EVALUATION OF DULUTH-SUPERIOR HARBOR FEDERAL NAVIGATION CHANNEL DREDGED MATERIAL WITH RESPECT TO SUITABILITY FOR OPEN-WATER PLACEMENT

1.0 INTRODUCTION AND BACKGROUND

Duluth-Superior Harbor is located in the States of Minnesota and Wisconsin at the western tip of Lake Superior. Federal navigation channels are deep-draft and designed to accommodate commercial navigation, and include two Entrance Channels (Superior Entry and Duluth Ship Canal) and a series of Inner Harbor Channels in Superior Bay, Allouez Bay, St. Louis Bay and St. Louis River. These channels have authorized depths ranging from -20 to -32 feet low water datum (LWD)[1]. Duluth-Superior Harbor is situated within the designated St. Louis River System Great Lakes Area of Concern (AOC) (U.S. Environmental Protection Agency [USEPA] 2012a). The Remedial Action Plan (RAP) focus is mainly on the lower 39 river miles of the St. Louis River downstream of Cloquet, Minnesota, and the Nemadji River watershed.

The objective of this report is to serve as a preliminary evaluation of whether material dredged from Duluth-Superior Harbor Federal navigation channels meets Federal guidelines for open-water placement. This evaluation is in accordance with the protocols and guidelines prescribed in the Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/U.S. Army Corps of Engineers [USACE] 1998a) and Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.—Testing Manual (USEPA/USACE 1998b), and is specific to 40 CFR 230.11(d) ("contaminant determination") (USEPA 2012b). This evaluation is consistent with 33 CFR 336 toward establishment of the Federal standard relating to the least costly dredged material management alternative, consistent with sound engineering practices and selected through Section 404(b)(1) Guidelines (USACE 2012).

2.0 SEDIMENT SAMPLING AND TESTING

This evaluation is based mainly on 2011 analyses performed on sediment samples collected from Duluth-Superior Harbor Federal navigation channels, two deep water open-lake areas offshore of Minnesota and Wisconsin in Lake

[1] Low Water Datum for Lake Superior is elevation 601.1 feet above mean water level at Rimouski, Quebec, Canada (International Great Lakes Datum [IGLD] 1985).

Superior, and two inner harbor areas within Minnesota in Saint Louis Bay and Superior Bay.

2.1 2011 Investigation

The objective of this effort was to determine whether material dredged from Duluth-Superior Harbor Federal navigation channels will meet Federal guidelines (which includes compliance with applicable State water quality standards [WQSs]) for open-water placement. This investigation entailed the collection of bulk surface grab samples from the Federal navigation channels, which were represented by Sites DS-11-01 through DS-11-30 (Figure 1). In addition, surface grab discrete samples were collected from a total of four proposed open-water placement areas, including two deep water open-lake areas—Minnesota open-lake placement area (Sites DS-11-31 through DS-11-35) and Wisconsin open-lake placement area (Sites Sites DS-11-36 through 40); and two inner harbor areas—Hearding Island area (Sites DS-11-41 through DS-11-45); and Interstate Island area (DS-11-46 through 50) (see Figure 1). Sediment samples were analyzed as follows:

●All discrete samples were analyzed for bulk particle size, metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc), total cyanide, oil and grease, total organic carbon (TOC), ammonia (as nitrogen [N]), total Kjedlahl nitrogen (TKN), total phosphorus (tP), polychlorinated biphenyls (PCBs) (as Aroclors) and polycyclic aromatic hydrocarbons (PAHs) (16 USEPA priority pollutants). The primary purpose of this bulk sediment testing was to identify any contaminants of concern (COC) in the dredged material and, should any toxicity be observed, provide information concerning the potential cause of that toxicity at the benthic level.

