US Army Corps of Engineers
Buffalo District

CLEVELAND HARBOR, CUYAHOGA COUNTY, OHIO

EVALUATION OF FEDERAL NAVIGATION CHANNEL SEDIMENTS WITH RESPECT TO THEIR SUITABILITY FOR OPEN-LAKE PLACEMENT

I. Introduction

This preliminary Tiered Evaluation on Cleveland Harbor Federal navigation channel sediments has been performed in accordance with guidelines contained in the 1998 U.S. Environmental Protection Agency (USEPA)/U.S. Army Corps of Engineers (USACE) Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998). It is based on 2007 data on the Federal navigation channel sediments (Engineering and Environment, Inc. [EEI] 2007).

II. Sediment Quality Assessment

Background and Potential Sources of Sediment Contamination

Traditional chemical contaminants in Cleveland Harbor Federal navigation channel sediments include heavy metals, nutrients, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides. Cleveland Harbor is located within the Cuyahoga River Area of Concern (AOC), which includes the lower 45 miles of the river between the Ohio Edison Dam and mouth, and approximately 10 miles of Lake Erie shoreline, between Edgewater Park eastward to Wildwood Park (http://www.epa.gov/glnpo/aoc/cuyahoga.html). Major sources of contamination to bottom sediments in the harbor's Cuyahoga River, Old River and Outer Harbor Channels include (1) point source municipal and industrial wastewater discharges; (2) bank erosion; (3) commercial/recreational development; (4) atmospheric deposition; (5) leachate from hazardous waste disposal sites; (6) urban storm water runoff; (7) combined sewer overflows (CSOs); and (8) wastewater treatment plant bypasses.

Evaluation Based on Existing Sediment Data

In 2007, 30 surface grab samples were collected from the River Channel (Sites CH-1 through CH-19), Old River Channel (Sites CH-20 through CH-22) and Outer

Harbor Channels (Sites CH-23 through CH-30) (Figure 1). The reach of River Channel, referred to as the "Upper End" located at the upstream limit between approximate Stations 799+92 and 788, was sampled more rigorously relative to other areas of the harbor, and was represented by Sites CH-1 through CH-5. In addition, four surface grab sediment samples were collected from the open-lake reference area in Lake Erie (Sites CL-1 through CL-4) (Figure 2). All sediment samples were subjected to bulk particle size analyses, and analyzed for the following: Inorganics—heavy metals, total cyanide, ammonia and total organic carbon (TOC); and organics—PAHs, PCBs and pesticides (EEI 2007). A modified elutriate test (MET) for the same inorganic and organic contaminants was performed on five composited sediment samples used to represent management units (MUs) within the Federal navigation channels: CH-UEMU (CH-1 through CH-5); CH-URMU (CH-6 through CH-11); CH-LRMU (CH-12 through CH-19); CH-ORMU (CH-20 through CH-22); and CH-OHMU (CH-23 through CH-30). In addition, two solid phase acute toxicity tests (bioassays) were applied to the Cuyahoga River Upper End MU sediments (EEI 2007) to verify that the material dredged from this reach, which is traditionally comprised of an appreciable fraction of coarse-grain sediment, does not meet Federal guidelines for open-lake (and/or nearshore) placement.

Based on the 2007 data, our toxicological assessment of these sediments is summarized as follows:

a. Bulk sediment analyses.

1. **Physical testing:** Table 1 presents the results of the sieve analyses performed on the sediment samples. The River Channel material was comprised of between 35.7% (Site CH-1) and 98.3 % (Site CH-13) silts and clays, with the remainder sands. The Upper End material within the River Channel was comprised of between 49.8% (Site CH-4) and 64.3% (Site CH-1) sands, with the remainder silts and clays. The Old River Channel material was composed of between 39.8% (Site CH-22) and 63.4% (Site CH-21) sands, with the remainder silts and clays. With respect to the Outer Harbor Channel material, it was comprised of between 90.9% (Site CH-30) and 99.1% (Site CH-27) silts and clays, with the remainder sands. Sediments at the open-lake reference area were comprised predominantly of silts and clays (98.3% [Site CL-4] to 98.9% [Site CL-2]), with a very small fraction of sands.

2. **Chemical testing:** The open-lake reference area was (Figure 2) was used to represent the Lake Erie environs. As such, contaminant concentrations in the Federal navigation channel sediment samples were compared to these areas to determine if they significantly exceeded lake sediment concentrations.

(a) *Inorganic analyses*—Table 2 presents the results of inorganic analyses on the sediment samples.

(1) Heavy metals—Relative to open-lake reference area levels, heavy metal concentrations in the Federal navigation channel sediments were generally comparable. Some sediment samples within the Federal navigation channel showed significantly elevated heavy metals concentrations in comparison when compared to those at the open-lake reference area. Arsenic concentrations at Sites CH-9, CH-12, CH-13, CH-14, CH-25 and CH-29, which range from 17.4 mg/kg to 20.3 mg/kg, may be of toxicological concern. At Site CH-6, the mercury concentration of 2.88 mg/kg could be acutely toxic. The lead concentration of 127 mg/kg at Site CH-22 would appear to be acutely toxic. Zinc concentrations at Sites CH-9, CH-13 and CH-17, which ranged from 379 mg/kg to 428 mg/kg, may be of toxicological concern. Based on these data, the following heavy metal COCs were identified: mercury at Site CH-6; arsenic and zinc at Site Ch-9; arsenic at Site CH-12; arsenic and zinc at Site CH-13; arsenic at Site CH-14; zinc at Site CH-17; lead at Site CH-22; arsenic at Site CH-25; and arsenic at Site CH-29.

(2) TOC and other inorganic parameters—TOC levels in the Federal navigation channel sediment samples ranged from 0.68% (Site CH-22) to 4.0% (Site CH-30). At the open-lake reference area, TOC concentrations ranged from 2.7% (Site CL-4) to 3.06% (Site CL-2). With respect to other inorganic contaminants, ammonia levels at Sites CH-3, CH-10 and CH-25 (range 190 mg/kg to 201 mg/kg) may be toxicologically significant. With respect to cyanide, concentrations at Sites CH-21 and CH-22 (range 2.62 mg/kg to 3.63 mg/kg) could be of toxicological concern. Based on these data, ammonia was identified as a COC at Sites CH-3, CH-10 and CH-25, and cyanide was identified as a COC at Sites CH-21 and CH-22.

(b) *Organic analyses*

(1) PAHs—Table 3 presents the results of these analyses. Total PAH concentrations in the Federal navigation channel sediments ranged from 1.13 mg/kg (Site CH-11) to 7.18 mg/kg (Site CH-6). Total PAH levels at the open-lake reference area were quite low, ranging from 0.03 mg/kg (Site CL-1) to 0.69 mg/kg (Site CL-4). While total PAH concentrations at all of the Federal navigation channel sites exceeded those at the open-lake reference area, many may not be of significant toxicological concern. Nevertheless, given the relatively low level of TOC throughout the Federal navigation channel sediments and an assumed low fraction of black carbon, some PAH compounds may be more bioavailable and therefore capable of exerting acute toxicity. For example, TOC levels at all sites, except for Sites CH-6, CH-7, CH-9, CH-10, CH-13, Ch-23 and CH-30, were significantly below the lowest open-lake reference area TOC level of

2.7%.

In order to ascertain whether total PAHs would bioaccumulate from harbor sediments at levels higher than those of the open-lake reference area, a Tier 2 theoretical bioaccumulation potential (TBP) model was employed. TBP is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, in sediments (McFarland 1984). This model is expressed as:

$$TBP = BSAF\ (L)\ (C_s/TOC)$$

Where:

TBP = Predicted whole body tissue concentration of the neutral organic compound (µg/kg wet weight)
BSAF = Biota-sediment accumulation factor, a measure of bioavailability
L = Concentration of lipid in target animals (percent of wet weight)
C_s = Concentration of neutral organic compound in sediment (µg/kg dry weight)
TOC = Total organic carbon concentration in sediment (percent of dry weight)

The target animal used in this case is an oligochaete worm. In this model, a 1% lipid content in oligochaete worms, an average that is characteristically representative (e.g., Ankley *et al.* 1992, Pickard *et al.* 2001), a BSAF of 1.0 (Pickard *et al*. 2006) and TOC data from Table 2 were used. The total PAH TBP for open-lake reference area sediments (Site CL-4) was 0.26 mg/kg. The total PAH TBP predictions for the Federal navigation channel sediments are summarized in Table 4. Predicted TBP values for total PAHs at individual harbor sites ranged from 0.41 mg/kg (Site CH-10) to 3.76 mg/kg (Site CH-22), and were 1.6 to 14.6 times that of the open-lake reference area sediments.

Great Lakes harbor and lake reference sediments with total PAH levels on the order of up to about 7 mg/kg have been shown to not exhibit acute toxicity. However, in this case, generally lower TOC levels and other factors (coarse-grain fraction of sediment, origin of organic carbon, etc.) could be factors that contribute to lower total PAH levels potentially being acutely toxic. For example, in the Upper End of the River Channel, sediments were one-half or greater coarse-grain and had TOC levels (1.42% to 2.19%) that were below those of the open-lake reference area. As a result, it is possible that some total PAH concentrations in this reach, which ranged from 1.55 mg/kg to 5.85 mg/kg (mean = 3.03 mg/kg), could potentially exert some acute toxicity.

Preliminary calculations were performed on selected Cleveland Harbor sites to derive concentrations of PAH mixtures in sediments that may be toxic to benthic organisms. The equilibrium partitioning (EqP) approach was applied to calculate

EqP sediment benchmarks (EBS) for PAH mixtures, termed an EqP Sediment Benchmark Toxic Unit ($\sum ESBTU_{FCV}$) (USEPA 2003). Using this approach, freshwater sediments containing $\sum ESBTU_{FCV} \leq 1.0$ of a mixture of 34 or more PAH compounds are acceptable for the protection of aquatic organisms. In this case, an uncertainty factor had to be applied because the analyses covered only 16 PAHs. These calculations suggested that most of the concentrations of most of the PAH mixtures in Cleveland Harbor sediments probably cause chronic toxicity. In addition, it suggested that the total PAH concentrations at Sites CH-9, CH-11, CH-25 and CH-28 are not chronically or acutely toxic. It should be noted that ESBs do not consider the antagonistic, additive or synergistic effects of other sediment contaminants in combination with PAH mixtures or the potential for bioaccumulation and trophic transfer of PAH mixtures to aquatic life, wildlife or humans. The weight-of-the-evidence suggests that total PAHs are COCs at all sites, excluding Sites CH-9, CH-11, CH-25 and CH-28.

