Human Health Risk Assessment for Dredged Material Management on Minnesota Point Beach Duluth Harbor

EXECUTIVE SUMMARY

Historical high water levels for Lake Superior and increasing frequency of storm events are increasing erosion of the beach dune shoreline located along Minnesota Point Beach in Duluth, MN. The State of Minnesota and City of Duluth have expressed interest in using dredged material from the Duluth-Superior Harbor federal navigation channel as a means to provide storm protection and reduce additional erosion of this sensitive Lake shore resource. The U.S. Army Corps of Engineers (USACE) developed risk-based sediment screening levels for polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and dioxin-like polychlorinated biphenyls (PCDD/F and PCB aka dioxins) in order to determine whether or not placement of material dredged from the Duluth-Superior Harbor federal navigation channel onto the Minnesota Point Beach has the potential to adversely affect public health. The sediment screening levels were developed using Minnesota Pollution Control Agency protocols for derivation of soil screening levels (soil reference values), but modified for recreational use of the shoreline. A conservative risk-based sediment screening level was developed (dioxin Toxicity Equivalents [dioxin TEQ] = 4.7 ng/kg) that is protective for recreational users of the beach including areas adjacent to residences along the northern-most portion of Minnesota Point. Dredged material was placed on the southern portion of Minnesota Point Beach in the fall of 2019. In order to characterize levels of dioxins which would be present on the beach following dredged material placement, beach sediment samples were collected prior to, during, immediately after, and several months after construction. The sampling effort was coordinated with the Minnesota Pollution Control Agency with a final sampling event conducted in May 2020. Due to dredge material placement occurring in the fall, and winter conditions along the shore of Lake Superior, spring sampling after ice-melt is more reflective of the exposure of beachgoers to placed dredge materials. Samples that were collected from the beach in May 2020 had a concentration of 0.05 ng/kg dioxin TEQ (almost 100 times lower than the screening level). This indicates the levels of dioxins on the beach after dredged material placement would not pose a risk to human health. The extensive characterization of levels of dioxins on the beach associated with this dredged material placement action, in conjunction with the large difference between the measured concentrations and the dioxin sediment screening levels indicates that placement of dredged material on Minnesota Point Beach would provide shoreline protection benefits without adversely affecting human health.

INTRODUCTION

Historical high water levels for Lake Superior and increasing frequency of storm events are increasing erosion of the beach dune shoreline located along Minnesota Point Beach in Duluth, MN. The State of Minnesota and City of Duluth have expressed interest in using dredged material from the Duluth-Superior Harbor federal navigation channel as a means to provide storm protection and reduce additional erosion of this sensitive Lake shore resource.

Project background, including origin of the dredged material, and the sampling regimes to characterize dioxin concentrations in the sediments, are described in the Sediment Monitoring Plans and Reports (USACE 2019a and 2020, AEM Group 2020 a - d).

Dioxins are ubiquitous in the environment at low levels and will be present in many areas even when no historical release has occurred. Very low concentrations of polychlorinated dibenzo-p-dioxins and furans (PCDD/F) and polychlorinated biphenyls (PCBs; some congeners exhibit dioxin-like toxicity) have been previously measured in St. Louis River Estuary sediments and in sediments dredged from the Federal navigation channel within the estuary. As a result of the United State Environmental Protection Agency's (USEPA) re-assessment of the toxic effects of dioxin (USEPA 2003a, 2012), levels of dioxins which may pose some risks to human health may be similar to the low levels of dioxin found in the environment resulting from non-point source releases. For this reason, ambient levels of dioxins present at the placement site, in the absence of dredged material management, should be considered as part of this risk assessment.

The purpose of this human health risk assessment (HHRA) is to provide the US Army Corps of Engineers (USACE) Detroit District and the Minnesota Pollution Control Agency (MPCA) with a decision-making tool for use in determining appropriateness of placing dredged material having trace levels of dioxins on the Minnesota Point Beach site.

Specific objectives of the HHRA are to

- Establish acceptable risk-based concentrations of dioxins in Minnesota Beach sediments, thus allowing more efficient decisions regarding dredged material management to be made.
- Estimate potential human health risks associated with exposure to dioxins in sediments when placed at Minnesota Point Beach.

The HHRA is conducted using methodology primarily developed by the State of Minnesota (MDH 2009, 2013, MPCA 2016a,b, 2019a,b). Additional USEPA risk assessment guidance is also used as appropriate (e.g., USEPA 1989, 1997, 2002a, 2002b, 2003b, 2004, 2005a, 2005b, 2009, 2014).

The MPCA provided calculation spreadsheets (MPCA 2016b) and "range of risk" spreadsheets (here called HHRA Tables) to use in quantifying risk and developing sediment risk-based screening levels.

The risk characterization for exposure to dioxins in sediment are largely based on modeling results for exposures to representative receptors that may come into contact with dioxins at the site. An overview of the exposure pathways being evaluated in this assessment is provided in Table 1-0. The risk estimates are not based on observed impacts to people at the site. The risk estimates were developed using mathematical models as opposed to actual observed or measured effects.

Risk assessments performed by MPCA (MPCA 2019a, b) and preliminary risk calculations performed by USACE evaluated all major exposure pathways identified in Table 1-0. Because the greatest exposure, and subsequent risk, is to dry beach sediments, this initial HHRA focuses on that exposure pathway associated with recreational exposure to the dry beach (rather than under water) sediments. These risk-based sediment screening levels represent the most restrictive screening levels for the risk calculation. Additional risk assessment may be performed in the future to establish acceptable risk-based concentrations of dioxin in submerged sediments alongside the beach area, if warranted.

DATA EVALUATION AND HAZARD ASSESSMENT

Data evaluation and hazard assessment is the first step in the HHRA process, in which all relevant environmental data for the site were compiled and reviewed.

Data included in the HHRA

The data included in this risk assessment are expressed as 2,3,7,8- polychlorinated dibenzo-p-dioxin dioxin toxicity equivalents (dioxin TEQ) results that include the measurement of PCDD/F and dioxin-like PCB congeners. Samples were collected and analyzed as described in the Sampling and Analysis Plans (USACE 2019a and 2020) and the Sediment Monitoring Reports (AEM 2020 a, b, c and d). Samples were collected from the beach over the course of four mobilizations as described below. Tables 3, 4a, 4b, and 5 summarize results from these four sampling events. Two electronic workbooks are provided which include all of the individual PCDD/F (Attachment 1) and PCB (Attachment 2) congener results as well as the dioxin TEQ calculations.

- The first mobilization involved collection of beach sediments as well as sediments from shallow and deep water areas adjacent to the beach, prior to placing any dredged material on the beach in September 2019. These are considered “pre-placement” samples. The outer shoreline samples were analyzed for both PCDD/F and also PCB congeners, while the sediment samples collected from under shallow and deep water areas were analyzed only for PCDD/F. These results are not used in the HHRA but included in Tables 3 through 5 for context.
- A second mobilization occurred in October 2019 while the dredged material was in the process of being placed on the beach. These “mid-placement” samples of beach material collected along the outer shoreline and from construction stockpiles were not identified in the Sampling and Analysis Plan submitted to and approved by MPCA (USACE 2019a), but rather were collected in an attempt to obtain rapid and informal results for use in dredged material management decision making. These samples were only analyzed for PCDD/F. These results are not used in the HHRA but included in Tables 4 and 5 for context.
- The third mobilization occurred in November 2019 immediately after the dredged material placement was complete. Samples were collected from only the outer shoreline (beach sand) and are referred to as the “post-placement” samples. These samples were analyzed for both PCDD/F and also PCB congeners. The results are included in Tables 3 through 5 for context, but not used to calculate risk in this HHRA.
- The final (fourth mobilization) occurred in May 2020. Samples were collected from the beach (outer shoreline), shallow water, and deep water areas. The outer shoreline samples were analyzed for PCDD/F and PCB congeners, while the sediment samples collected from shallow and deep water areas were analyzed only for PCDD/F. The May 2020 sampling event represents the levels of dioxins recreational users of the beach may be exposed to during the summer months and the HHRA relies on the results from this sampling event to draw conclusions. Samples from the outer shoreline (beach area) and sediments from shallow water areas used for wading and swimming have been evaluated in the HHRA.

Development of exposure concentrations (dioxin TEQ) from these data is described below within the section describing the Exposure Assessment.

Note that the vast majority of PCDD/F and PCB congener results were not reported above method detection limits; in other words, they were not detected (see Tables 4a and 4b). As indicated in the Risk Characterization and the Uncertainty Assessment sections, it is estimated that the detection limit for dioxin TEQ for beach samples is approximately 1 ng/kg or 1 part per trillion. The lowest risk-based sediment screening level for dioxin protective of human health at Minnesota Point Beach was calculated to be approximately 5 ng/kg or 5 part per trillion dioxin TEQ, indicating that our laboratory analytical procedures were sensitive enough to identify dioxin concentrations below this acceptable level. Detection limits for individual PCDD/F congeners were between 0.03 to 1.5 ng/kg (0.03 to 1.5 part per trillion). For individual PCB congeners, the reporting limit (used in lieu of a detection limit for dioxin TEQ calculations) was between 2 to 10 ng/kg (2 to 10 parts per trillion).

EXPOSURE ASSESSMENT

The second step of the HHRA process is the exposure assessment, in which the receptors of concern and potential exposure pathways are identified. The constituents of potential concern (COPCs) (dioxin concentrations in placed sediments following completion of construction) are converted into systemic doses (intakes), taking into account contaminant concentrations, rates of contact (e.g., ingestion rates), and absorption rates of different COPCs. The magnitude, frequency, and duration of these exposures are then integrated to obtain estimates of daily doses over a specified period of time (e.g., lifetime, activity-specific duration).