●Discrete sediment samples were composited into management unit/open-water placement area samples as follows (see Figure 1): Federal navigation channel management units—DS-11-MU1 (DS-11-01 through DS-11-05); DS-11-MU2 (DS-11-06 through DS-11-10); DS-11-MU3 (DS-11-011 through DS-11-15); DS-11-MU4 (DS-11-16 through DS-11-20); DS-11-MU5 (DS-11-21 through DS-11-25); and DS-11-MU6 (DS-11-26 through DS-11-30); Proposed open-water placement unit—Wisconsin: WOPU (DS-11-31 through DS-11-35); Minnesota: MOPU (DS-11-36 through DS-11-40); Hearding Island, HIPU (DS-11-41 through DS-11-45); and Interstate Island, IIPU (DS-11-46 through DS-11-50). The following

standard tests were performed:

◊10-day solid phase toxicity tests (bioassays) employing the test species *Hyalella azteca* (amphipod) and *Chironomus dilutus* (midge fly) were applied to all management unit and placement area composite sediment samples. The biological measurement endpoints for these tests were survival, and survival and growth, respectively. The primary purpose of these bioassays was to assess the potential toxicity of the dredged material to benthic organisms relative to lake/bay bottom sediments.

◊48-hour *Ceriodaphnia dubia* (water flea) acute toxicity test and 96-hour *Pimephales promelas* (fathead minnow) acute toxicity test were performed on 100% elutriate from the management unit samples. Survival was the biological measurement endpoint for both tests. The primary purpose of these bioassays was to assess the toxicity of contaminants potentially released to the water column during dredged material placement in the lake/bay environs.

◊28-day *Lumbriculus variegatus* bioaccumulation test for PCBs (analysis of the primary congeners PCB 8, 18, 28, 44, 49, 52, 66, 77, 87, 101, 105, 110, 118, 126, 128, 138, 153, 169, 170, 180, 183, 184, 187, 195, 206 and 209) was applied to all management unit and placement area composite sediment samples. This list was selected based on an assumption that tPCB tissue residues (i.e., total of 209 congeners) can be reliably estimated by doubling the subtotal concentration of the 22 PCB congeners PCB 8, 18, 28, 44, 49, 52, 66, 87, 101, 105, 118, 128, 138, 153, 170, 180, 183, 184, 187, 195, 206 and 209 (e.g., Committee on Remediation of PCB-Contaminated Sediments *et al.* 2001; USEPA 2002). PCBs 77, 110 and 226 were added to this group of congeners due to their toxicological importance. The subset of 26 congeners was analyzed to reduce testing costs within budget. Lipid content in *L. variegatus* was also measured.

◊Standard elutriate testing (SET) for metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc), ammonia, TKN and tP were applied to all management unit composite sediment samples. The primary purpose of this test was to quantify the potential release of contaminants from the dredged material during placement and ascertain compliance with applicable WQSs. SET data on the dredged material indicate that releases of metals and organic contaminants during open-lake

placement would comply with existing, applicable State Water Quality Standards for the Protection of Aquatic Life

◊Bulk sediment testing for PCBs (26 congeners) and TOC was applied to all management unit and placement area composite sediment samples. In addition, these samples were analyzed for ammonia (as N), TKN and tP.

3.0 DREDGED MATERIAL EVALUATION

In general, bulk contaminant concentrations in the Federal navigation channel sediment samples were compared to those at the open-water placement areas. If any management unit contaminant concentration exceeded open-water placement sediment concentrations such that they would present a potential toxicological risk, it was identified as a preliminary COC subject to further testing and/or evaluation.

3.1 2011 Investigation

3.1.1 Bulk sediment analyses

a. **Physical testing**

Table 5 (Appendix B) of the draft analytical report (Futurenet Group 2012) presents the results of these analyses. The particle size data showed that the physical composition of Federal navigation channel sediments to be variable, being comprised of a mixture of coarse-grain (fine to medium sands) and fine-grain sediment (silts and clays). The sediments ranged from about 55.1% (DS-11-05) to 98.5% (DS-11-20) sands, with the remainder silts and clays. Bottom sediments at the two open-lake placement areas were also variable and composed of a range of 56.9% (DS-11-40) to 99% sands (DS-11-34), with the remainder silts and clays. Bottom sediments at the two inner harbor placement areas were comparably more consistent, comprised of a range of 56.9% (DS-11-40) to 79.7% (DS-11-37) sands, with the remainder silts and clays.

b. **Chemical testing**

(1) ***Inorganic analyses***

Tables 1 and 2 (Appendix B) of Futurenet Group (2012) presents the results of these analyses. The concentration of contaminants at management unit sites with the highest overall contaminant concentrations (DS-11-01, DS-11-09 and DS-11-24) were compared to those at the open-water placement areas (e.g., DS-11-32 [WOPU], DS-11-36 [MOPU], and DS-11-42 [HIPU] and DS-11-49 [IIPU]). While some dredged material concentrations significantly exceeded those of the open-water placement areas (e.g., tP, TKN, barium, chromium, iron, lead, mercury, nickel and zinc), none were of significant toxicological concern.

