TECHNICAL MEMORANDUM

Development of Human Health Risk-Based Preliminary Remediation Goals for Operable Unit 5

PREPARED FOR:	Katrina Coltrain/U.S. Environmental Protection Agency (EPA), Region 6 Remedial Project Manager
PREPARED BY:	CH2M HILL, Inc. (CH2M)
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This technical memorandum presents the approach, assumptions, and results from developing human health risk-based preliminary remediation goals (PRGs) for Operable Unit 5 (OU5) of the Tar Creek Superfund Site in Ottawa County, Oklahoma. The objective of this evaluation was to develop sediment PRGs protective of human health, not only for direct sediment contact but also secondary exposure through direct contact of associated surface water and aquatic food consumption. Note that the remedy associated with chemicals of concern (COCs) in surface water, including analysis of applicable or relevant and appropriate requirements (ARARs), will be further evaluated in the feasibility study (FS). In addition, mine discharge will be addressed in the FS. The PRGs that have been developed as described in this memorandum represent multiple exposure scenarios for the three sediment COCs identified in the human health risk assessment (HHRA): lead, cadmium, and zinc (CH2M, 2020). Version 1.2 of the memorandum provided an update to version 1.1, dated January 29, 2021, and considered review comments received from U.S. EPA's Technical Review Workgroup (TRW) for metals and asbestos ("TRW Lead Committee") and Site stakeholders. EPA and CH2M appreciate the Tar Creek Trustee Council Indian Tribes (TCTCIT) and their representative (Abt Associates), Oklahoma Department of Environmental Quality, Quapaw Nation, and the LEAD Agency for their collaboration, comments, and input during PRG development.

This version 1.3 of the memorandum has been updated based on stakeholder comments received on version 1.2, and includes attachments as follows:

- Attachment 1 is the TRW Lead Committee's response letter.
- Attachment 2 is the sediment and aquatic plant regression analysis.
- Attachment 3 is the sensitivity analysis.
- Attachment 4 provides the responses to comments received on version 1.2 of this technical memorandum, including copies of the written comments received and copies of previous presentations from exchanges with stakeholders.

After completion of the OU5 HHRA, initial lead PRG development approaches, representing numerous exposure scenarios, were developed for the analysis using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, Windows version 1.1, build 11 (EPA, 2010), with the EPA Region 6 remedial project manager for OU5 and EPA regions 6 and 7 risk assessors during a series of technical meetings. On October 14, 2020, a request was submitted to the TRW Lead Committee to review the developed lead PRG approaches. EPA's TRW Lead Committee responded to this request and provided review comments and recommendations on November 20, 2020 (Attachment 1 provides a copy of the TRW Lead Committee's response letter). Version 1.1 of this memorandum addressed the TRW Lead Committee's review comments and recommendations and EPA provided it to stakeholders for review on January 29, 2021. EPA received review comments on the draft technical memorandum from TCTCIT and their representative Abt Associates on March 12, 2021; EPA then initiated a series of technical collaboration meetings with TCTCIT and Abt Associates. Based on the discussions during these meetings, the approach to development of PRGs for tribal lifeway (TLW) receptors was revised in version 1.2 of the memorandum (CH2M, 2021a) to align with the scenarios evaluated in the HHRA.

Written review comments were received from four stakeholder groups (Abt Associates on behalf of TCTCIT [received on July 9, 2021], L.E.A.D Agency, Inc. [received on July 9, 2021], AESE on behalf of Quapaw Nation [received on July 13, 2021], and Oklahoma Department of Environmental Quality [ODEQ; received on July 14, 2021]), which are presented in Attachment 4A. The written review comments received from these stakeholders on the technical memorandum, version 1.2, as well as responses to comments are presented in Attachment 4B. After receipt of review comments on the technical memorandum version 1.1, several technical meetings were held to discuss stakeholder comments. Copies of presentation slides presented by EPA and used in these technical meetings are presented in Attachment 4C. Based on ODEQ's review comments, a few changes were made to the general public (GP) PRGs presented in the technical memorandum, version 1.2, as follows:

- The approach addressing lead exposure through OU5 fish consumption in GP Scenario 1 was modified.
- The PRGs using the time-weighted average (TWA) presented in the addendum to the technical memorandum version 1.2 (Scenario 4) (CH2M, 2021b) were added to the main section of this version of the memorandum.
- The updated GP Scenario 1 PRGs were further refined using the TWA approach and included in this memorandum (as GP Scenario 5).

All IEUBK model runs presented in this PRG memorandum (except for GP Scenario 1) were completed using the most recent IEUBK model available at the time (IEUBK Windows, version 1.1, build 11), with modifications to input parameter values reflecting the same changes that are incorporated in the new IEUBK model, version 2.0 (released in May 2021). Because of changes in the dietary information in the IEUBK model, version 2, the PRGs under Scenario 1 using the "alternate dietary values" option were calculated using the IEUBK model, version 2. Therefore, with a few minor exceptions[1], the results of the IEUBK model runs in this memorandum provide the same results as those that would be produced using the new IEUBK model, version 2.

1.0 Site Background

The Tar Creek Superfund Site is located within the Tri-state Mining District (TSMD), a historical lead and zinc mining area that includes portions of southeastern Kansas, southwestern Missouri, and northeastern Oklahoma (Figure 1). Historical mining activities in the TSMD resulted in contamination of soil, surface water, groundwater, and sediments in the Neosho River and Spring River basins by cadmium, lead, zinc, and other heavy metals.

Generally, EPA Region 6 defines OU5 as sediments and surface water in perennially flowing creeks, streams, and rivers that may be impacted by historical mining activities within the Oklahoma portion of the TSMD and upstream portions in Kansas and Missouri. The potential exposures addressed under OU5

[1] Due to changes in the dietary information in the IEUBK model, version 2, the PRGs calculated using the "alternate dietary values" option in the sensitivity analysis (Attachment 3) estimated higher PRGs than those that would be calculated using version 2.

are associated with the aquatic environment. The definition of OU5 has been further refined by EPA Regions 6 and 7 for conducting the remedial investigation and HHRA to include the following seven specific watersheds that flow downstream from EPA Region 7 states (Kansas and Missouri) into EPA Region 6 (Oklahoma):

- Fourmile Creek (upstream background or reference location unaffected by historical mining activities)
- Elm Creek
- Tar Creek (including Lytle Creek)
- Neosho River
- Beaver Creek
- Lost Creek
- Lower Spring River (the portion of Spring River downstream of Empire Lake in Kansas)

2.0 Preliminary Remedial Action Objectives

Remedial action objectives (RAOs) are medium-specific or operable unit-specific goals for protecting human health and the environment (EPA, 1988). Remedial actions must protect public health and the environment, and address potential risks identified in the human health and ecological risk assessments. Once RAOs are designated, they serve as a basis for developing the remedial action alternatives necessary to meet remedial goals. In general, remedial goals are media- and chemical-specific concentrations that pose no unacceptable risk to human health and the environment (or background levels if the risk-based levels are below background). For OU5, RAOs have been developed for the media of concern that have potentially unacceptable risks to human health and the environment based on the findings of the HHRA (CH2M, 2020a) and the advanced screening level ecological risk assessment (MESL, 2010). The media of concern for the site are sediment, surface water, and biota.[2]

The following preliminary human health RAOs were identified in the remedial investigation report (CH2M, 2020b) based on the anticipated outcome of the HHRA at that time:

- Minimize or prevent human exposures from direct or indirect contact with elevated metals in OU5 sediment and surface water[3] that may pose an unacceptable risk
- Minimize or prevent human exposures to elevated metals found in OU5 aquatic biota that may pose an unacceptable risk

In addition, the advanced screening level ecological risk assessment (MESL, 2010) identified preliminary RAOs for sediment and pore water that address potential risks to aquatic receptors, aquatic-dependent wildlife, and humans associated with exposure to contaminated sediments. These preliminary RAOs related to aquatic receptors and aquatic-dependent wildlife include:

- RAO for aquatic receptors: Minimize or prevent exposure to sediments and/or pore water that are sufficiently contaminated to pose moderate or high risks to microbial, aquatic plant, benthic invertebrate, or fish communities (particularly for fish species that use sediment substrates for spawning).
- RAO for aquatic-dependent wildlife: Minimize risks to sediment-probing birds or omnivorous mammals associated with incidental ingestion of sediments during feeding activities.

3.0 Overview of the Basis for Preliminary Remediation Goals

To meet the RAOs, human health and ecological PRGs typically are developed for use in the FS to define the extent of contaminated media requiring remedial action. In general, PRGs establish media-specific

[2] Surface water and biota impacts are primarily due to sediment concentrations; therefore, RAOs are established for sediments.

[3] Potential exposure to mine discharge also was evaluated based on the same exposure assumptions used for surface water.

concentrations of COCs that will pose no unacceptable risk to human health and the environment. Section 4 summarizes the ecological PRGs developed using the detailed environmental risk assessment (DERA) (CH2M, 2020c); Section 5 summarizes the HHRA (CH2M, 2020a); and Section 6 presents the approach used to develop the human health PRGs described herein. The human health and ecological PRGs were developed considering the following:

- Human health risk-based concentrations associated with a noncancer hazard index (HI) of 1
- Human health risk-based concentrations associated with lead exposure corresponding to a 5% probability of exceeding a target blood lead level (BLL) (5, 8, and 10 micrograms per deciliter [µg/dL])
- Site-specific toxicity thresholds (SSTTs) corresponding to a 10% (T10) or 20% (T20) reduction in survival or biomass compared to various reference envelope limits and/or multi-metal risk-based concentration (RBC) Σ PEC-$Q_{Cd,Pb,Zn}$, indicating a significant ecological risk
- Contaminant-specific ARARs; however, no sediment ARARs are available (Note: Although surface water ARARs exist, the additional analysis of surface water ARARs will be conducted in the FS. Therefore, no ARAR-based PRGs were identified in this technical memorandum.
- Background concentrations

4.0 Summary of Ecological Preliminary Remediation Goals

The DERA (CH2M, 2020c) did not explicitly identify RBCs for surface water, pore water, or sediment. However, SSTTs used in the DERA can be used as RBCs to support PRG development. SSTTs were defined for:

- Surface water
- Sediment
- Pore water
- Invertebrate tissue
- Freshwater mussel species richness

The DERA focused on evaluating risks to the benthic invertebrate community posed by exposure to contaminated environmental media in the study area; sediment chemistry was used as a primary line-of-evidence for evaluating and summarizing risks to the benthic community. As such, risk associated with direct contact and toxicity of sediments to benthic invertebrates is the primary risk driver for OU5, and RBCs associated with low and moderate risk may serve as the basis for PRG selection.

The concentrations of each chemical of potential concern (COPC) or COPC mixture that corresponded to a 10 and 20% reduction in survival or biomass, compared to various reference envelope limits, are defined as the “T10” and “T20” values, respectively. Selection of a SSTT as an RBC provides significant risk reduction. Using a T10 SSTT as an RBC, for instance, the incidence of toxicity would be reduced from approximately 80% to less than 10%. The SSTT as an RBC could serve as a reasonable basis for identifying a PRG that addresses the RAO for aquatic receptors. The RBCs based on the T10 and T20 for the single metals of cadmium, lead, and zinc as well as the multi-metal RBC Σ PEC-$Q_{Cd,Pb,Zn}$ are as follows:

- Cadmium – 11.1 (T10) and 17.3 (T20) milligrams per kilogram of dry weight sediment (mg/kg dw)
- Lead – 150 (T10) and 219 (T20) mg/kg dw
- Zinc – 2,083 (T10) and 2,949 (T20) mg/kg dw
- $\sum$ PEC-$Q_{Cd,Pb,Zn}$ - <6.47 (T10) and 10.04 (T20)[4]

[4] Please note that there was a typographic error in Appendix H (Baseline Ecological Risk Assessment Technical Memorandum) in the RI report (CH2M, 2020b). The $\sum$ PEC-Q presented in the fourth bullet of Section 2.2 (the T10 and T20 SSTTs of 7.92 and 11.26) should be 6.47 and 10.04 for the T10 and T20 SSTTs, respectively.

5.0 Summary of Human Health Risk Assessment

The HHRA (CH2M, 2020a) was conducted to evaluate the potential risks associated with exposures to COPCs by human receptors identified in the OU5 study area under current and reasonably foreseeable future land use conditions. The HHRA was conducted consistent with EPA *Risk Assessment Guidance for Superfund* (EPA, 1989) and other supplemental EPA guidance documents (EPA, 1995, 2001, 2003a, 2004, 2009, 2010, 2011, 2014). In addition, input from stakeholders was considered in developing the conceptual exposure model and exposure assumptions for characterizing exposures to tribal members and citizens (TLW receptors), aquatic workers (AW) and the GP. EPA's TRW Lead Committee also was consulted regarding the approach for lead evaluation for the OU5 study area.

The HHRA evaluated potential exposures to sediment, surface water, mine discharge, and aquatic biota at the site, and estimated potential risk for the following receptors:

- TLW (adults and children)
- AW (adults only) (for example, hatchery or environmental employees)
- GP (adults and children)

Table 1 summarizes the exposure scenarios evaluated for each receptor.

Using the data groupings identified for each watershed and exposure medium, potential exposures to COPCs were quantified based on exposure factors developed using EPA guidance documents, literature describing exposure characteristics of tribal members and citizens, and inputs from the Quapaw Nation and TCTCIT. For metals other than lead, the Comprehensive Environmental Response, Compensation, and Liability Act specifies an acceptable site excess lifetime cancer risk (ELCR) range of one in a million to one in ten thousand (1×10^{-6} to 1×10^{-4}). Generally, remedial actions are not warranted for site media with an ELCR of 1×10^{-4} or a HI of 1 or less, although it may be warranted if other site-specific information suggests to risk managers that action is appropriate.

The final COCs in sediment discussed in this memorandum are identified using a stepwise approach.

1. First, preliminary COCs were identified for non-lead chemicals based on the risk estimates. The preliminary COCs are identified for a receptor scenario when the potential ELCR or HI exceeds EPA cancer threshold values (a cumulative ELCR of 1×10^{-4} or a target-organ-specific HI of 1), except for lead. When a target ELCR of 1×10^{-4} is exceeded for sediment for the receptor scenario, the COPCs posing an individual ELCR greater than 1×10^{-6} in sediment were identified as preliminary COCs. When a target-organ-specific HI of 1 is exceeded for sediment for the receptor group, the COPCs posing a hazard quotient (HQ) greater than 0.1 for that target organ in sediment responsible for the unacceptable HI are identified as preliminary COCs.
2. Second, the list of preliminary COCs was refined using two additional considerations to identify final COCs: (a) background comparisons, and (b) attribution to mine-related contamination.

Final sediment COCs for each watershed are listed in Table 2. As shown in the table, lead, cadmium, and zinc are only the final COCs identified in sediment.

In addition to the analysis of non-lead COCs discussed above, potential exposure to lead in environmental media within the OU5 study area was evaluated separately because the approach for the evaluation of lead (using biokinetic modeling) is different from other COPCs. The purpose of the lead analysis included in the HHRA was to identify potential unacceptable risk associated with exposure to lead in environmental media within the OU5 study area. Given the elevated concentrations of lead detected in OU5 media (for example, the average lead concentration in Elm Creek sediment is as high as 4,281 milligrams per kilogram [mg/kg]) and the limitations of the available lead models, a conscious effort was made to streamline the evaluation without expending considerable effort in identifying representative central tendency exposure parameter values (needed for the biokinetic modeling) characterizing the unique OU5 study area exposure scenarios. Potential lead exposure was evaluated using the IEUBK model (EPA, 2010) and the Adult Lead Methodology (ALM) (EPA, 2017).

Based on the results of the analyses, the HHRA concluded that potential lead exposure at OU5 leads to a level above the target lead exposure criterion (i.e., more than 5 percent probability of exceeding the target BLL of 5 µg/dL); therefore, lead was identified as a preliminary COC in all six OU5 watersheds. Additionally, the lead exposure estimated based on the exposure point concentrations (EPCs) at the reference watershed (Fourmile Creek, which represents background lead concentrations in sediment and surface water) also exceeds the target lead exposure criterion. As done for non-lead COPCs, lead was further evaluated based on results of background comparisons to determine if lead is a final COC in each of these watersheds. Concentrations of lead in sediment and surface water at two of the watersheds (Neosho River and Lost Creek) are comparable to background concentrations; therefore, lead was identified as a final COC in all watersheds (Elm Creek, Tar Creek, Beaver Creek, and Lower Spring River) except these two watersheds.

6.0 Human Health Risk-Based PRG Development Approach

To support the remedial alternative selection process, sediment PRGs were developed for the final COCs (lead, cadmium, and zinc) identified in the HHRA. In general, the PRGs can be based on either the ARARs or the RBCs associated with specified target risk levels. No sediment ARARs are available. Although ARARs for surface water exist, the additional analysis of these ARARs will be conducted in the FS.

The objective of this evaluation is to develop sediment PRGs protective of human health, not only for direct sediment contact, but also for secondary exposure through direct contact of associated surface water and aquatic food consumption. Based on the historical site activities and findings of the previous investigations, lead, cadmium, and zinc are the primary chemicals of interest. Also, these are the only chemicals identified as the final COCs in sediment. Therefore, PRG development focuses on sediment PRGs for these three COCs. Because the approach used in the exposure analysis of lead is different from that of the cadmium and zinc hazard assessment, PRGs are discussed separately in the following sections.

6.1 PRG Development Approach for Lead

Developing a PRG for lead in sediment requires consideration of a wider range of potential exposure assumptions to provide risk managers with a range of PRGs for decision-making. The OU5 HHRA (CH2M, 2020a) addressed three potential receptor scenarios (tribal lifeway [TLW], AW, and GP). The discussion presented herein describes the approach for use of the IEUBK model for lead exposure by child receptors under the TLW and GP exposure scenarios. Although lead was identified as a sediment COC for adult receptors (including AW), lead PRGs were developed for child receptors using the IEUBK model only because children are a more sensitive receptor group for lead exposure than adults. Additionally, the IEUBK model has greater capability as a multimedia exposure model than the ALM model (i.e., the ALM is limited primarily to exposure through the ingestion route).

6.1.1 Methodology

PRGs for TLW (child) and the first three GP (child) scenarios were developed based on the general (streamlined) approach and reasonable maximum exposure (RME) assumptions used in the lead exposure analysis in the HHRA (CH2M, 2020a). In the PRG development for these scenarios, sediment exposure is treated as soil exposure in the model (that is, assumed daily exposure to OU5 sediment without considering receptors' exposure frequency and time at OU5) and the calculated soil PRGs are presented as sediment PRGs. Additionally, lead PRGs, which were developed for two of the first three GP (child) scenarios, were refined using the TWA approach and accounting for lead exposure in two exposure areas (OU5 and home). Although an attempt was made to refine the PRGs for the TLW (child) scenario using the TWA approach, the PRGs established using the streamlined approach were so low that no refined PRGs were calculated based on the assumed residential soil concentration[5].

All the IEUBK model runs used target BLLs of 5, 8, and 10 µg/dL, which are consistent with the lead exposure analyses in the HHRA (CH2M, 2020a). The six sets of PRGs (one TLW and five GP scenarios) are described in the following paragraphs. General descriptions of the scenarios are presented in Table 3. Table 4 summarizes assumptions and estimated PRGs for these scenarios.

The objective was to calculate sediment PRGs protective of both surface water and biota consumption exposures, assuming sediment is the main source of contamination affecting concentrations in surface water and biota. However, while mine discharge could be an additional source of contamination to surface water and biota, the direct measured concentrations in surface water and biota that were used in the HHRA are reflective of any possible impacts that may result from mine discharge.

The development of lead PRGs in OU5 sediment using a multimedia exposure model (the IEUBK model) posed some technical challenges because some of the input parameter values (lead concentrations in surface water and biota) are assumed to be dependent variables to the lead concentrations in sediment. In other words, as lead concentration in sediment increases, concentrations of lead in surface water and aquatic biota are also expected to increase.

Typically, the IEUBK model calculates a PRG in a single exposure medium at a time based on a set of fixed exposure variables that are independent of the calculated PRG (for instance, lead PRG in soil is calculated based on fixed lead concentrations in drinking water or supermarket food because the lead concentrations in these media do not vary based on lead concentration in soil). However, this is not the case for the complex OU5 aquatic environment because a change in sediment lead concentration is expected to result in some change in lead concentrations in the secondary exposure media (surface water and biota that the receptor consumes as drinking water or food).

To overcome this technical issue, a streamlined approach was used to estimate surface water and biota concentrations corresponding to varying lead concentrations in sediment. As presented in Appendix E, Table 1, of the HHRA (2020a), lead EPCs in OU5 sediment vary widely watershed by watershed, ranging from 27 mg/kg in Fourmile Creek to 4,281 mg/kg in Elm Creek. For the scenarios requiring site-specific EPCs in surface water (GP scenario 2) or surface water and biota (TLW scenario), lead concentrations in these secondary exposure media were estimated using the actual measured data from the watershed with lead EPCs most closely corresponding to the calculated sediment PRGs. The following stepwise approach was used to calculate sediment PRGs for lead for these scenarios:

1. Sediment PRGs based on a target BLL of 5 µg/dL were calculated for these scenarios using background lead EPCs for surface water and biota.[6]
2. The calculated sediment PRG for a target BLL of 5 µg/dL (from Step 1) was compared to OU5 watershed-specific sediment EPCs for lead.
3. The OU5 watershed with a sediment EPC for lead that most closely matched the calculated sediment PRG for a target BLL of 5 µg/dL (from Step 1) was identified as the representative watershed for that scenario.
4. Sediment PRGs were recalculated using the surface water and biota EPCs for lead from the representative watershed (based on a target BLL of 5 µg/dL).

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[5] No refined PRGs using the TWA approach could be calculated under the TLW scenario because lead exposure from the residential yard soil (EPC of 133 mg/kg) is so significant that even if the sediment concentration was zero, it would not achieve all three target BLLs. Therefore, no TWA PRGs were calculated for the TLW scenario.

[6] Biota consumption based on site-specific lead EPC was assessed for the TLW scenario only.

For instance, the surface water EPC for lead in Lost Creek was selected as the representative EPC of drinking water for GP scenario 2 because the sediment EPC for lead in Lost Creek (168 mg/kg) most closely represented the calculated sediment PRG based on a target BLL of 5 µg/dL (173 mg/kg). Similarly, the surface water and biota EPCs for lead in Fourmile Creek were selected as representative EPCs for the TLW scenario because the sediment EPC in Fourmile Creek (27 mg/kg), the lowest of all seven watersheds, most closely represented the calculated sediment PRG based on a target BLL of 5 µg/dL (the PRG value was not calculated, meaning that even if the lead concentration in sediment is zero, it would not achieve the target BLL of 5 µg/dL). Although this method may underestimate lead exposure from the secondary exposure media (surface water and biota) for higher target BLLs (such as 8 and 10 µg/dL) with higher calculated sediment PRGs, the approach focusing on the target BLL of 5 µg/dL was used to maintain simplicity, avoiding overcomplication of the procedure. The uncertainty associated with use of this estimation method is presented in Section 7.2.1.

Tribal Lifeway (Child)

Sediment PRGs are based on the TLW child RME parameter values (sediment ingestion rate of 400 milligrams per day [mg/day], surface water ingestion rate of 0.78 liters per day, and site-specific dietary intake for OU5 aquatic biota) evaluated in the HHRA. Specific input parameter values used in the IEUBK model are in Table 5. Please note that the TLW scenario using the RME sediment ingestion rate of 400 mg/day is included in the PRG development to reflect the scenario evaluated in the HHRA. EPA's TRW Lead Committee does not consider 400 mg/day to be a central tendency soil-dust ingestion rate for a child receptor (TRW Lead Committee's review comments are included in Attachment 1).

For this analysis, surface water and aquatic biota EPCs were based on concentrations detected in Fourmile Creek, the reference location representative of background, because the calculated sediment PRGs are most closely represented by the Fourmile Creek data. The calculation of dietary lead intake for OU5 aquatic biota is provided in Table 6. Note that although the HHRA estimated dietary lead intake based on consumption of OU5 aquatic food only, the TLW PRGs incorporate dietary lead intake based on consumption of OU5 aquatic food in addition to the IEUBK model's default values for dietary intake, to encompass dietary lead exposure from a large variety of non-OU5 sources. Average concentrations of aquatic biota were calculated based on Fourmile Creek (reference watershed) data. Aquatic food consumption rates for the TLW were estimated based on Harper, 2008 and child/adult ingestion fractions from EPA's *Exposure Factor Handbook* (EFH) (1997) and updates (EPA, 2011, 2018a, and 2018b). Figure 2 is a screenshot of the IEUBK model inputs used, showing OU5 aquatic biota dietary intakes used for the TLW child.

General Public (Child)

Sediment PRGs were developed for a total of five GP (child) scenarios: three GP (child) scenarios (using the streamlined approach, not accounting for lead exposure at home), including the GP child scenario evaluated in the HHRA; and two additional scenarios refining two of the three GP (child) scenarios (using the TWA approach, accounting for lead exposure in two exposure areas [OU5 and home]). GP scenario 2 reflects the high-end GP child scenario evaluated in the lead exposure analysis of the HHRA. The other two scenarios (GP Scenarios 1 and 3) were added as variations of GP scenario 2. GP Scenarios 4 and 5 are refinements of the PRGs calculated under GP Scenarios 3 and 1, using the TWA approach, accounting for lead exposure in two exposure areas (OU5 and home). A brief description of each GP scenario follows:

- GP Scenario 1: Sediment PRGs are based mostly on the high-end exposure assumptions used in the lead exposure analysis for GP in the HHRA (GP scenario 2), except two changes (surface water EPC and dietary lead intake through consumption of OU5 fish fillet). Assuming that surface water is not used as drinking water, the IEUBK model's default drinking water EPC of 0.9 microgram per liter (µg/L) is used. Dietary lead intake was addressed using the IEUBK model's "alternate dietary values" approach for OU5 fish consumption[7]. OU5 sitewide fish (fillet) data are used as a representative EPC, assuming that recreational anglers catch fish from any watersheds within OU5. It is assumed that 25% of total meat consumption is replaced with consumption of OU5 fish (fillet).

- GP Scenario 2: Sediment PRGs are based on the high-end exposure assumptions used in the lead exposure analysis for GP in the HHRA. IEUBK model default values and the site-specific EPC for surface water (based on the average surface water concentration of lead in Lost Creek) are used in the PRG calculation.
- GP Scenario 3: Sediment PRGs are based mostly on the high-end exposure assumptions used in the lead exposure analysis for GP in the HHRA (scenario 2), except one change (surface water EPC). As with GP Scenario 1, assuming that surface water is not used as drinking water, the IEUBK model's default drinking water EPC of 0.9 µg/L is used. Hence, all IEUBK model default exposure assumptions are used in this scenario.
- GP Scenario 4: Refinement of the sediment PRGs calculated under GP Scenario 3 using the TWA approach.
- GP Scenario 5: Refinement of the sediment PRGs calculated under GP Scenario 1 using the TWA approach. Note that GP Scenario 5 was added based on the input received from ODEQ on the technical memorandum, version 1.2.

The TWA approach used under Scenarios 4 and 5 accounts for the lead exposure in two exposure areas: 1) exposure to sediment at OU5; and 2) exposure to lead-impacted soil at home. The fraction of time spent at each exposure area is calculated based on assumed GP child exposure frequency (1 day per week) and exposure time (3 hours per day) at OU5 and total waking hours in a day (12 hours) (EPA, 2003). A residential yard soil concentration of 133 mg/kg (that is, the mean lead concentration in residential yards based on a dataset composed of 233 Quapaw Nation residences) is used to represent the lead EPC in residential yard soil. Most members of the general public in Picher and Cardin have moved to where soil lead concentrations are near background levels, so using the average lead concentrations measured in residential yards in the Quapaw Nation is conservative.

The PRGs calculated under GP Scenarios 3 and 1 (PRGs under a baseline scenario before applying the TWA) and the sediment PRGs calculated under GP Scenarios 4 and 5 (a combination of the sediment PRGs and the EPC in residential yard soil) have the following relationship:

$$PRG_{GP\ Scenario\ 1} = (PRG_{Sed-GP\ Scenrio\ 5} \times EF_{OU5}) + (EPC_{Soil} \times EF_{Res})$$

where:

$PRG_{GP\ Scenario\ 1}$ (mg/kg) = PRG estimated in GP Scenario 1 without considering receptors' exposure to lead in residential yard soil

$PRG_{Sed-Scenario\ 5}$ (mg/kg) = Sediment PRG estimated using a TWA approach (Scenario 5)

F_{OU5} (unitless) = Fraction of exposure at OU 5 (GP child receptors are assumed to spend 1 day/week and 3 hours/day at OU5; based on the assumed waking hours of 12 hours/day, EF_{OU5} is assumed to be 3 hours/week, divided by 84 hours/week, or approximately 0.036.)

EPC_{Soil} (mg/kg) = Lead EPC in residential yard soil: 133 mg/kg

[7] ODEQ has been performing ongoing fish tissue metals analysis in the Tri-State Mining Area to develop fish consumption advisory levels. The use of the IEUBK model's "alternate dietary values" approach to evaluate lead intake through OU5 fish consumption is consistent with the approach used in the ODEQ's fish tissue analysis (ODEQ, 2007).

F_{Res} (unitless) = Fraction of exposure at residence (1 – EF_{OU5} or approximately 0.964) (Note: Receptors are assumed to spend their entire waking hours [12 hours/day or 84 hours/week] between their homes and OU5.)

The equation is modified and solved for the sediment PRG (for GP Scenario 4) as follows:

$$PRG_{Sed-GP\ Scenario\ 5} = \frac{PRG_{GP\ Scenario\ 1} - (EPC_{Soil} \times EF_{Res})}{EF_{OU5}}$$

Note that these equations present the relationship between PRGs calculated under GP scenarios 1 and 5 as an example. The calculated PRGs and input parameter values used for each set of IEUBK model runs are summarized in Table 4 and graphically presented on Figure 4.

6.2 PRG Development Approach for Cadmium and Zinc

Sediment PRGs were developed for cadmium and zinc based on direct contact pathways and aquatic plant consumption. Because the approach used in the cadmium and zinc hazard assessment is different from that of the exposure analysis of lead, cadmium and zinc PRGs are discussed separately in this section. The remedy associated with COCs in surface water, including analysis of ARARs, will be further evaluated in the FS.

6.2.1 Sediment PRG for Direct Contact Exposure Pathway

Cadmium and/or zinc were identified as final COCs in sediment for the direct contact pathways (incidental ingestion and dermal contact) under two exposure scenarios:

- TLW receptors (cadmium and zinc)
- AWs (cadmium only)

The general descriptions of these scenarios are presented in Table 7. With the exception of lead, no final sediment COCs were identified for GP receptor scenarios; therefore, sediment PRGs for cadmium and zinc were not calculated for the GP receptor.

Human health risk-based PRGs for the direct contact exposure pathway were calculated based on the site-specific RME assumptions and toxicity values used in the HHRA (see Tables 4.1 [exposure assumptions] and 5.1 [toxicity values] of Appendix B of the HHRA [CH2M, 2020a]). Because child receptors are assumed to have a higher COC intake (per kg body weight) than adult receptors, the PRGs for the TLW receptor scenario were calculated using the child receptor exposure assumptions. Because cadmium and zinc do not share the same target organ for noncancer effects, the target HI is set at 1 for each COC. PRGs are calculated based on the general equations below:

Equation 1:

$$PRG = \frac{RfD}{Intake} \times HI$$

where:

RfD = reference dose (mg/kg_{BW} per day)
Intake = calculated based on RME assumptions (mg/kg_{BW} per day)
HI = target hazard index of 1 (unitless)

As indicated in Equation 1, the PRGs for each exposure route (ingestion or dermal contact) were calculated first. Then, the overall PRGs for the direct contact exposure pathways were calculated as an inverse sum of the reciprocals of PRGs for each exposure route as indicated in Equation 2.

The PRGs for the direct contact exposure pathway were calculated using the following equation:

Equation 2:

$$Sediment\ PRG_{DC}\ \left(\frac{mg}{kg_{sed}}\right) = \frac{1}{\left(\frac{1}{PRG_{ing}} + \frac{1}{PRG_{derm}}\right)}$$

where:

Sediment PRG_{DC} = sediment PRG for direct contact pathways (mg/kg of sediment)
Sediment PRG_{ing} = sediment PRG for ingestion route (mg/kg of sediment)
Sediment PRG_{derm} = sediment PRG for dermal contact pathway (cadmium only) (mg/kg of sediment)

Note that PRGs in the equations above are presented in units of milligrams of COC per kilogram of sediment (dry weight). Specific exposure factor values and toxicity values used in the calculations are summarized in Table 8.

6.2.2 Aquatic Plant PRGs for Aquatic Food Consumption Pathway

Similar to the approach used to develop the PRGs in Equation 1, PRGs were calculated for the aquatic plant consumption pathway (Table 8). Although four additional COCs (barium, copper, nickel, and silver) were identified in various OU5 aquatic food items for the biota consumption pathway under the TLW exposure scenario, the development of PRGs focuses on cadmium and zinc in aquatic plants only, because cadmium and zinc in aquatic plants constitute more than 90% of the total HI associated with COC exposure through consumption of OU5 aquatic food items. A discussion about the protectiveness of the calculated sediment PRGs for consumption of other OU5 aquatic food items is included in the uncertainties section (Section 7.2.2).

The relationship between COC concentrations in sediment and aquatic plants is estimated using the regression equations empirically developed based on site-specific collocated sediment and aquatic plant data (arrowhead root). Refer to the sediment and aquatic plant regression analysis presented in Attachment 2. The following equations were developed:

Equation 3:

$$\text{Cadmium: } Aquatic\ Plant\ Conc. = Sediment\ Conc. \times Slope\ (0.136) + Intercept\ (-1.64)$$

Equation 4:

$$\text{Zinc: } Aquatic\ Plant\ Conc. = Sediment\ Conc. \times Slope\ (0.120) + Intercept\ (-194.3)$$

6.2.3 Sediment PRG for Combined Direct Contact and Aquatic Food Consumption Exposure Pathways

The sediment PRGs addressing combined exposure from the direct contact exposure pathways (incidental ingestion and dermal contact) and aquatic plant consumption pathway can be expressed in the following general equation:

Equation 5:

$$Sediment\ PRG_{DC-AP}\ \left(\frac{mg}{kg_{sed}}\right) = \frac{1}{\left(\frac{1}{PRG_{DC}} + \frac{1}{PRG_{AP-Sed}}\right)}$$

where:

Sediment PRG_{DC-AP} = sediment PRG protective of direct contact and aquatic plant consumption pathways (mg/kg of sediment)

Sediment PRG_{DC} = sediment PRG for direct contact pathways (mg/kg of sediment)

Sediment $PRG_{AP\text{-}Sed}$ = sediment PRG protective of aquatic plant consumption (mg/kg of sediment)

$PRG_{AP\text{-}sed}$ is the estimated risk-based COC concentration in sediment that would be protective of the aquatic plant consumption pathway. $PRG_{AP\text{-}sed}$ is the reciprocal of the ratio for a unit increase of HI per a unit increase of COC (cadmium or zinc) in sediment. Please note, however, that the relationship between aquatic plant and sediment is not explained as this simple ratio; instead, the relationship is described by the regression equations. The actual equations used in the calculations of the final PRG protective of direct contact and aquatic plant ($PRG_{DC\text{-}AP}$) are in Table 8.

As presented in Table 8, the sediment PRGs calculated for direct contact exposure pathways (PRG_{DC}) and sediment PRGs calculated for aquatic plant consumption pathway ($PRG_{AP\text{-}Sed}$) were combined to calculate the final sediment PRGs that are protective of both direct contact exposure and aquatic plant consumption pathways ($PRG_{DC\text{-}AP}$). The calculated final cadmium and zinc PRGs for the TLW and AW (cadmium only) scenarios are presented in Table 9 and Figure 5.

7.0 Uncertainties

As indicated in Section 6.6 of the HHRA, the methodologies, assumptions, and toxicity information used in the PRG development share the same uncertainties identified in the HHRA. The major sources of the uncertainties associated with the calculated PRGs are the limitation of the biokinetic model (IEUBK model) used for the lead PRGs, the development of a TLW scenario lead PRG using RME exposure assumptions, and protectiveness of the calculated sediment PRGs to address secondary exposure through surface water and biota consumption.

7.1 Exposure Assumptions Used to Develop Lead PRGs

In addition to the inherent uncertainty associated with RME exposure values identified for the TLW exposure scenario, the use of such exposure parameter values in the IEUBK model also introduces a significant uncertainty because the model is designed to predict the cumulative distribution of BLLs based on central tendency exposure parameter values. Furthermore, uncertainties are also associated with applying the IEUBK model to the evaluation of the unique OU5 exposure scenarios. For instance, the model was designed to predict BLL to mainly address continuous lead exposure for the GP under a residential exposure setting, which differs from the TLW and GP scenarios at OU5. The OU5 exposure can be characterized as intermittent exposure to sediment or surface water occurring for a part of the day or week, at a location separate from residences by a specific subpopulation (such as TLW receptors).

Among the various input variables, sediment ingestion rate is one of the most influential parameter variables on the sediment PRG for lead (the sensitivity analysis of various key parameter values is presented in Attachment 3). As mentioned, there is a degree of uncertainty associated with the use of RME values such as a sediment ingestion rate of 400 mg/day as a central tendency estimate in the IEUBK model. The TRW Lead Committee made the following recommendation regarding the sediment ingestion rate of 400 mg/day used in the lead exposure analysis: "…the selected ingestion rate of 400 mg/day for sediment seems very high compared to what is typically used for children (generally 100 mg/day or less). Central tendency estimates are recommended for lead risk assessment (CH2M, 2020a)." Furthermore, the TRW Lead Committee commented*:*

> *Because of the way the EPA Lead models use statistical parameters to calculate an upper bound exposure, BLL, and PRG, central tendency values should be used for inputs in the IEUBK and Adult Lead Methodology (ALM). The TRW Lead Committee does not consider 400 mg/day to be a central tendency soil-dust ingestion rate (IR) for a human child receptor* (CH2M, 2020a).

The committee further indicated uncertainties associated with soil ingestion rates of 400 mg/day as a result of the date and study period of the original study (see specific TRW Lead Committee review comments in Attachment 1). Please note that Abt Associates on behalf of TCTCIT provided additional clarification and justification regarding the source and use of this soil ingestion rate (400 mg/day) in the IEUBK model in their comments on version 1.2 of the memorandum (Attachment 4A).

Note that the approach of sediment PRG development established with EPA Region 6 is considered highly conservative because sediment samples were collected from perennially flowing creeks, streams, and rivers and were attached to skin surface, which is expected to be readily washed off when receptors are out of water. Some of the EPA regions have an established policy of not evaluating exposure to sediment perennially covered with water for this reason. For instance, EPA Region 4 (2018c) has long followed a policy of only quantifying human exposure to sediment that is not covered by water (for example, sediment in an intermittent stream for the portion of the year the stream is without water) and generally considers it unnecessary to evaluate human exposure to sediments that are always covered by surface water. EPA Region 1 evaluates only sediments and water to about knee depth. Additionally, all the scenarios included in the lead PRG development assume that track-in of OU5 sediment into a residence occurs, and that additional sediment exposure occurs through indoor dust ingestion at the residence. Although some level of sediment track-in may occur in a home, the degree of it is expected to be limited for the reasons discussed above.

7.2 Protectiveness of the Calculated Sediment PRGs to Address Secondary Exposure through Surface Water and Biota Consumption

Some uncertainty is associated with the assumption used to predict the media transfer of COCs (for example, COC transfer from sediment to surface water or biota). In this subsection, the uncertainty associated with the following three subjects are discussed:

- Lead PRGs for the scenarios using site-specific surface water and biota EPCs
- Cadmium and zinc PRGs for consumption of aquatic food items other than aquatic plants
- Lead PRGs based on assumption that surface water is not used as a drinking water source

7.2.1 Protectiveness of Lead PRGs for the Scenarios using Site-specific Surface Water and Biota EPCs

As discussed in Section 6.1, surface water or biota concentrations of lead were estimated using the actual measured data from the representative watershed that had lead sediment EPCs most closely corresponding to the calculated sediment PRGs. It is acknowledged that this method may underestimate lead exposure from the surface water and biota as the calculated PRGs increase for a higher target BLL (e.g., 10 µg/dL). The purpose of using this approach, which focused on the calculated PRGs based on a target BLL of 5 µg/dL, was to streamline the process. PRGs calculated based on target BLLs of 8 and 10 ug/dL for the scenarios using site-specific surface water or biota EPCs are evaluated to understand the degree of uncertainty associated with the calculated PRGs.

For the TLW scenario, no sediment PRG value was calculated based on a target BLL of 8 µg/dL; and the calculated sediment PRG for lead (23 mg/kg) based on a target BLL of 10 µg/dL is about the same as the lead EPC in Fourmile Creek (background watershed). Note that the background threshold value (BTV) of lead in sediment (based on 95/95 Upper Tolerance Limit) is 58 mg/kg. Therefore, the use of Fourmile Creek surface water and biota EPCs in the calculation of TLW PRGs is considered to be a reasonable representation of surface water and biota EPCs for all three target BLLs.

Regarding GP scenario 2, the surface water EPC for lead in Lost Creek is used because the calculated sediment PRG based on a BLL of 5 ug/dL (173 mg/kg) most closely corresponds to the sediment EPC in Lost Creek (168 mg/kg). However, the calculated sediment PRGs (using Lost Creek surface water EPCs for surface water ingestion) based on higher target BLLs (413 mg/kg based on 8 µg/dL and 583 mg/kg based on 10 µg/dL) are noticeably higher than the sediment EPC for lead in Lost Creek. It is expected that the surface water EPC would be higher than the Lost Creek surface water EPC at these increased sediment PRGs. Because of increased contribution of surface water exposure to overall lead intake, the sediment PRGs at a higher target BLL would be considerably lower than the calculated values based on the surface water EPC in Lost Creek. Beaver Creek is the watershed with a sediment EPC for lead that most closely corresponds to the calculated PRGs for higher target BLLs. When the surface water EPC for lead in Beaver Creek (the sediment EPC for lead in Beaver Creek is 278 mg/kg) is used, PRGs of 300 and 469 mg/kg are calculated for target BLLs of 8 and 10 µg/dL, respectively. Therefore, the GP Scenario 2 PRGs, based on target BLLs of 8 and 10 µg/dL in Table 4, most likely underestimate surface water exposure and if higher surface water EPCs corresponding to the concentrations in sediment are used, the sediment PRGs would be lower than the values presented in Table 4.

