Appendix E

Use of Area-Based Average Concentration to Meet Clean-Up Level

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Provided As Part of Pre-Final 90% Remedial Design - Northern Impoundment
San Jacinto River Waste Pits Site
Harris County, Texas

International Paper Company
McGinnes Industrial Maintenance Corporation

June 27, 2022

→ The Power of Commitment

Contents

1. Introduction

GHD Services Inc. (GHD), on behalf of International Paper Company and McGinnes Industrial Maintenance Corporation (collectively Respondents), has analyzed how the clean-up level of 30 nanogram per kilogram (ng/kg) Toxicity Equivalence (TEQ) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site, located in Harris County, Texas (Site), was developed. GHD performed this analysis as a basis for proposing that the clean-up level of 30 ng/kg TEQ be implemented on an area-based average concentration rather than on a point-by-point basis. That analysis, detailed below, was presented to the United States Environmental Protection Agency (USEPA) during a Technical Working Group (TWG) Meeting on November 16, 2021.

2. Use of Average Concentrations to Meet Clean-Up Level

Several lines of evidence support the use of an average concentration statistic as the appropriate means to achieve the clean-up level of 30 ng/kg TEQ. These are discussed below as they pertain to (1) the derivation of risk estimates for the Northern Impoundment by Integral Consulting and Anchor QEA (Integral & Anchor; 2013) and (USEPA, 2016); (2) how the clean-up level of 30 ng/kg TEQ was derived; and (3) the proper application of the clean-up level based on how it was derived. In addition, as discussed below, the USEPA has approved the use of area-based average concentrations at Superfund sites throughout the country.

The general premise underlying the use of average concentrations is that estimates of risk, which are the basis of action for the ROD, are based on exposures to conservative estimates of the average concentrations of a chemical (USEPA, 1989, 2002a). When human health risk assessments are conducted, risk is not characterized based on exposure to a single concentration of a chemical. It is instead assessed based on exposure to a concentration that represents an average of the concentrations to which a person is exposed over time. This is a fundamental principle of risk assessment and risk management and was the basis for the risk assessments performed with respect to the Northern Impoundment. As such, it is appropriate to apply the clean-up level for the Northern Impoundment on an area averaged basis and not on a point-by-point basis.

2.1 Assessment of Risk to Human Health

2.1.1 Baseline Human Health Risk Assessment (Integral and Anchor, 2013)

A site-specific baseline human health risk assessment (BHHRA) was conducted by Integral and Anchor (2013) to determine potential pathways by which human receptors could be exposed to upland or aquatic contamination in sediment, soil, water, or biota, the amount of contamination receptors of concern may be exposed to, and the toxicity of those contaminants if no action were taken to address contamination at the Northern Impoundment (Integral & Anchor 2013b, Integral 2012). Subsequently, the (USEPA, 2017) accepted the BHHRA as:

> *“the basis for taking action and [to] identify the contaminants and exposure pathways that need to be addressed by the remedial action.”* (p. 37).

The cancer risks and non-cancer hazards developed in the BHHRA are based on a series of exposure assumptions applicable to the three types of exposures evaluated: (1) ingestion of sediment or soil; (2) dermal absorption of chemicals from sediment or soil; and (3) the ingestion of fish or shellfish. Specifically, the risk estimates for the *recreational child fisher*, identified in the ROD as the basis for action, were based on exposure through direct contact with sediment (incidental ingestion and dermal contact), and ingestion of finfish (represented by hardhead catfish).

Cancer risks and non-cancer hazards for the *child recreational fisher* presented in the BHHRA were calculated using exposure point concentrations (EPCs) for each exposure medium (i.e., sediment and fish). Consistent with USEPA guidance (1989, 2002a), the EPCs used in the BHHRA were conservative estimates of the *arithmetic average* for each medium. These EPC values were chosen because, as described in USEPA guidance (1989, page 6-19):

> *"The concentration term in the intake equation is the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time. This is because in most situations, assuming long-term contact with the maximum concentration is not reasonable." (Emphasis added).*