(2) ***Organic analyses***

(a) **PAHs**—Tables 1 and 2 (Appendix B) of Futurenet Group (2012) presents the results of these analyses. All PAH compound concentrations in the Federal navigation channel sediments, as well at open-water placement area sediments, were non-detectable at detection limits (DLs) ranging from 330 µg/kg to 590 µg/kg.

(b) **PCBs**

●*Aroclors*—Tables 1 and 2 (Appendix B) of Futurenet Group (2012) present the results of these analyses. With few exceptions, Aroclor concentrations in the Federal navigation channel sediments, as well as at open-water placement area sediments, were non-detectable at DLs ranging from 81 µg/kg to 210 µg/kg. At harbor Site DS-11-09 (in management unit DS-11-MU2), all Aroclors were detected at estimated concentrations of 140 µg/kg (note that since so few congeners were detected across the range of Aroclors and homolog groups, no single Aroclor mixture could be clearly identified). Assuming the estimated concentration of 140 µg/kg pertains to a single Aroclor, this concentration was assessed with respect to TOC content and PCB bioavailability relative to open-water placement area sediments. It translates to a TOC-normalized concentration of 2917 µg/kg-TOC, which is lower than the lowest open-water placement site TOC-normalized concentrations of 5263 µg/kg-TOC (open-lake, DS-11-36) (assuming Aroclor concentration equal to 100% the RL) and 4750 µg/kg-TOC (inner harbor, DS-11-42) (note that lake area bulk sediment PCB data with TOC content of less than 0.5% were not used in these calculations because at such low TOC concentrations, factors other than TOC content can have a substantial influence on equilibrium distribution and partitioning of neutral organic compounds [e.g., McFarland *et al.* 1996; USEPA/USACE 1998a]). Therefore, the PCB concentration at DS-11-09 was determined to be

unremarkable with respect to bioaccumulation. All Aroclors were also detected at estimated concentrations at harbor sites DS-11-42 (190 µg/kg) and DS-11-44 (180 µg/kg) in the management unit HIPU sediment (note that since so few congeners were detected across the range of Aroclors and homolog groups, no single Aroclor mixture could be clearly identified). At DS-11-28, Aroclor 1242 and 1260 were measured at concentrations of 1100 µg/kg and 610 µg/kg, respectively (i.e., tPCB concentration = 1.71 mg/kg). This tPCB value translates to a TOC-normalized concentration of 53438 µg/kg-TOC, which is substantially higher than those at placement area sediments (e.g., up to 14709 µg/kg-TOC at DS-11-31 [assuming Aroclor concentration equal to 100% the RL]). Therefore, tPCBs was identified as a COC at this site.

●*Congeners*—Table 6 (Appendix B) of Futurenet Group (2012) presents the results of these analyses. With few exceptions, PCB congener concentrations in management unit sediments, as well as at open-water placement area sediments, were non-detectable. PCBs 101, 138, 153, 170 and 180 were detected in management unit DS-11-MU2 sediments at estimated concentrations (range 0.43 µg/kg to 0.79 µg/kg), and PCBs 138, 153, 170 and 180 were detected in management unit DS-11-MU5 at estimated concentrations (range 0.51 µg/kg to 1.6 µg/kg).

3.1.2 Solid phase bioassays

The results of these tests are summarized in Table 1.

a. H. azteca—The mean survival of this test species exposed to the management unit sediment samples ranged from 88±13.6% (DS-11-MU1) to 98±5.28% (DS-11-MU4, DS-11-MU5 and DS-11-MU6), and were not statistically different than that associated with the open-water placement areas (mean survival range 94% [IIPU] to 100% [WOPU and HIPU]).

b. C. dilutus—The mean survival of this test species exposed to the management unit sediment samples ranged from 92±14.2% (DS-11-MU6) to 98±5.28% (DS-11-MU4 and DS-11-MU5), and was not reduced by more than 20 percent, and was not statistically different than that associated with the open-water placement areas (mean survival range 94% [IIPU] to 98% [WOPU, MOPU and HIPU]). With respect to *C. dilutus* growth, mean biomass expressed as mean ash-free dry weight (AFDW) exposed to the management unit sediment samples ranged from 1.06 mg (DS-11-MU3), to 1.22±0.04 mg (DS-11-MU1) and

1.22±0.05 mg (DS-11-MU4). All values exceeded a mean AFDW of 0.48 mg (and MDW of 0.6 mg).

