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Project Number 08005-WE04

Ms. Andrea Barbieri
United States Environmental Protection Agency
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Mr. Colin Wade
Pennsylvania Department of Environmental Protection
Southeast Regional Office
2 East Main Street
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Reference: Contract No. N6247016D9008
Contract Task Order (CTO) No. WE04

Subject: Updated Soil Remediation Goals
Site 12 – South Landfill
Former Naval Air Station Joint Reserve Base Willow Grove
Horsham Township, Pennsylvania

Dear Ms. Barbieri and Mr. Wade:

On behalf of the Navy, Tetra Tech is pleased to provide the Final Updated Soil Remediation Goals for Site 12 South Landfill located at Former Naval Air Station Joint Reserve Base Willow Grove, Horsham Township, Pennsylvania. This technical memorandum was prepared to update soil Remediation Goals for Site 12 based on the revisions to toxicity values and PA Act 2 standards. It should be noted that the revised Remedial Goals are higher than established in the Record of Decision. This document does not revise the Remedial Goals established in the Record of Decision. It is understood that a post-Record of Decision document would be needed to revise the Remedial Goals established in the Record of Decision. If you have any questions or require additional copies, please contact me.

Sincerely,

A handwritten signature in black ink that reads 'Tricia E. Moore'.

Tricia E. Moore, PG
Senior Project Manager

TM/nfs

Enclosure

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**FINAL
UPDATED SOIL REMEDIATION GOALS
SITE 12 RECORD OF DECISION
FORMER NAVAL AIR STATION JOINT RESERVE BASE WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
FEBRUARY 2022**

This technical memorandum was prepared to update soil remediation goals (RGs) for Site 12 – South Landfill based on the revisions to the benzo(a)pyrene (BaP) toxicity values (EPA, 2017), to revise some proposed RGs of chemicals of concern (COCs) identified in the Feasibility Study (Tetra Tech, 2019), Proposed Plan (NAVFAC, 2020), and draft Record of Decision (ROD) (NAVFAC, 2021) at Site 12 located within the former Naval Air Station Joint Reserve Base (NASJRB) Willow Grove (Willow Grove), Horsham Township, Montgomery County, Pennsylvania.

BACKGROUND

The RGs for surface soil COCs were developed based on the Pennsylvania Act 2 Land Recycling Program (PA Act 2) medium-specific concentrations (MSCs), human health risk-based preliminary remediation goals (PRGs), ecological PRGs, and representative background concentrations. The RGs for total soil COCs were developed based on the PA Act 2 MSCs, human health risk-based PRGs, and representative background concentrations. Additionally, background concentrations of COCs and analytical detection limits were evaluated to ensure selection of RGs that are reasonably attainable and measurable. Typically, the lowest of promulgated regulated applicable or relevant and appropriate requirements (ARARs) (which are the PA Act 2 MSCs), human health PRGs, and ecological PRGs are selected as the RG unless the background level or the analytical detection limit is higher. No site-specific ecological PRGs have been developed at Site 12, and the ecological soil PRGs are conservative ecological soil screening levels (Eco-SSLs). RGs are selected based on an evaluation of these criteria.

Human health risk-based PRGs are developed by calculation of an acceptable risk using a back calculation for soils and for each compound identified as a COC. PRGs for residential exposures to total soil are calculated and presented in this memorandum. Total soil (surface and subsurface combined) PRGs are discussed in this memorandum as all of these PRGs are based on human health (hypothetical future on-site residential scenario) rather than ecological receptors. However, the updates to the total soil PRGs for carcinogenic polycyclic aromatic hydrocarbons (PAHs) also apply to surface soil carcinogenic PAH PRGs, which are also based on human health risk and the hypothetical resident scenario.

The human health risk-based PRGs for soil are based on the Site 12 human health risk assessment (HHRA; Tetra Tech, 2014), which was prepared prior to the updated toxicity assessment for benzo(a)pyrene in 2017. The evaluation of site soils using the updated toxicity values indicates that the revised risk-based

PRGs for the carcinogenic PAHs are higher (i.e., less conservative); therefore, the proposed selected remedy is still protective for human health risk.

OBJECTIVES

This technical memorandum:

1. Compares the updated toxicity values for BaP to the toxicity values that were applied in the HHRA.
2. Discusses how the revised risk-based PRGs for total soil were calculated.
3. Presents revised PRGs and RGs based on the updated BaP toxicity assessment.
4. Addresses whether any localized soil removal areas identified in the draft Site 12 ROD may not require remediation based on the revised RGs for surface soil and total soil.