Therefore, consistent with USEPA guidance and policy, conservative estimates of the mean were used to calculate cancer risks and non-cancer hazards for the child recreational fisher that served as the basis for action at the Northern Impoundment. Exposure to a child was found to be more conservative than exposure to adult or a combined adult and child exposure. The excess lifetime cancer risk for the *child recreational fisher* scenario was calculated from direct exposure to sediment through: (1) the incidental ingestion of sediment; (2) dermal contact with sediment; and (3) indirect exposure to sediment through the ingestion of fish. The cancer risk estimated for the child recreational fisher at Beach Area E was $2x10^{-5}$, which is within USEPA's generally accepted excess cancer risk range of $1x10^{-6}$ to $1x10^{-4}$. The BHHRA also assessed the potential for non-carcinogenic effects posed by exposure to site-related chemicals. The non-cancer hazard index (HI = sum of hazard quotients [HQ]) for the recreational fisher was greater than 1, which is USEPA's threshold of significance for non-cancer health impacts for chemicals with similar target organs and mechanisms of action. For the child recreational fisher, a HI of 45 was calculated based on dermal contact and incidental ingestion of sediment and direct consumption of fish from the Northern Impoundment. The breakdown is as follows.

Exposure Pathway	Hazard Quotient	Percent Contribution to Hazard Index
Sediment - Dermal Contact	37	82 percent
Sediment - Incidental Ingestion	7	16 percent
Fish - Ingestion	1	2 percent
Hazard Index (ΣHQ)	**45**	

Based on the results of the BHHRA, dermal contact and incidental ingestion of sediment contributed to 98 percent of the non-cancer hazard, whereas ingestion of fish contributed to only 2 percent.

2.1.2 Human Health Risk Evaluation and Recommended Clean-Up Level (USEPA, 2016)

In August 2016, the USEPA re-evaluated the risks posed to the child recreational fisher and derived the sediment clean-up level of 30 ng/kg TEQ, based mostly on the same exposure assumptions used to develop the cancer risk and non-cancer hazards in its human health re-assessment. In reassessing cancer risks and non-cancer hazards, and in developing the recommended sediment clean-up level, USEPA utilized exposure assumptions that were either equal to, or were generally consistent with, those used in the BHHRA. This included using conservative estimates of the arithmetic average concentration for sediment and fish tissue.

2.1.2.1 Risk Re-Evaluation

In USEPA's reassessment of risk, the cancer risk for the child recreational fisher was $6.6x10^{-4}$, which is marginally above than the upper end of USEPA's cancer risk range of $1x10^{-6}$ to $1x10^{-4}$. The non-cancer hazard for the child recreational fisher was generally consistent but slightly higher than that calculated in the BHHRA. The HI in the USEPA's reassessment was 66 versus 45 in the BHHRA. The breakdown is as follows:

Exposure Pathway	Hazard Quotient	Percent Contribution to Hazard Index
Sediment - Dermal Contact	47	71 percent
Sediment - Incidental Ingestion	17	26 percent
Fish - Ingestion	2	3 percent
Hazard Index (ΣHQ)	**66**	

Consistent with the BHHRA, dermal contact and incidental ingestion of sediment contributed to 97 percent of the non-cancer hazard, whereas ingestion of fish contributed only 3 percent to the final HI.

2.1.2.2 Development of the TEQ Clean-Up Level

As described in USEPA, 2016, the clean-up level 30 ng/kg TEQ for dioxin and dioxin-like compounds was based on the non-cancer hazards, posed by this class of chemicals. This clean-up level was based on a non-cancer HI of 1 for a child recreational fisher exposed to Beach Area E. The USEPA acknowledged that this clean-up level is also protective of potential cancer risks posed to the child recreational fisher and results in a cancer risk estimate of $2x10^{-5}$. The USEPA adopted the child recreational fisher scenario because:

> *"Risk to a child was found more conservative than exposure to adult or a combined adult and child exposure."* [USEPA, 2016, p. 3].

Consequently, the clean-up level developed by the USEPA for the child recreational fisher is protective of all other reasonably possible human receptor populations. The steps by which the USEPA derived the clean-up level are described below.