These solid phase bioassay data show that placement of the dredged material at any of the open-water placement areas would not result in any contaminant-related unacceptable, adverse impacts.

3.1.3 PCB bioaccumulation testing

The results of this testing, in terms of lipid-normalized sum concentrations of the 22 PCB congeners (∑22 PCBs), are summarized in Table 2. Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to the management unit sediments ranged from 172 µg/kg-lipid (DS-11-MU6) to 654 µg/kg-lipid (DS-11-MU2) (note that comparisons of lipid-normalized tissue residues [vs. just PCB residues] of PCBs among test groups and species is typically more biologically relevant). For the open-lake placement area sediments, associated mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues ranged from 151 µg/kg-lipid (WOPU) to 339 µg/kg-lipid (MOPU). For the inner harbor placement area sediments, associated mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues ranged from 276 µg/kg-lipid (IIPU) to 633 µg/kg-lipid (HIPU). Table 2 also includes the predicted mean tPCB concentrations for all management unit and placement area sediments. For the management unit sediments, mean tPCB residues in *L. variegatus* tissues ranged from 11 µg/kg (DS-11-MU6) to 47.8 µg/kg (DS-11-MU2). These PCB bioaccumulation data were interpreted as follows:

a. **Comparisons to open-water placement areas**

(1) ***Open-lake areas***

Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to management unit DS-11-MU1 and DS-11-MU6 sediments were not significantly greater relative to sediments at open-water placement area MOPU. This indicates that material dredged from these management units meets Federal guidelines for placement at the Minnesota open-lake area. Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to management unit DS-11-MU2, DS-11-MU3, DS-11-MU4 and DS-11-MU5 sediments were significantly greater relative to sediments at open-water placement area MOPU; and mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to all

management unit sediments, with the exception of DS-11-MU1 and DS-11-MU6, were significantly greater relative to sediments at open-water placement area WOPU. This indicates that material dredged from these management units requires additional evaluation for placement at each of the respective open-lake areas. For this reason, tPCBs was identified as a preliminary COC in these management unit sediments relative to the respective open-water placement area(s).

(2) ***Inner harbor areas***

Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to all management unit sediments were not significantly greater relative to HIPU. This indicates that material dredged from all management units meets Federal guidelines for placement at the Hearding Island area. Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to the DS-11-MU1 and DS-11-MU6 sediments were not significantly greater relative to IIPU. This indicates that material dredged from these management units meets Federal guidelines for placement at the Interstate Island area. Mean lipid-normalized ∑22 PCB residues in *L. variegatus* tissues exposed to DS-11-MU2, DS-11-MU3, DS-11-MU4 and DS-11-MU5 were significantly greater relative to IIPU. This indicates that material dredged from these management units requires additional evaluation for placement at the Interstate Island area, with respect to the PCB bioaccumulation measurement endpoint. Therefore, tPCBs was identified as a preliminary COC in these management unit sediments relative to the Interstate Island placement area.

a. **Additional evaluation**

USEPA/USACE (1998b) provides that when the bioaccumulation of contaminants from dredged material significantly exceeds that associated with an open-water reference area sediment, several other factors should be assessed (Section 6.3) to determine the acceptability of open-water placement. These factors define the biological significance of the exceedance, and include such things as the toxicological importance of the contaminants, potential for effects at the observed concentrations, magnitude of increase observed, and concentrations found in species living in the vicinity of the proposed dredged material placement area.

