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Taxonomic Evaluation of Cleveland Harbor Lake Areas

Alan J. Kennedy, Nathan E. Harms, and James M. Miller

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Final report

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Washington, DC 20314-1000

Abstract

The U.S. Army Corps of Engineers (USACE) performs routine maintenance dredging of federal navigation channels. Prior to dredging, an evaluation of the dredged material may be needed to determine the best management alternative. A dredging evaluation involves chemical and biological analysis to determine the potential impacts of the dredged material in both the water column during placement and the settled (in-place) material. Biological analysis employs laboratory toxicity bioassays using water column or sediment-dwelling organisms. Standardized test organisms are used in bioassays as surrogates for organisms indigenous to the dredged material disposal site. Thus, it is important to determine what organisms are present at the disposal site. This report provides a survey of indigenous benthic macroinvertebrates present at prospective disposal site locations considered by USACE Buffalo District for use in the dredging of Cleveland Harbor. Results indicated a relatively low abundance and diversity of benthic macroinvertebrate organisms at the study locations. An analysis of pollution sensitivity of the organisms at the prospective disposal sites indicated that the standard surrogate organisms used in laboratory toxicity bioassays would be adequately protective of the species present at these locations.

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Preface

This study was conducted for the Buffalo District of the U.S. Army Corps of Engineers (USACE-LRB) under Project "FY12 CLV DREDGE ERDC TECH SUPPORT & DATA MANAGEMENT." The technical monitor was James M. Miller.

The work described herein resulted from communications between the USACE Buffalo District (LRB), the Dredging Operations and Technical Support Program (Cynthia Banks, Program Manager) and the Dredging Operations Environmental Research Program (Dr. Todd Bridges, Program Manager). USACE-LRB executed the field collection effort and directly funded the laboratory work conducted at the US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL).

The work was performed by the Environmental Risk Assessment Branch (EP-R), of the Environmental Processes and Engineering Division (EP), ERDC-EL. At the time of publication, Buddy Goatcher was Chief, CEERD-EP-R; Warren Lorentz was Chief, CEERD-EP; and Al Cofrancesco, CEERD-EM-W, was the Technical Director. The Deputy Director of ERDC-EL was Dr. Jack Davis and the Director was Dr. Beth Fleming.

COL Jeffrey R. Eckstein was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
gallons (US liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
inches	0.0254	meters
miles (US statute)	1,609.347	meters
mils	0.0254	millimeters
yards	0.9144	meters

1 Introduction

Cleveland Harbor is located in north-central Ohio within Cuyahoga County along the southern shore of Lake Erie at the mouth of the Cuyahoga River. The US Army Corps of Engineers (USACE), Buffalo District (LRB), conducts annual maintenance dredging within the Federal navigation channels of the harbor. As part of these maintenance activities, the USACE is required to evaluate the quality of the dredged material in accordance with standard guidance (US Environmental Protection Agency (USEPA)/ USACE 1998a,1998b) to determine the best available management option. This evaluation involves chemical and toxicological analysis in the laboratory of field-collected sediment and water. The quality of Federal navigation channel sediments is compared to reference (open-water) area sediments. Due primarily to numerous past and present industrial uses of the area, sediments historically dredged from the Federal navigation channels at Cleveland Harbor have contained levels of contamination that cause them to be unsuitable for open-water placement. As a result, these sediments have been placed in a series of constructed confined disposal facilities (CDFs). However, recent sediment data generated on Cleveland Harbor Federal navigation channels suggest that sediment quality in the upper reach of the Cuyahoga River Channel has substantially improved, and has the potential to be suitable for open-water placement. Typically, placement of relatively clean dredged material in a designated open-water area is the most economical management alternative relative to use of a CDF or upland placement. If some of the dredged material from the harbor is determined suitable for open-lake placement, this could substantially reduce the need for CDF or other upland disposal capacity. However, since sediments from the harbor have historically been placed within CDFs, there is no existing, authorized open-water placement area for Cleveland Harbor dredged material.

Accordingly, in an effort to identify a suitable placement area in Lake Erie, sediment samples were collected from two candidate open-water areas to assess the existing physical, chemical, and toxicological sediment characteristics of the lake environments. An additional important consideration is the indigenous benthic community present within each lake area. According to the Code of Federal Regulations (CFR) § 230.61:

> *When an analysis of biological community structure will be of value to assess the potential for adverse environmental impact at the proposed disposal site, a comparison of the biological characteristics between the excavation and disposal sites may be required by the permitting authority. Biological indicator species may be useful in evaluating the existing degree of stress at both sites. Sensitive species representing community components colonizing various substrate types within the sites should be identified as possible bioassay organisms if tests for toxicity are required. Community structure studies should be performed only when they will be of value in determining discharge conditions. This is particularly applicable to large quantities of dredged material known to contain adverse quantities of toxic materials. Community studies should include benthic organisms such as microbiota and harvestable shellfish and finfish. Abundance, diversity, and distribution should be documented and correlated with substrate type and other appropriate physical and chemical environmental characteristics.*

Thus, knowledge of the biological community at the site of exposure is important for determining the baseline health of the system. Dredging evaluations can benefit from knowledge of the types of benthic macroinvertebrates present at the site(s) to elucidate which organisms the evaluation is attempting to protect and whether the standard organisms used in laboratory toxicity bioassays are representative and protective of the most pollution-sensitive organisms at the site. The USACE-LRB requested that the US Army Engineer Research and Development Center (ERDC) Environmental Laboratory (ERDC-EL) identify benthic macroinvertebrates from the two lake areas to provide an idea of indigenous taxa present. Sediments were collected by USACE-LRB and shipped to ERDC-EL for processing. This report summarizes the results of the taxonomic analysis of the selected lake areas.