UPDATED TOXICITY ASSESSMENT OF BENZO(A)PYRENE

Table 1 below compares the previous toxicity values for BaP used in the Site 12 HHRA (Tetra Tech, 2014) and the updated toxicity values (EPA, 2017):

Table 1: Toxicity Values for Benzo(a)pyrene

Toxicity Criteria	Previous Toxicity Values	Updated Toxicity Values
Inhalation Reference Concentration (RfC)	--	2×10^{-6} mg/m ³
Oral Reference Dose (RfD)	--	3×10^{-4} mg/kg-day
Inhalation Unit Risk (IUR)	1.1×10^{-3} (μg/m ³) ⁻¹	6×10^{-4} (μg/m ³) ⁻¹
Oral Cancer Slope Factor (CSF)	7.3 (mg/kg-day) ⁻¹	1 (mg/kg-day) ⁻¹

μg/m³: Micrograms per cubic meter

mg/m³: Milligrams per cubic meter

mg/kg-day: Milligrams per kilogram per day

The 2017 toxicological review for BaP addressed both cancer and noncancer toxicity (EPA, 2017). For potential cancer effects, there are both updated oral CSF and IUR values for BaP. The revised oral CSF (1 [mg/kg-day]⁻¹) is approximately one-seventh the previous Integrated Risk Information System (IRIS) slope factor (7.3 [mg/kg-day]⁻¹), which means that the risks associated with the ingestion of soil pathway are approximately 7 times lower with the updated CSF. With regard to inhalation exposure, the updated IUR (6×10^{-4} [μg/m³]⁻¹) is approximately one-half the previous IUR used in the HHRA (1.1×10^{-3} [μg/m³]⁻¹). While the revised IUR yields approximately two times higher risks from the inhalation pathway, the impact on the total BaP risks for all pathways and for the PRG is insignificant given the much higher exposure potential through incidental ingestion of soil and dermal contact with soil. Carcinogenic PRGs for BaP were revised using the updated CSF and IUR.

The updated carcinogenic toxicity assessment of BaP also results in updates to the carcinogenic toxicity criteria for six other carcinogenic PAHs by application of toxicity equivalency factors (TEFs) in comparison to BaP toxicity. The six carcinogenic PAHs and their respective BaP TEFs are: benzo(a)anthracene (BaA: 0.1), benzo(b)fluoranthene (BbF: 0.1), benzo(k)fluoranthene (BkF: 0.01), chrysene (0.001), dibenzo(a,h)anthracene (D[ah]A: 1), and indeno(1,2,3-cd)pyrene (IP: 0.1). Therefore, revised carcinogenic PRGs were also calculated for these PAHs.

The 2017 toxicological review included a noncancer effects assessment of BaP (EPA, 2017). There were no noncancer toxicity criteria (i.e., RfD or RfC) available for BaP when the Site 12 HHRA was prepared. However, the updated toxicity criteria for BaP includes both an oral RfD (3×10^{-4} mg/kg-day) and RfC (2×10^{-6} mg/m³). Therefore, a PRG based on noncancer effects can be calculated for BaP with the updated toxicity criteria. Please note that a toxicity equivalency approach is not applied between BaP and other PAHs for noncancer effects, and therefore a noncancer PRG is calculated only for BaP based on the updated BaP toxicity assessment. The carcinogenic PRG for BaP is applied for remedial decision-making because the BaP PRG for cancer effects is lower (i.e., more conservative) than the BaP PRG for noncancer effects.

UPDATE OF RISK-BASED PRG CALCULATIONS

Risk-based PRGs for human health COCs were selected based on the hypothetical residential scenario of the HHRA for total soil (i.e., the combination of surface soil and subsurface soil). The COCs for total soil per the ROD are 2,3,7,8-tetrachlorodibenzodioxin (TCDD) equivalents, chromium (based on hexavalent chromium toxicity criteria and site-specific percentage of hexavalent chromium to total chromium), arsenic, and carcinogenic PAHs (BaP, BaA, BbF, BkF, D(ah)A, and IP).

The cancer risks for BaP and the carcinogenic PAHs were recalculated for the lifetime resident receptor (over the years from very young child to adulthood) with the updated toxicity criteria and a few revised U.S. Environmental Protection Agency (EPA) default exposure factors (EPA, 2014¹). The noncancer hazard index (HI) for BaP was also calculated for the young child residential receptor with the new RfD and RfC values for BaP. The original exposure point concentrations (EPCs) for total soil COCs were applied in the recalculated risks and noncancer hazards.

Updated PAH PRGs were calculated in a cumulative risk and cumulative noncancer hazard context with the other total soil COCs so that summed risks for all carcinogenic COCs do not exceed a 1×10^{-4} risk level

¹ Per Human Health Evaluation Manual Supplemental Guidance (EPA, 2014), the following represent EPA default exposure factors for a residential scenario that were revised: exposure duration (from 30 years to 26 years); adult body weight (from 70 kilograms [kg] to 80 kg), adult residential exposed skin surface area (from 5,700 square centimeters [cm²] to 6,032 cm²) and child residential exposed skin surface area (from 2,800 cm² to 2,373 cm²).

and organ-specific hazard indices do not exceed 1. The revised risk-based PRGs for the carcinogenic PAHs are presented in Table 2, along with revised risk-based PRGs for arsenic, chromium and 2,3,7,8-TCDD equivalents. Appendix A provides the revised PRG calculation spreadsheet and the risk assessment summary tables used to recalculate the PRGs.