(1) ***Number of contaminants that significantly exceed those bioaccumulated from open-water reference area sediments***—PCBs are the only preliminary COC in the dredged material. The low concentrations of PCB congeners detected in the *L. variegatus* tissue samples consist of 15 individual congeners that span in molecular weight across all homolog groups and do not provide a chemical signature that can be associated with a specific Aroclor mixture. PCBs have not been identified as a COC for the St. Louis River/Interlake/Duluth Tar (SLRIDT) site although there currently is a fish consumption advisory (FCA) on the lower portion of the St. Louis River from Scanlon to Lake Superior (which includes the SLRIDT site) because of the presence of PCBs and mercury. Strachan and Eisenreich (1988) estimate that 90% of the total inputs of PCBs to Lake Superior are attributable to direct atmospheric deposition. The remaining 10% of the inputs are primarily from tributaries. Since the rivers that flow into the lake primarily drain non-industrialized, forested land, PCB inputs from the tributaries are considered to be minimal. Because of the predominant influence from air source deposition, the contribution of low-level PCBs present in dredged material would not significantly impact the potential PCB exposure to fish consumed by lake ecological receptors (e.g., piscivorous birds and mammals) or anglers.

(2) ***Tissue levels and toxicological significance*** —In this case, while several PCB congeners do biomagnify, the estimated mean tPCB levels in *L. variegatus* tissues exposed to the management unit sediments were low (tPCB range 11 µg/kg to 47.8 µg/kg) (see Table 2). Such levels of tPCBs in benthic tissues reflect typical background PCB concentrations in Great Lakes bottom sediments. For example, it is lower or within the range of measured tPCB residues in *L. variegatus* exposed to Lake Erie background sediments (e.g., 28 µg/kg [USACE 2010] to 160 µg/kg [Environmental Science and Engineering 1993]). Dredged material associated with such low PCB benthic bioaccumulation is routinely placed in Lake Erie and has not been linked to any unacceptable, adverse effects.

Across the management unit samples, PCB 8, 18, 44, 49, 52, 77, 87, 101, 105, 110, 118, 138, 153, 170 and 187 were the only congeners detected in *L. variegatus* tissue, spanning across the di-, tri-, tetra-, penta-, hexa- and hepta-chlorobiphenyl isomer groups. Only one of the congeners (PCB 77) detected in a single replicate tissue sample (in DS-11-MU4) is considered a strong inducer of aryl hydrocarbon hydroxylase (AAH) in ecological receptors and humans. Low concentrations of two other AAH-inducing PCB congeners (PCB 105 and PCB

118) were detected in tissue samples of worms exposed to both management units and open-water placement areas; however, these congeners are considered to be orders of magnitude less toxic in comparison to PCB 77. Based on the available data, the toxicity to humans, birds and fish from PCB congeners that may bioaccumulate is low and near the background levels for lake sediments.

(3) ***Magnitude by which bioaccumulation from the dredged material exceeds that associated with open-water reference area sediments—*** Analytical variability, along with all other sources of uncertainty in predicting PCB bioaccumulation into higher trophic level species, are important considerations for the interpretation of laboratory test results. A statistically significant difference between mean bioaccumulation from dredged material and reference area sediments from laboratory tests may not be biologically or ecologically significant because it may simply fall within the range of natural variation. The absolute difference in measured bioaccumulation should also be considered in addition to a statistically significant difference. Standard guidance in American Society of Testing Material (ASTM) (2010) indicates that a two-fold difference between tissue residues in test and reference sediments should in most cases provide a sufficient signal for ecological and human health concerns. Therefore, it is recommended that tissue concentrations less than twice those of reference tissue concentrations should not be considered a *biologically* significant difference within the context of bioaccumulation evaluation of dredged material.

In the present investigation, mean lipid-normalized sum concentrations of ∑22 PCBs in *L. variegatus* tissues exposed to management unit DS-11-MU2, DS-11-MU3, DS-11-MU4 and DS-11-MU5 sediments ranged from 448 µg/kg-lipid to 654 µg/kg-lipid, all of which were less than two times that of open-lake placement area MOPU (339 µg/kg-lipid). This suggests that the measured PCB tissue residues associated with these management unit sediments was not biologically or ecologically significant relative to open-lake area MOPU. Further, mean lipid-normalized sum concentrations of ∑22 PCBs in *L. variegatus* tissues exposed to management unit DS-11-MU4 and DS-11-MU5 sediments was 488 µg/kg-lipid and 448 µg/kg-lipid, both of which were less than two times that of open-water placement area IIPU (277 µg/kg-lipid). This suggests that the measured PCB tissue residues associated with these management unit sediments was not biologically or ecologically significant relative to these two placement areas.