2.1.2.2.1 Dermal Exposure

For dermal exposure by the child recreational fisher, the USEPA derived a health-protective sediment preliminary remediation goal (PRG) of $2.77x10^{-4}$ milligram per kilogram (mg/kg) or 277 ng/kg TEQ. This equates to 0.000277 mg/kg or 277 ng/kg. This PRG differs from other PRGs developed by the (USEPA, 2016), in that dermal exposure was by far the greatest driver of risk (71 percent of the HI) in both the BHHRA and USEPA's reassessment, yet this PRG is orders of magnitude greater than the PRG associated with the fish ingestion pathway (35 ng/kg - see Section 2.1.2.2.4), which only accounted for 3 percent of the non-cancer hazard.

2.1.2.2.2 Incidental Ingestion

For incidental ingestion of sediment by the child recreational fisher, which represented 26 percent of the HI, the USEPA derived a health-protective sediment PRG of $7.86x10^{-4}$ mg/kg TEQ or 786 ng/kg. As with dermal exposure, this PRG is orders of magnitude greater than the PRG associated with the fish ingestion pathway (35 ng/kg - see Section 2.1.2.2.4), which only accounted for 3 percent of the non-cancer hazard.

2.1.2.2.3 Fish Ingestion

For ingestion of fish by the child recreational fisher, which represented <u>only</u> 3 percent of the risk posed to this receptor, the USEPA derived a health-protective fish tissue PRG of 3.13^{-6} mg/kg TEQ or 3.13 ng/kg. This value is only slightly lower than the fish tissue exposure point concentration (EPC = 5.63 ng/kg; 95% upper confidence limit (UCL) of the mean concentration) used in the risk assessment.

2.1.2.2.4 Total Sediment Clean-Up Level

The USEPA subsequently derived a total health protective sediment clean-up level that included risk contributions from:

– Dermal exposure to the conservative estimate of an arithmetic average concentration of sediment (277 ng/kg).

– Incidental ingestion of the conservative estimate of an arithmetic average concentration of sediment (786 ng/kg).

– Ingestion of a conservative estimate of the arithmetic average concentration in fish.

Deriving a sediment clean-up level for direct exposure to sediment (dermal exposure and incidental ingestion) is straightforward and is completed by calculating a sediment concentration that corresponds to a safe level of sediment exposure (i.e., an HI of 1). Deriving a sediment clean-up level that translates to a safe concentration in fish is more complicated. To calculate a sediment PRG for human protection from ingestion of fish, a biota-sediment accumulation factor (BSAF) is required that correlates sediment concentrations to fish tissue concentrations. This is accomplished by the following equation used by (USEPA, 2016):

$$Sediment_{fish}PRG = \frac{Fish\ PRG}{BSAF}$$

Where:

$Sediment_{fish}PRG$ (ng/kg)	=	sediment PRG for fish consumption
Fish PRG (ng/kg)	=	fish tissue concentration deemed safe to eat
BSAF	=	the ratio of contaminant concentration in tissue to the contaminant concentration in sediment.

The BSAF is an extremely important parameter that describes the relationship between the concentration of a chemical in sediment and the concentration of that chemical in animal tissue and should be selected based on well-established scientific methods and principles.

In deriving a sediment concentration that yields a health-protective fish tissue concentration, the USEPA selected and applied a generic TEQ BSAF of 0.09 (found in USEPA guidance documents [2000 and 2005a]) to calculate the sediment PRG for the fish consumption pathway. The selection of this generic TEQ BSAF assumes a fish lipid content of 7 percent for fish species which may or may not be relevant to the Northern Impoundment and a sediment total organic carbon (TOC) content of 3 percent. USEPA disregarded a site-specific 2,3,7,8-TCDD BSAF (Usenko, et al., 2012) and other BSAFs available from USEPA (2003a). USEPA also disregarded its own recommendation (USEPA, 2000) to use different BSAF values for different homolog classes - hexaCDD/Fs, heptaCDD/Fs, and OCDD/F, despite the relevance of these homologs with respect to the Northern Impoundment. Instead, the USEPA erroneously chose a value for 2,3,7,8-TCDD presented in the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (USEPA, 2005a) when the BSAFs for different homologues should have been applied.