COMPARISON OF DECISION DOCUMENT RGS TO REVISED RGS

The revised risk-based PRGs for the PAHs are approximately one order of magnitude higher than the decision document PRGs, and therefore the original RGS are more conservative and the selected remedy based on these is protective even with consideration of the updated toxicity assessment of BaP.

To calculate the revised total soil PRGs of the carcinogenic PAHs for human health, the PRGs of the other human health-related COCs for total soil were included to assure that cumulative risks for total soil exposure meet a 1×10^{-4} risk level or lower. These additional COCs are 2,3,7,8-TCDD equivalents, arsenic, and chromium.

The PRG for 2,3,7,8-TCDD equivalents is based on noncancer health effects (0.00005 mg/kg or 50 nanogram per kilogram [ng/kg], that yields a HI of 1 for reproductive health effects). The corresponding cancer risk associated with this EPC was taken into account in calculating the PRGs of the other carcinogenic COCs.

The original PRG for arsenic is a risk-based value (EPA Regional Screening Level [RSL] for residential soil at a target risk level of 10^{-5} [EPA, 2020]), and the background value presented in the PRG table in the decision documents is slightly lower (noted as the 95 percent upper tolerance limit [UTL] of 6.65 mg/kg). The original PRG for chromium in the decision documents is presented as a site-specific background limit rather than a risk-based level. However, while the site-specific background limits are described as "95% UTLs" in the PRG tables of the decision documents, the background values presented in these tables for arsenic and chromium are actually mean values (6.65 mg/kg and 15.3 mg/kg, respectively [Appendix K, Table K-6, of the Phase II Remedial Investigation (RI) (Tetra Tech, 2014)] not 95 percent UTLs. The 95 percent UTL of arsenic is 11.7 mg/kg (Appendix K, Table K-6, of the Phase II RI (Tetra Tech, 2014), which when presented at two significant figures (12 mg/kg) is the same as the Pennsylvania background level for arsenic presented in the Pennsylvania Department of Environmental (PADEP) MSC Table 4a for inorganic chemicals in soil (PADEP, 2016). Based on Appendix A, the revised risk-based PRG for arsenic is the same as the MSC of 12 mg/kg for arsenic. Therefore, the risk-based PRG for arsenic was incorporated in the calculation of the revised PRGs for carcinogenic PAHs.

The 95 percent UTL of total chromium is 21.6 mg/kg, not 15.3 mg/kg (the mean) (Appendix K, Table K-6, of the RI). However, the human health risk-based PRG for total chromium is higher than the background

UTL, and should have been identified as the PRG. The risk-based PRG for total chromium is 33.6 mg/kg based on site-specific hexavalent chromium data (i.e., hexavalent chromium is estimated less than 12.2 percent of total chromium) and the decision document PRG for hexavalent chromium of 4 mg/kg. Only the risk-based PRG for hexavalent chromium was incorporated into the revised PRG calculations for carcinogenic PAHs.

Tables 2 and 3 provide the total soil revised RGs and revised surface soil RGs, respectively, for Site 12 along with the basis for selection. In addition, Table 2 presents a comparison of the revised total soil RGs for COCs to the total soil RGs presented in the draft Site 12 ROD. Table 3 also presents a comparison of the revised surface soil RGs for COCs to the surface soil RGs presented in the draft Site 12 ROD. Please note that the PA Act 2 MSCs for the carcinogenic PAHs, which are selected as the RGs for these chemicals on the basis of their being lower than the revised risk-based PRGs, are dated 2016 and are based on the outdated not the current EPA toxicity assessment of BaP. Therefore, as such, application of these MSCs as soil RGs for the carcinogenic PAHs is conservative for the protection of human health.

If excavation is necessary as a component of remedial action for the suspected source and associated contaminated soils, then revised RGs for surface soil and total soil could be used to determine the extent of soils removal or fill that may be needed.

UPDATED RGS AND THE PROPOSED PLAN CONCLUSIONS

The preferred remedial alternative for Site 12 of former NASJRB Willow Grove is Alternative 3: Limited Soil and Sediment Removal with On-Site Consolidation, Soil Cover, Land Use Controls and Long-Term Monitoring. Installation of 2-foot thick vegetative soil covers over the landfill waste materials in two areas within Site 12 would eliminate potential exposure of human and ecological receptors to the buried landfill waste materials, prevent migration of contaminated surface soils to surface water, and reduce the infiltration of precipitation into the landfill and subsequent leaching of contaminants to groundwater. This alternative also includes hot spot removal of contaminated soils located outside of the cover areas. The goals of covering and eliminating potential exposure to buried waste (identified through test pitting and delineating underground electromagnetic anomalies) and preventing disturbance of radiological investigation survey units are not affected by changes in chemical-specific RG concentrations. Therefore, the proposed footprints of the soil covers proposed in Alternative 3 which are designed to cover these features would not be affected by updated RGs for surface soil and total soil. However, the proposed soil removal areas that were characterized as “hot spots” based on the current RGs of PAHs and metals may be shown to meet the revised RGs.