7.2.2 Protectiveness of Cadmium and Zinc PRGs for Consumption of Aquatic Food Items Other than Aquatic Plants

As discussed in Section 6.2.1, cadmium and zinc sediment PRGs were calculated to address direct contact and consumption of aquatic plants. Although the HHRA evaluated exposure from other aquatic food items (fish, shellfish, amphibians/aquatic reptiles, and semi-aquatic mammals), they were not included in the PRGs calculations. To provide additional supporting information for this approach, discussions are provided in this section related to the following:

- Composition of dietary health effects
- Relationship between sediment and aquatic food items
- Review of site-specific measured data

As indicated in Section 6.2.1, aquatic plant consumption accounts for the majority of the calculated HIs associated with consumption of OU5 aquatic food based on the sitewide biota data. The HQ associated with aquatic plants comprises more than 90% of the total HI associated with OU5 aquatic food. Therefore, the PRGs are calculated targeting the aquatic food item predominantly driving the HI associated with OU5 aquatic food consumption. Additionally, the comparison of the HI profile between the sitewide data and Neosho River data indicate effectiveness of sediment remediation targeting aquatic plants on mitigation of the aquatic food consumption related HI. Table 10 presents compositions of aquatic food consumption HI's for sitewide data and Neosho River data. Note that Neosho River is used in this comparison because Neosho River is the least contaminated watershed among the six watersheds evaluated in the HHRA and is one of the two watersheds where biota samples were collected for all five aquatic food categories (fish, shellfish, aquatic plants, amphibians/aquatic reptiles, and semi-aquatic mammals). As presented, the HQs for non-plant biota are similar between the sitewide and Neosho River data, indicating that aquatic plants' contribution to the overall aquatic food consumption HI is more highly affected by sediment concentrations than other non-plant aquatic food items.

An additional simple analysis of concentrations in sediment and biota samples further support the observation that there are no apparent correlations between sediment and some biota. Figure 6A through 6D present the cadmium EPCs in sediment and fish and the cadmium EPCs in sediment and racoon. Although the cadmium sediment EPC in the most contaminated watershed (Tar Creek) is noticeably higher than the EPCs in less contaminated watersheds (for example, Tar Creek EPC is more than 500 times higher than the EPC in Fourmile Creek [reference watershed]), no apparent positive relationship between sediment EPCs and biota EPCs is observed for fish and racoon. Similarly, no apparent correlations between sediment EPCs and biota EPCs for fish and racoon is observed for zinc. This observation makes practical sense for mobile biota, such as fish and racoon, because they are less likely to be affected by localized sediment impact than immobile biota, such as aquatic plants and shellfish. See additional discussion of risk associated with shellfish consumption in the next paragraph. This suggests difficulties in establishing reasonable positive correlations between sediment and biota samples for some of the mobile animals. Additionally, because of the complex nature of biota samples with various determinants of biota chemical burdens (e.g., species, size, age, and variabilities in habitats and food sources potentially impact chemical concentrations in biota even if the chemical concentration in the surrounding environmental is the same), without having samples collected from a well-designed correlation study, it would be difficult to establish a meaningful correlation between sediment and biota.

Further, potential future risks, if OU5 sediment is remediated to the calculated cadmium and zinc PRGs, are evaluated by reviewing the risk results of a watershed with cadmium and zinc concentrations in sediment similar to the calculated PRG values. As presented in Figures 7A and 7B, cadmium and zinc sediment EPCs in Lost Creek are nearly identical to the calculated respective PRGs. Hence, Lost Creek biota data and associated HIs are considered to provide reasonable predictions of future conditions if sediments are remediated to the calculated PRGs. Figure 7C and Table 11 present HQs associated with biota samples collected in Lost Creek. Although total HIs from all five aquatic food items (fish, shellfish, aquatic plant, frog, and racoon) are slightly above 2, HQs associated with aquatic food items, where cadmium and zinc concentrations are considered closely related to sediment (aquatic plants and shellfish), are on the borderline between 1 and 2. Angelo et al., (2007) established empirical correlations between concentrations of lead, cadmium, and zinc in sediment and freshwater mussels in Spring River Basin (Kansas, Missouri, and Oklahoma). The estimated concentrations in mussels using the regression equations in Angelo et al. (2007)[8] based on the calculated PRGs reasonably well-matched the shellfish EPCs estimated for Lost Creek and were within an order- of-magnitude difference (Table 12). Note that cadmium and zinc EPCs in fish and racoon in Lost Creek are similar to those observed in Fourmile Creek (reference watershed). Also refer to the discussions of no apparent relationships between sediment and these biota in Section 6.2.2. Dietary HQs estimated based on Lost Creek data are 2. An HQ of 3 is generally considered a reasonable risk level for removal management levels for non-carcinogenic chemicals because of the inherent uncertainty associated with the non-carcinogenic RfD (EPA, 2020).[9] Therefore, the calculated cadmium and zinc PRGs addressing aquatic plant consumption are considered acceptable for addressing site-related risks from non-aquatic-plant biota. Because of high variability of COC concentrations in biological samples, the efficacy of sediment remediation for protection of aquatic biota consumption will be assessed in the future monitoring and periodic review process.

7.2.3 Lead PRGs Based on Assumption that Surface Water Is Not Used as a Drinking Water Source

During the collaboration meeting between EPA and the TCTCIT on April 28, 2021, the TCTCIT representative, Abt Associates, indicated that tribes do not use OU5 surface water as a source of drinking water. Because of this additional finding, another scenario was run using the IEUBK model by replacing the site-specific surface water EPC based on Fourmile Creek data to the IEUBK model default value. Note that the site-specific surface water EPC represents combined water exposure from three exposure pathways: (1) use of OU5 surface water as a drinking water source, (2) incidental ingestion of OU5 surface water during hunting/gathering/recreational activities, and (3) use of surface water during sweat lodge use. Fourmile Creek EPCs were selected as representative EPCs for the TLW scenario because the sediment EPC for lead in Fourmile Creek most closely represents the calculated PRG based on a target BLL of 5 µg/dL (see Section 6.1.1). For this uncertainty analysis, the surface water ingestion rates that are higher than the IEUBK default value (drinking water ingestion rates) are kept to account for increased ingestion of water resulting from incidental intake during the hunting/gathering/recreational activities at OU5. The calculated sediment PRGs for this additional scenario are in Table 13. As presented, the calculated sediment PRGs increased slightly from those

[8] The regression equations for the two mussel models in Table 10 of Angelo et al., (2007) are used to estimate cadmium and zinc concentrations in mussels.

[9] For a further discussion of the reasonable range of target non-cancer HQs, refer to methodology section of the Regional Removal Management Levels (RMLs) User's Guide (EPA, 2020).

calculated under the TLW scenario, but they are all below the BTV of 58 mg/kg. For both exposure scenarios, no sediment PRG can be calculated for the target BLL of 5 µg/dL because of the elevated lead intake through exposure to media other than sediment (that is, even if the lead concentration in sediment is zero, it would not achieve the target BLL).

8.0 Conclusions

Human health risk-based PRGs have been calculated for the final sediment COCs (lead, cadmium, and zinc) identified in the HHRA (CH2M, 2020a). The objective of the work described by this technical memorandum was to identify sediment PRGs protective of direct contact exposures to sediment as well as secondary exposure through direct contact with surface water and aquatic food consumption. These human health risk-based PRGs are provided to EPA risk managers for their use in selecting the final remedial goals for the site, in consideration also of the ecological PRGs. Because the approach used in the human health exposure analysis of lead is different from that of the cadmium and zinc hazard assessment, PRGs are calculated separately for lead (Table 4) using EPA's biokinetic model (IEUBK model). Cadmium and zinc PRGs (Table 9) were calculated using the toxicity values and RME assumptions used in the HHRA and empirically established regression equations between sediment and aquatic plants. A summary of calculated human health risk-based PRGs is as follows:

Summary of Human Health Risk-Based PRG (mg/kg)

COC	Scenario (child)	BLL=5 µg/dL	BLL=8 µg/dL	BLL=10 µg/dL	ERA (T10)	ERA (T20)	BTV
Lead	TLW	n/v	n/v	23	150	219	58
	GP1	146	387	557			
	GP2	173	413†	583†			
	GP3	199	439	609			
	GP4	1,981	8,701	13,461			
	GP5	497	7,245	12,005			

COCs	Scenario	HI=1	ERA (T10)	ERA (T20)	BTV
Cadmium	AW	214	11.1	17.3	0.7
	TLW (child)	13.2			
Zinc	TLW (child)	2,095	2,083	2,949	543

n/v = no sediment PRG value can be calculated

† = surface water exposure is likely underestimated

As part of the sensitivity analysis, various PRG input variables were tested for their impact on the resulting lead PRG in sediment (Attachment 3), and it was concluded that the sediment ingestion rate and dietary lead intake are two of the most influential parameter variables on the resulting sediment PRG. All scenarios using a sediment ingestion rate of 400 mg/day yield a PRG lower than the lead BTV of 58 mg/kg based on a target BLL of 5 µg/dL. For the scenarios using a sediment ingestion rate of 400 mg/day, a reduced soil/dust absorption fraction (such as, 20%) does not noticeably increase the sediment PRG above the BTV. Further, no PRG could be calculated using a target BLL of 5 µg/dL for the scenario with dietary intake estimated based on tribal OU5 aquatic food ingestion rates and biota EPCs based on Fourmile Creek data, even when the remaining input parameter values were set at the IEUBK model's default values (that is, even if the lead concentration in sediment is zero, it would not achieve the target BLL).

The sediment PRGs were developed for the final HHRA COCs in sediment (lead, cadmium, and zinc) under various exposure scenarios. Lead PRGs in sediment were developed using the IEUBK model for one TLW (child) and five GP (child) scenarios, based on three target BLLs of 5, 8, and 10 µg/dL. Cadmium PRGs in sediment were developed for one AW and one TLW (child) scenario, while a zinc PRG in sediment was developed for a TLW scenario. Cadmium and zinc PRGs were developed based on a target HI of 1. No lead PRG was calculated for the TLW (child) based on the target BLL of 5 µg/dL because of the elevated lead intake through exposure to media other than sediment (that is, even if the lead concentration in sediment is zero, it would not achieve the target BLL of 5 µg/dL). The lead PRG (146 mg/kg based on BLL of 5 µg/dL) for GP Scenario 1 (scenario incorporating lead intake through OU5 fish [fillet] consumption) is lower than the ERA PRGs (T10 of 150 mg/kg and T20 of 219 mg/kg). However, lead PRGs based on BLL of 5 µg/dL for the other two GP scenarios (Scenario 2 based on the exposure assumptions used in the HHRA and Scenario 3 based on the IEUBK model default values) are higher than the ERA PRG (T10), but lower than the ERA PRG (T20). All of the lead PRGs under Scenarios 1 through 3, based on higher target BLLs (8 and 10 µg/dL) and Scenarios 4 and 5 (refinement of Scenarios 3 and 1 using the TWA approach) based on all target BLLs (5, 8, and 10 µg/dL) are higher than the ERA PRGs (both T10 and T20). The cadmium and zinc PRGs for all scenarios are higher than the ERA PRGs based on T10 (cadmium 11.1 mg/kg and zinc 2,083 mg/kg), but lower than ERA PRGs based on T20 (cadmium 17.3 mg/kg and zinc 2,949 mg/kg).

9.0 References

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Tables

Table 1. Summary of Exposure Scenarios Evaluated in the HHRA

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Exposure Medium	**Exposure Scenario/Receptor Population**	
	Tribal Lifeway	**General Public**
Sediment	Hunting/fishing/gathering and recreational activities • Incidental ingestion • Dermal contact	Recreational activities • Incidental ingestion • Dermal contact
Surface Water	Hunting/fishing/gathering and recreational activities • Incidental ingestion • Dermal contact Potable source • Ingestion • Dermal contact Sweat lodge use • Ingestion • Dermal contact • Inhalation (water vapor)	Recreational activities • Ingestion • Dermal contact Potable source • Ingestion • Dermal contact
Mine Discharge	Hunting/fishing/gathering and recreational activities • Dermal contact	Recreational activities • Dermal contact
Fish Tissue (Estimated Whole Fish Concentrations)	• Aquatic food consumption	
Fish Tissue (Game Fish Fillet)		Recreational Fishing • Fish consumption
Shellfish Tissue (Mussel and Asian Clam)	• Aquatic food consumption	
Aquatic Plant as Food (Arrowhead and Duckweed)	• Aquatic food consumption	
Aquatic Plant as Salve (Arrowhead)	• Dermal contact (medicinal use)	
Amphibian/Aquatic Reptile Tissue (Frog Legs)	• Aquatic food consumption	
Semi-Aquatic Mammal Tissue (Raccoon)	• Aquatic food consumption	

Notes:

This table presents exposure scenarios/pathways for child receptors only.

HHRA = human health risk assessment

Table 2. Final COCs for Tar Creek OU5

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Final COCs	Sitewide (Biota Only)	Elm Creek	Tar Creek	Neosho River	Beaver Creek	Lost Creek	Lower Spring River
Sediment							
Cadmium		TLW	TLW, AW		TLW		
Lead		TLW, AW, GP	TLW, AW, GP		TLW, GP		TLW, GP
Zinc		TLW	TLW		TLW		
Surface Water							
Antimony		TLW					
Arsenic			TLW, AW, GP				
Barium				TLW			
Cadmium		TLW, AW, GP	TLW, GP		TLW		
Cobalt			TLW, AW, GP		TLW		
Iron			TLW, GP	TLW			
Lead[a]		TLW, GP	TLW, GP		TLW, GP		
Manganese			TLW, AW, GP				
Nickel		TLW	TLW, AW		TLW		
Zinc		TLW	TLW				
Biota [b]							
Barium	TLW						
Cadmium	TLW						
Copper	TLW						
Lead	TLW, GP						
Nickel	TLW						
Silver	TLW						
Zinc	TLW						

Notes:

[a] Lead in surface water was not evaluated for aquatic workers because of the limitations of the ALM.

[b] Final COCs were identified based on sitewide dataset.

Final COCs are identified for the following receptors: TLW = Tribal Lifeway, AW = Aquatic Worker, GP = General Public.

ALM = Adult Lead Methodology

COC = chemical of concern

OU5 = Operable Unit 5

Table 3. Human Health Exposure Scenarios for Lead PRG Development

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Scenario	Scenario Description	IEUBK Exposure Factors	OU5 SW as DW	OU5 Aquatic Biota as Food
TLW	TLW exposure assumptions used in the HHRA[a].	Same as HHRA	Yes	Yes
GP Scenario 1	GP exposure, all IEUBK default values. Assumes no use of OU5 SW as DW source. Dietary lead intake was addressed using the IEUBK's "alternate dietary values" approach for OU5 fish consumption.	Default	No	Yes - fish only[b]
GP Scenario 2	GP exposure assumptions used in the HHRA. All IEUBK default values except SW EPC. Assumes use of OU5 SW as DW source.	Same as HHRA	Yes	No
GP Scenario 3	GP exposure, all IEUBK default values. Assumes no use of OU5 SW as DW source.	Default	No	No
GP Scenario 4	Refinement of GP Scenario 1 PRGs using a TWA approach accounting for lead exposure in two exposure areas (OU5 and home).	See the exposure assumptions presented for GP Scenario 3.		
GP Scenario 5	Refinement of GP Scenario 3 PRGs using a TWA approach accounting for lead exposure in two exposure areas (OU5 and home).	See the exposure assumptions presented for GP Scenario 1.		

Notes:

[a]Note: Although the HHRA estimated dietary lead intake is based on consumption of OU5 aquatic food only, the TLW PRGs incorporates dietary lead intake based on consumption of OU5 aquatic food in addition to the IEUBK's default values for dietary intake.

[b]Dietary lead intake was addressed using the IEUBK model's "alternate dietary values" approach for OU5 fish consumption.

DW = drinking water

GP = General Public

HHRA = human health risk assessment

OU5 = Operable Unit 5

PRG = Preliminary Remediation Goal

SW = surface water

TLW = tribal lifeway

TWA = time-weighted average

Table 4. Estimated Lead Sediment PRGs for 6 Human Exposure Scenarios

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

		Soil/Sediment Ingestion		SW Ingestion		SW EPC		Dietary Intake			PRG (mg/kg)		
Scenarios[a]	Scenario Description	Value (mg/day)	Basis	Value (L/day)	Basis	Value (µg/L)	Basis	Value (µg/day)	Value (µg/day) Entered as additional intake	Basis	BLL=5 µg/dL	BLL=8 µg/dL	BLL=10 µg/dL
TLW Scenario[b,e]	TLW exposure assumptions used in the HHRA.	400	Harper (2008)	0.78	SW IR = EPA default RME residential DW IR (2014). Used EPA's RME residential DW IR to account for the following three exposure scenarios: · SW as DW source · Incidental ingestion of SW at OU5 · SW during sweat lodge use	2.35 [c]	Average lead concentration (total) in Fourmile Creek (background). Fourmile Creek is used as a representative watershed because sediment concentration (EPC = 27 mg/kg) is close to estimated PRGs (18 - 50 mg/kg).	5.03 - 6.04 (IEUBK default)	13.6 - 17.6 (additional lead intake from OU5 aquatic food consumption)	IEUBK default + dietary lead intake through consumption of OU5 aquatic food. Dietary lead intake through OU5 aquatic food consumption estimated based on TLW child aquatic biota IRs and average lead concentration in biota samples in Fourmile Creek (background). Fourmile Creek is used as a representative watershed since sediment concentrations are close to estimated PRGs.	n/v	n/v	23
GP (Scenario 1)	GP exposure, all IEUBK model default values. Assumes no use of OU5 SW as DW source. Dietary lead intake was addressed using the IEUBK model's "alternate dietary values" approach for OU5 fish consumption.					0.9 (IEUBK default)	IEUBK default.	Dietary lead intake was addressed using the IEUBK model's "alternate dietary values" approach for OU5 fish consumption. Lead concentration in fish (fillet) (0.100 mg/kg [Table 6]) and estimated percentage of fish originating from OU5 (25%) are entered into the model.			146	387	557
GP (Scenario2)[b]	GP exposure assumptions used in the HHRA. All IEUBK model default values except SW EPC. Assumes use of OU5 SW as DW source.	52 - 94 (IEUBK default)	IEUBK default	0.43 - 0.60 (IEUBK default)	IEUBK default	2.70 [c]	Average lead concentration (total) in Lost Creek SW. Lost Creek is used as a representative watershed because sediment concentration (EPC = 168 mg/kg) close to the estimated PRG based on BLL of 5 µg/dL (173 mg/kg).	5.03 - 6.04 (IEUBK default)	n/a	IEUBK default[d]	173	413 [e]	583 [e]
GP (Scenario 3)	GP exposure, all IEUBK model default values. Assumes no use of OU5 SW as DW source.					0.9 (IEUBK default)	IEUBK default.			IEUBK default	199	439	609
GP (Scenario 4)[f]	Refinement of GP Scenario 3 PRGs using a TWA approach accounting for lead exposure in two exposure areas (OU5 and home).	See the IEBUK input parameter values presented for GP (Scenario 3). GP receptors are assumed to visit OU5 at exposure frequency of 1 day/week and exposure time of 3 hours/day (i.e., 3 hours/week) and to spend the rest of waking hours (12 hours/day) at their home (81 hours/week: a total waking hours/week [84 hours/week] minus 3 hours/week) where yard soil lead EPC is 133 mg/kg.									1,981	8,701	13,461
GP (Scenario 5)[f]	Refinement of GP Scenario 1 PRGs using a TWA approach accounting for lead exposure in two exposure areas (OU5 and home).	See the IEBUK input parameter values presented for GP (Scenario 1). GP receptors are assumed to visit OU5 at exposure frequency of 1 day/week and exposure time of 3 hours/day (i.e., 3 hours/week) and to spend the rest of waking hours (12 hours/day) at their home (81 hours/week: a total waking hours/week [84 hours/week] minus 3 hours/week) where yard soil lead EPC is 133 mg/kg.									497	7,245	12,005

Notes:

All IEUBK model runs except for GP (Scenario 1) were completed using the most recent IEUBK model available at the time (IEUBK Windows, Version 1.1, Build 11), with modifications to input parameter values reflecting the same changes that are incorporated in the new IEUBK model, Version 2.0 (released in May 2021). Due to changes in the dietary information in the IEUBK model, Version 2, the PRGs under GP (Scenario 1) using the "alternate dietary values" approach were calculated using the IEUBK model, Version 2.

[a] For all scenarios, PRGs are calculated for EPA's recommended age range (12 to 72 months old).

[b] PRGs corresponding to the TLW and GP scenarios evaluated in the HHRA. Note that although the HHRA estimated dietary lead intake based on consumption of OU5 aquatic food only, the TLW PRGs incorporates dietary lead intake based on consumption of OU5 aquatic food in addition to the IEUBK's default values.

[c] Surface water exposure is estimated using the EPC of the watershed with sediment concentrations similar to the calculated PRG for a target BLL.

[d] In the HHRA (Scenario 2), for general public, default dietary intake was conservatively used as lead intake through consumption of OU5 fish fillet was lower than default dietary intake.

[e] Because surface water exposure is estimated using the EPC of the watershed with sediment concentrations lower than the calculated PRG, surface water exposure is underestimated. If lead concentration in sediment is the level presented, the lead in surface water is expected to be higher than the value used in the calculation.

[f] PRGs under Scenarios 4 and 5 are calculated using the TWA approach based on the PRGs of baseline scenario (i.e., Scenarios 3 and 1, respectively), as follows.

Table 4. Estimated Lead Sediment PRGs for 6 Human Exposure Scenarios

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Scenarios[a]	Scenario Description	Soil/Sediment Ingestion		SW Ingestion		SW EPC		Dietary Intake			PRG (mg/kg)		
		Value (mg/day)	Basis	Value (L/day)	Basis	Value (μg/L)	Basis	Value (μg/day)	Value (μg/day) Entered as additional intake	Basis	BLL=5 μg/dL	BLL=8 μg/dL	BLL=10 μg/dL

Equations: PRG ("base") = EPC_Res x F_Res + PRG_OU5 x F_OU5
PRG_OU5 = (PRG ("base") - EPC_Res x F_Res) / F_OU5

Where: PRG ("base") = "Base" PRGs calculated before applying a TWA approach (e.g., PRGs calculated under Scenarios 1 or 3).
EPC_Res = Residential yard soil EPC (133 mg/kg), the mean lead concentration calculated based on a dataset composed of 233 residences in Quapaw, Oklahoma.
Most members of the general public in Picher and Cardin have moved to where soil lead concentrations are near background levels, so using the average lead concentrations measured in residential yards in Quapaw is conservative.
PRG_OU5 = OU5 sediment PRG
F_OU5 = Fraction of waking hours spent at OU5. (3 hours per week divided by 84 waking hours/week or approximately 0.036)
F_Res = Fraction of waking hours spent home (1 - F_OU5 or approximately 0.964).
Receptors are assumed to spend their entire waking hours (12 hours/day or 84 hours/week) between their home and OU5.

See the additional uncertainty discussion presented in Section 7.2.1.

μg/L = micrograms per liter
μg/day = micrograms per day
μg/g = micrograms per gram
BLL = blood lead level
DW = drinking water
EPC = exposure point concentration
IR = ingestion rate
L/day = liters per day
mg/day = milligrams per day

n/v = no sediment PRG value can be calculated using the IEUBK model, because of the elevated lead intake through exposure to media other than sediment (e.g., even if lead concentration in sediment is zero, it would not achieve the target BLL)
OU5 = Operable Unit 5
PRG = Preliminary Remediation Goal
RME = reasonable maximum exposure
SW = surface water
TLW = Tribal Lifeway
TWA = time weighted average

Table 5. IEUBK Input Parameter Values

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Exposure Medium Interface	Parameter		Value	Basis	Scenario
Air Data	Indoor air lead concentration (percentage of outdoor)		30	Default	All Scenarios
	Outdoor Air Pb Concentration (μg/m³)		0.1	Default	All Scenarios
Diet Data	Use alternate dietary value?		No	Default	All Scenarios except GP (Scenario 1)
			Yes	--[a]	GP (Scenario 1)
Drinking Water Data	Use alternate water value? If No, please enter the lead concentration in drinking water (μg/L)		See Drinking Water EPC below		Scenario-specific
Site Specific Soil Dust Data	Soil/Dust Ingestion Weighting Factor (percent soil)		45	Default	All Scenarios
	Outdoor Soil Lead Concentration (μg/g)		PRG		All Scenarios
	Indoor Dust Lead Concentration (μg/g)		Multiple Source Analysis		All Scenarios
Maternal Data	Mother's Blood Lead Concentration at Childbirth (μg Pb/dL)		0.6	Default	All Scenarios
GI Values/Bioavailability Information	Absorption Fraction Percent	Soil	30	Default	All Scenarios
		Dust	30	Default	All Scenarios
		Water	50	Default	All Scenarios
		Diet	50	Default	All Scenarios
		Alternate	50	Same as Diet	TLW Scenario only

Receptor Scenarios	**Input Parameter Values Applied**										**Water EPC (μg/L)**	**Basis**
TLW Scenario	x	x	x	x	x	x	x	x			2.35	Fourmile Creek EPC
GP (Scenario 1)[b]	x	x	x	x	--[a]				x	x	0.9	IEUBK default
GP (Scenario 2)	x	x	x	x	x				x	x	2.70	Lost Creek EPC
GP (Scenario 3)[c]	x	x	x	x	x				x	x	0.9	IEUBK default
	Air				Diet	Water	Soil	Alternate Source Intake	Water	Soil		
Age	Outdoor Air Pb Concentration (μg/m³)	Time Spent Outdoors (hr/day)	Ventilation Rate (m³/day)	Lung Absorption (%)	Dietary Lead Intake (μg/day)	Water Consumption (L/day)	Total Dust+Soil Intake (g/day)	Additional Dietary Lead Intake (μg/day)	Water Consumption (L/day)	Total Dust+Soil Intake (g/day)		
0-1	0.1	1	3.22	32	2.66	--[d]		0	0.4	0.086		
1-2	0.1	2	4.97	32	5.03	0.78	0.4	13.6	0.43	0.094		
2-3	0.1	3	6.09	32	5.21	0.78	0.4	14.8	0.51	0.067		
3-4	0.1	4	6.95	32	5.38	0.78	0.4	17.3	0.54	0.063		
4-5	0.1	4	7.68	32	5.64	0.78	0.4	17.3	0.57	0.067		
5-6	0.1	4	8.32	32	6.04	0.78	0.4	17.6	0.6	0.052		
6-7	0.1	4	8.89	32	5.95	--[d]		0	0.63	0.055		
Basis	Default	Default	Default	Default	Default	EPA (2014)	Harper (2008)	Site-specific	Default	Default		

Notes

a = Dietary lead intake was addressed using the IEUBK model's "alternate dietary values" approach for OU5 fish consumption under Scenario 1. Lead concentration in fish (fillet) (0.100 mg/kg [Table 6]) and estimated percentage of fish originating from OU5 (25%) are entered into the model.

b = GP (Scenario 1) PRGs are used as a basis of PRGs calculated for GP (Scenario 5) using the TWA approach.

c = GP (Scenario 3) PRGs are used as a basis of PRGs calculated for GP (Scenario 4) using the TWA approach.

d = The values are unchanged from the IEUBK model default values.

"x" indicates the receptor scenario for which input parameter values are applied.

μg/dL = micrograms per deciliter

μg/m³ = micrograms per cubic meter

g/day = grams per day

Table 6. Estimation of Lead Intake Through Consumption of OU5 Aquatic Food Items

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Table 6a. Lead EPC in Aquatic Food Items (µg/g)[a]

Age Group	Tribal Lifeway[b]					General Public[c]
	Fish (Total)[(d)]	Shellfish	Amphibian / Aquatic Reptile	Semi-Aquatic Mammal	Aquatic Plant	Fish (Fillet)[d]
Years	0.117	0.133	0.180	0.120	0.110	0.100

a Average concentrations are used as EPC. For non-detected results, one half of detection limit is used to calculate average concentration.

b Because sediment lead concentrations in Fourmile Creek are close to the estimated PRGs under the Tribal Lifeway scenario, data from Fourmile Creek are used as representative concentrations in aquatic food items.

c Average lead concentrations in OU5 sitewide fish (fillet) samples are used as representative concentrations, assuming that recreational anglers catch fish from all watersheds within OU5.

Lead was not detected in any fish (fillet) samples collected in Fourmile Creek. Also, the calculated sediment PRGs for General Public (Scenario 1) are higher than the sediment in Fourmile Creek.

d Fish (Total) data are used for tribal lifeway exposure scenario, while Fish (Fillet) data are used for general public exposure scenario.

See Table 2 of Appendix E of the HHRA (CH2M, 2020) for more detailed information about the analytical data used for the EPC calculation.

Table 6b. Aquatic Food Consumption Rate (g/day)

Age Group		Tribal Lifeway					
		Fish (Total)	Shellfish	Amphibian / Aquatic Reptile	Semi-Aquatic Mammal	Aquatic Plant	Ref
Years	Adult	90	30	24	69	133	Harper (2008)[e]
1-2	Child[f]	31.77	6.38	5.10	21.64	50.01	Estimated based on EPA EFH data (2011, 2018a, 2018b)
2-3		31.77	6.38	5.10	27.73	54.17	
3-4		30.57	8.21	6.57	35.49	65.04	
4-5		30.57	8.21	6.57	35.49	65.04	
5-6		33.80	7.97	6.38	35.49	65.04	

e RME aquatic food ingestion rates established for tribal lifeway adult based on Harper (2008). The ingestion rates presents in Table 6b are consistent with the values used in the HHRA.

f Aquatic food consumption rates for child were calculated by multiplying adult aquatic food consumption rate by Child/Adult fraction estimated based on EPA EFH and updates (2011, 2018a, 2018b).

See Supplemental Table A of Appendix E of the HHRA (CH2M, 2020) for more detailed information about the calculation of child aquatic food consumption rates.

Table 6c. Daily Lead Intake Through Aquatic Food Consumption (µg/day)[g]

Age Group Years	Tribal Lifeway					
	Fish (Total)	**Shellfish**	**Amphibian / Aquatic Reptile**	**Semi-Aquatic Mammal**	**Aquatic Plant**	**Total Lead Intake (µg/day)**
1-2	3.72	0.85	0.92	2.60	5.50	13.6
2-3	3.72	0.85	0.92	3.33	5.96	14.8
3-4	3.58	1.09	1.18	4.26	7.15	17.3
4-5	3.58	1.09	1.18	4.26	7.15	17.3
5-6	3.95	1.06	1.15	4.26	7.15	17.6

[g] Dietary lead intake (µg/day) is calculated by multiplying EPC in food item (µg/g) by aquatic food consumption rate (g/day).

Acronyms:

EFH = exposure factors handbook

EPA = U.S. Environmental Protection Agency

RME = Reasonable Maximum Exposure

References:

CH2M. 2020. *Human Health Risk Assessment. Version 1.1. Tar Creek Superfund Site Operable Unit 5. Ottawa County, Oklahoma.* May.

EPA. 2011. *Exposure Factors Handbook: 2011 Edition* . EPA/600/R-090/052F. September.

EPA. 2018a. *Update for Chapter 9 of the Exposure Factors Handbook. Ingestion of Fruits and Vegetables.* EPA/600/R-18/098F. August.

EPA. 2018b. *Update for Chapter 11 of the Exposure Factors Handbook. Ingestion of Meats, Dairy Products, and Fats.* EPA/600/R-17/485F. April.

Harper, Barbara. 2008. *Quapaw Traditional Lifeways Scenario.* Prepared by Barbara Harper, PhD, DABT. AESE, Inc.

Table 7. Human Health Exposure Scenarios for Cd and Zn PRG Development

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Scenarios	Scenario Description	Media Evaluated	Exposure Factors	OU5 Aquatic Biota as Food
TLW Scenario[a]	TLW exposure assumptions used in the HHRA.	Sediment Biota (Aquatic Plants)	Same as HHRA	Yes (aquatic plants only) [b]
AW Scenario[a]	Aquatic worker exposure assumptions used in the HHRA.	Sediment	Same as HHRA	No

Notes:

[a] PRGs corresponding to the TLW and Aquatic Worker scenarios evaluated in the HHRA.

[b]Aquatic plants accounts for more than 90% of risk from diet. Sediment PRGs focusing on aquatic plants are expected to address risk from other food items.

AW = Aquatic Worker

Cd = cadmium

TLW = Tribal Lifeway

Zn = zinc

Table 8. Values and Equations Used in Cadmium and Zinc PRGs

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Exposure Factors	Exposure Factors Symbol	Units	TLW Child		Aquatic Worker	Equations
			Cd	Zn	Cd	
Exposure Frequency (Sediment Direct Contact)	EF_{DC}	day/year	312	312	250	
Exposure Frequency (Aquatic Plant Consumption)	EF_{AP}	day/year	365	365	n/a	
Exposure Duration	ED	year	6	6	25	
Body Weight	BW	kg_{BW}	15	15	70	
Averaging Time	AT_{NC}	days	2190	2190	9125	
Sediment Ingestion Rate	IR_{Sed}	mg/day	400	400	400	
Skin Surface Area	SA	cm^2	6365	6365	19652	
Sediment Adherence Factor	SSAF	mg/cm^2-day	0.1	0.1	0.1	
Dermal Absorption Factor	DABS (Cd only)	unitless	0.001	0.001	0.001	
Aquatic Plant Ingestion Rate	IR_{AP}	g/day	66.5	66.5	n/a	
Aquatic Plant Fraction Ingested	FI	unitless	1	1	n/a	
Reference Dose for Ingestion	RfDoral	mg/kg_{BW}-day	1.0E-03	3.0E-01	1.0E-03	
Reference Dose for Dermal Contact	RfDdermal	mg/kg_{BW}-day	2.5E-05	3.0E-01	2.5E-05	
Sediment PRG for ingestion route	PRGing	mg/kg_{sed}	43.9	13161	255.5	PRG_{ing} = (RfDoral * HI) / (IR_{Sed} * EF_{DC} * ED * 1E-6 * [1/BW] * [1/AT_{NC}])
Sediment PRG for dermal contact route	PRGderm	mg/kg_{sed}	689.2	n/a	1300	PRG_{Derm} = (RfDderm * HI) / (SA * SSAF * DABS * EF_{DC} * ED * 1E-6 * [1/BW] * [1/AT_{NC}])
Sediment PRG for direct contact pathway	PRG_{DC}	mg/kg_{sed}	41.2	13,161	214	PRG_{DC} = 1/ (1/PRG_{ing} + 1/PRG_{derm})
Aquatic Plant PRGS for Aquatic Plant Consumption Pathway	PRG_{AP}	mg/kg_{AP}	0.226	67.7		PRG_{AP} = (RfDoral * HI) / (IR_{AP} * EF_{AP} * ED * FI * 1E-3 * [1/BW] * [1/AT_{NC}])
Regression Equation (Slope)	Slope	kg_{sed}/kg_{AP}	0.136	0.120	n/a	
Regression Equation (Intercept)	Int	mg/kg_{AP}	-1.64	-194.29		
Sediment PRG for Direct Contact and Aquatic Plant Consumption	PRG_{DC+AP}	mg/kg_{sed}	13.2	2,095		PRG_{DC+AP} = 1-(Int*(1/PRG_{AP})))/((1/PRG_{DC})+Slope*(1/PRG_{AP}))

Notes:

cm^2 = square centimeter

kg_{AP} = kilograms of aquatic plant (wet weight)

kg_{BW} = kilograms of body weight

kg_{sed} = kilograms of sediment (dray weight)

mg = milligram

PRG = preliminary remediation goal

TLW = Tribal Lifeway

Table 9. Summary of the Calculated Cadmium and Zinc Sediment PRGs

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Exposure Scenario	**Cadmium**	**Zinc**
Aquatic Worker Scenario (direct contact pathway)	214	**n/a**
Tribal Lifeway (child) Scenario (direct contact + aquatic biota consumption)[a]	13.2	2,095
Ecological Risk Assessment PRG (T10)	11.1	2,083
Ecological Risk Assessment PRG (T20)	17.3	2,949

Notes:

[a]PRG was calculated using aquatic plant consumption only as aquatic plant contributed >90% of total hazard for aquatic biota consumption.

Units are presented in milligrams of COCs per kilograms of sediment (dry weight).

n/a = not applicable; zinc was not identified as a COC for Aquatic Worker

PRG = preliminary remediation goal

T10 = site-specific toxicity threshold corresponding to 10% reduction in survival or biomass

T20 = site-specific toxicity threshold corresponding to 20% reduction in survival or biomass

Table 10. Comparison of Aquatic Dietary HQs between Sitewide and Neosho River Data

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Biota	Sitewide Data[a]		Neosho River[b]	
	HQ	%	HQ	%
Fish	0.7	0.8%	0.6	15%
Shellfish	3	3.1%	2	39%
Amphibian/Aquatic Reptiles	0.2	0.2%	0.2	4%
Semi-Aquatic Mammals	0.6	0.6%	0.8	19%
Aquatic Plants	91	95%	0.9	22%
Total	95	100%	4	100%

Notes:

[a] Table 6-15 “Summary of Receptor Hazards for Final COCs - Tribal Lifeway Child “ of the HHRA

[b] Appendix F5, Table 2, “Summary of Watershed-specific Receptor Hazards for Biota Consumption COCs (Child)" of the HHRA

COC = chemical of concern

HQ = hazard quotient

Table 11. Aquatic Dietary HQs Associated with Samples Collected in Lost Creek

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Aquatic Food	Aquatic Dietary HQs[a]	
	Cadmium	Zinc
Fish[b]	0.3	0.2
Shellfish[c]	0.4	1
Aquatic Plant	1	0.6
Amphibian / Aquatic Reptile (Frog)	n/d	0.02
Semi-Aquatic Mammal (Raccoon)[b]	0.1	0.3

Notes:

[a] Appendix F5, Table 2. "Summary of Watershed-specific Receptor Hazards for Biota Consumption COCs (Child) " of the HHRA

[b] Cadmium and zinc EPCs in Lost Creek are similar to those calculated in Fourmile Creek (reference watershed).

[c] Because no shellfish samples were collected in Lost Creek, HQ was estimated based on the average HQs for Lower Spring River & Neosho River.

EPC = exposure point concentration

n/d = not detected

Table 12. Estimated HQs associated with consumption of mussels based on the calculated Cadmium and Zinc PRGs

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

COCs	Calculated PRG in Sediment (mg/kg)	Estimated Concentrations in Mussels (mg/kg)[a]	HQ Associated with Mussel Consumption (Unitless)	Note	HQ Associated with Mussel Consumption in Lost Creek (Unitless)[b]
Cadmium	13.2	3.75	3.7	Using Eq. 1	0.4
		5.77	5.8	Using Eq. 2	
Zinc	2095	856.7	2.9	Using Eq. 1	1
		1601.1	5.3	Using Eq. 2	

Regression Equations	Cadmium		Zinc		Reference
	INT	Slope	INT	Slope	
Mussels incl. Spr6. (Eq. 1)	-0.1569	0.573	2.4285	0.5655	Angelo (2007)[a]
Mussels minus Spr6 (Eq. 2)	-0.0894	0.7141	1.8548	0.7223	Angelo (2007)[a]

Notes:

[a] Cadmium and zinc concentrations in mussels are estimated based on the calculated PRGs using the two regression equations presented in Angelo (2007).

[b] Because no shellfish samples were collected in Lost Creek, HQ was estimated based on the average HQs for Lower Spring River and Neosho River.

Reference:

Angelo, R.T., M.S. Cringan, D.L. Chamberlain, A.J. Stahl, S.G. Haslouer, and C.A. Goodrich. 2007. Residual effects of lead and zinc mining on freshwater mussels in the Spring River Basin (Kansas, Missouri, and Oklahoma, USA). Science of the Total

mg/kg = milligram per kilogram

Table 13. Lead PRGs associated with TLW Exposure Assumption and IEUBK Default DW EPC

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Sediment Ingestion (g/day)[a]	SW/DW Ingestion (L/day)[a]	Dietary Intake (µg/day)[a]	DW EPC (µg/L)[b]	Sediment PRGs		
				BLL=5	BLL=8	BLL=10
0.4	0.78	Aquatic food (13.6 - 17.6)	IEUBK default (0.9)	n/v	24	55

Notes:

PRGs are calculated for EPA's recommended age range (12 to 72 months old).

PRGs are calculated for target BLLs of 5, 8, and 10 µg/dL.

[a] Input parameter values used for the TLW scenario in the HHRA.

[b] It is assumed that surface water is not used as a source of drinking water. Therefore, IEUBK default drinking water EPC (0.9 ug/L) is used in the calculation.

n/v = no sediment PRG value can be calculated using the IEUBK model because of the elevated lead intake through exposure to media other than sediment (e.g., even if lead concentration in sediment is zero, it would not achieve the target BLL)

BLL = blood lead level

DW = drinking water

EPC = exposure point concentration

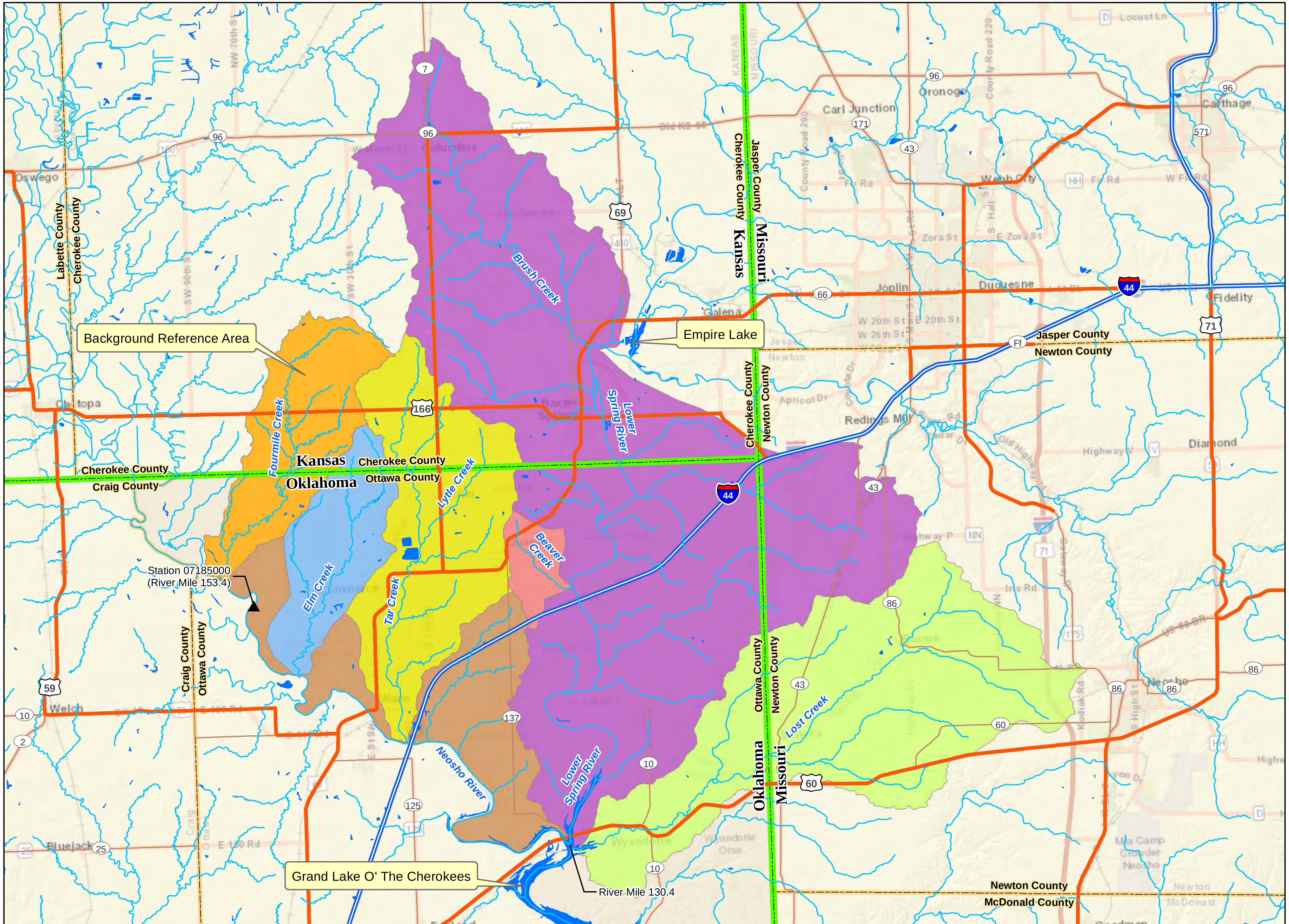
HHRA = human health risk assessment

IEUBK = integrated exposure uptake biokinetic model

SW = surface water

TLW = tribal lifeway

Figures



Legend

- ▲ USGS Stream Gage
- NHD Stream
- State Boundary
- County Boundary
- Fourmile Creek (Background/Reference Watershed)
- Elm Creek Watershed
- Tar Creek Watershed
- Neosho River Watershed
- Beaver Creek Watershed
- Lost Creek Watershed
- Lower Spring River Watershed

Notes:
1) Imagery Source: ESRI World Street Map online mapping service
2) Operable Unit 5 (OU5) does not have specific boundaries, but is defined by the extent of the watersheds that have been identified by the EPA as relevant to Tar Creek Superfund Site OU5.
3) River Mile 130.4 represents the downstream extent of the OU5 study area.