(2) PCBs—Table 5 presents the results of these analyses. PCBs were measured at all of the Federal navigation channel sites, with Aroclors 1242, 1254 and 1260 being the mixtures that were predominantly detected. Individual Aroclor mixtures that were detected ranged from 22.2 μg/kg of Aroclor 1254 at Site CH-8 to 260 μg/kg of Aroclor 1254 at Site CH-27_{QC}. "Total PCB" concentrations (the sum of the three predominant Aroclors, valuing non-detectable concentrations at the laboratory reporting limit [LRL]) in the Federal navigation channel sediments ranged from 96.6 μg/kg to 504 μg/kg at Sites CH-14 to CH-27_{QC}, respectively. Aroclor 1254 was the only PCB mixture detected in the open-lake reference area sediments, ranging in concentration from 35.4 μg/kg (Site CL-3) to 42.8 μg/kg (Site CL-2). Since Aroclor 1254 was the only detected PCB mixture, the measured level was assumed to represent the "total PCB" concentration. Total PCB concentrations at all of the Federal navigation channel sites exceeded those at the open-lake reference area sediments.

The TBP model was employed to ascertain whether total PCBs would bioaccumulate from Federal navigation channel sediments at levels higher than the open-lake reference area. The model used an oligochaete worm as the target animal with a 1% lipid content, PCB BSAF of 1.2 (unpublished Lake Erie data) and TOC data from Table 2. The open-lake reference area PCB TBP was calculated to be 16.8 μg/kg, and the total PCB TBP predictions for the Federal navigation channel sediments are summarized in Table 6. The TBP for total PCBs ranged from 44.2 μg/kg (Site CH-10) to 388 μg/kg (Site CH-27), all of which exceeded the open-lake reference area total PCB TBP. The predicted total PCB TBP values were over 2.6 to 23-fold that of the open-lake reference area. Relative to the open-lake reference area sediments, it is possible that PCBs may not bioaccumulate to statistically significant higher levels at Sites CH-6 through CH-17 (TBP range = 44.2 μg/kg to 84.4 μg/kg). Nevertheless, based on these

TBP predictions and existing information, total PCBs were retained as a COC at all of the Federal navigation channel sites.

(3) Pesticides—Table 7 presents the results of these analyses. Most pesticides in the Federal navigation channel sediment samples were non-detectable at LRLs ranging from 1.02 μg/kg to 623 μg/kg. With the exception of dieldrin at Site CH-10 (11.6 μg/kg), 4,4′-dichlorodiphenyltrichloroethane (DDT) and its metabolites/breakdown products 4,4′-dichlorodiphenyldichloroethylene (DDE) and 4,4′-dichlorodiphenyldichloroethane (DDD) were detected at most of the Federal navigation channel sites. DDD was the only pesticide detected in the open-lake reference area sediments, ranging in concentration from 7.89 μg/kg to 8.95 μg/kg at Sites CL-1 and CL-2, respectively. The sum of DDT, DDE and DDD (ΣDDT) was used to interpret the data and for comparison purposes, based on the following rationale:

1—4,4′-DDT, 4,4′-DDE and 4,4′-DDD are considered highly hydrophobic, having Log K_{ow}s of 6.91, 6.51 and 6.02 respectively (ATSDR 2002). Hydrophobicities tend to reduce the bioavailability of sediment-associated neutral organic contaminants;

2—BSAFs in the literature for sediment-processing benthic organisms show that the bioavailability of DDT, DDE and DDD is similar (Ingersoll *et al.* 2003), or that DDT (Mulsow and Landrum 1995) can be less bioavailable than DDE (Ferraro *et al.* 1990); and

3—The sediment samples were processed through gas chromatographic analysis. This method has been shown to cause a breakdown of DDT into DDE and DDD, which would tend to make the analytical differentiation of the three compounds based on these sediment data obscure (Forman and Gates 1997).

Concentrations of ΣDDT in the Federal navigation channel sediments ranged from 6.09 μg/kg (Site CH-21) to 105 μg/kg (Site CH-4) (see Table 8). The open-lake reference area ΣDDT concentration was 41.4 μg/kg. Concentrations of ΣDDT at Sites CH-4, CH-5 and CH-8 (range 59.4 to 105 μg/kg) significantly exceeded that of the open-lake reference area. Tier 2 TBP predictions using an oligochaete worm as the target animal, 1% lipid content, BSAF of 2.5 (Ingersoll *et al.* 2003) and TOC data from Table 2 are summarized in Table 8. Projected ΣDDT bioaccumulation levels at these sites ranged from 85.8 μg/kg (Site CH-8) to 120 μg/kg (Site CH-4), and were 2.5 to 3.6 times the open-lake reference area ΣDDT TBP of 33.8 μg/kg. Therefore, ΣDDT was determined to be a COC at Sites CH-4, CH-5 and CH-8.

(c) *Elutriate testing*—Tables 9 through 12 present the results of

the MET performed on the Federal navigation channel sediments. The results showed releases of some heavy metals, ammonia and cyanide from the sediments (Table 9). Evidenced heavy metal releases from the harbor sediments were low, and maximum releases (dissolved) generally occurred from MUs CH-URMU and CH-LRMU sediments. The highest releases of copper and mercury (dissolved) were 1.5 μg/L and 0.0024 μg/L from MU CH-URMU sediments, respectively. Maximum ammonia-nitrogen (total) releases ranged from 5.22 μg/L (MU CH-ORMU) to 11 μg/L (MU CH-URMU). At a water pH of 8.1 and temperature of 21°C, and after consideration of mixing in the water column, ammonia concentrations would not appear to contravene applicable State Water Quality Standards. Releases of PAH compounds (dissolved) were indicated at several of the Federal navigation channels sites (Table 10). Maximum benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, chrysene, fluoranthene and pyrene releases (dissolved) were 0.156 μg/L, 0.181 μg/L, 0.405 μg/L, 0.143 μg/L, 0.172 μg/L, 0.254 μg/L and 0.386 μg/L at MU CH-LRMU in the Lower River channel reach, respectively. With respect to PCBs, no releases (dissolved) were shown at LRLs ranging from 0.0102 μg/L to 0.104 μg/L (Table 11). Pesticide releases (dissolved) from the sediments were non-detectable at LRLs ranging from 0.0222 μg/L to 2.78 μg/L (Table 12).

b. Biological testing. Tier 3, 10-day solid phase bioassays applied to MU CH-UEMU sediments employed the test species *Hyalella azteca* (amphipod) and *Chironomus tentans* (mayfly nymph) (USEPA/USACE 1998). The biological measurement endpoints for the *H. azteca* and *C. tentans* bioassays were survival, and survival and growth, respectively. The results are presented in Table 13 and are summarized as follows:

1. ***H. azteca***: The mean survival of this species was 0.52±0.02% and statistically lower than the survival associated with open-lake reference area sediments (0.88%).

2. ***C. tentans***: The mean survival of this species was 0.72±0.03% and statistically lower than the survival associated with the open-lake reference area sediments (0.94%). The mean growth of this species was 1.06±0.09 mg/org and not statistically different from that associated with open-lake reference area sediments (1.01mg/org).

These combined bioassay results indicate that the MU CH-UEMU sediments are acutely toxic. Based on the bulk chemistry data on these sediments, this toxicity may be attributable to total PAHs and/or ∑DDT.

c. Final COC List. COCs identified in Cleveland Harbor Federal navigation channel sediments are summarized as follows:

1. Arsenic at Sites CH-9, CH-12, CH-13, CH-14, CH-25 and CH-29 in the River and Outer Harbor channels.

2. Lead at Site CH-22 in the River Channel.

3. Mercury at Site CH-6 in the River Channel.

4. Zinc at Sites CH-9, CH-13 and CH-17 in the River Channel.

5. Ammonia-nitrogen at Sites CH-3, CH-10 and CH-25 in the River and Outer Harbor channels.

6. Cyanide at Sites CH-21 and CH-22 in the River Channel.

7. Total PAHs at all River, Old River and Outer Harbor Channel sites, except Sites CH-9, CH-11, CH-25 and CH-28.

8. Total PCBs at Sites CH-1 through CH-30 in the River, Old River and Outer Harbor Channels.

11. ΣDDT at Sites CH-4, CH-5 and CH-8 in the River Channel.

Based on the data considered in this evaluation, it is possible that PCBs may not bioaccumulate to statistically significant higher levels from sediments at Sites CH-6 through CH-17. If that were shown to be the case, and if the sediments were also shown to not exhibit acute toxicity through the prescribed bioassays, dredged material at Sites CH-7, CH-11, CH-15 and CH-16 would meet Federal guidelines for open-lake placement. All three solid-phases tests would be required on these sediments to make such a determination.

d. Quality Assurance (QA)/Quality Control (QC) Documentation. QA/QC information and records on the data contained in this evaluation are available in EEI (2007).

Conclusion

This evaluation has determined that sediments dredged from all Cleveland Harbor Federal navigation channels, as represented by Sites CH-1 through CH-30 (Figure 1), do not meet Federal guidelines for open-lake placement based on existing information.

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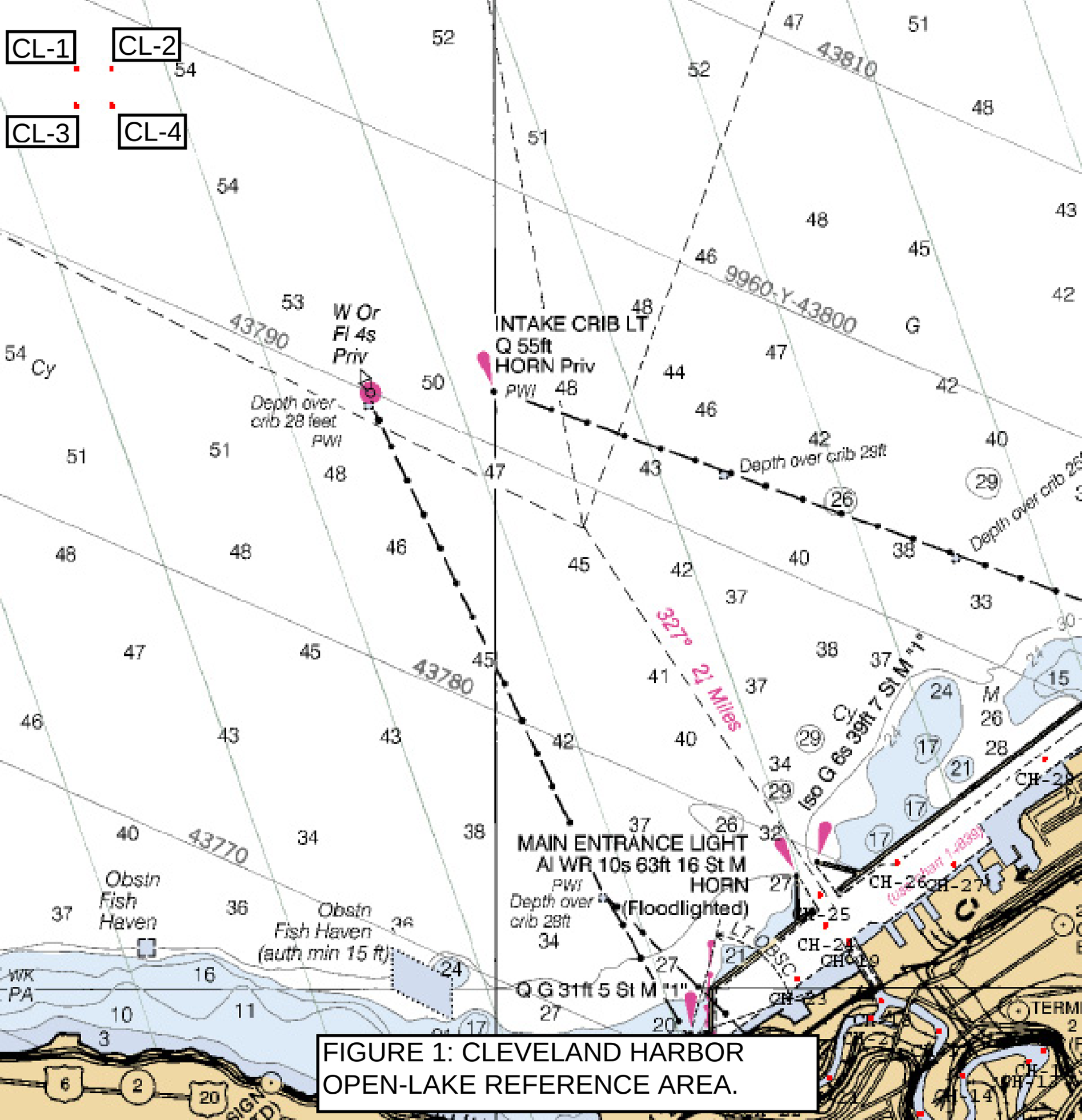