The exposure assessment includes several steps:

- Evaluating the exposure setting. This includes a description of the site uses and the potentially exposed human populations.
- Developing the conceptual site model (CSM). This includes identifying the source of contamination, the contamination transport and release mechanisms, the exposure media, the exposure routes, and the potentially exposed populations.
- Calculating exposure point concentrations (EPCs) for each COPC for each of the complete exposure pathways identified in the CSM.
- Identifying the exposure models and parameters with which to calculate the exposure doses.
- Calculating exposure doses (intake quantities).

Exposure Setting

The Lake Superior shoreline of Minnesota Point between Superior Entry and Duluth Entry has suffered from significant erosion. This erosion has impacted old growth trees, USACE structures, private property and private structures. Beach nourishment using dredged material is being contemplated for this shoreline to help provide shoreline protection and habitat restoration, and is the subject of this HHRA. Data have been collected as part of a pilot demonstration project during which the engineering and natural processes affecting the nourishment of the beach are being evaluated.

Conceptual Site Model

The CSM presents the potential sources of contamination, transport mechanism, and potential receptors for the site, and is illustrated in Table 1-0. An exposure pathway describes a mechanism by which a population or individual may be exposed to COPCs present at the Site. A completed exposure pathway requires the following four components:

- A source and mechanism of chemical release to the environment (e.g., the placement of dredged material in the nearshore environment at Minnesota Point)
- An environmental transport medium for the released chemical
- A point of potential human exposure with the contaminated medium
- A human exposure route at the point of exposure

All four components must exist for an exposure pathway to be complete and for exposure to occur. Incomplete exposure pathways do not result in actual human exposure and are not included in the exposure assessment and resulting risk characterization. The CSM identifies which exposure pathways are complete and require further evaluation in the HHRA.

Source and Exposure Media

Very low concentrations of PCDD/F and PCB congeners have been previously measured in St. Louis River Estuary sediments and in the dredged material present in the Federal navigation channel. When used beneficially for storm protection and dune erosion control, dredged sediments are believed to have higher concentrations of dioxins than what currently exists at Minnesota Point Beach. The dredged sediment is thus considered the source media. However, during dredging operations and the hydraulic transport of the dredged material to the placement site, significant losses of fine-grained sediment and associated dioxins will occur as the water used for hydraulic transport returns to the lake. In addition, wave action and natural sorting of sandy sediment placed on the beach is expected to further reduce dioxins to pre-placement concentration levels over time.

Exposure media

Over time, wave action would act to separate the dredged material into different exposure media, including

- Beach sand (dried sediments)
- Suspended solids (in the water column)
- Lake bed sediments (submerged under the water column)

Although equilibrium partitioning of dioxins occurs between suspended solids in the water column and their dissolved state, surface water carrying dissolved concentrations of dioxins and furans (in the absence of suspended solids) has not been considered an exposure media. This is because the partitioning of these non-polar, very hydrophobic organic compounds would highly favor the solid over the aqueous phase; partitioning coefficients are on the order of a million to 1 (ratio of solid to dissolved aqueous phases). Therefore, this assessment will only consider exposure to the solid phase.

Human Receptors and Exposure Scenarios

The CSM identifies the potential pathways for human exposure to dioxins and furans at the Site. The potential human receptors are recreational users of the beach who live on or in the vicinity of Minnesota Point and are expected to have repeated contact with beach and shoreline sediments over an extended duration. Different age groups are being evaluated in order to fully assess both carcinogenic risks and also non-cancer hazards from exposure to dioxins, and also to consider site-specific exposures for the different exposure units. Total duration of exposure would be considered 26 years, consistent with MPCA assumptions regarding duration for residential and recreational exposure scenarios.

Seasonal (summer) exposure scenario

The exposure assessment focuses on the long term, seasonal exposure to beach sediments during the warmer months of the year.

Age groups evaluated for exposure to beach (dried) sediment/sand (on the shoreline) include:

- Child (0 – 6 years) (assessed for non-carcinogenic hazards)
- Baby (0 - 2 years) (included in the assessment for carcinogenic risks)
- Child –Youth (2 – 16 years) (included in the assessment for carcinogenic risks)
- Adult (16 – 26 years) (included in the assessment for carcinogenic risks)

Quantification of Exposure Concentration and Pathway-Specific Intakes

In the exposure assessment, the groups of individuals potentially exposed to site media (i.e., potential human receptors) are characterized. Pathways applicable to potential receptors at the site are identified from the many potential pathways of exposure. The COPCs in relevant media (e.g., sand, sediment) are converted into systemic doses, taking into account rates of contact (e.g., ingestion rates, inhalation rates) and absorption rates of different COPCs. The magnitude, frequency, and duration of these exposures are then integrated to obtain estimates of daily doses over a specified period of time (e.g., lifetime, activity-specific duration).

These calculations are all performed within the MPCA calculator developed under their risk-based site evaluation guidance (MPCA 2016b). Equations are presented in the spreadsheets which were submitted to MPCA in January, and reviewed and approved in February 2020 (see Attachment 3 for discussion of that review).

Exposure Concentrations

As explained below in the Toxicity Assessment section, dioxin TEQ is calculated from these results using the relative toxicity equivalence factors (TEFs) for 2,3,7,8 tetrachlorinated dibenzo-p-dioxin (TCDD; USEPA 2013a). Individual PCDD/F and PCB congeners were present at low concentrations in many sediment samples. For the purposes of calculating dioxin TEQs, nondetect values were handled using the Kaplan-Meier (KM) method with Efron's adjustment using ProUCL statistical software (v 5.0) (USEPA 2013a,b, 2014b). Uncertainties associated with nondetect values and the dioxin TEQ calculation are explained in the Uncertainty Assessment section.

Because only a few samples were collected from Area E (where the dredged material was placed), the maximum dioxin TEQ values observed in the outer shoreline and shallow water sediment samples were used as the exposure point concentrations.

Table 3 presents a summary of dioxin TEQ results calculated using both PCDD/F and PCB congeners. The exposure point concentration for outer shoreline exposure is highlighted on this table (0.05 ng/kg dioxin TEQ). The exposure point concentrations for the shallow water sediments was 0.03 ng/kg dioxin TEQ (based on PCDD/F congeners only; Table 4a).

Sensitivity analysis of key exposure factor values

Evaluation of the MPCA's risk assessment and preliminary risk characterization by USACE indicated that the dermal exposure pathway is the major exposure pathway and contributes the majority of overall risk. The inhalation pathway contributed a negligible amount to the site-specific risk-based concentration. USACE did consider the site-specific physical parameters of the dredged material placement on the beach in order to derive a site-specific particulate emissions factor (PEF; amount of solids becoming airborne) in order to assess the inhalation pathway in a site-specific manner. But, adjusting the PEF had little impact on final risk characterization of the inhalation pathway.

Quantifying the dermal exposure pathway involves a great deal of uncertainty, as exposure factor values are not well established for dermal exposure to sediment. The key exposure factor values involved in this pathway, along with the ingestion pathway, were further evaluated in order to perform a sensitivity analysis of the characterization of risk.

Exposure frequency

The frequency of exposure (number of days per year) to dredged material placed on Minnesota Point Beach affects all exposure pathways, and may also vary depending on exact dredged material placement location on the beach, the weather patterns in a given year, as well as individual circumstances. The number of days someone may be spending on this beach may differ from year to year, especially over the course of a lifetime (26 year exposure duration for cancer risk assessment). The exposure frequency was varied from 5 days/week (105 days/year) down to 2 days/week (42 days a year). The sediment screening levels developed using the greater exposure frequency are appropriate when placing dredging material on the beach closest to the residences, while the sediment screening levels derived using the lower exposure frequency are more appropriate when placing dredged material on the beach further from residential areas, where only recreational exposure is expected.

Amount of skin exposed

The amount of skin exposed is assumed to be greater while playing on a beach in the summertime than the amount of skin exposed to soil in a typical residential, year-round exposure scenario. For the purposes of this assessment, it is assumed that dermal exposure to sediment could occur through the head, full arms, hands, full legs, and feet. However, it is also reasonable to expect that dermal exposure may be limited through the head due to either the presence of hair, or by wearing a hat. In that case, only the face would be subject to dermal exposure to sediment. For this reason, a sensitivity analysis was performed by reducing the amount of skin exposure from head to face only (along with the other body parts mentioned). In addition, the amount of skin which may be exposed could vary due to colder weather during portions of the 5 month exposure period. On cooler days, it is reasonable to assume that only the face, forearms, hands, lower legs, and feet are exposed to beach sand/sediments. In all cases, the mean skin areas are used in this assessment, consistent with MPCA and USEPA guidance (MPCA 2016, USEPA 2011, 2014).

Sediment adherence factor onto skin

The amount of solids that adhere to the skin and result in absorption via the dermal exposure pathway will vary depending on activity, moisture content, and grain size. Because this factor can vary widely and may also be a key factor in determining overall exposure and thus risk, several resources were consulted to determine the most appropriate values to use for assessing exposure of children and adults to dredged material slated for placement on the beach at Minnesota Point.