NHD = National Hydrography Dataset
USGS = U.S. Geological Survey

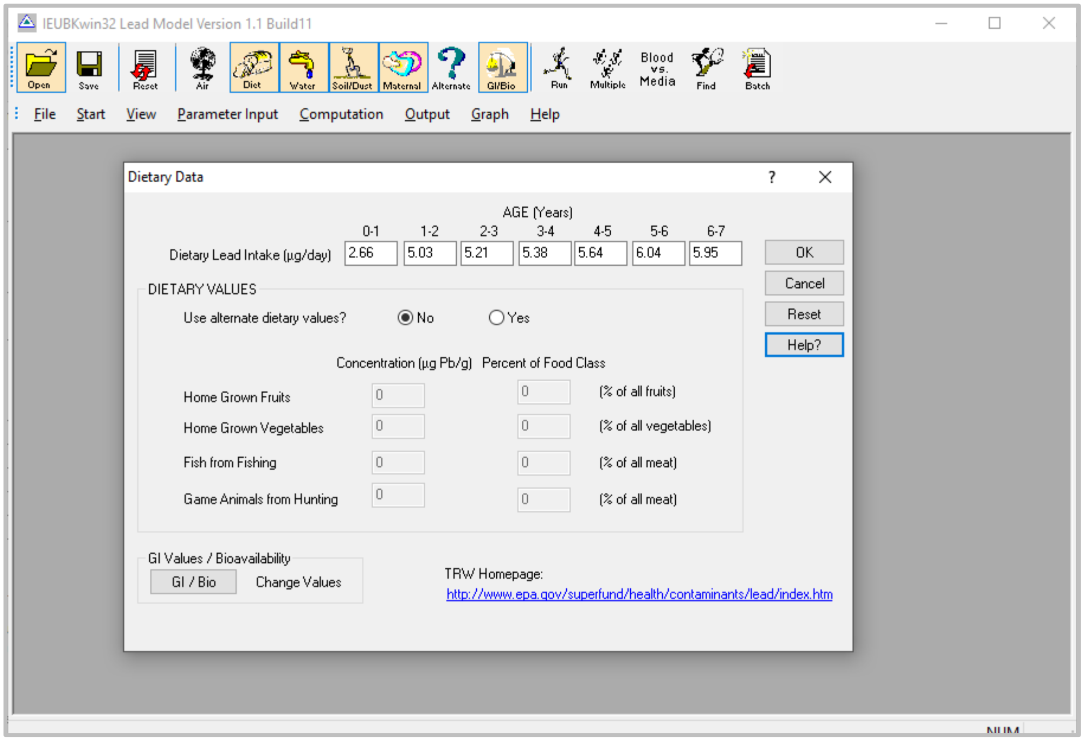
N

0 1.75 3.5 7 Miles

Figure 1.
Operable Unit 5 Watersheds
Tar Creek Superfund Site
Operable Unit 5
Ottawa County, Oklahoma

Figure 2. IEUBK Inputs for Tribal Lifeway Dietary Intake
Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma

Default Dietary Intake



PLUS Additional OU5 Aquatic Food Intake (see Table 6)

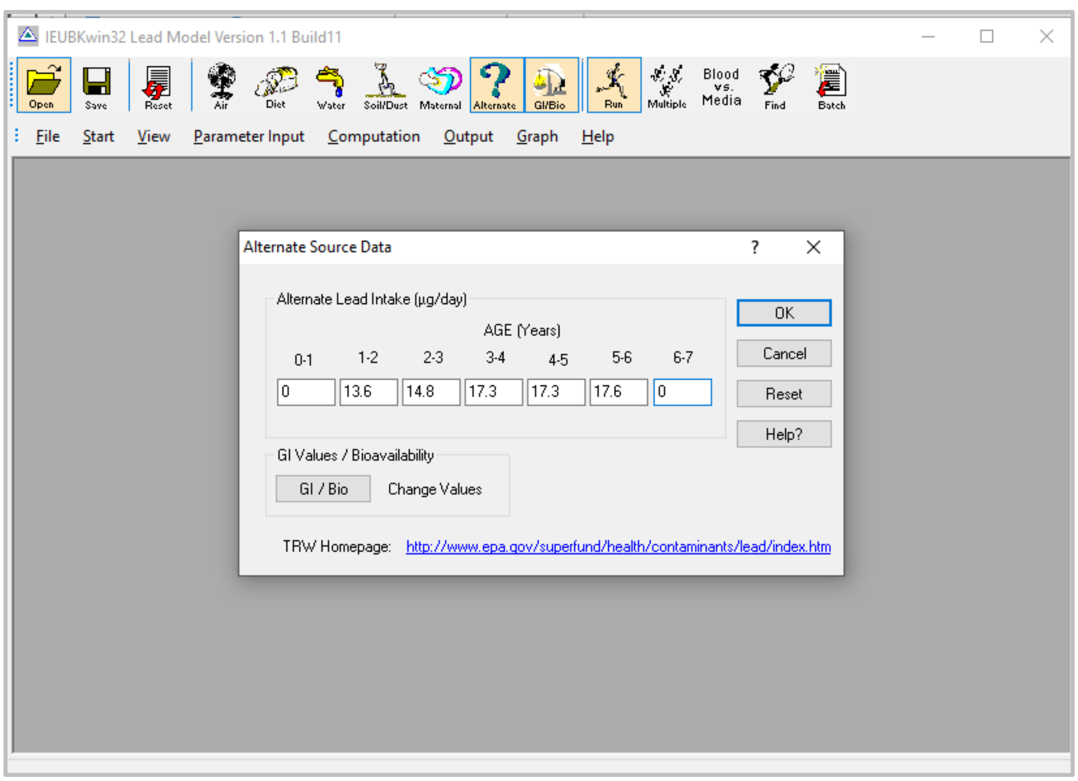


Figure 3. IEUBK Inputs for General Public Scenario 1 Dietary Intake
Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma

Dietary intake using "alternate dietary values?" option

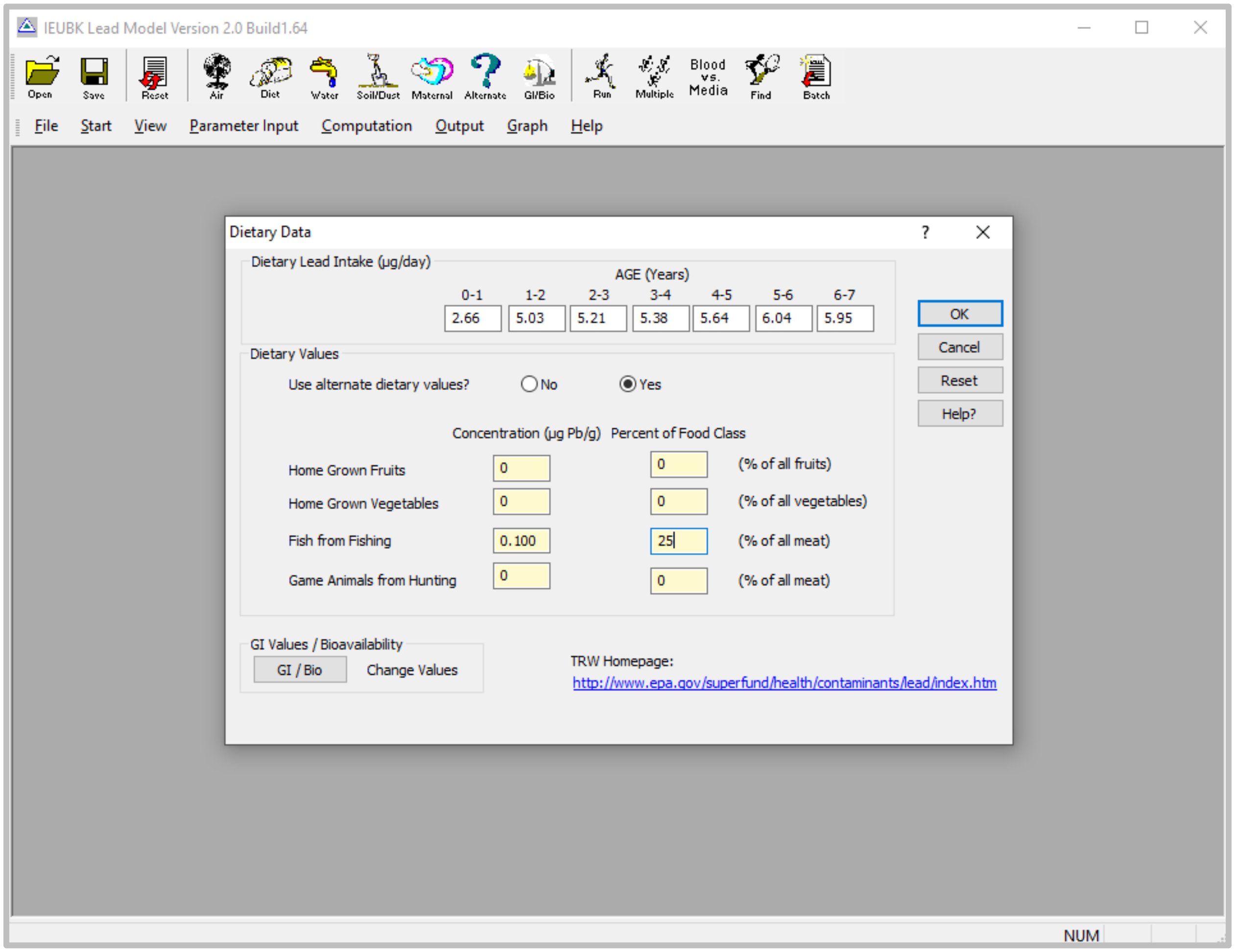
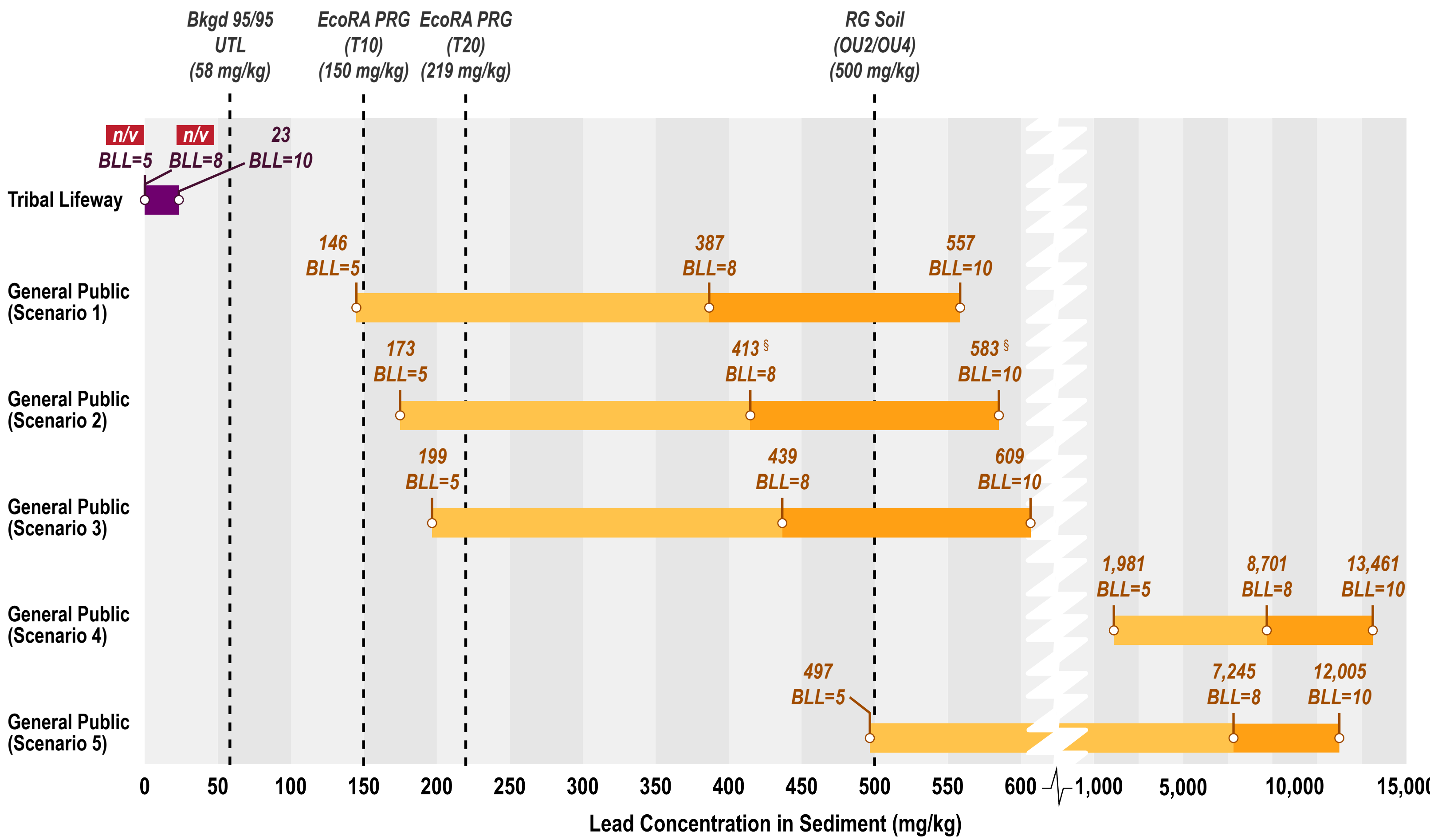


Figure 4. Estimated Lead PRGs Under Various Scenarios
Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma



	TRIBAL LIFEWAY[1‡]	GENERAL PUBLIC[1] Scenario 1	Scenario 2[†]	Scenario 3
Sediment Ingestion (mg/day)	400	IEUBK default (52–94)		
SW Ingestion (L/day)	0.78	IEUBK default (0.43–0.60)		
SW EPC (µg/L)	Bkgd mean [total][2] (2.35)	IEUBK default (0.9)	Lost Creek mean [total][2] (2.70)	IEUBK default (0.9)
Dietary Intake (µg/day)	IEUBK default (5.03–6.04)	"Alternate dietary values" approach [4] (Fish fillet = 0.100 mg/kg; OU5 fish % = 25)	IEUBK default[3] (5.03–6.04)	IEUBK default (5.03–6.04)
Additional Dietary Intake (µg/day)	OU5 Aquatic Food (13.6–17.6)[5]	n/a	n/a	n/a

Scenarios using TWA approach	Scenario 4[6]		Scenario 5[6]	
Exposure Area	OU5	Home	OU5	Home
Waking Hours (hours/week)[7]	3	81	3	81
Fraction of Waking Hour (unitless)	0.036	0.964	0.036	0.964
Soil EPC at Residence (mg/kg)[8]	n/a	133	n/a	133

Notes:

† The scenario corresponds to the GP exposure scenario evaluated in the HHRA.

‡ The scenario corresponds to the TLW exposure scenario evaluated in the HHRA. Note: Although the HHRA estimated dietary lead intake is based on consumption of OU5 aquatic food only, the TLW PRG incorporates dietary lead intake based on consumption of OU5 aquatic food in addition to the IEUBK's default values for dietary intake.

§ Because surface water exposure is estimated using the EPC of the watershed with sediment concentrations lower than the calculated PRG, surface water exposure is underestimated. If lead concentration in sediment is at the level presented, the lead in surface water is expected to be higher than the value used in the calculation.

1. PRGs are calculated for the CDC's recommended age range (12–72 months old) based on target BLLs of 5, 8, and 10 µg/dL.
2. Surface water exposure is estimated using the EPC of the watershed with sediment concentrations similar to the calculated PRG for a target BLL.
3. In the HHRA (Scenario 2), for general public, default dietary intake was conservatively used because calculated lead intake through consumption of OU5 fish fillet was lower than default dietary intake.
4. Dietary lead intake is addressed using the IEUBK's "alternate dietary values" approach for OU5 fish consumption. Lead concentration in fish (fillet) (0.100 mg/kg) and estimated percentage of fish originating from OU5 (25%) are entered into the model.
5. Dietary lead intake through OU5 aquatic food consumption estimated based on TLW child aquatic biota ingestion rates and average lead concentration in biota samples in Fourmile Creek (background). Fourmile Creek is used as a representative watershed since sediment concentrations are close to estimated PRGs.
6. The PRGs calculated for Scenario 1 and 3 are refined using the TWA approach, accounting for lead exposure in two exposure areas (OU5 and home).
7. GP receptors are assumed to visit OU5 at exposure frequency of 1 day/week and exposure time of 3 hours/day (i.e., 3 hours/week) and to spend the rest of waking hours (12 hours/day) at their home (81 hours/week: a total waking hours/week [84 hours/week] minus 3 hours/week) where yard soil lead EPC is 133 mg/kg.
8. Residential yard soil EPC (133 mg/kg), the mean lead concentration calculated based on a dataset composed of 233 residences in Quapaw, Oklahoma. Most members of the general public in Picher and Cardin have moved to where soil lead concentrations are near background levels, so using the average lead concentrations measured in residential yards in Quapaw is conservative.

n/v No sediment PRG value can be calculated using the IEUBK model, because of the elevated lead intake through exposure to media other than sediment (e.g., even if lead concentration in sediment is zero, it would not achieve the target BLL).

Acronyms:

Bkgd – background
BLL – blood lead level
CDC – Centers for Disease Control and Prevention
EPC – exposure point concentration
EcoRA – ecological risk assessment
GP – general public
HHRA – human health risk assessment
n/a – not applicable
n/v – no value
OU – operable unit
PRG – preliminary remediation goal
SW – surface water
TLW – tribal lifeway

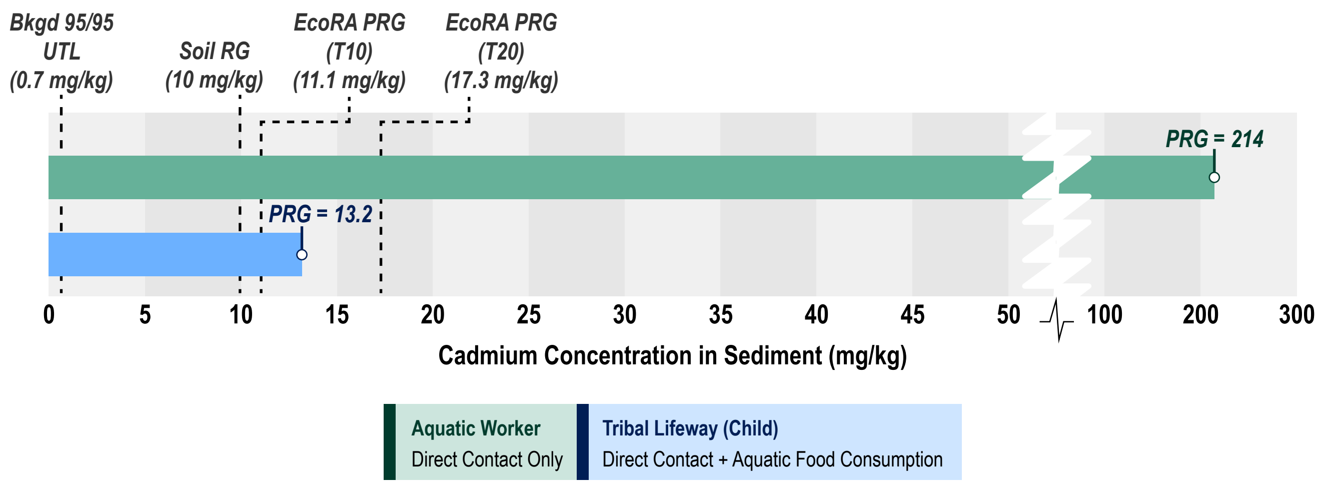
Units:

µg/dL – microgram(s) per deciliter
µg/L – microgram(s) per liter
µg/day – microgram(s) per day
mg/day – milligram(s) per day
mg/kg – milligram(s) per kilogram
L/day – liter(s) per day

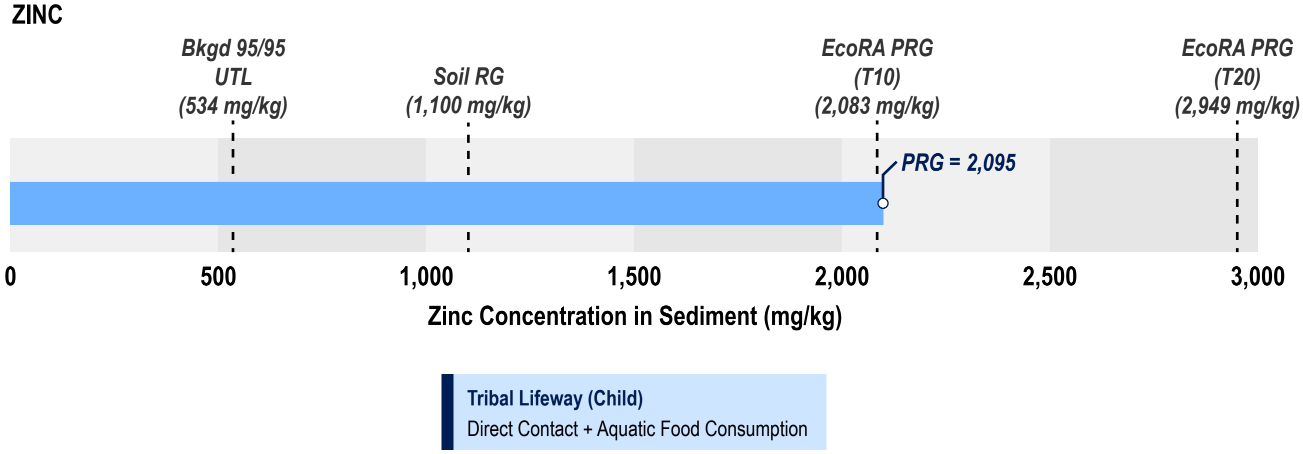
Figure 5. Estimated Cadmium and Zinc PRGs Under Various Scenarios

Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma

CADMIUM



ZINC



† Sediment PRGs protective of aquatic plant consumption are calculated using the regression equations established based on the collocated sediment and aquatic plant data.

Acronyms:

Bkgd – background	T10 – Site-specific toxicity threshold corresponding to 10% reduction in survival or biomass
EcoRA – ecological risk assessment	T20 – Site-specific toxicity threshold corresponding to 20% reduction in survival or biomass
mg/kg – milligram(s) per kilogram	TLW – tribal lifeway
PRG – preliminary remediation goal	UTL – upper tolerance limit

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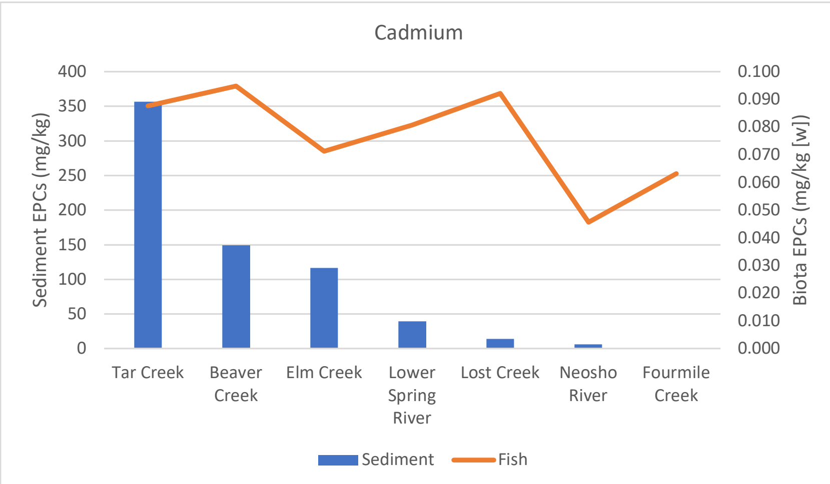
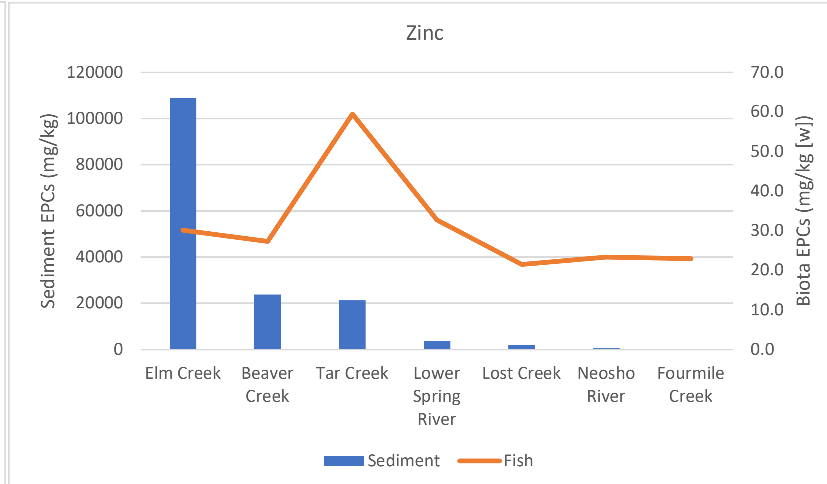
Figures 6A and 6B. Comparisons of Cadmium and Zinc EPCs in Sediment and Fish

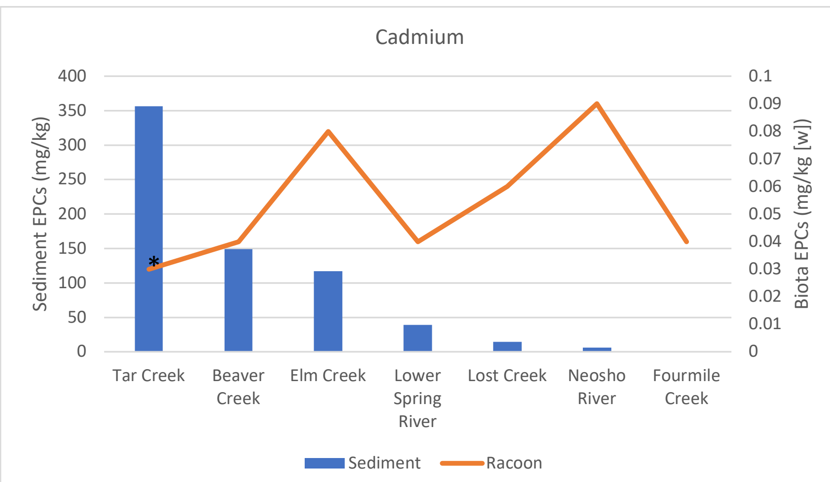
Tar Creek Superfund Site Operable Unit 5

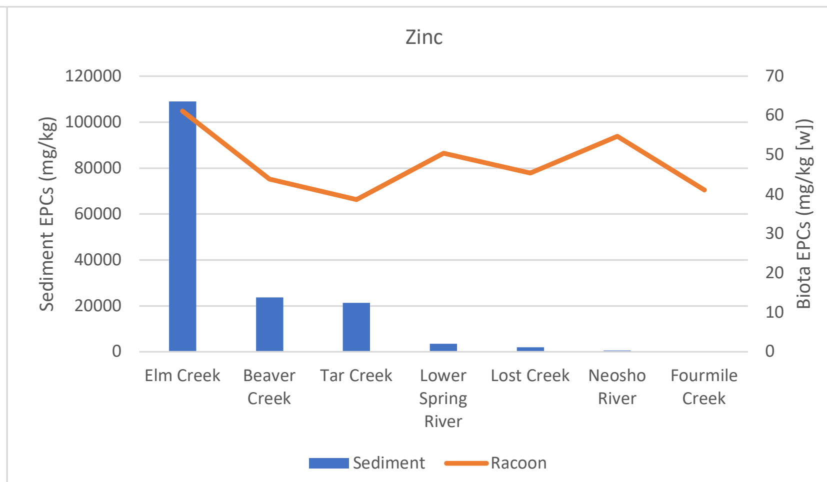
Ottawa County, Oklahoma





Figures 6C and 6D. Comparisons of Cadmium and Zinc EPCs in Sediment and Racoon





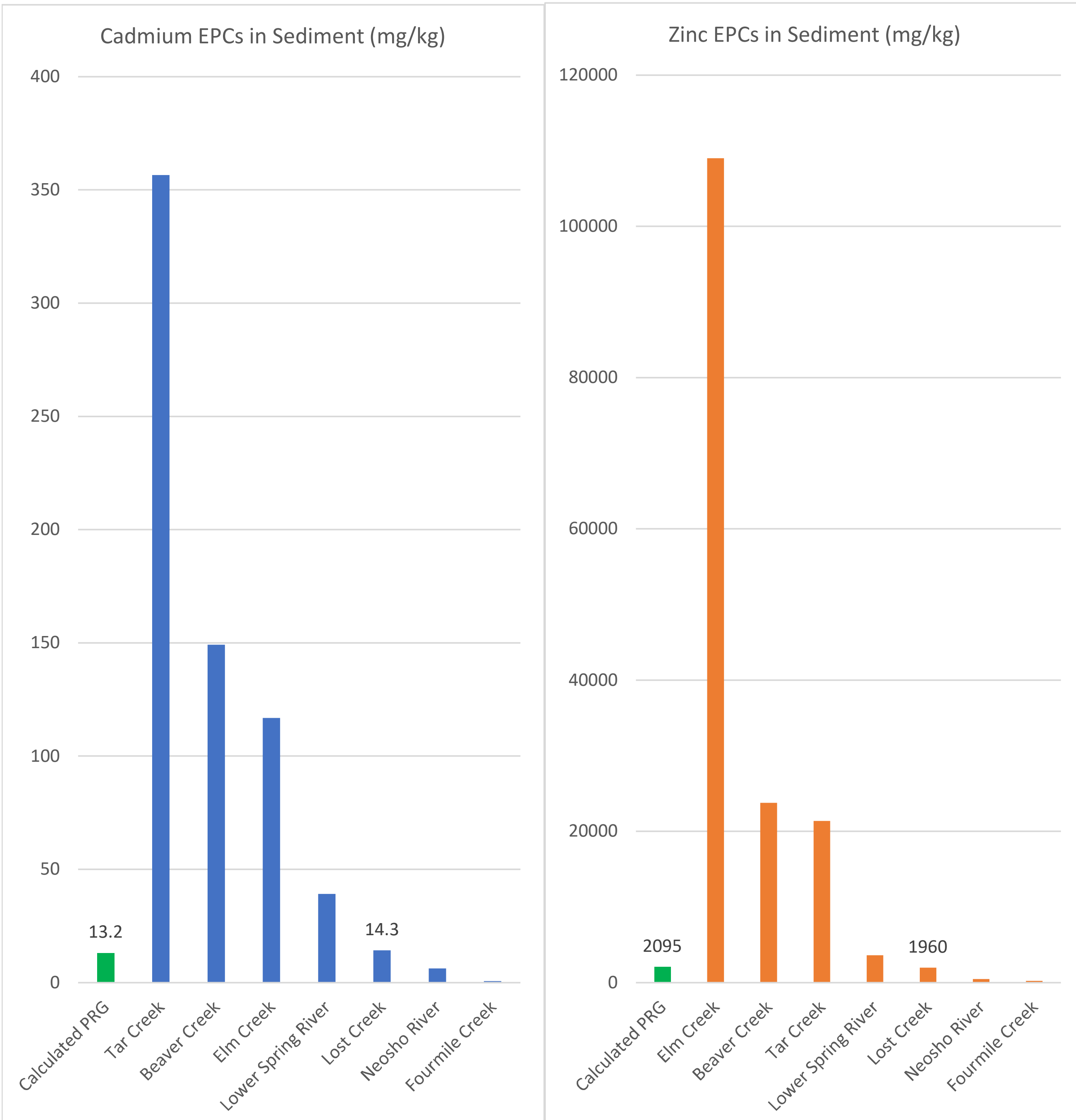
Notes:

EPC = exposure point concentration

mg/kg= milligrams per kilogram

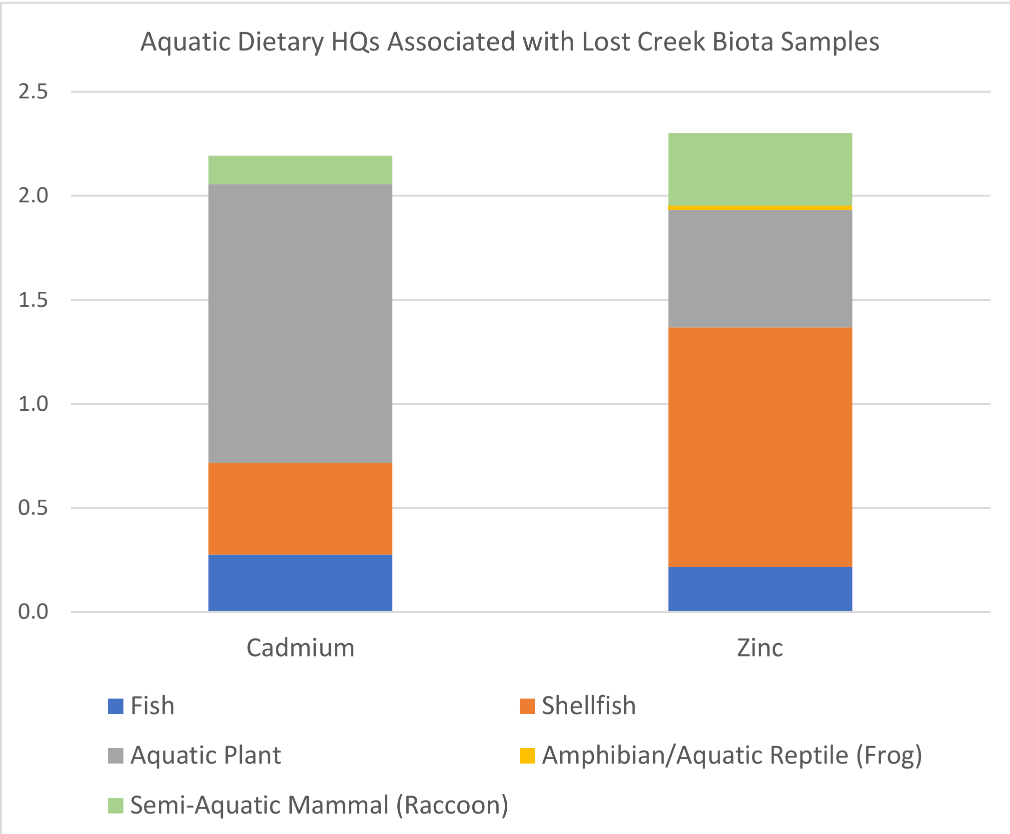
* cadmium was not detected in any raccoon samples collected in Tar Creek. Concentration presented is based on detection limit.

Figures 7A and 7B. Calculated PRGs and Watershed-Specific EPCs
Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma



Notes:
EPC = exposure point concentration
mg/kg = milligrams per kilogram

Figure 7C. Aquatic Dietary HQs Associated with Lost Creek Biota Samples
Tar Creek Superfund Site Operable Unit 5
Ottawa County, Oklahoma



Note:
HQ = hazard quotient

Attachment 1

TRW Memo

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Technical Review Workgroup Lead Committee

An interoffice workgroup convened by Office of Superfund Remediation and Technology Innovation

MEMORANDUM

Date: November 20, 2020

Subject: TRW Lead Committee Consultation: Review of Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma

From: Matt Lambert (acting), Sophia Serda, and James Brown
Co-Chairpersons of the Technical Review Workgroup
Lead Committee

To: Katrina Coltrain, US EPA Region 6

The Technical Review Workgroup (TRW) Lead Committee prepared this memorandum in response to your request on October 14, 2020 for review of Tar Creek Superfund Site Operable Unit 5. As part of this review, the Lead Committee reviewed the 3 exposure scenarios and invited Region 6 to participate in the November 12 monthly teleconference to discuss the site.[1]

TRW Lead Committee has prepared the following responses to questions in your October 14 Consultation Memo (hereafter PDF):

1. *Is there precedence for using the IEUBK model for deriving a lead PRG based on sediment exposure at other Superfund sites? If so, did the PRG consider potential concomitant exposures from other media like water, soil, or biota? In general, our experience is that sediment actions are driven by ecological receptors.*

Yes, and yes. Other sites have used the IEUBK model to derive preliminary remediation goals (PRGs) for lead in sediment (e.g., Cherokee County OU2 Upper Spring River Human Health Risk Assessment [HHRA], Coeur d'Alene HHRA, and Upper Columbia River HHRA). In Region 10, the Coeur d'Alene and Upper Columbia River assessments modeled intermittent exposure to sediments via ingestion from direct contact in recreational or residential areas. Sediment PRGs for children and eco-receptors (swans)

[1] Technical support for this review was provided by SRC, Inc.

were similar at 700 and 520 mg/kg, respectively. In some cases, the PRG reflected exposure to other site related media (incidental ingestion of surface water is common with the sediment exposure pathway). As discussed on the November 12 Lead Committee teleconference, EPA Regions define sediment differently. Because of these differences, which may impact how it should be assessed in risk assessments, this decision is left to Region 6.

2. *For an investigation of one OU at a large environmental remediation site such as Tar Creek Superfund site, could the lead analysis using the IEUBK model focus only on the exposure media associated with the specific OU without considering exposure from other OUs or background lead exposure through typical diet in the United States (the approach used for Set 2 PRGs)?*

No, at this time, lead risk assessment policy calls for all media for which there is a complete exposure pathway to be assessed in the HHRA. The purpose of the IEUBK model is to:

- estimate a blood lead level for a human child receptor
- estimate a risk of exceeding a specified target blood lead level (BLL) for a given exposure scenario
- estimate a PRG, from a set of exposures at the specified target BLL

The IEUBK sums all sources of exposure to estimate blood lead levels. As a biomarker of exposure, blood lead does not simulate "source apportionment". This is the meaning of "Integrated" in the IEUBK model. Unavoidable sources of exposure are typically included in background levels of lead in air, water, and diet. While potentially cumbersome, it may be useful to estimate risks for each of these approaches (sets), and for each approach that results in unacceptable risks, calculate scenario specific PRGs. Across OUs, one may consider the PRG for the residential OU as the *home soil* exposure point concentration (EPC) in the time-weighted average (TWA) calculation for the non-residential OU risk calculations. Then use risk management to select a PRG for Lead (and possibly other chemicals of concern) in each OU5 media.

3. *Given the finding that all the scenarios using a sediment ingestion rate of 400 mg/day yield a PRG lower than the lead Background Threshold Value (BTW) of 59 mg/kg, what does the TRW Lead Committee recommend for handling exposures specific to a Tribal Lifeway (TLW) receptor for their future potential beneficial use of their lands (knowing that the IEUBK model was not developed for subsistence TLW high exposure levels)? That is, if we cannot use the IEUBK lead model to develop PRGs for a TLW exposure scenario, what other tools are available to evaluate such exposures?*

The TRW Lead Committee made the following recommendation regarding the soil ingestion rate in their December 2019 Tar Creek review:

> "For Model Run 2, the selected ingestion rate of 400 mg/day for sediment seems very high compared to what is typically used for children (generally 100 mg/day or less). Central tendency estimates are recommended for lead risk assessment."

Because of the way the EPA Lead models use statistical parameters to calculate an upper bound exposure, BLL, and PRG, central tendency values should be used for inputs in the IEUBK and Adult Lead Methodology (ALM). The TRW Lead Committee does not consider 400 mg/day to be a central tendency soil-dust ingestion rate (IR) for a human child receptor. Because the IEUBK model estimates exposure over months, the current IRs should be considered in conjunction with time weighted averaging to estimate the impact of sediment. A Harper (2008) report is cited in the PDF as the basis for using an IR of 400 mg/day, which comes from Harper et al. (2007). The Harper et al. (2007) soil IRs are outdated. The 400 mg/day for soil (i.e., not dust) relies in large part on the U.S. EPA's 1997 Exposure Factors Handbook (EFH) Table 4-23 upper percentile (i.e., defined as 95th percentile, not undefined as suggested by Harper on p. 259 of that 2007 report). However, the 1997 EFH footnoted the 400 mg/day for soil with "Study period was short; therefore, these values are not estimates of usual intake." Irvine et al. (2014) reported a 95th percentile IR of 361 mg/day for soil IR but stated, "… the mean as well as the 95th percentile estimates [determined by Irvine et al.] lower than Harper et al.'s (2007) prediction of soil ingestion rates for First Nations people (i.e. 400 mg/day)." Harper et al. (2007) did not actually provide a prediction of 400 mg/day IR for soil, but rather relied in large part on the EPA's 1997 EFH Table 4-23 upper percentile.

There are two relatively small studies (Irvine et al., 2014; Doyle et al., 2012) of tribal adults (16 subjects in total) practicing tribal lifestyles for short periods of time (in one case, 2 weeks). The most reliable tracers estimated that mean soil ingestion was 32 to 74 mg/day. If reasonable maximum exposure (RME) values (e.g., 200 mg/day) are used to represent a child's mean soil IR, this should be discussed in the uncertainty section of the risk assessment.

The TRW believes that the IEUBK model is a reasonable tool for assessing the risk to tribal children. See Question 6 below for a discussion of exposure scenarios and associated PRGs. It is the Superfund program's policy to select background as a cleanup level where the risk-based PRG is below background levels (US EPA, 2002).

4. *Given the finding that no sediment PRG value can be calculated for the TLW child when using the Time Weighted Average (TWA) approach to include added soil exposure from residential properties, does the TRW recommend that the PRG focus only on the exposure media associated with OU5?*

We recommend using the current IEUBK intermittent exposure guidance (U.S. EPA, 2003). The All Ages Lead Model (AALM) could be run to support a sensitivity analysis consistent with what was done on the R10 Upper Columbia River HHRA to better quantify uncertainty, but the AALM is currently being revised to reflect a recent EPA Scientific Advisory Board review. One approach may be to use the relative bioavailability (RBA)-adjusted PRG for the residential OU as the PRG for the sediment (so that a child's recreational exposure is no greater than the residential exposure). Also, by reducing the soil IR the results of some of the alternatives may be above background.