By applying a generic TEQ BSAF of 0.09 without regard to appropriate consideration of sediment total organic carbon, the lipid content of the fish that would be found in the vicinity of the Northern Impoundment, or the various homologue classes, the USEPA derived a sediment PRG for fish consumption of $3.5x10^{-5}$ mg/kg or 35 ng/kg.

By adding in the incremental non-cancer hazard from exposure to dioxin and dioxin-like compounds through dermal contact with sediment and incidental ingestion of sediment, the USEPA derived a “total PRG” of $2.89x10^{-5}$ mg/kg or 28.9 ng/kg, which the USEPA rounded up to 30 ng/kg TEQ. This value was adopted as the clean-up level in the 2017 ROD. The table below summarizes the risk components that drive the 30 ng/kg TEQ clean-up level.

Exposure Pathway	Sediment PRG (ng/kg TEQ)	Percent Contribution to Remedial Goal	Percent Contribution to Risk (USEPA, 2016)
Sediment - Dermal Contact	277	11 percent	71 percent
Sediment - Incidental Ingestion	786	4 percent	26 percent
Fish - Ingestion	35	85 percent	3 percent
Clean-Up Level	**30**		

The clean-up level adopted in the ROD is driven primarily by the fish consumption pathway. Although this pathway accounted for 85 percent of the final clean-up level, it only accounted for 3 percent of the risk in USEPA’s risk re-evaluation (USEPA, 2016). Therefore, risk at the Northern Impoundment is driven by dermal contact with and incidental ingestion of sediment (97 percent), but paradoxically, fish ingestion is the dominant driver of the clean-up level (85 percent). This paradox is attributable solely to the USEPA’s erroneous selection of its generic BSAF.

2.1.3 USEPA's BSAF

When appropriately applied, a BSAF never corresponds to a single location represented by a single sediment concentration. USEPA's own research (2009, page 5) states specifically:

> *"Probably the most important factor in measuring a BSAF with predictive power is the requirement that the sediment samples analyzed be reflective of the foraging range of the fish."*

Therefore, a fish BSAF represents the relationship between the fish tissue concentration and the concentration in sediment over the foraging range of the fish. It *does not* represent the relationship between the fish tissue concentration and the maximum concentration in sediment to which the fish is exposed. As such, any clean-up goal based on a BSAF should represent an *average* sediment concentration over which a fish is potentially exposed.

Not only does USEPA's own research establish that a fish BSAF does not correspond to a single sediment concentration (and instead represents the exposure over the foraging area of the fish) but there is a vast body of scientific knowledge that supports this (e.g., USEPA, 1995, USEPA, 2009, Gobas and Arnot, 2010, Usenko, et al., 2012, Burkhard, et al., 2010, Carbonaro and Howell, 2009, etc.).

To underscore the importance of this issue, the flathead catfish, which was used by USEPA as a conservative estimate of exposure through fish ingestion, is not a sedentary species. Flathead catfish are known to move and forage over areas much larger than the area contained within the Northern Impoundment. Daugherty and Sutton, 2005, documented a mean seasonal home range of flathead catfish of in the spring of 1.5 km, 1.3 km in the fall, and 0.5 km in the summer months. Vokoun and Rabeni, 2006, radio-tracked adult flathead catfish and documented linear movement paths with a median of 0.6 km in just 24 hours. Another study documented movement distances in the Pascagoula River of up to 23 km (Barabe, 2009). Therefore, applying the chosen TEQ BSAF as if that fish was exposed only to conditions in the Northern Impoundment and not to conditions across a much larger range results in a clean-up standard that is much lower than what the data supports.

USEPA's direct misuse of the TEQ BSAF without regard to fish lipid content or sediment total organic carbon adds another level of conservatism to the 30 ng/kg clean-up level. The chosen TEQ BSAF of 0.09 is based on a fish lipid content of 7 percent and a sediment organic carbon content of 3 percent. While the organic carbon content of 3 percent falls within the range of values in the Northern Impoundment, flathead catfish (used by USEPA to estimate exposure through fish ingestion) are known to have lipid contents significantly lower than 7 percent.