2 Methods

Study sites

Four candidate areas (Figure 1) were preliminarily identified by the USACE-LRB. These proposed areas were shared with local agencies and sponsors in an effort to identify any significant resources or other interests that may be affected by the use of the areas. Through this coordination, USACE initially determined that Areas 3 and 4 were the preferred locations for an eventual open-water area. However, once field collection efforts commenced, it was discovered that the predominant substrate present within Area 3 was coarse sands and gravels. These types of substrates are different from those that would eventually be placed there (which are predominantly fine sands, silt, and clay), and they typically represent preferred spawning/foraging habitats for Lake Erie aquatic biota. Therefore, it was determined in the field that it would be more appropriate to sample and further evaluate Area 1. A brief description of the evaluation of Areas 1 and 4 follows:

Lake Area 1 (CLA1): This area, shown in Figure 1, represents the historic open-lake placement area for Cleveland Harbor (per 1941 USACE drawing). While this area was historically used for dredged material placement prior to the implementation of the Clean Water Act, it is not an authorized area under the Act (Section 404) and thus has not been authorized for further use. This site is approximately 5 km^2 (518 ha), and is located 14.5 km due north of the West Breakwater Light (Main Entrance Light). Average water depth in the area is over 18 m. Four replicate samples were collected from this area, with coordinates and depths provided in Table 1.

Lake Area 4 (CLA4): This area, shown in Figure 1, represents a proposed new open-lake placement area for the Cleveland Harbor and has not been historically used. The area is approximately 5 km^2 (518 ha) and is located 8 km northwest of the West Breakwater Light (azimuth 305°), directly north of the authorized Rocky River Harbor placement areas. Average water depth in the area is approximately 16.8 m. Four replicate samples were collected from this area, with coordinates and depths provided in Table 1.

Figure 1. Map of study areas. CLA1 and CLA4 are represented with a red 1 and 4, respectively.

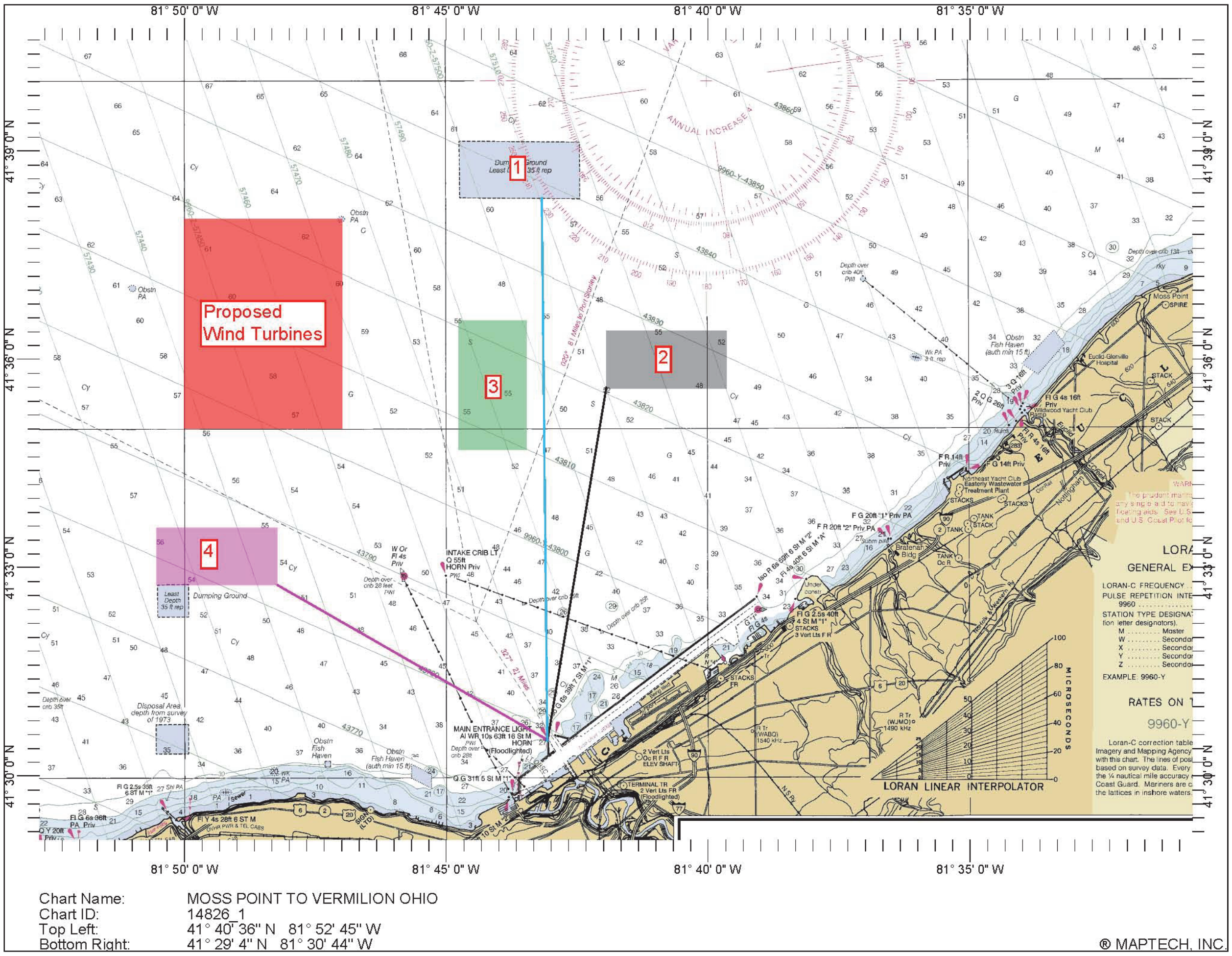


Table 1. Study area locations.