5. *What does the TRW Lead Committee recommend for addressing intermittent lead exposure to sediment or surface water occurring a part of the day or week (knowing that the IEUBK model was developed for continuous residential lead exposure for general public)?*

For an intermittent exposure, the portion of the total exposure frequency (EF) (i.e., days per week, days per year, etc.) that would occur for OU5 media should be determined. For the remaining portion of the total EF, the lead EPC would be based on the receptor's non-site soil lead concentration (e.g., residence, child care facility, schoolyard, etc.), to arrive at a TWA soil (or sediment) lead concentration. The OU5 PRG can then be calculated by knowing what the PRG is for the total receptor exposure and what the lead concentration is in the non-site soil. The TRW Lead Committee recommends using a TWA approach with a soil IR <400 mg/day. The intermittent exposure guidance (U.S. EPA, 2003) provides recommendations for assessing intermittent or variable exposures at lead sites, including sediment exposure scenarios. The Lead Committee does not usually subdivide a day of exposure for lead risk assessment. If subdividing a day is necessary, it could be considered as an acute exposure.

6. *Which of the 3 sets and/or IEUBK iteration(s) depicted in Figures 1 through 3 is the preferable or recommended approach for identifying the site specific PRG for lead in sediment?*

The TRW Lead committee recommends either using all 3 sets of exposure options to calculate a range of PRGs, or using only set 3b (hybrid scenario with TWA as described on page 9 of the PDF) as the best option since it considers all sources of exposure, while at the same time using a lower soil ingestion rate and TWA strategy to address residential soil exposure. Note that option 3b results in a sediment PRG that is above background levels and reflects risk using appropriate exposure assumptions. The high PRGs in some scenarios are misleading, potentially making people think that the high levels of lead are safe when no exposures to lead are safe. As discussed on the November 12 Lead Committee teleconference and in response to Question 1 above, EPA Regions define sediment differently and because of these differences the selection of an approach to calculate a PRG is a decision left to Region 6.

Other Comments

The TRW Lead Committee has made comments to the PDF file. The results for the TLW scenario are challenging to replicate based on the information provided. Additional information is recommended for transparency (see Appendix 1). Also, the TRW Lead Committee recommend site sampling should characterize bioavailability in solid media (soil and sediment) using the in vitro bioaccessibility assay (IVBA) (U.S. EPA, 2007).

References

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Irvine, G; Doyle, JR; White, PA; Blais, JM. 2014. Soil ingestion rate determination in a rural population in Alberta, Canada practicing a wilderness lifestyle. Sci Tot Environ. 470-471:138−146.

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U.S. EPA. 2007. Estimation of Relative Bioavailability of Lead in Soil and Soil-like Materials Using In Vivo and In Vitro Methods. OSWER 9285.7-77. May 2007. Online at: https://semspub.epa.gov/work/HQ/175416.pdf

Appendix 1. Reproducing the Results

The IEUBK results for the general public (GP) and TLW can be reproduced. The GP results can be readily reproduced based on the text and table; however, the TLW results required some additional effort as described below.

The TLW low-end exposure scenario used default soil intake (where dust lead concentration = 0 ppm) for the three years prior to the 36-72 month age range. Default soil/dust ingestion rates were used for the 0-35 months age range (instead of zero). A PRG of approx. 605 ppm for P5 (compared to 671 ppm if the prior years are zeroed out) and approximately 1400 ppm for the P10 (compared to 1,552 ppm).

If the objective was to set the diet intake equal to zero except for the intake from aquatic plants, entering zero for diet lead intakes does not achieve the intended results. The series of screen captures below compares the diet lead uptake (not intake) for the GP Low-End Exposure (first two images) to the diet lead uptake using the same exposure parameters except the default intakes are entered for diet (images 3-4). Note the diet lead uptakes are the same. This is expected because once the 'Use alternate diet values' option is selected, the code does not use the values for 'Dietary Lead Intake' that appear at the top of the Dietary Data window. The code calculates intakes using the default consumption data and concentration data along with the values for alternate dietary concentration and percent of food class. Only alternate food categories with non-zero percentages are used to calculate the dietary intake. The last two images illustrate this point. Figure 5 effectively shows intake from vegetables, fruits and market meats (which includes fish) was zeroed out by entering 100% for vegetables and fruits (with zero concentration) and entered 75% for game animals from hunting (with zero concentration). Figure 6 shows the diet lead uptakes are now lower than they are in Figures 2 and 4, which correspond to the parameter values shown in Figures 1 and 3. The diet lead uptakes are still not zero because of the other diet categories that are not available to the user (e.g., dairy, bread, pasta).

The resulting P5 and P10 PRGs for soil lead at 15 ppm and 91 ppm (respectively) are shown in Figures 7 and 8, respectively.

Figure 1. diet parameter values corresponding to GP-Low End Exposure.

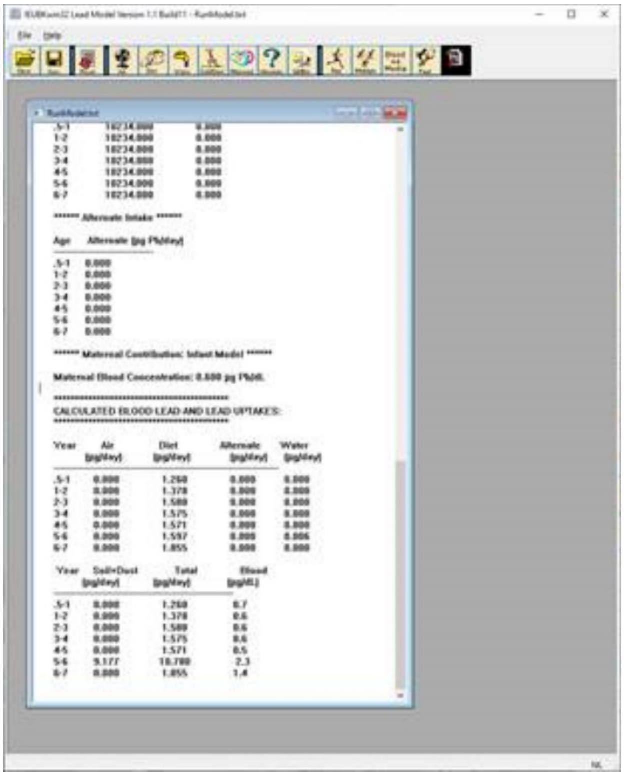


Figure 2. Diet lead uptake corresponding to GP-Low End Exposure.

Figure 3. Diet parameter values with default values in the 'Dietary Lead Intake' instead of zero (compare to Figure 1).

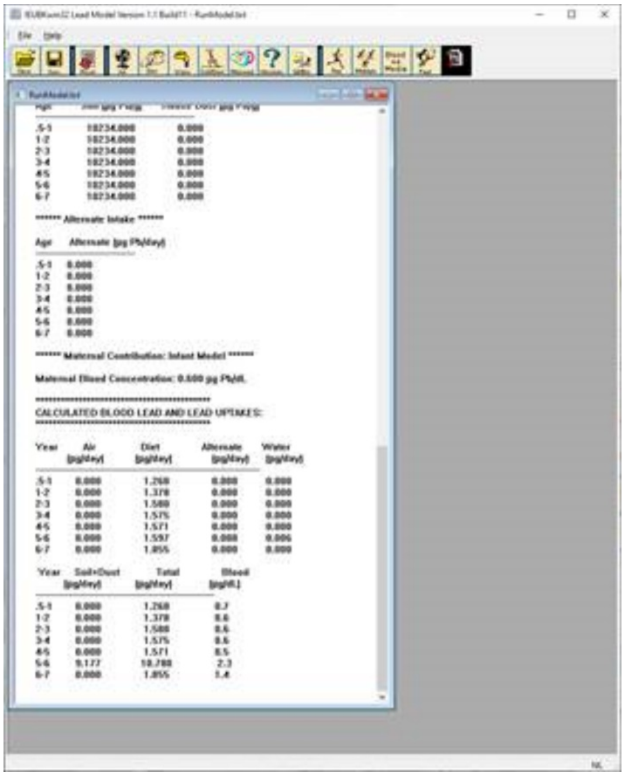


Figure 4. Diet lead uptake corresponding to default values in the 'Dietary Lead Intake' instead of zero (Figure 3). Compare to Figure 2: no change in the diet lead uptake values.

Figure 5. Diet parameter values with default values in the 'Dietary Lead Intake' set to zero – which has no effect on the calculations of lead intake, uptake or BLL because the 'Use alternate dietary values?' button has been selected (set to 'Yes'). The combination of the Percent of Food Class' values and zero concentration for home grown fruits and vegetables effectively sets the intake from total fruits and total vegetables (market and home grown) equal to zero. By setting the percentage of game animals to 75% results in self-caught fish being the only lead intake from meats. Market meats (fish and non-fish) and game animals contribute zero lead intake (compare to Figures 1 and 3).

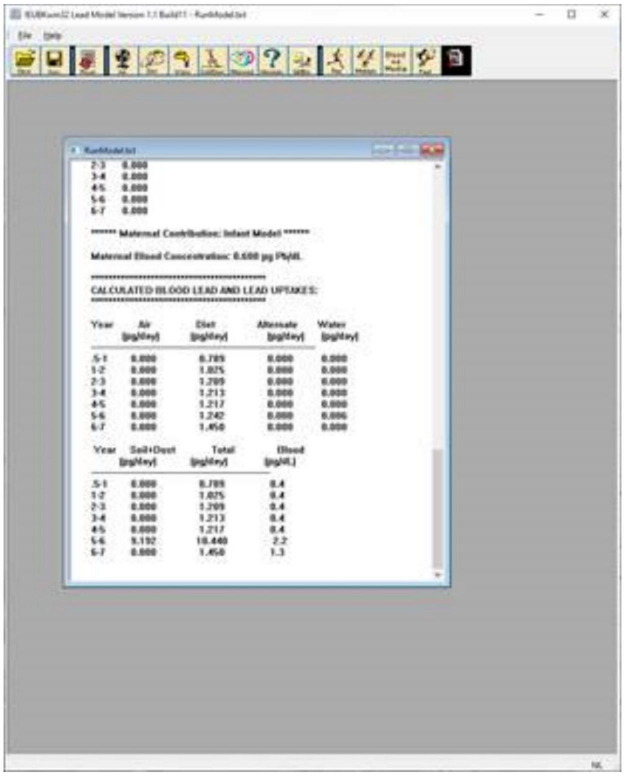


Figure 6. Diet lead uptake corresponding to parameter values shown in Figure 5, which shows lead intake/uptake from home grown fruits and vegetables, and game animals set to zero. Compare to Figure 6 to Figures 2 and 4. Dietary lead uptake is lower but not zero due to lead intake from other diet categories that are not available to the user (e.g., dairy).

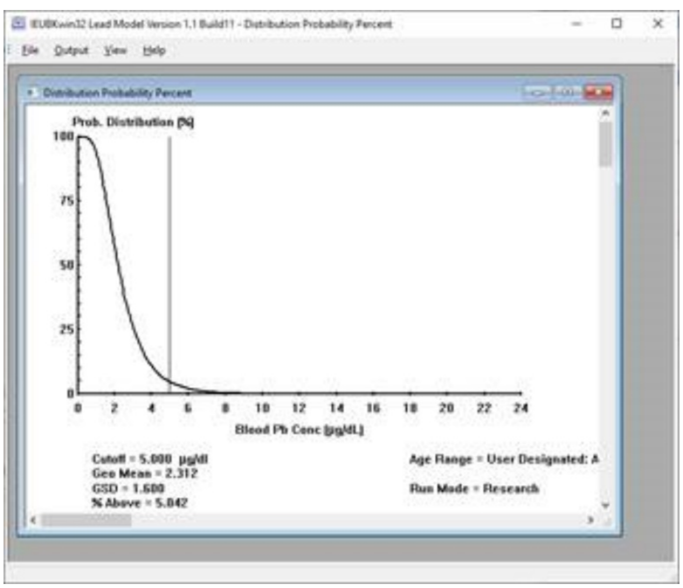


Figure 7. Calculated PRG for the P5 TLW-high, using the svd file for TLW-high with soil = 15 ppm.

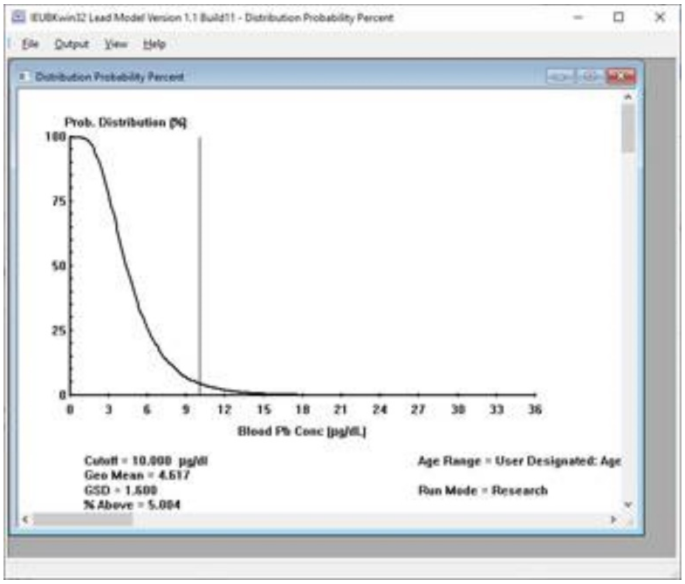


Figure 8. Calculated PRG for the P10 TLW-high, using the svd file for TLW-high with soil = 91 ppm.

Attachment 2
Sediment and Aquatic Plant Regression Analysis

Attachment 2

Sediment and Aquatic Plant Regression Analysis, Tar Creek Superfund Site, Operable Unit 5

During the development of preliminary remediation goals (PRGs), an evaluation of the correlation between the sampled aquatic plants (arrowhead) and their collocated sediment samples was performed. Aquatic plant data were obtained from four collocated sediment/aquatic plant sample locations: one from each of the four watersheds (Elm Creek [EC AR 01], Tar Creek [TC AR 01], Lost Creek [LC AR 01], and Lower Spring River [LS AR 01]) (Table 1). For each arrowhead sample, an attempt was made to collect a sample from three different parts (leaf, root, and tuber) of the arrowhead plant; however, a tuber was developed only in the sample collected in Lost Creek (LC AR 01), where the lowest concentrations of chemicals of concern (COCs) in sediment were observed. Without a sufficient quantity of tuber data, an evaluation was performed to develop a regression equation predicting aquatic plant concentrations from sediment concentrations for two aquatic plant parts (leaf and root).

These evaluations include calculations of the Pearson correlation coefficient (the most widely used measure of paired correlation) and the Spearman correlation coefficient, a nonparametric version (based on ranks) of the Pearson correlation coefficient. Both of these values range from -1 to 1 where 1 represents perfect correlation, -1 represents perfect inverse correlation, and 0 represents no correlation. Another well-known measure of correlation, R^2, was also calculated. This value is merely the square of the Pearson correlation coefficient and thus ranges from 0 to 1, where increasing correlation or inverse correlation is indicated by higher R^2 values.

Review of correlation analysis revealed that the plant data correlates to sediment data very well for all cases (R^2 of 0.91 and above) (Table 2). The calculated measures of correlation are presented in Table 2 with the estimates for the slope and intercept of regression equations and the Pearson and Spearman correlation coefficients; scatter plots are presented on Figure 1.

Among the regression equations established for root and leaf data, the equations developed for root data are selected to estimate the relationship between aquatic plant and sediment concentrations because they predict higher concentrations of COCs in aquatic plant than those based on leaf data (Table 2).

The equations below present the relationships between aquatic plant and sediment.

Cadmium: $$Aquatic\ Plant\ Conc. = Sediment\ Conc. \times Slope\ (0.136) + Intercept\ (-1.64)$$

Zinc: $$Aquatic\ Plant\ Conc. = Sediment\ Conc. \times Slope\ (0.120) + Intercept\ (-194.3)$$

Attachment 2. Table 1. Summary of Analytical Data for Collocated Sediment and Arrowhead Samples

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

COC	Medium	Plant Part	Watershed				BTV (Sediment, unsieved)
			Elm Creek	Tar Creek	Lost Creek	Lower Spring River	
Lead	Sediment (unsieved)[a]	n/a	15,700	199	23.5	236	58.4
	Aquatic Plant	Root	838	2.5	1.2	12.1	n/a
		Leaf	304	1.6	0.93	3.1	
		Tuber[b]	n/s	n/s	0.43	n/s	
Cadmium	Sediment (unsieved)[a]	n/a	160	13.9	0.080	52.6	0.7
	Aquatic Plant	Root	21.2	0.73	0.21	2.13	n/a
		Leaf	6.6	0.20	0.21	0.26	
		Tuber[b]	n/s	n/s	0.05	n/s	
Zinc	Sediment (unsieved)[a]	n/a	16,400	3,810	141	5,210	534
	Aquatic Plant	Root	1,840	51.1	30.7	366	n/a
		Leaf	793	46.9	25.2	132	
		Tuber[b]	n/s	n/s	17.5	n/s	

Notes:

[a] All sediment samples were collected from the 0- to 6-inch interval except the sample collected from Elm Creek, which was collected from the 3- to 6-inch interval.

[b] Tuber was not developed in the samples collected from Elm Creek, Tar Creek, and Lower Spring River.

Units are presented in mg/kg on a dry weight basis for sediment and a wet weight basis for aquatic plant.

COCs were detected in all of the sediment and aquatic plant samples, except cadmium in Lost Creek sediment.

Acronyms:

COC = chemical of concern

BTV = background threshold value

n/a = not applicable

n/s = not sampled

Units:

mg/kg = milligrams per kilogram

Attachment 2. Table 2. Summary Statistics for Regression Models

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

COC	Plant Part	Intercept	Slope	Pearson Correlation Coefficient	R squared	Spearman Correlation Coefficient
Lead	Root	-2.92	0.054	1.00	1.00	1.00
	Leaf	-1.09	0.019	1.00	1.00	1.00
Cadmium	Root	-1.64	0.136	0.97	0.95	1.00
	Leaf	-0.56	0.042	0.95	0.91	0.80
Zinc	Root	-194.29	0.120	0.98	0.96	1.00
	Leaf	-76.25	0.051	0.98	0.95	1.00

Notes:

Regression equation: Concentration in Aquatic Plan (mg/kg[w]) = Slope * Concentration in Sediment (mg/kg[d]) + Intercept.

Acronyms:

COC = chemical of concern

PRG = Preliminary Remediation Goal

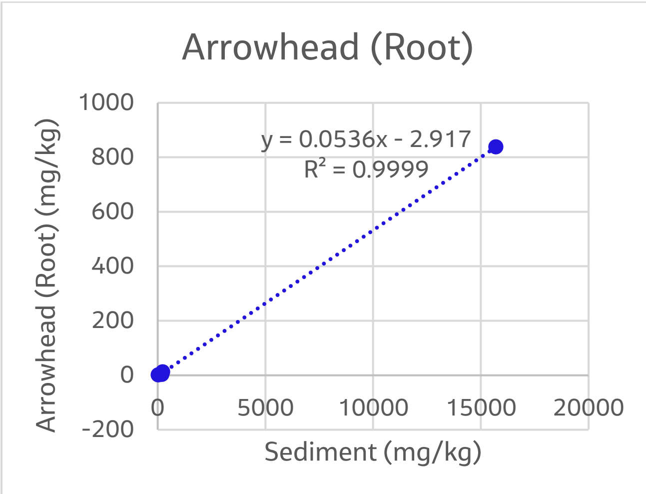
Units

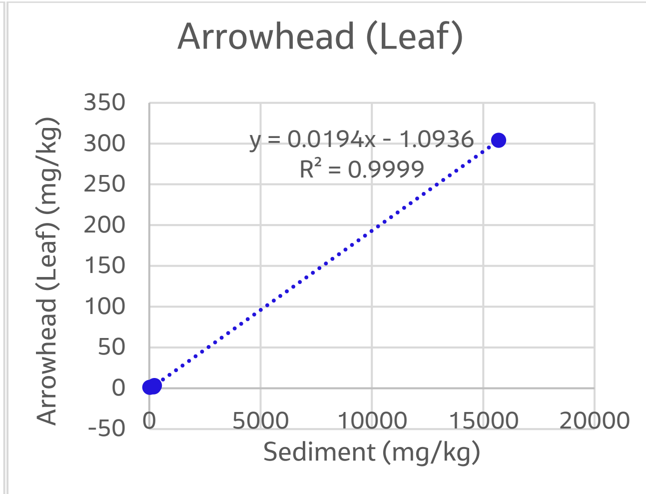
mg/kg[d] = milligrams per kilogram on a dry weight basis

mg/kg[w] = milligrams per kilogram on a wet weight basis

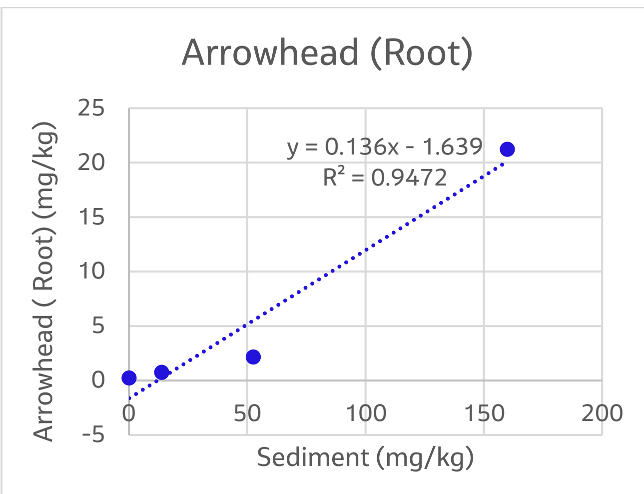
Attachment 2. Figure 1. Scatter Plots

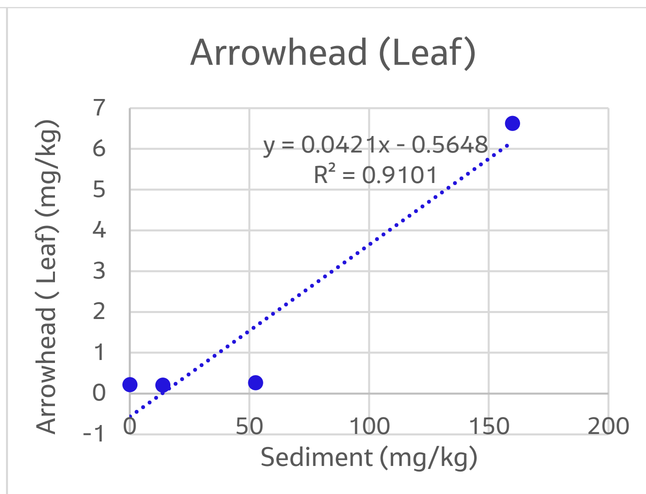
Lead





Cadmium





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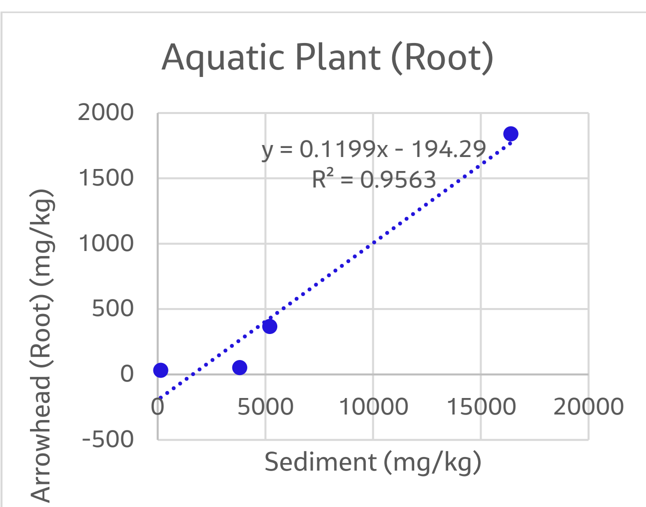
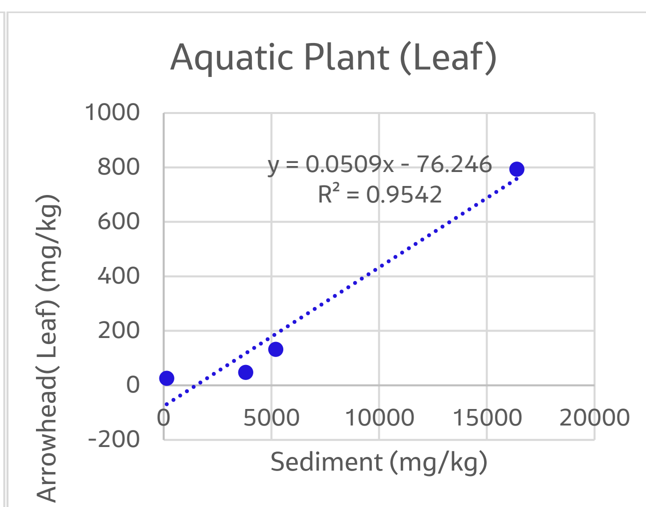




Attachment 3
Sensitivity Analysis

Attachment 3

Sensitivity Analysis of the Key Input Parameter Values in the Integrated Exposure Uptake Biokinetic (IEUBK) Model

Approach

To assess the sensitivity of key input variables, a preliminary assessment of sediment preliminary remediation goals (PRGs) was performed for each of the three key exposure pathways (sediment ingestion, surface water ingestion, and aquatic food consumption [i.e., dietary intake]). Table 1 summarizes key input variables and values that are assessed. In this analysis, sediment exposure is simply treated as soil exposure and surface water exposure is treated as drinking water in the model, and the calculated soil PRGs are presented as sediment PRGs. As such, it is assumed that Operable Unit 5 (OU5) sediments are brought home and children are exposed to sediment at home in the form of dust ingestion and that they are exposed to lead in indoor and outdoor air originating from a non-OU5-related source. In this analysis, to expedite the calculation process, PRGs are calculated for the age group 12 to 84 months old, an age group closely encompassing the age group of our interest (12 to 72 months old) (EPA, 2017), among the age group options available in the IEUBK's "Find" function.

Brief descriptions of input parameter values are presented below.

Sediment Ingestion

- Sediment ingestion rate was incrementally increased from the default values (ranging from 52 to 94 milligrams per day [mg/day] for various age groups) to 100, 200, 300, and up to 400 mg/day (i.e., the reasonable maximum exposure [RME] sediment ingestion rate identified based on Harper [2008]). For the scenario using the RME sediment ingestion rate of 400 mg/day, two additional scenarios incorporating a reduced absorption fraction of soil/dust (from the default value of 30 percent to 25 percent and 20 percent) were evaluated to see if they would change the PRG values.

Surface Water Ingestion

- Surface water ingestion rate and exposure point concentration (EPC) are the two input variables determining lead intake through surface water ingestion. The model was run using an RME surface water ingestion rate of 0.78 liter per day (L/day), the U.S Environmental Protection Agency's (EPA's) RME default drinking water ingestion rate (EPA, 2014). This conservative surface water ingestion rate is assumed to account for three TLW exposure pathways: (1) incidental ingestion through hunting/fishing/gathering and recreational activities, (2) ingestion of surface water as a drinking water source, and (3) ingestion of surface water during sweat lodge use. The background mean lead concentration (2.35 micrograms per liter [µg/L]) is used as the EPC in surface water because of the lack of specific media transfer information between sediment and surface water.

Dietary Lead Intake

- Dietary lead intake is estimated using two approaches:
  - In the first approach, dietary lead intake was calculated based on the RME aquatic food ingestion rates used in the Human Health Risk Assessment (CH2M, 2020) and mean background concentrations. The RME aquatic food ingestion rates were estimated based on adult food ingestion rates identified in Harper (2008) and child/adult ingestion rate ratios identified for the major food groups in the EPA's *Exposure Factors Handbook* updates (2011, 2018a, 2018b) presented in Table 6 of the PRG TM.
  - The second approach uses the "Alternate Dietary Value" option in the IEUBK model, and lead concentration and percentage of aquatic food originating from OU5 are entered as input into the model.
- Because of the lack of media transfer information between sediment and biota, lead EPCs in aquatic biota were estimated based on mean background concentrations. For the scenario assessing dietary lead intake from fish ingestion for the general public children, the background mean concentration of fish (fillet) (0.116 milligram per kilogram [mg/kg]) is used. For the Tribal Lifeway scenario addressing aquatic dietary lead intake from all aquatic food categories sampled from OU5 (fish, shellfish, aquatic reptile/amphibian, semi-aquatic mammal), a weighted average of lead concentration was calculated based on the adult ingestion rate of each aquatic food category (Table 6 of the PRG TM).
- Additionally, the sediment PRGs are calculated for three additional scenarios using various combinations of exposure assumptions to yield the higher end of the potential PRG range.

Dust Ingestion and Outdoor/Indoor Air Exposure

Lead exposure through dust ingestion is evaluated using the IEUBK's multiple source analysis function. Inhalation of lead in indoor and outdoor air is evaluated using the IEUBK's default setting (that is, outdoor air lead concentration of 0.1 microgram per cubic meter [$\mu g/m^3$] and indoor air lead concentration is 30 percent of outdoor air lead concentration).

Findings

The results of each set of the IEUBK model runs are summarized and shown in the attached Table 1 and Figure 1. Findings of the sensitivity analysis are summarized as follows:

- Among the input variables, sediment ingestion rate is one of the most influential parameters on the sediment PRG. The scenario using a sediment ingestion rate of 200 mg/day calculated a sediment PRG (70 mg/kg) slightly above the lead background threshold value of 59 mg/kg. For the scenario using a sediment ingestion rate of 400 mg/day, a reduced soil/dust absorption fraction does not noticeably change the sediment PRG.
- Surface water EPC based on background mean and ingestion rate are not as influential as sediment ingestion rate.
- The scenario using the first approach of estimating aquatic dietary lead intake was not able to calculate a sediment PRG for a target blood lead level of 5 micrograms per deciliter (µg/dL) because of the significant contribution of lead intake from aquatic food consumption. In other words, even if the lead concentration in sediment is zero, the percentage of children with a blood lead level exceeding the target of 5 µg/dL is more than 5 percent.
- When aquatic dietary lead intake through fish consumption is entered, the model using the alternate dietary value option (the second option above), the model estimated a higher sediment PRG than the scenario using the default dietary intake values.

References

CH2M HILL (CH2M). 2020. *Tar Creek Superfund Site Operable Unit 5. Ottawa County, Oklahoma. Human Health Risk Assessment. DCN: 0079-02017.* May.

Harper, Barbara. 2008. *Quapaw Traditional Lifeways Scenario.* Prepared by Barbara Harper, PhD, DABT. AESE, Inc.

U.S. Environmental Protection Agency (EPA). 2011. *Exposure Factors Handbook: 2011 Edition.* National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F. September.

U.S. Environmental Protection Agency (EPA). 2014. *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.* OSWER Directive 9200.1-120. February 6.

U.S. Environmental Protection Agency (EPA). 2017. *Recommendations for Default Age Range In the IEUBK Model.* Office of Land and Emergency Management (OLEM) Directive 9200.2-177. November 15.

U.S. Environmental Protection Agency (EPA). 2018a. Update for Chapter 9 of the Exposure Factors Handbook. Intake of Fruits and Vegetables. Table 9-3. EPA/600/R-18/098F. August.

U.S. Environmental Protection Agency (EPA). 2018b. Update for Chapter 11 of the Exposure Factors Handbook. Intake of Meats, Dairy Products, and Fats. Table 11-3. EPA/600/R-17/485F. August.

Attachment 3. Table 1. Sensitivity Analysis of Key Input Parameter Values

Tar Creek Superfund Site Operable Unit 5

Ottawa County, Oklahoma

Medium/Exposure Pathway	Age Group[a]	Soil/ Sed Ingestion (mg/day)	SW Ingestion (L/day)	SW EPC (µg/L)	Dietary Intake (µg/day)	Absorption Fraction (percent)	Estimated PRGs BLL=5	BLL=8	BLL=10
All Default	12-84 mo.	Default (52-94)	Default (0.43 - 0.63)	Default (0.9)	Default (5.03 – 6.04)	Default (30%)	216	474	656
Soil/Sediment	12-84 mo.	100	Default	Default	Default	Default	147	325	450
	12-84 mo.	200	Default	Default	Default	Default	70	159	221
	12-84 mo.	300	Default	Default	Default	Default	44	104	145
	12-84 mo.	400	Default	Default	Default	Default	32	76	107
	12-84 mo.	400	Default	Default	Default	25%	39	93	130
	12-84 mo.	400	Default	Default	Default	20%	51	118	164
SW	12-84 mo.	Default	Default	Bkgd mean [dissolved] (1.63)	Default	Default	205	463	644
	12-84 mo.	Default	Default	Bkgd mean [total] (2.35)	Default	Default	194	452	633
	12-84 mo.	Default	0.78	Bkgd mean [total] (2.35)	Default	Default	177	435	616
Aquatic Diet	12-84 mo.	Default	Default	Default	Fish (25%)[b]	Default	279	538	720
	12-84 mo.	Default	Default	Default	All aquatic food (25%)[c]	Default	272	530	713
	12-84 mo.	Default	Default	Default	All aquatic food (100%)[c]	Default	155	412	594
	12-84 mo.	Default	Default	Default	13.6 – 17.6[d]	Default	n/v	180	360
Combined Scenario 1	12-84 mo.	Default	Default	Bkgd mean [total] (2.35)	Fish (25%)[b]	Default	257	516	698
Combined Scenario 2	12-84 mo.	400	0.78	Bkgd mean [total] (2.35)	Default	Default	25	69	100
Combined Scenario 3	12-84 mo.	400	0.78	Bkgd mean [total] (2.35)	All aquatic food (100%)[c]	Default	14	59	90

Notes:

[a] To expedite the calculation process, PRGs are calculated for age group 12-84 months old, because among the available age groups in the IEUBK's "Find" function, this age group closely represents age group of our interest (i.e., 12-72 months old, the CDC's recommended age range).

[b] The PRGs are calculated using the "Alternate Dietary Values" option and entering lead concentration in fish (fillet) and percentage of fish originating from OU5. The average lead concentration in background fish fillet samples (0.116 µg/g) are used in the calculations (see Table 6).

[c] The PRGs are calculated using the "Alternate Dietary Values" option, accounting for all aquatic food categories sampled from OU5 (i.e., fish, shellfish, aquatic reptile/amphibian, semi-aquatic mammal, and aquatic plant). Lead concentration in meat/fish (total) and vegetables and percentage of aquatic food originating from OU5 are entered into the model. The weighted average lead concentration in meat/fish (0.127 µg/g) and vegetables (0.11 µg/g) in background samples are used in the calculations (see Appendix E Supplemental Tables B and A of the human health risk assessment [CH2M, 2020]).

[d] The PRGs are calculated entering dietary lead intake values calculated based on background mean concentrations and RME ingestion rates (see Table 6).

Acronyms
Bkgd = background
BLL = blood lead level
CDC = Centers for Disease Control and Prevention
HHRA = human health risk assessment
IEUBK = Integrated Exposure Uptake Biokinetic (model)
mo. = months
n/v = because of the lead intake through dietary intake, no sediment PRG value can be calculated using the IEUBK model (i.e., even if lead concentration in sediment is zero, it would not achieve the target BLL)
OU = Operable Unit
PRG = preliminary remediation goal

Units
L/day = liters per day
mg/day = milligrams per day
µg/day = micrograms per day
µg/g = micrograms per gram
µg/L = micrograms per liter

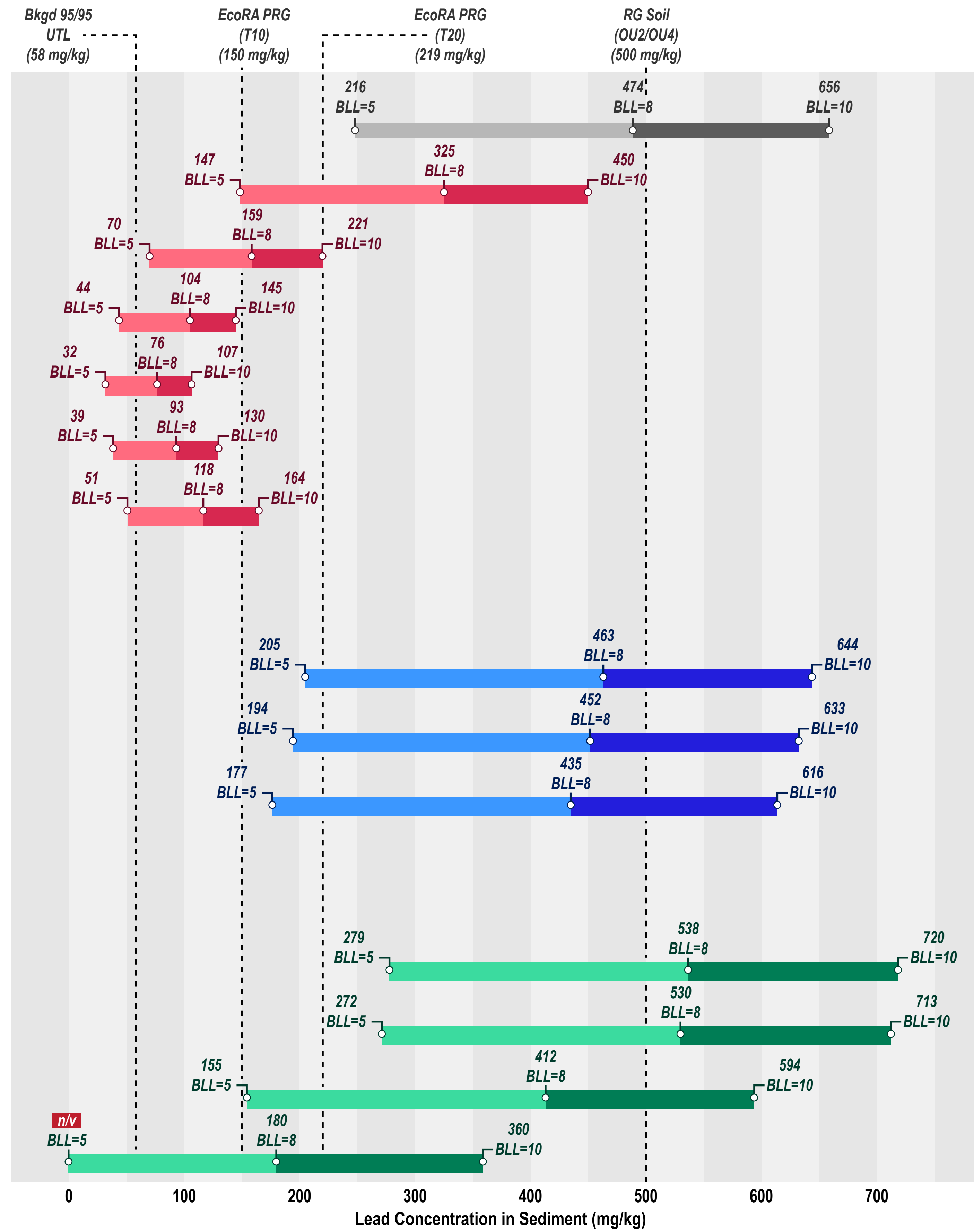
Attachment 3. Figure 1. Sensitivity Analysis of Key Input Parameter Values[1)(2)]

Medium/Exposure Pathway	Soil/Sed Ingestion (mg/day)	Absorption Fraction (percent)
All Default	default (52-94)	default (30%)
Soil/Sediment	100	default
	200	default
	300	default
	RME (400)	default
	RME (400)	25%
	RME (400)	20%

Medium/Exposure Pathway	SW Ingestion (L/day)	SW EPC (µg/L)
All Default	default (52-94)	default (0.9)
SW	default	Bkgd mean [dissolved] (1.63)
	default	Bkgd mean [total] (2.35)
	RME (0.78)	Bkgd mean [total] (2.35)

Medium/Exposure Pathway	Dietary Intake (µg/day)
All Default	default (5.03 – 6.04)
Diet	Fish (25%)[3a]
	All Food (25%)[3b]
	All Food (100%)[3b]
	13.6 – 17.6[4]

mg/kg – milligrams per kilogram
mg/day – milligrams per day
L/day – liters per day
µg/L – micrograms per liter
µg/day – micrograms per day
µg/g – micrograms per gram



Notes:

1. PRGs are calculated for age group 12-84 months old.
2. The input parameter values other than those presented in the left of the graph are set at the IEUBK model's default values.
3. The 'Alternate Dietary Value' option was used.
   a. The average lead concentration in background fish fillet samples (0.116 ug/g) are used in the calculations.
   b. The weighted average lead concentration in meat/fish (0.127 ug/g) and vegetables (0.11 ug/g) in background samples are used in the calculations.
4. The PRGs are calculated entering dietary lead intake values calculated based on background mean concentrations and RME ingestion rates.

n/v - because of the lead intake through dietary intake, no sediment PRG can be calculated (i.e., even if lead concentration in sediment is zero, it would not achieve the target BLL).

Acronyms:
Bkgd - background
BLL - bloood lead level
EPC - exposure point concentration
EcoRA - ecological risk assessment
n/v - no value
PRG - preliminary remediation goal
RME - Reasonable Maximum Exposure
sed - sediment
SW - surface water
UTL - upper tolerance limit

Attachment 4
Written Stakeholder Comments on Version 1.2 Memorandum

Attachment 4A
Written Stakeholder Review Comments

memorandum

Division of Health and Environment

Date: 7/9/2021

To: The Tar Creek Trustee Council Indian Tribes (TCTCIT)

cc: Brian Cleary, The Cleary Law Group

From: Molly McLaughlin, PhD; Kaylene Ritter, PhD; Heather Forth, PhD; and Michelle Krasnec, PhD, Abt Associates (Abt)

Subject: Comments on the *Development of Human Health Risk-Based Preliminary Remediation Goals for Operable Unit 5 Version 1.2,* dated June 9, 2021

At the request of the TCTCIT, Abt has prepared this memorandum (memo) to provide our comments on the technical memo entitled *Development of Human Health Risk-Based Preliminary Remediation Goals for Operable Unit 5 Version 1.2,* dated June 9, 2021 (hereafter referred to as the PRG memo). The PRG memo was prepared for the U.S. Environmental Protection Agency (EPA) by their contractor, CH2M Hill, and presents the approach, assumptions, and outcomes from developing human health risk-based preliminary remediation goals (PRGs) for Operable Unit 5 (OU5) of the Tar Creek Superfund Site (the Site).

This PRG memo is an update to a previous version (version 1.1) dated January 29, 2021. On March 12, 2021, Abt and the TCTCIT provided comments to EPA on that version. As a result of these comments, EPA coordinated a series of technical collaboration meetings with Abt and the TCTCIT. EPA addressed many of our comments through that process and this memo outlines our remaining comments.

As indicated in the PRG memo, the approach used in the exposure analysis of lead is different from that of the cadmium and zinc hazard assessment. Thus, lead PRGs were discussed separately from cadmium and zinc PRGs in the PRG memo and will also be discussed separately here. In this memo we first provide comments on the development of sediment PRGs for lead. Next, we provide comments on the development of sediment PRGs for cadmium and zinc, followed by references cited in the text. Attachment 1 is provided to support our comments on the Tribal soil ingestion rate.

1. Development of Sediment PRGs for Lead

1. EPA calculated the lead PRG value (presented in Table 4 of the PRG memo) based on the assumption that Tribal members consume surface water as drinking water.