(4) ***Spatially Explicit Screening-level Exposure Evaluation of Bioaccumulation Test Data on Dredged Material***—Predictions of potential exposure to PCBs and risk to ecological receptors and human health require explicit consideration of both spatial and temporal factors within food web models. A Spatially Explicit Screening-level Exposure procedure has been developed to address the relatively small spatial area for dredged material placement compared to the overall area utilized by receptors to obtain food. This area is referred to as the receptor's home range. Fish, such as lake trout,

deepwater sculpin and rainbow smelt with a home range larger than the placement area will obtain only a fraction of their diet from the area influenced by the placement of dredged material, thus resulting in a reduction in net bioaccumulation compared to what is reflected in laboratory bioaccumulation experiments alone. The following equation provides a simple way to apply this approach:

(1)

$$C_o = \frac{(HR - PA)\ (C_r) + (PA)\ (C_{dm})}{HR}$$

Where:

C_o = Estimated PCB tissue residue in oligochaete populations across fish species' home range (µg/kg wet weight)
HR = Assumed home range of fish species of interest (in same units as area of open-water site)
PA = Assumed area of dredged material placement site (in same units as receptor's home range)
C_r = Measured PCB tissue residue in *L. variegatus* exposed to open-water reference/placement area sediments (µg/kg wet weight)
C_{dm} = Measured PCB tissue residue in *L. variegatus* exposed to dredged material (µg/kg wet weight)

Using this equation, lake trout that may be caught by anglers near the open-lake placement area is expected to have a home range on the order of nine square miles (e.g., Eschmeyer *et al.* 1953). If it is assumed that the "footprint" of dredged material placement is 0.25 square mile resulting in oligochaete tPCB bioaccumulation equal to 47.8 µg/kg (using sediments from DS-11-MU2 as the worst-case scenario) and the remaining area of the fish home range offers oligochaete populations with tPCB tissue residues of 11 µg/kg (conservatively using open-lake area sediments at WOPU), this results in an average oligochaete tissue exposure level of 12 µg/kg. This value is comparable to the estimated mean tPCB tissue concentration in *L. variegatus* of 11 µg/kg exposed to the open-lake area sediments and well within the range of analytical variability alone (e.g., ±20%).

A screening level model to estimate bioaccumulation exposure, referred to as spatially-explicit screening-level exposure comparison (SESLEC), has been developed that can be applied to conservatively identify the need for more extensive, complicated and costly dredged material evaluations. This model generates a value referred to as a bioaccumulation exposure factor (BEF), which is a spatially weighted average concentration in oligochaetes (in this case) after dredged material placement, divided by the spatially weighted average concentration in oligochaetes (in this case) prior to placement. A BEF of 2 or greater indicates that exposure to PCBs via bioaccumulation after dredged material placement is expected to be twice that associated with open-water reference area sediments. A BEF of less than 2 indicates that the exposure of receptors to PCB as a result of dredged material placement is less than two times higher than that associated with the open-water reference area sediment condition, and that such bioaccumulation is not predicted to result in unacceptable risk to fish, wildlife and human health via bioaccumulation. The BEF model is presented as follows:

(2)

$$BEF = \frac{(PA)\ (C_{dm})\ /\ C_r\ +\ (HR - PA)}{HR}$$

Where:

PA = Assumed area of dredged material placement site (in same units as receptor's home range)
C_{dm} = Measured PCB tissue residue in *L. variegatus* exposed to dredged material (µg/kg wet weight)
C_r = Measured PCB tissue residue in *L. variegatus* exposed to open-water reference/placement area sediments (µg/kg wet weight)
HR = Assumed home range of receptor species (in same units as area of open-water site)

Using this equation, lake trout that may be caught by anglers near the open-lake placement area is expected to have a home range on the order of nine square miles (e.g., Eschmeyer *et al.* 1953). Based on the assumptions that a 0.25 square mile placement area results in oligochaete tPCB bioaccumulation equal to

47.8 µg/kg (again using sediments from DS-11-MU2 as the worst-case scenario) and the remaining area of the fish home range offers oligochaete populations with tPCB tissue residues of 11 µg/kg (conservatively using open-lake area sediments at WOPU), this yields a BEF of 1.09. Such a BEF, which is based on the worst-case scenario relative to the DS-11-MU2 sediments, is not substantially greater than 1 and is well below 2, indicating negligible exposure risk with respect to fish, wildlife and human health via PCB bioaccumulation from sediments at open-lake areas WOPU.