Study Location	Latitude (N)	Longitude (W)	Depth (m)
CLA1-01	41.64828°	081.73908°	19.2
CLA1-02	41.64859°	081.71592°	18.6
CLA1-03	41.64000°	081.73888°	18.6
CLA1-04	41.64435°	081.72788°	18.9
CLA4-01	41.55190°	081.83347°	17.4
CLA4-02	41.55175°	081.83328°	16.5
CLA4-03	41.55908°	081.81408°	16.8
CLA4-04	41.55173°	081.81448°	16.5

Benthic macroinvertebrate collection

Samples from CLA4 were collected on 1 May 2012; those from CLA1 were collected on 2 May 2012. Four replicate samples from each location were collected using a standard (8.2-L) stainless steel ponar grab (229 x 229 mm) in basic accordance with USEPA (2001). The grab sampler was dropped from a sufficient height to penetrate the sediment without overtopping. Upon retrieval, the grab was inspected to determine if the sample was intact or if it was compromised (e.g., overtopping, uneven sediment distribution). If the sample was compromised, it was discarded and a new sample was collected. Generally, the grab was relatively full, with slightly more volume collected for CLA4 relative to CLA1. Each replicate sample was transferred to a separate 2.5-gallon (9.5-L) HDPE bucket and the grab was inspected for remaining material, which was rinsed into the bucket. Between each sample, the grab was thoroughly cleaned with site water to avoid cross-contamination of samples. The buckets were shipped overnight on ice to the ERDC-EL in good condition (2.5–4 °C; Appendix A).

Benthic macroinvertebrate sample sorting

Upon receipt, samples were immediately processed by wet sieving through stacked 1.0- and 0.5-mm stainless steel sieves to separate coarse and fine material. Sample material retained in both sieves was thoroughly backwashed into pans and inspected and rinsed again for leftover debris. Sample that passed through the 0.5-mm sieve was discarded, as directed by standard guidance (Barbour et al. 1999). Material retained in the sieves was immediately preserved in ethanol, diluted to 70%, and stored for further processing.

Preserved samples were examined and sorted with a dissecting microscope (max objective: 100x) by experienced laboratory technicians until all macroinvertebrates were removed. Morphologically similar macroinvertebrates within each sample were sorted into separate 20-ml glass scintillation vials containing 70% ethanol for taxonomic identification. In addition, a quality assurance–quality control (QA-QC) check of all sorted samples was conducted by an experienced ERDC scientist to ensure that specimens were not missed during initial sorting.

Benthic macroinvertebrate identification

Sorted benthic macroinvertebrates were identified to the lowest practical taxonomic designation (usually genus) using standard dichotomous keys. Insects were identified to genus using Merritt et al. (2008) and Oliver and Roussel (1983), while worms and bivalves were identified to the lowest practical taxonomic designation (usually family or genus) using Smith (2001) or Thorp and Covich (2001). Generally, a dissecting microscope was used to examine specimen anatomy. However, identifying some macroinvertebrates required assessing characteristics that are difficult to distinguish with a dissecting microscope. For this reason, morphotypes in the oligochaete and chironomid groups were distinguished and representative specimens were mounted on microscope slides. Oligochaete specimens were placed into CMC-10 mounting media (Masters Company, Inc., Wood Dale, Illinois) and covered with a cover slip. Chironomids were decapitated and both head capsule and body were mounted in CMC-10 under separate cover slips. Chironomid head capsules were mounted in a ventral view, which allowed for examination of key features. Slide mounts were stored at room temperature for approximately 1 week to allow the clearing action of the mounting media to complete. Slide-mounted specimens were then identified using a compound microscope at various objectives (up to 500X).

Data analysis

Benthic macroinvertebrate indices such as abundance, richness, diversity, and similarity descriptions are provided in Table 2 and are further described in Barbour et al. (1999).

Enumerations from each taxonomic group were summarized in Microsoft Excel and mean values, variability (expressed as one standard deviation from the mean), and graphics were generated using Microsoft Excel pivot tables. Pollution tolerance values and functional feeding group information were obtained from Barbour et al. (1999) and Merritt et al. (2008). Pollution tolerance scores range from 0-10, with 0 being most pollution sensitive and 10 being most pollution tolerant. All statistical comparisons and determinations of data normality (Kolmogorov-Smirnov test) and homogeneity (Levene's test) were performed using Sigmastat v3.5 software (SSPS, Chicago, Illinois, USA). A simple t-test was used to determine statistical differences in biological metrics at the level of $\alpha = 0.05$.

Table 2. Metrics used to summarize the benthic macroinvertebrate community data.