FIGURE 1: CLEVELAND HARBOR OPEN-LAKE REFERENCE AREA.

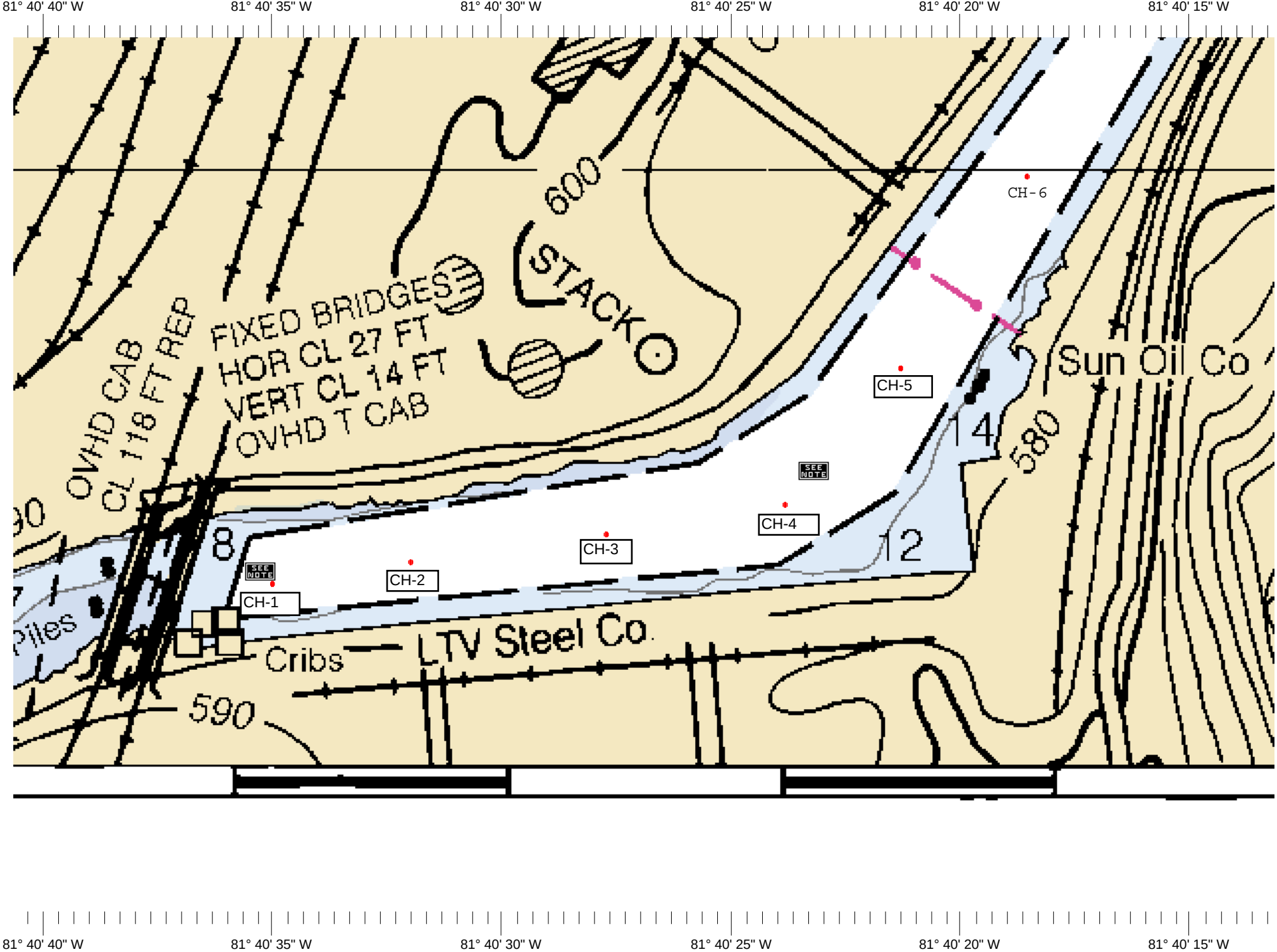

FIGURE 2: CLEVELAND HARBOR (CUYAHOGA RIVER) UPPER END MANAGEMENT UNIT

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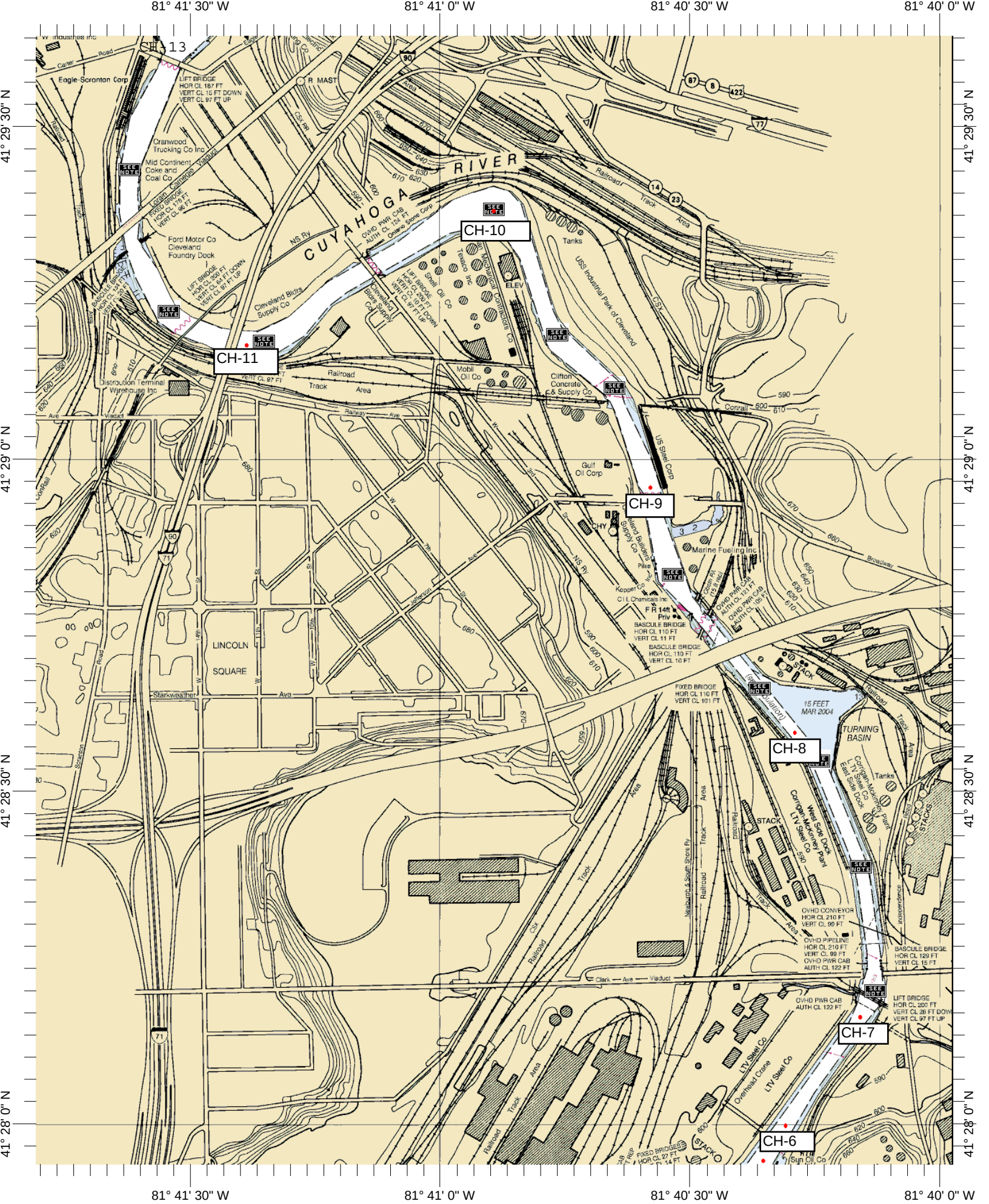