Application of the TEQ BSAF using more Site-specific values would have a significant impact on the derived clean-up level. Using a lipid content of 1.31 percent for flathead catfish in the Houston shipping channel (Carbonaro and Howell, 2009) would increase the clean-up level to 243 ng/kg. This example alone illustrates how the current clean-up level of 30 ng/kg TEQ is not consistent with site-specific data.

Lastly, to illustrate how inappropriate USEPA's BSAF is, if its TEQ BSAF of 0.09 was applied to the existing sediment EPC that was used in the BHHRA and used by USEPA (USEPA, 2016), the predicted fish tissue concentration would be 1,170 ng/kg. This is 200 times higher than the maximum fish tissue concentration ever measured at the Northern Impoundment. Therefore, USEPA's TEQ BSAF of 0.09 overpredicts fish tissue concentrations by two orders of magnitude.

2.2 Appropriate Application of a BSAF-Based Clean-Up Level

Compliance with any BSAF-based sediment clean-up level, including USEPA's 30 ng/kg TEQ clean-up level, should be on a surface-weighted average concentration (SWAC). Application of a BSAF-based clean-up level on a point-by-point basis is inappropriate for the Northern Impoundment for the following reasons:

– Estimates of risk, which are the basis of action for the ROD, are based on exposures to conservative estimates of the average concentrations of chemical (USEPA, 1989, 2002a). This is a fundamental principle of risk assessment and risk management.

- At the Northern Impoundment, assuming long-term contact with the maximum concentration is not reasonable (USEPA, 1989). Therefore, the sediment clean-up level of 30 ng/kg, which is the concentration that the (USEPA, 2016) determined is protective of human health must be based on:

  ".. the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time." (USEPA, 1989).

- BSAFs represent the relationship between tissue concentrations and exposure to sediment over the entire foraging range of a fish (USEPA, 2009). Therefore, because BSAFs are based on an average exposure over a foraging area, any sediment clean-up criteria derived using a BSAF should be interpreted and applied on the basis of an area-weighted average concentration.
- With current knowledge of the nature and extent of contamination at the Northern Impoundment, remediation of all sediment with concentrations above 30 ng/kg TEQ on a point-by-point basis achieves an EPC - which is based on an average concentration, of 14.9 ng/kg TEQ. This is the 95% Adjusted Gamma UCL recommended by USEPA's ProUCL software.

2.3 Applicable Pathways After Remediation

Following remediation, the only applicable exposure pathway would be the potential ingestion of fish. Incidental ingestion of sediment and sediment direct contact pathway will be completely eliminated. Therefore, any PRG for the Northern Impoundment should be based only on the fish consumption pathway. This means that the USEPA's reduction of the PRG for the fish consumption pathway (of 35 ng/kg TEQ, derived using an inappropriate TEQ BSAF) to 30 ng/kg TEQ to reflect the other pathways was inappropriately low.

2.4 Achieving the Intent of the Remedial Goal

In the simplest terms, the intent of establishing a clean-up level of 30 ng/kg TEQ, is to protect human health and the environment. An EPC of 30 ng/kg at the Northern Impoundment is best represented by generally accepted and USEPA approved risk assessment practices as "*the arithmetic average of the concentration that is contacted over the exposure period.*" (USEPA, 1989). The sections below describe the approach that is being proposed to USEPA to achieve the intent of the ROD and meet the clean-up level using an exposure point concentration of 30 ng/kg.

2.4.1 Excavation Strategy

The Respondents proposed at the November 2021 TWG Meeting to demonstrate compliance with the clean-up level in a manner that is consistent with the underlying assumptions used to develop it, by utilizing a site-wide SWAC.

Using the abundant analytical data that has been collected at the Northern Impoundment over the years, a target excavation surface had been developed for all of the Northern Impoundment (excluding the northwest corner). The excavation surface was developed utilizing several guiding principles:

- Areas that are sensitive to hydraulic heave were identified.
- Areas in which there were several feet of clean overburden atop a low-level exceedance of the clean-up level were identified.
- Target excavation depths were identified across the Northern Impoundment such that the resulting surface will meet the clean-up level of 30 ng/kg TEQ on a SWAC basis.
- A not-to-exceed threshold value lower than 300 ng/kg was applied to the extent practicable.