Comment: EPA should use the Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 2010) default drinking water value as the drinking water concentration when calculating the lead PRG for the Tribal Lifeway (TLW) scenario. We note that EPA used this drinking water value to calculate a lead PRG value in the uncertainty analysis (Section 7.2.3), however, this drinking water value should be used to calculate the lead PRG value presented in the Findings section of the PRG memo (Section 8). As stated in Section 7.2.3 of the PRG memo, Abt previously indicated, on behalf of TCTCIT, that the Tribes do not use OU5 surface water as a source of drinking water. Use of this value for drinking water does not accurately reflect Tribal Lifeways for Tribal members, and can exaggerate the risk associated with lead exposure from drinking water. Use of the IEUBK default drinking water value for the drinking water concentration more accurately reflects both Tribal Lifeways and a central tendency exposure value. We also note that the drinking water exposure route is not included in the development of cadmium or zinc. Exposure scenarios should be consistent between the contaminants of concern (COCs).

2. To calculate the lead PRG value, EPA treats sediment exposure as soil exposure, assuming daily exposure to OU5 sediment "without considering receptors' exposure frequency and time at OU5 (pg. 6)."

Comment: As described in the Human Health Risk Assessment (HHRA), Tribal members are exposed to sediments for 312 days/year and 6 hours per day (CH2M HILL, 2021a). Thus, this exposure is intermittent and EPA's assumption of "daily exposure to OU5 sediment" (pg. 6) is inaccurate. As the Technical Review Workgroup (TRW) Lead Committee describes in Attachment A of the PRG memo (response to question 5), "For an intermittent exposure, the portion of the total exposure frequency (EF) (i.e., days per week, days per year, etc.) that would occur for OU5 media should be determined. For the remaining portion of the total EF, the lead exposure point concentration (EPC) would be based on the receptor's non-site soil lead concentration (e.g., residence, childcare facility, schoolyard), to arrive at a TWA soil (or sediment) lead concentration. The OU5 PRG can then be calculated by knowing what the PRG is for the total receptor exposure and what the lead concentration is in the non-site soil." Thus, a time-weighted average (TWA) soil/sediment concentration should be calculated that considers both time spent at OU5 and time spent at the residence. We note that EPA uses a TWA in the "Addendum to Development of Human Health Risk-Based Preliminary Remediation Goals for Operable Unit 5, Version 1.2, Dated June 9, 2021" for General Public receptors (CH2M HILL, 2021b), and should use a similar approach, with the correct EF, here. EPA's current approach effectively assumes that Tribal members are exposed to sediments continuously, which does not accurately reflect Tribal Lifeways.

3. Based on the current definition of OU5, EPA is not including all plant dietary exposure media in the PRG analysis. These plant dietary exposure media are not included in any of the other OUs and thus, if not included in the OU5 analysis, they will be excluded from EPA's remedial investigation of the Site.

Comment: The estimation of risk due to consumption of gathered plants was limited to the "roots and bulbs" dietary exposure pathway (as identified by Harper, 2008), which EPA has defined as aquatic plants. Therefore, the calculated risk does not account for lead intake due to the consumption of other plants gathered from the Site (i.e., "greens and sweets"; "fruits and berries"). The available data for greens and sweets and fruits and berries demonstrate elevated contaminant concentrations that correlate with contaminated sediments (Abt, 2021). Therefore, there is a complete exposure pathway from sediments to these plants and subsequently the TLW receptors. This pathway indicates that these plants should be included in OU5.

4. If available, EPA should use site-specific contaminant exposure data and Tribal consumption rates to estimate risk due to the consumption of terrestrial dietary items.

Comment: During discussions with EPA, Abt recommended that EPA include all exposure media in the development of PRG values, including media sourced from within OU5 and outside of OU5. This includes dietary items, which are one of the main sources of lead exposure in the TLW scenario. From our understanding, EPA has taken this recommendation and included IEUBK's default values for dietary intake to represent terrestrial sources of lead in the diet. We appreciate that this update was made, however, we recommend the use of site-specific data and Tribal consumption rates for inclusion of terrestrial dietary inputs. Although more data is needed to understand tissue concentration for some terrestrial sources (e.g., deer), this approach would allow for inclusion of that data if sampling were conducted. Additionally, this approach could be repeated for development of cadmium and zinc PRG values, which do not have default dietary values, such as those for lead in the IEUBK. At the least, if EPA is including IEUBK's default values for dietary intake to represent terrestrial sources, we recommend that they state that in the PRG memo, and note that this is likely an under-estimate of terrestrial background lead exposure levels.

5. In developing lead PRG values, EPA identified a "representative watershed" for each receptor scenario and calculated the PRG using surface water and biota EPCs from that representative watershed.

Comment: Rather than using a representative watershed approach, EPA should develop simple regression models to estimate biota input values for PRG calculations. Site-specific data are available to develop regression models between sediment and aquatic foods. In fact, EPA developed a regression model between sediment and arrowhead root (Figure 1, Attachment 2) for all three COCs. These relationships were used to estimate tissue concentrations for cadmium and zinc and subsequently to develop PRG values for these COCs. It follows that the sediment-plant tissue relationship developed for lead could also be used to estimate the lead concentrations in aquatic plants at different sediment concentrations. Additionally, as shown in Abt's PRG Report, site-specific data are available to develop regression models for fish, shellfish, amphibians and plants (Abt, 2021).

If the PRG value falls between sediment concentrations in two watersheds, regression models will work better than EPA's representative watershed approach because no watershed would be representative and thus biota values would need to be interpolated between two watersheds. Additionally, EPA accurately notes that the representative watershed approach is further complicated if it is necessary to calculate PRG values at multiple blood lead level (BLL) threshold values since the PRG value changes at each BLL and thus the representative watershed may change as well. Development of regression models would not only be simpler but would also provide versatility. Versatility is especially important if developing multiple PRG values for each COC, as was done in the OU4 HHRA (CH2M HILL, 2006).

6. EPA indicates that the Tribal soil ingestion rate of 400 mg/d recommended in the Harper et al, 2007a, and used in the "*Quapaw Traditional Lifeways Scenario*" (Harper, 2008) is inappropriate to use as an input to the IEUBK. EPA states this is because 1) it "relies in large part" on outdated information in EPA's 1997 Exposure Factors Handbook, and 2) it is a reasonable maximum exposure (RME) value, rather than a central tendency.

Comment: We would like to clarify both of these points. First, the ingestion rate proposed by Harper of 400 mg/d (Harper, 2007a; 2007b; 2008) does not in fact "rely in large part" on the 1997 EFH (EPA, 1997). In "Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual", Harper et al. (2007b) presents an entire literature review on soil ingestion rates (see Attachment 1 of this comments memo, Appendix B of Harper et al., 2007b), and synthesized all the reviewed information to develop the 400 mg/d value. Specifically, Harper et al. (2007b) reviewed and synthesized EPA guidance, military guidance, as well as information from the literature on ingestion rates observed in suburban/urban populations (adults and children), and in indigenous populations. Harper et al. (2007b) did report the 400 mg/day value from EPA (1997), but they also summarized information from many other sources. For example, Harper et al. (2007b) reported that the US military assumes ingestion rates of 480 mg per field day, while the UN Balkans Task Force assumes 1 g per field day, and they interpreted a field day to be somewhat analogous to Tribal exposure levels. Notably, they summarized ingestion rates reported in the literature for indigenous populations of several grams per day. According to Harper et al. (2007b), Simon (1998) recommends using a soil ingestion rate for adults of 1g/d (1,000 mg/d) in wet climates, 2 g/d (2,000 mg/d) in dry climates, and 3 g/d (3,000 mg/d) for children. As noted above, Harper et al. (2007b) reviewed all this information and derived a value of 400 mg/d as a reasonable Tribal soil ingestion rate. This value is much lower than the upper end indigenous values from the literature and is meant to reflect a mix of low-contact days and higher contact days (e.g., days spent gathering roots, active at powwows, etc. vs rest days). Hence, it is not intended to be a RME as indicated by EPA, but rather a central tendency value for Tribal populations, based on a synthesis of information from guidance documents and published literature.

2. Development of Sediment PRGs for Cadmium and Zinc

7. In the development of PRGs for cadmium and zinc, EPA did not include several aquatic exposure pathways that contribute to risk in the TLW scenario. This includes ingestion of fish, shellfish, amphibian and semi-aquatic mammal as well as ingestion of drinking water. This contrasts with the development of the lead PRGs, which included all of these exposure routes.

Comment: The PRG values for all COCs should be evaluated using the same exposure scenario, including the same exposure routes and media, unless appropriate toxicological values are unavailable. It is confusing for a receptor (i.e., Tribal member, general public) to understand the risk associated with Site activities if the PRG values are developed using different exposure scenarios. Additionally, all three contaminants are present at all locations. The Remedial Action Objectives will address sediment as a whole and thus, while it is acceptable to present a range of PRG values, it is important that a sediment PRG value for each COC be developed for each exposure scenario. EPA provides multiple explanations for why inclusion of all aquatic dietary items is unnecessary and we address those in the comments below.

8. EPA concludes that the only aquatic food item that needs to be included in the PRG calculations for cadmium and zinc is aquatic plants. In Section 6.2.2 of the PRG memo, they state that "the development of PRGs focuses on cadmium and zinc in aquatic plants only, because cadmium and zinc in aquatic plants constitute more than 90% of the total [hazard index] HI associated with COC exposure through consumption of OU5 aquatic

food items." This is discussed further in Section 7.2.2 and Table 10 of the PRG memo, which present the hazard quotients (HQs) for sitewide data and Neosho River data.

Comment: In the PRG memo, EPA states that "aquatic plants constitute more than 90% of the total HI associated with COC exposure through consumption of OU5 aquatic food items." The HQ data in Table 10 show that aquatic plants account for 95% of total dietary HQ when an average of all the sitewide data (including biota from highly contaminated areas) are used to calculate risk. However, when risk is determined using concentrations for biota from less contaminated areas, risk from aquatic plants account for much less of the total dietary risk. For example, when a total dietary HQ is calculated using concentrations from Neosho River (a less contaminated river), aquatic plants account for only 22% of the total dietary HQ (Table 10). This indicates that the proportion of dietary HQ associated with aquatic plants decreases with decreasing sediment concentration. This is further supported by Figure 7C, which shows the HQ values for aquatic dietary items in Lost Creek, the second least contaminated watershed, and indicates that aquatic plants account for much less than 90% of the aquatic dietary HQ at this sediment concentration.

All dietary items should be included in the development of cadmium and zinc PRGs. This includes all aquatic food items (including greens and sweets and fruits and berries, see Comment 3) and all terrestrial food items.

9. EPA further justifies excluding other aquatic dietary items from PRG calculations by stating that "there are no apparent correlations between sediment and some biota" (pg. 13) including fish and raccoon.

Comment: Our analysis shows that there are correlations between sediment and most aquatic dietary biota including fish, shellfish, amphibians, and aquatic plants. As stated on pg. 13, Angelo et al., (2007) is a peer-reviewed study that established an empirical relationship between concentrations of COCs in sediment and in co-located freshwater mussels collected from the Spring River Basin. Additionally, Abt's PRG Report presents correlations between sediment and all riparian plant groupings (roots and bulbs, greens and sweets, and fruits and berries), as well as between sediment and fish (Abt, 2021). We note that EPA conducted a regression analysis for sediment and arrowhead root and recommend that EPA use regression models for the additional biota described above. We also recognize that regression analyses may not be appropriate for all dietary exposure media, for example, a correlation between sediment and raccoon is not apparent in the available data.

10. Re: The risk-based PRG values calculated by EPA for cadmium and zinc were developed including aquatic plants only and no other aquatic dietary items. EPA concludes that this approach is justified because empirical data for aquatic dietary items from the reference watershed (Lost Creek) result in a HQ between 2 and 3 for cadmium and zinc.

Comment: As stated on pg. 8, "the target HI is set at 1 for each COC." Thus, while we agree that a HQ value of 2 is not particularly large, the PRG values for cadmium and zinc do not meet the target HI of 1. It should also be noted that these HQ values only include risk from dietary items and do not include the other exposure routes including sediment/soil incidental ingestion and drinking water. Overall, the analysis presented on the HQs for Lost Creek do not seem to justify exclusion of other aquatic biota from the development of cadmium and zinc PRGs.

3. References

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Attachment 1: Appendix B from Harper et al., 2007b.

APPENDIX B

SOIL INGESTION RATE

Indigenous Soil Ingestion Rate = 400mg/d (all ages)

B.1 SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The indigenous soil ingestion rate is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous settings, pica and geophagia, and dermal adherence studies. It is also based on Columbia Plateau subsistence lifestyles with their higher environmental contact rates, and local climatic and geologic conditions.

The soil ingestion rate of 400mg/d for all ages is the upper bound for suburban children (EPA 1997) and within the range of outdoor activity rates for adults. Subsistence lifestyles were not considered by the EPA guidance, but are generally considered to be similar in soil contact rates to construction, utility worker, or military soil contact levels. However, it is lower than 480mg/d to allow for some low-contact days and balanced with many 1-gram days and events, such as root gathering days, tule and wapato gathering days, powwows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).

B.2 EPA GUIDANCE

EPA has reviewed the studies relevant to suburban populations and has published summaries in its "Exposure Factors Handbook" (1989, 1991, and 1997). In the current iteration of the "Exposure Factors Handbook"[1], EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39mg/day to 271mg/day with an average of 146mg/day for soil ingestion and 191mg/day for soil and dust ingestion. Based on these studies, EPA originally recommended a value of 200mg/day. EPA now recommends 100mg/d as a mean value for children in suburban settings, 200mg/day as a conservative estimate of the mean, and a value of 400mg/day as an

[1] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.

upper bound value (exact percentile not specified). Most state and federal guidance uses 200mg/d for children.

For adults, the USEPA now suggests a mean soil ingestion rate in suburban settings of 50mg/day for adults (USEPA 1997), which has been decreased from 100mg/d as recommended in earlier guidance. However, EPA says that this rate is still highly uncertain and has a low confidence rating due to lack of data. An adult soil ingestion rate of 100mg/day is most commonly used for residential or agricultural settings.

Other EPA guidance such as the Soil Screening Level Guidance[2] recommends using 200mg/d for children and 100mg/d for adults, based on RAGS HHEM, Part B (EPA 1991), or an age-adjusted rate of 114mg-y/kg-d.

A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 “Exposure Factors Handbook” for adults as it is “too speculative.” However, the soil screening guidance still recommends 330mg/d for a construction worker or other outdoor worker, and risk assessments for construction workers typically use a rate of 480mg/d (EPA 1997, Hawley 1985).

Other soil ingestion rates are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event[3] to approximate a non-average day for children, such as an outdoor day.

B.3 MILITARY GUIDANCE

The US military assumes 480mg per exposure event[4] or per field day. For military risk assessment, the US Army uses the Technical Guide 230 (TG) as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.[5] No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental US facilities or during deployment. Department Of Defense (2002)[6] recommendations for certain activities, such as construction or landscaping which

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[2] EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (http://www.epa.gov/superfund/resources/soil/toc.htm#p2), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 (http://www.epa.gov/superfund/resources/soil/ssg_main.pdf).

[3] MADEP (1992). Background Documentation For The Development Of An “Available Cyanide” Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

[4] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, “Exposure Factors Handbook,” Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480mg/d.

[5] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine. Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[6] Reference Document (RD) 230, “Exposure Guidelines for Deployed Military.” A Companion Document to USACHPPM Technical Guide (TG) 230, “Chemical Exposure Guidelines for Deployed Military Personnel,” January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

involve a greater soil contact rate, is a soil ingestion rate of 480mg/day. This value is based on the assumption that the ingested soil comes from a 50µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50mg/d) for a chronic average rate of 265mg/d.

The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day.[7]

B.4 STUDIES IN SUBURBAN OR URBAN POPULATIONS

Written knowledge that humans often ingest soil dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high inadvertent, based on studies of pica children (e.g., Kimbrough 1984). This triggered a great deal of research with industry (e.g., the Calabrese series) or federal funding (e.g., the DOE-funded studies of fallout and bomb test contamination).

Some of the key studies are summarized here. Other agencies (including the EPA[8] and California OEHHA) have reviewed more studies and provide more detail. To quote form OEHHA:

> There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil.[9]

In general, two approaches to estimating soil ingestion rates have been taken. The first method involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and in the soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are associated with large uncertainty due to their

[7] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.**un**ep.ch/btf/missions/september/dufinal.pdf

[8] http://www.epa.gov/ncea/pdfs/efh/sect4.pdf.

[9] California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion. http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf

somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

B.4.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. In particular, one study of soil ingestion from “sticky sweets” was estimated at 10mg to 1g/d (Day et al. 1975).

Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250mg/d. For outdoor activities from May through October, Hawley estimated the ingestion amount as 480mg per active day, assuming that 8 hours is spent outdoors per day, 2 d/week.

Other early tracer studies in American children (Binder et al. 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in all subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch rather than American children. Neither study included the trace minerals from food or medicine. A third study (van Wijnen et al. 1990) used the same approach, and was the first to include a consideration of camping and the presence or absence of gardens.

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicates a mean soil ingestion rate of 91mg/d, and a 90th percentile of 143mg/d.

Davis et al. (1990), in Calabrese’s laboratory, included an evaluation of food, medicine, and house dust as a better approximation of a total mass balance. As with the earlier studies, using titanium as the tracer results in estimates of large soil ingestion rates, while Al and Si tracers resulted in a narrower range of soil ingestion rates. However, Ti is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). This illustrates the difficulty of using mineral tracers to calculate mass balance and soil ingestion, but trace studies provide the most quantitative estimates.

Calabrese et al. (1989) based estimates of soil ingestion rate in children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in Amherst, Massachusetts. They used a method similar to Binder et al. (1986) but included an improved mass balance approach. They evaluated soil ingestion over eight days rather than three days, and collected duplicate samples of food, medicine, and house dust. In addition, the children used tracer-free toothpaste and ointment. The adult (n = 6) validation portion of the study indicated that study methodology could adequately detect soil ingestion at rates expected by children. Recovery data from the adult study indicated that Al, Si, Y, and Zr had the best recoveries (closest to 100%). Zirconium as a tracer was highly variable, and Ti was not reliable in the adult studies. The investigators conclude that Al, Si, and Y are the most reliable tracers for soil ingestion. This was also the first study to evaluate whether pica children were present in the sampled population; one diagnosed pica child was found.

Stanek and Calabrese (1995a) adjusted their 1989 data for the 64 children. The primary adjustment was related to intestinal transit time, which allowed an adjustment for clearance of minerals on days when fecal samples were not collected. They concluded that daily intake based on the “overall” multi-tracer estimates is 45mg/day or less for 50% of the children and 208mg/day or less for 95% of the children. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1–2268mg/d; the median (lognormal) was 75mg/d, the 90^{th} percentile was 1190mg/d, and the 95^{th} percentile was 1751mg/d. The known pica child was not included, and individual “outlier” results for individual tracers were also omitted. Even so, the range of rates is so large that it is evident that there are still methodological difficulties.

Stanek and Calabrese (1995a) also evaluated the number of days a child might have excessive soil ingestion events. An estimated 16% of children are predicted to ingest more than 1 gram of soil per day on 35–40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35–40 days per year.

Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study with data from Davis et al. (1990) and using a different methodology. This methodology, the Best Tracer Method (BTM), is designed to overcome intertracer inconsistencies in the estimation of soil ingestion rates. The two data sets were combined, with estimates as follows: 50^{th} percentile = 37mg/d, 90^{th} = 156mg/d, 95^{th} = 217mg/d, 99^{th} = 535mg/d, mean = 104mg/d ±758. Even with this method, they conclude that the large standard deviation indicates that there are still large problems with “input-output misalignment.” They also write that soil ingestion cannot even be detected, in comparison to food, unless more than 200mg/d is ingested, rather than at the lower rates they indicated in 1989.

Stanek et al. (2000) conducted a second study of 64 children aged 1–4 at a Superfund site in Montana, using the same methods from their earlier study, with three additional tracers. Soil, food, and fecal samples were collected for a total mass balance estimate. The home or daycare settings were not described, nor were the community conditions or the typical daily activities of the children, and 32% of the soil ingestion estimates were excluded as outliers. In addition, only soil with a grain size of 250µm or less was used; no explanation of concentration differences between large and small grain sizes were given (see discussion on dermal adherence), and no concentration data were included.

B.4.2 Studies in Adults

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese, and co-authors (1997) conducted a second adult pilot study (n = 10) to compare tracers. This study was done as a method validation, and was “not designed to estimate the amount of soil normally ingested by adults.” Each adult was followed for 4 weeks. The median, 75^{th} percentile, and 95^{th} percentile soil ingestion estimates were 1, 49, and 331mg/day, with estimates calculated as the median of the three trace elements Al, Si, and Y.

B.5 STUDIES IN INDIGENOUS POPULATIONS

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests, such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1992) evaluated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. Annual doses to individuals following an aboriginal lifestyle could result in annual effective dose equivalents of several mSv within contours enclosing areas of several hundred square kilometers. The most significant dose pathways are inhalation of resuspended dust and ingestion of soil by infants. Haywood and Smith constructed a table showing hours per week spent sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

> virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1gpd was estimated based on fecal samples of nonaboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aboriginals under camp conditions. In the absence of better information, a soil intake of 10gpd has been assumed in the assessment for all age groups.

They noted a “very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent.”

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of 500mg/d. This was based on the primary work of Haywood and Smith who “reported an average soil intake of 10,000mg/d in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia.” The authors state that:

> Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of 1,000mg/d was established from the fecal samples of the investigators who made field trips to the affected areas.
>
> It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported a maximum intake of 500mg/d for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average for the Marshallese people. Therefore, this work adopts 500mg/d as the average life-time intake of soil by the Marshallese.

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunting/food gathering/nomadic societies of 1g/d in wet climates and 2g/d in dry climates. He recommends using 3g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5g/d. These are all geometric means (lognormal) or modes (triangular distribution), not maxima.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that “the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined.”

B.6 GEOPHAGIA

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams 1997, Callahan 2003, Johns and Duquette 1991, Reid 1992). It also routinely occurs in primates (Krishnamani and Mahaney 2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the Philippines, New Guinea, Costa Rica, Guatemala, the Amazon and Orinoco basins of South America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan 2003, Johns and Duquette 1991).

> There are two types of edible clays, sodium and calcium montmorillonite[10]. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming, USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite, the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the Western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid 1992, Krishnamani and Mahaney 2000).

Krishnamani and Mahaney (2000) propose several hypotheses that may contribute to the prevalence of geophagy:

1. Soils adsorb toxins.
2. Soil ingestion has an antacid action.
3. Soils act as an antidiarrheal agent.
4. Soils counteract the effects of endoparasites.
5. Geophagy may satiate olfactory senses.
6. Soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette 1991). This is especially important in pregnancy and at high altitudes.

Several studies of geophagia in pregnancy have been done. In countries such as Uganda, where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may be very important as a mineral supplement,

[10] http://www.the-vu.com/edible_clay.htm

particularly iron and calcium during pregnancy (Abrahams 1997). One widely held theory suggests that iron deficiency is a major cause of geophagia[11]. Several reports have described an extreme form of geophagy (pica) in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of pica or a result of it. Because some substances, such as clay, are believed to block the absorption of iron into the bloodstream, it was thought that low blood levels of iron could be the direct result of pica. Some studies have shown that pica cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces pica (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C. Serum ferritin concentrations of pica women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their nonpica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less than those of nonpica women. Again, low ferritin and hemoglobin are hypothesized to result in pica.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother's secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines. Adjuvants are compounds that nonspecifically amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al was one of Calabrese's preferred tracers due to the assumption that it is inert at trace levels and not adsorbed (it is quite toxic at high levels).

B.7 ACUTE SOIL INGESTION AND PICA

There is a gradient between geophagy and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails,

[11] http://www.ehendrick.org/healthy/001609.htm

paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults; 10–32% of children aged 1 to 6 may exhibit pica behavior at some point[12]. LaGoy (1987) estimated that a value of 5gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 5000mg of soil per day but cautioned that the amount selected was arbitrary[13]. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25–60g soil during a single day. When a set of 13 chemicals were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

1. EPA (1997) recommends a value of 10g/d for a pica child.
2. Florida recommends 10g per event for acute toxicity evaluation[14].
3. ATSDR uses 5g/day for a pica child[15].

B.8 DATA FROM DERMAL ADHERENCE

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Although this

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12 http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors

13 Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: http://www.atsdr.cdc.gov/NEWS/soilpica.html

14 Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf.

15 For Example: El Paso Metals Survey, Appendix B, www.atsdr.cdc.gov/HAC/PHA/**elpaso**/epc_toc.html.

body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers from Kissel's laboratory are summarized here. Kissel et al. (1996) included reed gatherers in tide flats. The category of "kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35mg/cm^2 for 6 children and an average of 58mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66mg/cm^2 with an upper bound of >1mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers, and kids in mud had the highest overall skin loadings, up to 27mg/cm^2. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3mg/cm^2), followed by archaeologists, and several other occupations (0.15–0.1mg/cm^2). The higher skin loadings of reed gatherers, farmers, and gardeners are supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) said that variability in estimating soil ingestion rates using tracer elements was reduced when grain sizes of less than 250µm were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size, with particles above the sand-silt size division (0.075mm) adhering less than smaller sizes. Average adherences of 1.40mg/cm^2 for particle sizes less than 150µm, 0.95mg/cm^2 for particle sizes less than 250µm, and 0.58mg/cm^2 for unsieved soils were measured (see EPA 1992[16] for more details). Soil samples should be sieved and concentrations should be evaluated for sizes below 0.075mm.

A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil. Soil loading on various parts of the body is collected with wipes, tape, or rinsing in dilute solvents, which would generally collect the smaller particle sizes[17]. Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size <0.044cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size.

[16] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B
[17] Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2mm; silt = 1/256 to 1/16 mm; clay = <1/256mm.

B.9 DATA FROM WASHED OR UNWASHED VEGETABLES

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is an important source of radionuclides for grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

B.10 SUBSISTENCE LIFESTYLES AND RATIONALE FOR SOIL INGESTION RATE

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle is lived in close contact with the environment.
- Columbia Plateau winds and dust storms are fairly frequent, and incorporated into overall rate, rather than trying to segregate ingestion rates according to number of high-wind days per year, because low-wind days are also spent in foraging activities.
- The original Columbia Plateau lifestyle—pit houses, caches, gathering tules and roots—includes processing and using foods, medicines, and materials. This is considered but not as part of today’s living conditions.
- An average house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as powwows, horse races, and seasonal ceremonial, as well as private family, cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater.

- 400mg/d is based on the following:

  1. 400mg/d is the upper bound for suburban children (EPA); traditional or subsistence activities are not suburban in environs or activities.
  2. This rate is within the range of outdoor activity rates for adults (between 330 and 480); the soil contact levels of subsistence activities are more like those of construction, utility work, or military activity. However, the rate is lower than 480 to allow for some low-contact days. The consideration of the number of windy-dusty days does not further quantify air particulates.
  3. The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al. 1999), such as root gathering days, tule and wapato gathering days, powwows, rodeos, horse training and riding days, sweat-lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
  4. This rate is lower than Simon's (1998) estimate of 500mg/d and lower than the recommendations of 3g/d for indigenous children and 2g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles. For original housing conditions, a higher rate would be clearly justified; for today's housing conditions, a lower rate is adequate.
  5. This rate does not account for pica or geophagy
  6. Primary data is supported by dermal adherence data in gatherers and *kids in mud*. Tule and wapato gathering are kid-in-mud activities
  7. This rate includes a consideration of residual soil on roots (a major food category) through observation and anecdote, but there is no quantitative data.

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L.E.A.D. AGENCY, INC. LOCAL ENVIRONMENTAL ACTION DEMANDED

July 9, 2021

Janetta Coats: coats.janetta@epa.gov
Katrina Coltrain: coltrain.katrina@epa.gov

Re: Tar Creek Superfund Site Operable Unit 5 Human Health Preliminary Remediation Goals (PRGs) Technical Memorandum (Version 1.2). Public Comment Period ending 7-9-21.

Dear Ms. Coats,

This letter constitutes the comments for Local Environmental Action Demanded (LEAD) Agency, Inc., a 501(C)(3) Environmental Justice organization headquartered in Miami, Oklahoma. We are providing public comments via the EPA comment period referenced above.

LEAD would like to start by saying that our previous comments regarding the OU-5 Remedial Investigation document (RI) and the OU-5 Human Health Risk Assessment (HHRA) have, thus far, gone unanswered by the EPA. Moreover, our Freedom of Information Act Request, which asks for documents show what specific comments led EPA to this revised PRG, has also been stalled by EPA for months (in fact this entire time since the first PRG was withdrawn). Now we are asked to comment on this, revised, document with insight from EPA regarding our previous comments or what led to this revision.

LEAD, in addition, would like to state, for the record, that our community is confused by the comment periods offered by both EPA Region 6 and Region 7 over the same project area that Region 6 calls OU-5 and Region 7 calls the Lower Spring River Watershed that is in data gap analysis phase and a very different Conceptual Site Model (CSM), while covering the same watersheds in Ottawa County Oklahoma. We see two different CSMs presented by the two Regions investigating the same terrain, taking different approaches to impacted media and, yet Region 7 is behind Region 6 in that they are in the data gap analysis phase. The confusion is on the public to figure out how to respond to the needs of the two Regions for community input/comments.

Moreover, we are not only confused by the differing time tables, CSMs and approaches, we are confused by what Region 6 wants us to respond to with documents like this PRG 1.2. Our questions in EPA webinars about this seem to get answers that refer us to OU-4 for answers or, like in the case of this document, we find that some of our concerns will be answered in a coming document referred to as a "Proposed Plan" that will be coming out for public comment. To us, it appears that EPA documents out for public comment are fragmented approaches that ignore the reality that OU-4 and OU-5 are interrelated and further that when questions arise regarding these inter-OU concerns that EPA can't answer, EPA states that an answer will come in later documents. We find that EPA RPMs are also having difficulty answering our questions, even while attempting to do this dance!!

If this is confusing for EPA (both Regions when we ask), why are you burdening the community with this confusion? Your documents should be ready for our comments and questions! It would help if you would address our past OU-5 comments and engage us in OU-4 progress. We ask this every time we meet and in every comment letter.

We will now address certain points with the PRG 1.2 document for comments and questions:

"Remedial action objectives are medium-specific or OU-specific goals for protecting human health and the environment. They are used to develop cleanup alternatives. Media in OU5 are surface water, sediment, and aquatic plant and animal tissues." (EPA PRG 1.2)

1. **Our comment remains:** Why is OU-5 CSM only considering these media stated above and not also including riparian and floodplain areas, groundwater and air deposition? The Region 7 CSM does include these, as well as the others. We do not accept that OU-4 takes care of these media, because this is off-site of OU-4 and these are all different watersheds, except for Tar Creek, Elm and Fourmile Creeks. Springs are located along these watersheds that have not been identified and studied by EPA, for example. Groundwater discharge and re-charge zones need to be identified and make clear to the public for our comment in these documents. Air monitoring data, supposedly taken by the Quapaw Nation should either be made available to the public or new data be collected for the public knowledge. We know that the riparian and floodplains have been contaminated and the plants, foods that are harvested are contaminated. Previous studies presented by the tribes and LEAD bear that out. Why are they not relevant to OU-5?

2. In Table 2 of the Technical Memorandum, no chemicals of concern were identified for the sediment in Neosho River and Lost Creek. Only lead in sediment is identified in Lower Spring River. In discussing this aspect of Table 2, EPA states:

> [T]he lead exposure estimated ... at the reference watershed (Fourmile Creek, which represents background lead concentrations in sediment and surface water) also exceeds the target lead exposure criterion... Concentrations of lead in sediment and surface water at two of the watersheds (Neosho River and Lost Creek) are comparable to background concentrations; therefore, lead was identified as a final COC in all watersheds (Elm Creek, Tar Creek, Beaver Creek, and Lower Spring River) except these two watersheds.

3. Because lead levels in Neosho River and Lost Creek are comparable to background, it is likely these lead levels, like those at Fourmile Creek, exceed the target lead exposure criterion. Nonetheless, EPA declines to establish PRGs for lead in Neosho River and Lost Creek. While we understand the function of a background and that lead levels in this region tend to be higher than in other regions, we nevertheless maintain that in declining to set PRGs for lead in Neosho River and Lost Creek EPA fails to adequately protect the health of the community. We are very concerned with metals in Neosho River and what happens to them between the convergence with Tar Creek and the Twin Bridges State Park. We urge EPA to set PRGs for lead in both waterways – and to reevaluate the appropriateness of using a contaminated waterway as the background reference for sitewide remediation. In this regard, we ask EPA to compare Tar Creek's background with backgrounds from other sites with similar watershed characteristics and exposure concerns and identify off-site alternative backgrounds for LEAD/Community.

4. It is unclear how site cleanup will be staged and whether runoff from mine wastes on surrounding land is expected to significantly affect the long-term success of a sediment cleanup. This may be evaluated during the feasibility study. We request that during the feasibility study EPA discuss how long-term maintenance of sediment PRG levels will be evaluated.

   We believe it may be appropriate to set variable PRGs for sediment. Background values could be appropriate for areas where sediment is being washed downstream and deposited as soils due to flood scour. OU5 sediments could be deposited along creek shorelines or even on the Grand Lake shoreline. We ask that EPA identify stream reaches that are susceptible to flood scour and set stream-specific or stream reach-specific PRGs.

   Additionally, during numerous future flooding events OU5 sediments **will be** repeatedly deposited atop OU2 properties, remediated and unremediated alike. We ask EPA investigate the feasibility of setting OU5 PRGs that consider flood-borne contamination of OU2 properties.

5. There is substantial uncertainty in the protectiveness built into the model-derived PRG values. There are more contaminants present in sediment from Elm Creek, Tar Creek and Beaver Creek that may affect the potential toxicity of the sediments. Acid mine drainage and runoff (including from riparian and floodplains) could make metals in surface water and sediment more bioavailable. How it will EPA determine if sediment PRGs are suitably conservative to account for the multiplicative effects arising from exposure to multiple metals?

6. The ecological-based T10 PRGs are lower (more conservative) than most of the Human Health PRGs presented in the Technical Memorandum. It seems appropriate to conduct a

literature-based evaluation of other sediment PRGs from comparable sites to assist EPA in selecting PRGs that are suitably conservative (protective). Please compare site-specific PRGs with PRGs from other sites with similar watershed characteristics and exposure concerns and provide to LEAD/Community.

7. It is not clear if or how ΣPEC-Q could be used as one of the final PRGs. How will this PRG affect cleanup decisions and post-remedial levels of cadmium, lead and zinc in sediment. Please address flood scour in the erosion of a riverbed or riverbank by fast-flowing floodwater.

8. The presented ecological (T10) PRGs are several times greater than background levels for cadmium (16 times), lead (3 times) and zinc (4 times). The Technical Memorandum indicates that these ecological PRGs would also protect human health for cadmium and zinc. LEAD agrees with the Quapaw Nation that the sediment PRGs should be the same as background levels. Setting PRGs to be the same as background could be more protective. LEAD does not accept that time and funding should dictate cleanup levels where human & ecological health is at stake!

LEAD wants to thank the EPA Region 6 for the opportunity to provide our comments during this comment period. We do look forward to your response and our active participation toward the cleanup of our area. Should you have further questions, please do not hesitate to ask. We would like to say how grateful we are to Region 6 for including us in discussion about these documents via webinars, assistance EPA staff has given us through this process and would like to express our gratitude for the TASC Program, without which, we would be handicapped in this process.

Sincerely,

Rebecca Jim
Executive Director

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: July 13, 2021

SUBJECT: Review of: ***Tar Creek Superfund Site Operable Unit 5 Remedial Investigation EPA Region 6 Remedial Action Contract EP-W-06-021 Task Order No. 0079-RICO-06TS, June 9, 2021***

CC: File

The Tribe performed a rapid review of the aforementioned document. Concerns and errors or omissions associated with this work have been understood by the QTO for a long-time. The QTO requires a response to the following comments as well as those raised in all of the attachments.

1. After more than 40 years involvement in the TCSFS, more than 20 of which have been on behalf of the QTO, EPA finally concludes that, in order to be protective of the QTO and comply with QTO's ARARs, PRGs need to be set to pre-release baseline conditions (PRB, the condition prior to man-made contamination).[1,2]

2. The HHRA supporting the determination that PRGs must be set to PRB, is flawed in several ways, but more importantly, the HHRA is not multi-pathway, is not multi-media, and is not multi-contaminant in nature. This concern was raised in

[1] The line of reasoning supporting this decision for superfund sites on Tribal lands is described in Attachments 1 and 2.
[2] The amount of time and resources wasted on these sites is the subject of a current research paper.

comments on the workplan, way back in 2004, (see Attachment 3 and Attachment 4, for problems with the final HHRA). This realization results in all abiotic media (i.e. soil, sediment, surface water, ground water, and air) requiring PRGs being set to PRB [3].

3. The implications of the PRGs being set to PRB are immense with major consequences. More importantly, upstream sources of multi-media contaminants feeding the QTO reservation also need to meet PRB. This means that areas within Treece, KS may require a second cleanup. Such work will be costly and was clearly foreseeable (see Attachment No. 5).

4. Since the PRB or BGTV's estimated by EPA are now the PRG, and since superfund risk is clearly associated with COCs in minor excess these levels[4], it is clear that error associated with the estimation of PRBs/BGTVs will result in detrimental human health affects to future users. This means that such errors have large human health implications. The QTO is on record voicing this concern and voicing the concern with EPA's estimation of these BTVs (See Attachment No. 6).

5. This document memorializes EPA use of the antiquated IEUBK risk model as well as antiquated methods of assessing risk[5].

6. OU5 is nearly entirely on QTO lands. This PRGs memo contains much unnecessary discussion on the general public--a population that does not and never will reside there. This is yet another example of a major waste of time and valuable resources.

[3] The document is silent on this issue.
[4] Many of the COC's exceed allowable daily intake concentrations.
[5] Single COC, associated with a single medium, following a single pathway. Clearly not a cumulative multi-pathway human health risk assessment, and clearly does not meet the requirements of CERCLA.

Attachment No 1. Berrey, J.[6], Kent, T.[7], Kirschner, F.E. [8] and, Harper, B. 2019[9], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[6] Chairman of the Quapaw Nation
[7] Environmental Director, Quapaw Nation
[8] Senior Scientist, AESE, Inc.
[9] Senior Scientist, AESE, Inc.

QUAPAW NATION

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

February 12, 2019

Mr. Steven Cook,
Deputy Assistant Administrator
Office of Land and Emergency Management
U.S. Environmental Protection Agency, Region 6
1200 Pennsylvania Ave. NW
Mail Code: 5101T
Washington DC 20460

RE: Superfund Task Force Recommendations

Dear Mr. Cook,

I am taking this opportunity to thank you and EPA for creating the Superfund Task Force in 2017 to review Superfund sites across the nation, primarily for the purpose of prioritizing cleanups and identifying innovative approaches that would help expedite and streamline remediation of these sites. As the primary stakeholder affected by the Tar Creek Superfund site, the Quapaw Nation believes that reevaluating how the Superfund process is working at larger, seemingly intractable sites, is a worthwhile endeavor. That's why I have joined with our consulting scientists (Dr. Fred Kirschner and Dr. Barbara Harper) and our Environmental Director (Tim Kent, PG) in writing the enclosed White Paper (**Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources**) which summarizes recommendations for streamlining the Superfund process at mining Superfund sites in Indian Country. As you may be aware, utilizing the current Superfund process is time consuming and expensive and always achieves the same results at tribal Superfund sites: tribal lands require cleanup to pre-contamination conditions. By following the recommendations in the White Paper, EPA would address one of the primary findings of the referenced Superfund Task Force which is to identify innovative approaches that would help expedite and streamline remediation at legacy sites.

Please look over the enclosed White Paper and feel free to share it with your staff. If you have any questions, or if you would like to discuss the issues presented, please let me know and I will arrange a conference call or even a face-to-face meeting. Again, thank you for elevating the discussion of persistent obstacles to cleanups at these sites.

Sincerely,

John Berrey, Chairman
Quapaw Nation

cc: Dr. Fred Kirschner
Dr. Barbara Harper
Tim Kent, PG

Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources

By

Chairman Berrey, Quapaw Nation

Tim Kent, Environmental Director, Quapaw Nation

Dr. Frederick Kirschner, Quapaw Nation

Dr. Barbara Harper, Quapaw Nation

Prior to delving into RI/FS studies, EPA needs to realize that the goal of any tribe is to restore its traditional cultural practices and lifeways, including returning to a subsistence level of hunting, gathering, and fishing. It is our experience that this reasonably anticipated future land use (RAFLU) is not contemplated by EPA, DOI, USDA, the State, and their consultants early in the Superfund Process.

By definition, a reservation is reserved by the Federal Government, the land owner, to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. In nearly all superfund cases, the current demography is highly influenced by contamination and subsequent advisories or other institutional controls that reflect reduced land uses that have resulted from current contaminated conditions. Therefore, current demographic conditions and land uses should not be considered as RAFLU in any of the risk assessments. Again, the lands were reserved by congress or executive order for traditional Tribal uses—not current uses that have evolved as a consequence of widespread contamination.

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land <u>must be cleaned up for Unrestricted Land Use</u>. This concept of identifying the RAFLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to attempt to compartmentalize a given problem, it is very important that EPA and the designer of the Remedial Action Alternatives realize that maximizing lands for RAFLU is an overarching goal—capping a lake bottom or capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.[1] Similarly, a brownfield remediation is, by definition, a land use restriction that should not be a final remedy unless the land owner is fully cognizant of the residual contamination and

[1] This discussion applies to Brownfield designation as well.

is in agreement that a brownfield land use is a permanent deed restriction with associated responsibilities of monitoring and informing its members/constituents.

This RAFLU goal does not only apply to lands held in trust by the federal government. Tribes are repatriating lands with the ultimate goal of re-acquiring all nearby non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect the Tribe's members for unrestricted uses (including but not limited to historical traditional cultural practices), these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

It is extremely important that EPA view the remediation of sites containing widespread contamination[2] in the broader context of the environmental justice initiatives that have been developing in the recent years. In the past, the implementation of CERCLA has predominantly focused on cleaning-up organic chemical-related sites that affected large populations of U.S. citizens. Remediation of these sites has been viewed from the narrow lens of protecting the "general public", without taking into account the needs of more sensitive populations. For the citizens of the Tribe, who have the right to "live close to the land" and are forced to live on a parcel of land termed a reservation, creating a remedy that is sufficiently protective of human health poses a new challenge—the resources affected by the site must be much more clean than lands used by members of the General Public, since the General Public is much less exposed than those who rely on the land for sustenance. This is particularly true of mine sites, because, unlike organic chemicals that can be expected to eventually degrade, metals and minerals do not degrade.

As discussed, above, If RAFLU is not contemplated by the parties, the initial preliminary remedial objectives/remedial action objectives (PRGs/RAOs) employed to evaluate the Remedial Action Alternatives (and all of their supporting documents) will not be protective of a Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. Again, in general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture.