In conclusion:

(a) **Management unit DS-11-MU1**—Material dredged from this management unit meets Federal guidelines for placement at all open-water areas.

(b) **Management unit DS-11-MU2**—Material dredged from this management unit meets Federal guidelines for placement at open-water areas MOPU and HIPU due to sufficiently low PCB bioaccumulation. Material dredged from this management unit meets Federal guidelines for placement at open-water area WOPU via an evaluation through the SESLEC model. Further evaluation of this management unit to IIPU would be required once a suitable receptor species is determined to evaluate the placement of dredged material at IIPU.

(c) **Management unit DS-11-MU3**—Material dredged from this management unit meets Federal guidelines for placement at open-water areas MOPU and HIPU due to sufficiently low PCB bioaccumulation. Material dredged from this management unit meets Federal guidelines for placement at open-water area WOPU via an evaluation through the SESLEC model. Further evaluation of this management unit to IIPU would be required once a suitable receptor species is determined to evaluate the placement of dredged material at IIPU.

(d) **Management unit DS-11-MU4**—Material dredged from this management unit meets Federal guidelines for placement at open-water areas MOPU, HIPU and IIPU due to sufficiently low PCB bioaccumulation. Material dredged from this management unit meets Federal guidelines for placement at open-water area WOPU via an evaluation through the SESLEC model.

(e) **Management unit DS-11-MU5**—Material dredged from this management unit meets Federal guidelines for placement at open-water areas MOPU, HIPU and IIPU due to sufficiently low PCB bioaccumulation. Material dredged from this management unit meets Federal guidelines for placement at open-water area WOPU via an evaluation through the SESLEC model.

(f) **Management unit DS-11-MU6**—With the exception of material at Site DS-11-28, material dredged from this management unit meets Federal guidelines for placement at all open-water areas due to sufficiently low PCB bioaccumulation.

In summary, this evaluation of PCB bioaccumulation showed that the placement of dredged material at all open-water placement areas, except for potentially IIPU, would not result in an unacceptable risk. A receptor species needs to be identified to evaluate through the SESLEC model whether the placement of material dredged from management units DS-11-MU2 and DS-11-MU3 at this area would not result in an unacceptable risk with respect to PCB bioaccumulation.

3.1.4 Elutriate testing

a. **SET**

Table 3 presents the results of this test. The elutriate data show very low to moderate releases of metals and other inorganics. Previous elutriate testing for PCBs showed no releases of Aroclors at DLs ranging from 0.2 µg/L (Thermo Analytical 1995), to 0.2 µg/L to 0.4 µg/L (Altech Environmental Services 2002).

b. **Water column bioassays**

The results of these tests are summarized in Table 4.

(1) ***C. dubia***—The mean survival of this test species exposed to all management unit sediment elutriates was 100%.

(2) ***P. promelas***—The mean survival of this test species exposed to all management unit sediment elutriates was 100%.

These elutriate bioassay data show that the release of contaminants from the dredged material to the water column during open-water placement would not result in any contaminant-related unacceptable, adverse impacts.

COCs

Based on the 2012 data, tPCBs were identified as a preliminary sediment COC at DS-11-MU2, DS-11-MU3, DS-11-MU4 and DS-11-MU5 relative to open-water and/or inner harbor placement areas. At discrete Site DS-11-28 within DS-11-MU6, tPCB was identified as a sediment COC. In addition, further evaluation through the SESLEC model is necessary to determine whether the placement of material dredged from management units DS-11-MU2 and DS-11-MU3 at open-water area IIPU would not result in an unacceptable risk with respect to PCB bioaccumulation. With this exception, PCBs were eliminated as a preliminary COC in the Federal navigation channel sediments.