Using the above guidelines, an excavation surface has been developed across the Northern Impoundment for purposes of the 90% RD that would be implementable, protective of human health and the environment, and results in an exposed surface that is below the clean-up level on a SWAC basis. The use of such an excavation surface would also address significant uncertainties in implementing the RA for the Northern Impoundment, as discussed in Section 5.10 of the main text of the 90% RD package.

In order to determine the excavation surface, each of the 69 soil borings (excluding the northwest corner) across the Northern Impoundment was assigned a polygon with a defined surface area. Some soil borings were combined due to close proximity or redundant data with the more conservative (i.e., higher) TEQ values selected to carry forward. Each of the remaining soil borings was examined to determine the appropriate excavation elevation. As previously mentioned, areas that are at risk of hydraulic heave and/or areas with several feet of clean overburden were targeted for shallower excavation elevations. A "not-to-exceed" value of 300 ng/kg TEQ was applied, such that concentrations above this level would not be left in place, no matter the depth. There were three exceptions to this "rule" in locations in which there is a risk of hydraulic heave, but the resulting surface concentration of those polygons was only 347 ng/kg at -18 to -20 ft NAVD88 (SJSB047-C1), 369 ng/kg at -18 to -20 ft NAVD88 (SJSB054), and 219 at -20 to -22 ft NAVD88 (SJSB048-C1), and did not affect the overall SWAC that was calculated to be below 30 ng/kg TEQ (23.31 ng/kg TEQ). Once the target excavation elevations were selected, the SWAC was calculated by multiplying the resulting surface concentration (post-excavation) by the assigned surface area for that polygon and calculating an overall average across the resulting surface of the Northern Impoundment.

An example that was shared in the November 2021 TWG Meeting is shown below to illustrate the methodology for determining the excavation surface. In this example, the selected excavation depths are 4 feet below ground surface (bgs) at Soil Boring 1 (SB-1), 12 feet bgs at SB-2, 6 feet bgs at SB-3, 4 feet bgs at SB-4, and 2 feet bgs at SB-5. Assuming all material above these depths will be removed, the remaining surface concentrations would be 26.8 ng/kg (SB-1), 1.3 ng/kg (SB-2), 24 ng/kg (SB-3), 27 ng/kg (SB-4), and 53 ng/kg (SB-5). Each of these concentrations is then multiplied by the surface area specific to that polygon and a surface weighted average for the entire 0.94-acre area is calculated to be 25.89 ng/kg, which is below the clean-up level of 30 ng/kg.

	Soil Boring 1	Soil Boring 2	Soil Boring 3	Soil Boring 4	Soil Boring 5
0-1	**34,700**	**4,050**	**1,400**	**42,000**	**820**
1-2	**34,700**	**4,050**	**1,400**	**42,000**	**820**
2-3	**45,900**	**25,065**	**5.9**	**720**	**53**
3-4	**45,900**	**25,065**	**5.9**	**720**	**53**
4-5	26.8	**24,424**	**340**	27	18
5-6	26.8	**24,424**	**340**	27	18
6-7	2.24	**17,740**	24	**44**	3.5
7-8	2.24	**17,740**	24	**44**	3.5
8-9	1.03	**12**	5.6	25	**52**
9-10	1.03	**12**	5.6	25	**52**
10-11	1.48	**340**	2.5	4.3	**34**
11-12	1.48	**340**	2.5	4.3	**34**
12-13	0.52	1.3	**34**	7.0	2.00
13-14	0.52	1.3	**34**	7.0	2.00
14-15	**44.6**	1.7	1.4	11	2.30
15-16	**44.6**	1.7	1.4	11	2.30
16-17	**45.4**	**34**	**110**	7.8	0.40
17-18	**45.4**	**34**	**110**	7.8	0.40
18-19		0.52	8.9		
19-20		0.52	8.9		
20-21		**120**	3.9		
21-22		**120**	3.9		
22-23		0.81	4.0		
23-24		0.81	4.0		

Boring Location	Polygon Area (Acres)	Concentration (ng/kg)	Concentration per Acre
Soil Boring 1	0.21	26.8	5.62
Soil Boring 2	0.25	1.3	0.32
Soil Boring 3	0.1	24.0	2.40
Soil Boring 4	0.16	27.0	4.32
Soil Boring 5	0.22	53.0	11.66
Sum	0.94		24.33