It is our experience working with tribes on superfund issues throughout the U.S., that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of site contamination[3]. In essence, the Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. Our experience at more than 10 Tribal-related sites indicates that cleanups are being driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an applicable relevant or appropriate requirement (ARAR)[4]. In many cases, a true non-risk based cleanup is required (i.e. pre-mining baseline/background becomes the PRG/RAO/ARAR). This is clearly the case for mine sites in which a fingerprint of naturally

[2] For example mining-related Superfund sites such as Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, or Yerington.
[3] Contaminants released from the site that are in excess of natural pre-mining background (PMB).
[4] Non-Tribal ARARs are designed to protect the General Public, not Citizens of the Tribe.

occurring contaminants was present prior to mining[5]. In such instances, PMB is clearly the PRG/RAO, since PRPs cannot be forced to cleanup to conditions better than PMB. Finally, in practice, since excavators cannot "see the PRG/RAO contour line on the ground", and since excavators benefit more financially when more dirt is moved, all near-mine areas that do not rely on institutional controls are generally more protective than estimated.[6]

This concept of cleaning-up a site based on "what the site looked like prior to contamination" also is not new to the U.S. For example for uranium mill sites, the US Nuclear Regulatory Commission (NRC) employs the concept of cleaning-up to As Low as Reasonably Achievable (ALARA, 10 CFR 20) and at a minimum 25 mrem incremental risk above background. Since the difference between 25 mrem and background for a mill tailings pond is on the order of 1 foot of cover soil, the majority of sites are cleaned up to PMB. The DOI NRDAR regulations 43 CFR 11 revised in 2008 also acknowledge the restoration goal[7] for any site, regardless of Tribal involvement is pre-release baseline (PRB)[8]. Finally, when a reasonable U.S. citizen is asked what he or she believes to represent cleanup, the result is invariably "what the area looked like before it was contaminated"—not to a level that results in no more than risk 10^{-6} chance of premature cancer from residual contamination or exceeding hazard indices (HI) as specified under Superfund (40 CFR 300).

In Summary, for mine sites affecting Tribal resources, drawing the conclusion that PMB is the PRG/RAO early in the process enables the focus of work to shift from estimating risk and back-calculating PRG/RAOs, to determining PMB and mapping the nature and extent of contamination. This early realization will result in saving large sums of time and money, makes EPA to appear more credible to the public, speeds the cleanup process while not costing the responsible parties additional sums, and more rapidly brings closure to the RI/FS and NRDA processes. Aspects of the Baseline Human Health Risk Assessment may still be necessary to assess residual risk associated with each general action evaluated in the FS and to ensure that the proposed alternative is protective of human health and the environment. However, this work can come later.

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[5] This is the case for most mining-related superfund sites, including the Midnite Uranium Mine, Leviathan Mine, Sulphur Bank Mercury Mine, etc.

[6] Large sites Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, etc., where residual mine contamination and concomitant residual risk will occur in distal waterways for geologic time, require the pathway from source areas to be fully broken via removal action.

[7] From 43 CFR Part 11, Subpart A § 11.14 Definitions. (e) Baseline means the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred. (ll) Restoration or rehabilitation means actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided, when such actions are in addition to response actions completed or anticipated, and when such actions exceed the level of response actions determined appropriate to the site pursuant to the NCP.

[8] PRB and PMB are synonymous.

Attachment No 2. Review of: Tar Creek Source Material Operable Unit 4 Remedial Action Input Parameters for the Calculation of Preliminary Remediation Goals for Ecological Receptors February 19, 2018.

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: August 11, 2019

SUBJECT: Review of: ***Tar Creek Source Material Operable Unit 4 Remedial Action Input Parameters for the Calculation of Preliminary Remediation Goals for Ecological Receptors February 19, 2018.***

CC: File

This memo constitutes a review of the aforementioned document. A few general comments follow. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

General Comments

1. Table 14 poorly depicts the outcome of the study as well as the effect on the preliminary remediation goal (PRG).

Table 14. Comparison of Proposed PRGs to PRGs Calculated in Lockheed Martin (2016) and Current OU4 ROD PRGs
Source Material Operable Unit 4 Remedial Action
Tar Creek Superfund Site, Ottawa County, Oklahoma

ROD RGs (mg/kg)	Species and Analyte	PRGs -Lockheed Martin (2016)	PRGs (Proposed)
	Woodcock		
Cadmium	Cadmium	24.5	33.7
10	Lead	1260	1033
Lead	Zinc	7800	7609
500	*Shrew Species*		
Zinc	Cadmium	19.8	51.7
1,100	Lead	15800	10651
	Zinc	14900	5554

Notes:
OU4 = Operable Unit 4
ROD = Record of Decision
PRG = Preliminary Remediation Goals
RGs = Remediation Goals
mg/kg = milligrams per kilogram

We have revised Table 14 to reveal the magnitude of the proposed changes in terms of multiples of the ROD values, based both on the Lockheed 2016 data as well as changes proposed by this study.

Table 14 revised. Comparison of Proposed PRGs to PRGs Calculated in Lockheed Martin (2016) and Current OU4 ROD PRGs **based on the lowest value for either the Woodcock or the Shrew.**

Analyte	ROD RGs (mg/kg)	Lockheed (2016) (mg/kg)	Mult of ROD	PRGs (Proposed) (mg/kg)	Mult of ROD
Cd	10	19.8	**2.0**	33.7	**3.4**
Pb	500	1260	**2.5**	1033	**2.1**
Zn	1100	7800	**7.1**	5554	**5.0**

If the dietary consumption percentage is correct[1], earthworms are driving exposure. It is clear that the earthworm BAFs for Cd, Pb, and Zn, at catholic 40, are much lower than observed over a much broader area. This is likely due to an artifact associated with differences in experimental design, geochemistry, or chance. Regardless, EPA is attempting to apply this "fortuitous result" site-wide is clearly inappropriate when

[1] This assumption cannot be confirmed nor denied based on this study design.

we now believe BAFs may not be stationary (in space or perhaps time). Based on the quality/quantity of data and the subsequent experimental design, changing the ROD-based region-wide PRGs is unwarranted and unsupportable.

Although it could appear be advantageous to employ the proposed PRGs from a clean-up cost standpoint, the Tribe cannot support revising the site-wide PRGs for these COCs based on the current information. From a construction standpoint, we do not feel the proposed PRGs necessarily benefits the reduction in construction costs for two reasons: First, EPA does not understand where "any of these COC PRG isopleths are located on the ground, and second, even if EPA had perfect knowledge of where these isopleths reside, dirt movers could not strictly follow these contours anyway.

Therefore, for reasons described above, we still cannot support the proposed PRGs or spending resources on any more work related to fine-tuning PRGs, when we really cannot fine-tune the locations of these isopleths.[2] Our lack of support for tinkering with PRGs was first stated in our February 26, 2018 review of an earlier document on this issue (Attachment 1).

2. PRGs are tied directly to reasonably foreseeable future land uses (RFFLU). The Quapaw Nation raised issues regarding RFFLU as early as 2005. We also pointed-out that since the area is perpetually federally reserved for the benefit of the Quapaw Tribe, the RFFLU has to be flexible to encompass all future potential uses. This means that the land and appurtenant resources must be free of restrictions. In other words cleanup goals should be those for unrestricted land use. The Tribe has given this issue much thought in the past few years, leading us to draft the whitepaper entitled: **Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources** (Attachment 2). The aforementioned whitepaper provides guidance on selection on the necessary remediation goal.

3. The report is directed at terrestrial receptors. Therefore the title should focus the reader on "Soils" since sediments, bedrock, and other solids are "source materials" that are not considered in this work.

[2] The Tribe is currently reviewing "Remedial Investigation Report Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma." One of our major comments on this document is that regardless of the millions spent on studies, EPA has not gained any further knowledge of importance to the Feasibility Study regarding the nature and extent of contamination since 2005, and perhaps much earlier, when investigators concluded that the contaminants are numerous and pervasive and the extent of contamination is not contained in OUs 4 or 5. FS designers require three-dimensional delineation of the nature and extent of contamination in order to estimate volumes of materials requiring removal or treatment. The OU5 RI does not meet these FS requirements.

4. As stated in various past communications, EPA's attempt to compartmentalize the site via OUs is not likely protective and could result in unnecessary large expenditures of valuable resources. For example, soils become sediments after annual overland flow events (i.e. soils cross OU boundaries). Therefore, if aquatic receptors are more sensitive to concentrations of sediments, soils should not exceed sediment PRGs. This fact also has been a concern of the Tribe predating 2005, and has direct implications on the effectiveness of the remedial action for OU4 (upland soils).

5. It has been EPA's position that the PRG for Zn will be ecological receptor-based, since ecological receptors are currently believed to be more sensitive to excess Zn than humans. However, recent work is indicating dietary zinc is capable of altering the digestive tract microbiota and decreasing the resistance of humans to infection. Work on gut-flora is a new frontier; however, its implications could have direct consequences on the effectiveness of the remedy if not fully considered early. For example, it is quite likely that excess Zn could be more of a human health concern than an ecological concern. Ultimately future workers will conclude that the approach described in Appendix 2 should have been adopted and pursued early in the RI/FS process.

Attachment No 1. February 28, 2018 memo entitled Review of: "Tar Creek Source Material Operable Unit 4 Remedial Action Input Parameters for the Calculation of Preliminary Remediation Goals for Ecological Receptors, January 23, 2018"

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: February2 8, 2018

SUBJECT: Review of: ***"Tar Creek Source Material Operable Unit 4 Remedial Action Input Parameters for the Calculation of Preliminary Remediation Goals for Ecological Receptors, January 23, 2018"***

CC: File

This memo constitutes a review of the aforementioned document. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan. A few General comments follow.

General Comments:

1. Proposed changes to the PRGs are predominantly affected by radical changes to the "Dietary Percentages for Prey Item" as well as the proposed changes to the estimated concentration of COCs in the prey items. These changes result in in PRGs that are less protective than the other nearby sites/OUs in Jasper County. The Tribe realizes that the receptors are only models that represent current/post remedy feeding guilds in the area. The Tribe also realizes that EPA is tasked with a tough position of being required to protect human health and the environment, comply with ARARs, while attempting to reduce costs associated with soil removals and replacement. Hypothetically speaking, If the Tribe wishes, PRGs/RAO's based on human health may be relaxed to fit a non-highest and best use scenario; however, PRG's based on ecological receptors cannot be relaxed.

   Therefore, the Tribe cannot support this work since it is clear that EPA is attempting to back-fit the "science" to support a less protective cleanup value in order to reduce the cost of the remedy—a subordinate criterion.

2. The *(new)* recommended dietary percentages are as follows:

   - American woodcock – 82% earthworm, 15% other invertebrate, 3% plant
   - Shrew – 19% earthworm, 73% other invertebrate, 8% plant

   As discussed in the General Comment No. 1 these are radical changes from the previous estimates and it is clear that would reduce on PRG/RAOs that are less protective than those defined in the ROD or in RODs for nearby sites/OUs. It is also clear that the cited new information regarding these proposed dietary percentages are not of the quantity nor the quality to illicit the proposed changes. The Tribe recommends that the PRG/RAOs enumerated in the ROD remain unchanged

3. Explicit definitions of BCFs and BAFs are required in this TM. The Tribe realizes that both are transfer coefficients from soils/pore water either to tissue (BAF) or the whole receptor (BCF); however, it appears that BAFs (depurated, generally represent soil to tissue transfer) are used to model up-chain transfer to the shrew and the woodcock. If this is correct, it appears that the gut content (i.e. predominantly soil) has been omitted in the calculation of up-chain transfer.

4. This statement is inconsistent with the title. The TM appears to go far beyond evaluating just catholic 40 work.

Page 1; Paragraph 2:

> *Recent studies have been performed that include development of site-specific preliminary remediation goals (PRGs) for the Catholic 40 property located within OU4. The purpose of this technical memorandum (TM) is to review the input parameters used to derive these PRGs and provide a summary of results and recommendations. This TM has been prepared to address stakeholder comments on the version dated August 18, 2017 and to add some additional supporting information.*

Attachment No 2. Berrey, J.[3], Kent, T.[4], Kirschner, F.E. [5] and, Harper, B. 2019[6], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[3] Chairman of the Quapaw Nation
[4] Environmental Director, Quapaw Nation
[5] Senior Scientist, AESE, Inc.
[6] Senior Scientist, AESE, Inc.

Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources

By

Chairman Berrey, Quapaw Nation

Tim Kent, Environmental Director, Quapaw Nation

Dr. Frederick Kirschner, Quapaw Nation

Dr. Barbara Harper, Quapaw Nation

Prior to delving into RI/FS studies, EPA needs to realize that the goal of any tribe is to restore its traditional cultural practices and lifeways, including returning to a subsistence level of hunting, gathering, and fishing. It is our experience that this reasonably anticipated future land use (RAFLU) is not contemplated by EPA, DOI, USDA, the State, and their consultants early in the Superfund Process.

By definition, a reservation is reserved by the Federal Government, the land owner, to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. In nearly all superfund cases, the current demography is highly influenced by contamination and subsequent advisories or other institutional controls that reflect reduced land uses that have resulted from current contaminated conditions. Therefore, current demographic conditions and land uses should not be considered as RAFLU in any of the risk assessments. Again, the lands were reserved by congress or executive order for traditional Tribal uses—not current uses that have evolved as a consequence of widespread contamination.

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land <u>must be cleaned up for Unrestricted Land Use</u>. This concept of identifying the RAFLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to attempt to compartmentalize a given problem, it is very important that EPA and the designer of the Remedial Action Alternatives realize that maximizing lands for RAFLU is an overarching goal—capping a lake bottom or capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.[1] Similarly, a brownfield remediation is, by definition, a land use restriction that should not be a final remedy unless the land owner is fully cognizant of the residual contamination and

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This RAFLU goal does not only apply to lands held in trust by the federal government. Tribes are repatriating lands with the ultimate goal of re-acquiring all nearby non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect the Tribe's members for unrestricted uses (including but not limited to historical traditional cultural practices), these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

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[3] Contaminants released from the site that are in excess of natural pre-mining background (PMB).
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occurring contaminants was present prior to mining[5]. In such instances, PMB is clearly the PRG/RAO, since PRPs cannot be forced to cleanup to conditions better than PMB. Finally, in practice, since excavators cannot “see the PRG/RAO contour line on the ground”, and since excavators benefit more financially when more dirt is moved, all near-mine areas that do not rely on institutional controls are generally more protective than estimated.[6]

This concept of cleaning-up a site based on “what the site looked like prior to contamination” also is not new to the U.S. For example for uranium mill sites, the US Nuclear Regulatory Commission (NRC) employs the concept of cleaning-up to As Low as Reasonably Achievable (ALARA, 10 CFR 20) and at a minimum 25 mrem incremental risk above background. Since the difference between 25 mrem and background for a mill tailings pond is on the order of 1 foot of cover soil, the majority of sites are cleaned up to PMB. The DOI NRDAR regulations 43 CFR 11 revised in 2008 also acknowledge the restoration goal[7] for any site, regardless of Tribal involvement is pre-release baseline (PRB)[8]. Finally, when a reasonable U.S. citizen is asked what he or she believes to represent cleanup, the result is invariably “what the area looked like before it was contaminated”—not to a level that results in no more than risk 10^{-6} chance of premature cancer from residual contamination or exceeding hazard indices (HI) as specified under Superfund (40 CFR 300).

In Summary, for mine sites affecting Tribal resources, drawing the conclusion that PMB is the PRG/RAO early in the process enables the focus of work to shift from estimating risk and back-calculating PRG/RAOs, to determining PMB and mapping the nature and extent of contamination. This early realization will result in saving large sums of time and money, makes EPA to appear more credible to the public, speeds the cleanup process while not costing the responsible parties additional sums, and more rapidly brings closure to the RI/FS and NRDA processes. Aspects of the Baseline Human Health Risk Assessment may still be necessary to assess residual risk associated with each general action evaluated in the FS and to ensure that the proposed alternative is protective of human health and the environment. However, this work can come later.

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Attachment No 3. Review of "DRAFT: Work Plan Tar Creek OU4 RI/FS Program, Prepare for The Tar Creek Respondents and the U.S. Environmental Protection Agency by AATA International, Inc., October 2004"

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-924-0184
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Environmental Division Director,
Quapaw Tribe of Oklahoma (O-Gah-Pah)

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: August 7, 2004

SUBJECT: Review of ***"DRAFT Data Gap Analysis Report Tar Creek 0U4 RI/FS Program Prepared for the Tar Creek Respondents and the U.S. Environmental Protection Agency by AATA International, Inc., June 2004"***

CC: Chairman John Berrey
File

This memo constitutes a review of the aforementioned document. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Preferred Plan. In places, conflicts in logic also have been identified. General comments are followed by specific comments.

General Comments

1. The sequence of RI/FS events depicted in the report is not in logical order. Figure 1 is a flowsheet for the generalized RI/FS process. Some of these important steps or requirements have been overlooked or have been omitted.

The sequence of events should be as follows:

A. Develop the preliminary conceptual site models (PCSMs) for: (1) Contaminant Transport & Fate (CT&F) ; (2) ecological exposure; and (3) human exposure. These are separate devices and are usually compiled for each OU (especially if each OU or other management unit is defined geographically).

   The CT&F PCSMs and the Ecological Exposure CSMs can probably be developed today; however, the human exposure CSMs will need to be informed by human health risk scenarios developed for the QTO and downstream tribes. A short discussion on HH exposure scenarios and their uses follows. The Spokane Scenario (Attached) is used as an example:

> An exposure scenario is a representative portrayal of the interactions between human and/or ecological receptors and their immediate environment. Exposure scenarios include development of exposure factors required to estimate dose to the target receptor. For Tribal applications, the scenario may reflect traditional subsistence lifeways, or a current lifestyle that combines traditional and modern activities and foods related to a localized area.
>
> The Spokane Scenario identifies general exposure pathways specific to the Spokane lifestyle, and key resources that the Spokane people use from the area affected or potentially affected from the mine site. It includes the activities that Spokane members undertake during their residence on nearby allotments, their food acquisition (hunting, gathering, fishing, pasturing livestock, and gardening with irrigation) on and off their allotments, as well as activities associated with their cultural heritage and identity (for instance: gathering basket-making materials, pit cooking, and ceremonial uses of places or resources affected by the mine).
>
> The Scenario, along with knowledge of contaminant transport and fate, are the bases of the Conceptual Site Models (CSM) and the Reasonable Maximally Exposed Individuals (RME). **CSMs are visual accounting tools used to develop work plans for site characterization activities such as :(1) development of data requirements (DQOs); (2) identifying or verifying contaminants of concern; (3) determining the nature and extent of contamination by identifying culturally relevant and ecologically important natural resources; (4) development of sampling plans for media and biota; and (5) evaluation of existing data.** The scenario will also aid in developing and reviewing: (1) the plans for the screening-level and full risk

assessments; (2) the draft screening-level and full risk assessment documents after they are prepared; and (3) remedial goals and objectives (what risk level will be achieved). Ultimately, the Scenario also can be used to determine residual risk once the remedy has been completed.

The approach to developing this site-specific scenario starts with a general description of the local ecosystem where people live or will return after cleanup and use the resources (Note that some of these resources are being used today even though they are known to be contaminated). A general understanding of what people do there and what resources are available for their use provides the basis for developing preliminary exposure factors. The Scenario describes things that traditional people do to survive or subsist in the local ecosystem include hunting, gathering foods and medicines, fishing, making material items, farming or gardening, raising livestock, irrigating, and various cultural activities. Subsistence means living off the land, or obtaining most necessities directly from the land, rather than working for money to purchase them.

Exposure factors for direct exposure pathways include exposure to biotic and abiotic media (air, water, and soil), resulting in inhalation, soil ingestion, water ingestion, and dermal exposure. Biotic-related pathways include food, medicine, tea, and materials. There are many unique exposure pathways that are not accounted for in scenarios for the general public, but may be significant to people with certain traditional specialties such as pottery or basket making, flint knapping, or using smoke, smudges, paints and dyes.

B. Once all of the PCSMs have been prepared, an exhaustive list of studies are developed to determine pertinent parameters such as transfer rates between "boxes" on the PCSM (e.g. flux between ground water and surface water, sediments to air, etc. in all locations represented by the CSM). This exhaustive list of studies identifies the Data Needs and subsequent Data Quality Objectives.

C. Existing data are then compared to the data Needs and DQOs. Figure 2 has been included to demonstrate this process. Shortfalls in this exercise are termed **data gaps.** Note that this step in the process as described here occurs immediately *after* the studies have been designed and before the data have been reviewed.

D. Studies are designed to fill the data gaps are then prioritized and marshaled as necessary.

In summary, each discipline or component of the RI/FS (e.g. Contaminant Transport and Fate, Baseline Human Health Risk Assessment, and Ecological Risk Assessment) has different data quality requirements or objectives (DQO's). This document attempts to identify "data gaps" prior to identifying all data requirements associated with each discipline, or each component of the RI/FS. As such, the majority of the conclusions made in this document are incorrect, premature, and inconsistent with the logical processes defined in the NCP. Moving ahead without considering the data gaps in multi-disciplinary comprehensive manner could result in a major irretrievable waste of time and money.

The Tribe would also like to point-out that there are several "ongoing" studies and it is ot clear as to how the results of these studies will be accommodated in an RI/FS.

2. The reservation is intended to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. The current demography is highly influenced by contamination and subsequent advisories and institutional controls designed to mitigate for current conditions. Therefore, current demographic conditions should not be considered as post-remediation land use (PRLU) in any of the risk assessments.

3. Although the report concludes that all flotation wastes and jig wastes (chat piles) must be managed/removed, fluxes of contaminants and chemical conditions governing CT&F and export of COCs to the unsaturated and saturated zones of the zone and ground water flow systems must be understood for EACH pile.

   As expected a significant positive correlation exists between particle size and effective concentration measured for the solid phase (e.g. soils and sediments). This means that particle size is probably a viable indirect tool for characterizing mine waste piles and their transition zones with respect to the soil-phase; however, no equivalent correlation exists for a single parameter and the mass-flux issuing from the base of each pile. This means that each pile and its associated groundwater flow system beneath and within each pile will require characterization in order to determine the positive (or negative) consequence on the ground water flow system associated with removing and remediating each pile.

4. The ultimate goal of the FS will include prioritization of removals of each waste pile (or unit) based on risk-reduction associated with removal of each feature, should be a major goal once the wastes have been characterized, the DQOs have been achieved for all disciplines (See General Comment No. 1) and risk has been calculated. This goal should be discussed somewhere in the document.

5. The document indicates that both the BHHRA and BERA will be completed by EPA (First mentioned on Page v). As discussed before in General Comment No. 1, DQO's cannot be developed without input from these disciplines.

6. For this site, which involves several Native American Tribes, typical PRG's/RAOs/ARARs will not be protective. Therefore, any sample designs based on the attainability of PRG's/RAOs/ARARs that are designed to protect the general population will not be applicable here (i.e. any study that uses these "standards", designed for the general population, to falsely and incorrectly screen-out COCs, media, pathways, or exposure areas) and will only complicate matters later on in the process when the BHHRA has been completed and it is "discovered" that ARARs, PRGs, and PRAOs are not protective of the Tribes.

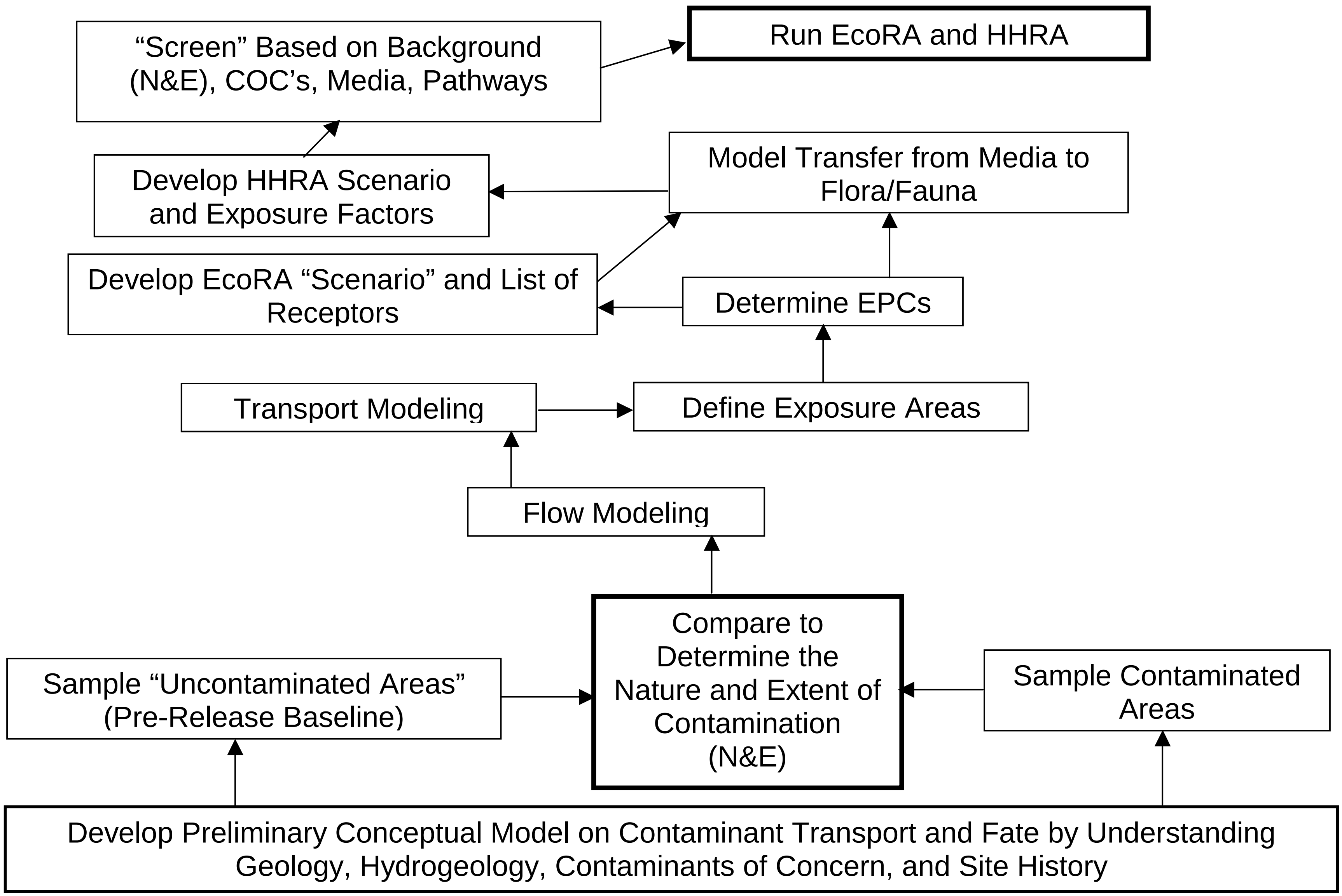

Figure 1. Generalized RI CERCLA process.

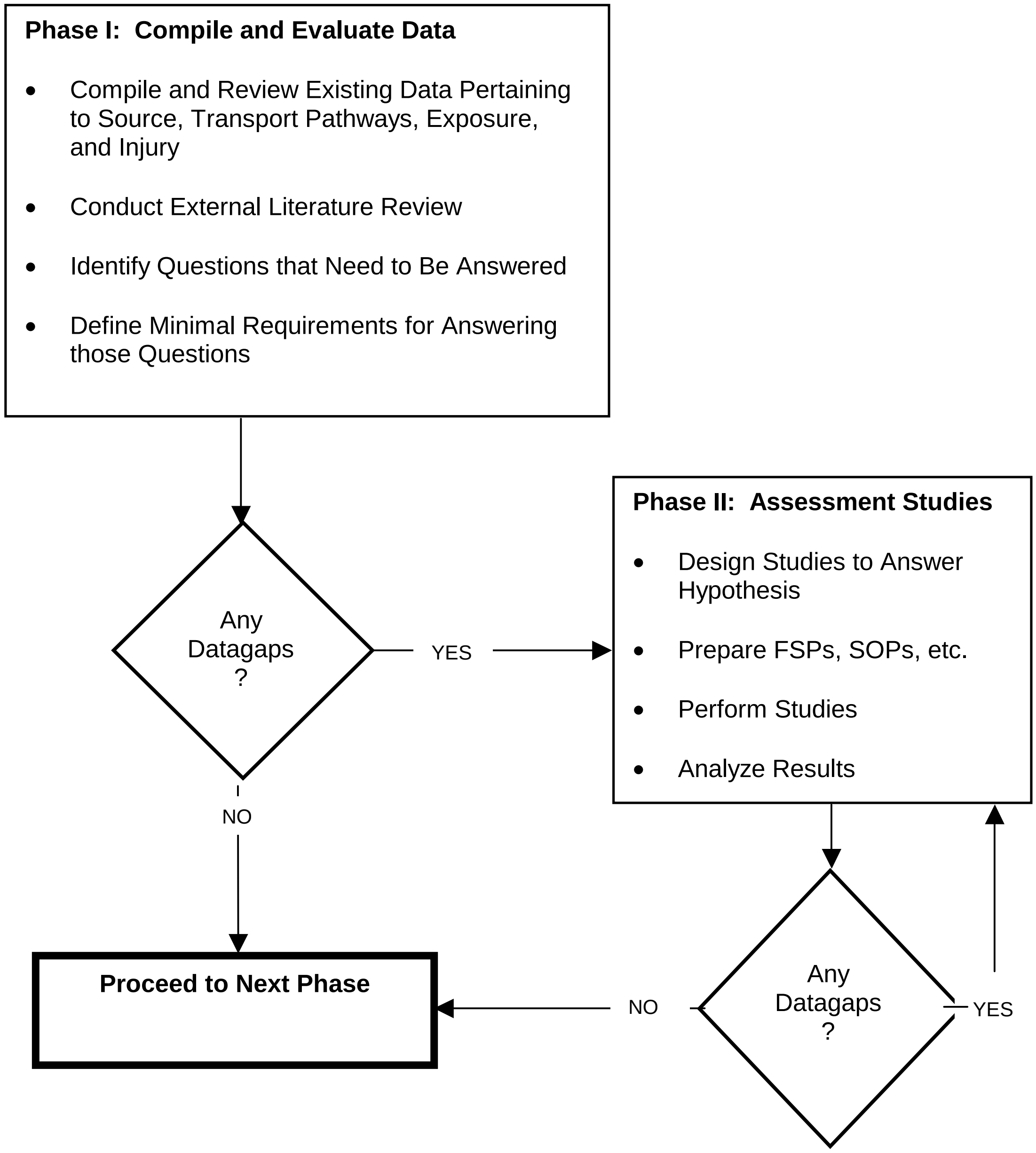

Figure 2. Phased assessment approach. Note that this process occurs for each process depicted within each "box" in Figure 1.

Specific Comments

1. Page i; Executive Summary; Paragraph 1:

A definition of OU4 needs to be included at the beginning of this section.

2. Page i; Executive Summary; Paragraph 1; Last Sentence:

> "The RI/FS for OU4 will address contamination from former milling and mill ***residues,*** and smelter wastes deposited at the Site." [Emphasis added.]

Recommend using the term "wastes" instead of residues when describing mine and mill wastes. Mine or mill "residues" can be construed much more broadly than just the solid and liquid mine and mill wastes.

3. Page i; Executive Summary; Paragraph 2; Last Sentence:

> "These existing data were evaluated with respect to OU4 RI/FS requirements."

This statement is incorrect. The data requirements have not been developed at this time. See General Comment No. 1.

4. Page i; Executive Summary; Paragraph 3; List:

"The tasks conducted for the DGA included:

1) a compilation and organization ***of all relevant data,*** documents, and publications pertinent to 0U4 and the District into a relational database and project website;
2) ***analysis and evaluation of the existing data to determine if the information could be used,*** including a quality assurance review and statistical analyses on air quality, mill residues, and transition zone soils data from the District;
3) ***identification of anticipated data needs for the RI/FS;***
4) **identification of the data gaps** that need to be addressed to meet RJ/FS requirements;
5) **defining the Data Quality Objectives** for the additional data needs; and,
6) preparation of the DGA report that characterizes the resources, summarizes the existing data, and identifies the data needs for the RI/FS."

[Emphasis added.]

This list demonstrates that the analytical sequence is not in logical order (See General Comment No. 1).

5. Page i; Executive Summary; Meteorology and Air Quality:

This entire section is devoted to air quality—not meteorology. Meteorologic data are necessary for CT&F modeling.

6. 4. Page ii; Executive Summary; Meteorology and Air Quality; Paragraph 1:

> "Air quality from the District was found to be ***similar or better than air quality data from Tulsa, Oklahoma.*** Analysis of the data from the nine studies conducted in the District indicated that air transport of lead, cadmium or zinc (COPCs) from mine and mill residues and smelter wastes ***is not a significant pathway for COPC exposure. The existing meteorology and air quality data satisfy the RI/FS and risk assessment data requirements.*** " [Emphasis added.]

Comparative evaluation criteria for the site is pre-mining baseline conditions—not contaminated areas such as Tulsa, OK.

The significance of the pathway cannot be determined until all of the DQO's (including selection of COPCs) have been developed for all of the disciplines. For example, this conclusion cannot be drawn until the aforementioned Exposure Scenario has been developed and the HHRA CSM has been developed. Once this has been accomplished, it is anticipated that the ingestion of dust on native vegetation will be a complete and significant pathway.

From this discussion and the current inability to determine if existing data meet the ultimate DQOs, it cannot be determined if the existing data satisfy RI/FS requirements.

7. 4. Page ii; Executive Summary; Geology; Paragraph 1:

> "The geological data show that the ore deposits throughout the District are of the same type and composition, and that they were formed during the same geological events. The existing information on geology is sufficient to meet the needs of the RI/FS."

Although the ore bodies *may* be somewhat grossly similar, it is hard to believe that the waste-piles are the same type and composition without three-dimensional statistical characterization of each pile. Such a characterization would include a broad range of COPCs—not the short list containing only Pb, Zn, Cd, and As often described in the report.

Although not necessarily discussed or described in this document, CT&F modeling of the ground water flow system and unsaturated zones will ultimately be necessary. Geology will form the foundation of such models.

Again, until the DQO's have been developed and the data have been reviewed in light of the DQO's, the conclusion that the "information is sufficient" is erroneous at this time.

8. Page ii; Executive Summary; Mine and Mill Residues and Smelter Wastes; Paragraph 1:

> "The physical and chemical properties of chat from numerous chat piles has been well characterized from analysis of over 1500 samples. Statistical analyses comparing the mean concentrations of cadmium, lead and zinc in bulk chat and in similar particle size fractions showed that there were no significant differences in chat between the Site and the Cherokee County Site."

The seemingly large number of surficial samples does not necessarily indicate the degree to which all of the piles have been characterized (especially at depth). The fact that no statistical difference was observable does not mean that in reality there is no difference. The only conclusion that can be drawn is that the current experimental design does not enable differentiation between piles. Again, until all of the DQO's have been developed, conclusions with respect to useability, adequacy, or completeness can be drawn.

9. Page iii; Executive Summary; Mine and Mill Residues and Smelter Wastes; Paragraph 2:

> "Vegetative [*sic*] chat has lower COPC concentrations than non-vegetative chat. The concentration of COPCs in remilled chat is also generally lower than bulk chat."

Note that the apparent negative correlation between density of vegetation on waste piles and concentration of the three COPCs has been attributed, elsewhere within the document, to dilution by leaf liter and other organics.

Phytotoxicty of the vegetation is another variable that should be explored.

10. Page iii; Executive Summary; Mine and Mill Residues and Smelter Wastes; Paragraph 3:

> "However, flotation tailings throughout the District have similar physical and chemical properties as they have a homogenous particle size range, they were derived from the same type of ore in the same geologic formation, and were processed with similar milling technologies. The overall conclusion is that flotation tailings from all three Sites may be used to characterize the nature of COPCs in tailings at Tar Creek."

In general the Tribe agrees with the conclusion that "flotation tailings from all three Sites ***may*** be used to characterize the nature of COPCs in tailings at Tar Creek." [Emphasis added]. However, even if indeed there is a close correlation between all COCs and some statistical parameter that represents the particle size distribution for each pile, it still remains that all of the tailings ponds have not been statistically classified.

The seemingly large number of surficial samples does not necessarily indicate the degree to which all of the ponds have been characterized. Also it is probable that inter-variability of COPCs sampled from different tailings ponds is probably related to the number of times the tailings have been reworked (note jig and flotation tailings and chat wash were routinely mixed, pg 56-57.), recovery efficiencies associated with each reworking, and amount of material that have been leached and transported downward into the pile. If samples from different generation tailing ponds have been included in a single "population" of tailings ponds (i.e. have not been classified based on generation), it is quite likely that the variability of COPCs is quite high, even though the samples have been sieved. For instances in which the variability is falsely high due to misclassification, it may appear that one cannot discriminate between tailings of different generation or between piles from different districts.

Again, the fact that no statistical difference was observable does not mean that in reality there is no difference. The only conclusion that can be drawn is that the current experimental design does not enable differentiation between tailings. Again, until all of the DQO's have been developed, conclusions with respect to useability, adequacy, or completeness cannot be drawn.

11. Page iii; Executive Summary; Mine and Mill Residues and Smelter Wastes; Paragraph 5:

> "The key data needs, associated data gaps, and tasks to be implemented to fulfill the data needs for mine and mill residues and smelter wastes are summarized as follows:"

Note that requisite data needs (DQOs) and data gaps have not been developed at this time. Therefore, these conclusions recommendations are premature and therefore not necessarily correct. See General Comment No. 1.

- Defining the physical and chemical characteristics of mine, mill and ***smelter residues*** to support the risk assessments and FS planning through analysis of the existing data along with new data to be collected as part of the RI will define the nature of COPC contamination;

The nature and extent of COPC contamination is determined by comparing predicted pre-mining baseline conditions to current conditions—not by characterizing physico-chemical characteristics of the wastes.

- Determining the location, area, and volume of current mine and mill residues, and smelter waste accumulations at the Site through analysis of the March 2004 aerial imagery of the Site and ground truthing during the reconnaissance will identify the extent of COPC contamination;

Although historical photographic analyses should prove useful for gross characterizations, comprehensive pile by waste pile characterization will be necessary to enable risk-based removal prioritization. Such characterization will be necessary to determine the nature and extent of contamination of the subsurface caused predominantly by liquid-phase releases.

- Determining the location and area of the foot print of former residue accumulations that have been excavated and removed to determine the extent of contamination through comparisons of historical aerial imagery with the new imagery of the Site;

These remnant areas will need to be characterized as described above.

"

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- I
- The sampling of chat and flotation tailings specified in the AOC exceeds the requirements based upon the data gap analysis."

This conclusion is not necessarily correct and cannot be evaluated at this time. See General Comment No. 1.

12. Page iv; Executive Summary; Soils; Paragraph 1:

> "The concentration of metals return to background levels in less than 300 feet from residue piles **in nearly all cases unless there are other sources such as mechanical redistribution, lead-based paint, or smelter sources.**"

Sampling results driving this conclusion are likely dependent on the sampling depth selected. Assuming that the main transport pathway away from the source is from surficial processes such as wind erosion and runoff, it would appear that the thickness of this deposition zone of contaminated material within the TZ would also correlate with distance, thinning with distance from the source. Depending on requisite depth of the sample, dilution of the contamination will increase with distance from the source. However, from a human health risk stand-point, the receptor is probably obtaining his/her exposure only from the upper portion of the TZ (non-diluted portion of TZ). In summary, the results of this exercise are probably an artifact of the sampling depth dictated in the sampling SOP. It is quite likely that the "TZ" would be interpreted to be much larger if a very shallow depth is selected. Conversely, the "TZ" would be interpreted to be much smaller if a relatively deeper sampling depth is selected.

13. Page iv; Executive Summary; Soils; Paragraph 1:

> "To evaluate the COPCs and to allow the evaluation of remediation alternatives, **a practical outer limit for the Transition Zone (TZ) soil needs to be determined,** which could then be applied to the definition of all TZ soils at the Site." [Emphasis added.]

Each pile should be characterized separately for CT&F purposes. Note that the emphasized portion of the previous comment (Specific Comment No. 10), indicates that this relationship for the TZ is not consistent. It also appears that previous investigators have invoked a myriad of posterior explanations for instances in which such relationships have been identified to have failed. In order to identify such failures (or prove that the TZ is consistent with the developed relationship) it is necessary to first characterize each pile.

It is also worthy to note that only surficial soils have been characterized. The vertical distribution of COPCs beneath contaminated zones also much be characterized.

14. Page iv; Executive Summary; Soils; Paragraph 2:

> "The following data needs, associated data gaps, and tasks to be implemented to fulfill the data needs for soils have been identified:

Note that as discussed elsewhere herein, requisite data needs (DQOs) and data gaps have not been developed at this time. Therefore, these conclusions recommendations are premature and therefore not necessarily correct. See General Comment No. 1.

- Determining concentrations of lead, cadmium, and zinc in TZ soils adjacent to a representative number of chat piles and tailings ponds through acquisition of new TZ soils data during the RI field program;

Again, the list of COPCs will not be determined until the PCSMs have been developed and individual studies have been designed by representatives of the different disciplines. See General Comment No. 1.

- Analyzing lead, cadmium, and zinc concentrations in yard soils of residences located in the rural areas of the Site not sampled during OU2 by obtaining new data during the RI field investigations;

Again, the list of COPCs will not be determined until the PCSMs have been developed and individual studies have been designed by representatives of the different disciplines. See General Comment No. 1.

- Nature and extent of contamination (if any) of soils at the former Ottawa smelter site by sampling soils at the former smelter site.

- The sampling of soils specified in the AOC exceed the requirements based upon data gap analysis."

This conclusion is not necessarily correct and cannot be evaluated at this time. See General Comment No. 1.

15. Page iv; Executive Summary; Groundwater; Paragraph 1:

"Groundwater issues were addressed in OU1 and are not the focus of OU4."

As the relationship between piles and tailings ponds is described in Specific Comment No. 6—these features are both sources of ground water and sources of mass (COPCs) to the ground water flow system. In essence the CT&F occurring along the ground water "pathway" is a major pathway that connects OU1 to OU4. Evidently, such interactions were not evaluated and remediated during the RI/FS for OU1. Therefore, this omission must be rectified in the RI/FS for this OU (OU4).

16. Page v; Executive Summary; Surface Water; Paragraph 1:

"Surface water resources have been **extensively** investigated in the District. Surface water issues at the Site were investigated as part of the RI/FS studies in OU1 and are **not the focus of OU4**."

As is the case with groundwater discussed in Specific Comment No. 13, evidently characterization of sources of water and COPCs to surface water also was not the focus of OU1. This means that each potential source such as a tailings pile or tailings pond will need to be evaluated as part of this OU (OU4).

17. Page v; Executive Summary; Surface Water; Paragraph 1:

> "The only surface water issue to be addressed in OU4 is estimating the amount of metal loadings from mill residues to nearby receiving waters."

It appears that estimating the flux and concentration of all COPCs from ALL to both groundwater and surface water sources will be necessary. Again, these conclusions are premature and will not be resolved until the DQO's have been developed and the data gaps have been identified.

> Determination of metal loading rates to surface waters from mine residue accumulation is necessary for the FS to allow for an evaluation of the effectiveness of various alternatives at reducing metal loadings to the receiving streams from the mine accumulation materials.

The Tribe fully agrees that it is necessary to know or estimate the metal "loading rates" (flux) AND concentrations from each source to each medium in order to make informed decisions related to proposed alternatives in the FS as well as prioritize features for remediation in the construction phase. However, currently it appears that this discussion falls short in that it only describes "receiving streams"—ground water has been excluded.

> The DGA analysis indicates that chat pile seepage and runoff is a minor contributor of COPCs **to surface waters compared with groundwater inputs;** however, a new study will be conducted using modern instrumentation and automatic samplers to provide a more accurate assessment of the contribution of COPCs from mill residues to surface water."
> [Emphasis added.]