In deriving human health sediment screening values for exposure to St. Louis River sediments at the U.S. Steel Site, the Minnesota Department of Health adopted a value of 1 mg/cm^2 recommended by the Massachusetts Department of Environmental Protection for children's exposure to sediments while swimming, playing, and wading (MDH 2013, MADEP 2002). In making their recommendation, the Massachusetts Department of Environmental Protection evaluated the studies of sediment adherence measured on children playing in sediment on the shore of a lake, as summarized in Table 7-20 of the *Exposure Factors Handbook* ("kids-in-mud"). They concluded, "Based on judgment and unpublished experimental observations, [MA] DEP has identified a value of 1 mg/cm^2 as a best estimate of the loading that corresponds to a monolayer with most sediment types encountered at hazardous waste sites. Thus, at soil loadings greater than 1 mg/cm^2, total absorption would not continue to increase."

Although it is not certain how the grain size or moisture content of "sediment types encountered at [Massachusetts] hazardous waste sites" compare to dredged material slated for placement at Minnesota Point Beach, this adherence factor value of 1 mg/cm^2 seems reasonable given the following excerpts from the USEPA's *Exposure Factor Values Handbook* Section 7.4 (USEPA 2011):

From EFH 2011 Section 7.4.2.6: "Generally, soil adherence to hands was directly correlated with moisture content, inversely correlated with particle size, and independent of clay content or organic carbon content. For dry soil, mean adherence was the lowest for the largest particle sizes (i.e., >250 μm) of dry soil (0.06 to 0.34 mg/cm^2) and highest for the smallest particle sizes (0.42 to 0.76 mg/cm^2). Adherence values based on moisture content ranged from 0.22 to 0.54 mg/cm^2 for soils with moisture contents of 9% or less, 0.39 to 3.09 mg/cm^2 for soils with moisture contents of 10 to 19%, and 1.64 to 14.8 mg/cm^2 for soils with moisture contents of 21 to 27%."

From EFH 2011 Section 7.4.2.7: "For dry soil containing no oil, adherence values ranged from 0.29 mg/cm^2 for sandy soil to 0.59 mg/cm^2 for silt loam. For wet soil containing no oil (13 to 15% moisture), adherence values were 0.25 mg/cm^2 for silt loam, 1.6 mg/cm^2 for sand, and 3.7 mg/cm^2 for loamy sand."

From EFH 2011 Section 7.4.2.12: "A separate field experiment was conducted in which ten 4-year-old children (five males and five females) attending a nursery school in Japan participated. After playing in the playground and sandbox for a morning or afternoon, the children's hands were washed in bottles containing 500 mL ultrapure water, and aliquots of the water were analyzed to determine the size distributions and of particles that had adhered to the hands. The particles sizes of soil samples collected from the children's playing area (i.e., playground, field, and sandbox) also were analyzed. The mean, median, and maximum amounts of soil adhering to the children's hands were 26.2, 15.2, and 162.5 mg/hand, respectively. Assuming a surface area of the hand of 210 cm^2, the amounts are equivalent to 0.125, 0.73, and 0.774 mg/cm^2, respectively. Compared to the soil in the children's play area, the soil adhering to the children's hands was composed primarily of the finer particles."

In order to perform some sensitivity analysis on this adherence factor value, an activity specific-surface area weighted value was derived from the body-part specific adherence values provided for children's exposure to sediment while playing on tidal flats ("kids-in-mud" studies), as recommended by USEPA and MADEP (USEPA 2004, MADEP 2002). The derivation of this value is presented in Table 2 of the HHRA Tables. These weighted-average adherence factor values range from 2.39 to 2.91 mg/cm^2, depending on the age grouping used.

For adults, a lower solids adherence value is more realistic and reasonable based on activity-specific solids adherence values presented in USEPA 2011 (Table 7-20) and also published (Shoaf et al., 2005). In Shoaf et al. (2005), adult dermal sediment loads were measured following clam digging in tide flats. An adult solids adherence factor of 0.34 mg/cm^2 can be developed from the body-specific solids adherence values in that study combined with the surface areas of the body parts exposed in the study (also presented on Table 2C). The Shoaf paper attempts to explain the lower adherence factors measured in its study in comparison to the adherence factors measured on children playing at a muddy lakeshore (up to 21 mg/cm^2 on feet as presented in USEPA 2011 Table 7-20) by stating that the differences "may be attributable to the differences in child and adult behavior and to the likely greater sand content in coastal sediments" (Shoaf et al., 2005). As noted above, guidance on exposure factor values from USEPA indicates that "soil adherence to hands was …. inversely correlated with particle size". The dredged material placed on the beach at Minnesota Point is primarily sand (approximately 14% coarse sand, 30 – 35% medium sand, and 48 – 52% fine sand) and the sediment used for the exposure studied by Shoaf was 29% very fine sand, 44% fine sand, 19% medium sand, and 3.8% coarse sand. Another estimate of adherence factor values for adult exposure to wet sand or sediment is presented on Table 7-20 of USEPA 2011 as "Reed Gatherer" (adults gathering reeds in August on tidal flats). Using that study, a weighted dermal adherence factor of 0.26 mg/cm^2 can be developed from the body-specific solids adherence values (presented in Table 2). This second study supports the use of a solids adherence factor value lower than 1 mg/cm^2 for adult exposure in this assessment. Furthermore, if greater body surface areas are used in the calculation of the weighted solids adherence factor than those presented in the studies, such as full head, full arms and legs, the weighted skin-solid adherence factors from both the Shoaf study and also the "reed gatherer" study are estimated to be 0.24 mg/cm^2. During the warmer summer months, it would be appropriate to assume that a greater amount of skin is exposed to beach sand. Note that the lower adherence factor value of 0.24 mg/cm^2, when combined with a greater skin surface area will result in a greater overall dermal exposure to constituents in the beach sand.

Relative Bioavailability of dioxin

Studies suggest that the bioavailability of dioxin in soil is less than 100% (USEPA 2010). For this specific scenario, MPCA has indicated that a relative bioavailability (RBA) of 0.7 is appropriate based on the data provided in EPA's 2010 guidance and this site-specific scenario.

TOXICITY ASSESSMENT

Toxicity assessment is the third step of the HHRA process. The toxicity assessment considers the types of potential adverse health effects associated with exposures to COPCs (here, dioxins/furans), the relationship between the magnitude of exposure and potential adverse effects, and related uncertainties—such as the weight of evidence of a particular COPC's carcinogenicity to humans. A toxicity assessment was performed to evaluate the toxicological effects associated with the dioxins at the site, and to select the toxicity values most appropriate for use in this HHRA. The USEPA and other scientific organizations have evaluated toxicological studies to establish a relationship between exposures to chemicals and the increased likelihood of developing cancer or the potential for inducing a non-cancer health effect, such as heart disease or neurological problems. Data synthesized from these evaluations have been used to develop standard toxicity values for estimating health effects from chronic exposures.

The USACE follows the USEPA (2003b) hierarchal approach for identifying quantitative indicators of chemical toxicity (e.g., cancer slope factors and reference doses) when conducting a risk assessment:

- Tier 1 - USEPA's Integrated Risk Information System (IRIS): Toxicity criteria used from the most current update of IRIS (USEPA 2019a).
- Tier 2 - USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs): The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical-specific basis when requested by USEPA's Superfund program.
- Tier 3 - other toxicity values: Tier 3 includes additional USEPA and non-USEPA sources of toxicity information. The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), the California EPA Office of Environmental Health Hazard Assessment Toxicity Criteria Database, and the California EPA Cancer Potency Values are the sources of Tier 3 toxicity criteria used in this assessment.

However, in this case, since the Minnesota site-specific risk calculation spreadsheet was used, the toxicity assessment utilized the toxicity hierarchy established by the MPCA (MPCA 2016a,b). The first source of toxicity criteria used by the MPCA are the values developed by the Minnesota Department of Health.

Toxicity criteria for the oral and the inhalation route exist and are discussed below. Toxicity criteria specific to the dermal exposure route do not exist. As explained in USEPA's *Risk Assessment Guidance for Superfund Part E, Supplemental Guidance for Dermal Risk Assessment,* USEPA 2004), in the absence of dermal toxicity factors, EPA has devised a simplified paradigm for making route-to-route (oral-to-dermal) extrapolations for systemic effects. This process is outlined in Appendix A of the *Human Health Evaluation*

Manual (USEPA 1989). Primarily, it accounts for the fact that most oral reference doses (RfDs) and slope factors are expressed as the amount of substance administered per unit time and body weight, whereas exposure estimates for the dermal pathway are expressed as absorbed dose. The process utilizes the dose-response relationship obtained from oral administration studies and makes an adjustment for absorption efficiency to represent the toxicity factor in terms of absorbed dose to characterize risk from the dermal exposure pathway.

Toxicity Assessment for Non-Carcinogens

An oral reference dose for dioxin is published in IRIS (Tier 1 toxicity criteria source). An inhalation reference dose is available from California EPA (Tier 3) (CalEPA 2013). These toxicity criteria were presented in the risk calculation spreadsheets submitted to MPCA in January 2020 (and approved in February 2020).

The methodology used by USEPA for deriving non-cancer reference values (reference doses or reference concentrations, RfD or RfC respectively) for non-carcinogens are discussed in detail in USEPA guidance (USEPA 2019a). Non-carcinogens are typically judged to have a threshold daily dose below which deleterious or harmful effects are unlikely to occur. This concentration is called the no-observed-adverse-effect-level (NOAEL), and may be derived from either animal laboratory experiments or human epidemiology investigations (usually workplace studies). In developing a toxicity value or human NOAEL for non-carcinogens (i.e., an oral reference dose or inhalation reference concentration), the regulatory approach is to (1) identify the critical toxic effect associated with chemical exposure (i.e., the most sensitive adverse effect); (2) identify the threshold dose in either an animal or human study; and (3) modify this dose to account for interspecies variability (where appropriate), intraspecies variability (differences in individual sensitivity), and other uncertainty and modifying factors.