4.0 CONCLUSION

Based on the data contained in Futurenet Group (2012) and other relevant information, contamination and toxicity associated with Duluth-Superior Federal navigation channel sediments has been shown to be comparable relative to open-water area sediments. With respect to PCBs in the dredged material, bioaccumulation, with the exception of material at discrete Site DS-11-28 and the exception of placement of management unit DS-11-MU2 and DS-11-MU3 dredged material at open-water area IIPU, would not result in unacceptable adverse impacts to the affected aquatic ecosystems. Therefore, all material dredged from the remaining Federal navigation channels meets Federal guidelines for open-water placement. DS-11-MU2 and DS-11-MU3 would require further evaluation once a receptor species is determined.

5.0 REFERENCES

Altech Environmental Services (2002) Collection and Testing of Sediment Samples from Duluth-Superior Harbor, Duluth/Superior, Minnesota/Wisconsin. Report prepared under contract to USACE, Detroit District.

ASTM (2010) Standard Guide for Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates. ASTM Standard E1688-10.

Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, Division on Life and Earth Studies, National Research Council (2001) A Risk-Management Strategy for PCB-Contaminated Sediments. Washington, DC: National Academy Press.

Environmental Science and Engineering (1993) Evaluation of Sediments from the Ashtabula Harbor area, Ashtabula, Ohio. Report prepare under contract to USACE, Buffalo District.

Eschemeyer PH, Daly R, Erkkila LF (1953) The movement of tagged lake trout in Lake Superior, 1950-1952. American Fish Soc 82:68-77.

Futurenet Group (2012) Duluth-Superior, Minnesota-Wisconsin Open-Water Placement Sediment Sampling, Analysis and Biological Testing. DRAFT report prepared for USACE, Detroit District.

Marvin C, Painter S, Williams D, Richardson V, Rossmann R, VanHoof P (2004) Spatial and temporal trends in surface water and sediment contamination in the Laurentian Great Lakes. Environ Poll 129:131-144.

McFarland VA, Honeycutt ME, Feldhaus J, Ace LN, Brandon JM, Weiss CA, Clarke JU, McCant D, Jones P (1996) Lower Limits of Organic Carbon Normalization: Results of Fish/Sediment/Water Equilibrium Partitioning Studies. Environmental Effects of Dredging Technical Note EEDP-01-38. Vicksburg, Mississippi: USAERDC.

Strachan WMJ, Eisenreich SJ (1988) Mass Balancing of Toxic Chemicals in the Great Lakes: The Role of Atmospheric Deposition. Report prepared for the International Joint Commission.

Thermo Analytical (1995) Sampling and Analysis of Sediments from Duluth-Superior Harbor. Report prepared under contract to USACE, Detroit District.

USACE (2010) Evaluation of Ashtabula Harbor Federal Navigation Channel Sediments with Respect to their Suitability for Open-lake Placement. Report prepared by USACE, Buffalo District.

USACE (2012) Title 33, Chapter II, Part 336, Factors to be Considered in the Evaluation of Army Corps of Engineers Dredging Projects Involving the Discharge

of Dredged Material into Waters of the United States and Ocean Waters. http://www.law.cornell.edu/cfr/text/33/336

USAERDC (2012) BSAF database. http://el.erdc.usace.army.mil/bsafnew/BSAF.html

USEPA (2002) 40 CFR 228, Final Rule, Historic Area Remediation Site (HARS)—Specific Polychlorinated Biphenyl Worm Tissue Criterion. http://www.epa.gov/region2/water/dredge/113rule.pdf

USEPA (2012a) Great Lakes Area of Concern—St. Louis River. http://epa.gov/glnpo/aoc/stlouis.html

USEPA (2012b) Title 40, Chapter 1, Subchapter H, Part 230, Section 230.11, Factual Determinations. http://www.law.cornell.edu/cfr/text/40/230.11

USEPA, USACE (1998a) Great Lakes Dredged Material Testing and Evaluation Manual. http://www.epa.gov/glnpo/sediment/gltem/manual.htm

USEPA, USACE (1998b) Evaluation of Dredged Material Proposed For Discharge in Waters of the U.S.—Testing Manual. http://www.spn.usace.army.mil/conops/References/National_Guidance/ITM-OTM-UTM-Framewk/ITM/%20ITM.pdf