Metric	Description
Total abundance	Total enumeration of all macroinvertebrates
Mean abundance	Average number of all macroinvertebrates between replicates (presented with one standard deviation around the mean)
Total taxa richness	Total number of different types of macroinvertebrate taxa at a site (all replicates).[1]
Mean taxa richness	Average number of taxa between replicates (presented with one standard deviation around the mean).[1]
Total family richness	Total number of different types of macroinvertebrate taxa at the family level. [1]
Mean family richness	Average number of taxa between replicates (presented with one standard deviation around the mean).[1]
Relative abundance	Proportion or percentage that a specific group makes up in the total community composition.
Diversity (Shannon Index)	Measure of species diversity that takes into account the number and evenness of species. The index is increased by having (1) additional unique species, or (2) greater species evenness. Diversity was assessed at the family level for tubificid worms and sphaeriid clams due to a number of immature specimens that could not be identified to genus level.
Similarity (Bray-Curtis)	An index that compares the benthic community composition between two sites. The index ranges from 0 to 1, with 1 being most similar and 0 being most dissimilar. Similarity was performed at the family level for tubificid worms and sphaeriid clams due to a number of immature specimens that could not be identified to genus level.

[1] Immature taxa that could not be identified to genus were not counted in richness indices if at least one mature specimen was present from the same family.

3 Results and Discussion

Benthic macroinvertebrate identification

It was possible to identify all specimens to the generic taxonomic level with the exception of some immature sphaeriid clams and tubificid worms that did not have the developed features necessary to key them out to the genus level. It was assumed that the immature specimens were from the same genus as the mature specimens present for the purposes of taxa richness indices. In addition, nematode worms and leeches were not identified to genus.

Study areas CLA1 and CLA4 were comparable in terms of total abundance, mean abundance (between replicates), and total and mean taxa richness (Table 3). No statistically significant differences were found for abundance or richness metrics between the areas using simple t-tests. However, the diversity scores for CLA4 were significantly greater than CLA1 (Table 3). The Bray-Curtis similarity index comparing CLA1 and CLA4 was 0.78. This indicates that taxonomic composition of the areas was fairly similar, with slight dissimilarity occurring due to presence/absence of leeches (one specimen in one sample), dreissenid mussels (present in one sample), and Nematode worms (present in two samples). Differences in diversity and similarity between the two areas were caused by the greater diversity of tubificid worm genera in CLA1 and the greater diversity of chironomid genera in CLA4.

The most abundant phylum was the segmented annelid worms (Figure 2), which consisted of three genera from the oligochaete family Tubificidae and one specimen from the leech family Glossiphoniidae (Figure 3). The second-most-abundant phylum was Arthropoda (e.g., insects, crustaceans), which was represented only by the insect family Chironomidae (midges, or non-biting flies). Mollusks were the third-most-abundant phylum, consisting of sphaeriid clams and dreissenid (zebra/quagga) mussels. Finally, the phylum Nematoda (segment-less worms) was represented by only four individual specimens (<2% of the total).

Table 3. Total abundance, richness, and diversity values for the study sites. Statistical results of simple t-tests are indicated to the right, with statistical significance and p-values also indicated. For statistically significant differences to be determined, the p-value must be less than 0.05 (i.e., alpha value).

Metric	CLA1	CLA4	Statistically significant? ($p < 0.05$)	p-value
Total abundance (in samples)	199	201	--	--
Mean abundance (in samples)	49.8 ± 15.4	50.3 ± 28.0	No	0.976
Total abundance (per square meter[1])	189 ± 46	191 ± 102	No	0.976
Total taxa richness	8	8	--	--
Mean taxa richness	3.8 ± 0.5	4.5 ± 1.9	No	0.477
Total family richness	4	4	--	--
Mean family richness	3.3 ± 0.5	3.5 ± 1.3	No	0.730
Diversity (Shannon Index)	0.81 ± 0.05	1.03 ± 0.07	Yes	0.002
Diversity (Simpson Index)	1.72 ± 0.02	2.27 ± 0.07	Yes	<0.001
Similarity (Bray-Curtis)	0.78		--	

[1]Calculated.

Table 4 is a more detailed summary of total and average abundance of the lowest practical taxonomic designation for each of the study areas. Appendix B is a list of specimens identified in each individual study area replicate, including functional feeding groups and pollution tolerance scores. The density ranged from 572–1,201 organisms per square meter, which is on the low end of previously reported densities in the Great Lakes (Barton and Griffiths 1984). Generally, pollution tolerance scores for macroinvertebrates in the CLA1 and CLA4 samples ranged from 4 to 10, with most species being more pollution tolerant (scores of 8–10). The majority of organisms identified were either collector-gathers or collector-filterers, with a small number of predators.

Figure 2. Relative abundance of different phyla at both sites (a), at CLA1 (b), and at CLA4 (c).

