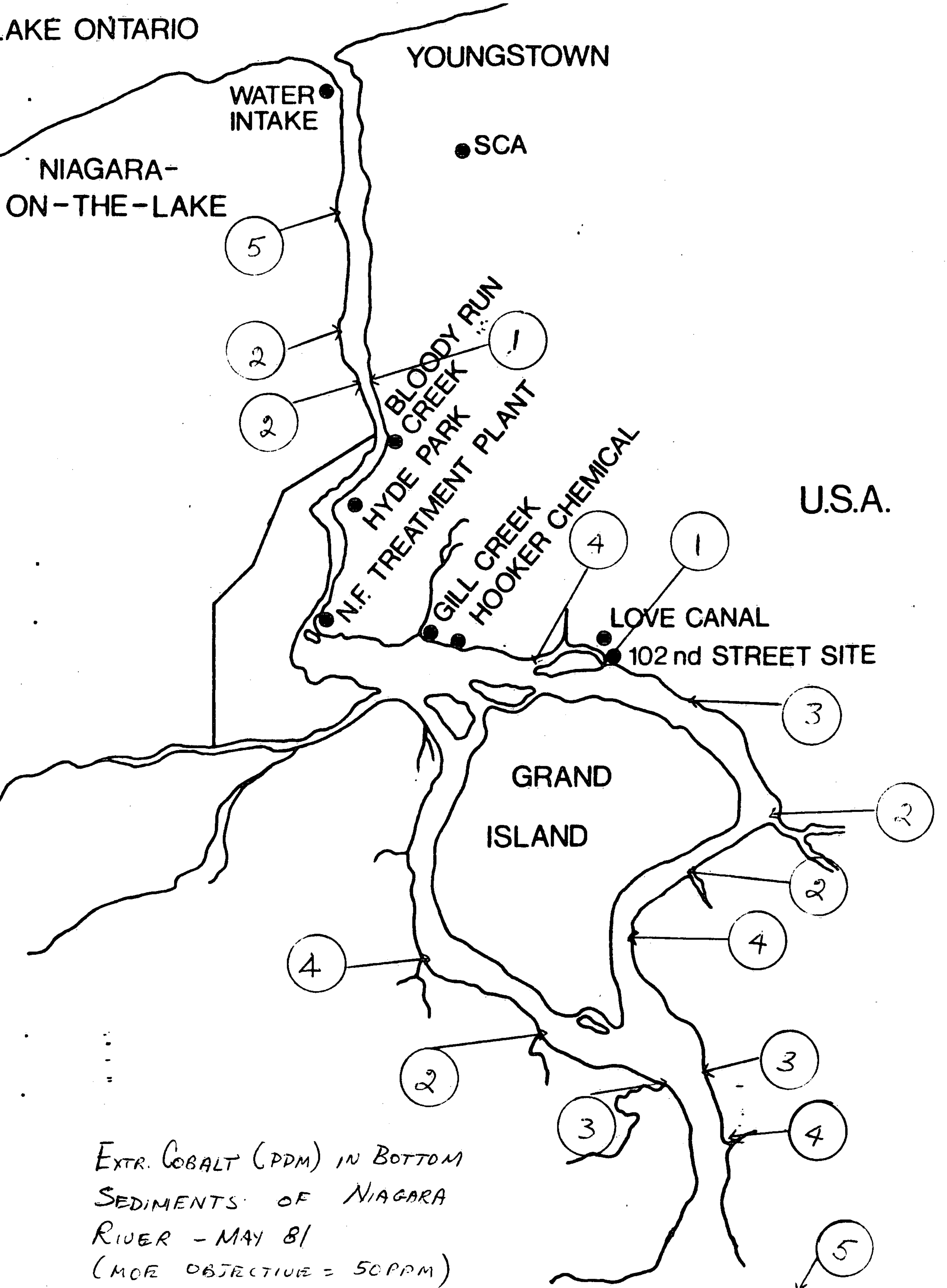
HCB (PPB) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (CAP. COLUMN)



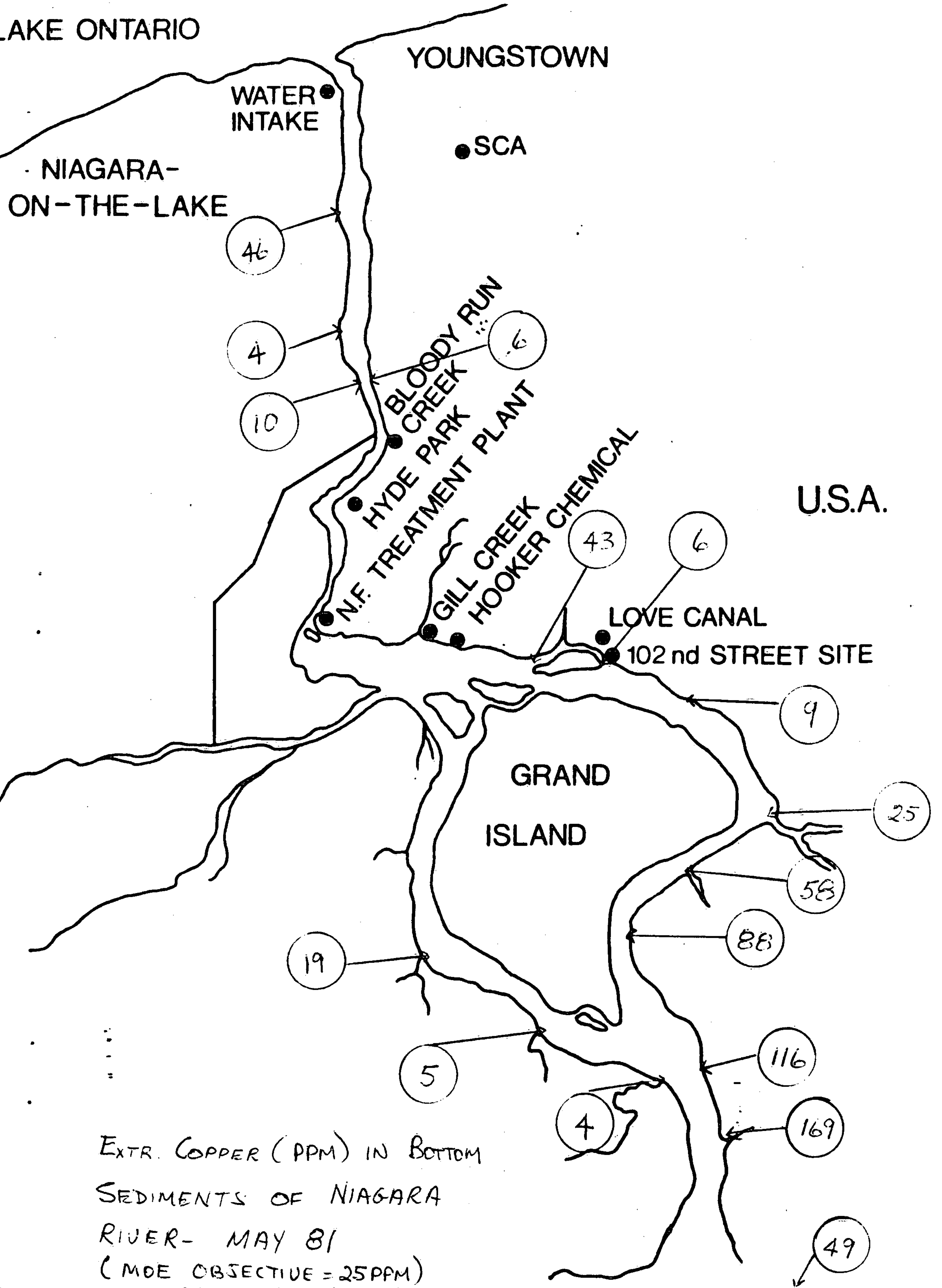
Extr. Cadmium (ppb) in Bottom Sediments of Niagara River – May 81
(MOE objective = 1000 ppb)



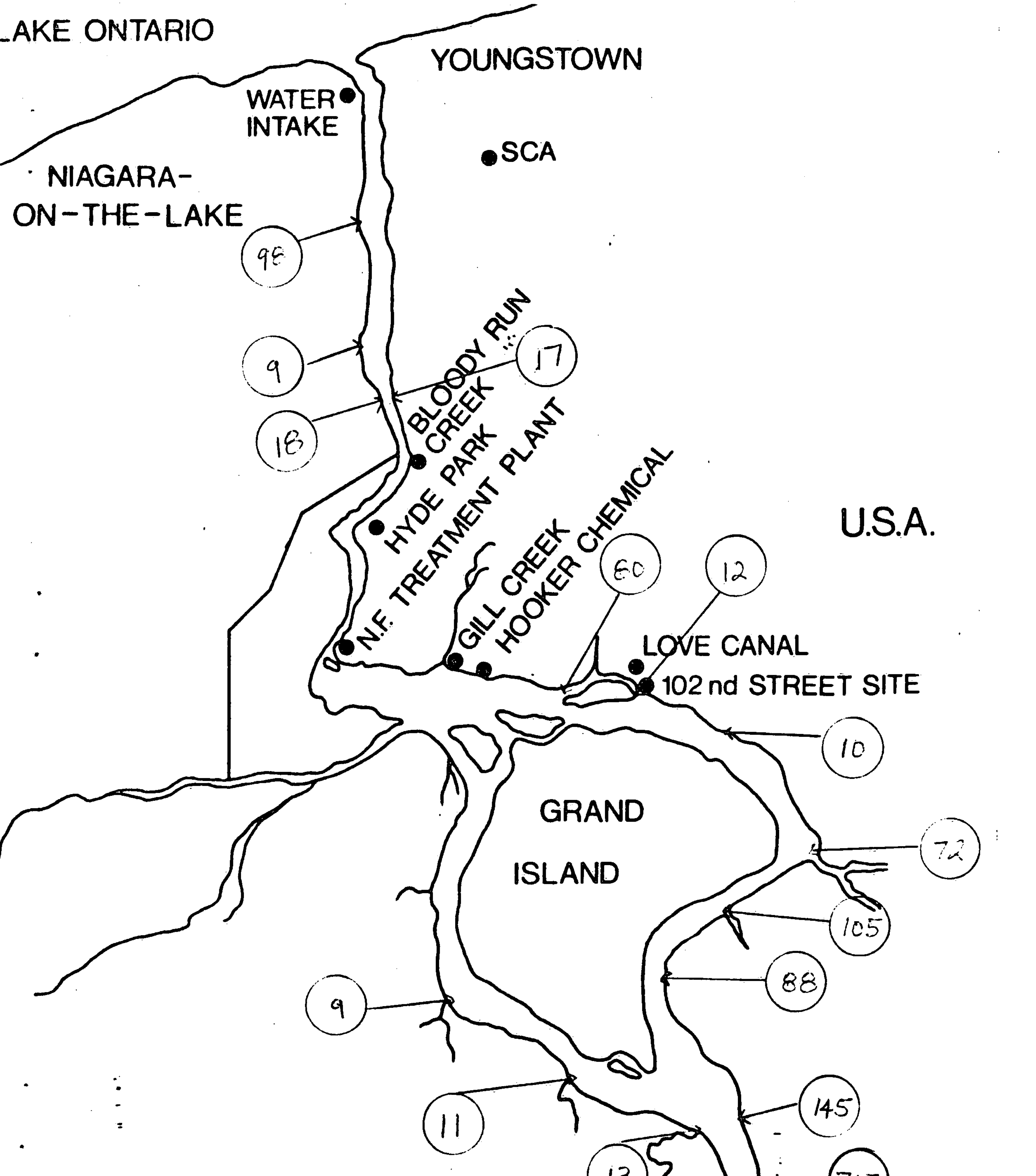
EXTR. CHROMIUM (PPM) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (MOE OBJECTIVE = 25 PPM)



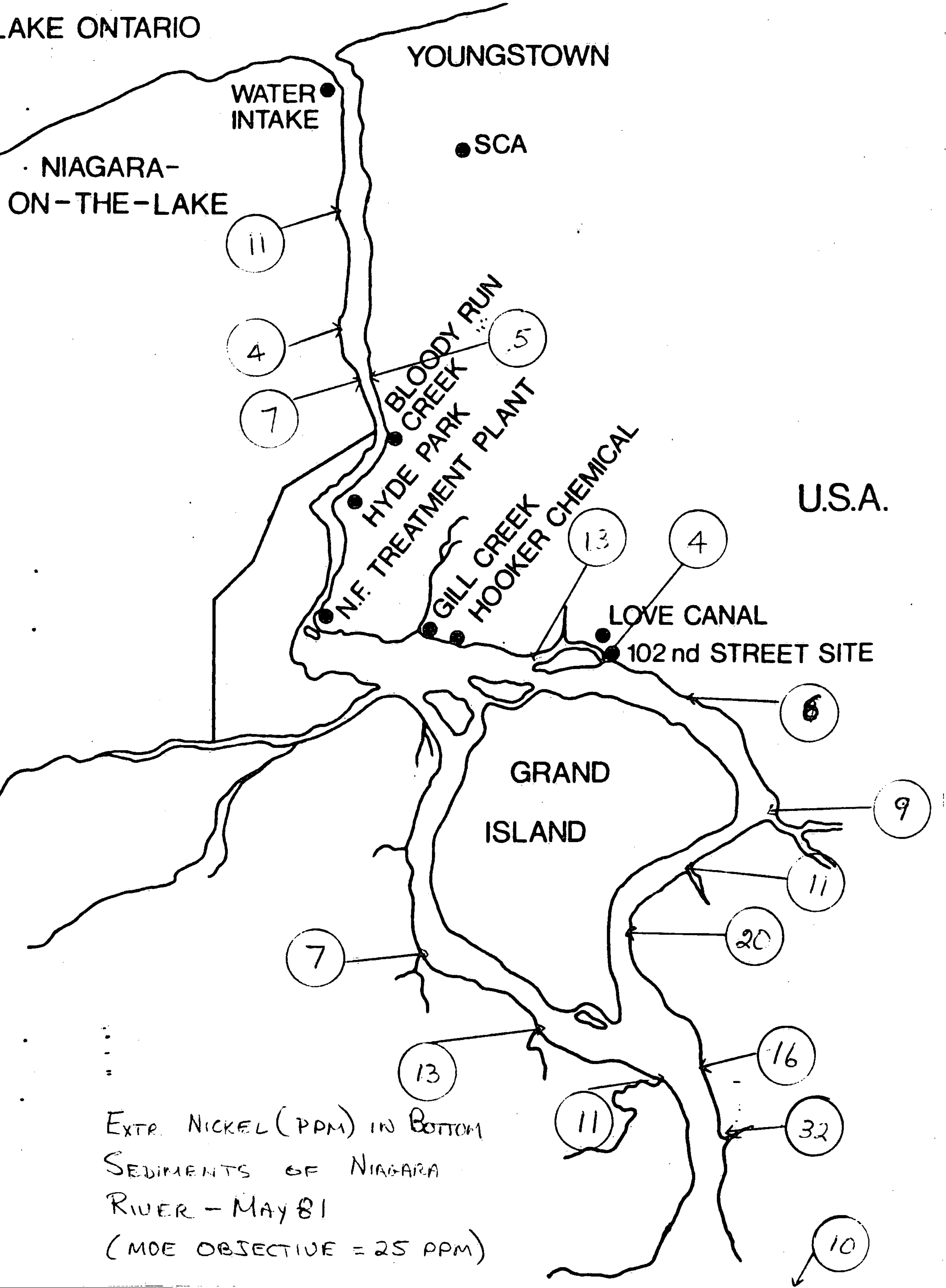
Extr. Cobalt (ppm) in Bottom Sediments of Niagara River - May 81 (MOE objective = 50ppm)



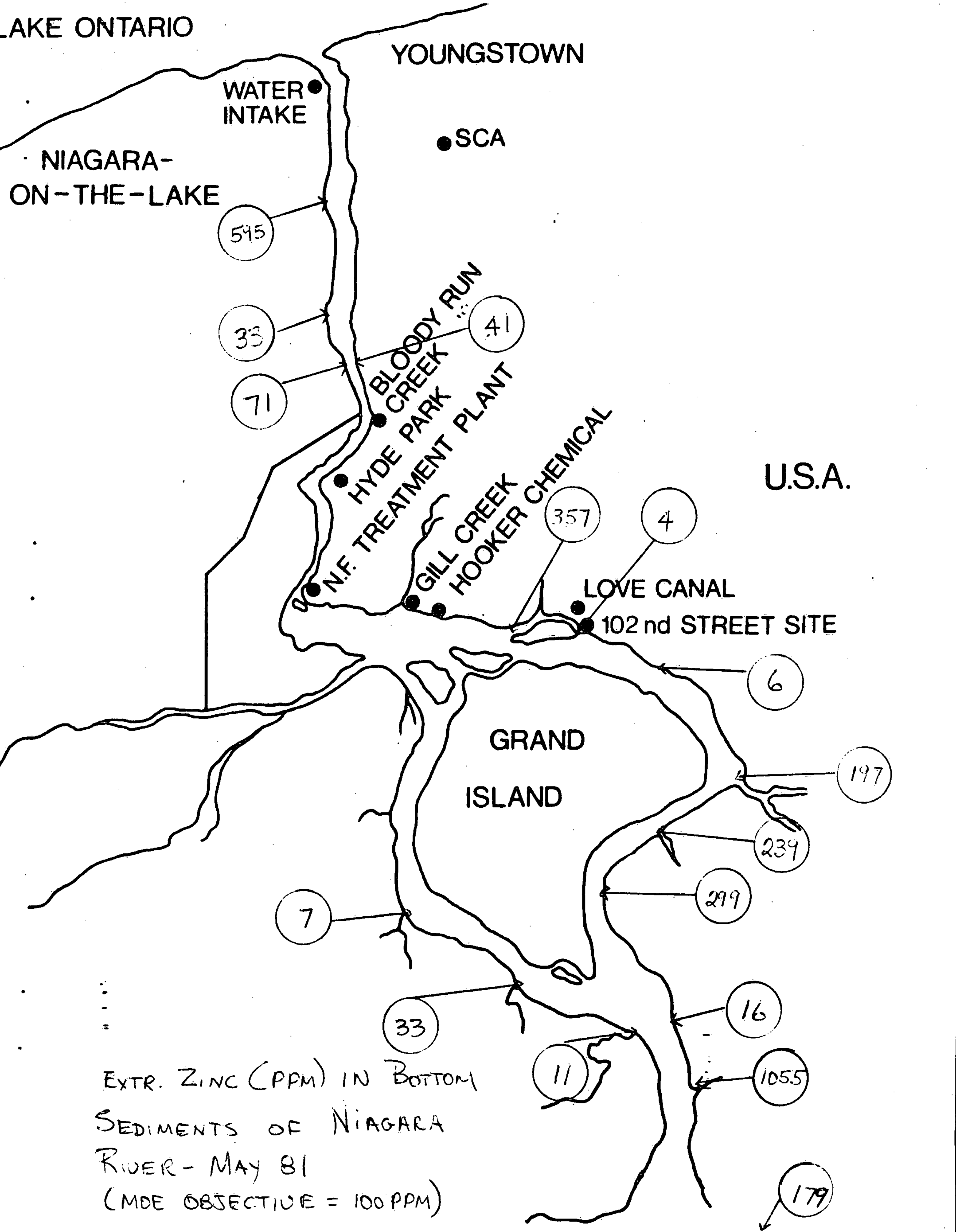
EXTR. COPPER (PPM) IN BOTTOM SEDIMENTS OF NIAGARA RIVER- MAY 81
(MOE OBJECTIVE = 25 PPM)



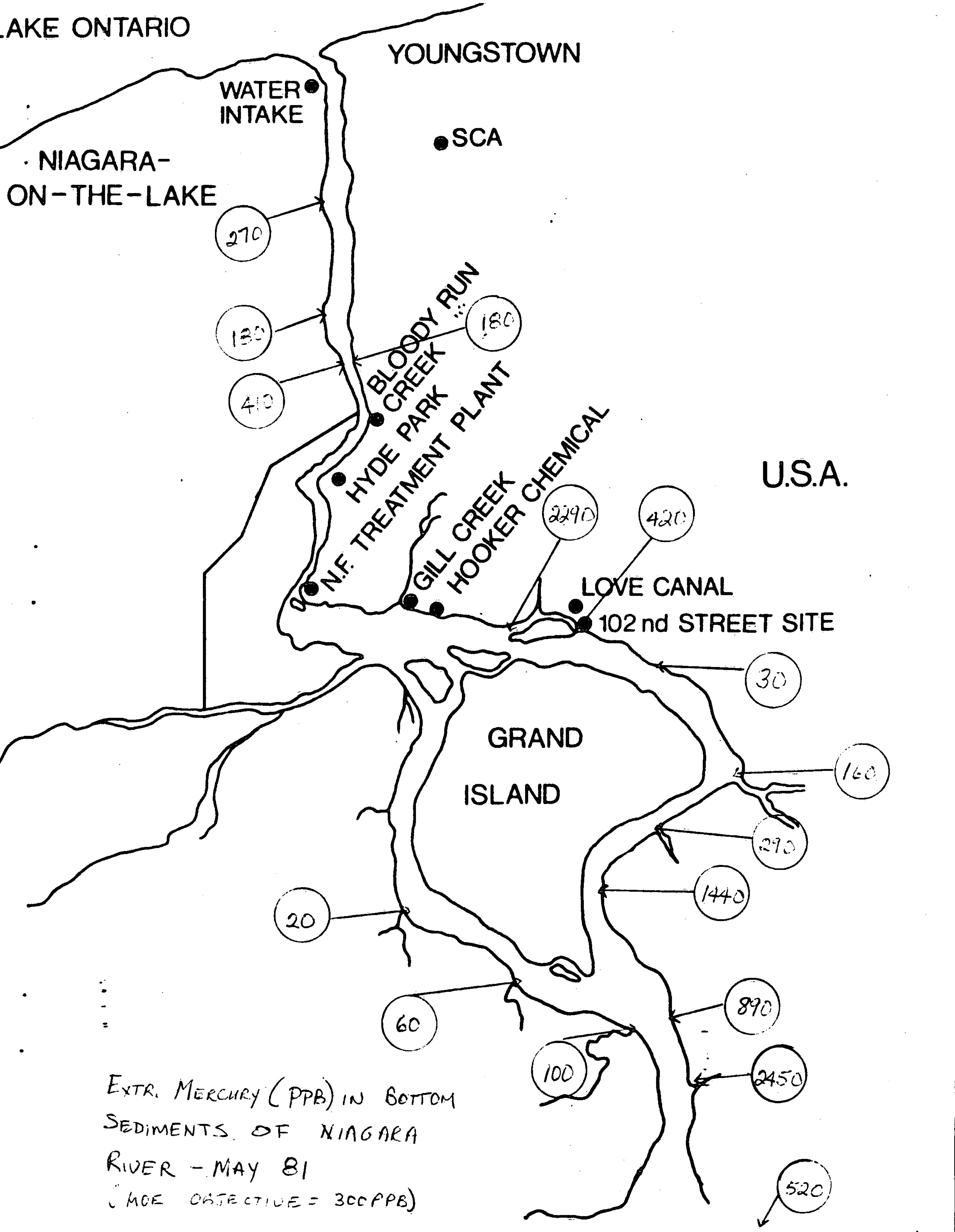
EXTR. LEAD (PPM) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (MOE OBJECTIVE = 50 PPM)