The oral reference dose for dioxins is based on decreased sperm count and motility in men exposed to TCDD as boys (USEPA 2019a). The California Reference Exposure Level (non-cancer chronic reference inhalation dose) for dioxin is based on adverse effects to the liver, reproductive, endocrine, respiratory and hematologic systems, and development (CalEPA 2013). The MPCA has adopted both these non-cancer toxicity criteria for use in developing their soil reference values (MPCA 2016a,b).

Uncertainty factors (UFs) are intended to account for specific types of uncertainty inherent in extrapolation from the available data. The UFs are generally 10-fold, default factors used in operationally deriving the RfD and RfC from experimental data. UFs less than 10 can be used. An UF of 3 can be used in place of one-half power ($10^{0.5}$) when appropriate. The UFs are intended to account for (1) variation in susceptibility among the members of the human population (i.e., inter-individual or intraspecies variability); (2) uncertainty in extrapolating animal data to humans (i.e., interspecies uncertainty); (3) uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure (i.e., extrapolating from subchronic to chronic exposure); (4) uncertainty in extrapolating from a lowest-observed-adverse-effect-level (LOAEL) to a NOAEL; and (5) uncertainty associated with extrapolation when the database is incomplete. The composite UF for the dioxin oral reference dose is 30 (USEPA 2019a).

Toxicity Assessment for Carcinogens

Carcinogenic toxicity values for dioxin were presented in the risk calculation spreadsheet. Unlike non-carcinogens, carcinogens are generally assumed to have no threshold. It is presumed there is no level of exposure below which carcinogenic effects will not manifest themselves. This “non-threshold” concept supports the idea that there are small, finite probabilities of inducing a carcinogenic response associated with every level of exposure to a potential carcinogen. USEPA uses a two-part evaluation for carcinogenic effects that first assigns a weight-of-evidence classification and second quantifies a cancer toxic potency concentration. Quantification is expressed as a slope factor (SF) for oral and dermal exposures and an inhalation unit risk (IUR) for inhalation exposures, which reflects the dose-response data for the carcinogenic endpoint(s) (USEPA 1989 and 2009).

The USEPA has not classified the carcinogenic potential of TCDD, and Tier 1 and Tier 2 cancer SF values for TCDD do not exist. According to USEPA (USEPA 2019b), several Tier 3 sources are available for TCDD oral SFs. The following are Tier 3 oral SF sources that can be considered.

- EPA's Office of Health and Environmental Assessment (EPA 1985) developed an oral cancer SF of 1.56E+05 $(mg/kg\text{-}day)^{-1}$. This was based on the combined incidence of lung, palate, and nasal carcinomas and liver hyperplastic nodules or carcinomas in female rats in the study by Kociba et al. (1978).
- EPA (1997a) (EPA's Health Effects Assessment Summary Table, or HEAST) provides an oral SFO of 1.5E+05 $(mg/kg\text{-}day)^{-1}$. The citation for the SF in HEAST lists EPA (1985) as one of the sources for the HEAST value.
- California (CalEPA) (1986, 2002) developed an oral cancer SF of 1.3E+05 $(mg/kg\text{-}day)^{-1}$. This is based on the occurrence of hepatocellular adenomas and carcinomas in male mice in a study by the National Toxicology Program (NTP 1982).
- Michigan (Michigan Toxic Steering Group 1990) utilizes an oral cancer SF of 7.5E+04 $(mg/kg\text{-}day)^{-1}$, which is based on a re-analysis of the histological slides of livers from female rats from the Kociba et al. (1978) study using the liver tumor classification scheme proposed by NTP in 1986 (Maronpot et al. 1986, EPA 1990).
- Minnesota Department of Health (MDH 2009) uses an oral cancer SF of 1.4E+06 $(mg/kg\text{-}day)^{-1}$, which is based on the draft re-evaluation of the exposure-response data for liver cancer in female rats reported in the draft USEPA (2003a) dioxin reassessment.

In developing their risk-based screening levels (USEPA 2019), USEPA uses California EPA's oral cancer SF because it is the first Tier 3 source to have an oral SF value. The methodologies used by California EPA in developing its toxicity criteria are quite similar to those used by USEPA's Integrated Risk Information System and Provisional Peer Reviewed Toxicity Value assessments.

On August 29, 2011 EPA announced a plan to separate the Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments into two volumes: Volume 1 (noncancer assessment) and Volume 2 (cancer assessment and uncertainty analysis). The noncancer assessment and TCDD RfD are provided on its website and discussed above in Section 1.3.1 (USEPA 2019a). The USEPA has yet to finalize Volume 2, despite indicating it will do so "as expeditiously as possible." In an effort toward performing the cancer assessment and uncertainty analysis, USEPA presented a range of candidate oral SFs are provided based on studies in human, mice, and rats dating from 1978 (Kociba et al.) to 2006 (Cheng et al.). These candidate oral cancer slop factors range from approximately 1.2E+05 per mg/kg-day to 1.9E+06 per mg/kg-day (USEPA 2010 "Draft do not cite or quote").

USEPA declined to finalize its cancer assessment in IRIS. Minnesota has adopted the draft EPA's dioxin re-assessment from 2003; California EPA uses studies from NTP (1980, 1982). Minnesota did not provide additional peer review on the draft USEPA assessment, but rather adopted the older draft USEPA value as-is. Minnesota's assessment (2009) preceded USEPA's draft re-analysis (2010) which proposed a slightly lower cancer SF [of 1E+06 vs. MDH 1.4E+06 $(mg/kg\text{-}day)^{-1}$]. USEPA finalized their IRIS assessment in 2012 and prior to that announced their intention to pursue the cancer endpoint separately, however, USEPA has not moved forward to finalize that part of the assessment. At that time, USEPA indicated that the low RfD would be protective of the cancer endpoint, although no written analysis of that evaluation has been provided.

Corresponding inhalation unit risks are extrapolated from the oral cancer SF values from the sources identified above.

In this assessment, the California EPA cancer SF values are included in the sensitivity analysis in order to quantify some of the uncertainty associated with the oral cancer slope value.

Toxicity Assessment for Dioxin and Dioxin-Like Compounds

As explained by the USEPA (USEPA 2013a), dioxins are a group of compounds that share distinct chemical structures and characteristics. The term "dioxin" commonly refers to the chemical in this group considered to be the most toxic; 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD). Dioxin-like is a description used for compounds that have chemical structures, physico-chemical properties, and toxic responses similar to TCDD. Dioxin-like compounds (individual PCDD/F and PCB congeners) are typically are found in mixtures in contaminated environmental media. The evaluation of TCDD and dioxin-like compounds in environmental media includes consideration of the toxicity (i.e., cancer risks and non-cancer effects) of these contaminants. In the absence of toxicity values for all dioxin-like compounds, dioxin toxicity equivalence factors (TEFs) are used as a measure of the toxicity of the dioxin-like compounds relative to TCDD. Concentrations of dioxin-like compounds measured in media are modified by TEFs to determine the dose of each dioxin-like compounds in a medium that is equivalent to a dose of TCDD. The modified PCDD/F and PCB congener doses are expressed in terms of TCDD toxicity equivalence (TEQ). The dioxin-like congener TEQ concentrations are used, rather than the dioxin-like congener concentrations measured in media, for site evaluations including site characterization and risk assessment. The U.S. Environmental Protection Agency (EPA) Office of Research and Development recommends the use of the 2005 human and mammalian WHO TEF values for dioxin-like congeners for HHHRA of TCDD and dioxin-like compounds.

RISK CHARACTERIZATION

Once final results are included for comparison to the sediment screening levels, risks can be characterized by simply dividing the sediment dioxin concentration by the screening level. Since the cancer based sediment screening level was developed using a cancer risk limit of 1E-05, the ratio between the dioxin concentration and the sediment screening level is multiplied by 1E-05 to obtain a cancer risk. The ratio between sediment dioxin concentration and the non-cancer sediment screening level provides a hazard quotient.

In the absence of a risk-based screening level, risks can be characterized by combining the exposure assessments with toxicity criteria in order to develop quantitative estimates of risk. The basic equations are as follows:

- $Cancer\ risk\ =\ average\ (chronic)\ daily\ exposure\ (or\ intake)\ \times\ cancer\ slope\ factor$
- $Non-cancer\ hazard\ quotient = \frac{exposure\ level\ (or\ intake)}{reference\ dose\ (or\ concentration)}$

Cancer risks are considered to be additive, such that cancer risks from individual COPCs and exposure pathways are summed to develop a total estimate of cancer risk. This total cancer risk is then compared to the acceptable risk threshold (1 in 100,000 or 1E-05).

Non-cancer hazard quotients from multiple exposure pathways and multiple COPCs that have the same target organ or health effect may also be considered to be additive, in which case, they are summed to develop a hazard index (HI) for all relevant media and COPCs. An HI greater than 1 indicates the potential for adverse non-cancerous health effects. This assumes that simultaneous sub-threshold exposures to several chemicals could result in an adverse health effect (USEPA 1989).

The HHRA spreadsheets, Tables 1-1 and 1-2 present currently estimated excess lifetime cancer risks. Hazard quotients are not presented, since the dioxin TEQ concentrations in the dredged material are below the risk-based sediment screening values derived to be protective of non-cancer hazards (all below hazard quotient of 1).