FIGURE 3: CLEVELAND HARBOR (CUYAHOGA RIVER) UPPER RIVER MANAGEMENT UNIT

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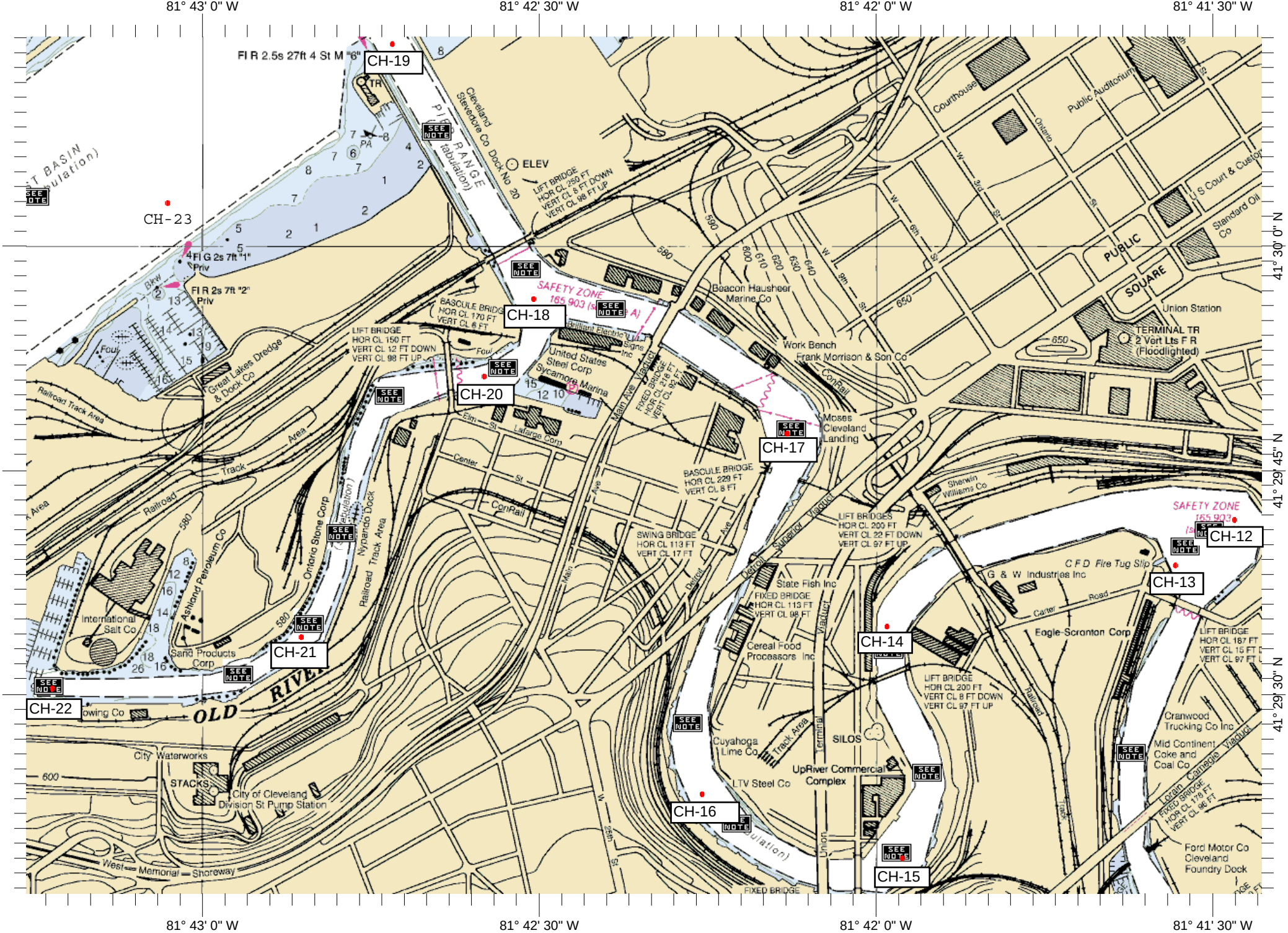

FIGURE 4: CLEVELAND HARBOR (CUYAHOGA RIVER) LOWER RIVER AND OLD RIVER CHANNEL MANAGEMENT UNITS.

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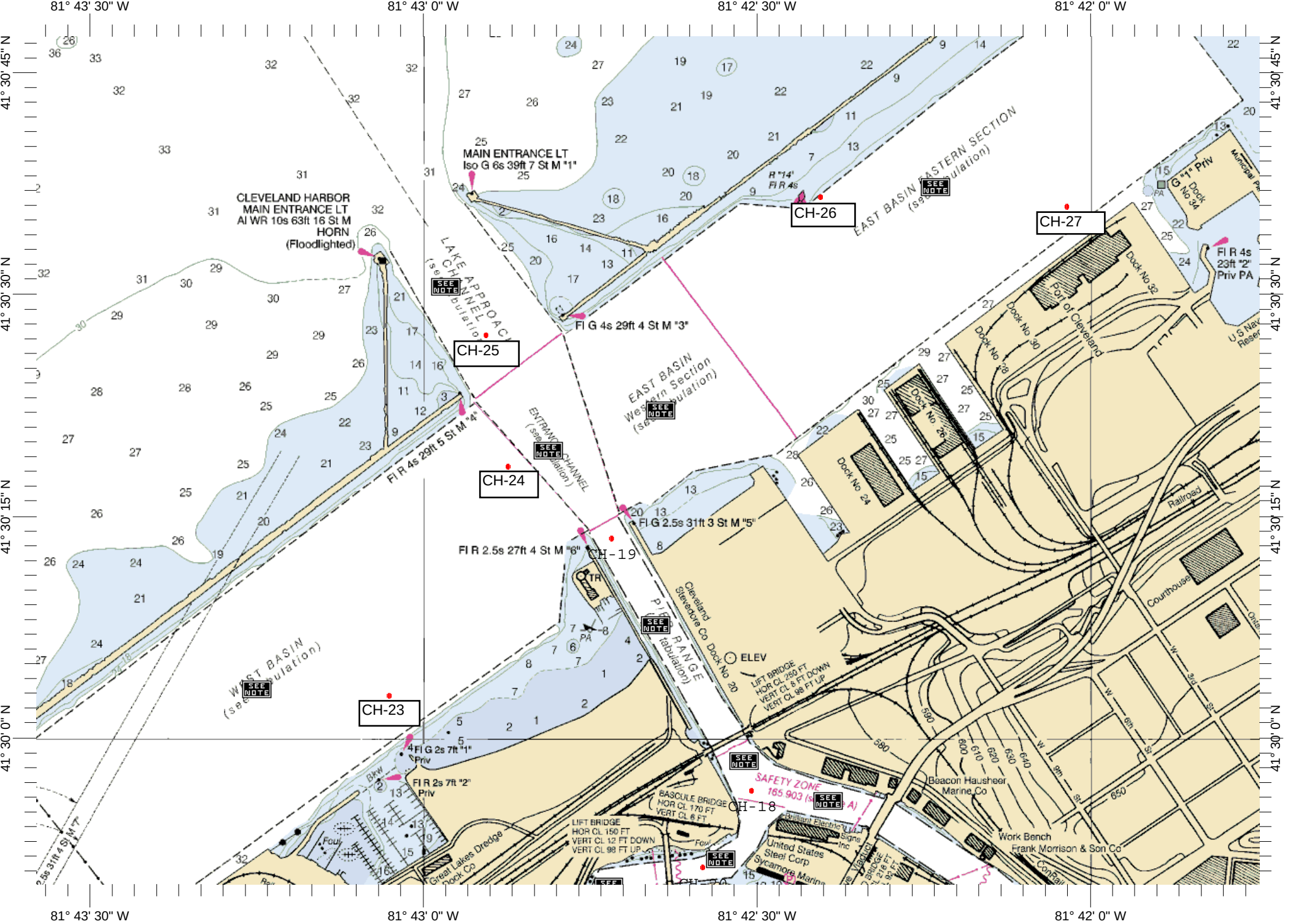

FIGURE 5: CLEVELAND HARBOR OUTER HARBOR MANAGEMENT UNIT (SITES CH-23 - CH-27)

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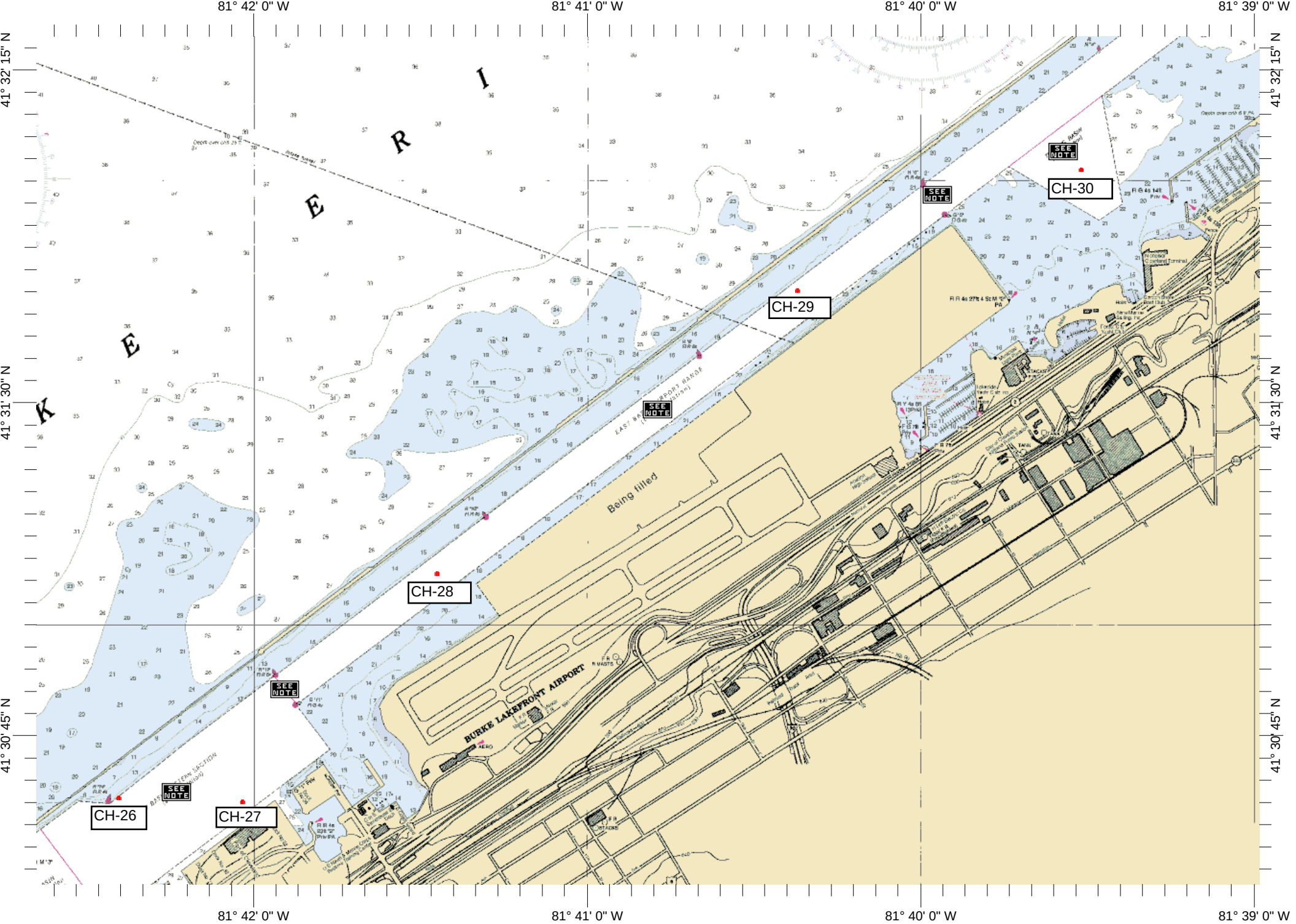

FIGURE 6: CLEVELAND HARBOR OUTER HARBOR MANAGEMENT UNIT (SITES CH-26 - CH-30)

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TABLE 1. Particle size distribution of Cleveland Harbor Federal navigation channel sediments (from EEI 2007).