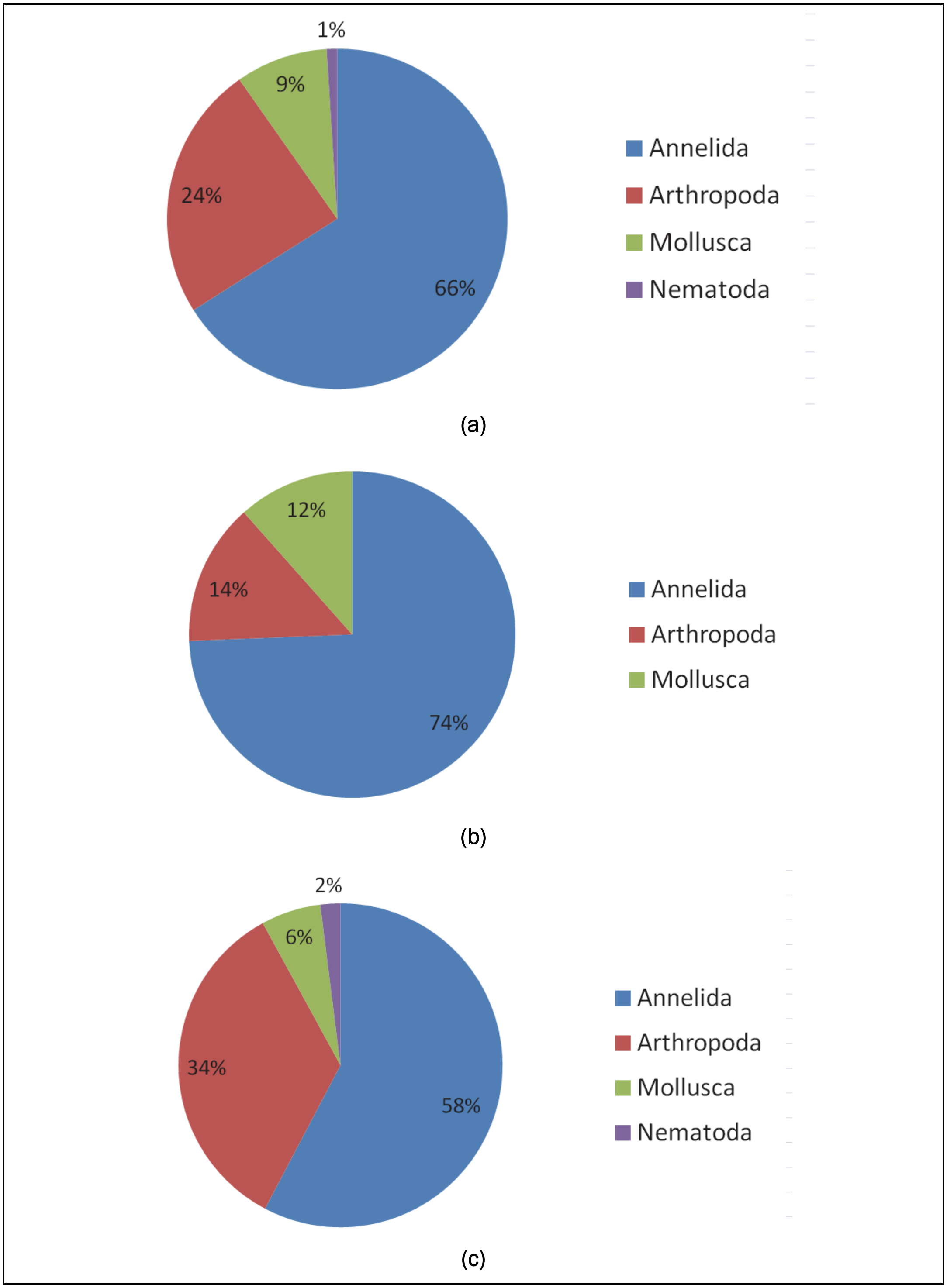
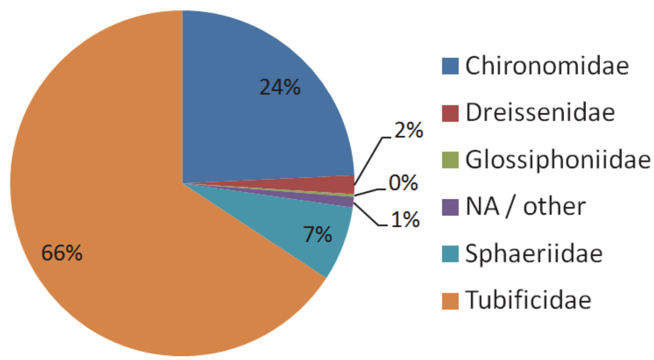
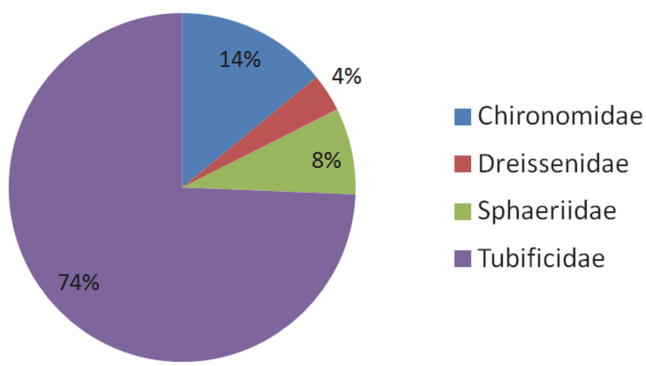


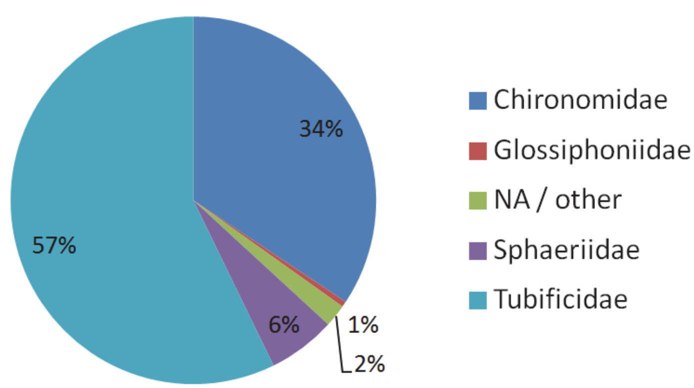
Figure 3. Relative abundance of different families at both study areas (a), at CLA1 (b), and at CLA4 (c). NA/other refers to specimens in the phyla Nematoda.