Total concentration per acre (24.33) / Total polygon area (0.94) = **25.89 ng/kg**

Total SWAC of 25.89 ng/kg < 30 ng/kg

This excavation surface results in approximately 177,000 cubic yards of total volume removed (not including the northwest corner), which accounts for 99.82 percent of the total mass of dioxins calculated to be present beneath the Time Critical Removal Action (TCRA) cap (excluding dioxins present in the northwest corner). It is important to note that the resulting surface concentrations would be verified through post-confirmation sampling.

2.4.2 Validity, Protectiveness and Use of a SWAC

Remediation goals based on SWACs are typically applied to bioaccumulative chemicals for human health and wildlife receptors, whereas specific action levels (i.e., not-to-exceed values) are typically used for chemicals that result in an acute toxicity to small home range, sediment-dwelling biota (Pelletier, et al., 2019). This is consistent with application of a SWAC for the Northern Impoundment remedy.

Because fish integrate exposure to sediments over the areas where they forage, SWAC-based remediation goals are used as a basis for developing remedies to be health protective against exposures from the ingestion of contaminated fish (e.g., USEPA, 2015a and 2017b). The use and validity and protectiveness of a SWAC approach for risk management has been established by the USEPA in several guidance documents (e.g., USEPA, 2002b, 2005b, and 2007).

For sites where clean-up goals are established to protect human health based on the fish consumption pathway (as is the case here), the use of a SWAC to determine the effectiveness of a remedy is appropriate. This has been demonstrated at numerous Federal Superfund sites including the Housatonic River, Hudson River, Lower Passaic River Study Area, Fox River, Willamette River, Lower Duwamish Waterway, LCP Chemicals, and Devils Swamp Lake, Kalamazoo River, and Sheboygan River, as detailed in the table below.

Site	USEPA Region	Contaminant	Risk Driver
Housatonic River	Region 1	PCBs	Fish ingestion
Hudson River	Region 2	PCBs	Fish ingestion
Lower Passaic River	Region 2	PCBs/Dioxins	Fish/shellfish ingestion
LCP Chemical	Region 4	PCBs/Mercury	Fish ingestion
Fox River	Region 5	PCBs	Fish ingestion
Kalamazoo River	Region 5	PCBs	Fish ingestion
Sheboygan River	Region 5	PCBs	Fish ingestion
Devil's Swamp	Region 6	PCBs	Fish ingestion
Willamette River	Region 10	PCBs/Dioxins/Furans	Fish ingestion
Lower Duwamish	Region 10	PCBs/Dioxins/Furans	Fish ingestion

At the sites listed above, the fish/shellfish ingestion pathway was the primary risk driver upon which the remedial goals were based. The remedy for each of these sites was chosen because it resulted in a SWAC(s) that not only achieved concentrations in fish/shellfish tissue that were protective of human health, but also significantly reduced the total mass of the constituents driving the risk. These SWAC remedial goals are measurable, directly related to the risk posed to receptors, and are consistent with final remedies. These are only some of the examples of contaminated sites where post-remediation SWACs were achieved to address unacceptable levels of contamination in fish tissue. Pelletier, *et al.,* 2019, documented that USEPA RODs used SWAC-based sediment remediation goals appropriately at 21 sites evaluated in that study. The acknowledged protectiveness of a SWAC by USEPA is underscored in the ROD for the Sheboygan Harbor & River Superfund Site (USEPA, 2000) where a SWAC of 0.5 mg/kg of PCBs was established to achieve fish tissue concentrations protective of human health:

> *"The selected remedy is protective of human health and the environment, complies with federal and state applicable or relevant and appropriate requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective."*

Although not addressed at the presentation during the November 2021 TWG Meeting, at some of the Superfund sites at which SWAC-based clean-up strategies have been adopted, the USEPA has relied on Explanation of Significant Differences (ESDs) and ROD Amendment documents to establish the use of SWACs to determine compliance. For example, at the St. Maries Creosote site located on the St. Joe River in Idaho, the ROD (USEPA, 2007) did not specify how compliance would be measured. In response to this gap, the USEPA issued an ESD (USEPA, 2014) that established a SWAC for polyaromatic hydrocarbons (PAHs) in the top 2 feet of sediment to be used to determine compliance with the ROD. In the ESD, the USEPA specifically noted that by using the SWAC-based approach, the remedy remained protective of human health and the environment and that the SWAC meets the ROD standards.