As with all of the other media, it appears that this DGA is making conclusions with respect to DQOs, prior to development of the DQOs (See General Comment No. 1). The DGA also concludes that ground water "inputs" [to surface water] are more significant than surface seepage AND runoff. However, this conclusion cannot be drawn because the relative contributions are not known at this time. For example, it is quite likely that the groundwater contamination is related to both ARD produced in the bedrock flow systems as well as ARD discharging from the base of each pile. To date, flux and concentration of COCs for both components is unknown.

18. Page v; Executive Summary; Sediments; Paragraph 1:

> "**Sediments were addressed as part of OU1**. The data need for sediments is to quantify the amount of sediments and associated COPC concentrations derived from stormwater runoff of chat piles to Site streams." [Emphasis added.]

This conclusion is not necessarily correct and cannot be evaluated at this time. It is quite likely that different disciplines will have different DQOs (especially sieve-size and sampling density). See General Comment No. 1.

19. Page v; Executive Summary; Flora and Fauna:

The DGA does not attempt to address pertinent COCs in aquatic and terrestrial vegetation. It appears that vegetation was inappropriately screened-out based solely on speculation on the degree of bioconcentration of a single COC in *some* plants.

The Tribe utilizes the roots, stems, and leaves of aquatic and terrestrial plants. Exposure associated with plant gathering and harvesting activities is generally determined via sampling the different parts of a variety of plants. Differentiation between tissue accumulation and external accumulation is generally determined by performing analyses on washed and unwashed replicates. For example, assuming for the moment that a single COC "X" is indeed not bioconcentrated in root tissue of plant "Y"; however, assume that COC "Y" *is* bioconcentrated in Tulle root tissue. Analysis of washed and unwashed root samples are likely to reveal that COC "Y" is greater in the washed sample than the unwashed sample and that COC "X" is higher in the unwashed sample (due to exclusion and subsequent concentration in the soils surrounding the roots) than in the washed sample. Another example is sampling and analyzing replicate samples of washed and unwashed leaves. The difference between the replicates is attributable to dust that has adhered to the leaves.

20. Page vi; Executive Summary; Flora and Fauna; last paragraph:

> "The effects of mine discharge and mill residue seepage/runoff to surface waters on aquatic organisms were previously addressed in OU1 and will not

> be considered for the OU4 RI/FS investigations."

Again, this conclusion is erroneous. See Specific Comment No. 15

21. Page v; Executive Summary; Demography and Land Use:

> "The EPA will obtain the appropriate demographic data for use in the human health risk assessment. The data need for land use is an updated Site map for the RI, FS and risk assessments."

See General Comment No. 2.

22. Page v; Executive Summary; Data Quality Objectives:

> "Data quality objectives (DQOs) were developed for OU4 to identify the quality of the data necessary to support the RI, the risk assessments, and the remedy selection and evaluation process for the FS."

See General Comment No. 1.

23. Page 1; Introduction; Bullet List:

> The objectives of the RI for OU4 include:
>
> - Identification of the nature and **extent of accumulated mine, mill and smelter residues** and affected soils at the Site;

Media contaminated by these residues also must be characterized. In order to do this it will be necessary to compare current and pre-release distribution of COPCs.

> - Definition and quantification of the transport of lead, zinc and cadmium from residues to air, water and soil;

Exposure point concentrations for the different COPCs for each of the RAs will also be necessary. Note that the list of COPCs or COCs for the BHHRA cannot be determined at this time. See General Comment No. 1.

> - Collection of necessary information to support the human health and terrestrial ecological risk assessments for this OU; and,

Again, the DQOs for this exercise as well as other have not been developed; therefore, data gaps are unknown at this time.

- Collection of necessary data to support and evaluate remedial alternatives to address risks to human health and the environment associated with lead, zinc and cadmium from accumulated mine and mill residues and smelter wastes.

This document speculates on data gaps associated primarily with CT&F—not any of the gaps (or DQOs for that matter) associated with the RA's. Moving ahead without considering the data gaps in multi-disciplinary comprehensive manner could result in a major irretrievable waste of time and money.

24. Page 2; Introduction; Third Paragraph:

> "The purpose of the DGA is to identify, compile, organize, analyze and summarize the substantial amount of data that exist from the District that are pertinent to the OU4 RI/FS, **and to identify data gaps** that need to be addressed to meet Rl/FS requirements."

This cannot and should not be attempted until all of the data needs have been defined. See Comment No. 1.

> A thorough analysis of the existing data helps avoid duplication of previous efforts and leads to an RI/FS that is more focused.

As demonstrated in General Comment No. 1 and elsewhere herein, this statement is false. In fact this entire document will need to be rewritten once all of the data needs and DQOs have been identified and agreed upon. Preparing this document without considering the data gaps in multi-disciplinary comprehensive manner has resulted in a waste of time and money.

> The DGA identifies any additional data gaps that are required to satisfy Rl/FS requirements, including:
>
> - additional data needed to characterize the site, refine the conceptual model, define source areas of chemicals of principal concern **(COPC);**
> - refinement of the potential pathways of COPC migration, potential receptors, and associated exposure pathways;
> - development and evaluation of remedial action alternatives;
> - refinement of the preliminary remedial action objectives; and,

- description of the Data Quality Objectives (DQO' s) for any additional data needed to satisfy RI/FS requirements."

This statement is incorrect see General comment No. 1.

25. Page 2; Introduction; Last Paragraph:

> "The similarities among the Jasper, Newton and Cherokee County Sites with the Site makes much of the data obtained in the Kansas and Missouri Rl/FS studies applicable to OU4."

Although this may be somewhat true, the useability of such data will not be known until steps outlined in General comment No. 1 have been completed.

26. Page 10; Methods:

See General Comment No. 1.

27. Page 11; Data analysis and Evaluation; Paragraph 2:

> "A quality assurance (QA) review was conducted to confirm the validity of the data utilized in the analysis. Data collected for Superfund investigations must meet Quality Assurance Project Plan (QAPP) requirements. Therefore, data compiled from the RJ/FS studies conducted at the Jasper County, Missouri Site, Cherokee County, Kansas Site, and the Tar Creek, Oklahoma Site were considered valid."

Although the QAPP may have ensured meeting of DQOs for these other OUs or sites, this premise is not necessarily correct and will have to be evaluated at a later date. See General Comment No. 1.

28. Page 12; Data Analysis and Evaluation; Paragraph 2:

> "Statistical analysis of COPCs for mill residues and TZ soils was performed by Jim zumBrunnen, Associate Director for the Center for Applied Statistical Expertise, Colorado State University, using the SAS statistical software program. The statistical methods utilized for the analysis of the air quality, chat, flotation tailings and transition zone soils data and SAS outputs are detailed in Appendix 2."

Again, a reanalysis will be warranted once COPCs, data needs, and DQOs have been developed. See General Comment No. 1.

29. Page 12; RI/FS Data Gaps/Data Needs:

See General comment No. 1.

30. Page 12; Data Quality Objectives:

See General comments No. 1 and 6.

31. Page 13; Meteorology:

From a CT&F point of view, the Meteorologic data are antiquated and incomplete. Evapotranspiration, flood frequency, etc, will also be needed. Other data gaps will be identified by other disciplines (See General Comment No. 1).

32. Page 16; Air Quality:

> "A quality assurance review of the data from the nine studies was performed. Air quality data from the following studies were considered valid because they were performed under a Quality Assurance Project Plan (QAPP) as mandated by CERCLA: KDHE 1983 (TSP and metals), Dames and Moore 1993a., Midwest Environmental Services unpublished, CDM Federal Programs *1995,* Dames and Moore 1995, and Brown and Root Environmental 1997. The remaining studies (Irwin, 1971; OSDH, *1983;* KDHE, 1983; CH_2M-Hill, 1986) described in Table 3 were either not performed using formal sampling protocols or used a study design that had specific objectives that prevented the use of standard protocols. While results from these studies were valid for their purposes, their contribution to comparative analysis of the air quality in the District is limited."

It is quite probable that the DQOs for OU4 will differ from DQOs developed for the previous studies. Therefore the useability of the data cannot be concluded at this time (See General Comment No. 1).

33. Page 25; Air Quality:

> "In summary, a total of ten air quality studies for TSP, PM-b, and metals have been conducted across the District (including TCAMP), most often in support of Superfund documentation efforts. Predominantly, these air quality studies were designed to determine the ambient air concentrations of particulates and metals adjacent to chat piles, tailings ponds, and mining-disturbed lands. These studies were summarized in the preceding sections and demonstrate that, with few exceptions, air quality in the District does not violate any air quality standards. Air quality data from the Site show that levels of lead, TSP and PM-10 samples are consistently below the NAAQS."

This entire section, along with these conclusions, suffers two main problems besides those already described. First, the criterion for comparison is not Tulsa, OK other within the district, or any other area suffering from air quality problems (see specific Comment No. 5). Second, although locations appear to comply with ARARs for the general population, such standards are undoubtedly not protective of the Tribe (See General Comment No. 6). Therefore, it is incorrect to prematurely screen-out further work based on achieving these types of ARARs (See General Comment No. 1)

34. Page 25; Air Quality; Data Needs:

> "Air quality data are needed for the RI to determine the nature and extent of COPC in windblown particles from mill residues. **However, analysis of the existing air quality data show that air transport of COPC from mill residues is not a significant transport mechanism from the residue accumulations.** Air quality data are needed for the FS in evaluating the effectiveness of remedial actions on air quality. Air quality data are needed for the Human Health Risk Assessment (HHRA) to evaluate the risks to residents in the area." [Emphasis added]

Air is the first medium discussed and analyzed in the current data gap analysis process followed throughout this document. This analysis and summary fully demonstrate the problems associated with the current process being out of logical sequence (See General Comment No. 1). For example, nothing can be said for data needs, DQOs, and data gaps related to the BERA and BHHRA—all the reports conclude is that data are need. Another example is that the air-pathway is being prematurely screened-out based on CT&F concerns that are likely to be erroneous for several reasons—two of which follow. The first is that even though the air pathway may contain low concentrations of COPCs, accumulation of certain particle sizes (those capable of being re-suspended) via depositional buildup over large time periods is likely. Specific Comment No. 10 summarizes another problem that could lead to the false conclusion that the air-pathway is incomplete or insignificant.

It also should be noted that current meteorological data including current ET data will be necessary for future CT&F modeling. However, such data gaps are not identified nor described.

35. Page 26; Air Quality Data Gap Analysis:

See General Comment Nos. 1 & 6

36. Page 27; Physiography; RI/FS Data Needs:

It would appear that digital rectified orthophotos would be helpful in generation of an accurate base map.

37. Page 34; Geology; RI/FS Data Needs:

> "The Tar Creek OU4 RI/FS has the following data needs for geology:
>
> - General geological framework of the Site (including a generalized geology map).
> - Stratigraphy of the rock formations (including a stratigraphic column).
> - Detailed description of the ore-hosting rock formation.
> - Appearance (strike and dip, shape and size), mineralogy and mined reserve of the ore deposits at Site."

In order to understand the relative contribution to COPCs in ground water associated with changing hydrogeologic and hydrogeochemical conditions the underground workings, it may be necessary to perform CT&F modeling for these zones. If indeed this is true, a fairly thorough understanding of the three-dimensional nature of hydrostratigraphic units and their boundaries will also be necessary. Again it is too premature to conclude any thing with respect to data gaps or data needs at this time (See General Comment No. 1).

38. Page 37; Mine and Mill ***Residues*** and Smelter Wastes; Last Paragraph:

> "While most chat at the Site was remilled at least once, many chat piles in Kansas and Missouri were not re-processed."

This statement indicates that their probably is an inherent variability between chat piles as well as the tailings ponds depending on the degree and time that the piles were reworked. This knowledge undermines the credibility of attempting to treat all chat piles alike. See

Specific Comment No. 10.

39. Page 38; Mine and Mill ***Residues*** and Smelter Wastes; Third Paragraph:

> "Therefore, mine waste rocks are not considered a significant potential COPC source."

Depending on the release characteristics (governed predominantly by surface area to bulk volume ratio, mineralogy, and degree of decrepitation) and hydrogeologic setting, mine waste rock can be a significant contributor. Again it is too premature to screen out this media (See General Comment No. 1).

40. Page 38; Mine and Mill ***Residues*** and Smelter Wastes; Last Paragraph:

> "The ore deposits in the District were processed utilizing similar technologies, mainly gravity separation with flotation. It was, therefore, postulated that the general physical and chemical properties of the mine and mill residues are similar throughout the District."

The underlying assumptions that the mill efficiencies and mill heads are similar is rather questionable. The fact that both portions of tailings piles and portions of ponds were likely reworked (piling new tails on top of old tails) also undermines the credibility of this generalization.

41. Page 40; Mine and Mill ***Residues*** and Smelter Wastes; Last Paragraph:

> "The main issue is to determine whether the chemical composition (zinc, lead and cadmium) of the chat and flotation tailings from the nearby Cherokee County Site, Kansas and Jasper County Site, Missouri are statistically similar to the chemical composition of the chat and flotation tailings obtained at the Tar Creek Site. If they are determined to be statistically similar, then the data from the Cherokee County Site and Jasper County Site may be useful in characterizing and evaluating the chemical composition, behavior, and nature of the chat and flotation tailings at the Tar Creek Site."

It would be useful if indeed the same populations are compared. See specific Comment Nos. 8 and 41. Even if the concentration of all COPCs correlate well with some statistic of the particle size distribution, other factors are equally important. Depending on the release characteristics and hydrogeologic setting the concentrations and flux of COPCs will be pile/pond-specific. Again it is too premature to screen out or make broad assumptions regarding this media (See General Comment No. 1).

42. Page 41; Mine and Mill ***Residues*** and Smelter Wastes; First Paragraph:

> "A quality assurance review of the data was performed. Nearly 80% of the chat chemical analysis data included in the database is from the RI activities conducted in the 3 Sites. Sample collections during these RIs were conducted under an EPA approved QAPP."

See specific Comment No. 27 and General Comment No.1

43. Page 41; Mine and Mill ***Residues*** and Smelter Wastes; Paragraph 3:

> "Data from Table 6 show that there are great variabilities in COPC concentrations in chat from the different sites, as well as within the same Site."

Potential source of the large inter and intra pile/pond variances have been discussed elsewhere herein (See Specific Comment No. 10). Much of which is probably associated with pooling and comparing different populations of piles.

44. Page 45; Mine and Mill ***Residues*** and Smelter Wastes; Last Paragraph:

> "The information presented above suggests that all of the chat piles at the Site will need to be addressed during the FS, and that taking more samples for chemical characterization will not affect the decision-making process for remediation of the Site."

See General Comment No. 3.

45. Page 55; Mine and Mill ***Residues*** and Smelter Wastes; First paragraph:

> "In summary, the discussion presented above indicate[s] that:
>
> - COPC concentration in chat is affected by the particle size distribution (i.e., chat comprised of larger particle size shows lower COPC levels);
> - Chat from all of the 3 Sites in the District COPC concentration ranges; and

- the COPC chemical characteristics of chat from the Site are similar to the chat from the Cherokee and Jasper County Sites."

See Specific Comment No. 41.

46. Page 62; Mine and Mill ***Residues*** and Smelter Wastes; RI/FS Data Needs:

"2.4.2 RI/FS Data Needs

Data on mine and mill residues and smelter wastes are needed to define the nature and extent of these source materials, to provide information for the **ecological and human health risk assessments being prepared by the EPA,** and to develop and screen alternatives for addressing these source materials in the Feasibility Study. [Emphasis added]

See General Comment No. 1

47. Page 62; Mine and Mill ***Residues*** and Smelter Wastes; RI/FS Data Needs:

More specifically, data needs on mine and mill residues and smelter wastes include:

- Defining physical and chemical characteristics of mine and mill residues and smelter wastes;
- Determining the location, area, and volume of current mine and mill residues and smelter wastes accumulations at the Site by major category, including waste rock, development rock, overburden, chat, flotation tailings, and smelter wastes;
- Determining the location and area of the foot-print of former chat piles that have been excavated and removed;
- Identifying the use of chat from the Site including descriptions of chat operations, the rate of chat removal, as well as the existing and potential future environmental and safety controls associated with the excavation and use of chat."

The N&E of contamination of all media associated with each waste/pile/pond and other features must be delineated. Once this is accomplished, hopefully, a relationship between gross pile geochemistry and hydrogeologic setting can be used to characterize the rate of release and strength of the source term contributing to groundwater and ultimately surface water. This information will be needed to project and subsequently assess the consequence of sequentially removing source-terms via remediation. The result of this work can be used to prioritize site construction activities.

48. Page 62; Mine and Mill ***Residues*** and Smelter Wastes; Data Gap Analysis:

See General Comment No. 1 & 6

49. Page 63; Mine and Mill ***Residues*** and Smelter Wastes; Last Paragraph:

> "**For the purpose of the risk assessments, however, additional sampling of chat and flotation tailings for this RI/FS is recommended.** Calculations based on statistical data and the formula defined in EPA's Guidance for Data Usability in Risk Assessment (EPA, 1992) suggested that a total of 21 chat samples from *3* chat piles (7 samples per pile) and *63* flotation tailings samples from 7 locations (9 samples per location) should be sufficient to characterize chat and tailings in Tar Creek OU4 (see Appendix 2, Statistical Methods and SAS Outputs). The calculated number of samples is less than what was outlined in the AOC for OU4, which proposed the sampling of 20 chat piles with 8 samples per pile (total of 160 samples) and 10 flotation ponds with 10 samples for each pond (total of 100 samples)."

EPA is performing the RAs. These data needs will be determined at a later date (See General Comment No. 1).

The sample size is an iterative approximation that must be updated with a new CV once results have been obtained. Therefore, the conclusion with respect to sample size is premature.

50. Page 64; Mine and Mill ***Residues*** and Smelter Wastes; Paragraph 4:

> "Vertical sampling (coring) at key locations will be required to delineate the depth of the tailings in order to obtain accurate volumetric information. Surface sampling will be required to delineate horizontal extension of the tailings at places where the berms defining the edges of the tailings pond are not evident. Generally, fine tailings can easily be identified by visual inspection in the field."

It is expected that vertical sampling will reveal a leached zone near the surface and enriched zone somewhere at depth where ET and geochemical conditions favor precipitation of solids dissolved in the leachate. This will probably also influence some of the statistically based conclusions (See Specific Comment No. 49)

51. Page 65; Mine and Mill ***Residues*** and Smelter Wastes; Paragraph 3:

> "The fine portion (<250 um*)* of 16 surface chat samples plus 10% of all chat and flotation tailing samples will be analyzed for all metals. Information from these samples will be provided to EPA for risk assessment."

This distribution cut-off has not been agreed upon. Note that it is quite probable that the HHRA and BERA have different requirements, depending on the HHRA scenario.

(See General Comment No. 1)

52. Page 65; Soils; Paragraph 2:

> "These data were considered to be valid because they were generated from proper sampling and analytical methods defined by EPA."

See Specific Comment No. 27.

53. Page 69; Soils; Table 18:

It would be useful to included the CV for each of these as a summary statistic.

54. Page 70; Soils; Paragraph 3:

> "The soil area from the edge of a chat pile or tailings pond where metal concentrations are elevated out to the point where metal concentrations are below levels of concern is referred to as transition zone (TZ) soil."

See Specific Comments no. 12 and 13.

55. Page 71; Soils; Last Paragraph:

> "However, statistical analysis of these data with T-tests showed that these differences were not statistically significant (Table 20)."

Conducting T-tests on non-stationary populations and relying on these results requires further explanation.

56. Page 72; Soils; Paragraph 1:

> "The concentration of metals return to near background levels in less than 300 feet from the residues in nearly all cases."

This conclusion is a likely artifact of sampling. See Specific Comments no. 12 and 13.

57. Page 72; Soils; Paragraph 2:

> "The Exponent (2002) study also examined the concentration of Pb in TZ soils versus sampling depth. It is apparent that all samples collected at depth showed lower Pb level that the surface sample collected at the same location."

This realization supports concerns described in Specific Comments no. 12, 13, and 34, indicates that air and/or overland flow are important pathways, and depending on the ratios of Pb and the other COPCs, could indicate that leaching also is occurring.

58. Page 77; Soils; Paragraph 2:

> "Data on affected soils at the Site are needed to define the nature and extent of contamination from mine and mill residues and smelter wastes, to provide information for the ecological and human health risk assessments being prepared by the EPA, and to develop and screen alternatives for addressing this media in the Feasibility Study. More specifically, data needs on affected soils include:
>
> - Location and extent of TZ soils;
> - Concentrations of lead, cadmium, and zinc in TZ soils;
> - Extent of contamination in seeps and runoff channels that drain mill residue accumulations and go beyond the transition zone soil;
> - Concentrations of lead, cadmium, and zinc in yard soils of residences located in the rural areas of the Site that were not sampled as part of OU2 RI/FS;
> - Nature and extent of contamination (if any) of soils at the former Ottawa smelter plant site."

Even without the benefit of input from those performing the BERA and HHRA, pre-release baseline of COPCs for each natural soil-type needs to be developed in order to determine the N&E of contamination attributable to the release. This will require identification of reference areas followed by sampling using an appropriate statistical experimental design—the use of Jasper County soils is not appropriate for the Tar Creek Site in Oklahoma.

Sampling studies need to be designed to address concerns described in Specific Comments no. 12 and 13.

Again these are not the only data needs at this time. The assessors working on the HHRA and the BERA will need to specify particle size cut-offs. This will definitely affect the data gaps analysis.

59. Page 78; Soils; Last Paragraph:

> "The chemical analysis results of TZ soil samples and other available existing information will be used to define a practical outer limit for COPC affected soils, which will then be applied to the definition of all TZ soils at the Site area using the GIS software."

The TZ is probably pile-specific. The Kansas and Missouri Piles were smaller, more widely dispersed, and therefore may not be comparable to piles in Oklahoma. See also Specific Comments Nos. 12, 13, and 35.

60. Page 82; Groundwater; Paragraph 2:

> "The water in the mine workings has a low pH with high concentrations of sulfate, fluoride, cadmium, copper, iron, lead, manganese, nickel, and zinc."

This statement along with other concerns described elsewhere herein indicates that the list of COPCs portrayed in this document must be revisited.

61. Page 86; Groundwater; RI/FS Data Needs:

See General Comment No. 3 and Specific Comments 15-18.

62. Page 86; Groundwater; Data Gap Analysis:

From previous discussions, it is obvious that the groundwater pathway has not been adequately addressed by the remedial action under OU1. The entire groundwater monitoring network will need to be reviewed as part of the data gap analysis.

See General Comments No. 1 & 6 and Specific Comments 15-18.

63. Page 96; Surface Water; Mill Residue Seepage and Runoff Water Quality; Paragraph 1:

> "The metal loading of stormwater runoff and seepage from tailings piles to surface waters was investigated by Barks (1977), OWRB (1983b), and Dames and Moore (1993; 1995). These studies demonstrated that metal loading from chat piles is a minor source of metals to surface waters compared with groundwater sources."

The groundwater is contaminated by oxidation of rocks in underground mine workings as well as contamination from leaching from ponds/piles. It is necessary to differentiate the relative contribution of each source over time as hydrogeologic conditions change. See Specific Comment No 37.

64. Page 97; Surface Water; Mill Residue Seepage and Runoff Water Quality; Paragraph 1:

> "Total chat pile metal loading rates were calculated based on the average metal concentrations and flow data obtained from sampling of the two tailings piles, and extrapolated to the entire Oklahoma portion of the Picher Field (Table 29). A total chat volume of 48.21 $X10^6$ yd^3 was estimated to be remaining in the Oklahoma portion of the Picher Field at the time of the study (Luza, 1986; OWRB, 1983b). OWRB estimated the total seepage from all of the tailings piles to be 0.19 cfs (0.12 mgd)."

This report needs a thorough analysis. Bases on the experimental design portrayed here (especially with respect to representativeness) as well as all of the previous discussions with respect site characterization, it does not appear these reports will meet the DQOs (See General Comment No. 1).

65. Page 97; Surface Water; Mill Residue Seepage and Runoff Water Quality; Paragraph 2:

> "OWRB (1983b) concluded that the metal loading rates from the chat piles into the Tar Creek basin were insignificant compared to metal loadings from the flooded underground mines. Leachate from tailings piles was also considered insignificant by the Tar Creek Superfund Task Force (TCSTF, 2000) compared to the contribution from mine discharges."

See Specific Comment Nos. 63 and 64.

66. Page 98; Surface Water; Mill Residue Seepage and Runoff Water Quality; RI/FS Data Needs:

> "Surface water issues were specifically addressed in the remedial actions performed for OU1.To support this evaluation, updated estimates of the metals loadings from mill residues is necessary. This information is needed to evaluate COPC reductions expected from the various alternatives addressed in the FS. The main surface water requirements for OU4 will focus on:
>
> 1) estimating the amount of COPC loadings from mine and mill residues to nearby receiving waters; and,
> 2) determining the relative contribution (in terms of metal loading rates and percent metals contribution) of COPC from mine and mill residues via surface water runoff as compared to the amount of metals contributed from groundwater sources."

This discussion focuses on questions that authors believe need to be answered—not specific data needs (See Figure 2). For example, the data needs associated with answering questions of items 1 and 2 listed above are fairly large. Again, this just point to the fact that this document is premature.

Also the most important question with respect to the piles has not been asked here—what is the flux and concentration of COPCs exported from the base of these ponds/piles?

See General Comment No. 1 and Specific Comment No. 16.

67. Page 98; Surface Water; Mill Residue Seepage and Runoff Water Quality; Data Gap Analysis; Paragraph 2:

> "The Tar Creek OU4 RI will conduct detailed studies on the COPC loadings from 2 representative chat piles, which includes the following:"

The report concludes that a certain cut-off the particle size distribution can be used to characterize the solid-phase chemistry of the piles/ponds. Note that the results for each pond/pile vary widely. Momentarily giving the respondents the benefit of the doubt, if indeed this relationship holds, it means that CT&F within each pile may be related to this relationship. From this and the fact that the hydrogeologic status varies for each pond/pile it appears that CT&F is probably also pile/pond-specific. This means that two chat piles will probably not meet any statistical determination of representativeness.

68. Page 99; Surface Water; Mill Residue Seepage and Runoff Water Quality; Data Gap Analysis; Paragraph 3:

> "To determine the relative contribution of COPC loadings from the chat piles compared with surface water and groundwater COPC contributions, the following data need to be collected:
>
> - Obtain **dry weather samples** at upstream and downstream locations (total of 8) from potential chat pile runoff in Tar Creek, Beaver Creek, Lytle Creek and Elm Creek. This is the dry weather baseline condition **and assumes 100% groundwater input;**
> - Obtain **wet weather samples** at upstream and downstream chat pile locations (total of 8) using composite, flow-proportional sampling COPCs in Tar Creek, Beaver Creek, Lytle Creek and Elm Creek;
> - **Determine the surface water inputs by subtracting the groundwater inputs determined from the dry weather baseline from the wet weather baseline results; and,**
> - Parameters to be monitored include precipitation, COPCs, pH, TSS, turbidity, alkalinity, conductivity, and temperature."

It not clear what is meant here by groundwater input. Dry-weather AND wet weather groundwater baseflow are a mixtures of natural baseline waters, waters affected by ARD generated in underground mine working, as well as ARD produced and exported through the bases of each pile/pond or other contaminated area. Again more input from experts in the specific discipline is necessary here (See General Comment No. 1).

It is quite likely that hydraulic stress testing, modeling, and monitoring will be required to differentiate between these types of waters.

69. Page 98; Surface Water; Data Gap Analysis:

From previous discussions, it is obvious that the surface water pathway has not been adequately addressed by the remedial action under OU1. As discussed elsewhere herein, the entire surface water monitoring network will need to be reviewed as part of the data gap analysis.

See General Comments No. 1 & 6 and Specific Comments 15-18.

70. Page 100; Sediments; Paragraph 2:

> "Sediments generally act as a sink for metals, essentially removing them from the water column."

Evidence supporting for this conclusion is required here. See General Comment No. 1.

71. Page 100; Sediments; Paragraph 2:

> "Sediments were addressed in OU1 and are not the focus of OU4."

Problems with OU1 have been identified at numerous locations herein. It is highly probable that sediments sampled during OU1 probably do not meet DQOs that support both the BHHRA and BERA (See General Comment No. 1).

72. Page 101; Sediments; Resource Characterization; Table 3:

The sampling protocol (grab vs. composite, sample depth, depositional vs. erosional area, distance from source, etc), sample prep (sieve size), type of digestion, and laboratory chemical analytical techniques probably differ for each of these studies and are therefore not comparable.

73. Page 103; Sediment; Data Gap Analysis:

> "Sediment issues were addressed as part of OU1. The primary data need for OU4 is to evaluate the transport of COPC from mill residues to stream sediments during storm water runoff events."

See Specific Comment No. 72.

74. Page 103; Sediment; Data Gap Analysis:

> "Sediments transported via storm water runoff from mill residues in the form of total suspended solids (TSS) will be studied as one of the tasks discussed in section 2.7, Surface Water."

See Specific Comment No. 71.

75. Page 129; Demography and Land Use: Entire Discussion

See General Comment No. 2

76. Page 132; Figure 18:

Figure 18 is incomplete and incorrect.

77. Page 130; Data Quality Objectives : Entire Discussion

This entire section including Table 37 contains numerous errors and omissions, does not follow EPA Guidance, and is inconsistent with the NCP. See General Comment No. 1.

Attachment

The Spokane Tribe's Multipathway Subsistence Exposure Scenario and Screening Level RME

Barbara L. Harper,[1]* Brian Flett,[2] Stuart Harris,[3] Corn Abeyta,[1] and Fred Kirschner[1]

Exposure scenarios are a critical part of risk assessment; however, representative scenarios are not generally available for tribal communities where a traditional subsistence lifestyle and diet are relevant and actively encouraged. This article presents portions of a multipathway exposure scenario developed by AESE, Inc. in conjunction with the Spokane Tribal Cultural Resources Program. The scenario serves as the basis for a screening-level reasonable maximum exposure (RME) developed for the Midnite Uranium Mine Superfund site. The process used in developing this scenario balances the need to characterize exposures without revealing proprietary information. The scenario and resulting RME reflect the subsistence use of original and existing natural resources by a hypothetical but representative family living on the reservation at or near the mine site. The representative family lives in a house in a sparsely populated conifer forest, tends a home garden, partakes in a high rate of subsistence activities (hunting, gathering, fishing), uses a sweat lodge daily, has a regular schedule of other cultural activities, and has members employed in outdoor monitoring of natural and cultural resources. The scenario includes two largely subsistence diets based on fish or game, both of which include native plants and home-grown produce. Data gaps and sources of uncertainty are identified. Additional information that risk assessors and agencies need to understand before doing any kind of risk assessment or public health assessment in tribal situations is presented.

KEY WORDS: Native American; subsistence diet; multipathway; exposure scenario

1. INTRODUCTION

Exposure assessment has been termed the "wasteland of risk assessment"[4] because so much information is lacking with regard to exposure patterns and rates, and this is especially true for specific populations such as Native American communities. The need to address a tribe's subsistence exposure is based on fundamental considerations of the tribe, as a people, and the role the reservation and its natural resources play in supporting them. The United States recognizes that Indian reservations were, and are, intended to provide permanent homelands for members of the particular tribes. As such, those members possess the inherent right to use reservation natural resources for subsistence, religious, and other cultural purposes. The Spokane

[1] AESE, Inc., Valleyford, WA.
[2] Spokane Tribe of Indians, Wellpinit, WA.
[3] Confederated Tribes of the Umatilla Indian Reservation, Pendleton, OR.
[4] Carol Henry, American Chemistry Council, quoted in Wakeland, 2001 *EHP 108*(12): A559.
* Address correspondence to Dr. Barbara L. Harper, AESE, Inc., 44803 E. Alderbrook Ct., West Richland, WA 99353; Bharper@nwinfo.net.

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Tribe's effort to preserve its culture and environmental quality has, on numerous occasions, been formally memorialized by pronouncements of the tribe's official governing body. The immediate impetus for developing this tribal scenario is the Midnite Uranium Mine Superfund Site, an inactive open-pit uranium mine located on the Spokane Reservation, that has contaminated various media with radionuclides and heavy metals. The exposure scenario described herein is an effort to ensure the proper evaluation of risk to Spokane Tribal members who engage in traditional practices in areas affected by the mine. While this scenario attempts to include as many activities related to Spokane cultural practices as possible, there undoubtedly exist unintended omissions and instances of understated exposure. It is important for readers to understand that this scenario is designed to reflect traditional lifestyles whose practice has been and remain the long-term intent of the tribal council, rather than a current snapshot of statistical cross-sectional surveys. While the latter may be more "quantitative," such surveys would not provide the level of protection needed for safe practice of traditional ways.

The scenario relies on existing ethnographic information about traditional Spokane lifestyles identified by the tribe as accurate[1–3] as well as confirmatory interviews with elders. The Spokane Tribe has determined that information regarding cultural activities, gathering areas, and resources is a cultural resource, and restricts access to that information (Spokane Tribal Resolution 1996-0018); therefore, details regarding specific species, locations, uses, or activities that are deemed proprietary have been omitted.

The scenario also serves as the basis for a screening-level reasonable maximum exposure (RME) developed for the Midnite Uranium Mine Superfund site. This article presents portions of a multipathway exposure scenario developed by AESE, Inc.[4] in conjunction with the Spokane Tribal Cultural Resources Program. It includes dietary factors specific to the Spokane Tribe and builds on previous work,[5] refines some of the exposure factors used in earlier work, and demonstrates how a complex scenario can be used to develop a screening-level RME under CERCLA. It should be noted that the term "subsistence" has been used in this article as a short-hand term that encompasses a broader range of activities than those necessary to sustaining human life such as eating and drinking. It includes other cultural and religious practices as well, such as medicinal and ceremonial uses of natural resources.

Our experience in developing tribal subsistence-based exposure scenarios has led to a set of technical, ethical, and procedural rules:

- To be most useful to regulators and others seeking to protect the health of subsistence users, the information should be developed with an eye toward satisfying appropriate court rules for admissibility of expert testimony. While both state and federal courts have such rules, Federal Rule of Evidence 702, on which many state court rules are modeled, is the most widely applied and interpreted. Rule 702 permits "a witness qualified as an expert by knowledge, skill, experience, training, or education" to testify when his or her "scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue." In response to two U.S. Supreme Court cases holding trial judges responsible for excluding unreliable expert testimony, Rule 702 recently was qualified by amendment. To be admissible, the rule now requires federal courts to find: "(1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case." The subsistence scenario incorporates information from a variety of disciplines, including cultural and traditional environmental knowledge. To prevent a challenge to the admissibility of the subsistence scenario as being unreliable, we wish to ensure that the subsistence scenario has been developed as much as possible using general scientific criteria adopted from the *Daubert* case:[5]

- That each parameter can be tested or verified (documented, modeled, measured, or elicited from acknowledged experts), and that each assumption has been systematically validated. Risk assessors can rely on ethnographic data, verbal representations from subsistence practitioners, and so on. We relied on (1) open peer-reviewed literature on exposures through different but analogous pathways and caloric content of foods, (2) ethnographic documents and reports concerning traditional lifestyles and practices, and (3) statements from tribally recognized cultural experts. This latter expertise derives from their traditional environmental knowledge, and is based on confidential information, so we cannot verify it in the sense of reanalyzing raw numerical data, but we can verify the expertise of the cultural experts who summarized their knowledge of resources and activity patterns for us.
- That another risk assessor could repeat the same steps and would construct essentially the same scenario, because the approach for developing an exposure scenario is fairly standardized.
- That the scenario is accepted by colleagues as reasonable and factual rather than eccentric, unreliable, or mere opinion, or that it meets the "general acceptance" test set forth in *Frye v. United States*, 293 F. 1013 (App. D.C. 1923), the predecessor case to *Daubert*. We satisfy this criteria by obtaining peer review from qualified colleagues ("the relevant scientific community") even beyond the editorial peer-review process. Does this mean that exposure scenarios for over 500 tribes must be peer reviewed and published in *Risk Analysis* in order to be admissible in court should they be challenged during a CERCLA or NEPA process? We believe that if a standardized process is followed and the scenario is reviewed by an advisory board of qualified peers that actual publication is not necessary, even though publication in a peer-reviewed journal is a commonly accepted standard for peer review.

- The scenario must be both scientifically relevant and reliable, and culturally relevant and reliable. The process must be culturally sensitive, respectful, draw on traditional environmental knowledge (such as the observational expertise of elders), and must be developed from within the tribe by a toxicologist/risk assessor in partnership with tribal cultural and technical experts. Collaboration with the Cultural Resources Program provided the cultural assurance.
- Policy-level approval must be obtained. The process must meet Institutional Review Board rules or their equivalent for conducting human research (which we believe includes cultural or anthropological research)

[5] See *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993) (holding trial courts responsible for excluding unreliable scientific expert testimony); *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999) (holding trial courts responsible for excluding unreliable nonscientific expert testimony). An authoritative discussion of *Daubert* and the reliability tests for expert testimony is contained in the Federal Rules of Evidence Advisory Committee Notes, which accompany Rule 702. They include a "nonexclusive" list of considerations for reliability of scientific expert testimony under *Daubert*:

(1) whether the expert's technique or theory can be or has been tested—that is, whether the expert's theory can be challenged in some objective sense, or whether it is instead simply a subjective, conclusory approach that cannot reasonably be assessed for reliability;
(2) whether the technique or theory has been subject to peer review and publication;
(3) the known or potential rate of error of the technique or theory when applied;
(4) the existence and maintenance of standards and controls; and
(5) whether the technique or theory has been generally accepted in the scientific community.

Kumho found that depending on the particular circumstances of the case, these factors may also apply to nonscientific testimony. Other factors considered by post-*Daubert* courts include: whether the expert's opinions were developed independent of litigation or for the purpose of testifying; whether there exists too great an analytical gap between data and opinion; whether obvious alternative explanations have been accounted for; and whether the same level of intellectual rigor is applied in the testimony as would be required in field practice. In addition to reliability, courts will require a testifying expert to be "qualified," and the testimony must be relevant and helpful to the trier of fact. Thus, the emphasis is on testimony being relevant and reliable more than on whether there is a strict litmus test of generating a theory and statistically testing a null hypothesis.

such as informed consent, benefit to the tribal community, disclosure of the risk of adverse consequences, and confidentiality. Repeated conversations with tribal program managers and/or policymakers ensured that there was an understanding of the way that the risk information was to be used, the potential adverse consequences of developing a scenario from a risk acceptance perspective or precedent, and related concerns.

- Identifying resources and activities on a base map overlain by ecological habitats, and constructing a dependency web (culturally relevant natural history diagrams)[6] as a pictorial representation of the ethnohabitat proved helpful. A subsistence food pyramid is another useful tool.

2. THE SPOKANE TRIBE AND ITS ECOCULTURAL LANDSCAPE

The Spokane Indians are part of the Interior Salish group, which has inhabited northeastern Washington and northern Idaho since time immemorial.[1] The Spokane Reservation lies at the confluence of the Spokane and Columbia Rivers in northeastern Washington. Salmon was the most important commodity in the early economy of the tribe. Since the construction of Columbia River dams the anadromous salmon are no longer available. Instead, Kokanee (landlocked sockeye salmon) and resident trout and other species have been substituted. Abundant game also supports an alternative game diet, along with a wide variety of roots, berries, and other plants. Because the reservation is still fairly pristine and undeveloped, it provides enough resources for some members to continue a traditional subsistence dietary lifestyle, and for all members to obtain traditional foods.

The ecology of the reservation area is characteristic of the arid montane areas of the northern Columbia Basin transitioning into the Okanagon highlands to the north. Annual precipitation is approximately 16 inches. The Spokane lands include the two major rivers (the Columbia River and one of its tributaries, the Spokane River) including the waters to their far banks, and various other large and small tributaries, springs, ponds, and wetlands. Mount Spokane is a central feature of the reservation landscape. A Douglas fir zone exists at the highest elevations, with Ponderosa pine and Western juniper zones with a variety of understories at lower elevations, and grassland-sagebrush shrub steppe and riparian areas along the waterways.[7–9] Areas affected by activities at the Midnite Mine include the mined area on Mount Spokane and adjacent upland habitats, several seeps and springs with riparian habitats, and a major creek (Blue Creek) that empties into the Spokane River arm of Lake Roosevelt, the reservoir created in the Columbia River by the Grand Coulee Dam.[10]

The Spokane traditional lifestyle is governed by ecological seasons and the activities that people undertake in response. A significant portion of the population follows this lifestyle in full or in part. Hunting, fishing, and gathering are essential to support nutritional, cultural, spiritual, and medicinal needs of tribal members. Hunting and gathering on the reservation is allowed based on the needs of the family. Typically, all family members work in the field on a regular basis to keep the extended family unit stocked with a wide variety of plants and wildlife. While in the field, tribal members live off the land by consuming surface and spring water, wild plants, and wildlife. In addition to the time spent in hunting, fishing, or gathering, time is also spent cleaning, processing, and preserving hides, drying vegetal food or medicines, and making a wide variety of items. The Spokane people use over 200 varieties of plants.[11] Huckleberries are gathered, as are a wide variety of roots, shoots, moss, leaves, stems, cambium, seeds, and flowers. Most natural resources have several human uses[12,13] as well as providing multiple ecological functions and services. A more complete description of edible plants, ethnographic information, plant technology, ethnobotany, and ethnopharmacology is found in AESE.[4]

3. GENERALIZED LIFESTYLE OF A REPRESENTATIVE COMPOSITE SPOKANE TRIBAL FAMILY

This section describes a family-based exposure scenario founded on traditional Spokane lifestyles and diets (one fish-based diet and one game-based diet). This hypothetical but representative family lives in a house in a sparsely populated conifer forest, tends a home garden, pursues a high rate of subsistence activities and a regular schedule of other cultural activities. The lifestyle is moderately active, with daily sweat lodge use and outdoor employment.

The family composition was determined with the guidance of the Spokane Tribal Culture Program and current tribal demographics. Each family includes an infant/child (age 0–2 years) who breastfeeds for two years and crawls and plays; a child (age 2–6), a youth (age 7–16) who attends school, plays outdoors near the residence, and is learning traditional practices; two adult workers (one male, one female, age 17–55; the female breastfeeds the infant) who work outdoors on reclamation and environmental and cultural activities and also engage in subsistence activities, and an elder (age 56–75) who is partly at home and partly outdoors teaching and demonstrating traditional cultural practices. All members (except the infant) partake in family sweat lodge use and in cultural activities throughout the year. In actuality, a family typically includes members who are employed conventionally and members who are full-time subsistence providers.

3.1. Residence

A conventional suburban scenario would identify a person living at home and growing a garden. The subsistence family is superficially similar to this, but they live in a more open house, spend more time outdoors in cultural and subsistence activities, eat both garden and native foods, and are fully interactive with the environment. The family spends its entire lifetime on the reservation, rather than the suburban default assumption of 30 years. The house has no landscaping other than the natural Ponderosa and understory, some naturally bare soil, a gravel driveway, no air conditioning, and a wood-burning stove in the winter for heat. Each house has its own well for domestic use and a garden irrigated with groundwater and/or surface water. Each house has a nearby sweat lodge. The amount of indoor dust is not known, but is likely to be higher than in suburban communities with manicured lawns, air conditioning, and paved streets.