(a)



(b)



(c)

Table 4. Summary of total and average abundance of taxa present at the study sites.

Common name	Lowest Practical Taxon	CLA1		CLA4	
		total	Average	total	Average
Clams	*Pisidium* sp.	13	3.3 + 2.2	10	2.5 + 2.6
	Sphaeriidae[1]	3	0.8 + 1.5	2	0.5 + 1.0
	Total Clams	16	4.0 + 2.9	12	3.0 + 3.6
Leech	Glossiphoniidae	0	0 + 0	1	0.3 + 0.5
Midges	*Chironomus* sp.	27	6.8 + 1.7	63	15.8 + 14.1
	Paratanytarsus sp.	1	0.3 + 0.5	1	0.3 + 0.5
	Procladius sp.	0	0 + 0	5	1.3 + 1.0
	Total midges	28	7.0 + 1.6	69	17.3 + 14.6
Mussels	*Dreissena polymorpha*	7	1.8 + 3.5	0	0 + 0
Nematodes	Nematoda	0	0 + 0	4	1.0 + 1.4
Oligochaete worms	*Aulodrilus* sp.	1	0.3 + 0.5	0	0 + 0
	Limnodrilus sp.	6	1.5 + 3	0	0 + 0
	Quistadrilus sp.	21	5.3 + 4.1	7	1.8 + 2.4
	Tubificidae	120	30.0 + 7.3	108	27.0 + 12.2
	Total worms	148	37.0 + 9.7	115	+ 11.6

[1] Immature.

Comparison to previous collections

Although benthic invertebrates were not previously collected for USACE-LRB from the current study areas, general taxonomic information is available for benthic communities assessed at other locations in the region. The nearest site for which comparison information is available is Vermilion Harbor, Ohio (Engineering and Environmental, Inc. 2002). Thus, the relevance of this comparison is low. However, a comparison does provide context in regard to the diversity of taxa that would need protection at the current, candidate sites versus other areas in the lake. There were considerable differences in invertebrate community taxa between Vermillion and Cleveland Harbor, including the presence of *Hexagenia* sp. (Ephemeroptera: Ephemeridae), *Amnicola* sp. (Gastropoda: Hydrobiidae), *Campeloma* sp. (Gastropoda: Viviparidae), *Ablabesmyia* sp. (Diptera: Chironomidae), *Cryptochironomus* sp., *Rheotanytarsus* sp., *Optioservus* sp., *Larsia* sp., *Stictochironomus* sp., *Paratendipes* sp., *Coelotanypus* sp. (Diptera: Chironomidae), *Phaenospectra* sp. (Diptera: Chironomidae), *Branchiura sowerbyi* (Oligochaeta: Tubificidae), and *Potamothrix* sp. in the Vermilion Harbor samples. *Amnicola* sp. and *Campeloma* sp. require increased dissolved oxygen levels (Berry 1943, Dillon et al. 2006). Though little site information was available in the report, field notes indicate that the Vermilion Harbor locations were shallower (13.7 m) than the locations in this study (Table 1). In summary, the candidate sites in Cleveland Harbor have relatively lower diversity and fewer pollution-sensitive organisms. Thus, disposal activity would be expected to have relatively less of an impact than at a site with high taxa diversity and large numbers of pollution-sensitive organisms.

Comparison to organisms in standard sediment toxicity bioassays

Most organisms collected from the lake areas were relatively pollution-tolerant (8-10). The standard 10-d whole sediment toxicity tests employed in freshwater dredging evaluations utilize the midge *Chironomus dilutus* (formerly *C. tentans*) and the amphipod *Hyalella azteca* (USEPA/USACE 1998a, 1998b; USEPA 1994). A relatively large number (24% of the community) of larval midge flies (Chironomidae) were found in the lake samples (Figure 3), with most in the genus *Chironomus*. The standard toxicity test organism *C. dilutus* has a pollution tolerance score of 8 to 10, indicating high tolerance. The other standard sediment toxicity bioassay organism is the amphipod *Hyalella azteca*. This organism was not found at the lake areas, and also has a tolerance value of 8. However, amphipods are generally considered a sensitive sediment test organism (USEPA 1994) and thus should be protective of the organisms found at the lake areas. While it cannot be stated that one species used in the laboratory whole sediment toxicity tests is more sensitive to pollutants than the other, *H. azteca* is typically more sensitive to metals while the genus *Chironomus* was reported to be more sensitive to pesticides (Phipps et al. 1995; Milani et al. 2003). Oligochaete worms, which were very abundant at both sites, are generally less sensitive than *Chironomus* species and *H. azteca* (Milani et al. 2003).

4 Conclusion

The benthic macroinvertebrate community samples collected from the two Lake Erie areas were fairly similar, with slightly greater diversity at Lake Area 4 (CLA4). Overall, the communities in both areas had a relatively low density (572–1201 m^2) and low taxonomic richness. Further, the majority of the organisms present were rated pollution tolerant (8-10). Typically a benthic community with predominately pollution-tolerant organisms is considered adversely impacted. However, the depth of these samples (16.5-19.2 m) is likely to be at least partially responsible for the reduced density of benthic macroinvertebrates compared to densities found in fine-grained sediments at more shallow (<10 m) sites (Barton and Griffiths 1984). Finally, of the two organisms used in toxicity testing of Great Lakes sediments (*Chironomus dilutus*, *Hyalella azteca*), only *Chironomus spp.* was found. Both toxicity test organisms have a similar pollution tolerance score that is also comparable to the organisms collected from the lake areas; thus, it is expected that laboratory toxicity tests with the standard organisms *C. dilutus* and *H. azteca* would be protective of the indigenous organisms (pollution tolerance: 8-0) at the two lake areas.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish*. 2nd ed. EPA 841-B-99-002. Washington, DC: U.S. Environmental Protection Agency; Office of Water.