Another example is provided by the *Fourth Explanation of Significant Differences for the L.A. Clarke and Son Superfund Site* (USEPA, 2015b). Because the ROD did not contain an ecological clean-up level for surface soil, the USEPA adopted an ecological clean-up level 50 mg/kg total PAHs as a site-wide average, with a not-to-exceed value of 100 mg/kg total PAHs. This ecological clean-up level reflected soil-based ecological exposures, as well as exposures based upon migration to aquatic areas.

A final example involves the USEPA's use of a ROD amendment to implement a SWAC comes from the Continental Steel Superfund Site in Kokomo, Indiana (USEPA, 2003b). USEPA altered its approach to site clean-up by incorporating a SWAC-based approach along lengths of a Kokomo and Wildcat Creeks. The SWAC approach was undertaken because the area over which humans might be exposed was much larger than the areas containing contaminated sediment. For this reason, the USEPA determined that the average concentration was more appropriate and should be used.

The SWAC-based application of a 30 ng/kg for the Northern Impoundment will be protective of human health and the environment and consistent with the National Contingency Plan (NCP). According to 40 Code of Federal Regulations (CFR) §300.430(a)(1)(i), the “national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste.”

Within the methodology used by the USEPA to develop the clean-up level, 30 ng/kg represents an exposure point concentration to which the child recreational fisher may be exposed through incidental ingestion, dermal contact, and the average concentration to which a fish is exposed. By virtue of this alone, USEPA’s own guidance establishes this exposure assumption as “a conservative estimate of the average chemical concentration in an environmental medium” (USEPA, 1989). This conservative estimate, coupled with the use of other conservative although not technically justified exposure assumptions (e.g., all fish eaten come from the Northern Impoundment), were used by the USEPA to establish the 30 ng/kg, which make it a highly conservative human health protective clean-up criterion. As such, the application of a BSAF-based clean-up level on an area average basis will be consistent with the NCP.

3. Conclusion

Compliance with the clean-up level should be demonstrated in a manner that is consistent with the underlying assumptions used to develop it, by utilizing a SWAC to determine excavation elevations and for use in confirmatory sampling. Given that the risk assessment methodology used to develop the 30 ng/kg TEQ clean-up level relies on, not only estimates of average contaminant concentration to which humans are exposed, but also on the average concentration of sediment to which fish are exposed, the most appropriate way to implement the clean-up level of 30 ng/kg TEQ is on an area-weighted average concentration, and not on a point-by-point basis. Remediation goals based on SWACs are common at Superfund sites because the utilization of SWACs not only achieves concentrations in fish/shellfish tissue that are protective of human health, but also significantly reduces the total mass of the constituents driving the risk. Likewise, SWAC goals are measurable, directly related to the risk posed to receptors, and are consistent with final remedies.

The abundant analytical data that has been collected at the Northern Impoundment allows for the development of a well-informed target excavation surface that meets a 30 ng/kg SWAC. In the Respondents’ plan, the excavation surface was established by creating polygons with defined surface areas using the soil borings across the Northern Impoundment. The resulting SWAC is 23.31 ng/kg, which results in a 99.8 percent reduction in the mass of dioxins. These concentrations would subsequently be validated by the post-confirmation sampling required by the ROD (which would also be based upon a SWAC). Following remediation, the only applicable exposure pathway will be the potential ingestion of fish. Incidental ingestion of sediment and the sediment direct contact pathway will be eliminated completely given the depth below the river surface of the sediment. Because the bottom of the excavation will be significantly below the river surface, there is no reasonable way for a human receptor to contact these sediments. Consequently, with a 99.8 percent reduction in the mass of dioxins, the proposed remediation plan would be effective in both the short-term and long-term, and would reduce the volume and mobility of dioxins, thus protecting both human health and the environment.

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