CONCLUSION

The updated risk-based PRGs for carcinogenic PAHs are higher than the current PRGs for these COCs in draft Site 12 ROD, and therefore the Proposed Plan's preferred remedial alternative is still protective. The updated RGs for surface soil and total soil will support the hot spot removals of the selected remedy at Site 12, and would be used to determine if cleanup goals have been achieved at excavated areas by verification sampling.

Table 2: Compare Total Soil^a RGs to Revised RGs

COC	PA Act 2 Soil MSCs ^b (mg/kg) 0 - 15 feet	Concentration That Achieves HI and Cancer Risk Goals ^c (mg/kg)	Background Concentration (mg/kg)	Maximum Detected Site Concentration (mg/kg)	Original Selected RGs ^d (mg/kg)	Revised RGs (mg/kg)	Rationale for RG Selection
	Residential						
Total 2,3,7,8-TCDD Equiv.	1.4E-4	5E-5	NA	6.03E-4	5E-5	5E-5	Risk Based PRG
Arsenic	12	12	11.7 ^e	108 L	6.8	12	Risk Based PRG
Total Chromium	NA	33.6^f	21.6 ^g	192 L	15.3 ⁱ	33.6	Risk Based PRG
Chromium (VI)	4	4	NA	7.4	4.0 ^j	4.0	Risk Based PRG
Benzo(a)anthracene	6	6.0	0.306 ^h	22 J	0.4	6	Risk Based PRG
Benzo(a)pyrene	0.58	2.5	0.394 ^h	16 J	0.394	0.58	PA Act 2 MSC
Benzo(b)fluoranthene	3.5	6.0	0.507 ^h	15	0.4	3.5	PA Act 2 MSC
Benzo(k)fluoranthene	4	6.0	0.370 ^h	18 J	4.0	4	PA Act 2 MSC
Dibenzo(a,h)anthracene	1	2.5	0.161 ^h	4.1 J	0.32	1	PA Act 2 MSC
Indeno(1,2,3-cd)pyrene	3.5	6.0	0.251 ^h	10	0.4	3.5	PA Act 2 MSC

Notes:

- Bold values denote the selected RGs.
- COC: Chemical of concern
- HI: Hazard index
- J: Data qualifier for "estimated value."
- L: Data qualifier for "estimated value, biased low."
- NA: Not Available.
- PA Act 2: Pennsylvania Act 2 Land Recycling Program
- PRG: Preliminary remediation goal
- mg/kg: Milligram per kilogram
- MSC: Medium-specific concentration
- RG: Remediation goal
- UTL: Upper tolerance limit

Footnotes:

- a. Total soil exposure considers combined surface soil and subsurface soil.
- b. PA Act 2 soil MSCs were calculated by comparing the higher of 100 times the groundwater MSC to the generic values for the soil to groundwater pathway; then use the lower of this value compared to the soil direct contact value (PADEP, 2016).
- c. See Appendix A, Table A-1 for the revised PRG calculations based on updated benzo(a)pyrene toxicity assessment (EPA, 2017). PRG numerical values for carcinogens and non-carcinogens are based on residential exposure. When COCs share the same target organ effects, the sum of the hazard quotients of the individual COCs must be less than 1. PRGs for carcinogenic effects are selected so each compound contributes a cancer risk fraction such that the total target risk is less than or equal to 1×10^{-4} .
- d. Draft Site 12 Draft Record of Decision; Table 2-4: Total Soil Remediation Goals (NAVFAC, 2021).
- e. The Site 12-specific background 95 percent UTL of arsenic is 11.7 mg/kg. The mean background value is 6.65 mg/kg. (Tetra Tech, 2014. Appendix K, Table K-6.)
- f. The chromium PRG concentration applies to total chromium levels and assumes less than 12.2 percent of chromium is the hexavalent species (Tetra Tech, 2014).
- g. The Site 12-specific background 95 percent UTL of total chromium is 21.6 mg/kg. The mean background value is 15.3 mg/kg (Tetra Tech, 2014. Appendix K, Table K-6).
- h. The PAH background values are mean concentrations (Tetra Tech, 2014. Appendix K, Table K-26).

- i. The RG of total chromium presented in the Proposed Plan (NAVFAC, 2020) was incorrect. The RG of 33.6 mg/kg should be selected based on site-specific speciation evaluation presented in Appendix K of Site 12 Phase II RI (Tetra Tech, 2014) and the final Feasibility Study (Tetra Tech, 2019).
- j. The RG of chromium (VI) was not presented in the Proposed Plan (NAVFAC, 2020).