Particle Size Distribution	Harbor Sediments																
	Sampling Sites																
	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8	CH-9	CH-10	CH-11	CH-12	CH-13	CH-14	CH-15	CH-16	CH-17
Clay	8.1	11.2	12.6	10.6	8.4	15.1	15.3	11.2	25.4	25.2	31.1	25.8	33.1	23.4	28.7	26.9	32.9
Silt	27.6	34.1	35.4	39.6	36.6	56.2	55.2	68.4	71.3	68.3	62	71.2	65.2	72.1	66.8	67.8	53.5
Sand	64.3	54.7	52	49.8	55	28.7	29.5	20.4	3.3	6.5	6.9	3	1.7	4.5	4.5	5.3	13.6
Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Particle Size Distribution	Harbor Sediments													Open-Lake Reference Area Sediments			
	Sampling Sites													Sampling Sites			
	CH-18	CH-19	CH-20	CH-21	CH-22	CH-23	CH-24	CH-25	CH-26	CH-27	CH-28	CH-29	CH-30	CL-1	CL-2	CL-3	CL-4
Clay	24.1	18.6	12.6	14.3	28.2	38	26.3	25	36.9	48.9	46.3	45	30.3	33.8	28	38	33.7
Silt	69.4	73.6	29.2	22.3	32	53.5	70.6	72.2	58.3	50.2	51.1	53.5	60.6	64.7	70.9	60.7	64.6
Sand	6.5	2.8	56.5	63.4	39.8	8.5	3.1	2.8	4.8	0.9	2.6	1.5	9.1	1.5	1.1	1.3	1.7
Gravel	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 2. Bulk inorganic analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

	Harbor Sediments																
	Sampling Sites																
Metal (mg/kg)	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8	CH-9	CH-10	CH-11	CH-12	CH-13	CH-14	CH-15	CH-16	CH-17
Aluminum	6850	5860	6910	7720	7180	9040	8690	7950	11400	9130	10900	12800	13800	10300	9030	9560	10700
Antimony	0.895J*	0.782J	0.786J	0.849J	1.47U**	0.523J	1.55U	0.508J	**11**	1.31J	0.179U	0.157U	0.169U	0.146U	0.86	0.157U	0.180U
Arsenic	10.4	9.33	**11.1**	**14.1**	**12.5**	**14.5**	**16.8**	**12.8**	**17.4**	**13.7**	**16.1**	**20.3**	**20.2**	**19.4**	**14.5**	**14.3**	**14.4**
Barium	52.7	41.6	60	56.8	55.1	66.6	67.2	58.1	87.7	69.2	72.9	84	91.5	74.6	62.2	65.5	82.7
Beryllium	0.438J	0.387J	0.456J	0.553J	0.476J	0.561J	0.555U	0.515J	0.719J	0.571J	0.67	0.76	0.82	0.62	0.55	0.59	0.65
Cadmium	0.664J	0.456J	0.8	0.687J	0.577J	0.593J	0.311U	0.633J	1.31J	0.619J	0.99	0.96	1.6	1	0.37	0.47	1.2
Calcium	10400	10400	**13200**	**13700**	**14000**	**15100**	**14700**	**12500**	**18200**	**14200**	**15500**	**16300**	**19800**	**14200**	**13700**	**14500**	**16400**
Chromium	19.9	14.8	20.7	22.2	19.4	23.4	21.3	22.6	36	24.2	31	30.7	37.4	23.2	22.3	23	35.1
Cobalt	7.77	6.46	8.11	9.35	8.36	10.1	10.1	9.19	12.5	10.2	11.1	11.8	**14.2**	10.4	10	10.1	10.8
Copper	43.2	**55.5**	**56**	48.2	46.2	50.6	43.3	52.8	**67.8**	49.2	48.5	50.1	**67.6**	42.3	40.8	43.2	52
Iron	21000	18900	22800	27700	26000	30200	30300	27600	34100	29800	33100	35500	**42000**	33600	30600	32000	32100
Lead	36	26.1	41.6	39.8	36.7	41.8	38.9	38.2	**66.3**	41.3	45.4	43.9	62.3	37.9	36.4	41.7	45.9
Magnesium	4100	3370	4620	5090	4870	5700	5710	5070	6990	5640	7430	7780	8000	6590	5720	6170	6450
Manganese	455	397	485	498	517	661	576	462	580	525	528	585	580	512	443	434	486
Mercury	0.0855	0.0733	0.0708	0.0759	0.0702	**2.88**	0.0624	0.081	0.105	0.128	0.0793	0.0884	0.126	0.104	0.0766	0.0835	0.123
Nickel	25	34.7	28	31.7	31.2	31.4	29.7	27.7	39.1	30.9	34.1	34.4	41.4	29.4	28.5	28.7	31.2
Potassium	912	703	859	1000	926	1160	1070	988	1370	1230	1360	1560	1720	1180	1120	1180	1340
Selenium	0.752J	2.25U	1.46J	2.40U	1.5J	1.52J	2.34	1.72J	**13.9U**	1.62J	0.894U	0.785U	0.843U	0.729U	2	1.4	1.3
Silver	0.182J	0.155J	0.764U	0.802U	0.4J	0.198J	0.776U	0.194J	0.927U	0.192J	0.200J	0.26	0.33	0.250J	0.250J	0.2	0.33
Sodium	**232**	**207**	**224**	**222**	**198**	**254**	**216**	**214**	**304**	**247**	**269**	**236**	**328**	**232**	**255**	**252**	**269**
Thallium	2.91U	1.26J	1.36J	3.21U	1.03J	3.26U	1.14	1.07J	**18.5U**	3.31U	0.300J	0.42	0.49	0.37	1.9	1.8	0.360J
Vanadium	14.3	12.6	14.6	17.8	15.9	18.4	18.5	16.5	23.1	19.5	21	22.9	26.6	19.9	18.1	18.8	20.3
Zinc	156	130	137	193	170	189	167	**296**	**428**	**226**	**323**	243	**417**	194	216	**236**	**379**

	Harbor Sediments																
	Sampling Sites																
Misc. (mg/kg)	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8	CH-9	CH-10	CH-11	CH-12	CH-13	CH-14	CH-15	CH-16	CH-17
Ammonia	48	98.7	**201**	69.4	66.9	101	90.6	68.7	116	**195**	89.9	101	105	99.7	91.1	98.3	153
Total cyanide	0.117J	0.104J	0.355J	0.197J	0.101J	0.469	0.116J	0.492	0.531	0.430U	0.195J	0.190J	0.499	0.3J	0.548	**1.03**	**1.08**
TOC	14200	20500	21200	21900	20100	25200	24100	17300	26500	27400	22900	20300	28000	14000	14500	14500	22300

*Estimated value between the detection limit and reporting limit.
**Not detected at or above the specified reporting limit.

TABLE 2 (continued). Bulk inorganic analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

	Harbor Sediments													Open-Lake Reference Area			
	Sampling Sites													Sampling Sites			
Metal (mg/kg)	**CH-18**	**CH-19**	**CH-20**	**CH-21**	**CH-22**	**CH-23**	**CH-24**	**CH-25**	**CH-26**	**CH-27**	**CH-28**	**CH-29**	**CH-30**	**CL-1**	**CL-2**	**CL-3**	**CL-4**
Aluminum	9680	10600	5420	6460	10400	10800	9080	11700	9630	9490	11900	17200	11700	16600	19700	18600	17500
Antimony	**6.7**	0.190J	0.84	0.56	0.7	0.193U	1.2	**4.8**	1	0.197U	0.198U	0.239U	1.5	3.77U	3.87U	3.76U	3.74U
Arsenic	**16.3**	**16.5**	7.3	8.5	**15**	**12.8**	**15.9**	**20.2**	**12.8**	10	**13.8**	**17.5**	**12.9**	11	9.75	9.35	8.54
Barium	79.5	79.2	36.2	51.9	78.2	64.5	70.1	85.6	60.5	56.7	78	108	78.9	108	123	115	110
Beryllium	0.63	0.77	0.37	0.42	0.65	0.67	0.58	0.72	0.59	0.56	0.74	1.1	0.89	1.02J	1.22J	1.1J	1.07J
Cadmium	**3.4**	0.99	0.41	0.92	1.2	1	0.71	0.94	0.8	0.64	1.2	1.4	1.4	1.77J	1.97	1.78J	1.77J
Calcium	**14100**	**19500**	**22800**	**17400**	379	10300	11300	**13700**	9820	7130	11000	12000	9560	11900	12100	11300	10700
Chromium	41.5	26.1	14.8	21.2	38.3	27.2	23.8	26.9	24.4	22.1	31.3	44.5	36.2	46.6	55.7	49.6	49.9
Cobalt	11.5	10.8	6.1	5.6	9.7	11.1	10.2	12.2	10.3	9.3	12.2	**15.3**	11.4	12.8	14.1	13.7	12.8
Copper	**58.8**	47	24	32.5	**69.6**	38	48	47.1	40	32	49.8	**56.6**	53	46.6	53.4	49.2	47.1
Iron	30000	34400	18100	17700	34100	30100	28900	35900	29400	25000	33100	**45600**	**39800**	34100	39500	36800	35100
Lead	**71.5**	41.4	27.9	37.1	**127**	38.5	41	40.1	37.9	30.2	50.3	62.2	61.4	53.3	65.9	57.5	59.3
Magnesium	6160	9120	9350	6000	**12600**	5870	5320	6750	5590	4740	6740	9010	6580	10700	11500	10700	10100
Manganese	502	551	251	238	471	538	507	758	479	420	561	832	512	833	650	584	618
Mercury	0.151	0.0663	0.0352	0.0626	0.0177	0.0128	0.0763	0.0942	0.0118	0.0109	0.0122	0.0164	0.0211	0.253	0.294	0.286	0.345
Nickel	40.9	32.9	18.1	18.2	33.3	32.2	30.7	35.3	29.4	26.3	36.4	46.2	35.6	51	57.6	54.2	53.5
Potassium	1190	1250	710	808	1220	1540	1150	1450	1260	1360	154	2230	1560	2420	2790	2660	2490
Selenium	0.772U	0.744U	0.91	0.734U	1.5	2	1.7	0.792U	0.915U	1.4	1.1	1.19U	3.6	5.66U	3.94J	2.14J	5.60U
Silver	0.45	0.19	0.120J	0.170J	0.270J	0.330J	0.260J	0.280J	0.300J	0.43	0.31	0.53	0.75	1.89U	1.93U	1.88U	1.87U
Sodium	**252**	159	174	**445**	**306**	**203**	179	180	138	170	151	188	174	189	196	181	184
Thallium	0.49	6.2	0.240J	0.230J	0.47	0.6	0.46	0.42	0.38	0.58	0.57	0.51	0.82	7.55U	7.74U	7.52U	7.47U
Vanadium	21.2	21.7	12.2	11.7	19.8	22.1	19.4	23.4	19.3	18	23.5	33.5	25	36.7	43	40.6	38.5
Zinc	**339**	207	132	211	**307**	205	208	193	203	173	**259**	**299**	**238**	185	217	199	196

	Harbor Sediments													Open-Lake Reference Area			
	Sampling Sites													Sampling Sites			
Misc. (mg/kg)	**CH-18**	**CH-19**	**CH-20**	**CH-21**	**CH-22**	**CH-23**	**CH-24**	**CH-25**	**CH-26**	**CH-27**	**CH-28**	**CH-29**	**CH-30**	**CL-1**	**CL-2**	**CL-3**	**CL-4**
Ammonia	133	108	51.5	102	120	152	140	**190**	139	**165**	126	127	82	158	142	132	118
Total cyanide	**1.05**	0.111U	0.481	**2.62**	**3.63**	0.131U	0.189J	0.289J	0.121U	0.144U	0.148U	0.161U	0.153U	0.997U	1.01U	0.979U	0.965U
TOC	19900	17500	12500	6850	6780	26300	20700	20400	19400	15600	20400	15600	40000	30100	30600	29600	27000

*Estimated value between the detection limit and reporting limit.