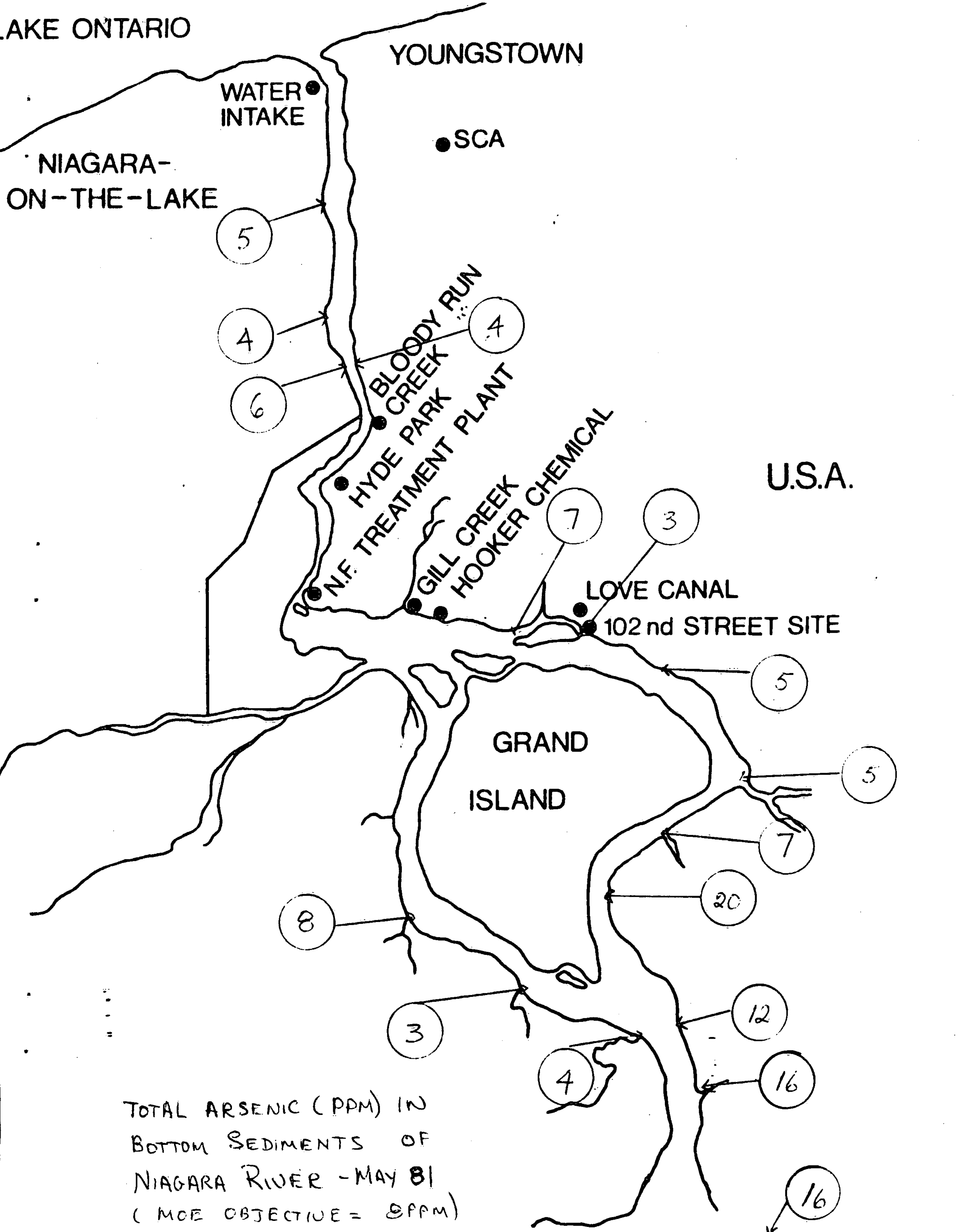
Extr. Nickel (ppm) in Bottom Sediments of Niagara River – May 81
(MOE Objective = 25 ppm)



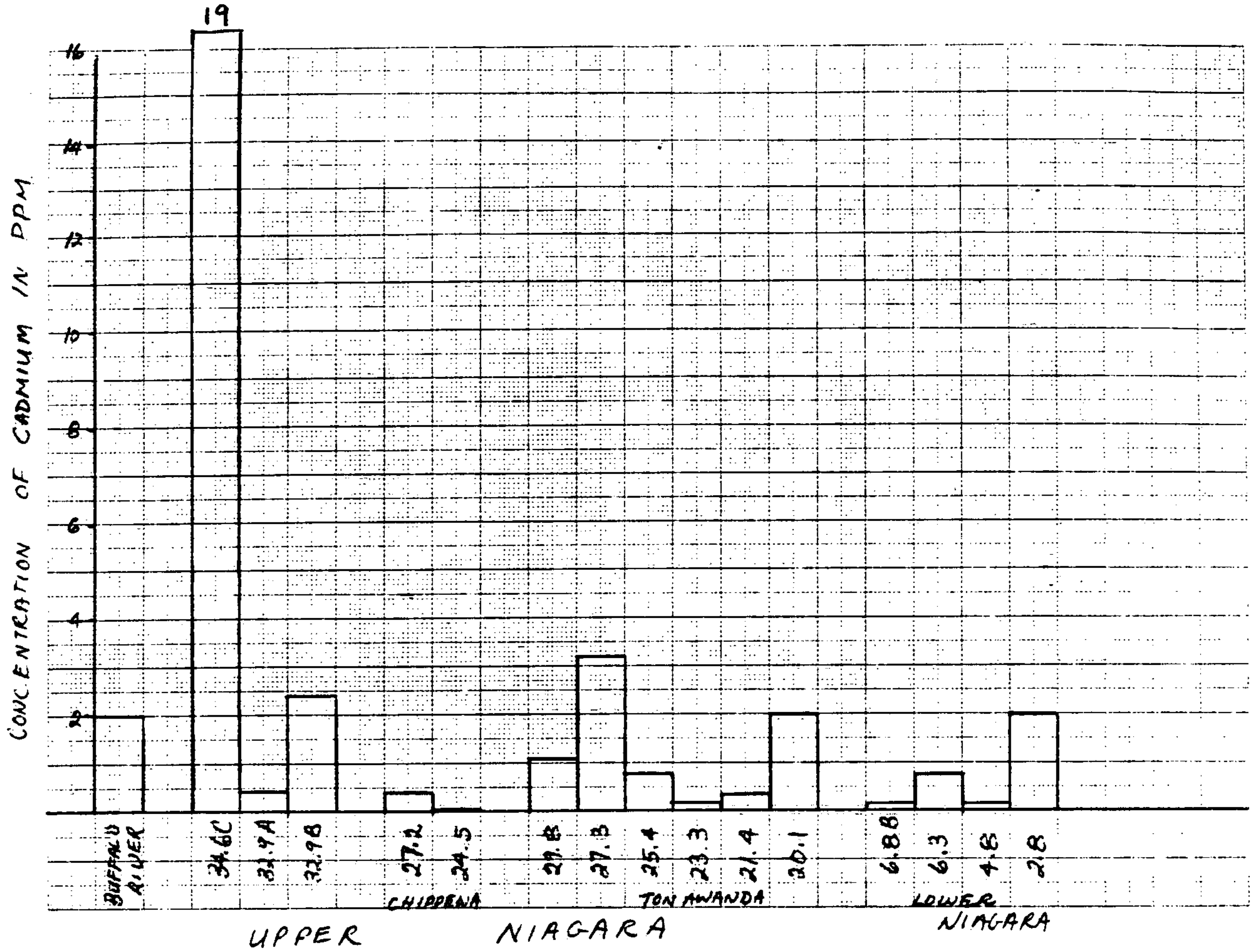
EXTR. ZINC (PPM) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (MOE OBJECTIVE = 100 PPM)



Extr. Mercury (PPB) in Bottom Sediments of Niagara River – May 81
(MOE objective = 300 PPB)



TOTAL ARSENIC (PPM) IN BOTTOM SEDIMENTS OF NIAGARA RIVER - MAY 81 (MOE OBJECTIVE = 8PPM)


19
16
14
12
10
8
6
4
2
CONCENTRATION OF CADMIUM IN PPM
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

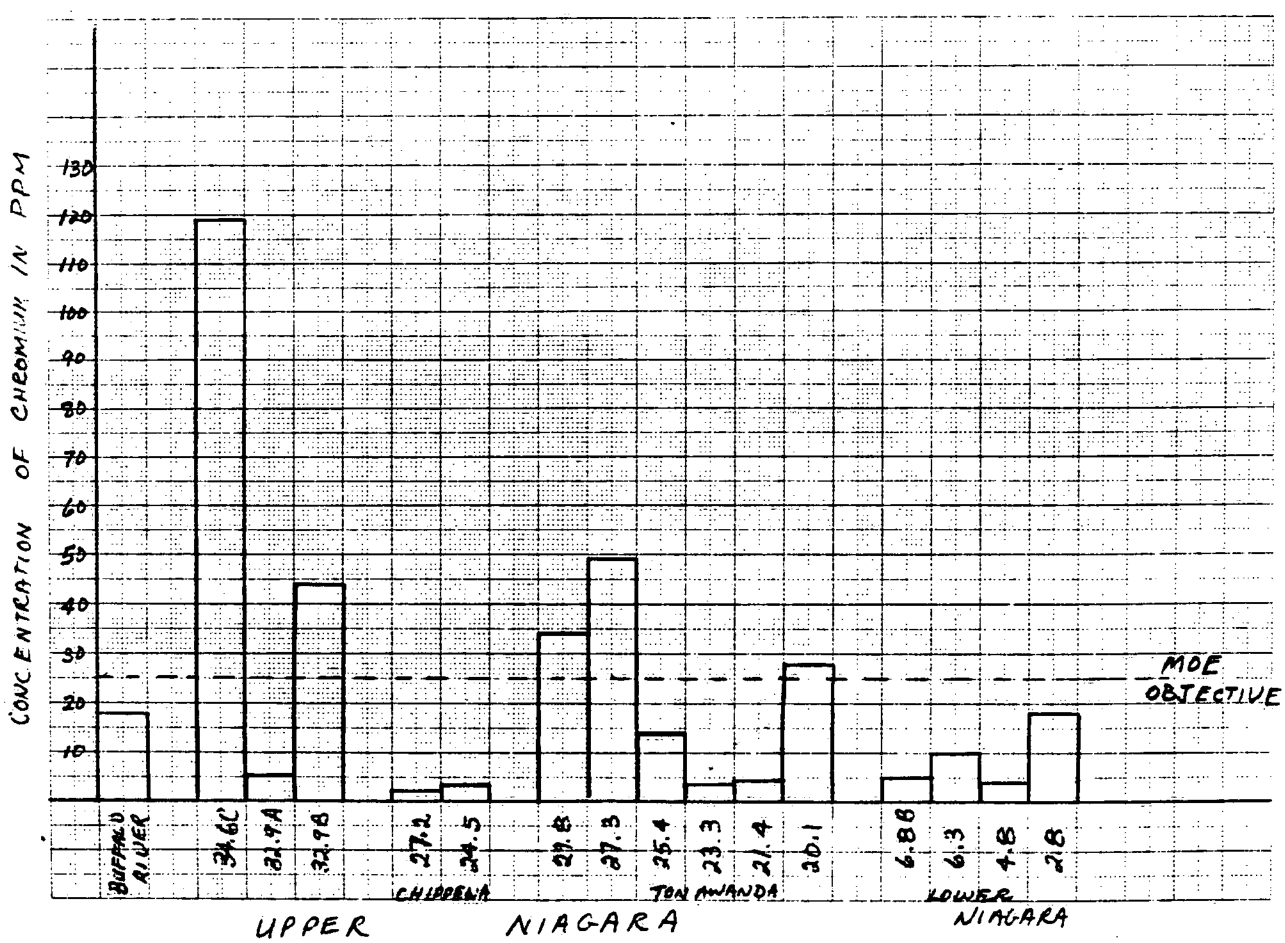
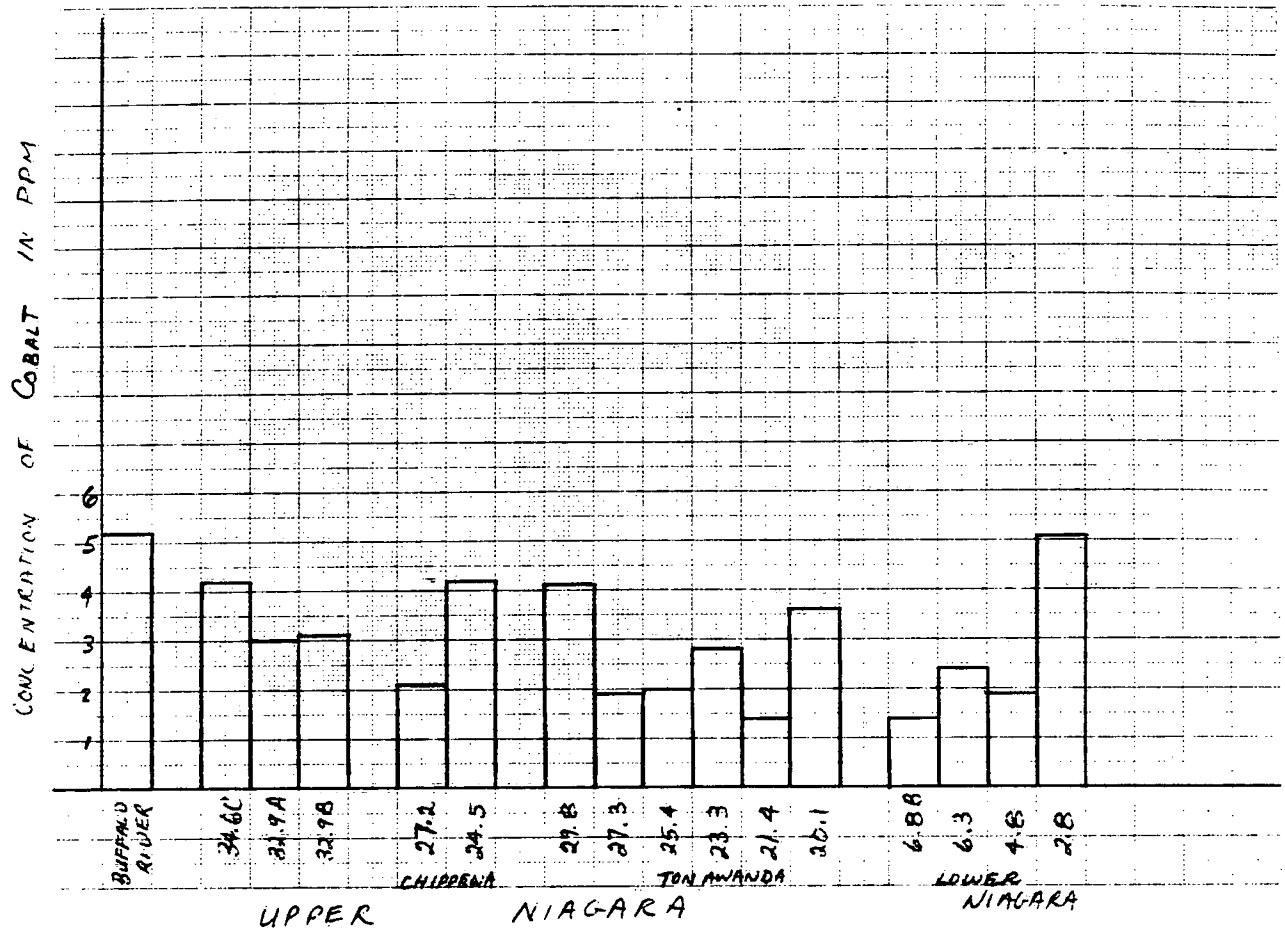

130
120
110
100
90
80
70
60
50
40
30
20
10
CONCENTRATION OF CHROMIUM IN PPM
MOE OBJECTIVE
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

FIGURE 4


CONCENTRATION OF COBALT IN PPM
1
2
3
4
5
6
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.8B
6.3
4.6
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

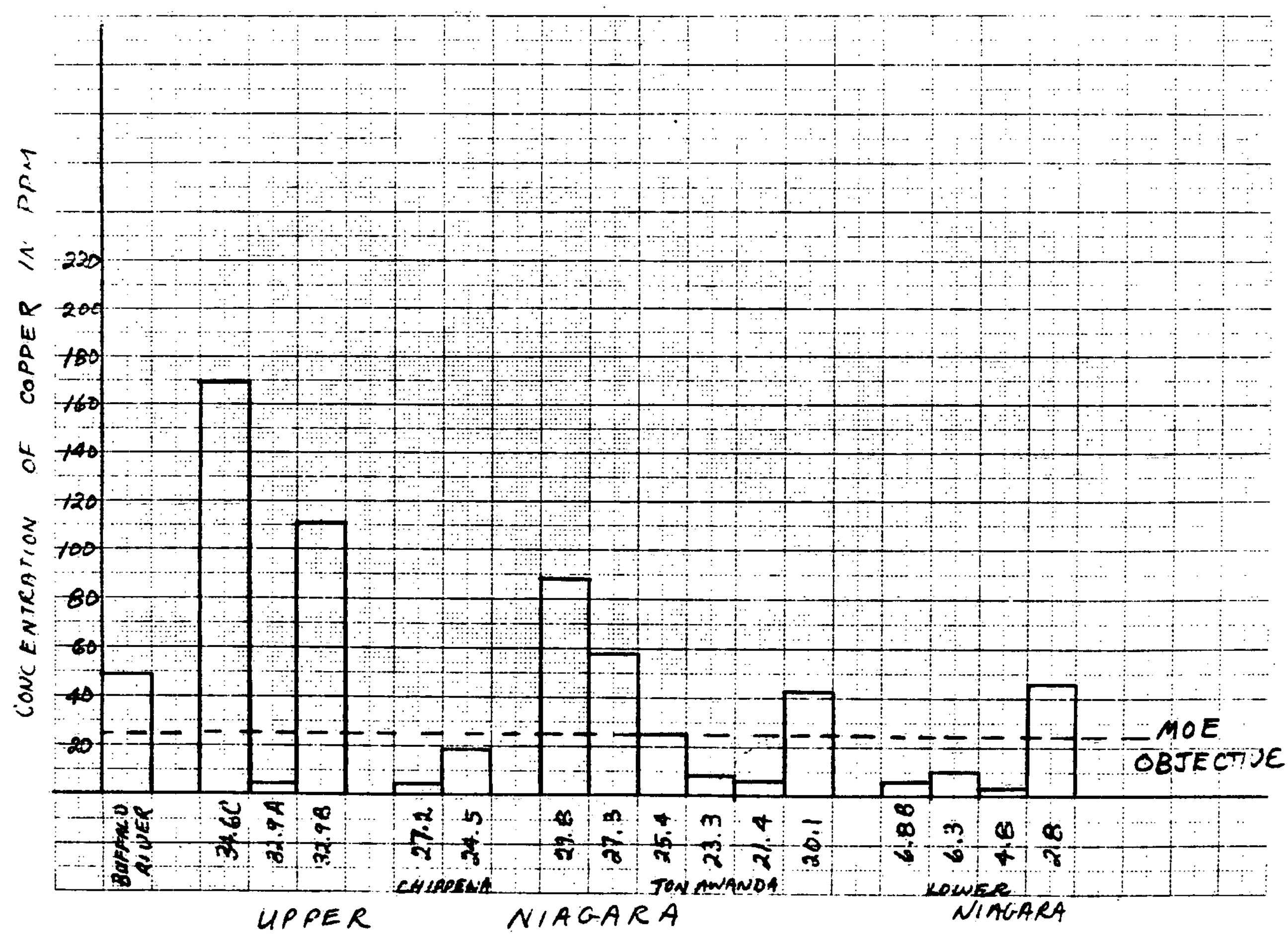
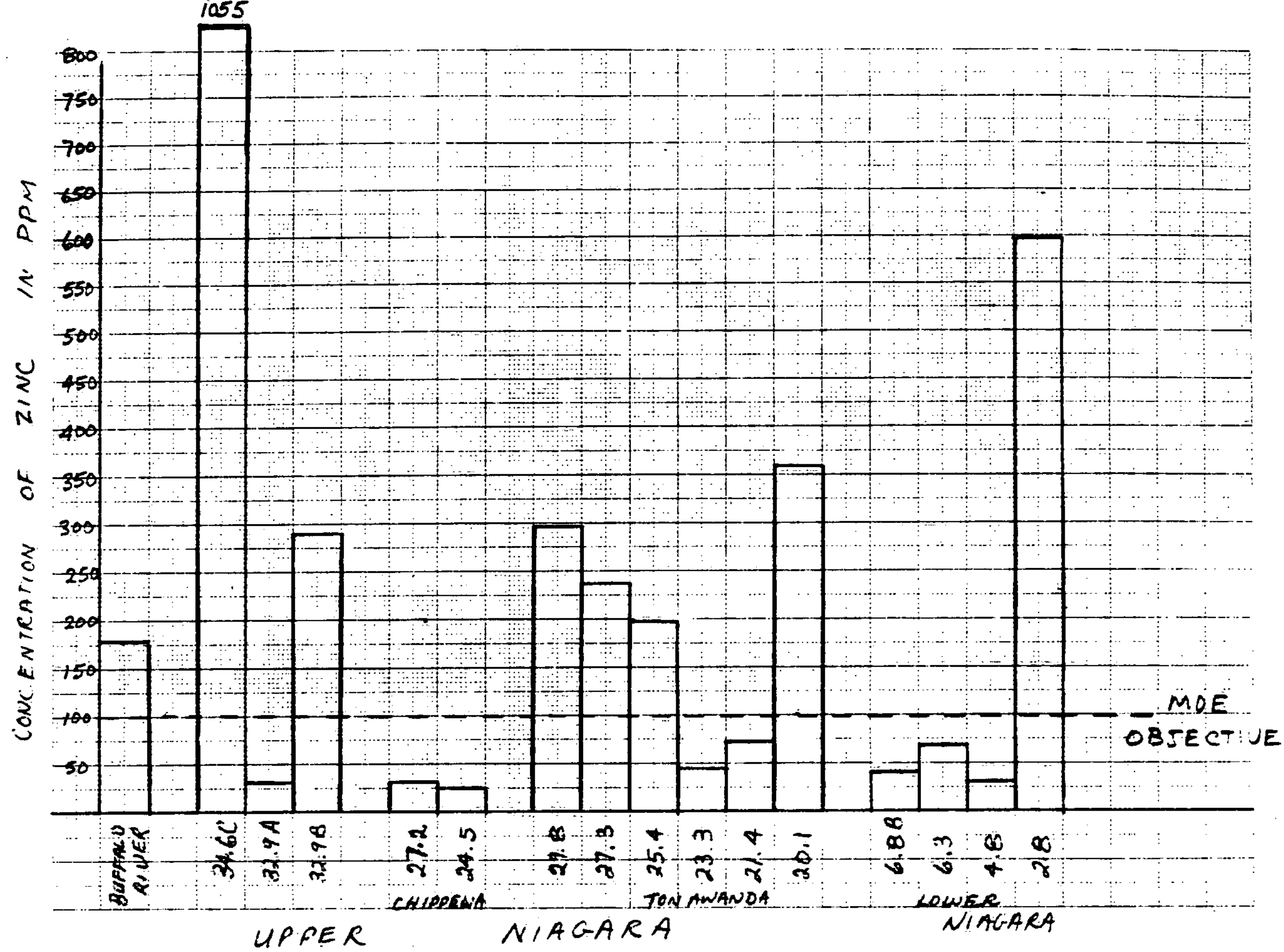