Barton, D.R., and M. Griffiths. 1984. Benthic invertebrates of the nearshore zone of eastern Lake Huron, Georgian Bay, and North Channel. *Journal of Great Lakes Research* 10:407-416.

Berry, E. 1943. *The Amnicolidae of Michigan: Distribution, ecology, and taxonomy*. Misc. Publ. Mus. Zool. U. Mich. 57:1-68.

Dillon, R. T., Jr., B. T. Watson, T. W. Stewart, and W. K. Reeves. 2006. *The freshwater gastropods of North America*. http://www.fwgna.org

Engineering and Environmental, Inc. 2002. *Sediment sampling for chemical and physical analysis – Vermillion Harbor, Ohio: Appendix B – Benthic macroinvertebrate enumeration results*. Technical Report, Contract No DACW49-00-D-004, Delivery Order No. 001.

Merritt, R. W., K. W. Cummins, and M. B. Berg, ed. 2008. *Aquatic insects of North America*. 4th ed. Dubuque, IA: Kendall/ Hunt Publishing Co.

Milani, D., T. B. Reynoldson, U. Borgmann, J. Kolasa. 2003. The relative sensitivity of four benthic invertebrates to metals in spiked-sediment exposures and application to contaminated field sediment. *Environmental Toxicology and Chemistry* 22: 845-854.

Oliver, D. R., and M. E. Roussel. 1983. The genera of larval midges of Canada (Diptera: Chironomidae). Agric. Can. Publ. No. 1746.

Phipps, G.L., V. R. Mattson, and G. T. Ankley. 1995. Relative sensitivity of three freshwater benthic macroinvertebrates. *Archives of Environmental Contamination and Toxicology* 28:281-286.

Smith, D.G. 2001. Pennak's *Freshwater Invertebrates of the United States*. 4th ed. John Wiley & Sons, Hoboken, NJ. 638 pp.

Thorp, J. H., and A. P. Covich. 2001. *Ecology and classification of North American freshwater invertebrates*. 2nd ed. San Diego, CA: Academic Press.

US Environmental Protection Agency (USEPA), 1994. *Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods*. EPA/600/R-94/025. US Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 2001. *Methods for collection, storage, and manipulation of sediments for chemical and toxicological analyses: Technical Manual*. EPA-823-B-01-002. Washington, DC: U.S. Environmental Protection Agency.

US Environmental Protection Agency/US Army Corps of Engineers (USEPA/USACE). 1998a. *Evaluation of Material Proposed for Discharge to Waters of the U.S. - Testing Manual (Inland Testing Manual)*. EPA-823-B-98-004, Office of Water, Washington DC.

US Environmental Protection Agency/US Army Corps of Engineers (USEPA/USACE). 1998b. *Great Lakes Dredged Material Testing and Evaluation Manual*. Prepared by US EPA Regions 2, 3 and 5, Great Lakes National Program Office and US Army Corps of Engineers Great Lakes and Ohio River Division. Office of Water, Washington DC.

Appendix A: Sample Chain of Custody

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: CLEVELAND HARBOR

SAMPLERS: (Signature) [signature]

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS	BENTHIC ENVIRONMENT						REMARKS
	5/2	0925		X	CLA1-1	1	X						4.5 °C
	5/2	0945		X	CLA1-2	1	X						3.5 °C

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
[signature]	5/2/12 1800	[signature] 1300 5/3/12			

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks
				* ATTN: AL KENNEDY

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

13376

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: CLEVELAND HARBOR

SAMPLERS: *(Signature)*

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	BENTHIC ENUMERATION						REMARKS
	5/2	1040		X	CLA1-3	1	X						25°C
	5/2	1010		X	CLA1-4	1	X						

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
	5/2/12 1800	1300 5/3/12			

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

13377

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.:

PROJECT NAME: CLEVELAND HARBOR

SAMPLERS: *(Signature)* [signature]

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	BENTHIC ENUMERATION					REMARKS
	5/1	1420		X	CLA4-1	1	X					4°C
	5/1	1455		X	CLA4-2	1	X					3°C

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
[signature]	5/1/12 1800	[signature] 5/2/12 1200			
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks
				SAMPLES FOR AL KENNEDY

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

13368

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.:

PROJECT NAME: CLEVELAND HARBOR

SAMPLERS: *(Signature)* [illegible]

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	BENTHIC ENVIRONMENTAL						REMARKS
	5/1	1510		X	CLAY-3	1	X						4°C
	5/1	1530		X	CLAY-4	1	X						4°C

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
[illegible]	5/1 1800	[illegible] 5/2/12 1200			
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks
				SAMPLES FOR AL KENNEDY

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

13369

Appendix B: Complete Taxa List, Including Functional Feeding Groups and Pollution Tolerance