**Not detected at or above the specified reporting limit.

TABLE 3. Bulk Polycyclic Aromatic Hydrocarbon (PAH) analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

PAH Compound (ug/kg)	Harbor Sediments																
	Sampling Sites																
	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8	CH-9	CH-10	CH-11	CH-12	CH-13	CH-14	CH-15	CH-16	CH-17
Acenaphthene	16.9	10.6	9.89	31.8	32.1	46.6	24.3	18.3	6.86	14.2	9.36	25.8	14.6	29.4	14.5	21.8	17.4
Acenaphthylene	16.2	11.4	8.24	32	30.3	42	14.4	15.2	5.88	12.1	6.84	20.5	11.7	24.7	12.7	18.5	18.4
Anthracene	61.3	27.6	31.3	117	134	137	74.8	64	20.8	39.5	19.7	65.5	32.9	83.5	36.1	44.1	50.9
Benzo(a)Anthracene	213	112	142	449	424	558	270	216	102	170	84.9	224	123	355	154	168	167
Benzo(a)Pyrene	262	136	163	495	426	628	268	227	122	196	99.1	266	148	401	191	205	190
Benzo(b)Flouranthene	352	203	260	814	719	948	391	356	204	340	166	449	272	695	338	347	291
Benzo(ghi)Perylene	141	77.6	91.9	273	242	340	144	116	72.6	117	56.7	160	98.4	248	117	113	96.1
Benzo(k)Fluoranthene	131	67.1	72.3	204	165	340	135	96.5	63.5	95.8	49.2	136	79.1	202	97.3	116	97.3
Chrysene	274	149	171	594	509	657	301	246	129	225	100	312	168	497	219	231	203
Dibenz(a,h)Anthracene	38.9	21	28.7	79.2	71.8	102	39.9	33.1	21.6	31.7	16.4	43.9	26.4	69.1	32.1	36.9	30.1
Fluoranthene	534	287	334	1020	991	1310	612	487	254	419	210	548	306	863	390	400	355
Fluorene	26.9	15.2	15.3	48.8	47.4	71.6	32.7	28.7	10.2	22.2	13.2	39.9	21.3	45.2	21.8	30.2	23.1
Indeno(1,2,3-cd)Pyrene	126	70.6	84.6	257	224	314	135	106	65.9	103	51.2	144	87.4	231	109	102	91.1
Naphthalene	4.08U*	3.94U	4.47U	4.61U	6.82U	22.1U	4.79U	4.39U	5.45U	5.06U	5.03U	17.2U	5.28U	25U	5U	5.13U	5.2U
Phenanthrene	258	138	154	522	488	618	327	269	106	199	89.4	290	135	429	176	187	155
Pyrene	452	223	271	909	825	1070	508	414	202	352	159	453	240	734	317	340	296
Total PAHs	**2903**	**1549**	**1837**	**5846**	**5329**	**7182**	**3277**	**2693**	**1386**	**2337**	**1131**	**3178**	**1764**	**4907**	**2226**	**2361**	**2081**

*Not detected at or above the specified reoprting limit.

TABLE 3 (continued). Bulk Polycyclic Aromatic Hydrocarbon (PAH) analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

PAH compound (ug/kg)	Harbor Sediments													Open-Lake Reference Area			
	Sampling Sites													Sampling Sites			
	CH-18	CH-19	CH-20	CH-21	CH-22	CH-23	CH-24	CH-25	CH-26	CH-27	CH-28	CH-29	CH-30	CL-1	CL-2	CL-3	CL-4
Acenaphthene	54.8	11.5	38.2	12.5	23.1	14.8	22	8.07	14.5	15.5	19.4	13	46.4	10.7U*	11.9U	12U	6.48
Acenaphthylene	47	12.9	20.3	12.4	22.7	12.5	20.7	9	25.1	16.9	23.8	30.8	50.4	10.7U	6.12	12U	13.5
Anthracene	122	33.4	59.1	31.8	70.7	41.9	63.9	24.6	40.6	42.3	38.4	41.3	145	10.7U	8.61	12U	18.4
Benzo(a)Anthracene	379	131	182	127	236	136	283	102	138	165	107	131	510	16.8	45.2	39.6	57.2
Benzo(a)Pyrene	417	159	205	142	222	141	327	112	165	192	126	152	478	10.7U	15.5	10.5	75.5
Benzo(b)Fluoranthene	677	253	315	242	338	239	586	202	242	346	187	232	818	10.7U	17.9	11.5	103
Benzo(ghi)Perylene	249	86.2	107	75.7	114	74.9	206	64.3	83.5	117	68.2	80.2	224	10.7U	6.38	12U	46.3
Benzo(k)Fluoranthene	193	86.1	106	58.1	91.9	60.9	156	51.4	60.7	94.6	69.2	66.4	221	10.7U	9.83	10.5	44.2
Chrysene	466	168	221	143	244	136	375	113	127	202	114	122	593	10.7U	11.9U	12U	40.1
Dibenz(a,h)Anthracene	75.5	26.4	33	21.8	38.6	23.1	60.2	19	26.2	33.3	22.9	25.8	74.5	10.7U	11.9U	12U	11.6
Fluoranthene	815	318	387	256	404	283	662	247	237	367	214	237	1040	13.2	34.3	25.5	122
Fluorene	84.4	17.7	39.7	18.4	37.1	23.1	35.3	12.3	21	26.7	25.9	22.8	73.9	10.7U	11.9U	12U	11.1
Indeno(1,2,3-cd)Pyrene	227	83	99.1	67.5	105	69.1	194	59.3	79.4	106	65.9	78.7	212	10.7U	11.9U	12U	41.7
Naphthalene	38	4.86U	77.4	4.06U	3.25	6.26U	4.81U	5.31U	5.42U	6.45U	6.26U	7.6U	39.2	10.7U	11.9U	12U	11.5U
Phenanthrene	465	143	220	114	206	141	324	103	120	156	78	97.3	515	10.7U	11.9U	12U	14.8
Pyrene	714	260	357	248	393	227	563	193	197	292	167	185	1020	10.7U	7.19	12U	87.2
Total PAHs	**5024**	**1789**	**2467**	**1570**	**2549**	**1623**	**3878**	**1320**	**1577**	**2172**	**1327**	**1515**	**6060**	30	151	97.6	693.08

*Not detected at or above the specified reporting limit.

TABLE 4. Theoretical bioaccumulation potential (TBP) for total PAH concentrations in Cleveland Harbor Federal navigation channel sediments (based on data from EEI 2007). TBP Boldface/shaded values indicate a TBP that is greater than the calculated open-lake reference area total PAH TBP of 257 μg/kg.

Site	Total PAH concentration (μg/kg)	TOC concentration (%)	BSAF	Lipid level (%)	TBP (μg/kg)
CH-1	2903	0.0142	1	0.01	**2044.3662**
CH-2	1549	0.0205	1	0.01	**755.60976**
CH-3	1837	0.0212	1	0.01	**2757.5472**
CH-4	5846	0.0219	1	0.01	**2433.3333**
CH-5	5329	0.0201	1	0.01	**3573.1343**
CH-6	7182	0.0252	1	0.01	**1300.3968**
CH-7	3277	0.0241	1	0.01	**1117.4274**
CH-8	2693	0.0173	1	0.01	**801.15607**
CH-9	1386	0.0265	1	0.01	**881.88679**
CH-10	2337	0.0274	1	0.01	**412.77372**
CH-11	1131	0.0229	1	0.01	**1387.7729**
CH-12	3178	0.0203	1	0.01	**868.96552**
CH-13	1764	0.028	1	0.01	**1752.5**
CH-14	4907	0.014	1	0.01	**1590**
CH-15	2226	0.0145	1	0.01	**1628.2759**
CH-16	2361	0.0145	1	0.01	**1435.1724**
CH-17	2081	0.0223	1	0.01	**2252.9148**
CH-18	5024	0.0199	1	0.01	**2524.6231**
CH-19	1789	0.0175	1	0.01	**1022.2857**
CH-20	2467	0.0125	1	0.01	**1973.6**
CH-21	1570	0.00685	1	0.01	**2291.9708**
CH-22	2549	0.00678	1	0.01	**3759.587**
CH-23	1623	0.0263	1	0.01	**617.11027**
CH-24	3878	0.0207	1	0.01	**1873.43**
CH-25	1320	0.0204	1	0.01	**647.05882**
CH-26	1577	0.0194	1	0.01	**812.8866**
CH-27	2172	0.0156	1	0.01	**1392.3077**
CH-28	1327	0.0204	1	0.01	**650.4902**
CH-29	1515	0.0156	1	0.01	**971.15385**
CH-30	6060	0.04	1	0.01	**1515**

TABLE 5. Bulk Polychlorinated Biphenyl (PCB) analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