Based on a comparison of measured dioxin TEQ to the site-specific sediment screening levels (also referred to as a site-specific sediment cleanup value, or SDCV by MPCA, Tables 1-1 and 1-2), the cancer risks for exposure to dioxins in outer shoreline sediments are estimated to range between 4E-09 (4 in a billion) to 1E-07 (1 in 10 million). For exposure to sediments under shallow water areas, cancer risks are even lower, ranging from 3E-09 (3 in a billion) up to 6 E-08 (6 in 100 million). This is well below the range of acceptable cancer risks established by the USEPA (1990); these exposures should be considered acceptable.

As mentioned in the Introduction, dioxins are ubiquitous in the environment, and ambient levels of dioxins present at the placement site, in the absence of dredged material management, should be considered as part of this risk assessment. In the accompanying HHRA workbook, the resulting sediment screening levels are formatted to reflect comparison to background values identified in the “background” tab, which come from published studies in Washington state, Montana, and the St. Regis site in Minnesota. These published background values vary between 1E-07 mg/kg to approximately 4.6E-05 mg/kg dioxins. Most of the cancer-based site specific sediment screening levels (also labeled as “sediment cleanup value” or SDCV in Tables 1-1 and 1-2) are within this “background” range.

As part of this study, concentrations of PCDD/F and dioxin-like PCB congeners were also measured on the beach sand prior to dredged material placement. Those results are presented in Tables 3, 4a/b, and 5. In the 5 samples analyzed of outer shoreline beach sand, only one (1) of the 17 PCDD/F congeners and 2 of the 12 dioxin-like PCB congeners were reported above laboratory detection limits in 5 samples analyzed. The detection of the single PCDD/F congener and the two PCB congeners occurred in different outer shoreline samples (MNP-19-OSA and –OSB, respectively). The other congeners could not be detected in any sample from that mobilization. If the method detection limit were substituted as the resulting concentration of each of the PCDD/F and PCB congeners, the estimated dioxin TEQ in these pre-placement beach samples would range between 5.5 to 7.3 E-07 mg/kg (0.55 to 0.73 ng/kg). This is near the low end of the range of published background concentrations of dioxins in reference soil locations, and almost 10 times lower than the site-specific risk-based sediment screening level (SDCV). Actual ambient concentrations at Minnesota Point Beach will be lower, as the reported concentrations of PCDD/F and PCB congeners are below laboratory analytical detection limits. Since dioxins tend to absorb to fine particles containing organic carbon, which is typically absent from the larger sand particles found on a beach, the very low ambient concentrations on Minnesota Point Beach are not surprising. In samples collected from Minnesota Point several months after dredged material placement (May 2020 sampling event), the upper end of dioxin TEQ concentrations, estimated by substituting the detection limit for the congener concentration for those congeners not reported above detection limits, is slightly greater, between 7.9 E-07 and 1.3 E-06 mg/kg. The risk characterization results indicate that the lower end of risk-based concentrations developed in this assessment (4.6 E-06 mg/kg dioxin TEQ), while greater than estimated ambient concentrations on the beach, are close to the limit of what can be reliably detected.

UNCERTAINTY ASSESSMENT

There are various uncertainties associated with the risk assessment process. Some of the uncertainties associated with characterizing risks at the placement site, and their potential impact on the risk assessment conclusions, are discussed below.

Uncertainty Related to Environmental Data

There are a few factors which may result in uncertainty in the environmental data used in this HHRA. One of these may be the number of samples used to characterize dredged material after beach placement. The dredged material placement configuration was adjusted during time of placement due to conditions in the field. Dredged material placement started at the southern portion of the beach and was to move northward. In 2019, approximately 53,000 cubic yards (CY) of dredged material was placed on Minnesota Point Beach directly north of the Superior Entry breakwall and south of the shipwreck exclusion zone. This area was designated as "Area E" in the sampling plan. The area of the placement site is approximately 253,000 square feet. Midway through placement operations there was a large storm that distributed placed material along Minnesota Point, including the active placement area. After the storm abated, the USACE contractor was able to continue placing the remainder of the 53,000 CY of material in the same location, Area E. All areas of the beach originally identified as dredged material placement areas (and identified in the Sediment Monitoring Plan, USACE 2019a) were sampled in November 2019 ("post-placement" or "mobilization 3" sampling). The resulting composite sample collected from Area E had the greatest concentration of dioxin TEQ (0.06 ng/kg, Tables 3 and 4a/b). Notably, this post-placement result in Area E is within the range of dioxin TEQ concentrations measured while the dredged material was being placed ("mid-placement" samples). During mid-placement sampling detected concentrations of dioxin TEQ ranged from 0.03 to 0.41 ng/kg. Additional sampling of Area E occurred in May 2020 (4^{th} mobilization). At that time, a total of fifteen (15) two-foot deep samples were obtained in the outer shoreline of Area E and composited into a total of three (3) samples. The maximum detected dioxin TEQ was 0.05 ng/kg. The consideration of multiple rounds of sampling with results all within a narrow range of concentrations (mostly below detection limits, with the few detections all between 0.01 to 0.41 ng/kg dioxin TEQ) reduces the uncertainty associated with the use of a single sampling result as a representative exposure point concentration for the beach. In addition, the maximum detected result from the spring 2020 sampling was used in the HHRA instead of an average concentration. The use of the maximum result would also reduce the likelihood of underestimating the risks from exposure to dioxins in the dredged material placed on the beach. The maximum detected result from the spring 2020 sampling (0.05 ng/kg) is almost 100 times lower than the lowest sediment screening level. The large difference between the measured concentrations and the sediment screening levels reduces the impact of the effect of any uncertainties associated with the environmental data set on the risk assessment conclusions.

The sampling methods and locations will impact the characterization of nature and extent of contamination, as well as associated risks. The handling of the sediment while dredging and placing the material on the site via a hydraulic slurry as well as the subsequent wave action after the material is placed will act to mix the dredged material, and also result in reduction of fines from the material. Since dioxins are sorbed preferentially to the fine material, this loss in fines will result in reduction in dioxin concentrations in the dredged material after placement and weathering on the beach. Multiple sediment sampling events were performed in an effort to characterize the change in dioxin concentrations over time.

Standardized laboratory analytical procedures were used to measure concentrations of PCDD/F in dredged material, and the data were reviewed and verified. These sampling, analysis, and review procedures act to reduce uncertainties associated with the results.

In the calculation of the dioxin TEQ, there is some uncertainty associated when individual congeners are not reported above detection limits and the Kaplan-Meir with Efron's adjustment has been used to help reduce this uncertainty. The ability for the Kaplan-Meir procedure to provide estimates of dioxin TEQ with confidence decreases when the number of detectable congeners is less than 5. In order to determine upper and lower limits to this uncertainty, instead of using the Kaplan-Meir methods for estimating mean congener concentrations below detection limits, two other substitutions were performed for non-detected congener results, consistent with USEPA guidance for estimating the dioxin TEQ (USEPA 2014b). For the lower estimated uncertainty in dioxin TEQ concentration, a value of zero (0) was substituted for each congener for samples that were below the detection limit. For the upper estimated uncertainty in dioxin TEQ concentration, the detection limit or the estimated maximum possible concentration (EMPC) was substituted for each congener for samples that were below the detection limit. When available, the EMPC is used as more conservative estimate (upper bound) estimate of the detection limit. However, an EMPC is not reported for every congener or sample (only 28 of 816 congener results). This upper bound estimate TEQ concentration is presented in Tables 4a/b and 5.

As indicated in the table summarizing the dioxin TEQ concentrations, when none of the 17 PCDD/F nor the 12 PCB congeners are reported above detection limits (nondetect or ND = 29) and the detection limit is used as a substitute for the congener concentration, the maximum dioxin TEQ was calculated to be less than 1.28 ng/kg (1.3E-06 mg/kg) in the May 2020 samples. Although the Kaplan Meyer statistical approach has been used for estimating the dioxin TEQ concentration, there is analytical uncertainty in estimated dioxin TEQ concentrations when reported below 1.28 ng/kg (1.3E-06 mg/kg or approximately 1 part per trillion). Note that this upper bound of the reportable dioxin mammalian based TEQ is below the lowest risk-based screening level of 4.7 ng/kg (4.7E-06 mg/kg or approximately 5 parts per trillion), which indicates that our analytical procedures are adequate to identify dioxin concentrations which may pose a risk to human health during management of dredged material on the beach.

Uncertainty in Exposure Assessment

As indicated above, there is some uncertainty associated primarily with quantifying dermal exposure to sediments. An attempt was made to quantify some of this uncertainty by performing a sensitivity analysis of some of the key parameters associated with this exposure pathway. The amount of skin exposed and the adherence factor are key parameters in this pathway. Conservative but reasonable values were utilized and also varied slightly in order to attempt to bound the possible exposure and subsequent risk via this pathway.

The exposure assessment also assumed that people would be exposed to dry beach sand (outer shoreline sediments) more than they would to sediments under shallow water. For this reason, risk-based sediment screening levels were only developed for outer shoreline exposures, and not for shallow water exposures. This assumption was to be re-visited upon review of results of sampling the sediments from under the shallow water areas. The dioxin TEQ concentrations measured in shallow water sediments were slightly lower than dioxin TEQ concentrations measured from the outer shoreline during the May 2020 sampling event (Table 4a). Therefore, application of the outer shoreline risk-based concentration to ensure protection of people being exposed to shallow water sediments remains protective. No derivation of a separate shallow water sediment screening level is warranted.