CG – collector-gatherer; CF – collector-filterer; PR – predator; PA - parasite

Site ID	Replicate	Phylum	Class/Order	Family	Genus	Lowest Designation	Functional Group†	Common Name	Pollution Tolerance#	Abundance	Density (m^2)
CLA1	1	Mollusca	Bivalvia	Sphaeriidae*		Sphaeriidae[1]	CF	Clam	8	3	57
	1	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	4	76
	1	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	9	172
	1	Annelida	Oligochaeta	Tubificidae	*Aulodrilus* sp.	*Aulodrilus* sp.	CG	Worm	5 - 8	1	19
	1	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	38	725
	1	Annelida	Oligochaeta	Tubificidae	*Quistradrilus* sp.	*Quistradrilus* sp.	CG	Worm	10	8	153
	2	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	2	38
	2	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	5	95
	2	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	26	496
	2	Annelida	Oligochaeta	Tubificidae	*Limnodrilus* sp.	*Limnodrilus* sp.	CG	Worm	10	6	114
	3	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium sp.*	CF	Clam	5‡ - 8	1	19
	3	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus sp.*	CG	Midge	8‡ - 10	6	114
	3	Arthropoda	Insecta/Diptera	Chironomidae	*Paratanytarsus* sp.	*Paratanytarsus* sp.	CG	Midge	4‡ - 6	1	19
	3	Annelida	Oligochaeta	Tubificidae*		*Tubificidae*[1]	CG	Worm	10	22	420
	3	Annelida	Oligochaeta	Tubificidae	*Quistadrilus* sp.	*Quistadrilus sp.*	CG	Worm	10	4	76
	4	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	6	114

Site ID	Replicate	Phylum	Class/Order	Family	Genus	Lowest Designation	Functional Group†	Common Name	Pollution Tolerance#	Abundance	Density (m²)
	4	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	7	133
	4	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	34	648
	4	Annelida	Oligochaeta	Tubificidae	*Quistadrilus* sp.	*Quistradrilus* sp.	CG	Worm	10	9	172
	4	Mollusca	Bivalvia	Dreissenidae	*Dreissena polymorpha*	*Dreissena polymorpha*	CF	Mussel	NA	7	133
CLA4	1	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	4	76
	1	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	21	400
	1	Annelida	Oligochaeta	Tubificidae	*Quistadrilus* sp.	*Quistradrilus* sp.	CG	Worm	10	5	95
	2	Mollusca	Bivalvia	Sphaeriidae*		Sphaeriidae[1]	CF	Clam	8	2	38
	2	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	6	114
	2	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	32	610
	2	Arthropoda	Insecta/Diptera	Chironomidae	*Procladius* sp.	*Procladius* sp.	PR	Midge	7‡ - 9	2	38
	2	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	44	839
	3	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	1	19
	3	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	4	76
	3	Arthropoda	Insecta/Diptera	Chironomidae	*Paratanytarsus* sp.	*Paratanytarsus* sp.	CG	Midge	4‡ - 6	1	19

Site ID	Replicate	Phylum	Class/Order	Family	Genus	Lowest Designation	Functional Group†	Common Name	Pollution Tolerance#	Abundance	Density (m^2)
	3	Arthropoda	Insecta/Diptera	Chironomidae	*Procladius* sp.	*Procladius* sp.	PR	Midge	7‡ - 9	1	19
	3	Nematoda				Nematoda	PA	Nematode	5	3	57
	3	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	16	305
	4	Mollusca	Bivalvia	Sphaeriidae	*Pisidium* sp.	*Pisidium* sp.	CF	Clam	5‡ - 8	3	57
	4	Annelida	Hirudinea	Glossiphoniidae		Glossiphoniidae	PR	Leech	8	1	19
	4	Arthropoda	Insecta/Diptera	Chironomidae	*Chironomus* sp.	*Chironomus* sp.	CG	Midge	8‡ - 10	23	439
	4	Arthropoda	Insecta/Diptera	Chironomidae	*Procladius* sp.	*Procladius* sp.	PR	Midge	7‡ - 9	2	38
	4	Nematoda				Nematoda	PA	Nematode	5	1	19
	4	Annelida	Oligochaeta	Tubificidae*		Tubificidae[1]	CG	Worm	10	27	515
	4	Annelida	Oligochaeta	Tubificidae	*Quistadrilus* sp.	*Quistradrilus* sp.	CG	Worm	10	2	38

* Immature specimen

† Merritt et al. (2008)

‡ Midwest (OH) from Barber et al. (1999)

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

The U.S. Army Corps of Engineers (USACE) performs routine maintenance dredging of federal navigation channels. Prior to dredging, an evaluation of the dredged material may be needed to determine the best management alternative. A dredging evaluation involves chemical and biological analysis to determine the potential impacts of the dredged material in both the water column during placement and the settled (in-place) material. Biological analysis employs laboratory toxicity bioassays using water column or sediment-dwelling organisms. Standardized test organisms are used in bioassays as surrogates for organisms indigenous to the dredged material disposal site. Thus, it is important to determine what organisms are present at the disposal site. This report provides a survey of indigenous benthic macroinvertebrates present at prospective disposal site locations considered by USACE Buffalo District for use in the dredging of Cleveland Harbor. Results indicated a relatively low abundance and diversity of benthic macroinvertebrate organisms at the study locations. An analysis of pollution sensitivity of the organisms at the prospective disposal sites indicated that the standard surrogate organisms used in laboratory toxicity bioassays would be adequately protective of the species present at these locations.

15. SUBJECT TERMS

	Dredged material	
Cleveland Harbor	Dredging toxicity	Sediment
Confined disposal facilities	Open-water placement	Upland disposal

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
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