Table 3: Surface Soil^a Revised RGs

COC	PA Act 2 Soil MSCs ^b (mg/kg) 0 - 15 feet	Concentration That Achieves HI and Cancer Risk Goals ^c (mg/kg)	Ecological PRGs ^d (mg/kg)	Background Conc. (mg/kg)	Maximum Detected Surface Soil Conc. (mg/kg)	Original Selected RGs ^j (mg/kg)	Revised RGs (mg/kg)	Rationale for RG Selection
	Residential							
Total Chromium	NA	33.6^e	NA	21.6 ^f	38.5	15.3	33.6	Risk Based PRG
Chromium (VI)	4	4.0	NA	NA	7.4	4	4	Risk Based PRG
Copper	8,100	NA	70^g	14.9 ^f	458	70	70	Ecological PRG
Lead	450	NA	120^g	72.1 ^f	1,410	120	120	Ecological PRG
Selenium	26	NA	0.52^g	not detected	2.6 L	0.52	0.52	Ecological PRG
Zinc	12,000	NA	120^g	90.1 ⁱ	731	120	120	Ecological PRG
Anthracene	350	NA	2.5^h	0.154 ⁱ	16	2.5	2.5	Ecological PRG
Benz(a)anthracene	6	6.0	NA	0.306 ⁱ	21 J	0.4	6	Risk Based PRG
Benzo(a)pyrene	0.58	2.5	20 ^h	0.394 ⁱ	21 J	0.394	0.58	PA Act 2 MSC
Benzo(b)fluoranthene	3.5	6.0	NA	0.507 ⁱ	19 J	0.507	3.5	PA Act 2 MSC
Benzo(k)fluoranthene	4	6.0	NA	0.370 ⁱ	30	4.0	4.0	PA Act 2 MSC
Dibenz(a,h)anthracene	1	2.5	NA	0.161 ⁱ	12	0.32	1	PA Act 2 MSC
Indeno(1,2,3-cd)pyrene	3.5	6.0	NA	0.251 ⁱ	30	0.4	3.5	PA Act 2 MSC

Notes:

Bold values denote the selected RGs.

COC: Chemical of concern

HI: Hazard index

J: Data qualifier for "estimated value."

L: Data qualifier for "estimated value, biased low."

NA: Not Available.

PA Act 2: Pennsylvania Act 2 Land Recycling Program

PRG: Preliminary remediation goal

mg/kg: Milligram per kilogram

MSC: Medium-specific concentration

RG: Remediation goal

UTL: Upper tolerance limit

UCL: Upper confidence limit

Footnotes:

a. Surface soil data were collected from 0 to 2 feet below ground surface (Tetra Tech, 2014).

b. PA Act 2 soil MSCs were calculated by comparing the higher of 100 times the groundwater MSC to the generic values for the soil to groundwater pathway; then use the lower of this value compared to the soil direct contact value (PADEP, 2016).

- c. See Appendix A, Table A-1 for the revised PRG calculations based on updated benzo(a)pyrene toxicity assessment (U.S. EPA, 2017). PRG numerical values for carcinogens and non-carcinogens are based on residential exposure. When COCs share the same target organ effects, the sum of the hazard quotients of the individual COCs must be less than 1. PRGs for carcinogenic effects are selected so each compound contributes a cancer risk fraction such that the total target risk is less than or equal to 1×10^{-4} .
- d. The ecological soil PRGs were based on conservative ecological screening values. However, the Eco-SSL documents indicate that Eco-SSLs are not designed to be used as cleanup levels and USEPA emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards. An evaluation will be conducted to assure the site-wide 95 percent UCLs of ecological COC mean concentrations are below their respective RGs following the remediation.
- e. The chromium PRG concentration applies to total chromium levels and assumes less than 12.2 percent of chromium is the hexavalent species (Tetra Tech, 2014).
- f. The Site 12-specific background 95 percent UTLs were from Phase II RI (Tetra Tech, 2014, Appendix K, Table K-6).
- g. Ecological PRGs based on Eco-SSLs: EPA (2007a) for copper; EPA (2005) for lead; EPA (2007b) for selenium; EPA (2007c) for zinc.
- h. Ecological PRGs based on Canadian Soil Quality Guideline (CCME, 2010).
- i. The PAH background values are mean concentrations (Tetra Tech, 2014. Appendix K, Table K-26. Anthracene: Table 2-11).
- j. Draft Site 12 Draft Record of Decision; Table 2-5: Surface Soil Remediation Goals (NAVFAC, 2021).

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NAVFAC, 2021. Draft Record of Decision. Site 12 - South Landfill. Former Naval Air Station Joint Reserve Base Willow Grove, Pennsylvania. Prepared by Tetra Tech. January.

PADEP (Pennsylvania Department of Environmental Protection), 2016. Statewide Health Standards, Medium Specific Concentrations (MSCs). Table 4a - MSCs for Inorganic Regulated Substances in Soil: Direct Contact Values.

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APPENDIX A
HUMAN HEALTH RISK-BASED PRGS FOR TOTAL SOIL

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APPENDIX A, TABLE A-1
HUMAN HEALTH RISK-BASED PRGs FOR TOTAL SOIL, LANDFILL AREA, RESIDENTIAL EXPOSURE
SITE 12 - SOUTH LANDFILL
NAS JRB WILLOW GROVE, PENNSYLVANIA

Soil PRGs - Noncancer Risk Consideration	Exposure Point Concentration (EPC) (mg/kg metals, ug/kg organics)	Child HQ Estimated in HHRA From Concentration Equal to EPC	Child HQ Estimated for Concentration Equal to the PRG Shown*	PRG That Achieves HI and Cancer Risk Goals* (mg/kg metals, ug/kg organics)	Target Organs
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PATHWAY: Direct Contact with Soil