	Harbor Sediments																
	Sampling Sites																
Aroclor (ug/kg)	CH-1	CH-2	CH-3	CH-4	CH-5QC	CH-6	CH-7	CH-8	CH-9	CH-10	CH-11	CH-12	CH-13	CH-14	CH-15	CH-16	CH-17
1016	58.1U*	60.7U	63.8U	67.3U	63.8U	66.8U	63.9U	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	36.0U
1221	58.1U	60.7U	63.8U	67.3U	63.8U	66.8U	63.9U	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	36.0U
1232	58.1U	60.7U	63.8U	67.3U	63.8U	66.8U	63.9U	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	36.0U
1242	58.8	56.2J**	61.6J	56.3J	**111**	51.6J	53.2J	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	36.0U
1248	58.1U	60.7U	63.8U	67.3U	63.8U	66.8U	63.9U	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	36.0U
1254	**163**	**75**	**63.2J**	**68**	**126**	**48.2J**	42.8J	22.2J	28.1J	30.1J	33.8J	32.9U	38.0U	32.2U	32.5U	34.0U	**46.7**
1260	29.1J	60.7U	63.8U	67.3U	32.4J	66.8U	63.9U	29.3U	36.9U	34.5U	35.9U	32.9U	38.0U	32.2U	32.5U	34.0U	27.1J
"Total"***	**251**	**192**	**189**	**192**	**269**	**167**	**160**	**80.8**	**102**	**101**	**106**	**98.7**	**114**	**96.6**	**97.5**	**102**	**110**

	Harbor Sediments													Open-Lake Reference Area Sediments			
	Sampling Sites													Sampling Sites			
Aroclor (ug/kg)	CH-18	CH-19	CH-20	CH-21	CH-22	CH-23	CH-24	CH-25	CH-26	CH-27QC	CH-28	CH-29	CH-30	CL-1	CL-2	CL-3	CL-4
1016	68.3U	65.3U	55.1U	60.9U	71.9U	77.8U	66.6U	76.4U	75.5U	90.3U	86.7U	48.8U	91.7U	78.6U	81.1U	77.1U	77.7U
1221	68.3U	65.3U	55.1U	60.9U	71.9U	77.8U	66.6U	76.4U	75.5U	90.3U	86.7U	48.8U	91.7U	78.6U	81.1U	77.1U	77.7U
1232	68.3U	65.3U	55.1U	60.9U	71.9U	77.8U	66.6U	76.4U	75.5U	90.3U	86.7U	48.8U	91.7U	78.6U	81.1U	77.1U	77.7U
1242	53.4J	43.7J	79.5	55.7J	47.7J	68.9J	60.8J	46.6J	**99.7**	**163**	**147**	48.8U	**83.0J**	78.6U	81.1U	77.1U	77.7U
1248	68.3U	65.3U	55.1U	60.9U	71.9U	77.8U	66.6U	76.4U	75.5U	90.3U	86.7U	48.8U	91.7U	78.6U	81.1U	77.1U	77.7U
1254	**56.6J**	65.3U	**73.5**	**80.9**	**75.5**	**85.3**	**64.4J**	38.7J	**138**	**260**	**221**	**62.1**	**102**	36.6J	42.8J	35.4J	37.9J
1260	68.3U	65.3U	55.1U	34.4J	30.5J	77.8U	66.6U	76.4U	44.9J	81J	62.6J	31.0J	44.4J	78.6U	81.1U	77.1U	77.7U
"Total"	**179**	**174**	**208**	**171**	**153**	**232**	**192**	**162**	**283**	**504**	**431**	**142**	**230**	36.6	42.8	35.4	37.9

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.
***Sum of aroclor(s) evidenced in harbor or lake sediments, with non-detectable concentrations valued at the reporting limit.

TABLE 6. TBP for total PCB concentrations in Cleveland Harbor Federal navigation channel sediments (based on data from EEI 2007). TBP Boldface/shaded values indicate a TBP that is greater than the calculated open-lake reference area total PCB TBP of 16.8 µg/kg.

Site	Total PCB concentration (µg/kg)	TOC concentration (%)	BSAF	Lipid level (%)	TBP (µg/kg)
CH-1	251	0.0142	1.2	0.01	**212.1127**
CH-2	192	0.0205	1.2	0.01	**112.3902**
CH-3	189	0.0212	1.2	0.01	**106.9811**
CH-4	192	0.0219	1.2	0.01	**105.2055**
CH-5	269	0.0201	1.2	0.01	**160.597**
CH-6	167	0.0252	1.2	0.01	**79.52381**
CH-7	160	0.0241	1.2	0.01	**79.66805**
CH-8	80.8	0.0173	1.2	0.01	**56.04624**
CH-9	102	0.0265	1.2	0.01	**46.18868**
CH-10	101	0.0274	1.2	0.01	**44.23358**
CH-11	106	0.0229	1.2	0.01	**55.54585**
CH-12	98.7	0.0203	1.2	0.01	**58.34483**
CH-13	114	0.028	1.2	0.01	**48.85714**
CH-14	96.6	0.014	1.2	0.01	**82.8**
CH-15	97.5	0.0145	1.2	0.01	**80.68966**
CH-16	102	0.0145	1.2	0.01	**84.41379**
CH-17	110	0.0223	1.2	0.01	**59.19283**
CH-18	179	0.0199	1.2	0.01	**107.9397**
CH-19	174	0.0175	1.2	0.01	**119.3143**
CH-20	208	0.0125	1.2	0.01	**199.68**
CH-21	171	0.00685	1.2	0.01	**299.562**
CH-22	153	0.00678	1.2	0.01	**270.7965**
CH-23	232	0.0263	1.2	0.01	**105.8555**
CH-24	192	0.0207	1.2	0.01	**111.3043**
CH-25	162	0.0204	1.2	0.01	**95.29412**
CH-26	283	0.0194	1.2	0.01	**175.0515**
CH-27	504	0.0156	1.2	0.01	**387.6923**
CH-28	431	0.0204	1.2	0.01	**253.5294**
CH-29	142	0.0156	1.2	0.01	**109.2308**
CH-30	230	0.04	1.2	0.01	**69**

TABLE 7. Bulk pesticide analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

	Harbor Sediments																
	Sampling Sites																
Pesticide (ug/kg)	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**CH-11**	**CH-12**	**CH-13**	**CH-14**	**CH-15**	**CH-16**	**CH-17**
4,4-DDD	4.70J*	6.07U**	6.38U	22.4U	20.0U	4.95J	2.13U	19.8U	8.16J	14.9J	2.38J	2.21J	2.58U	3.05	2.20U	2.06J	2.42U
4,4-DDE	5.81U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	11.1J	7.19U	5.54	2.58U	2.18U	2.20U	2.28U	4.36
4,4-DDT	5.81U	6.07U	6.38U	**60.6**	**55.7**	10.2	11.3	19.8U	10.7J	11.7J	7.19U	9.52	11.6	9.9	10.3	13.1	2.42U
Aldrin	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Alpha-BHC	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Beta-BHC	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.31	2.07
Chlordane	36.3U	37.9U	39.9U	140U	125U	41.8U	13.3U	124U	156U	145U	44.9U	16.8U	16.1U	13.7U	13.7U	14.3U	15.1U
Delta-BHC	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Dieldrin	5.81U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	**11.6**	7.19U	2.21U	2.58U	1.09U	2.20U	2.28U	2.42U
Endosulfan I	2.91U	6.07U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	2.28U	1.21U
Endosulfan II	2.91U	3.03U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	11.2J	7.19U	2.21U	2.58U	2.18U	2.20U	1.14U	2.42U
Endosulfan Sulfate	5.81U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.95U	11.6U	7.19U	2.21U	2.58U	2.18	2.20U	2.28U	2.42U
Endrin	5.81U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	23.2U	7.19U	2.21U	2.58	1.09U	2.20U	2.28U	2.42U
Endrin Aldehyde	2.91U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	7.23J	7.19U	2.21U	2.58U	2.18U	2.20U	2.28U	2.42U
Endrin Ketone	5.81U	6.07U	6.38U	22.4U	20.0U	6.68U	2.13U	19.8U	24.9U	8.34J	7.19U	2.21U	2.58U	2.18U	2.20U	1.14U	2.42U
Gamma-BHC	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Gamma-Chlordane	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Heptachlor	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Heptachlor Epoxide	2.91U	3.03U	3.19U	11.2U	10.0U	3.34U	1.07U	9.90U	12.5U	11.6U	3.59U	1.11U	1.29U	1.09U	1.10U	1.14U	1.21U
Methoxychlor	29.1U	30.3U	31.9U	112U	100U	33.4U	10.77U	99.0U	125U	36J	35.9U	11.1U	12.9U	10.9U	11.0U	1.14U	12.1U
Toxaphene	145U	152U	159U	561U	501U	167U	53.3U	495U	623U	579U	180U	55.3U	64.5U	54.6U	55.0U	57.0U	60.4U

*Estimated value between the detection limit and reporting limit.
**Not detected at or above the specified reporting limit.

TABLE 7 (continued). Bulk pesticides analyses on Cleveland Harbor Federal navigation channel sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference area (from EEI 2007).

	Harbor Sediments													Open-Lake Reference Area			
	Sampling Sites													Sampling Sites			
Pesticide (ug/kg)	CH-18	CH-19	CH-20	CH-21	CH-22	CH-23	CH-24	CH-25	CH-26	CH-27	CH-28	CH-29	CH-30	CL-1	CL-2	CL-3	CL-4
4,4-DDD	2.28U	6.53U	5.51U	2.03U	7.19U	7.78JU	6.66J	7.64J	7.55J	8.85J	**13.5**	9.82J	**12.5**	7.89J	8.95J	15.5U	7.92J
4,4-DDE	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
4,4-DDT	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	12.7	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Aldrin	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Alpha-BHC	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Beta-BHC	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Chlordane	14.2U	40.8U	34.4U	12.7U	44.9U	48.6U	41.6U	47.7U	47.2U	55.3U	54.2U	61.4U	57.3U	98.7U	101U	97.0U	97.5U
Delta-BHC	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Dieldrin	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Endosulfan I	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Endosulfan II	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Endosulfan Sulfate	2.28U	6.53U	5.51U	2.03U	7.19U	3.89U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Endrin	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Endrin Aldehyde	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	15.5U	15.6U
Endrin Ketone	2.28U	6.53U	5.51U	2.03U	7.19U	7.78U	6.66U	7.64U	7.55U	8.85U	8.67U	9.82U	9.17U	15.8U	16.2U	7.76U	15.6U
Gamma-BHC	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Gamma-Chlordane	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	15.8U	16.2U	15.5U	15.6U
Heptachlor	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	15.5U	7.80U
Heptachlor Epoxide	1.14U	3.27U	2.75U	1.02U	3.59U	3.89U	3.33U	3.82U	3.78U	4.43U	4.33U	4.91U	4.58U	7.89U	8.09U	7.76U	7.80U
Methoxychlor	11.4U	32.7U	27.5U	10.2U	35.9U	38.9U	33.3U	38.2U	37.8U	44.3U	43.3U	49.1U	45.8U	78.9U	80.9U	77.6U	78.0U
Toxaphene	56.9U	163U	138U	50.8U	180U	195U	166U	191U	189U	221U	217U	245U	229U	395U	405U	388U	390U

*Not detected at or above the specified reporting limit.