CONCENTRATION OF COPPER IN PPM
20
40
60
80
100
120
140
160
180
200
220
MOE OBJECTIVE
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.8B
6.3
4.6
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

FIGURE 5


1055
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
CONCENTRATION OF ZINC IN PPM
MOE
OBJECTIVE
BUFFALO RIVER
34.6C
32.9A
32.9B
27.1
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

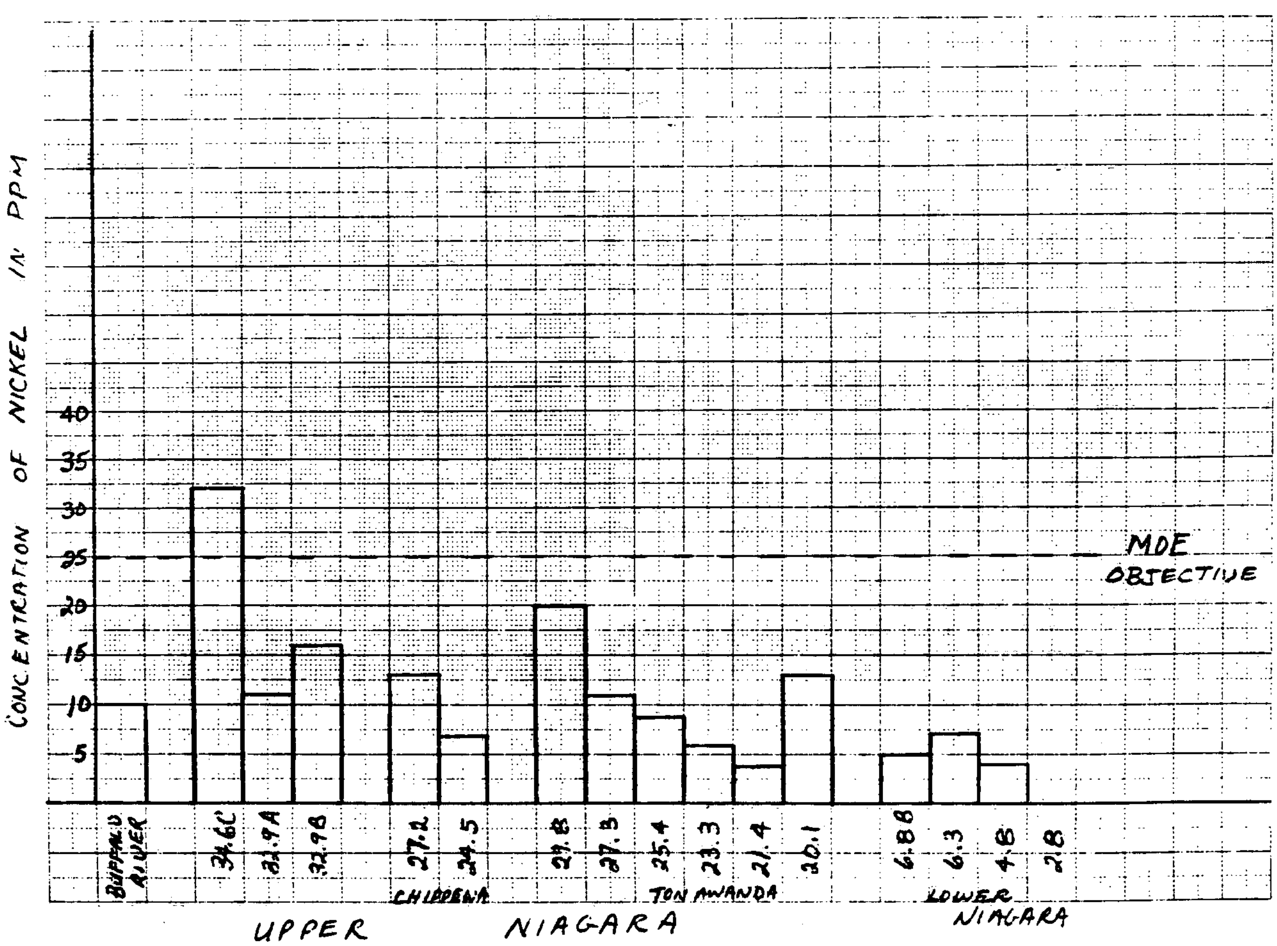
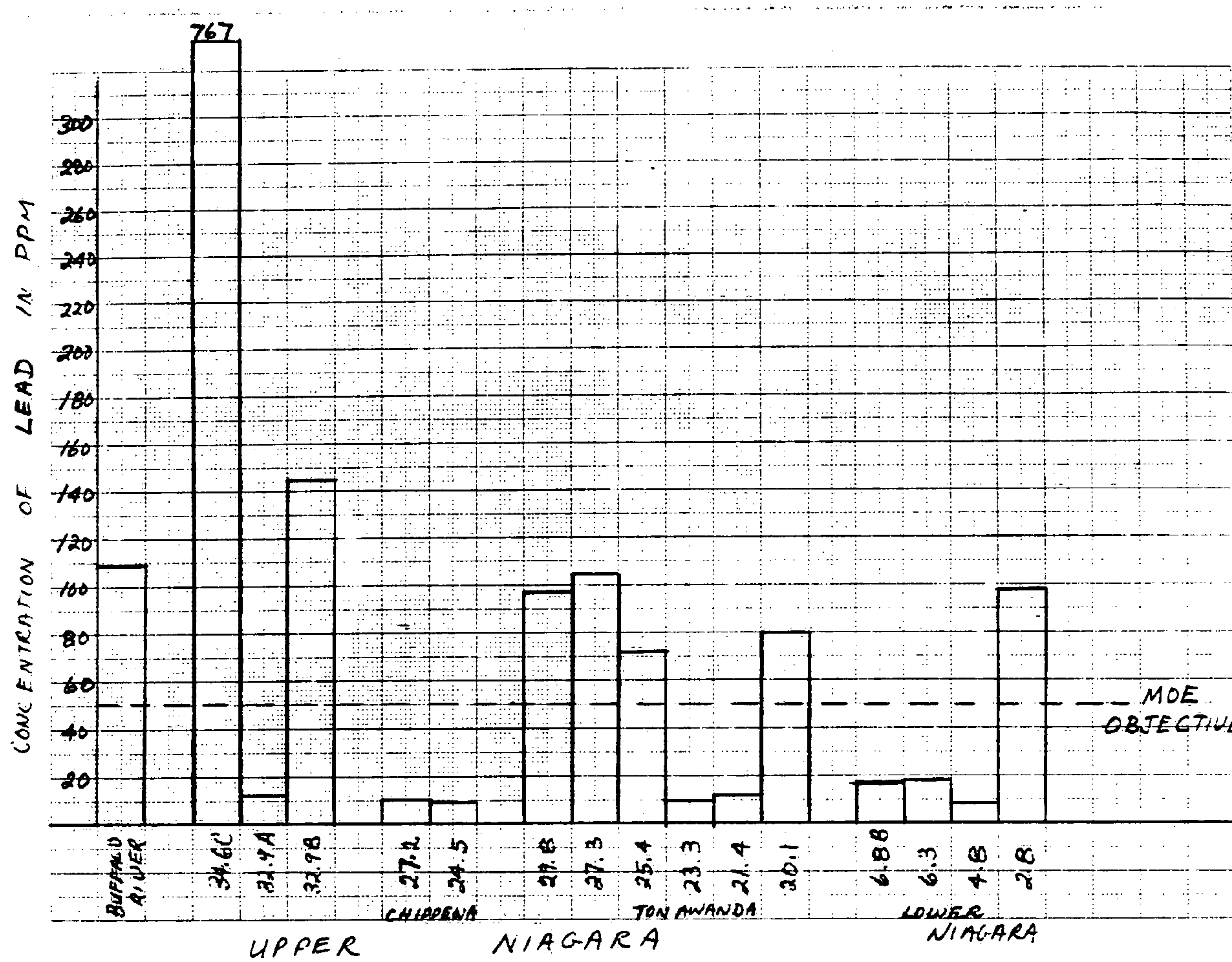

40
35
30
25
20
15
10
5
CONCENTRATION OF NICKEL IN PPM
MOE
OBJECTIVE
BUFFALO RIVER
34.6C
32.9A
32.9B
27.1
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

FIGURE 6


CONCENTRATION OF LEAD IN PPM
767
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
MOE OBJECTIVE
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
30.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

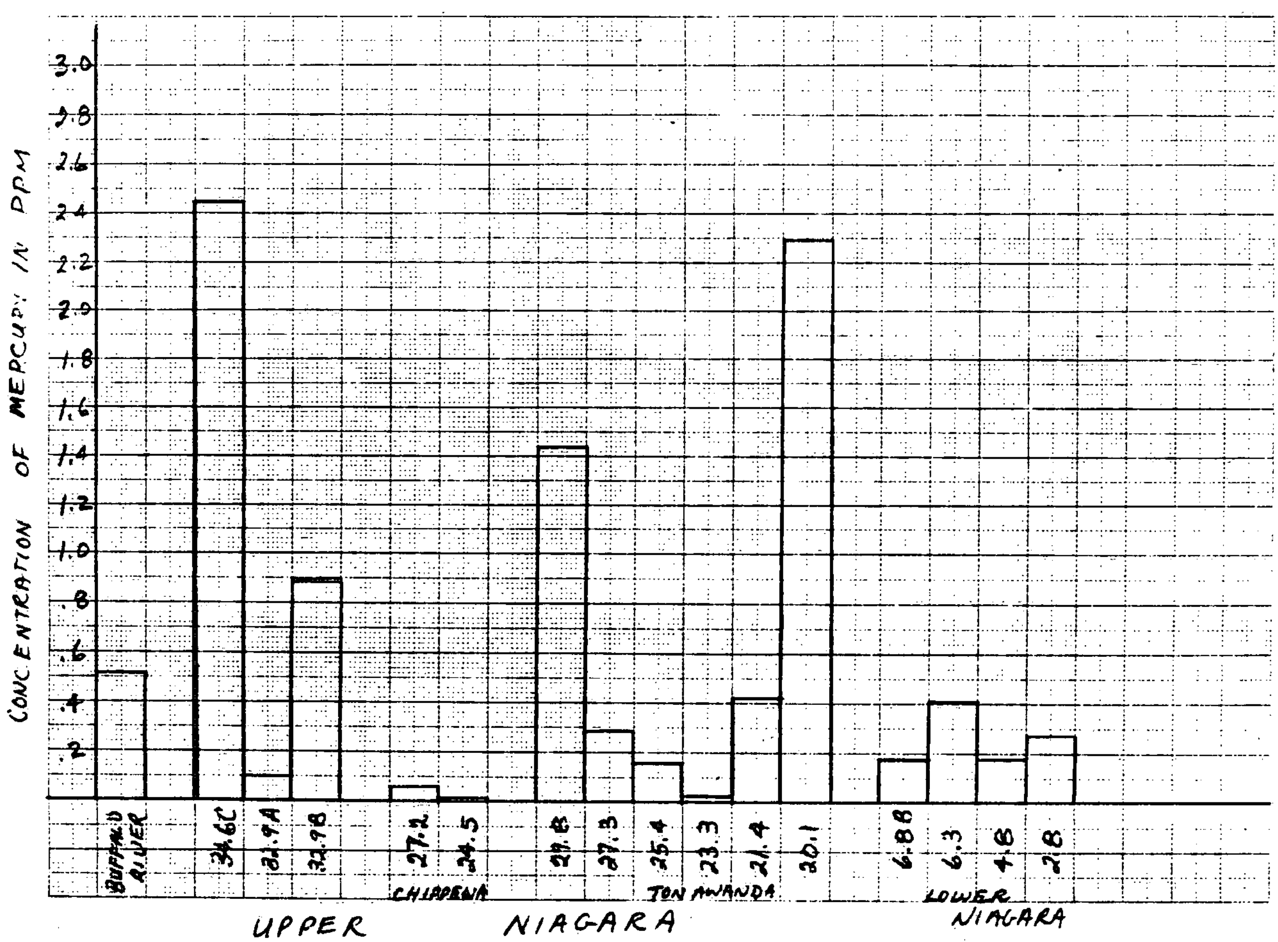
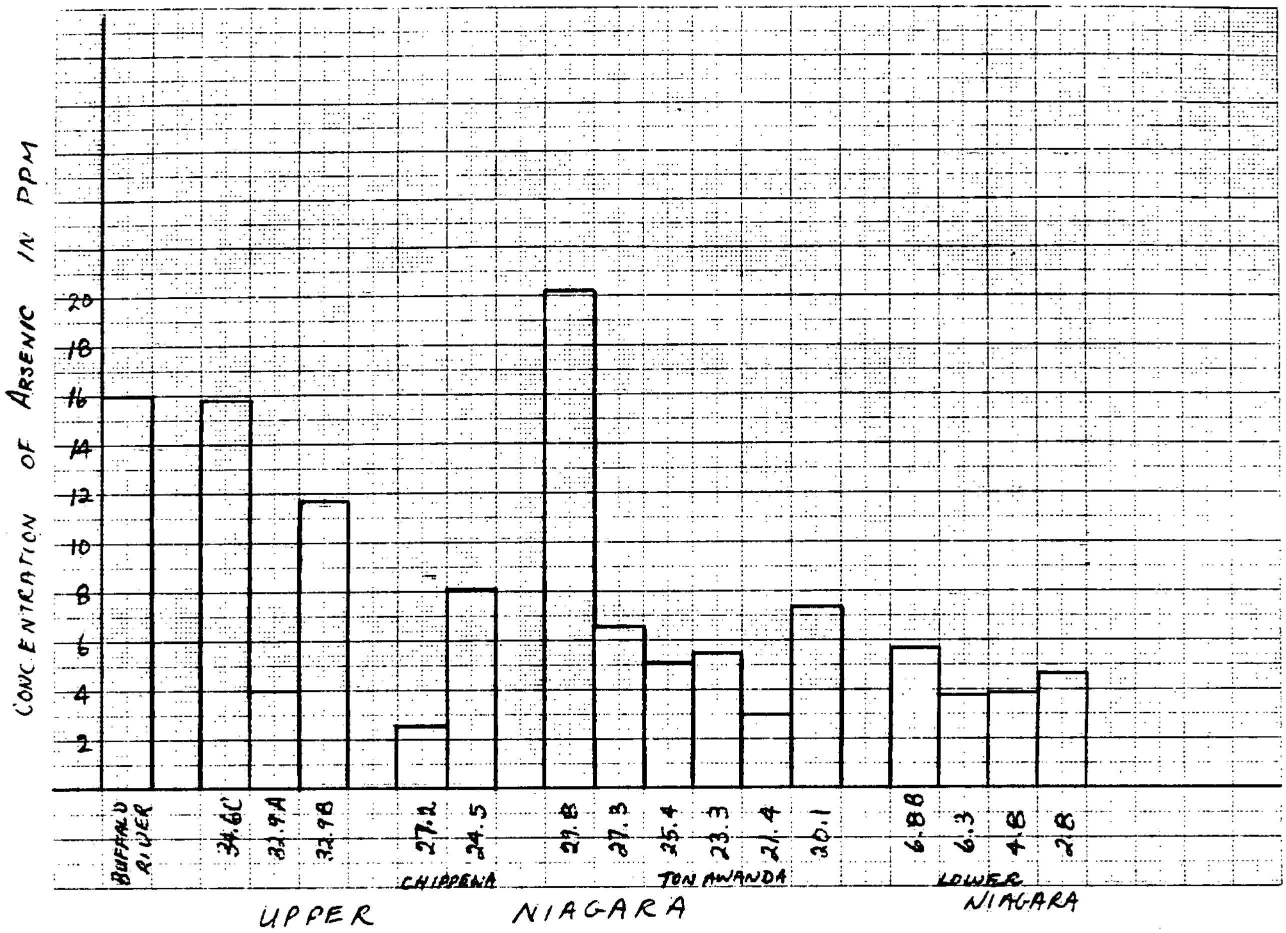

CONCENTRATION OF MERCURY IN PPM
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
30.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

FIGURE 7


CONCENTRATION OF ARSENIC IN PPM
20
18
16
14
12
10
8
6
4
2
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