Uncertainty Related to Toxicity Information

As discussed above, there is some uncertainty associated with the oral cancer SF. Although the value recommended by the MDH is used in this assessment, the MDH-recommended cancer SF indicates dioxin is an approximately 9 to 19 times more potent carcinogen than what some other state agencies, including California EPA and Michigan EGLE, assume. In developing their risk based screening levels, the USEPA uses the California EPA cancer SF. For this reason, a sensitivity analysis was performed using the oral cancer SF from California EPA, which is approximately 9 times lower than the Minnesota recommended cancer SF.

Uncertainty Related to Derivation of Dioxin TEQ

There is some uncertainty involved in not including polychlorinated biphenyls (PCBs) results in the calculation of the dioxin TEQ for the shallow water sediment samples. This should not significantly impact the dioxin TEQ estimate, since sampling results from 3 rounds of outer shoreline sediments (pre-, post, and spring sampling) indicated low or non-detectable concentrations of PCBs. As seen in Table 4b, only 2 of the 12 PCB congeners which contribute to dioxin-like toxicity were detected, and these detections occurred only in 2 samples (once in a pre-placement and once in an immediate post-placement sample). As indicated in Table 3, for those post-placement (fall and spring) outer shoreline samples in which a positive (above detection limit) dioxin TEQ was calculated, the contribution from PCB congeners to the dioxin TEQ was less than 4% (dioxin TEQ of 0.03 to 0.05 ng/kg).

CONCLUSIONS

The HHRA Table 1-1 presents dioxin TEQ sediment screening levels derived for 2 different exposure frequencies (5 days per week and 2 days per week), appropriate for exposure to nearby residents, or recreational visitors to the beach, respectively. The concentrations of dioxins measured in samples of the dredged material obtained during and after placement of the sediments on the beach in 2019 and 2020 are considerably lower than these sediment screening levels. Even considering an upper estimated dioxin TEQ value, developed by substituting the full detection limit for congeners not reported above detection limits indicates that the dioxin TEQ concentrations in beach sand after dredged material placement would not pose unacceptable risks to people on the beach. This indicates that use of dredged material for beach nourishment at Minnesota Point Beach should not adversely affect human health. This reduction in dioxin concentrations between navigation channel sediments and sediments placed on the beach is a result in reduction in fines which occurs during hydraulic placement of the sediments. This indicates that the dredged material is suitable for placement on the Minnesota Point Beach, even in areas closer to the residences.

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TABLE 1-0
SELECTION OF EXPOSURE PATHWAYS: SUMMER SEASONAL EXPOSURE
Minnesota Point Beach Nourishment using Dredged Material - Human Health Risk Assessment

Sediment location	Medium (1)	Exposure Medium (2)	Exposure Point (3)	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
SHORELINE	Dredged Sediments	Beach (dry) sediment	TBD (sampling areas in outer shoreline)	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion, inhalation, and dermal exposure	Quantitative	Assumes that families, including babies and toddlers, would be playing on the beach
SHALLOW WATER	Dredged Sediments	Surface water (dissolved concentrations)	None	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion	None (4)	Assumes that although partitioning can occur from solids fraction to water column, equilibrium would only occur in a boundary layer and then the minute TCDD aqueous concentrations would be rapidly dispersed and diluted to negligible levels.
						Dermal absorption	None (4)	
		Suspended sediments	TBD (shallow water sampling locations)	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion	Quantitative	Assumes that families, including babies and toddlers, would be wading and swimming in shallow water
		Submerged sediments	TBD (shallow water sampling locations)	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion	Quantitative	Assumes that families, including babies and toddlers, would encounter lake bed sediments while swimming in shallow waters
						Dermal absorption	Quantitative	
DEEP WATER	Dredged Sediments	Surface water (dissolved concentrations)	None	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion	None (4)	Assumes that although partitioning can occur from solids fraction to water column, equilibrium would only occur in a boundary layer and then the minute TCDD aqueous concentrations would be rapidly dispersed and diluted to negligible levels.
						Dermal absorption	None (4)	
		Suspended sediments	TBD (deep water sampling locations)	Residents / Recreational visitors	Babies & young children (0 - 6 years old)	Incidental ingestion	None (4)	Assumes that babies and small children would not be swimming in deep water
					Youth through adult (6 - 26 years old)	Incidental ingestion	Quantitative	Assumes that youth and adults may swim in deep water
		Submerged sediments	TBD (deep water sampling locations)	Residents / Recreational visitors	Childhood through adult (0 - 26 years old)	Incidental ingestion	None (4)	Assumes that water depth would preclude direct exposure to lake bed sediments while swimming
						Dermal absorption	None (4)	

(1) Source medium
(2) Environmental medium to which an individual may be exposed.
(3) Location of potential contact within an exposure medium, corresponds to sampling locations for purposes of assessment
(4) No analysis is performed for incomplete exposure pathways

Table 1 -1 Minnesota Point Human Health Risk Assessment Summary of Exposure and Toxicity Factor Values Sensitivity Analysis Effect on Risk-Based Site-Specific Sedime

spreadsheet name: "MN Point Calc c-r1-07 usace Jan2020_"	Exposure Frequency days/year[1]	Exposure Frequency days per week[1]	Ingestion Rate Adult [2] mg/day	Ingestion Rate Child [2] mg/day	Adherence Factor Adult [3] (16 - 26 years) mg/cm^2	Adherence Factor Child [3] (0 - 2 years) mg/cm^2	Adherence Factor Child [3] (2 - 16 years) mg/cm^2	Adherence Factor Child [3] (0 - 6 years) mg/cm^2	Skin surface area Adult[4] (16 - 26 years) cm^2	Skin surface area Child [4] (0 - 2 years) cm^2	Skin surface area Child [4] (2 - 16 years) cm^2	Skin surface area Child [4] (0 - 6 years) cm^2	fa
Birth to 26 years: Intertidal sediment, recreational activity exposure in all cases. Cancer exposure duration set to 26 years; non-cancer exposure duration set to 6 years.													
5 days/week													
A	105	5	100	200	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	
	vary cancer slope factor											*CalEPA*	
B	105	5	100	200	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	
	vary amount of skin exposed					*face instead of head skin surface area (also affects derivation of weighted skin-solids adherence factor)*							
C	105	5	100	200	0.25	2.9	2.9	2.9	11,846	2,456	6,532	3,397	
	vary skin-solids adherence factor												
D	105	5	100	200	1	1.0	1.0	1.0	12,680	2,988	6,975	3,834	
	vary sediment ingestion rate												
E	105	5	50	100	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	
2 days/week													
P	42	2	100	200	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	
	vary cancer slope factor											*CalEPA*	
Q	42	2	100	200	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	
	vary amount of skin exposed					*face instead of head skin surface area (also affects derivation of weighted skin-solids adherence factor)*							
R	42	2	100	200	0.25	2.9	2.9	2.9	11,846	2,456	6,532	3,397	
	vary skin-solids adherence factor												
S	42	2	100	200	1	1.0	1.0	1.0	12,680	2,988	6,975	3,834	
	vary sediment ingestion rate												
T	42	2	50	100	0.24	2.4	2.7	2.6	12,680	2,988	6,975	3,834	

Notes

Parameters that are consistently used (no variation) are not shown in this summary range of risks spreadsheet

Parameter changes are highlighted in purple

Exceeds cancer SDCV

Exceeds noncancer SDCV *100*

Exceeds cancer and noncan *100*

Bold and red high

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if le

Background threshold v

1 - A greater exposure frequency is appropriate when placing dredged material on the beach closest to the residences, while a lower exposure frequency would be more appro

2 - Ingestion rate was varied for sensitivity analysis purposes.

3 - AF of 1 from MDH U.S. Steel Public Health Consultation and MA DEP April 2002, April 2013 was used for sensitivity analysis due to uncertainty in adherence factor values; o

4 - Varied to include either head, arms, hands, legs and feet, or, face, arms, hands, legs, and feet. Both from EPA Exposure Factors Handbook September 2011

5- Cancer slope factor sensitivity analysis includes value derived by CalEPA (1.3E+05) as well as the value recommended by MDH 2009 (1.4E+06)

Table 1-2 Comparison of Sediment Screening Levels ("SDCV") with Beach Sampling Results, and Resulting Excess Lifetime Cancer Risks (ELCR)

spreadsheet name: "MN Point Calc c-r1-07 usace Jan2020_"	Cancer SDCV mg/kg	Noncancer SDCV mg/kg	2020 post-placement Outer Shoreline sample maximum detection (MNP-20-OS E3) dioxin TEQ mg/kg	2020 post-placement Outer Shoreline sample maximum detection (MNP-20-OS E3) Cancer Risk	2020 post-placement Shallow Water sample maximum detection (MNP-20-SW E3) dioxin TEQ mg/kg	2020 post-placement Shallow Water sample maximum detection (MNP-20-SW E3) Cancer Risk
A	*4.7E-06*	8.2E-05	5.0E-08	1.E-07	3.0E-08	6.E-08
B	4.8E-05	8.2E-05	5.0E-08	1.E-08	3.0E-08	6.E-09
C	*4.7E-06*	8.3E-05	5.0E-08	1.E-07	3.0E-08	6.E-08
D	*7.2E-06*	1.4E-04	5.0E-08	7.E-08	3.0E-08	4.E-08
E	*5.4E-06*	9.8E-05	5.0E-08	9.E-08	3.0E-08	6.E-08
P	**1.2E-05**	2.1E-04	5.0E-08	4.E-08	3.0E-08	3.E-08
Q	1.2E-04	2.1E-04	5.0E-08	4.E-09	3.0E-08	3.E-09
R	**1.2E-05**	2.1E-04	5.0E-08	4.E-08	3.0E-08	3.E-08
S	**1.8E-05**	3.5E-04	5.0E-08	3.E-08	3.0E-08	2.E-08
T	**1.3E-05**	2.4E-04	5.0E-08	4.E-08	3.0E-08	2.E-08