**Estimated value between the detection limit and reporting limit.

TABLE 8. TPB for ∑DDT concentrations in Cleveland Harbor Federal navigation channel sediments (based on data from EEI 2007). Boldface/shaded values indicate a TBP that is greater than the calculated open-lake reference area ∑DDT TBP of 33.8 μg/kg.

Site	∑DDT concentration (μg/kg)	TOC concentration (%)	BSAF	Lipid level (%)	TBP (μg/kg)
CH-1	16.3	0.0142	2.5	0.01	28.6971831
CH-2	18.2	0.0205	2.5	0.01	22.195122
CH-3	19.1	0.0212	2.5	0.01	22.5235849
CH-4	105	0.0219	2.5	0.01	**119.863**
CH-5	95.7	0.0201	2.5	0.01	**119.0299**
CH-6	21.8	0.0252	2.5	0.01	21.6269841
CH-7	15.6	0.0241	2.5	0.01	16.1825726
CH-8	59.4	0.0173	2.5	0.01	**85.83815**
CH-9	43.8	0.0265	2.5	0.01	**41.32075**
CH-10	37.7	0.0274	2.5	0.01	**34.39781**
CH-11	16.8	0.0229	2.5	0.01	18.3406114
CH-12	17.3	0.0203	2.5	0.01	21.3054187
CH-13	16.8	0.028	2.5	0.01	15
CH-14	15.1	0.014	2.5	0.01	26.9642857
CH-15	14.7	0.0145	2.5	0.01	25.3448276
CH-16	17.4	0.0145	2.5	0.01	30
CH-17	9.2	0.0223	2.5	0.01	10.3139013
CH-18	6.84	0.0199	2.5	0.01	8.59296482
CH-19	19.6	0.0175	2.5	0.01	28
CH-20	16.5	0.0125	2.5	0.01	33
CH-21	6.09	0.00685	2.5	0.01	22.2262774
CH-22	21.6	0.00678	2.5	0.01	**79.64602**
CH-23	23.3	0.0263	2.5	0.01	22.148289
CH-24	19.9	0.0207	2.5	0.01	24.0338164
CH-25	22.9	0.0204	2.5	0.01	28.0637255
CH-26	22.7	0.0194	2.5	0.01	29.2525773
CH-27	26.6	0.0156	2.5	0.01	**42.62821**
CH-28	34.9	0.0204	2.5	0.01	**42.76961**
CH-29	29.5	0.0156	2.5	0.01	**47.27564**
CH-30	30.8	0.04	2.5	0.01	19.25

TABLE 9. Inorganic Modified Elutriate Test results on Cleveland Harbor Federal navigation sediments (from EEI 2007).

	Harbor Sediments									
	Sampling Sites									
	CH-UEMU		CH-URMU		CH-LRMU		CH-OHMU		CH-ORMU	
Metal (µg/L)	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	4970	51.4	4970	126	2940	35.1	4530	46.9	3810	69
Antimony	1.3	0.89	2.3	0.85	1.7	1.1	0.5U	0.5U	0.8	0.75
Arsenic	16	4.6	13	9.4	16	12.1	10	4	7	4.1
Barium	81.9	32.3	83.2	46.4	82.2	59.1	104	67.7	53.4	30.2
Beryllium	0.42	0.1U*	0.31	0.1U	0.19	0.1U	0.2	0.1U	0.22	0.1U
Cadmium	0.88	0.11U	1.7	0.11U	1.1	0.11U	0.34	0.11U	0.39	0.11U
Calcium	49900	45900	55700	55400	59800	57800	44600	44200	36600	36100
Chromium	15.9	1U	17.8	1U	11	1U	7.3	1U	9.1	1U
Cobalt	5.1	1.2	4	1.6	2.5	1.1	2.8	1.1	2.1	1.2
Copper	37.5	1.3	27.9	1.5	18.1	0.66	11	1.1	13	1.5
Iron	13200	267	9090	582	5930	651	6280	245	5560	199
Lead	33.2	0.5U	30.3	0.77	20.9	0.5U	11.9	0.5U	13.8	0.5U
Magnesium	13300	11400	13500	13600	13800	13300	10800	10400	9820	8600
Manganese	748	323	430	396	591	509	1660	1530	248	157
Mercury	0.0398	0.0012	0.0391	0.0024	0.0267	0.0017	0.0212	0.00099	0.0251	0.0011
Nickel	20.6	4.1	17.3	5.4	11.7	4	9.1	3	8.2	2.2
Potassium	8030	6460	7750	7230	7080	6810	5010	4290	4520	3620
Selenium	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U
Sodium	22100	21200	25500	29900	28600	25000	20700	18500	22500	23400
Thallium	0.3U	0.3U	0.3U	0.3U	0.3U	0.3U	0.3U	0.3U	0.51	0.3U
Vanadium	14.1	3U	7.4	3U	4.8	3U	5.2	3U	4.5	3U
Zinc	131	3.4	163	7.4	103	2.8	48.5	3.3	61.2	6.6

	CH-UEMU		CH-URMU		CH-LRMU		CH-OHMU		CH-ORMU	
Misc. (mg/L)	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Ammonia	6.06	5.93	11	9.37	8.74	8.67	7.52	7.32	5.22	7.22
Total cyanide	0.00232J	0.00226J	0.0021J	0.00361J	0.0015U	0.0038	0.005U	0.00331U	0.00237J	0.0034J

*Not detected at or above the specified reporting limit.

**Estimated value between the detection limit and reporting limit.

TABLE 10. PAH Modified Elutriate Test results on Cleveland Harbor Federal navigation sediments (from EEI 2007).

	Harbor Sediments									
	Sampling Sites									
	CH-UEMU		CH-URMU		CH-LRMU		CH-OHMU		CH-ORMU	
PAH compound (µg/L)	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Acenaphthene	0.481U*	0.521U	0.485U	0.521U	0.197J**	0.521U	0.481U	0.521U	0.472U	0.521U
Acenaphthylene	0.481U	0.521U	0.485U	0.521U	0.481U	0.521U	0.481U	0.521U	0.472U	0.521U
Anthracene	0.481U	0.521U	0.485U	0.521U	0.481U	0.521U	0.481U	0.521U	0.472U	0.521U
Benzo(a)Anthracene	0.104	0.0786	0.127	0.0776	0.149	0.156	0.0839	0.0855	0.091	0.0784
Benzo(a)Pyrene	0.113	0.0917	0.152	0.0961	0.168	0.181	0.122	0.112	0.137	0.0957
Benzo(b)Fluoranthene	0.201	0.184	0.36	0.125	0.223	0.405	0.241	0.129	0.23	0.118
Benzo(ghi)Perylene	0.106	0.0871	0.142	0.0704	0.129	0.143	0.0762	0.0698	0.0693	0.0609
Benzo(k)Fluoranthene	0.024U	0.026U	0.0243U	0.026U	0.024U	0.026U	0.024U	0.026U	0.105	0.026U
Chrysene	0.134	0.113	0.17	0.0929	0.167	0.172	0.0918	0.0851	0.0922	0.0786
Dibenz(a,h)Anthracene	0.0481U	0.0521U	0.0485U	0.0521U	0.0481U	0.0521U	0.0481U	0.0521U	0.472U	0.0521U
Fluoranthene	0.287	0.234	0.379	0.169	0.411	0.254	0.213	0.149	0.134	0.0989
Fluorene	0.481U	0.521U	0.485U	0.521U	0.123J	0.521U	0.481U	0.521U	0.472U	0.521U
Indeno(1,2,3-cd)Pyrene	0.0481U	0.0521U	0.0485U	0.0521U	0.0481U	0.0521U	0.0481U	0.0521U	0.0472U	0.0521U
Naphthalene	0.481U	0.521U	0.485U	0.521U	0.481U	0.521U	0.481U	0.521U	0.472U	0.521U
Phenanthrene	0.481U	0.521U	0.294J	0.521U	0.258J	0.521U	0.481U	0.521U	0.472U	0.521U
Pyrene	0.303	0.249	0.444	0.203	0.506	0.386	0.268	0.159	0.237	0.154

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.

TABLE 11. PCB Modified Elutriate Test results on Cleveland Harbor Federal navigation sediments (from EEI 2007).

	Harbor Sediments									
	Sampling Sites									
	CH-UEMU		CH-URMU		CH-LRMU		CH-ORMU		CH-OHMU	
Aroclor (µg/L)	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
1016	0.0952U*	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1221	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1232	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1242	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1248	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1254	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U
1260	0.0952U	0.0106U	0.100U	0.103U	0.0952U	0.104U	0.098U	0.103U	0.0962U	0.0102U

*Not detected at or above the specified reporting limit.

TABLE 12. Pesticide Modified Elutriate Test results on Cleveland Harbor Federal navigation sediments (from EEI 2007).

Pesticide (µg/L)	Harbor Sediments									
	Sampling Sites									
	CH-UEMU		CH-URMU		CH-LRMU		CH-OHMU		CH-ORMU	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
4,4-DDD	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
4,4-DDE	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
4,4-DDT	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Aldrin	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Alpha-BHC	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Alpha-Chlordane	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Beta-BHC	0.0943U	0.111U	0.100U	0.111U	0.192U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Chlordane	1.18U	1.39U	1.25U	1.39U	1.20U	1.39U	0.243U	0.278U	1.23U	1.39U
Delta-BHC	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Dieldrin	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Endosulfan I	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Endosulfan II	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Endosulfan Sulfate	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Endrin	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Endrin Aldehyde	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Endrin Ketone	0.189U	0.222U	0.200U	0.222U	0.192U	0.222U	0.0388U	0.0444U	0.196U	0.222U
Gamma-BHC	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Gamma-Chlordane	0.0943U	0.111U	0.200U	0.111U	0.0962U	0.111U	0.0194U	0.0444U	0.098U	0.111U
Heptachlor	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Heptachlor Epoxide	0.0943U	0.111U	0.100U	0.111U	0.0962U	0.111U	0.0194U	0.0222U	0.098U	0.111U
Methoxychlor	0.943U	1.11U	0.100U	1.11U	0.962U	1.11U	0.194U	0.222U	2.45U	1.11U
Toxaphene	2.36U	2.78U	2.50U	2.78U	2.40U	2.78U	0.485U	0.556U	2.45U	2.78U

*Not detected at or above the specified reporting limit.

TABLE 13. Results of 10-day solid phase toxicity tests (bioassays) on Cuyahoga River sediments near upstream limit of Cleveland Harbor Federal navigation channels (from EEI 2007). Boldface/shaded values indicate statistically significant (P=0.05) difference relative to the open-lake reference area.

Composite sediment sample	Test species		
	H. azteca	***C. tentans***	
	Mean survival (%)	**Mean survival (%)**	**Mean growth (mg/org***
CH-UEMU	**0.52±02**	**0.72±0.03**	1.06±0.09
CL	0.88	0.94	1.01

*Ash-free dried weight.