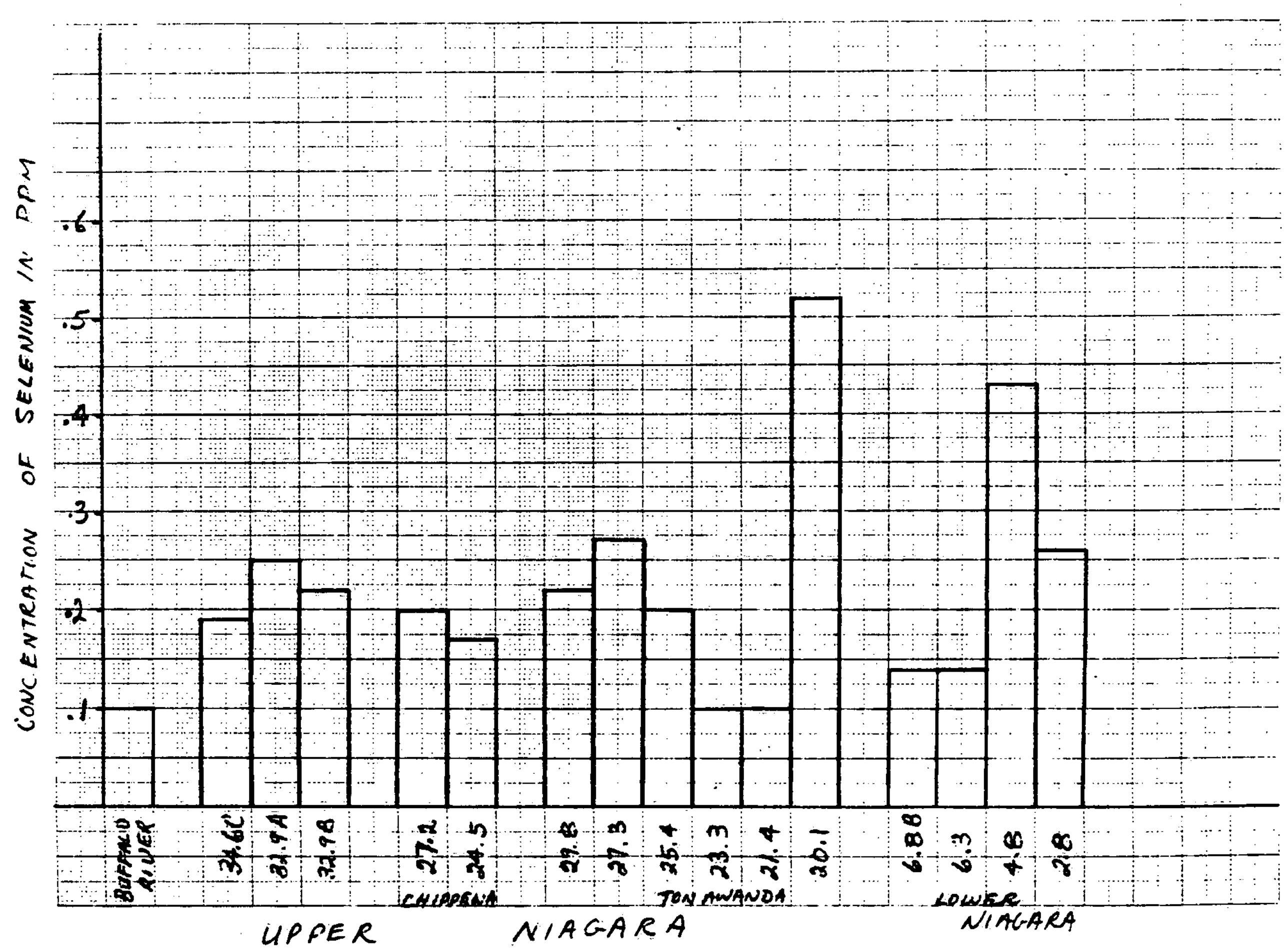
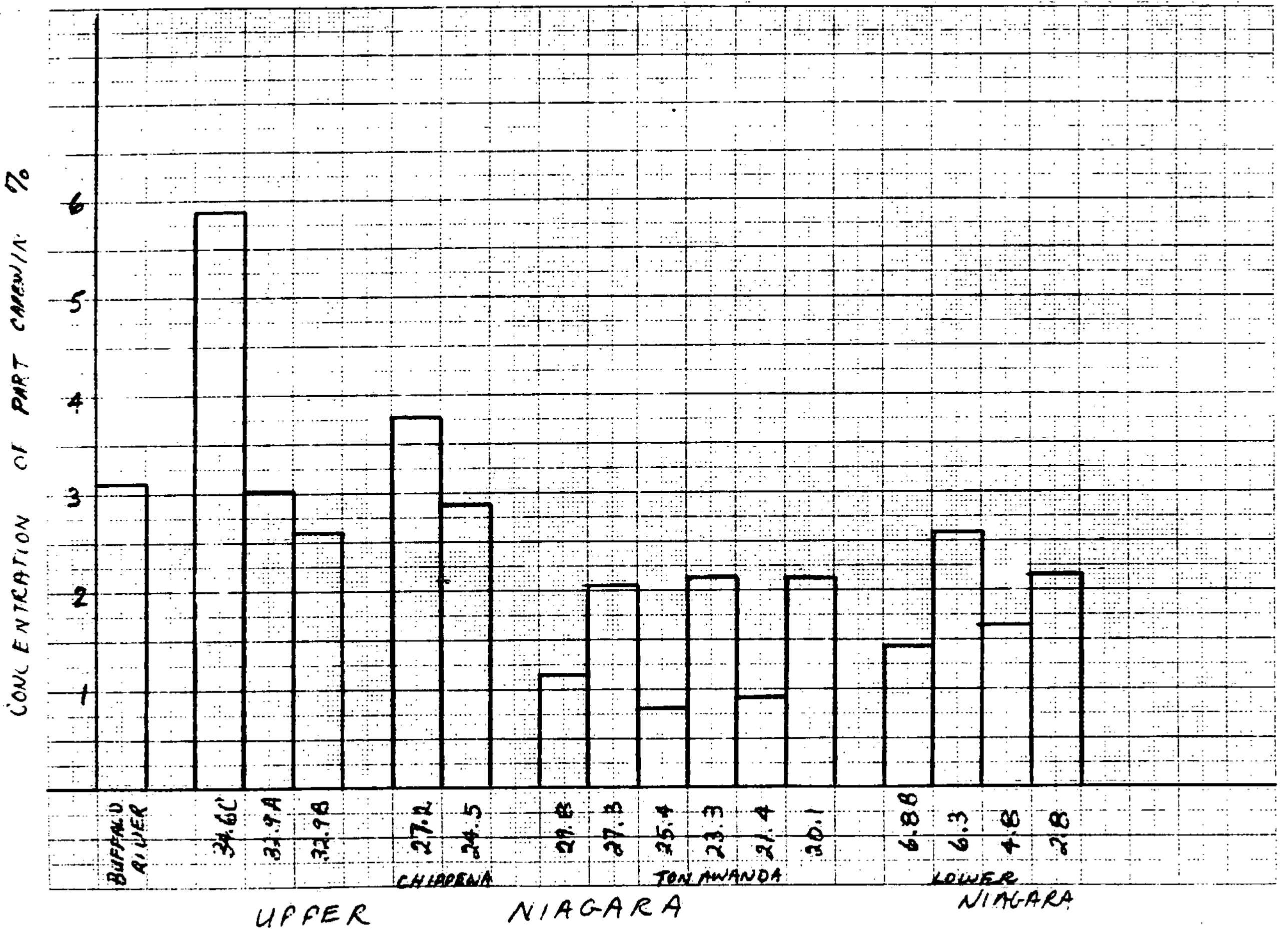

CONCENTRATION OF SELENIUM IN PPM
.6
.5
.4
.3
.2
.1
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

FIGURE 8


CONCENTRATION OF PART CARBON IN %
6
5
4
3
2
1
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

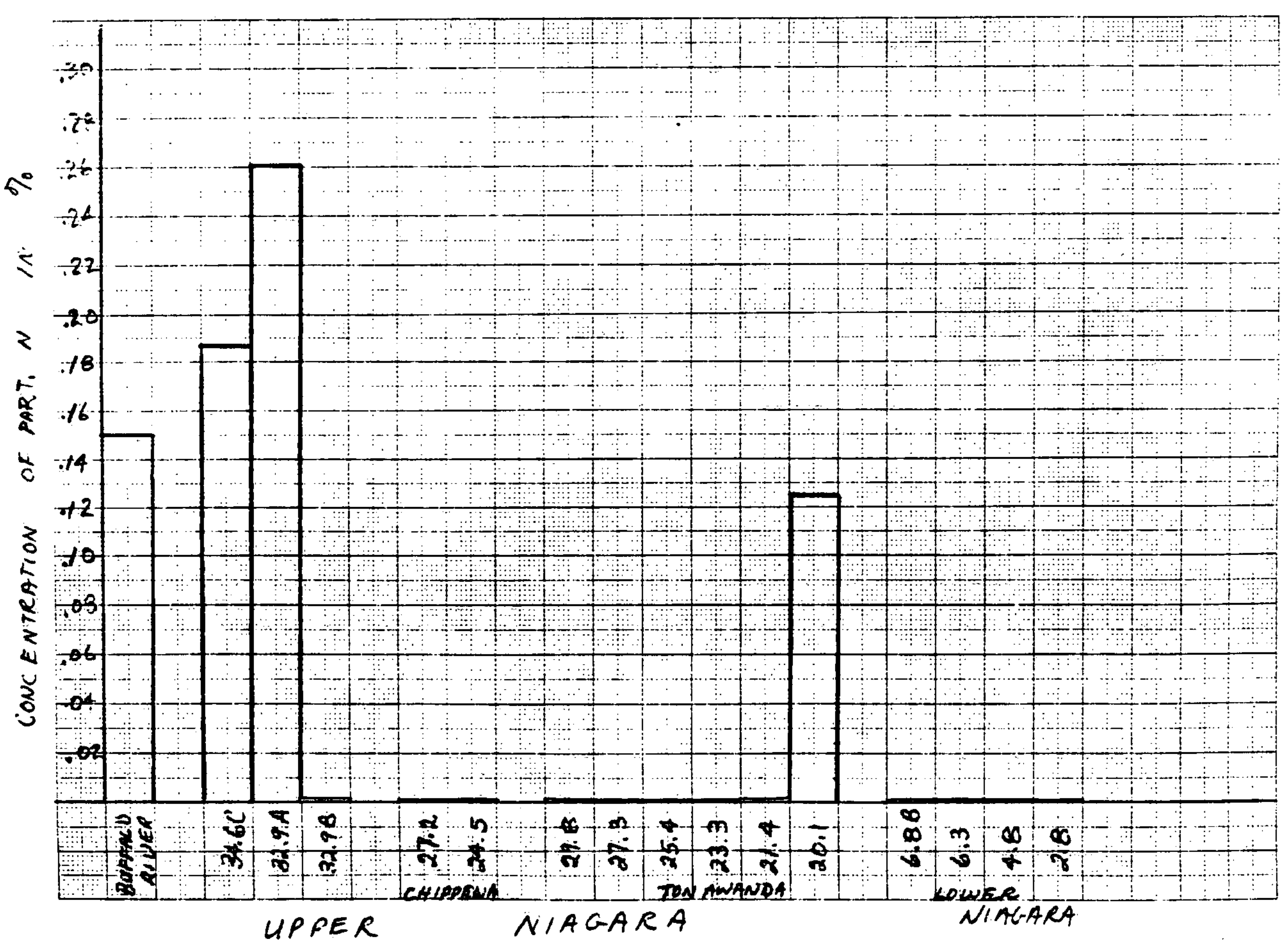
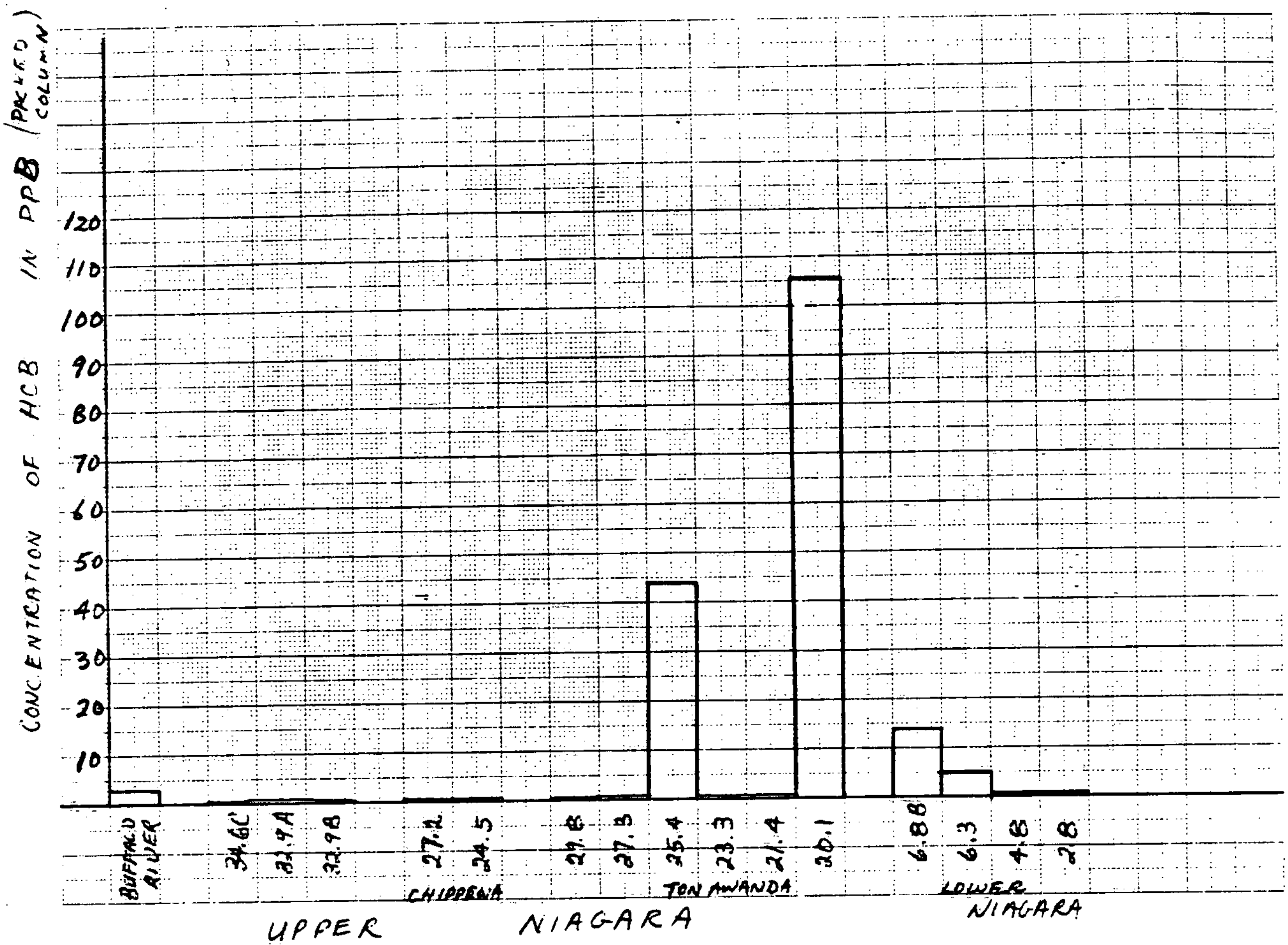
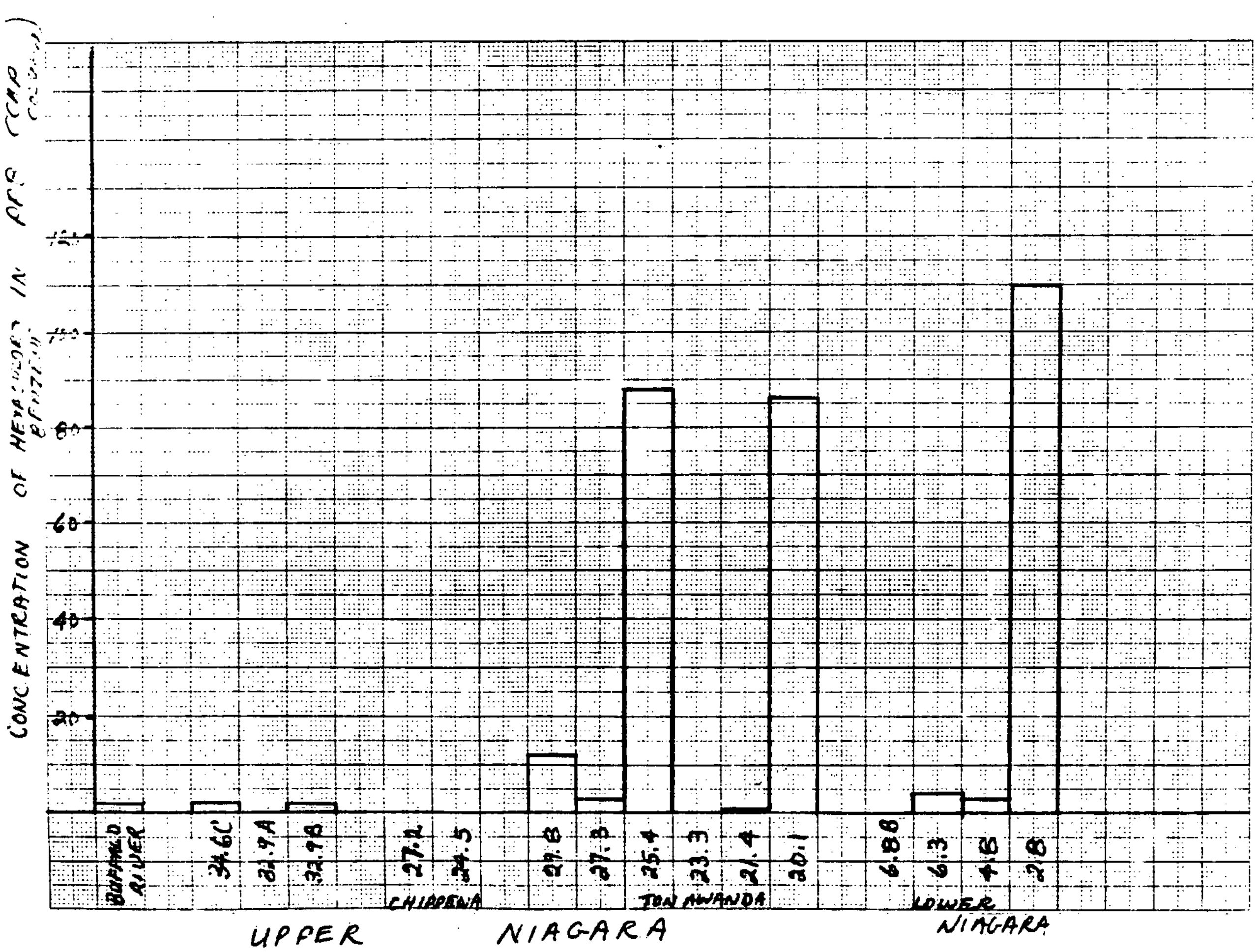
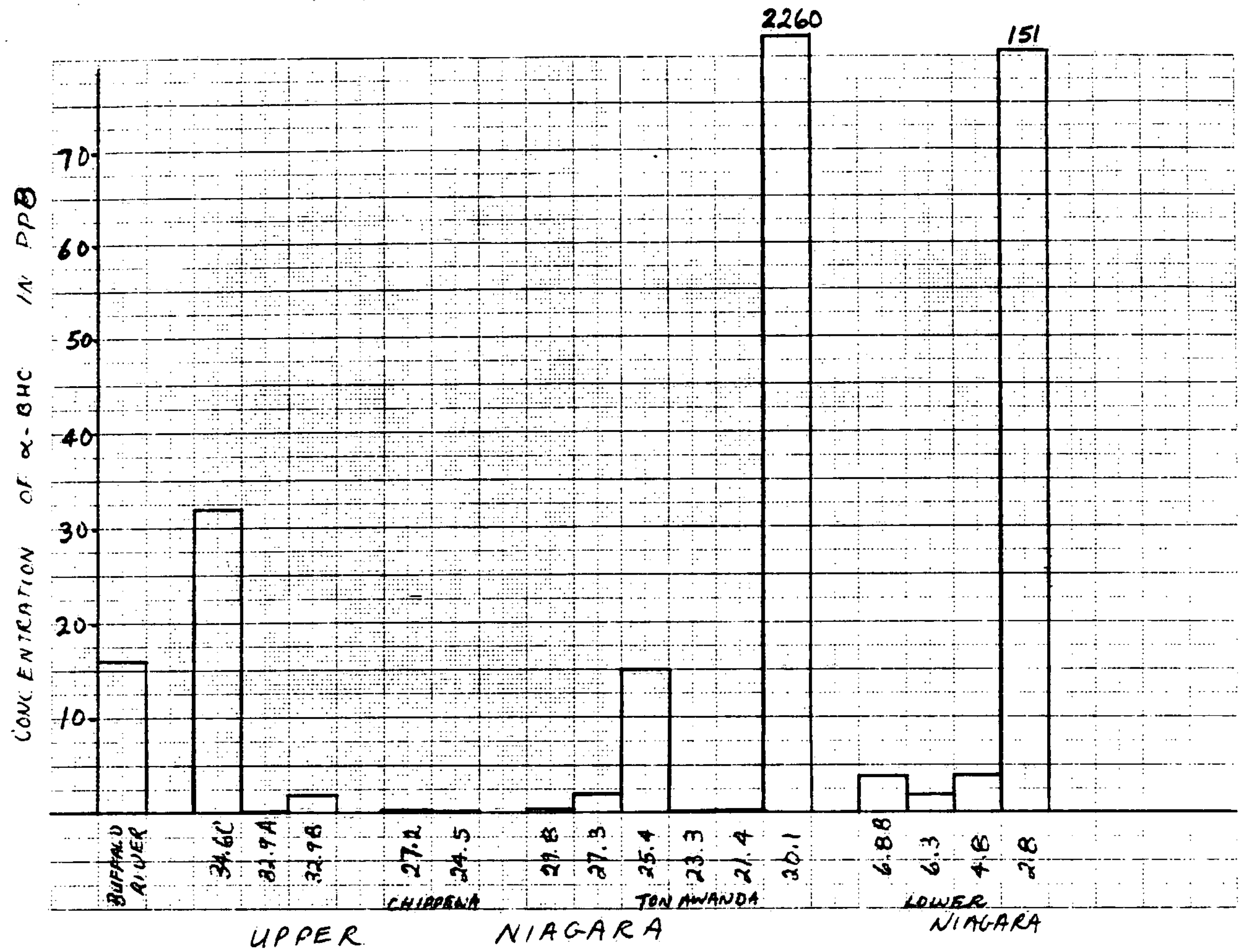
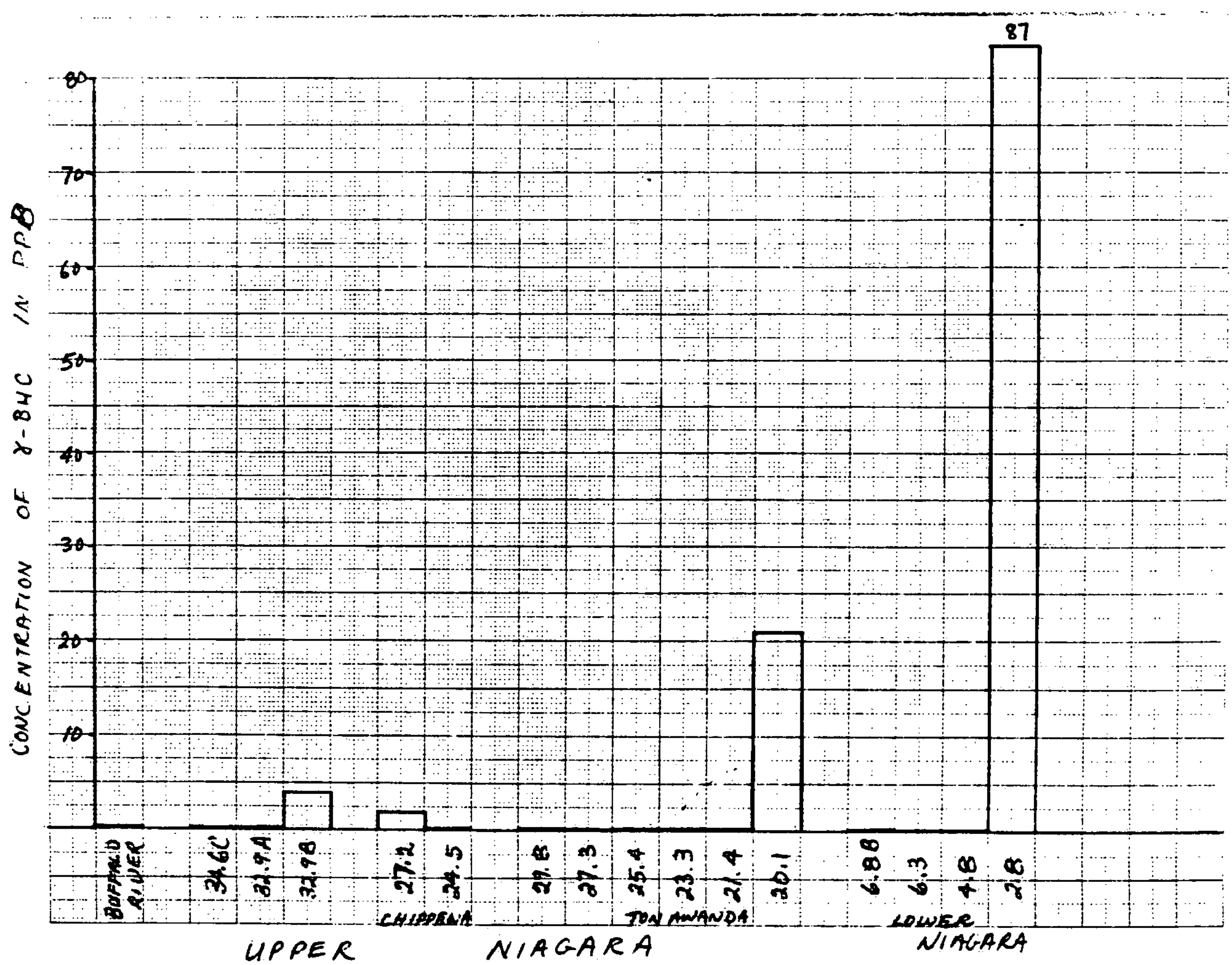