Bold and red highlight = less than maximum published background

Brown and italics = less then minimum published background

if less than max might not show up as less than min

TABLE 2

DERIVATION OF SEDIMENT ADHERENCE FACTORS: RESIDENTIAL / RECREATIONAL EXPOSURE

Minnesota Point Beach Nourishment using Dredged Material - Human Health Risk Assessment

Recommended adherence factor for kids playing in sediment (EFH 2011, Table 7-4, based on kids ages 7 - 12 playing in sediment /shoreline play)

mg/cm^2		0 - 2 years	0 - 6 years	2-16 years	6- 11 years	11 - 16 years	6- 16 years
AF	**body part**	**surface area cm^2**	**surface area cm^2**	**surface area cm^2**	**surface area cm^2**	**surface area cm^2**	**surface area cm^2**
0.04	**HEAD***	798	656	664	660	730	695
0.17	**full arms**	619	883	1640	1510	2270	1890
0.49	**hands**	255	317	539	51	72	61.5
0.7	**full legs**	1022	1572	3364	3110	4830	3970
21	**feet**	294	406	768	730	1050	890
	TOTAL skin area cm2	2988	3834	6975	6061	8952	7507
	weighted AF mg/cm2-day	2.39	2.60	2.73	2.94	2.89	2.91

*Note that the studies of adherence factor identify face-specific adherence factors. Here those face-specific factors are assumed to apply to the entire head.

Recommended adherence factor for adults clam diggin in tide flats (Shoaf et al, 2005. Soil and Sediment Contamination, 14:5, 463-470).

mg/cm^2		adults	
AF	**body part**	**surface area cm^2**	face instead of head
0.02	**HEAD***	1250	417
0.12	**full arms****	2755	2755
0.88	**hands**	980	980
0.16	**full legs****	6400	6400
0.58	**feet**	1295	1295
	TOTAL skin area cm2	12,680	11,847
	weighted AF mg/cm2-day	0.24	0.25

*Note that the studies of adherence factor identify adherence factors for forearms and lower legs. Here those face-specific factors are assumed to apply to the full legs and arms.

Reed gatherer, EFH 2011 Table 7-20

mg/cm^2		adults
AF	**body part**	**surface area cm^2**
0.02	**HEAD*****	1250
0.036	**arms**	2755
0.66	**hands**	980
0.16	**legs**	6400
0.63	**feet**	1295
	TOTAL skin area cm2	12,680
	weighted AF mg/cm2-day	0.24

*** This study did not provide any head or face-specific adherence factor. The value from the Shoaf paper is used here.

Table 3. Summary of the Dioxin TEQ from both PCB and PCDD/F analysis for the 2019-2020 Minnesota Point Outer Shoreline pre-placement and post-placement sampling events.

Dioxin TEQ $_{MAMMALS}$ (ng/kg)			
Data Set	**Sum of Kaplan Meier Total PCDD/F and PCB TEQ Estimate**	**Kaplan Meier Total PCDD/F TEQ % Contribution**	**Kaplan Meier Total PCB TEQ % Contribution**
2019 Pre-Placement Samples: Outer Shoreline			
- MNP-19-OS A	<0.01	55%	45%
- MNP-19-OS B	<0.01	34%	66%
- MNP-19-OS C	<0.01	39%	61%
- MNP-19-OS D	<0.01	70%	30%
- MNP-19-OS E	<0.01	74%	26%
2019 Post-Placement Samples (Fall): Outer Shoreline			
- MNP-19-OS A3	0.01	89%	11%
- MNP-19-OS B3	<0.01	69%	31%
- MNP-19-OS C3	<0.01	67%	33%
- MNP-19-OS D3	0.01	88%	12%
- MNP-19-OS E3	0.06	96%	4%
2020 Post-Placement Samples (Spring): Outer Shoreline			
- MNP-20-OS AB	<0.01	79%	21%
- MNP-20-OS CD	<0.01	75%	25%
- MNP-20-OS E1	0.01	89%	11%
- MNP-20-OS E2	0.03	97%	3%
- MNP-20-OS E3	0.05	99%	1%

PCB are polychlorintated biphenyls

PCDD/F are polychlorinated dibenzo-p-dioxins and furans

Highlighted result is used as the exposure point concentration in the HHRA.

Table 4a. Summary of PCDD/F Dioxin TEQ $_{MAMMALS}$ surface data from the 2019-2020 Minnesota Point pre-placement, mid-placement, and post-placement sampling events.

Data Set[1]	Number of NDs for Congeners[2]	Kaplan Meier Total PCDD/F TEQ Estimate	Total PCDD/F TEQ Estimate where ND = 0	Total PCDD/F TEQ Estimate where ND = DL[3]
	PCDD/F Dixon TEQ $_{MAMMALS}$ (ng/kg)			
2019 Pre-Placement Samples: Inner Shoreline				
- MNP-19-ISA	16	0.01	<0.01	0.36
- MNP-19-ISB	15	0.02	0.01	0.33
- MNP-19-ISC	13	0.04	0.01	0.30
- MNP-19-ISD	16	0.01	<0.01	0.30
- MNP-19-ISE	14	0.03	0.01	0.28
2019 Pre-Placement Samples: Outer Shoreline				
- MNP-19-OSA	16	<0.01	<0.01	0.20
- MNP-19-OSB	17	<0.01	ND	0.17
- MNP-19-OSC	17	<0.01	ND	0.18
- MNP-19-OSD	17	<0.01	ND	0.20
- MNP-19-OSE	17	<0.01	ND	0.24
2019 Pre-Placement Samples: Shallow Water				
- MNP-19-SWA	16	<0.01	<0.01	0.29
- MNP-19-SWB	16	<0.01	<0.01	0.34
- MNP-19-SWC	17	<0.01	ND	0.19
- MNP-19-SWD	17	<0.01	ND	0.26
- MNP-19-SWE	17	<0.01	ND	0.36
2019 Pre-Placement Samples: Deep Water				
- MNP-19-DW 1	15	0.01	<0.01	0.20
- MNP-19-DW 2	16	<0.01	<0.01	0.20
- MNP-19-DW 3	14	0.01	<0.01	0.18
- MNP-19-DW 4	14	0.01	<0.01	0.27
- MNP-19-DW 5	13	0.03	0.01	0.22
2019 Mid-Placement Samples: Outer Shoreline				
- MNP-19-OS 8-2	15	0.03	0.01	0.50
- MNP-19-OS 9-2	13	0.08	0.05	0.44
- MNP-19-OS 10-2	13	0.41	0.37	0.68
- MNP-19-OS - SP	13	0.16	0.09	0.62
- MNP-19-OS - Comp	12	0.08	0.05	0.32
2019 Post-Placement Samples (Fall): Outer Shoreline				
- MNP-19-OSA-3	16	0.01	<0.01	0.36
- MNP-19-OSB-3	17	<0.01	ND	0.54
- MNP-19-OSC-3	17	<0.01	ND	0.63
- MNP-19-OSD-3	15	0.01	<0.01	0.43
- MNP-19-OSE-3	13	0.06	0.03	0.33

Table 4a. Summary of PCDD/F Dioxin TEQ $_{MAMMALS}$ surface data from the 2019-2020 Minnesota Point pre-placement, mid-placement, and post-placement sampling events.

PCDD/F Dixon TEQ $_{MAMMALS}$ (ng/kg)				
Data Set[1]	**Number of NDs for Congeners[2]**	**Kaplan Meier Total PCDD/F TEQ Estimate**	**Total PCDD/F TEQ Estimate where ND = 0**	**Total PCDD/F TEQ Estimate where ND = DL[3]**
2020 Post-Placement Samples (Spring): Outer Shoreline				
- MNP-20-OS AB	16	<0.01	<0.01	0.57
- MNP-20-OS CD	16	<0.01	<0.01	0.85
- MNP-20-OS E1	16	0.01	<0.01	0.82
- MNP-20-OS E2	14	0.03	0.01	0.49
- MNP-20-OS E3	14	0.05	0.02	0.64
2020 Post-Placement Samples (Spring): Shallow Water				
- MNP-20-SW AB	17	<0.01	ND	0.73
- MNP-20-SW CD	15	0.03	0.01	0.30
- MNP-20-SW E1	15	<0.01	<0.01	1.1
- MNP-20-SW E2	14	0.02	0.01	0.24
- MNP-20-SW E3	15	0.03	0.01	0.38
2020 Post-Placement Samples (Spring): Deep Water				
- MNP-20-DW 1	17	<0.01	ND	1.4
- MNP-20-DW 2	16	0.01	<0.01	0.58
- MNP-20-DW 3	17	<0.01	ND	0.84
- MNP-20-DW 4	17	<0.01	ND	1.1
- MNP-20-DW 5	15	0.04	0.01	1.4

[1] Averages were taken for samples MNP-19-ISC, MNP-19-SWB, and MNP-20-SW E1 to account for duplicates.

[2] Number of NDs for congeners does not reflect the Efron's adjustment in this summary table.

[3] For non-detect samples, either the EMPC or EDL value was substituted for the Total PCDD/F TEQ estimate.

Highlighted result is used as the exposure point concentration in the HHRA.

Table 4b. Summary of Total PCB Dioxin TEQ $_{MAMMALS}$ surface data from the 2019-2020 Minnesota Point pre-placement and post-placement sampling locations.