Benzo(a)pyrene	1.65E+03	0.093	0.14	2500 ^	Developmental
Chromium (Hexavalent)*	3.35E+00	0.014	0.02	4.0 ^	Fetotoxicity/GI Tract/Bone
Arsenic	9.64E+00	0.28	0.34	12	Skin/vascular
Total 2,3,7,8-TCDD Equiv.	7.76E-01	15.19 ^^^	1.0	0.05	Reproductive

HI for CNS for conc. = PRGs	0.0
HI for Liver for conc. = PRGs	0.0
HI for Blood for conc. = PRGs	0.0
HI for GI Tract for conc. = PRGs	0.02
HI for Bone for conc. = PRGs	0.02
HI for Fetotoxicity for conc. = PRGs	0.02
HI for Developmental for conc. = PRGs	0.14
HI for Immune for conc. = PRGs	0.0
HI for Skin/Vascular for conc. = PRG	0.34
HI for Reproductive for conc. = PRGs	1.0

* HQ at the stated PRG, which considers applicable target organ-specific HIs.

When COCs share the same target organ effects, the HQ goal for an individual COC must be < 1.

Assumptions: 350 days per year of soil contact, ingestion of 200 mg/day for a child resident.

Hazard indices have been updated based on new toxicity factors and new exposure assumptions.

^ - PRG listed is based on cancer risk because that is a more sensitive endpoint than non-cancer PRG.

^^ - Child HQ listed has been adjusted for an updated toxicity value as of 4/6/2012.

Soil PRGs - Cancer Risk Consideration	Exposure Point Concentration (EPC) (mg/kg metals, ug/kg organics)	Lifetime Cancer Risk in HHRA-rev From Concentration Equal to EPC	Lifetime Cancer Risk for Concentration Equal to the PRG Shown**	PRG That Achieves HI and Cancer Risk Goals (mg/kg metals, ug/kg organics)	Fraction of Total Cancer Risk Represented by Concentration at the PRG**
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PATHWAY: Direct Contact with Soil

Chromium (Hexavalent)*	3.35E+00	1.11E-05	1.3E-05	4.0	0.133
Chromium (Total)*				33.6	
Total 2,3,7,8-TCDD Equiv. (ng)	7.76E-01	1.63E-04	1.0E-05	0.050 ^^	(non-cancer goal shown)
Arsenic	9.64E+00	1.43E-05	1.8E-05	12	0.180
Benz(a)anthracene	1.85E+03	1.64E-06	5.3E-06	6,000	0.053
Benzo(a)pyrene	1.65E+03	1.44E-05	2.2E-05	2,500	0.220
Benzo(b)fluoranthene	1.69E+03	1.47E-06	5.2E-06	6,000	0.053
Benzo(k)fluoranthene	1.89E+03	1.65E-07	5.2E-07	6,000	0.005
Dibenz(a,h)anthracene	5.76E+02	5.02E-06	2.2E-05	2,500	0.220
Indeno(1,2,3-cd)pyrene	1.49E+03	1.30E-06	5.2E-06	6,000	0.053

		Total risk for conc. = PRGs	1.0E-04		
BAP equivalents (See Note 2)	2.75E+03	2.40E-05	6.0E-05	6,900	0.603

Total Soil exposure considers surface soil and subsurface soil.

* The risk-based PRG for total chromium assumed less than 12.2% of soil chromium was present as the more toxic hexavalent species based on site-specific speciation evaluation presented in Appendix K of Site 12 Phase II RI (Tetra Tech, 2014).

** Risk goals selected so each compound contributes the cancer risk fraction shown to a total target risk <= 1E-4.

Assumptions: 350 days per year of soil contact, ingestion of 100 and 200 mg/day for an adult/child, respectively.

Cancer risks have been updated based on new toxicity factors and new exposure assumptions.

^^ - PRG listed is based on noncancer risk because that is a more sensitive endpoint than cancer PRG.

Note 1: Industrial worker PRGs were not applicable because risks did not exceed the acceptable range for an industrial worker.

Note 2: Using BAP equivalents instead of PRGs for each PAH compound maintains acceptable total risk for any mixture.

TABLE 7.1.RME
 CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
 REASONABLE MAXIMUM EXPOSURES
 SITE 12, WILLOW GROVE, PENNSYLVANIA
 PAGE 1 OF 1