CONCENTRATION OF PART. N IN %
.30
.28
.26
.24
.22
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

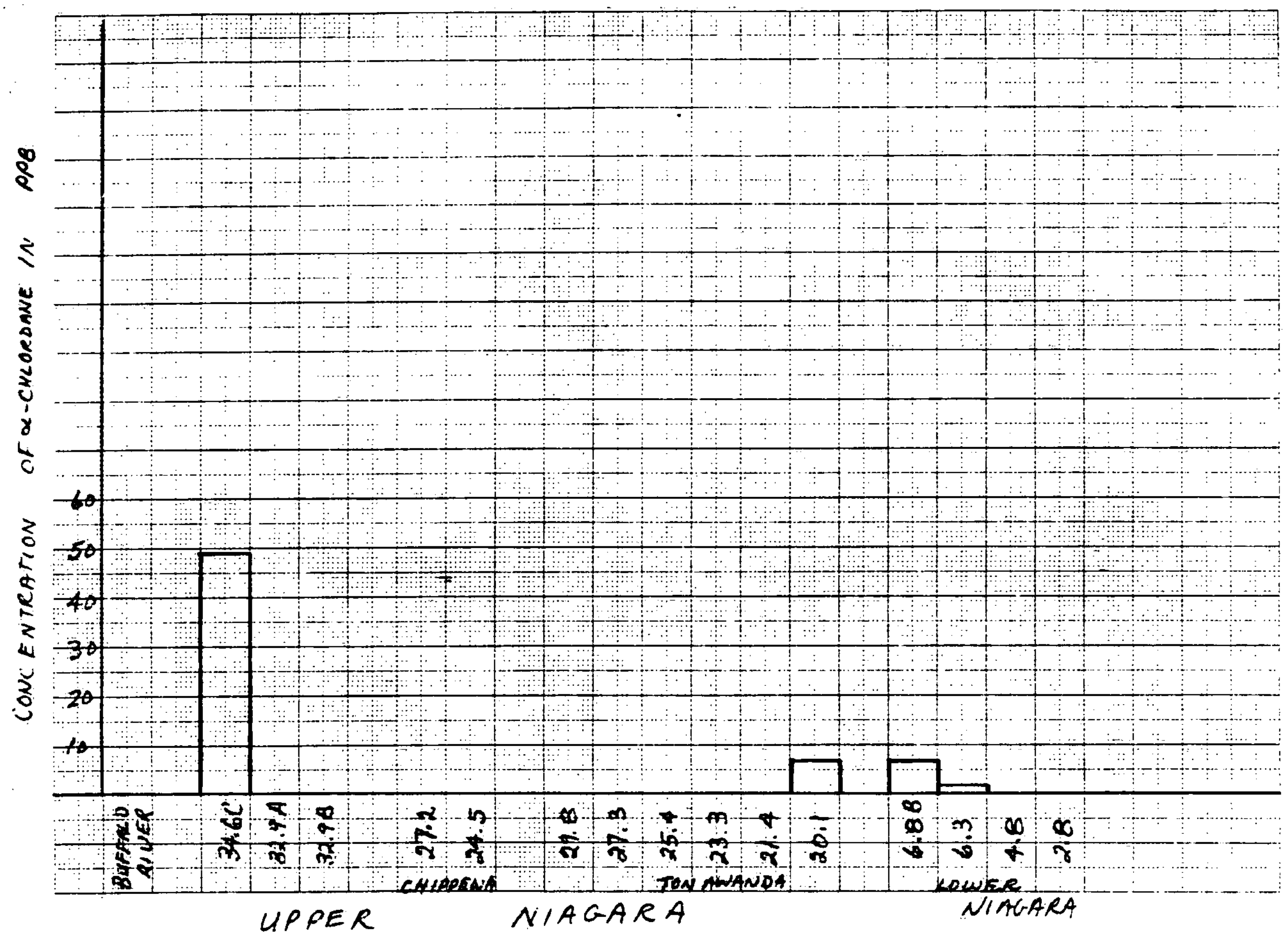
FIGURE 9

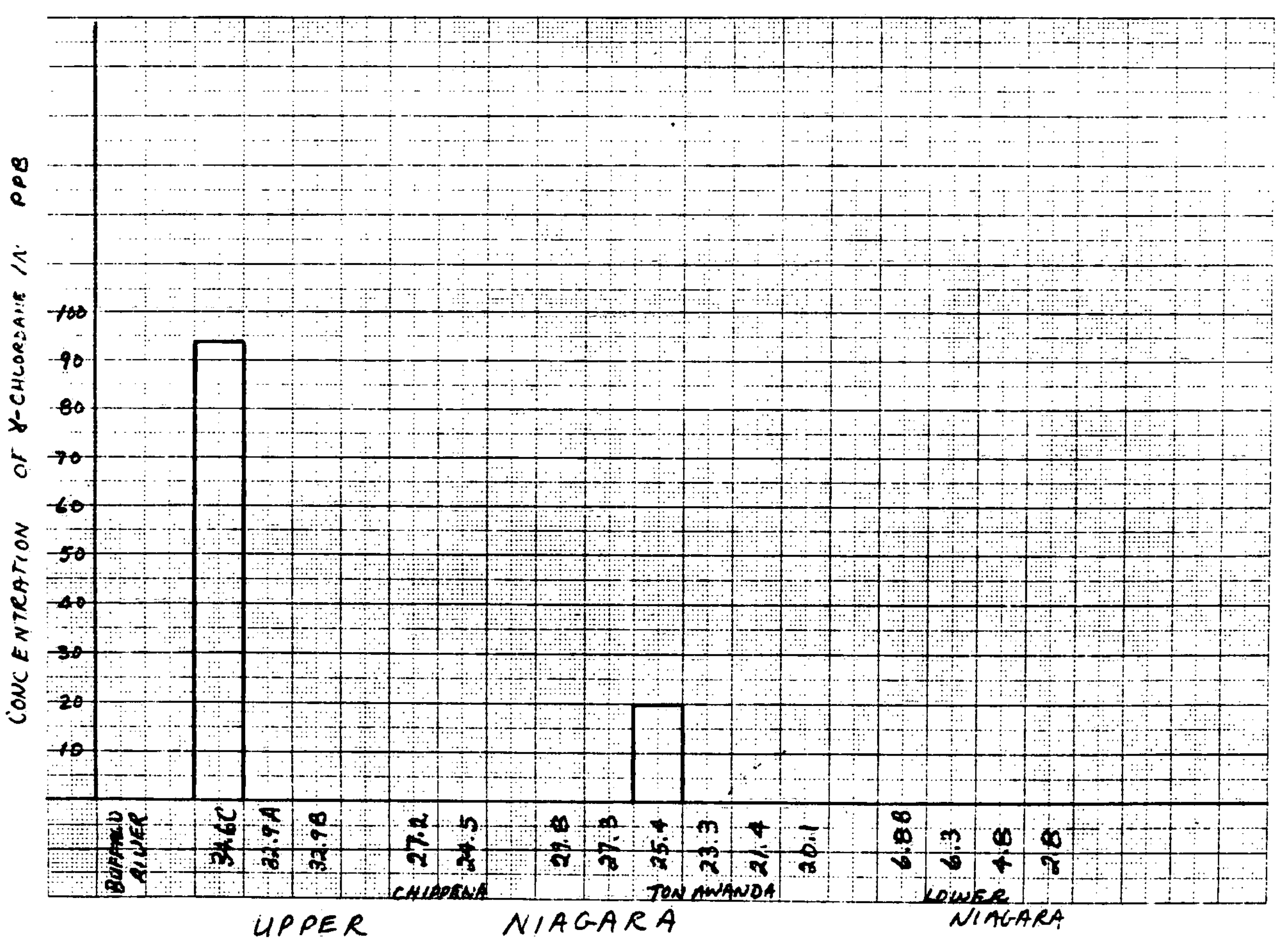

CONCENTRATION OF HCB IN PPB (PACKED COLUMN)
120
110
100
90
80
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

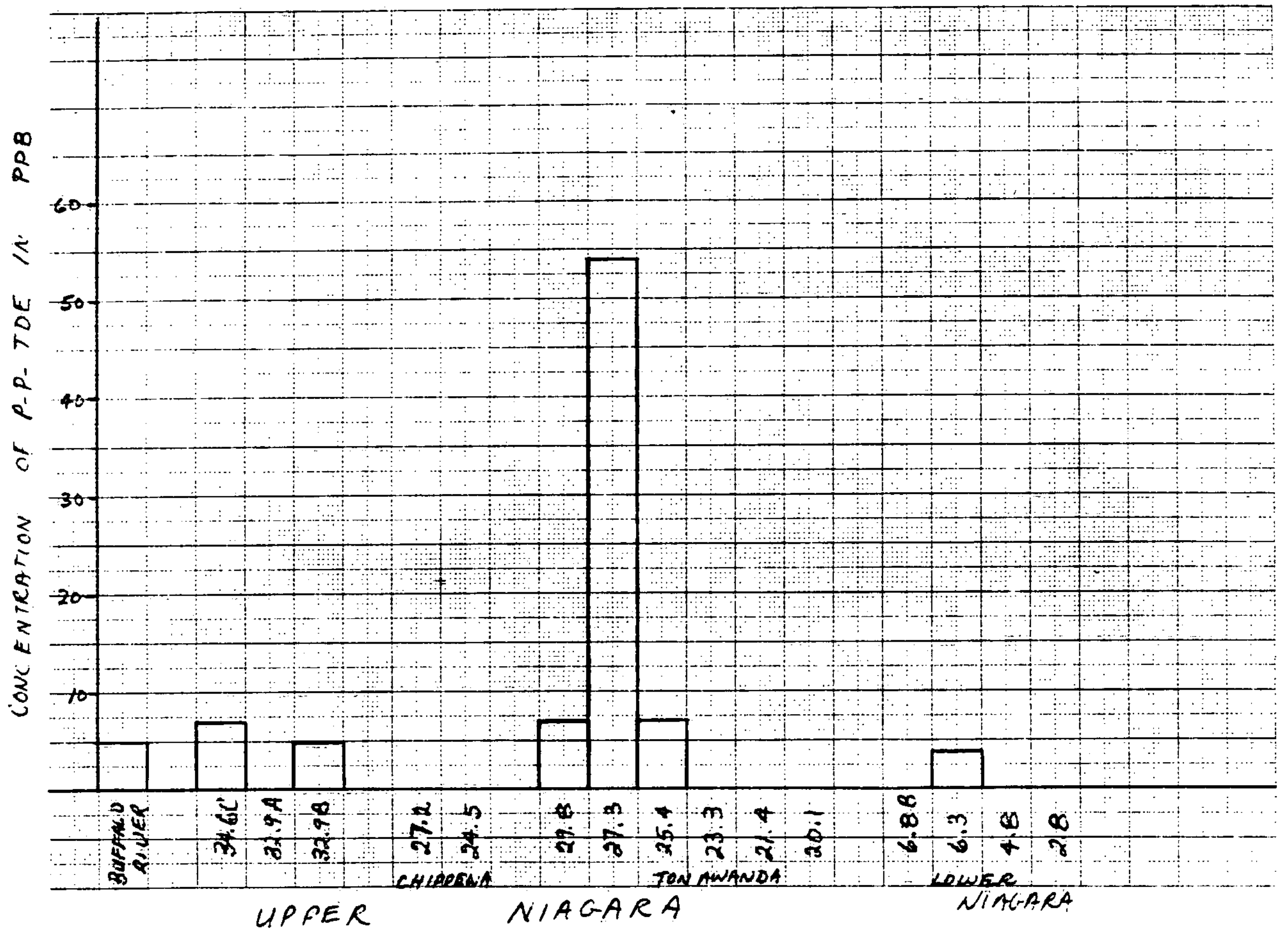

CONCENTRATION OF
IN
80
60
40
20
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

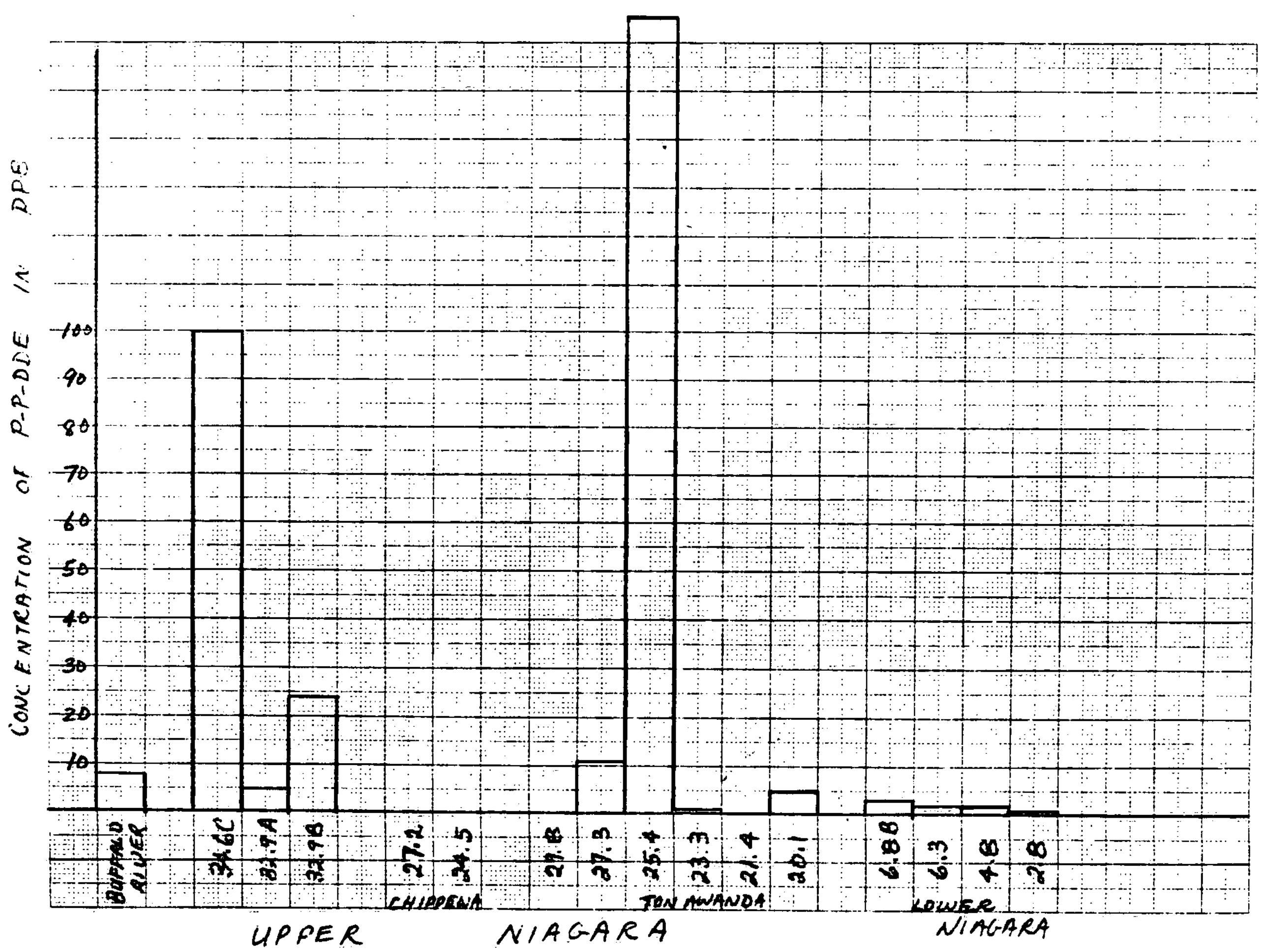

CONCENTRATION OF α-BHC IN PPB
2260
151
10
20
30
40
50
60
70
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

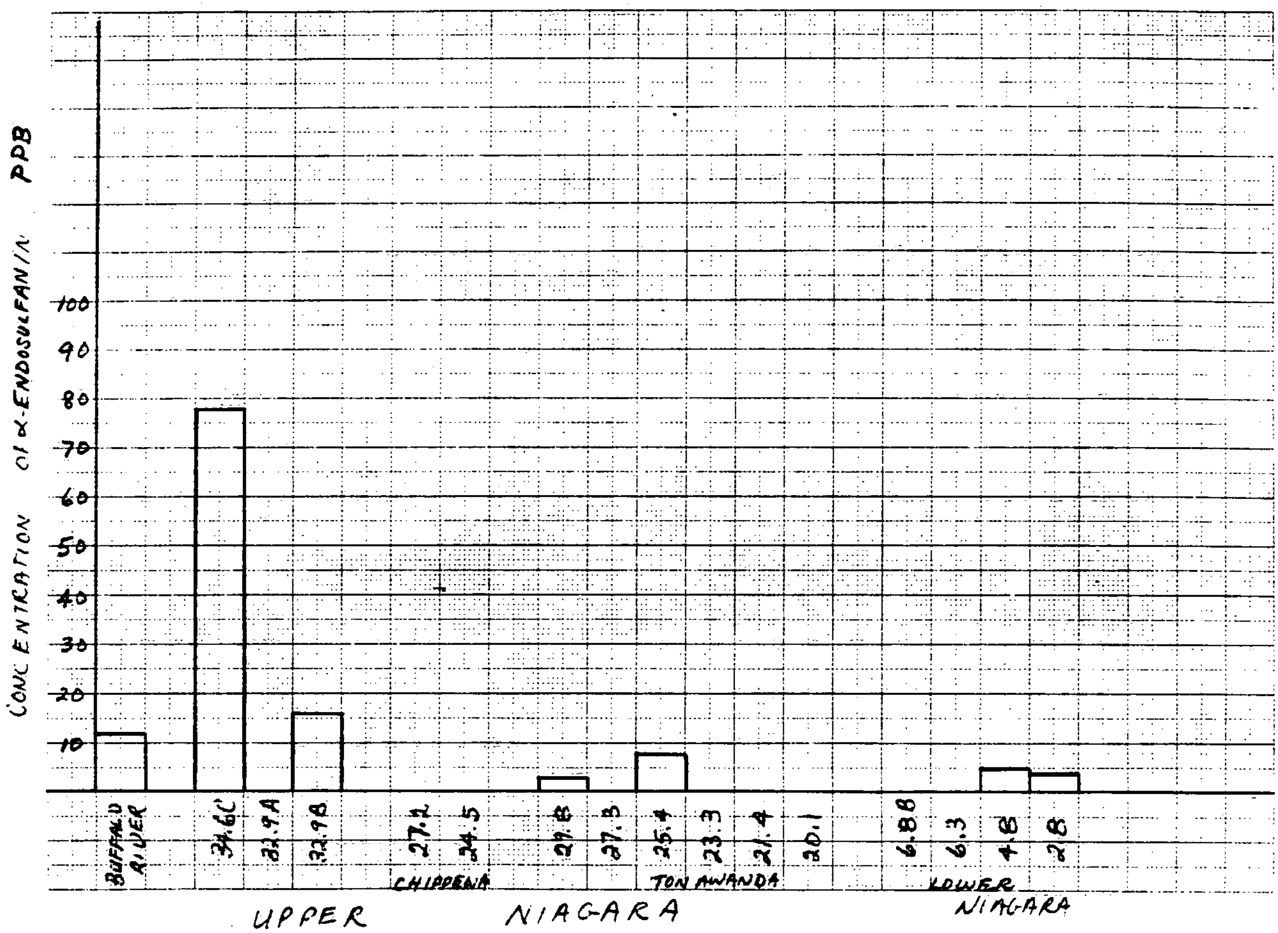

CONCENTRATION OF γ-BHC IN PPB
87
10
20
30
40
50
60
70
80
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.8B
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA


CONCENTRATION OF α-CHLORDANE IN PPB
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
21.8
37.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