PCB Dioxin TEQ $_{MAMMALS}$ (ng/kg)				
Data Set	**Number of NDs for Congeners[1,2]**	**Kaplan Meier Total PCB TEQ Estimate**	**Total PCB TEQ Estimate where ND = 0**	**Total PCB TEQ Estimate where ND = RL[3]**
2019 Pre-Placement Samples: Outer Shoreline				
- MNP-19-OS A	12	<0.01	ND	0.48
- MNP-19-OS B	10	<0.01	<0.01	0.43
- MNP-19-OS C	12	<0.01	ND	0.47
- MNP-19-OS D	12	<0.01	ND	0.38
- MNP-19-OS E	12	<0.01	ND	0.49
Fall 2019 Post-Placement Samples: Outer Shoreline				
- MNP-19-OS A3	12	<0.01	ND	0.42
- MNP-19-OS B3	12	<0.01	ND	0.35
- MNP-19-OS C3	12	<0.01	ND	0.41
- MNP-19-OS D3	12	<0.01	ND	0.41
- MNP-19-OS E3	10	<0.01	<0.01	0.43
Spring 2020 Post-Placement Samples: Outer Shoreline				
- MNP-20-OS AB	12	<0.01	ND	0.35
- MNP-20-OS CD	12	<0.01	ND	0.43
- MNP-20-OS E1	12	<0.01	ND	0.42
- MNP-20-OS E2	12	<0.01	ND	0.43
- MNP-20-OS E3	12	<0.01	ND	0.30

[1] Number of NDs for congeners does not reflect the Efron's adjustment in this summary table.

[2] Due to coeluting PCB congeners 156 and 157, half the reporting limit was used for each coelute.

[3] For non-detect samples, the reporting limit was substituted for the Total PCB TEQ estimate.

Table 5. Summary of PCDD/F and PCB Dioxin TEQ $_{MAMMALS}$ from the 2019-2020 Minnesota Point sampling events.

		PCDD/F Dioxin TEQ $_{MAMMALS}$						PCB Dioxin TEQ $_{MAMMALS}$ (ng/kg)[4,5]					
		Kaplan Meier Total PCDD/F TEQ Estimate		Total PCDD/F TEQ Estimate where ND = 0		Total PCDD/F TEQ Estimate where ND = DL[3]		Kaplan Meier Total PCB TEQ Estimate		Total PCB TEQ Estimate where ND = 0		Total PCB TEQ Estimate where ND = RL[6]	
Data Set [1,2]	N	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
- Pre-Placement Inner Shoreline	5	0.04	0.02	0.01	0.01	0.36	0.31	NA		NA		NA	
- Pre-Placement Outer Shoreline	5	<0.01	<0.01	<0.01	<0.01	0.24	0.20	<0.01	<0.01	<0.01	<0.01	0.49	0.45
- Pre-Placement Shallow Water	5	<0.01	<0.01	<0.01	<0.01	0.36	0.29	NA		NA		NA	
- Pre-Placement Deep Water	5	0.03	0.01	0.01	<0.01	0.27	0.21	NA		NA		NA	
- Mid-Placement Outer Shoreline	5	0.41	0.15	0.37	0.11	0.68	0.51	NA		NA		NA	
- Fall Post-Placement Outer Shoreline	5	0.06	0.01	0.03	0.01	0.63	0.46	<0.01	<0.01	<0.01	<0.01	0.43	0.40
- Spring Post-Placement Outer Shoreline	5	0.05	0.02	0.02	0.01	0.85	0.67	<0.01	<0.01	ND	ND	0.43	0.39
- Spring Post-Placement Shallow Water	5	0.03	0.02	0.01	0.01	1.1	0.55	NA		NA		NA	
- Spring Post-Placement Deep Water	5	0.04	0.01	<0.01	<0.01	1.4	1.1	NA		NA		NA	

PCDD/F are polychlorinated dibenzo-p-dioxins and furans

PCB are polychlorintated biphenyls

NA Samples were not analyzed for PCB congeners

[1] Results were not normalized for Total Organic Carbon (TOC) due to a high number of non-detects.

[2] Averages were taken for samples MNP-19-ISC, MNP-19-SWB, and MNP-20-SW E1 to account for duplicates.

[3] For non-detect samples, either the EMPC or EDL value was substituted for the Total PCDD/F TEQ estimate.

[4] Results were not normalized for Total Organic Carbon (TOC) due to all but 4 congeners being non-detect.

[5] Due to coeluting PCB congeners 156 and 157, half the reporting limit was used for each coelute.

[6] For non-detect samples, the reporting limit was substituted for the Total PCB TEQ estimate.

Human Health Risk Assessment for Dredged Material Management on Minnesota Point Beach Duluth Harbor

ATTACHMENTS 1 and 2
Provided electronically

Human Health Risk Assessment for Dredged Material Management on Minnesota Point Beach Duluth Harbor

ATTACHMENT 3

MPCA Comments regarding USACE's MN Point HHRA Submitted 1/28/2020 and April Sampling of 2019 Placement Site

Document Preparation Date: February 14, 2020

Comments

- Site-specific sediment values calculations are consistent with what has been agreed to between MPCA and USACE and are appropriate to use to assess potential risks to people from dioxin in sediment. Based on the HHRA and preliminary data from the sediment study at Minnesota Point, it appears that future placement of dredge material on Minnesota Point in recreational areas will not pose risks to people, although it is important for MPCA to review the applicable proposed dredged sediment data before approving additional placements. It also appears that placing sediments on the rest of the peninsula including behind residential housing may be appropriate depending on the specific material to be dredged, the sampling that was conducted in the harbor to characterize the sediment and the results from the April 2020 sampling as part of the sediment study at Minnesota Point.
    - *USACE April/June 2020 response: The comment is understood. We appreciate that we have come to agreement on the derivation of site-specific sediment values for dioxin that are protective of human health on all reaches of Minnesota Point Beach.*
- Data Evaluation and Hazard Assessment: MOB 2 is not mentioned, only MOB 1, 3 and 4. It would be beneficial to mention this data also since it does provide another line of evidence that may be taken into consideration when evaluating potential risks and support for decreases in dioxin concentrations after sediment dredging and management.
    - *USACE April/June 2020 response: The MOB 2 sampling results will be included in the data presentation and will be considered in the uncertainty analysis and HHRA conclusions.*
- Exposure Concentrations: This section states "If the post-placement sampling results continue to verify the modeled loss of dioxin concentrations from the dredged material once placed on the beach, the fate and transport model may be used to estimate dioxin concentrations on the beach from future navigation channel sampling results." A 90% decrease was used to estimate post sediment dredging and management concentrations. MPCA cannot agree to using this amount of a decrease for all harbor sediment concentrations based on the data provided and the type of sampling that has been conducted in the harbor in the past. MPCA can work with USACE to develop a sampling plan that more adequately characterizes the sediments in the harbor and discuss the use of some type of a reduction to use in the future based on the revised sampling plan, this data and the data from the April sampling event. In addition, if USACE begins using a revised sampling plan, the use of a more central tendency exposure concentration may be appropriate.
    - *USACE April/June 2020 response: This discussion of modeling concentrations on the beach using measurements made from material within the navigation channel will be removed from the HHRA. We will continue to work towards a mutually agreeable sediment characterization strategy.*
- Uncertainty Related to Derivation of Dioxin TEQ: Most of the PCB sampling that was conducted previously was based on aroclors which would not be appropriate in this case. The sampling of

some congeners in 2011 only included five of the 12 normally recommended to analyze per the World Health Organization. MPCA recommends the analysis of the 12 PCB congeners to determine if they significantly contribute to dioxin concentrations. To ensure all of the data needed to support future placements of sediments on the entire area of Minnesota Point, MPCA recommends analyzing the April samples from the 2019 placement area for the 12 PCBs. MPCA also recommends analyzing for the 12 PCB congeners during the next round of harbor sampling after USACE and MPCA agree on a new sampling strategy.

  - *USACE April/June 2020 response: PCB congeners were added to the analytical suite for both pre- and post-placement (November) samples from Minnesota Point (removed from archive and re-submitted to the laboratory), as well as spring 2020 sampling. The June 2020 HHRA will incorporate results from PCB analysis of these samples. The PCB congeners which contribute to dioxin-like toxicity will be included in the calculation of the dioxin TEQ and used to assess risk from exposure to beach sediments.*

- Site-specific value calculation spreadsheets: A surface area used for a child 0 to years of 3,835 cm^2 is used in the calculation spreadsheets E, P, S and T., but 3,384 cm^2 should be used. This has been corrected in the range of risks (ROR) spreadsheet, but not in the calculation spreadsheets. It does not appear to make a difference in the site-specific sediment values so there is no need to re-submit this at this time. Please change for future submissions.
  - *USACE April/June 2020 response: This has been corrected in the calculation workbooks. They are not being re-submitted in June because they were previously reviewed and approved, but can be provided again if requested.*
- Site-specific value calculation spreadsheets: Calculations spreadsheets C and R and the ROR spreadsheet list an adherence factor for the child ages 0 to 6 of 2.93 mg/cm2, but is listed as 2.9 in the adherence factor calculations. This was changed in the ROR spreadsheet, but not in the actual calculation spreadsheets. Rounding to two significant figures is more appropriate to use in the derivation. It does not appear to make a difference in the site-specific sediment values now that they are rounded to two significant figures so there is no need to re-submit this at this time. Please change for future submissions.
  - *USACE April/June 2020 response: This has been corrected in the calculation workbooks. They are not being re-submitted in June because they were previously reviewed and approved, but can be provided again if requested.*

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