Scenario Timeframe: Hypothetical
 Receptor Population: Residents
 Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations						Non-Cancer Hazard Calculations					
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RID/RFC		Hazard Quotient		
							Value	Units	Value	Units		Value	Units	Value	Units			
Surface/Subsurface Soil	Surface/Subsurface Soil	Site 12	Ingestion	Benzo(a)anthracene	1.85	mg/kg	1.2E-05	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	1E-06							
				Benzo(a)pyrene	1.65	mg/kg	1.1E-05	(mg/kg/day)	1.0E+00	(mg/kg/day) ⁻¹	1E-05							
				Benzo(b)fluoranthene	1.69	mg/kg	1.1E-05	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	1E-06							
				Benzo(k)fluoranthene	1.89	mg/kg	1.2E-05	(mg/kg/day)	1.0E-02	(mg/kg/day) ⁻¹	1E-07							
				Chrysene	2.01	mg/kg	1.3E-05	(mg/kg/day)	1.0E-03	(mg/kg/day) ⁻¹	1E-08							
				Dibenzo(a,h)anthracene	0.576	mg/kg	3.8E-06	(mg/kg/day)	1.0E+00	(mg/kg/day) ⁻¹	4E-06							
				Indeno(1,2,3-cd)pyrene	1.49	mg/kg	9.7E-06	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	1E-06							
				Arsenic	9.65	mg/kg	8.3E-06	(mg/kg/day)	1.5E+00	(mg/kg/day) ⁻¹	1E-05							
				Chromium VI	3.35	mg/kg	2.2E-05	(mg/kg/day)	5.0E-01	(mg/kg/day) ⁻¹	1E-05							
				2,3,7,8-TCDD Equivalents	0.000776	mg/kg	1.1E-09	(mg/kg/day)	1.3E+05	(mg/kg/day) ⁻¹	1E-04							
				Exp. Route Total														
				Dermal	Benzo(a)anthracene	1.85	mg/kg	4.0E-06	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	4E-07						
					Benzo(a)pyrene	1.65	mg/kg	3.6E-06	(mg/kg/day)	1.0E+00	(mg/kg/day) ⁻¹	4E-06						
			Benzo(b)fluoranthene		1.69	mg/kg	3.7E-06	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	4E-07							
			Benzo(k)fluoranthene		1.89	mg/kg	4.1E-06	(mg/kg/day)	1.0E-02	(mg/kg/day) ⁻¹	4E-08							
			Chrysene		2.01	mg/kg	4.4E-06	(mg/kg/day)	1.0E-03	(mg/kg/day) ⁻¹	4E-09							
			Dibenzo(a,h)anthracene		0.576	mg/kg	1.3E-06	(mg/kg/day)	1.0E+00	(mg/kg/day) ⁻¹	1E-06							
			Indeno(1,2,3-cd)pyrene		1.49	mg/kg	3.2E-06	(mg/kg/day)	1.0E-01	(mg/kg/day) ⁻¹	3E-07							
			Arsenic		9.65	mg/kg	1.2E-06	(mg/kg/day)	1.5E+00	(mg/kg/day) ⁻¹	2E-06							
			Chromium VI		3.35	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	(mg/kg/day) ⁻¹	- -							
			2,3,7,8-TCDD Equivalents		0.000776	mg/kg	9.4E-11	(mg/kg/day)	1.3E+05	(mg/kg/day) ⁻¹	1E-05							
			Exp. Route Total															
			Exposure Point Total															
			Exposure Medium Total															
			Air	Site 12	Inhalation	Benzo(a)anthracene	4.2E-07	mg/m ³	4.1E-07	(mg/m ³)	6.0E-05	(ug/m ³) ⁻¹	2E-08					
						Benzo(a)pyrene	1.2E-09	mg/m ³	1.2E-09	(mg/m ³)	6.0E-04	(ug/m ³) ⁻¹	7E-10					
Benzo(b)fluoranthene	1.2E-09	mg/m ³				1.2E-09	(mg/m ³)	6.0E-05	(ug/m ³) ⁻¹	7E-11								
Benzo(k)fluoranthene	1.4E-09	mg/m ³				1.4E-09	(mg/m ³)	6.0E-06	(ug/m ³) ⁻¹	8E-12								
Chrysene	1.5E-09	mg/m ³				1.5E-09	(mg/m ³)	6.0E-07	(ug/m ³) ⁻¹	9E-13								
Dibenzo(a,h)anthracene	4.2E-10	mg/m ³				4.2E-10	(mg/m ³)	6.0E-04	(ug/m ³) ⁻¹	3E-10								
Indeno(1,2,3-cd)pyrene	1.1E-09	mg/m ³				1.1E-09	(mg/m ³)	6.0E-05	(ug/m ³) ⁻¹	6E-11								
Arsenic	7.1E-09	mg/m ³				2.5E-09	(mg/m ³)	4.3E-03	(ug/m ³) ⁻¹	1E-08								
Chromium VI	2.5E-09	mg/m ³				2.4E-09	(mg/m ³)	8.4E-02	(ug/m ³) ⁻¹	2E-07								
2,3,7,8-TCDD Equivalents	4.0E-10	mg/m ³				1.4E-10	(mg/m ³)	3.8E+01	(ug/m ³) ⁻¹	5E-06								
Exp. Route Total																		
Exposure Point Total																		
Exposure Medium Total																		
Medium Total																		
Total of Receptor Risks Across All Media																		

Notes:
 1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
SITE 12, WILLOW GROVE, PENNSYLVANIA
PAGE 1 OF 1