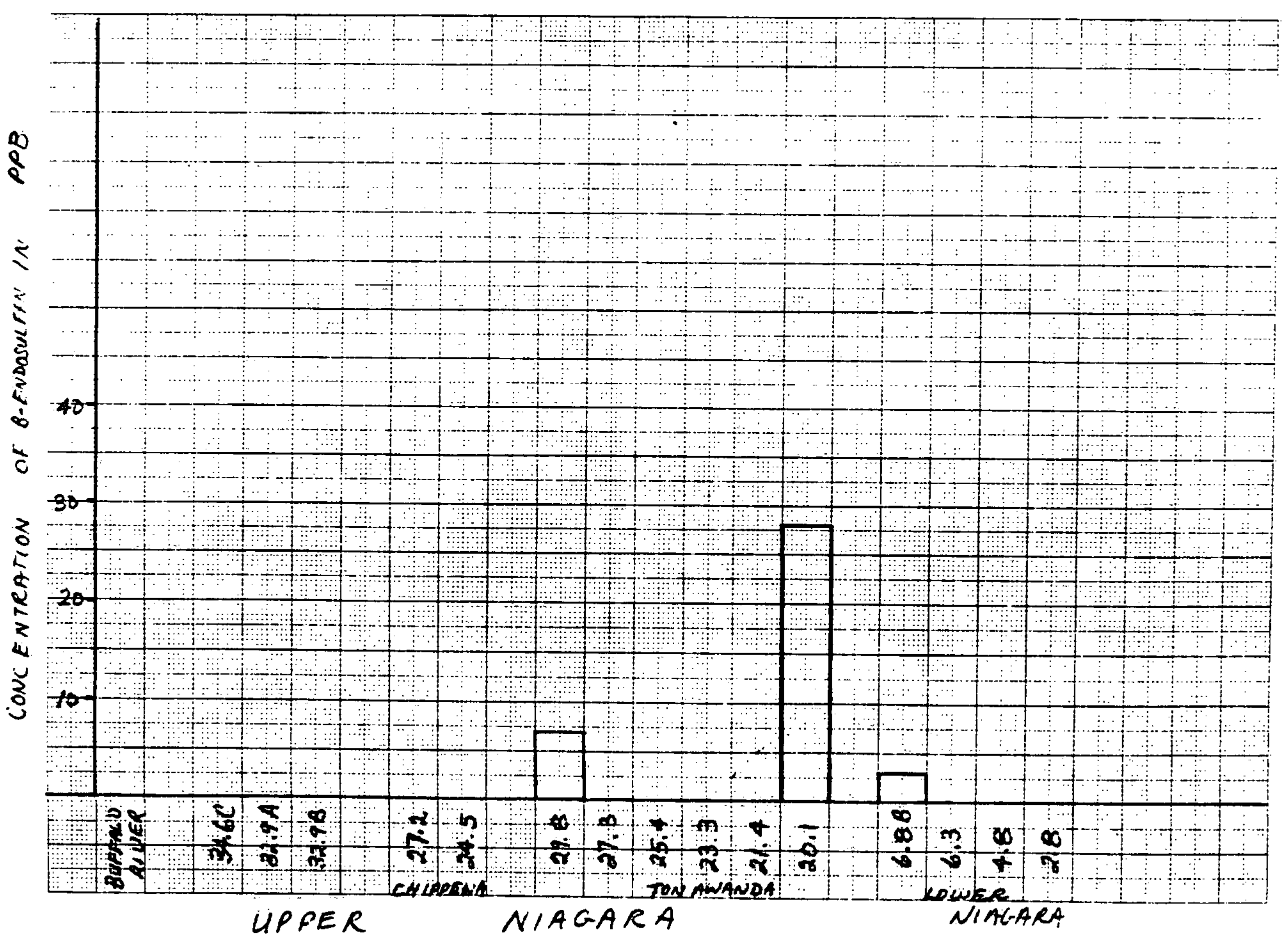

CONCENTRATION OF γ-CHLORDANE IN PPB
100
90
80
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
21.8
37.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


CONCENTRATION OF P-P- TDE IN PPB
60
50
40
30
20
10
BUFFALO RIVER
24.6C
23.9A
23.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

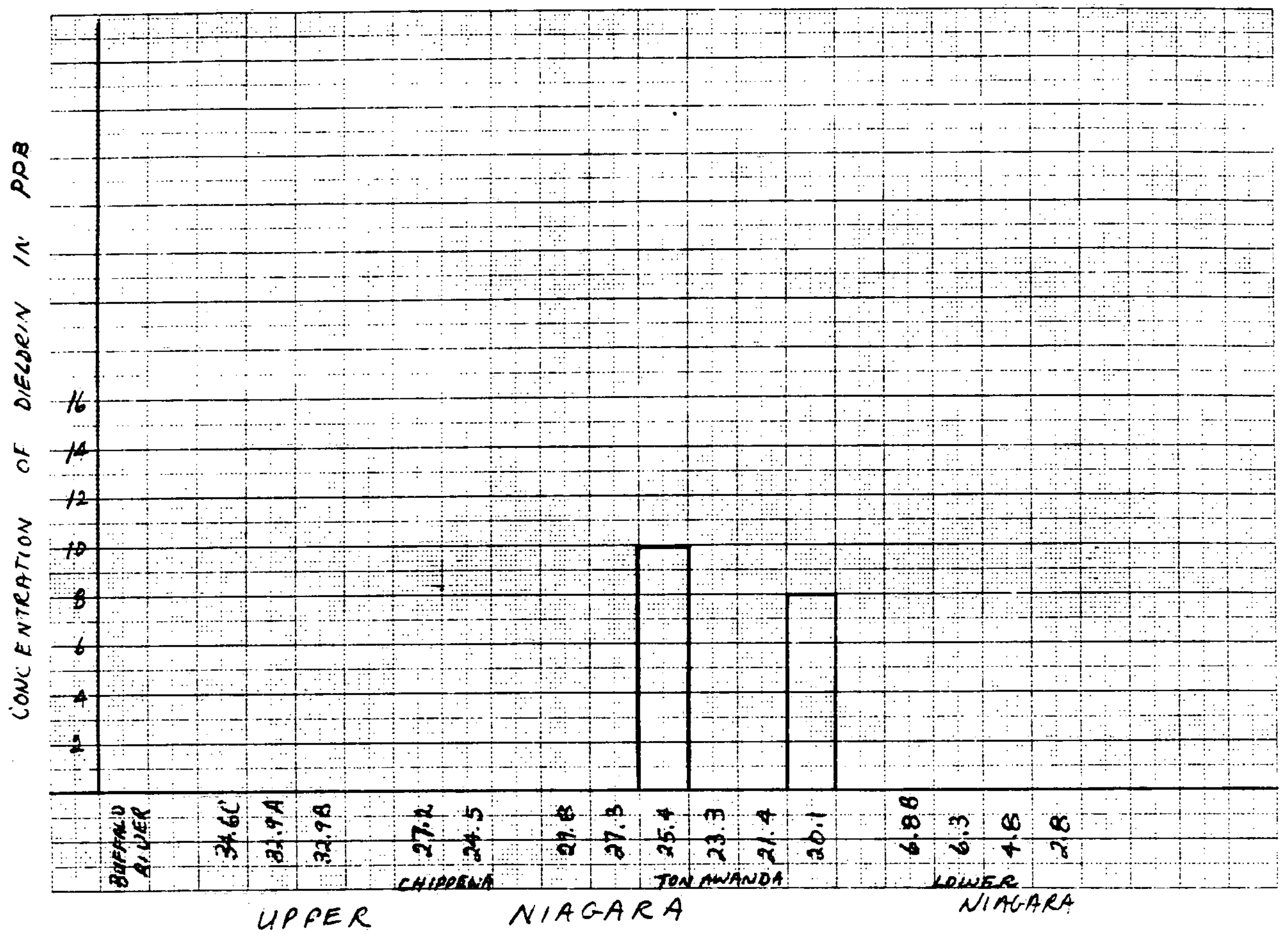

CONCENTRATION OF P-P-DDE IN PPB
100
90
80
70
60
50
40
30
20
10
BUFFALO RIVER
24.6C
23.9A
23.9B
27.2
24.5
CHIPPEWA
27.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA



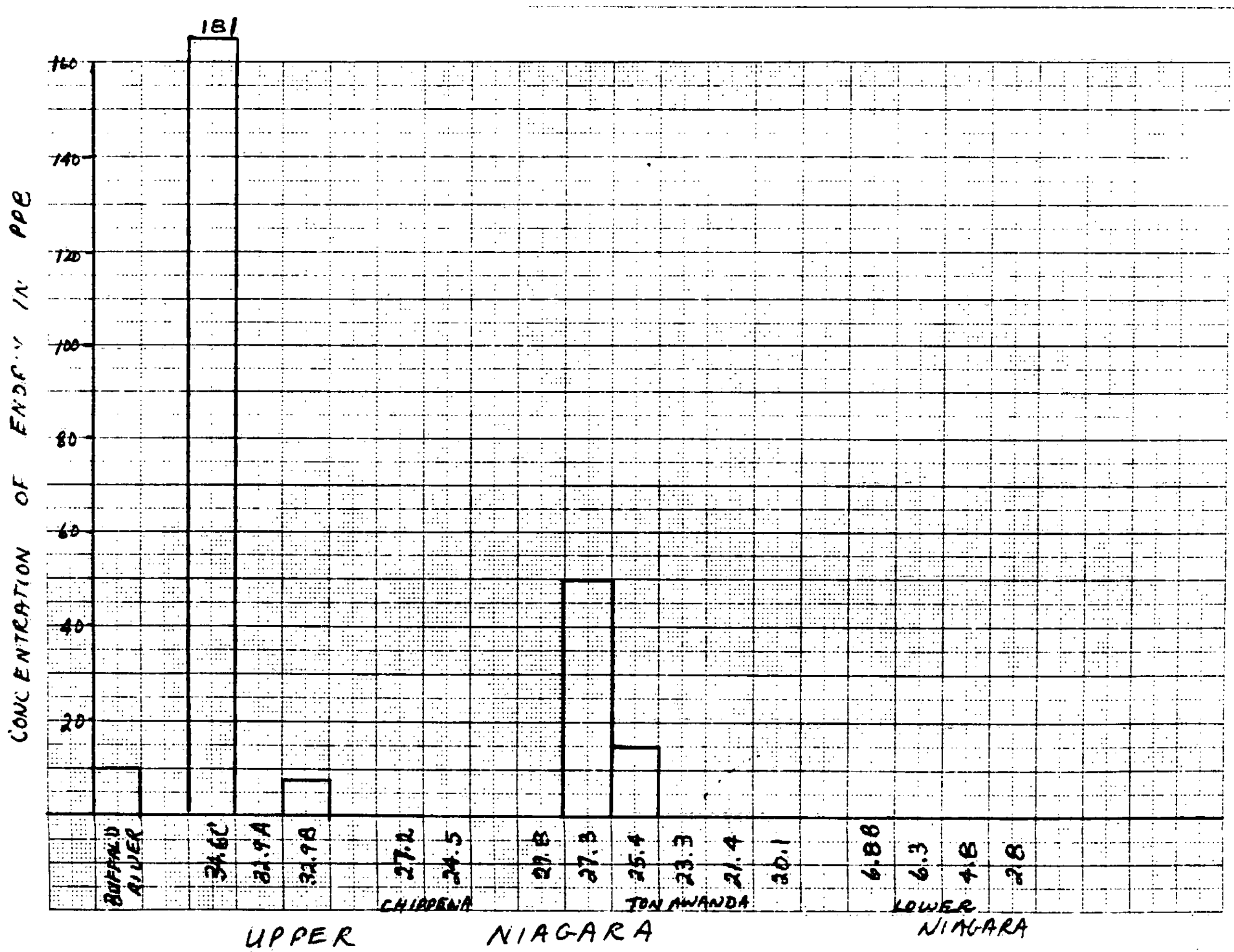
CONCENTRATION OF α-ENDOSULFAN IN PPB
100
90
80
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
22.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER
NIAGARA



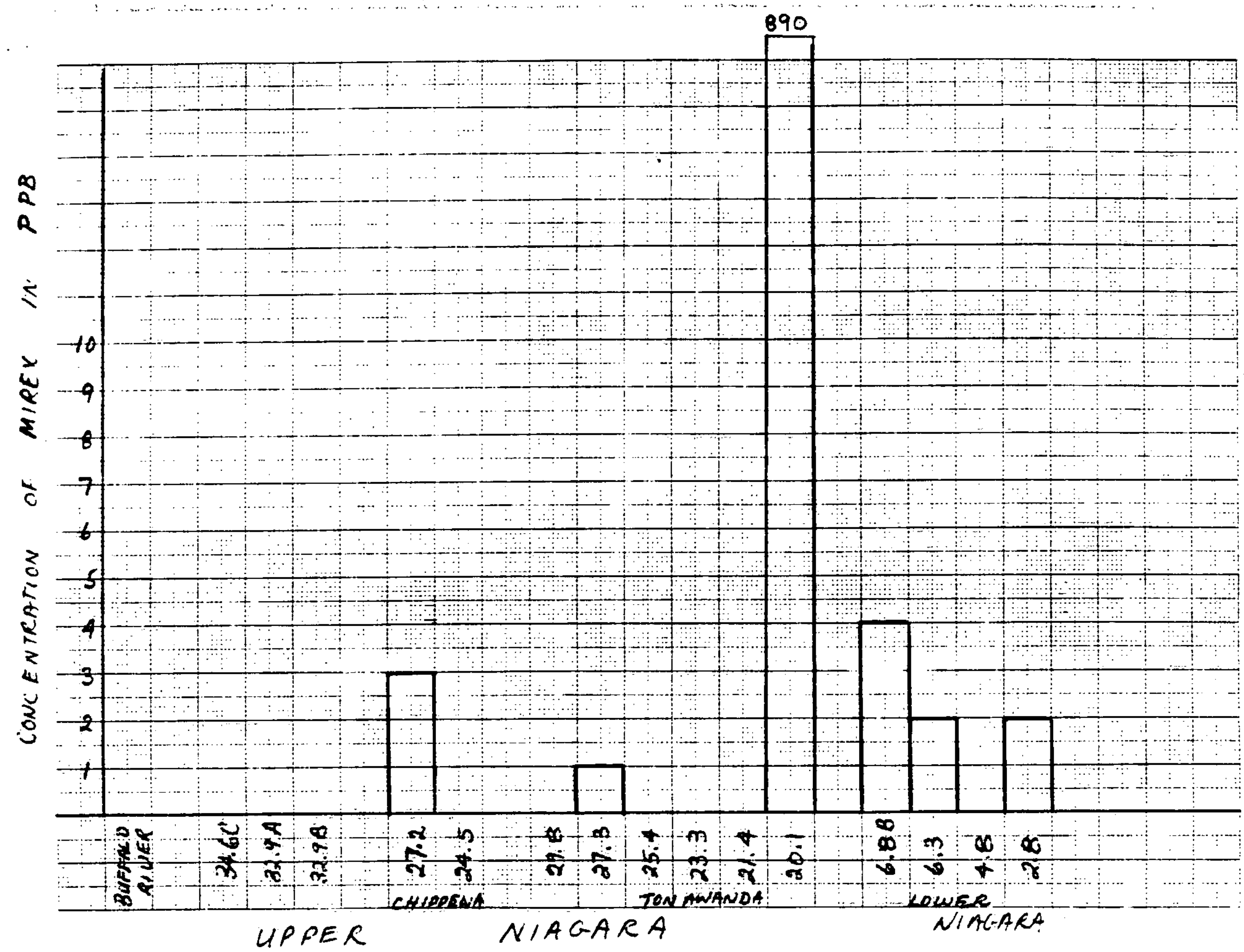
CONCENTRATION OF B-ENDOSULFAN IN PPB
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
22.8
27.3
25.4
23.3
21.4
20.1
TONAWANDA
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER
NIAGARA

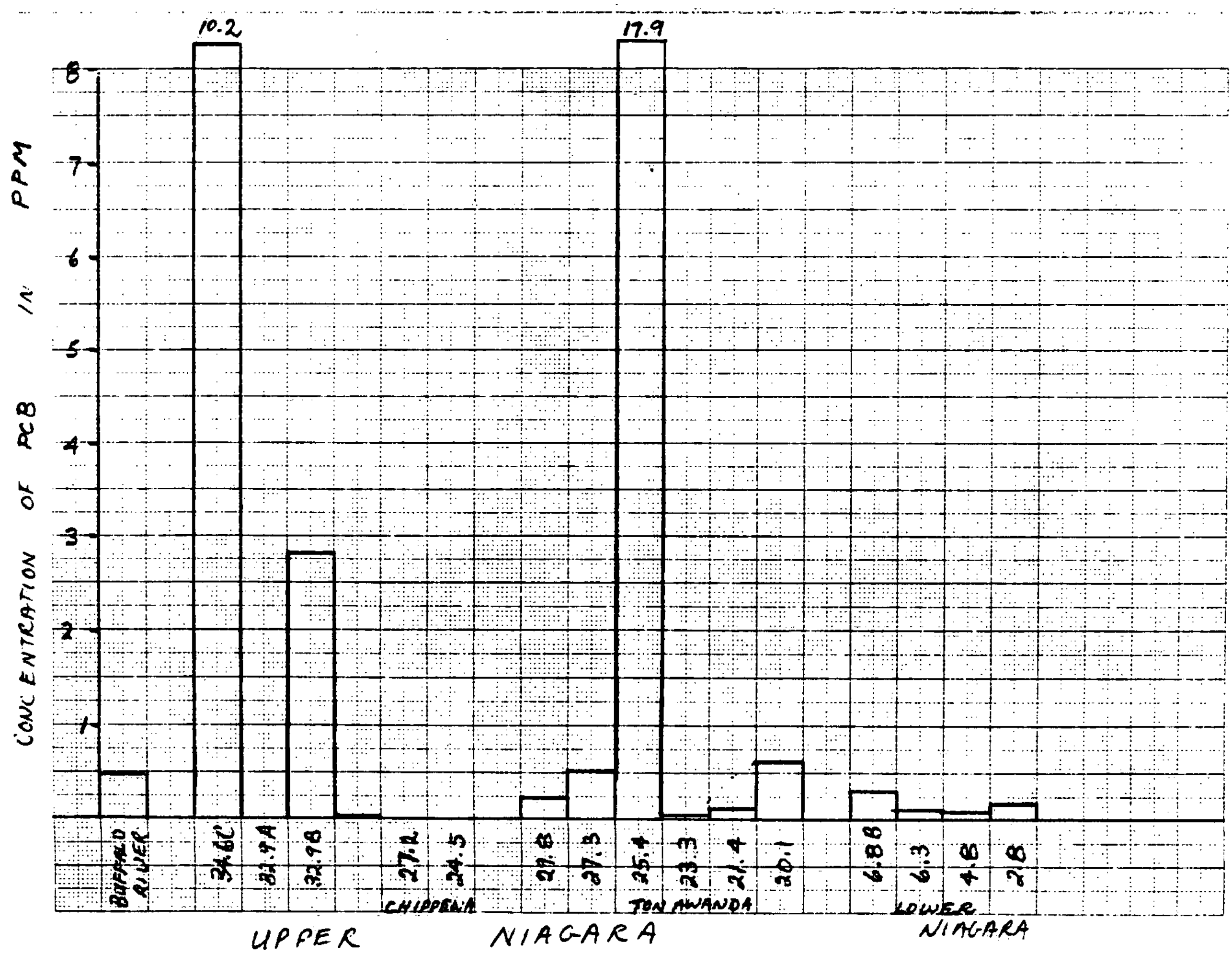


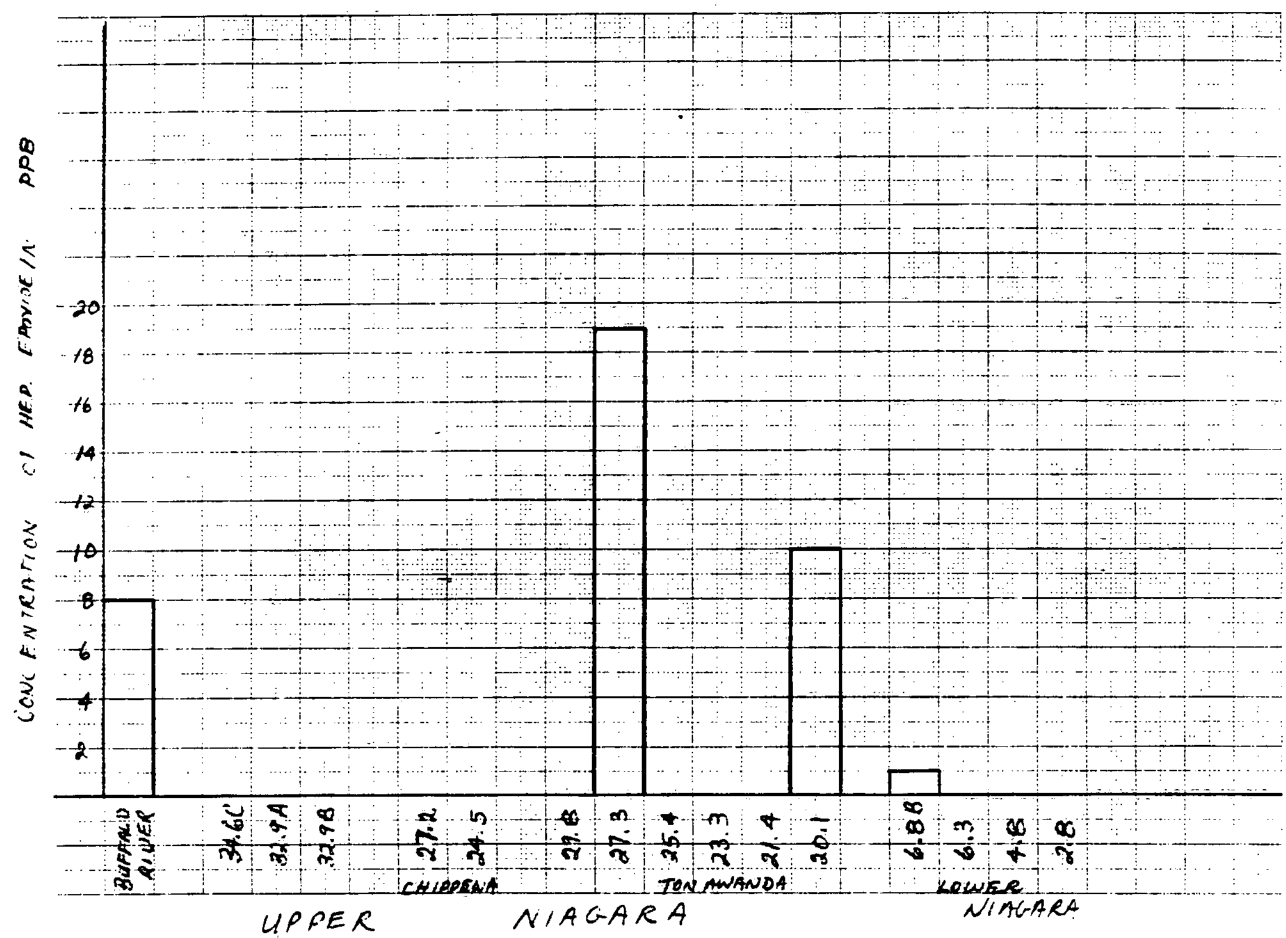
CONCENTRATION OF DIELDRIN IN PPB
2
4
6
8
10
12
14
16
BUFFALO RIVER
34.6C
31.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA



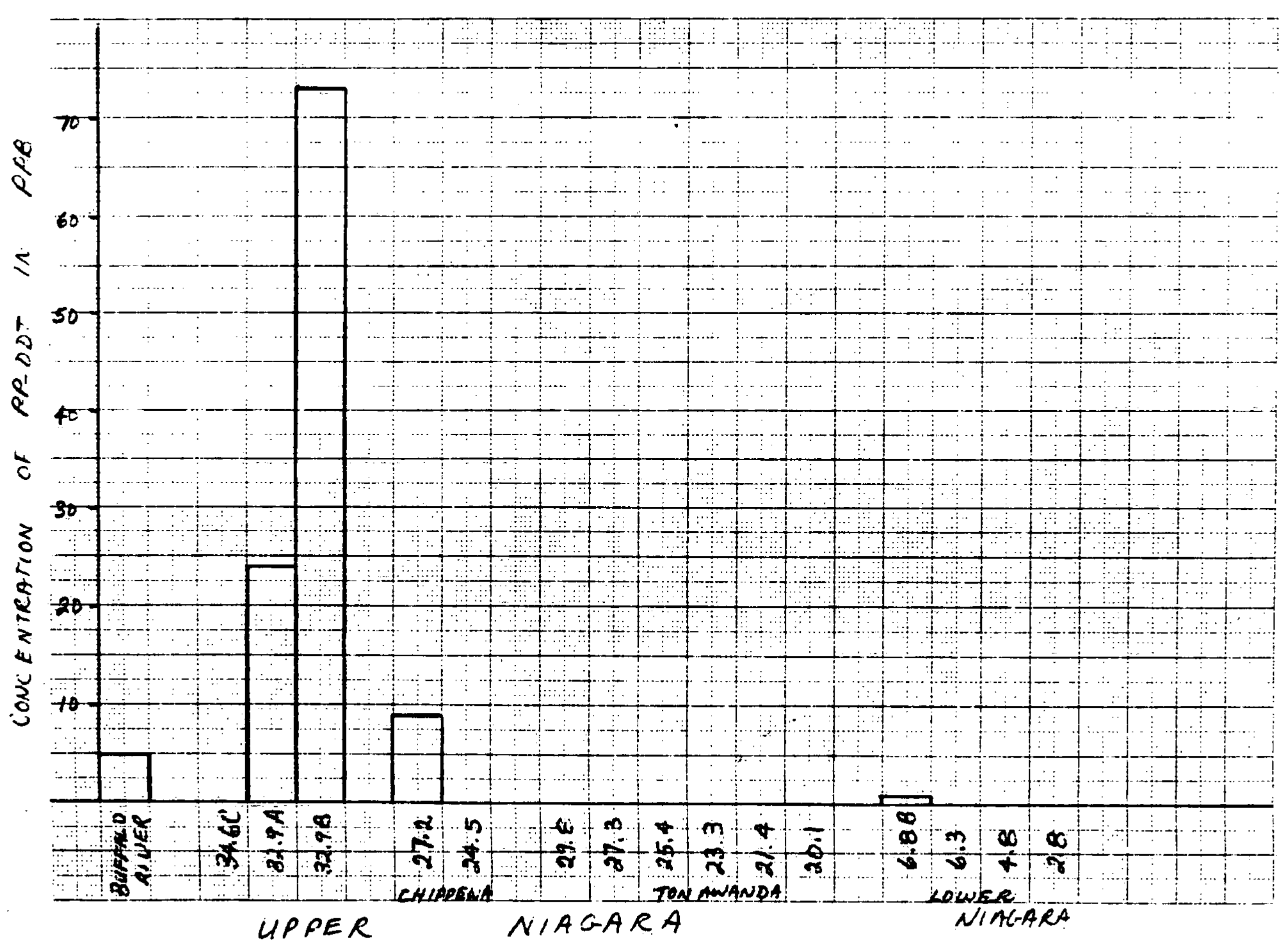
181
CONCENTRATION OF ENDR
IN PPB
20
40
60
80
100
120
140
160
BUFFALO RIVER
34.6C
31.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


890
CONCENTRATION OF MIREX IN PPB
10
9
8
7
6
5
4
3
2
1
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.8B
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

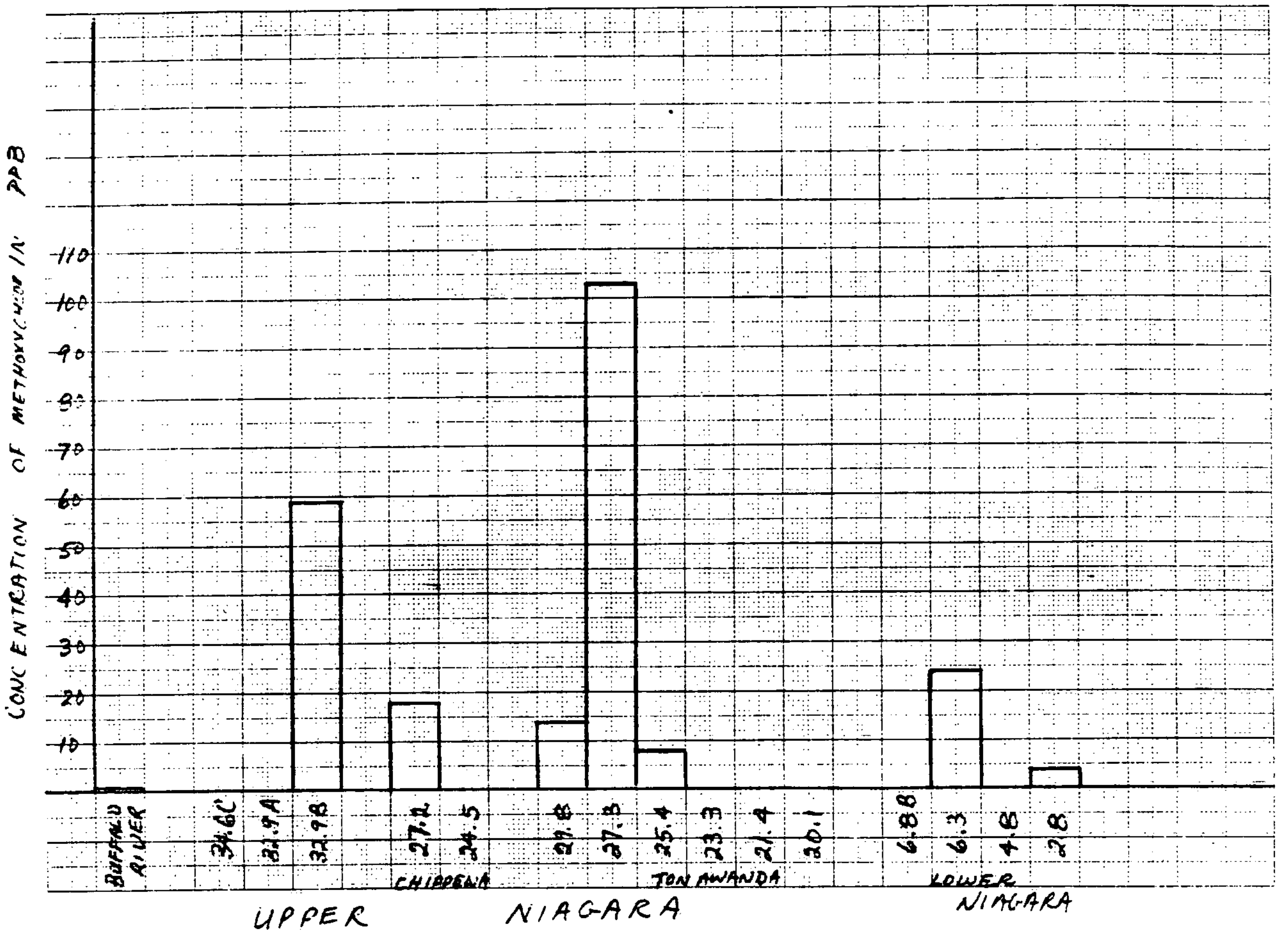

10.2
17.9
CONCENTRATION OF PCB IN PPM
8
7
6
5
4
3
2
1
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.8B
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

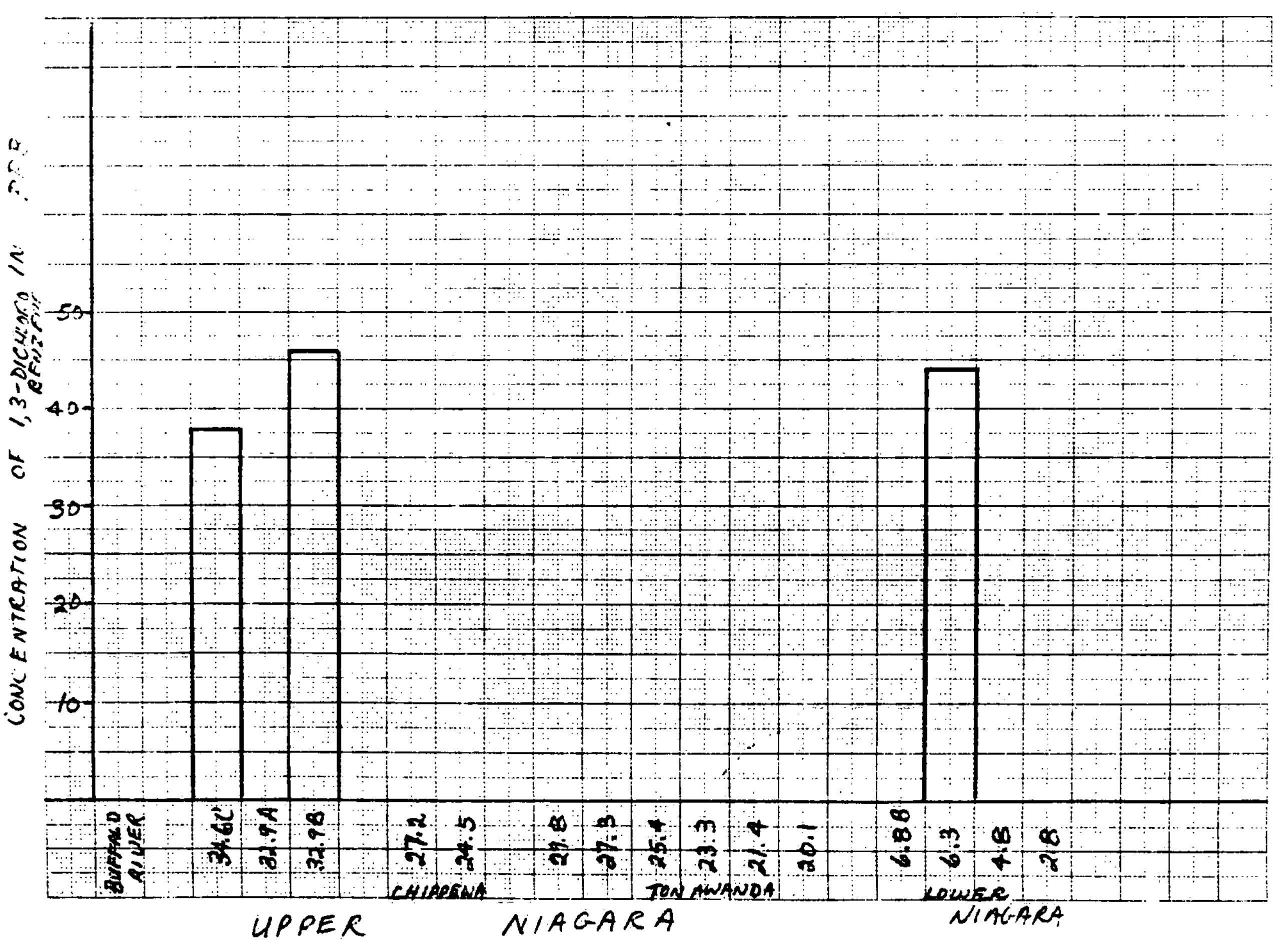


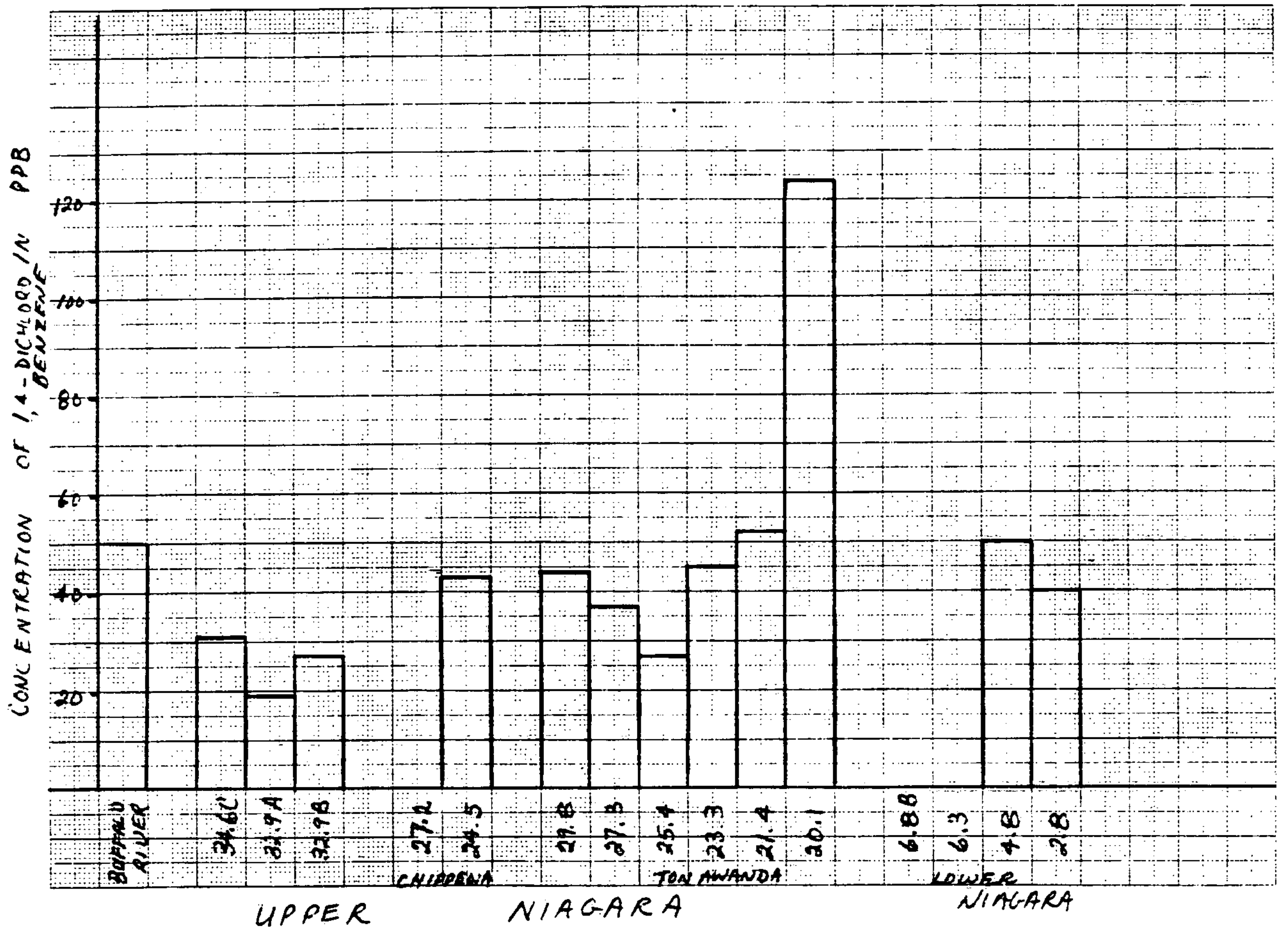
CONCENTRATION OF HEP. EPOXIDE IN PPB
20
18
16
14
12
10
8
6
4
2
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

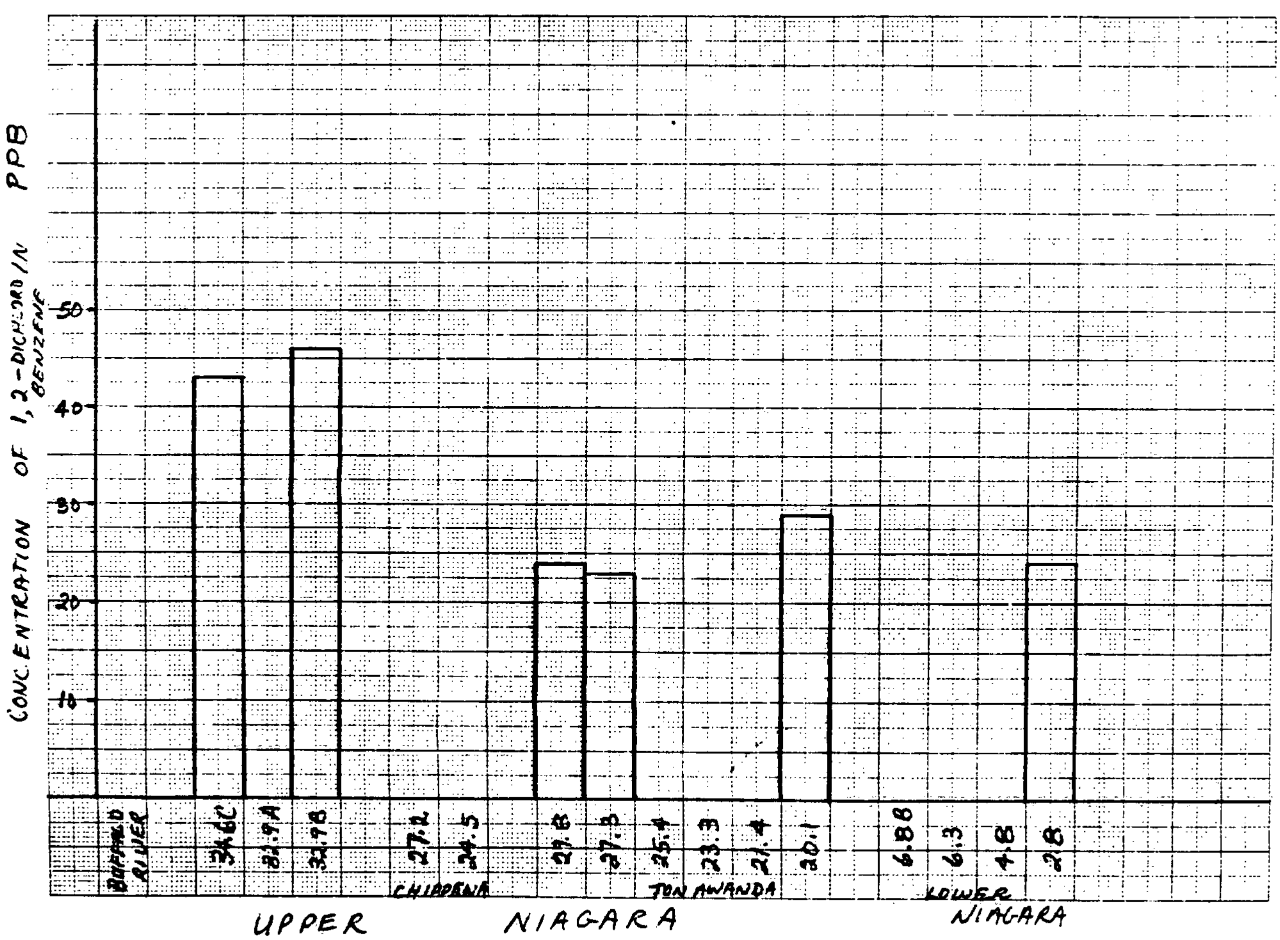


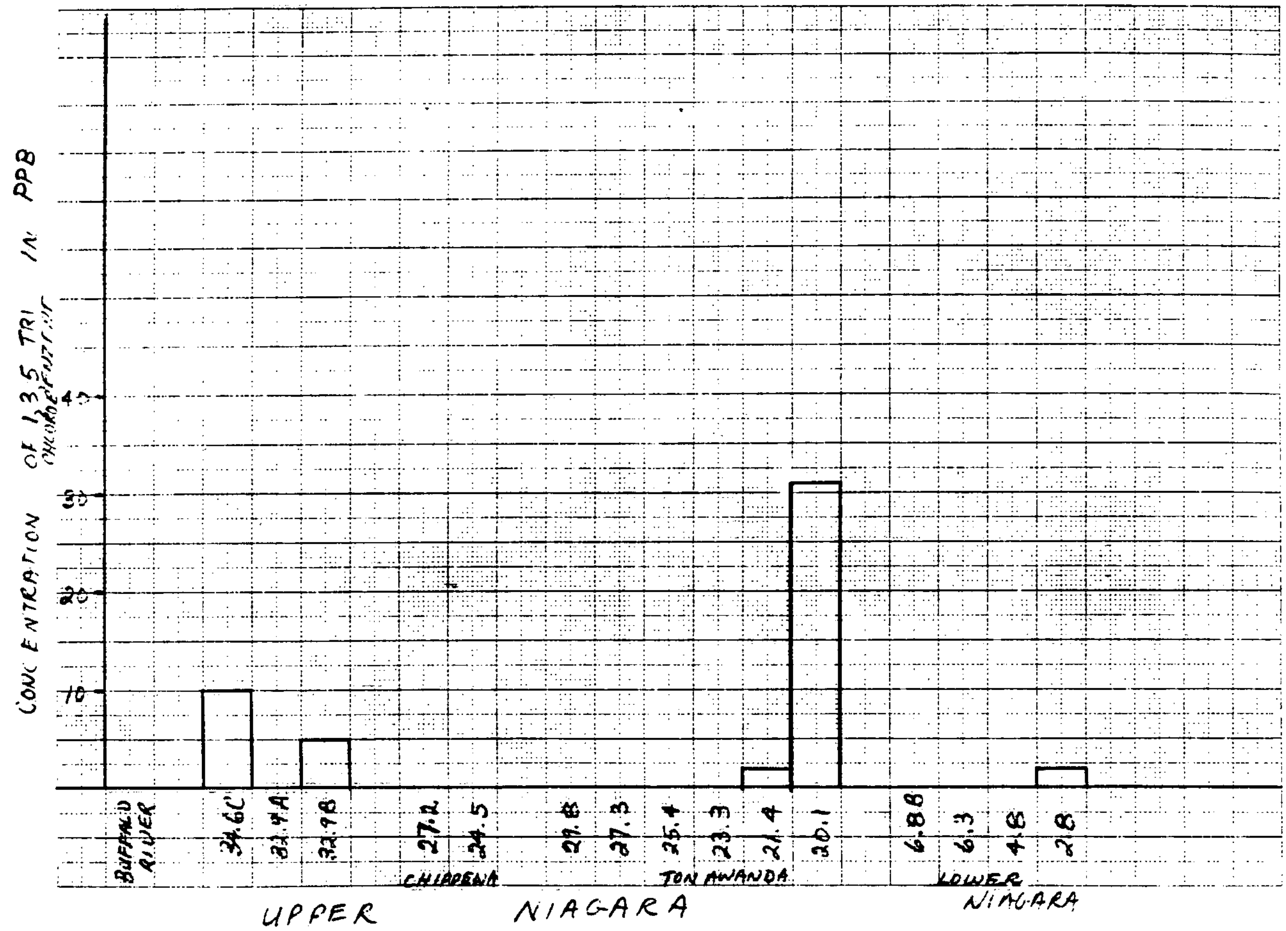
CONCENTRATION OF PP-DDT IN PPB
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