Scenario Timeframe: Hypothetical
Receptor Population: Residents
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface/Subsurface Soil	Surface/Subsurface Soil	Site 12	Benzo(a)anthracene	1E-06	--	4E-07	--	1.61111E-06					
			Benzo(a)pyrene	1E-05	--	4E-06	--	1.43693E-05					
			Benzo(b)fluoranthene	1E-06	--	4E-07	--	1.47177E-06					
			Benzo(k)fluoranthene	1E-07	--	4E-08	--	1.64594E-07					
			Chrysene	1E-08	--	4E-09	--	1.75045E-08					
			Dibenzo(a,h)anthracene	4E-06	--	1E-06	--	5.01621E-06					
			Indeno(1,2,3-cd)pyrene	1E-06	--	3E-07	--	1.29760E-06					
			Arsenic	1E-05	--	2E-06	--	1.42493E-05					
			Chromium VI	1E-05	--	--	--	1.09372E-05					
			2,3,7,8-TCDD Equivalents	1E-04	--	1E-05	--	1.57348E-04					
	Chemical Total	2E-04	--	2E-05	--	2E-04							
	Exposure Point Total					2E-04							
	Exposure Medium Total					2E-04							
	Air	Site 12	Benzo(a)anthracene	--	2E-08	--	--	2E-08					
			Benzo(a)pyrene	--	7E-10	--	--	7E-10					
			Benzo(b)fluoranthene	--	7E-11	--	--	7E-11					
			Benzo(k)fluoranthene	--	8E-12	--	--	8E-12					
			Chrysene	--	9E-13	--	--	9E-13					
			Dibenzo(a,h)anthracene	--	3E-10	--	--	3E-10					
			Indeno(1,2,3-cd)pyrene	--	6E-11	--	--	6E-11					
Arsenic			--	1E-08	--	--	1E-08						
Chromium VI			--	2E-07	--	--	2E-07						
2,3,7,8-TCDD Equivalents			--	5E-06	--	--	5E-06						
Chemical Total	--	6E-06	--	--	6E-06								
Exposure Point Total					6E-06								
Exposure Medium Total					6E-06								
Medium Total					2E-04								
Receptor Total					2E-04								

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
SITE 12, WILLOW GROVE, PENNSYLVANIA
PAGE 1 OF 1

Scenario Timeframe: Hypothetical
Receptor Population: Residents
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface/Subsurface Soil	Surface/Subsurface Soil	Site 12	Benzo(a)anthracene	1E-06	--	3E-07	--	1E-06	NA	--	--	--	--
			Benzo(a)pyrene	1E-05	--	3E-06	--	1E-05	Developmental	0.07	--	0.02	0.09
			Benzo(b)fluoranthene	1E-06	--	3E-07	--	1E-06	NA	--	--	--	--
			Benzo(k)fluoranthene	1E-07	--	3E-08	--	1E-07	NA	--	--	--	--
			Chrysene	1E-08	--	4E-09	--	2E-08	NA	--	--	--	--
			Dibenzo(a,h)anthracene	3E-06	--	1E-06	--	4E-06	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	9E-07	--	3E-07	--	1E-06	NA	--	--	--	--
			Arsenic	1E-05	--	1E-06	--	1E-05	Dermal, CVS	0.2	--	0.03	0.3
			Chromium VI	1E-05	--	--	--	1E-05	None Specified	0.01	--	--	0.01
			2,3,7,8-TCDD Equivalents	1E-04	--	8E-06	--	1E-04	Reproductive	14	--	1	15
	Chemical Total	1E-04	--	1E-05	--	2E-04		15	--	1	16		
	Exposure Point Total					2E-04					16		
	Exposure Medium Total					2E-04					16		
	Air	Site 12	Benzo(a)anthracene	--	1E-08	--	--	1E-08	NA	--	--	--	--
			Benzo(a)pyrene	--	3E-10	--	--	3E-10	Developmental	--	0.0006	--	0.0006
			Benzo(b)fluoranthene	--	3E-11	--	--	3E-11	NA	--	--	--	--
			Benzo(k)fluoranthene	--	4E-12	--	--	4E-12	NA	--	--	--	--
			Chrysene	--	4E-13	--	--	4E-13	NA	--	--	--	--
			Dibenzo(a,h)anthracene	--	1E-10	--	--	1E-10	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	--	3E-11	--	--	3E-11	NA	--	--	--	--
Arsenic			--	3E-09	--	--	3E-09	NA	--	0.0005	--	0.0005	
Chromium VI			--	9E-08	--	--	9E-08	Respiratory	--	0.00002	--	0.00002	
2,3,7,8-TCDD Equivalents			--	1E-06	--	--	1E-06	Hepatic, Reproductive, Respiratory	--	0.009	--	0.009	
Chemical Total	--	1E-06	--	--	1E-06		--	0.01	--	0.01			
Exposure Point Total					1E-06					0.01			
Exposure Medium Total					1E-06					0.01			
Medium Total					2E-04					16			
Receptor Total					2E-04					16			

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

Total CVS HI	0.3
Total Dermal HI	0.3
Total Developmental HI	0.09
Total Hepatic HI	0.009
Total None Specified HI	0.01
Total Reproductive HI	15
Total Respiratory HI	0.010