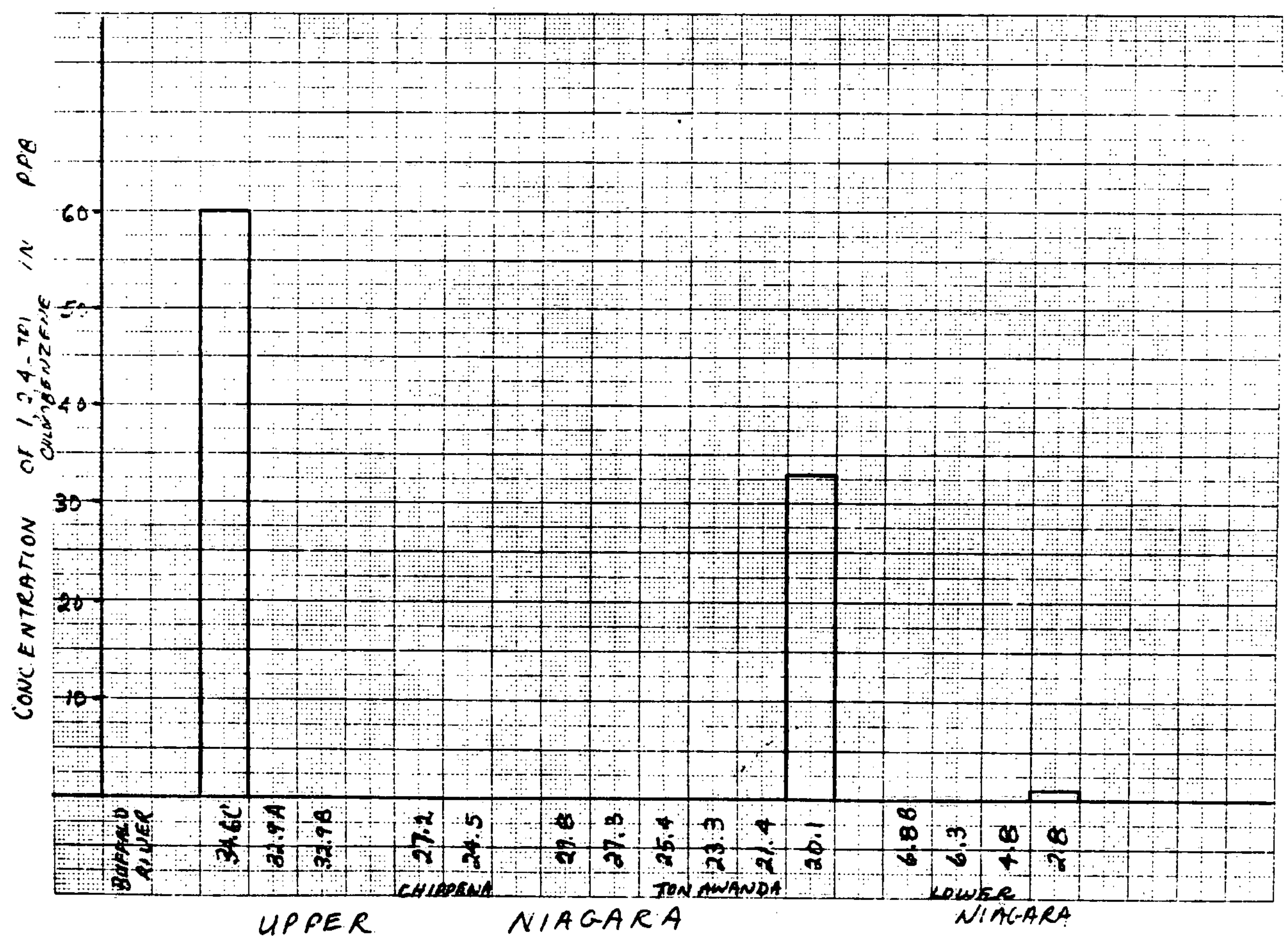

CONCENTRATION OF METHOXYCHLOR IN PPB
110
100
90
80
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

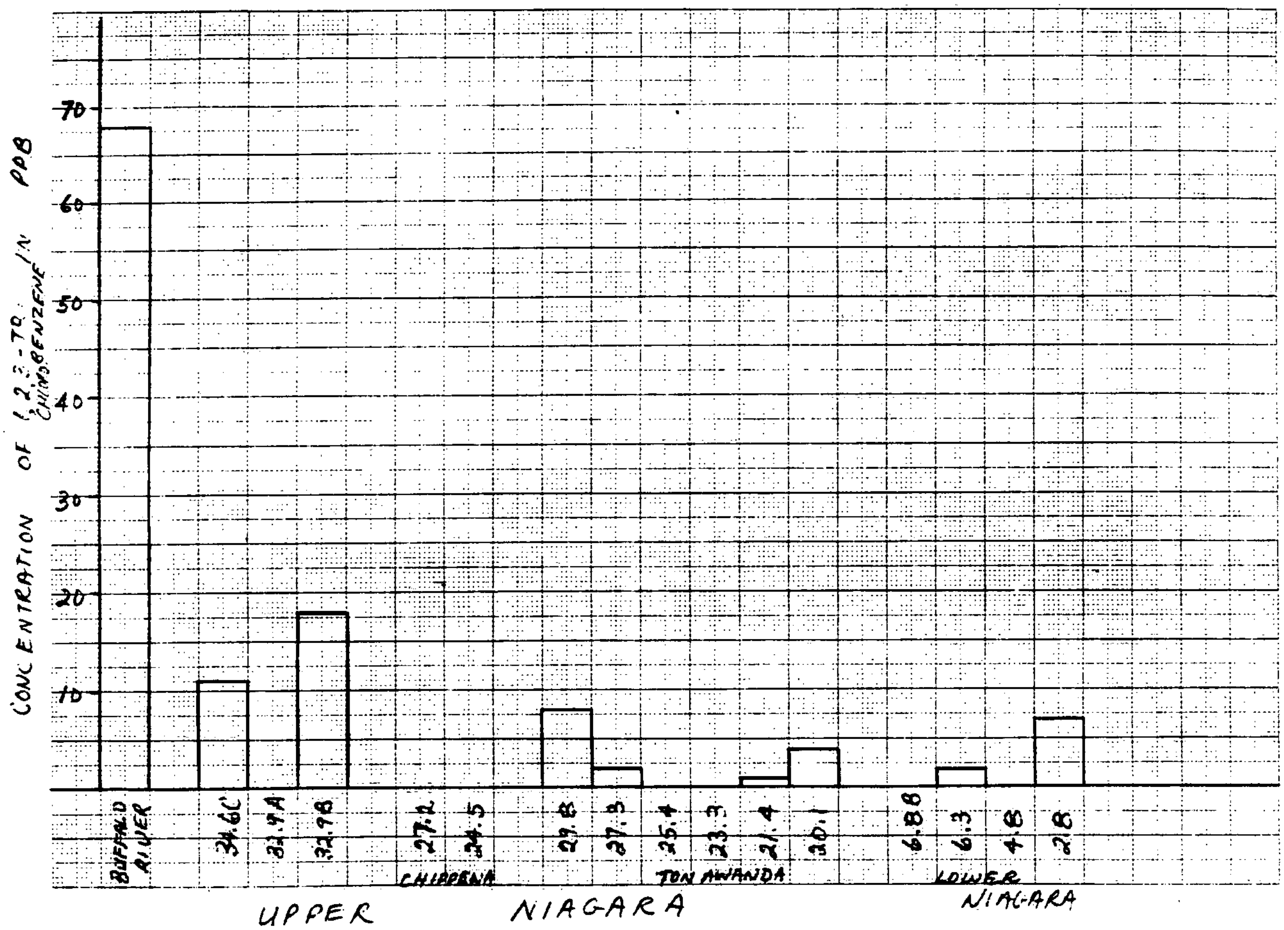

CONCENTRATION OF 1,3-DICHLORO IN PPB
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

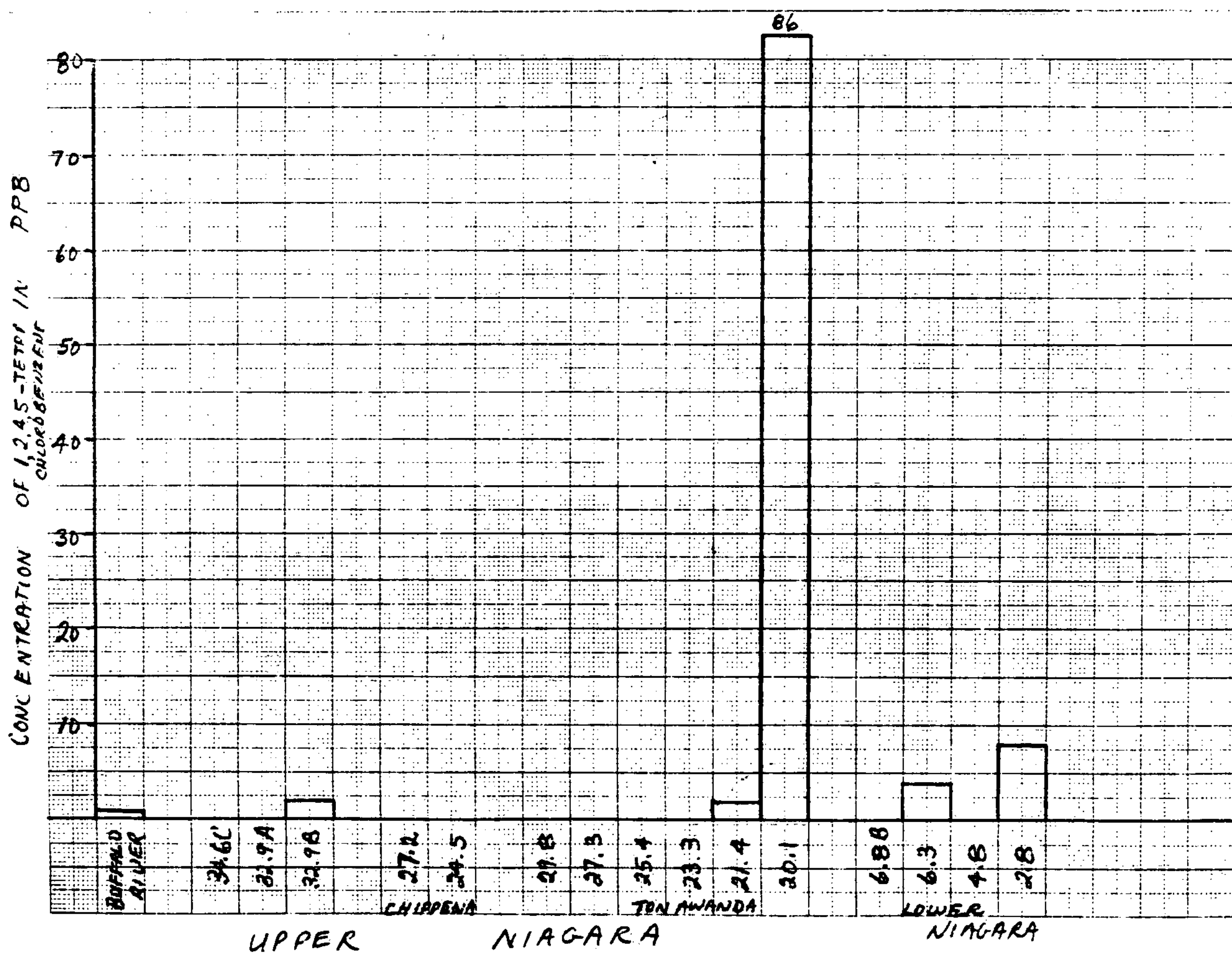

CONCENTRATION OF 1,4-DICHLORO/N BENZENE PPB
20
40
60
80
100
120
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

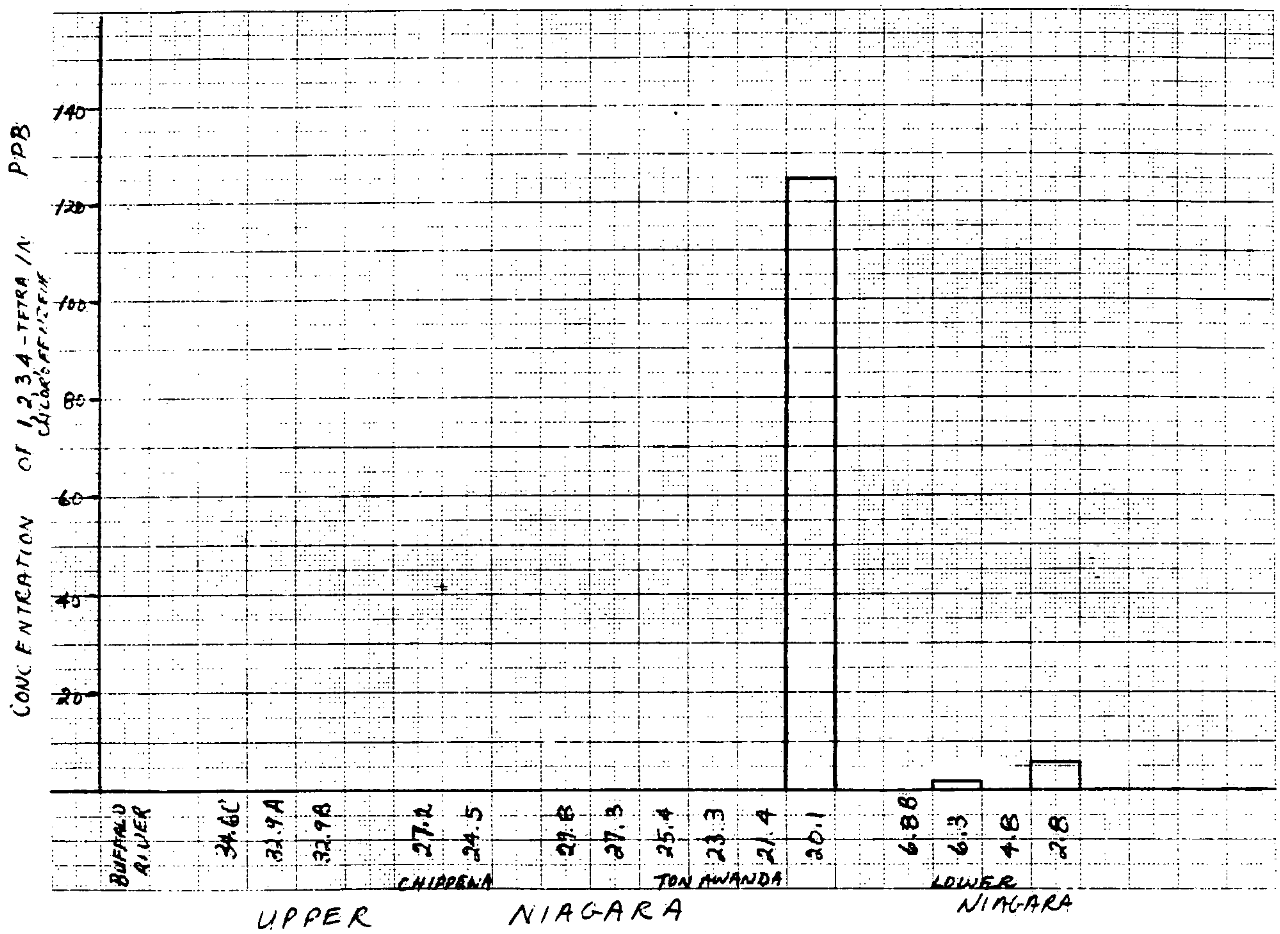

CONCENTRATION OF 1,2-DICHLORO/N BENZENE PPB
10
20
30
40
50
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
27.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA

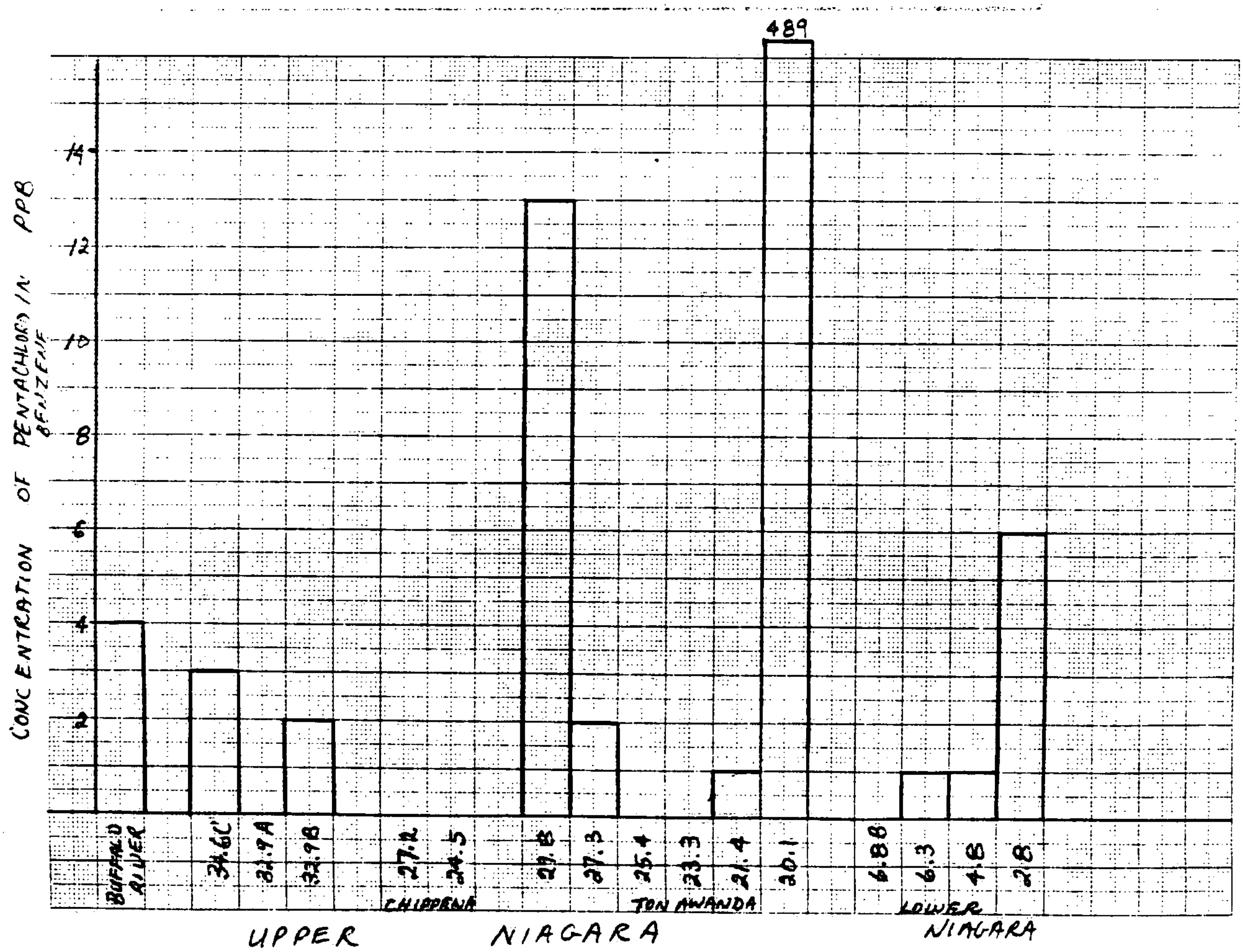

CONCENTRATION OF 1,3,5 TRI CHLOROBENZENE IN PPB
10
20
30
40
BUFFALO RIVER
34.6C
31.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


CONCENTRATION OF 1,2,4-TRI CHLOROBENZENE IN PPB
10
20
30
40
60
BUFFALO RIVER
34.6C
31.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


CONCENTRATION OF 1,2,3-TRICHLOROBENZENE IN PPB
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


86
CONCENTRATION OF 1,2,4,5-TETRACHLOROBENZENE IN PPB
80
70
60
50
40
30
20
10
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
29.8
27.3
25.4
23.3
21.4
20.1
6.88
6.3
4.8
2.8
CHIPPEWA
TONAWANDA
LOWER NIAGARA
UPPER NIAGARA


CONCENTRATION OF 1,2,3,4-TETRA CHLOROBENZENE IN PPB
140
120
100
80
60
40
20
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
TONAWANDA
20.1
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA


489
CONCENTRATION OF PENTACHLOROBENZENE IN PPB
14
12
10
8
6
4
2
BUFFALO RIVER
34.6C
32.9A
32.9B
27.2
24.5
CHIPPEWA
29.8
27.3
25.4
23.3
21.4
TONAWANDA
20.1
6.88
6.3
4.8
2.8
LOWER NIAGARA
UPPER NIAGARA

9237