3.2. Generalized Daily Activity Patterns of Each Family Member

Due to space limitations, the average daily activity pattern is not described for each age range and each gender, but in the full scenario, such information would be included in this section.[6] While activities of Spokane males and females are different, they likely result in a similar frequency and duration of environmental contact, so the genders may be separated or combined. The daily activity patterns can also be combined into entire lifetimes for the evaluation of cumulative risk.

3.3. Sweat Lodge Use (Ages 2–75)

The daily use of the sweat lodge is an integral part of the lifestyle that starts at age two. Sweat lodge construction has been described in the open literature.[14,15] Although the details vary among tribes and among individual families, sweat lodges are generally round structures (6 feet in diameter for single-family use). A nearby fire is used to heat rocks that are brought into the sweat lodge. Water (4L) is poured over the rocks to form steam (a confined hemispheric space with complete evaporation of the water, which is available for inhalation and dermal exposure over the entire skin area). Water is ingested (1L is included in the total drinking water ingestion rate) and medicinal plants are used (not specifically included).

3.4. Cultural Activities

All persons participate in day-long outdoor group cultural activities once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. Individuals also tend to be more active during the ceremonies, resulting in greater inhalation and water ingestion rates. These activities are folded into the higher soil ingestion, water ingestion, and inhalation rates rather than being estimated on a single-event basis.

3.5. Diet

The Spokane food pyramid looks markedly different from the USDA food pyramid. Caloric needs are generally cited in the range of 2,000 to 4,000 kcal per day for adult males, depending on the level of activity. We use 2,500 kcal/day for the Spokane Tribe, based on a moderately active outdoor lifestyle and renowned athletic prowess (as did Scholz[3]). The original diet of the Spokane Indians was based on salmon and included large and small game, roots, berries, and many other plants.[2,3,11] Hunn[16] estimated that 45% of the native Columbia Plateau dietary calories came from protein (fish and game), with higher estimates for upriver tribes such as the Spokane.[3] Historically, the Spokane Tribe consumed roughly 1,000 to 1,500 grams of salmon and other fish per day.[2,3] The most robust upper bound estimate of original (predam) salmon intake by the Spokane Tribe is the Walker estimate (cited in Reference 3) of 1,200 pounds per year of salmon per adult, or 1,426 gpd (about 3 pounds/day), yielding 2,566 kcal/day before migration (i.e., if caught in the estuary) and $2566 \times 0.64 = 1643$ kcal/day after migration from the ocean to the Spokane area. With the construction of the Grand Coulee Dam, the anadromous salmon runs were destroyed, so there was a shift to big game and to Kokanee and resident trout. Because the intent of this scenario is to evaluate exposures that traditional members currently receive and that more members will receive as they regain a traditional diet, two diets were evaluated: a high fish diet and a high game diet. Eighty percent of each diet is native, augmented with vegetables grown in a household garden. The current realistic high fish diet based on availability, percentage of the diet, and caloric content consists primarily of fish (885 g/d, somewhat lower than historical levels), supplemented by big game, aquatic amphibian/crustacean/mollusks, small mammals, and upland game birds. The high game diet reverses the fish-game quantities, and both diets include identical amounts of native and domestic plants. Both forms of the diet are approximately 40% protein, 25% fat, and 35% carbohydrate (given the limited data available for native foods), which is comparable to other hunter-gatherer diets.[17] Until recently, this diet was even higher in fish-derived protein, and was stable for at least 5,000 years (based on archaeological evidence of salmon runs). The carbohydrates are largely unprocessed and include many roots but little grain. The fats are from fish, game, nuts, and seeds.

3.6. Drinking Water

Daily replacement water needs are approximately 2L/100 pounds body weight (more during exercise or pregnancy).[6] Athletic activity can result in a loss of 1.5 L/hour; replacement volumes are recommended as 1 to 1.5 ml/kcal of energy expended.[18] Harris and Harper[5] estimated an average water ingestion rate of 3 L/day for adults, based on total fluid intake for the Confederated Tribes of the Umatilla Indian Reservation. However, that number did not account for all uses. This scenario includes adult water ingestion of 1L while at home (from the household water supply), 1L taken from home to the worksite, 1L consumed from worksite sources, and 1L from the household or spring to rehydrate during use of the sweat lodge, for a total of 4 L/d.

3.7. Soil Ingestion

Soil ingestion by young children (0–6 years) is assumed to be 400 mg/day for 365 days/year. This is higher than the prior EPA default value of 200 mg/day.[19] It reflects both indoor dust and continuous outdoor activities analogous to gardening or camping,[20] but is less than a single-incident sports or construction ingestion rate.[21,22,23] For adults, the soil ingestion value is also 400 mg/day, reflecting an unspecified upper percentile.[21] This value also better reflects the environmental setting, the typical residential situation, gardening and gathering activities, the preparation and consumption of native and garden plants, the consumption of other natural foods, and a variety of additional outdoor activities (work, play, cultural activities). However, it may still substantially underestimate the amount of soil and sediment on garden produce and gathered plant foods. In particular, episodic events such as gathering in wetlands or road work could result in 1 gram of soil ingested per event,[21,22,23] which may be over and above the 400 mg ingested daily. If there is geophagy (eating dirt for micronutrients or salt), the ingestion would be higher yet. In fact, the intentional presence of some Mother Earth in food may be beneficial medically[23] and spiritually.

3.8. Inhalation Rate

We believe that an inhalation rate of 30 m^3/d is more accurate for the Spokanes' active, outdoor lifestyle than the EPA default rate of 20 m^3/d.[21] EPA[21] reviewed several extensive studies that examined ventilation rates based on direct management and activity diaries in developing the default rate of 20 m^3/day. EPA recognizes that special populations, such as athletes or outdoor workers, have higher average rates and recommends

[6] U.S. Air Force at http://www.capnhq.gov/nhq/cp/ encampments/AETC.htm#AETC.; Coyle at http://www.veggie.org/veggie/fluid.exercise.shtml).

Table I. The Spokane Subsistence Composite RME Scenario

Medium	Description (Not All Routes of Exposure are Listed)
Groundwater	Each family has their own well for drinking/household, watering the garden, sweat lodge
Surface water	Each family uses surface water (seep and creek) for domestic and garden use, washing locally gathered materials, and the worker uses surface water during fieldwork and sweat lodge
Air	Indoor radon, sweat lodge radon, outdoor radon daughters, inhalation of resuspended dust, inhalation of aerosols
Soil	Direct ingestion, deposition on plants, as-gathered conditions, and indirect (uptake from soil to plant)
Sediment	Duplicates the soil; gathering may include high rates of sediment exposure that may be underestimated
Sweat lodge	Daily for 2 hours, using groundwater (springs) or surface water
Pathway	**Description (Not All Routes of Exposure are Listed)**
Inhalation	$30\,m^3/d$ to accommodate indoor and outdoor activities; the inhalation rate for strenuous outdoor activities may actually be underestimated (can be discussed as a source of uncertainty)
Drinking water	4 L/d; this is duplicated for surface and groundwater if both are contaminated; fluid replacement needs for strenuous activity may be underestimated
Other water uses	Garden irrigation, dermal and inhalation while showering, other standard routes of exposure
Sweat lodge	Steam, inhalation, immersion
Soil ingestion	400 mg/d (100 mg/d from indoor sources and 300 mg/d from outside sources); outdoor sources may vary in concentration; indoor dust is equal to local outside soil; this is duplicated if sediment is included; episodic events 1 gram each
Other	Other factors are as reported previously (dermal, etc.; Harris and Harper, 1997)

High Fish Diet—About 2500–3000 kcal/d (Moderate Adult Level)		High Game Diet—About 2500–3000 kcal/d (Moderate Adult Level)	
Fish (10% of which is organ meat with 10x concentrations; sockeye and mixed trout are used for calorie estimates)	885 g/d = 1300 kcal	Big game (10% of which is organ meat with 10x concentrations; deer and elk are used for caloric estimates, not beef)	885 g/d = 1000 kcal
Big game	100 g/d = 110 kcal	Fish	75 g/d = 180 kcal
Local small game, fowl	50g/d = 75 kcal (or 25g birds, 25g rabbits)	Local small game, fowl	50 g/d = 75 kcal (or 25g birds, 25g rabbits)
Aquatic foods (mussels and crayfish are nutritionally similar)	175 g/d = 120 kcal	Aquatic foods	175 g/d = 120 kcal
Vegetal calories	1600 gpd = about 1000 kcal (mixed species)	Vegetal calories	1600 gpd = about 1000 kcal (mixed species)
10% garden (above ground) 10% garden (below ground) 40% gathered terrestrial below ground 20% gathered terrestrial above ground 20% aquatic		10% garden (above ground) 10% garden (below ground) 40% gathered terrestrial below ground 20% gathered terrestrial above ground 20% aquatic	
Other calories (medicines, etc.)	Not determined	Other calories (medicines, etc.)	Not determined
Dairy (children only)	0.5 L/d milk	Dairy (children only)	0.5 L/d milk

Note: The best estimate of original (predam) salmon intake by the Spokane Tribe is the Walker estimate (cited in Scholz *et al.*, 1985) of 1,200 pounds per year of salmon per adult, or 1,426 gpd (about 3 pounds), yielding 2,566 kcal before migration and $2566 \times 0.64 = 1643$ kcal after migration from the ocean to the Spokane area. The current 885 gpd is based on a combination of calories estimates, availability, interviews, and dietary balance. The current Spokane diet relies on Kokanee (landlocked sockeye) and trout (bull or Dolly Varden, rainbow), suckers, whitefish, other species. Salmon and steelhead are obtained whenever possible. Mussels and crayfish were also eaten regularly.

Both fish and game are eaten fresh, smoked, or dried, but there are few data on calories or contaminant concentrations according to method of preparation. No contaminant loss during preparation is assumed, since contaminants could become more concentrated as well as being lost with fat loss.

The dietary data are not adequate to distinguish fruit, berries, greens, roots, bulbs, fungi/moss, seeds/nuts, medicines, or sweeteners on a caloric basis, nor domesticated from wild plants. If data for uptake from soil/sediment or dust/sediment load for a native species becomes available, the intake of that species will be estimated. The proportion of above and below ground plants is based on reliance on tubers and bulbs, using USDA caloric information on domesticated plants from the same plant families. Intake of other plants (medicines, rose hips, etc.) occurs but was not determined.

Dairy may be underestimated (cheese, milk), and eggs are not specifically included, but should be included depending on the information supplied by tribal members.

While many animal species are similar with respect to how much nutrition they provide to people, their contaminant concentration will vary according to their habitat and ecological niche, as well as their location and size of home range. This is estimated through the ecological food web or actual sampling data.

All the exposure factors are constant through the year (i.e., they apply 365 days/year).

calculating their inhalation rates using the following median hourly intakes for various activity levels (in m^3/hr): resting = 0.4, sedentary = 0.5, light activity = 1, moderate activity = 1.6, heavy activity = 3.2. For outdoor workers, a median rate is 1.3, with an upper percentile of 3.3, depending on the ratio of light, moderate, and heavy activities during the observation time. "Inhalation rates may be higher among outdoor workers/athletes because levels of activity outdoors may be higher, therefore, this subpopulation group may be more susceptible to air pollutants and are considered a 'high risk' subgroup."[21] Using this EPA guidance, a median rate of 26.2 m^3/d is obtained from eight hours sleeping, two hours sedentary, six hours light activity, six hours moderate activity, and two hours heavy activity. This represents minimal heavy activity (construction, climbing hills, etc.), and is a median rather than a reasonable maximum. The California Air Resources Board[25] also reviewed daily breathing rates based on activity levels and concluded that 20 m^3/d represents an 85th percentile of typical American adult lifestyle (eight hours sleeping and 16 hours of light to moderate activity), a lifestyle that is less active than an outdoor lifestyle in a topography that includes steep slopes, as on the Spokane Reservation.

4. A SCREENING-LEVEL COMPOSITE RME

Due to the number of age groups, daily activities, and limited EPA funds for determining both media-specific exposure point concentrations as well as developing and subsequently running the risk model, EPA requested that the tribe condense the scenario into a screening-level composite RME application for use in the Midnite Mine risk assessment (Table I). The principle of developing a screening scenario is to reduce the number of calculations by combining (not eliminating) pathways and age groups, and maximizing exposure factors to a reasonable degree. The screening-level risk assessment then generally employs the composite RME and the upper 95th percentile exposure point concentrations in each medium, wherever they occur throughout the site, so that any location, activity, diet, or water source has the chance to drive risk. This means that the result of the screening-level risk assessment is not strictly location, pathway, age, or activity specific. It only indicates whether unacceptable sitewide risk is possible and shows the spatial aspects of the risk profile if plotted on a base map. In the future, EPA or the tribe will need to use the full scenario and location-specific exposure point concentrations to assess risk attributable to location, pathway, age, or activity. Such information will be required to evaluate the remedial alternative during the feasibility study and to quantify residual risk once remediation has been completed.

The full scenario was condensed as follows. The daily time allocation is 12 hrs/d indoors, 2 hours in the sweat lodge, 7 hours outdoors working, playing, and other nonsubsistence activities, and 3 hours of subsistence activities in *each* contaminated area where these activities might occur. This will result in more than a 24-hour day, but is necessary to reduce the number of calculations. Alternately, the person can live and subsist at the single most contaminated location. Soil ingestion remains at 400 mg/d for 365 days/year (100 mg from indoor sources and 300 from outdoor sources; for multiple contaminated subsites, each contributes 300 mg, which could result in more than 400 mg/d; alternately, the single most contaminated soil location can serve as the sole source of soil-based exposure). For application to other areas, such as wetlands, 1 gram per visit may be used.[21,22] Drinking water

Table II. Examples of Differences in Exposure Factors for a 70 kg Adult

Parameter	Default Value[1]	Subsistence Value[2]
Drinking water ingestion	2 L/day	4 L/d (includes 1L during sweat lodge use)
Soil ingestion	200 mg/d (children) 50 mg/d (adult)	400 mg/d for all ages
Inhalation rate	20 m^3/d	Varies by average activity level; 30 m^3/d.
Meat & fish ingestion[3]	21.1 g/d (general population) and 70–170 (subsistence); 17.5 g/d (general population) and 142.4 g/d (subsistence)	885–1000 g/d fish and 100 g/d meat (high fish diet), or 885 g/d meat and 75 g/d fish (high game diet); 50 g/d small game for each, 175 g/d shellfish for each; no dairy for adults is included in this total
Vegetable ingestion	Fruit and vegetable totals: 539 g/d; grain: 287 g/d[4]	1600 g/d; fraction obtained locally = 1, both gathered and home-grown
Exposure frequency	Varies according to climate and activity	365 d/yr unless documented otherwise
Exposure duration	30 yrs (assumes retirement elsewhere) or less (average time spent in a home)	70 yrs (a full lifetime)

[1] EPA *Exposure Factors Handbook*, in totals per day assuming 70 kg body weight.
[2] These values apply only to the Spokane Tribe unless verified specifically for other tribes. Dietary factors are specific to the Spokane Tribe. Total caloric intake is assumed to be the same for both scenarios but in fact may be higher for the more athletic outdoor lifestyle.
[3] *Exposure Factors Handbook*, Volume II, Section 10.10 recommends using 21.1 g/d total fish and shellfish as the mean value for the general population and 70 g/d for Native American subsistence populations (mean value) or 170 g/d (95th percentile). EPA Office of Water (Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health 2000, EPA-822-B-00-004 and Water Quality Standards for Indian Country at www.epa.gov/ost/standards/tribal/tribalfact.html) uses 17.5 g/d as the 90th percentile for the general population and 142.4 g/d for subsistence populations as the 99th percentile, all in uncooked weight. These values are all for adults and are all based on current cross-sectional surveys that likely omit traditional tribal members. The Spokane value reflects existing documentation on historical subsistence consumption rates with caloric evaluation, confirmatory interviews with the tribal cultural staff, and tribal policy goals for regaining traditional healthy cultural lifestyles, not on dietary surveys.
[4] *Exposure Factors Handbook*, Volume II (mean values).

remains at 4 L/d, which is derived from the most contaminated source (this is duplicated for surface and groundwater if both are contaminated). This results in an upper bound sitewide risk estimate. Risks for an actual individual who specializes in certain activities (i.e., the hunter or the fisher), spends more time in fewer locations or a single location, or fully utilizes a contaminated medium such as groundwater, could be as high as but no higher than this upper bound estimate. Subsequent analyses using either the complete scenario or the composite RME can examine particular pathways and locations, or can be used to support risk management decisions such as remedial goals, subsistence soil and water remedial screening levels, or tribal regulatory standards.

Table II shows some of the major differences between EPA default exposure factors and our subsistence scenario. We are not presenting a sensitivity analysis in this article because the relative contribution of various exposure factors will depend on the concentration of contaminants in various media and their physical parameters, and specific human activity patterns at the contaminated site. This will be the subject of another article. However, we expect that the major factors for subsistence lifestyles or lifestyles with high environmental contact rates will be soil ingestion, drinking water, exposure duration, and diet. We should note that the dietary factors in the *Exposure Factors Handbook* reflect major categories of the diet rather than a necessarily complete diet—adding average caloric content for the categories identified in the *Handbook* totals about 2000 kcal/d for the general population, which is lower than actual national average caloric intakes by up to one-third. That other third of the diet is not likely to come from the contaminated site, so from an exposure perspective this does not detract from suburban dietary exposure estimates. The subsistence diet in this article, however, yields a full day's calories (~2500 kcal). If one tried to construct a subsistence diet solely from the *Handbook*, the caloric intake would fall short of an adequate amount even if the intake factors for Native Americans were used. One could erroneously equate "subsistence" with a modern diet supplemented with fish, game, and wild plants using intake rates that are given in the *Handbook*. This could be due to several factors: whether reservation dwellers were specifically sampled during the three-day recall surveys (versus urban or suburban dwellers who happened to be Native American), the difference between current reservation conditions (with USDA commodity foods) and a truly subsistence lifestyle, socioeconomic factors, and so on. Thus, developing a subsistence exposure scenario with a traditional diet and cultural practices specific to reservation living needs to rely primarily on ethnographic data and cultural information, and only secondarily on national dietary survey data.

5. DATA GAPS AND SOURCES OF UNCERTAINTY ASSOCIATED WITH THE SCREENING-LEVEL RME

An incomplete list of data gaps and uncertainties are briefly discussed below. The relative error caused by each uncertainty cannot be ascertained at this time. We believe that the overall uncertainty and variability are greater in tribal communities than in suburban communities due to the greater number of risk factors and the potential for several risk factors to cluster in particular communities and individuals. Because tribal members could be at greater risk due to both greater exposure and greater sensitivity, an additional safety factor or precautionary approach may be warranted in these types of situations.

5.1. Mobile Versus Stationary RME

The typical suburban RME for members of the general population is a house-bound individual with a local garden, or a residential farmer who is largely self-sufficient. In these cases, the house and garden are assumed to be located at the contaminated site and available for unrestricted use. The subsistence family also lives where the contamination occurs if this is physically possible, but may spend more time away from the immediate residence during subsistence activities. However, a subsistence RME should not assume that exposure is diluted by spending significant amounts of time in uncontaminated areas. For large sites with variable contaminant concentrations, problems arise when trying to perform a single risk assessment to evaluate multiple hot spots (as not-to-exceed concentrations), even if the risk assessment assumes that the person moves around from hot spot to hot spot or if all subsistence activities are assumed to occur where the upper 95th concentration limit occurs. Additionally, the problem of spatially integrating widespread contamination still remains because, conceptually, 10 acres of contamination poses a greater risk than one acre with the same contaminant concentration. Temporally, persistent contaminants pose a longer risk, and therefore a greater total risk, than degradable contaminants. Unfortunately, the present regulatory framework does not use spatial or temporal risk metrics (such as risk acre-years, or dose per community gene pool across several generations) to account for this cumulative exposure over time and space and people.

5.2. Special Activities

There are special circumstances when some people may be highly exposed that have not been included in the complete scenario or the screening-level RME. For instance, some men hunt or fish for the general community, and many people provide roots and fish and game to elders in addition to their own families. Gathering of some plants (e.g., cattails, water potatoes, reeds, and rushes) is a very muddy activity and rivershore or lakeshore activities may underestimate sediment exposure (soil ingestion can be 1 gram per event[21,22,23]). Washing, peeling, weaving rushes, and other activities results in additional exposure. For example, basketmakers clean and wash their materials, incur cuts on their hands, and hold materials in their mouth. Flintknappers may receive additional exposure through obtaining and working with their materials. In addition, there are potential pathways that are not specifically identified but that might contribute additional exposure, such as contaminated firewood used for smoking food, plants used for teas, flavoring, smudging, or medicine, contact with contaminated animal parts (paints, bone ornaments, clothing), sitting on the ground for long periods of time while processing or during ceremonial activities, and so on. Even though the composite activity patterns are intended to reflect reasonable maximum exposures, there is a potential for underestimating some pathways (i.e., this is not a worst-case scenario).

5.3. Community Exposure Burdens

An entire community exposure burden estimate or population dose estimate may be needed that includes people who do not reside in but occasionally visit the contaminated area (this includes inadvertent intruders onto the site). If a resource is contaminated, the entire community is exposed. The assumption that protecting the RME adequately protects everyone else may result in a failure to provide all the information that the tribe's governing body needs for informing its members. There may be sensitive individuals (children, elders, the sick, the occupationally exposed) who, arguably, may or may not be protected by using standard reference doses and other factors. Also, tribal leaders often make decisions at the community rather than the individual level (i.e., the survival of the individual may not be as important as the survival of the family or community, so the community is also an appropriate unit of analysis). Therefore, decisions where everyone is exposed to a low level of contamination may be different from and more stringent than decisions where a few individuals are at high risk or decisions where risks are distributed over time, space, or populations rather than localized. We believe this to be an important but understated element of real risk and risk-based decision making (not to be dismissed as perceived risk, or cultural amplification of real risk, or a risk management determination). The nature and extent of community exposure can be estimated over time and space by estimating the number of people and the number of generations that could live in each area or concentration isopleth and be exposed (a community chemical effective dose equivalent). The total number of generations and the number of people per generation need to be described in terms of the total number of people exposed, total dose for the community (or the gene pool), proportion of each generation exposed, and so on. Even more broadly, the total dose for a small community's combined gene pool or neuronal pool could be estimated. Finally, the proportion of each generation that is affected, rather than simply the number of people (in a small population), can be determined.

5.4. Background Exposure and Communitywide Exposure from Other Sources

Under the National Contingency Plan and subsequent EPA guidance, EPA is charged with evaluating incremental risk to humans caused by a release from the subject site. This means that when evaluating a Superfund site, EPA is not charged with evaluating risk associated with high concentrations of naturally occurring substances, such as arsenic, measured in background soil, water, or food, if the concentrations were not increased by on-site activity, nor risk associated with releases of contaminants from another site. When there is background contamination (however that is defined), or widespread low-level contamination, this contamination contributes to cumulative exposure to many or all people in the community. From a human health standpoint, the origin of the contaminant is irrelevant. However, from a liability-based regulatory standpoint such as CERCLA, the origin is paramount. In the case of the Spokane scenario, it is known that Columbia River fish are contaminated with PCBs and metals (there are existing fish advisories for Lake Roosevelt and for an upriver portion of the Spokane River), but cleanup at the mine site is proceeding as if this contamination is not present or that people are not exposed to it. When an entire community is exposed to nonsite contaminants, we believe that this should be included as part of the total risk burden, and that the clean-up goals for the incremental risk posed by the site itself may need to be modified (see, for instance, OSWER Environmental Justice Action Agenda, EPA 540/R-95/023, which states that "OSWER supports Agency-wide efforts to develop scientifically valid standards to measure cumulative risk."). Other EPA approaches are more cumulative in nature, such as the Guidance on Cumulative Risk Assessment (http://www.epa.gov/ORD/spc/cumrisk2.htm); Toward Integrated Environmental Decision Making (EPA-SAB-EC-00-011; http://www.epa.gov/science1/ecirp011.pdf); and various permitting programs based on total toxicant burdens in a watershed or airshed. As another example, the EPA approach to arsenic or other substances in drinking water is to require treatment to safe levels even if these are lower than natural background levels.

5.5. Individual Exposure Factors

The exposure assessment literature is lacking relevant information for subsistence activities. For instance, gardening or camping are typically used by risk assessors as an analogue for hunting and gathering activities, athletic physiological factors are used as an analogue for more vigorous outdoor activities, sports nutrition information is used in checking diet, and so on. Several pathways are simply unknown, such as the use of medicinal plants (further, certain of these pathways need to be included in a way that does not violate confidentiality). We believe that some factors, particularly soil ingestion, are still underestimated. The amount of exposure obtained as a person consumes wild foods (often without being able to wash them first as is assumed in a typical suburban scenario) is unknown, as is the amount of soil remaining on gathered vegetation even if it is washed, because environmental samples are generally not analyzed in an as-gathered or as-consumed condition.

5.6. Ecological Food Web as an Input to Human Exposure

At present, the tribe does not know if the ecological risk assessments being prepared by EPA for the Midnite Mine will provide the appropriate information for estimating human subsistence dietary information. Existing ecological and human health risk models are generally incompatible. Ecological models typically have more species but fewer pathways, while human health models have many more pathways but generally less trophic-level capability. The lack of transfer factors (soil to plant, and dispersion through the food web) may also pose a problem. EPA is attempting to address this nationally; it is especially important to include tribal considerations during these discussions.

5.7. Seasonality and Acute Exposures

Some of the original activity patterns over the annual seasonal cycle have been modified in modern times, but the ecological cycles have not. Therefore, people must still gather plants according to when they are ripe, hunt according to game and fowl patterns, and fish when the spawning runs occur. The Spokane Tribe Cultural Resources Program confirmed that although specific activities change from one season to the next throughout the year, these activities are replaced by other activities with a similar environmental contact rate. This scenario assumes that exposure is fairly homogeneous because even in winter months materials are gathered, cleaned, and used, and native foods are eaten (i.e., all factors are applied 365 days per year). However, it is possible that excessive acute exposures occur, over and above the annually averaged exposure rates included in this scenario.

5.8. Co-Risk Factors

Many co-risk factors cluster in tribal communities, including poverty, higher rates of existing health conditions (such as diabetes), poorer access to health care, inadequate infrastructure, 500 years of cumulative psychological stress, employment in occupations with more chemical exposures, and so on. Data on other factors such as enzyme polymorphisms related to detoxification or disease susceptibility are simply absent. Each of these factors is known to influence the health response to chemicals, although data are lacking about their combined effect as well as their prevalence in any particular tribal community.

6. CONCLUSION

Although the scenario discussed in this article greatly improves the accuracy of risk-based decision making in Indian Country, much still remains to be done in order for tribes to achieve the same proportional degree of risk reduction that suburban communities have enjoyed for many decades. Existing human-health-based regulatory standards were not developed with subsistence in mind, so tribes are always less protected because they are always more exposed. This is not meant to indict standards as intentionally ignoring certain populations, simply that there are situations and populations that did not receive attention when the regulations were written many years ago. The inequity of this situation has not been fully explored, but is the topic of current research. Additionally, this scenario is not generalizable to other tribes, particularly the diet section, although the soil and drinking water exposure factors may prove to be fairly similar for many tribal settings.

The true worth of any risk assessment is measured by whether its results are used, even if the ultimate decision is based more on other factors such as economics, technical feasibility, or precaution. One of the goals of a project manager is to achieve a stable decision, or one that is durable over time, even if this is not explicitly stated. Decision stability is not merely due to compromise or consensus, but also to whether a community's expectations are met regarding the specific metrics and impacts to be assessed. Decisionmakers or community leaders have certain information needs that can help design a truly useful risk assessment, even if the assessment takes form somewhat differently from the norm. We believe that deliberately incorporating community concerns into both the risk assessment and the risk management decision makes decisions more stable and robust, not less scientific. It is a matter of opinion whether responding to community issues within the risk assessment itself, rather than deferring these items until a later risk management phase, improves the assessment and makes it more useful by tailoring it to the specific situation, or merely results in inconsistency by making results less useful for comparing risks between sites.

We would also like to raise the bar for risk ethics. The traumatic history of federal actions against tribes is still recent history for many tribal nations and tribal members experience remnants of federal extermination and assimilation policies literally every day. This is a strong and discomforting statement, but it is a reality risk assessors and project managers must recognize if they work on tribal risk issues. It might even be said that tribes are still at war, a war that is being fought in the courts on a daily basis to preserve their rights, jurisdiction, resources, religion, homeland, and way of life. We do not want risk assessors to underestimate how serious this is to tribal members and tribal staff. Many or most tribal members can name ancestors who died defending their rights and homelands, and the current generation of tribal scientists honors this by vigilantly protecting the rights and resources on which their culture and identity and existence depend. Mistrust of the federal government and its risk assessment tools can be extremely high and pervasive. Particularly in tribal communities, risk assessors or public health assessors typically run afoul of tribal perspectives because they do not understand the community and its history. There is a tendency to want to get the details right first, then step back and look at the implementation or consequences (i.e., to keep risk assessment separate from risk management). We do not intend to introduce bias into the risk assessment that might come from knowing so much about the community that unconscious judgments are made about how to tailor the assessment (for instance, making a subconscious determination that remediation might take dollars away from other visibly urgent needs). We simply want the assessor to be more aware of the subjects of his or her assessment from the start so as to avoid pitfalls, missteps, and negative community reactions. Currently, tribes and regulators still operate from two different decision paradigms. We wish to recognize the tremendous progress made in recent years by various federal agencies in increasing the attention paid to these issues, but we recognize how much remains to be done.

DISCLAIMER

This exposure scenario has been approved for publication by the Spokane Tribal Council and for use in the Midnite Mine risk assessments. It should not be viewed as a release or waiver of any claims or rights concerning the protection of human health and the environment, the injury of natural resources, or any other claim or right.

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Attachment No 4. Review of: Human Health Risk Assessment Version 1.1 Tar Creek Superfund Site Operable Unit 5, Ottawa County, Oklahoma September 26, 2018

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: July 31, 2020

SUBJECT: Review of: ***Human Health Risk Assessment Version 1.1***
Tar Creek Superfund Site Operable Unit 5, Ottawa County, Oklahoma
September 26, 2018

CC: Katrina Coltrain (EPA-RPM)
File

The **2014 Berrey, et. al. Whitepaper** (Attachment 1), which was a response to EPA Headquarters on how to streamline the Superfund process for Tribal affected sites, demonstrates that the usefulness of a Baseline Human Health Risk Assessment (BHHRA) in making cleanup decisions and targets (e.g. PRGs/RAOs) is quite tentative. Yet enormous sums have been spent in preparing the various BHHRA for the TCSFS.

The Quapaw Tribe of Oklahoma (QTO) provided comments on several earlier supporting documents related to the BHHRA (Attachments No. 2 through 4). The majority of concerns, raised in these previous reviews, are pertinent to all aspects of the BHHRA, and remain unresolved. In general, but for employing the QTO recommended 70kg body-weight in Tribal risk calculations, Appendix A which is EPA's response to comments made on only a subset of these support documents, are interpreted to be "non-responsive" (see Attachment No. 5), with many comments omitted. We are convinced that others, who also had spent resources commenting on this subset of documents, also share this concern. Comments on the site characterization portions of the Remedial

Investigation (RI) rely on the HHRA and vice versa. Until all comments have been addressed by the RI we cannot evaluate the HHRA.

If EPA still believes the BHHRA to be critical for developing PRGs/RAOs, then, once again, as proposed in the cover memo to the June 15, 2018 review:

> ***"The QTO believes it would be much more expeditious and cost-effective for EPA to respond to these previous concerns….. as well as additional concerns provided herein before proceeding any further."***

A few concerns in addition to those described and defined in Attachments 2 through 5, follow. Once again these concerns are in addition to those that remain to be responded to in Attachments 2 through 5.

Additional General Comments

1. **EPA has employed the now dated Scenario**. Humans, and animals in general, are hedonistic in nature, making dietary decisions based on each individual's preference. For example, we all know people that, regardless of its local prevalence and quality, "do not eat fish". This along with EPA's defining OU5 as being aquatic/riparian led the QTO to develop an aquatic-focused RME Scenario (Attachment No. 2 to Attachment No. 3) based on Quapaw Traditional Lifeways Scenario (Harper, 2008). This RME was designed specifically for OU5 and supersedes the earlier, more generalized, scenario. However, EPA has not employed this RME Scenario in this version of the BHHRA.

2. **The Groundwater (including mine-pool) to surface water pathway is responsible for sediment and surface water concentrations of COCs observed today.** EPA retention of the following misconception demonstrates their lack of understanding of the overall problem and its overall cause.

> *"Mine discharge has been found to occur in a few locations in the OU5 watersheds; however, the potential for exposure to mine discharge is expected to be highly limited because of its intermittent* occurrence, typical low flow rates, and relatively low accessibility."

The QTO has demonstrated EPA's conclusion to be blatantly incorrect. The mine periodically issues enormous quantities of water and COCs during storm events. Groundwater (including mine-pool) contributes to surface water in more diffuse areas the remainder of the year. EPA's misconceptualization of the cause of the problem, this late in the game, will have major consequences during the FS portion of the institutionalized study, likely creating even further unnecessary delays on cleanup.

3. **EPA omits upland exposures and does not even discuss how risk will be calculated and ultimately allocated between the OUs.** For example, since allowable risk to Tribal members is already usurped by OU4, no additional risk can be allocated for OU5. This comment is a thread sewn through all of the previous comments (Attachments including sub-attachments to 2 through 4).

4. **The individuals representing the RME are aquatic workers who are QTO members practicing a traditional lifestyle.** This version of the BERA does not evaluate risk to this group.

5. **Use of the term "potential risk" is inappropriate since both are synonyms and are of probability based.** ES Paragraph 2 Sentence 1:

   "The purpose of the HHRA is to evaluate the ***potential risks*** *associated with potential exposures to chemicals of potential concern (COPCs) by human receptors identified in the OU5 study area under current and reasonably foreseeable future land use conditions.*

   For example, its use is similar to saying EPA is 50% correct half of the time. Recommend using only the term "risk".

Attachment No 1. Berrey, J.[1], Kent, T.[2], Kirschner, F.E. [3] and, Harper, B. 2019[4], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[1] Chairman of the Quapaw Nation
[2] Environmental Director, Quapaw Nation
[3] Senior Scientist, AESE, Inc.
[4] Senior Scientist, AESE, Inc.

Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources

By

Chairman Berrey, Quapaw Nation

Tim Kent, Environmental Director, Quapaw Nation

Dr. Frederick Kirschner, Quapaw Nation

Dr. Barbara Harper, Quapaw Nation

Prior to delving into RI/FS studies, EPA needs to realize that the goal of any tribe is to restore its traditional cultural practices and lifeways, including returning to a subsistence level of hunting, gathering, and fishing. It is our experience that this reasonably anticipated future land use (RAFLU) is not contemplated by EPA, DOI, USDA, the State, and their consultants early in the Superfund Process.

By definition, a reservation is reserved by the Federal Government, the land owner, to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. In nearly all superfund cases, the current demography is highly influenced by contamination and subsequent advisories or other institutional controls that reflect reduced land uses that have resulted from current contaminated conditions. Therefore, current demographic conditions and land uses should not be considered as RAFLU in any of the risk assessments. Again, the lands were reserved by congress or executive order for traditional Tribal uses—not current uses that have evolved as a consequence of widespread contamination.

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land must be cleaned up for Unrestricted Land Use. This concept of identifying the RAFLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to attempt to compartmentalize a given problem, it is very important that EPA and the designer of the Remedial Action Alternatives realize that maximizing lands for RAFLU is an overarching goal—capping a lake bottom or capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.[1] Similarly, a brownfield remediation is, by definition, a land use restriction that should not be a final remedy unless the land owner is fully cognizant of the residual contamination and

[1] This discussion applies to Brownfield designation as well.

is in agreement that a brownfield land use is a permanent deed restriction with associated responsibilities of monitoring and informing its members/constituents.

This RAFLU goal does not only apply to lands held in trust by the federal government. Tribes are repatriating lands with the ultimate goal of re-acquiring all nearby non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect the Tribe's members for unrestricted uses (including but not limited to historical traditional cultural practices), these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

It is extremely important that EPA view the remediation of sites containing widespread contamination[2] in the broader context of the environmental justice initiatives that have been developing in the recent years. In the past, the implementation of CERCLA has predominantly focused on cleaning-up organic chemical-related sites that affected large populations of U.S. citizens. Remediation of these sites has been viewed from the narrow lens of protecting the "general public", without taking into account the needs of more sensitive populations. For the citizens of the Tribe, who have the right to "live close to the land" and are forced to live on a parcel of land termed a reservation, creating a remedy that is sufficiently protective of human health poses a new challenge—the resources affected by the site must be much more clean than lands used by members of the General Public, since the General Public is much less exposed than those who rely on the land for sustenance. This is particularly true of mine sites, because, unlike organic chemicals that can be expected to eventually degrade, metals and minerals do not degrade.

As discussed, above, If RAFLU is not contemplated by the parties, the initial preliminary remedial objectives/remedial action objectives (PRGs/RAOs) employed to evaluate the Remedial Action Alternatives (and all of their supporting documents) will not be protective of a Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. Again, in general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture.

It is our experience working with tribes on superfund issues throughout the U.S., that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of site contamination[3]. In essence, the Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. Our experience at more than 10 Tribal-related sites indicates that cleanups are being driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an applicable relevant or appropriate requirement (ARAR)[4]. In many cases, a true non-risk based cleanup is required (i.e. pre-mining baseline/background becomes the PRG/RAO/ARAR). This is clearly the case for mine sites in which a fingerprint of naturally

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[2] For example mining-related Superfund sites such as Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, or Yerington.

[3] Contaminants released from the site that are in excess of natural pre-mining background (PMB).

[4] Non-Tribal ARARs are designed to protect the General Public, not Citizens of the Tribe.

occurring contaminants was present prior to mining[5]. In such instances, PMB is clearly the PRG/RAO, since PRPs cannot be forced to cleanup to conditions better than PMB. Finally, in practice, since excavators cannot "see the PRG/RAO contour line on the ground", and since excavators benefit more financially when more dirt is moved, all near-mine areas that do not rely on institutional controls are generally more protective than estimated.[6]

This concept of cleaning-up a site based on "what the site looked like prior to contamination" also is not new to the U.S. For example for uranium mill sites, the US Nuclear Regulatory Commission (NRC) employs the concept of cleaning-up to As Low as Reasonably Achievable (ALARA, 10 CFR 20) and at a minimum 25 mrem incremental risk above background. Since the difference between 25 mrem and background for a mill tailings pond is on the order of 1 foot of cover soil, the majority of sites are cleaned up to PMB. The DOI NRDAR regulations 43 CFR 11 revised in 2008 also acknowledge the restoration goal[7] for any site, regardless of Tribal involvement is pre-release baseline (PRB)[8]. Finally, when a reasonable U.S. citizen is asked what he or she believes to represent cleanup, the result is invariably "what the area looked like before it was contaminated"—not to a level that results in no more than risk 10^{-6} chance of premature cancer from residual contamination or exceeding hazard indices (HI) as specified under Superfund (40 CFR 300).

In Summary, for mine sites affecting Tribal resources, drawing the conclusion that PMB is the PRG/RAO early in the process enables the focus of work to shift from estimating risk and back-calculating PRG/RAOs, to determining PMB and mapping the nature and extent of contamination. This early realization will result in saving large sums of time and money, makes EPA to appear more credible to the public, speeds the cleanup process while not costing the responsible parties additional sums, and more rapidly brings closure to the RI/FS and NRDA processes. Aspects of the Baseline Human Health Risk Assessment may still be necessary to assess residual risk associated with each general action evaluated in the FS and to ensure that the proposed alternative is protective of human health and the environment. However, this work can come later.

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[5] This is the case for most mining-related superfund sites, including the Midnite Uranium Mine, Leviathan Mine, Sulphur Bank Mercury Mine, etc.

[6] Large sites Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, etc., where residual mine contamination and concomitant residual risk will occur in distal waterways for geologic time, require the pathway from source areas to be fully broken via removal action.

[7] From 43 CFR Part 11, Subpart A § 11.14 Definitions. (e) Baseline means the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred. (ll) Restoration or rehabilitation means actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided, when such actions are in addition to response actions completed or anticipated, and when such actions exceed the level of response actions determined appropriate to the site pursuant to the NCP.

[8] PRB and PMB are synonymous.

Attachment No. 2 October 17, 2019 Memo entitled: Review of: Remedial Investigation Report Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma, June 2019.

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: October 17, 2019

SUBJECT: Review of: ***Remedial Investigation Report Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma, June 2019.***

CC: File

This memo constitutes a review of the aforementioned document. A few general comments follow. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

General Comments

1. **The Draft RI is Premature: issues surrounding the HHRA, BERA, ARARs and PRGs/RAO have not been resolved prior to publication of this document (40CFR300.430(c).[1]** Feasibility Study and remedy designers require delineation of the three-dimensional material that needs to be addressed under the remedial action. Delineation of the nature and extent of contamination (N&E) of all media is required in order to estimate volumes of materials requiring removal or treatment. The N&E is determined by comparing pre-contamination and post contamination levels of contaminants sampled in all media. Sometimes the extent of unallowable risk is determined by comparing risk-based numeric values of PRGs/RAOs to post release conditions. Remedies based on this approach are less protective and uncertain, since redistribution and re-concentration of residual contamination over time cannot be addressed[2]. As pointed out in numerous reviews dating back nearly 20 years, PRGs/RAOs for this site in which Tribal subsistence is the reasonably foreseeable land use, the PRGs must be based on background threshold values (BTVs). If cleanup achieves BTVs, the site is truly cleaned up for all foreseeable and unrestricted land uses. Below is a General Comment No. from 2005 regarding this issue (Attachment No. 1):

   > 6. *For this site, which involves several Native American Tribes, typical PRG's/RAOs/ARARs will not be protective. Therefore, any sample designs based on the attainability of PRG's/RAOs/ARARs that are designed to protect the general population will not be applicable here (i.e. any study that uses these "standards", designed for the general population, to falsely and incorrectly screen-out COCs, media, pathways, or exposure areas) and will only complicate matters later on in the process when the BHHRA has been completed and it is "discovered" that ARARs, PRGs, and PRAOs are not protective of the Tribes.*

   This issue is explored in much more detail in Berrey, et. al (2019; Attachment No. 1):

   The RI is of little use until issues surrounding the HHRA[3], BERA, ARARs and PRGs/RAO have been resolved. Regardless of the millions spent on studies, EPA has not gained any further knowledge of importance to the Feasibility Study

[1] The site characterization report, the BERA, the HHRA, and the PRGs/RAOs determination are finalized prior to publication of the RI. This is another example of "ready, fire, aim."

[2] This problem is amplified at sites like this where buried historic solids that have not been characterized, become available for erosion during annual runoff events.

[3] The Tribe provided over 100 pages of comments on the HHRA alone in its September 26, 2018 memo entitled: Review of: Tar Creek Source Material Operable Unit 4 Remedial Action Exposure Scenario for Human Receptors in Riparian Areas.

regarding the nature and extent of contamination since 2005, and perhaps much earlier, when investigators concluded that the contaminants are numerous and pervasive and the extent of contamination is not contained within the boundaries of OUs 4 or 5. Again, FS designers require three-dimensional delineation of the nature and extent of contamination in order to estimate volumes of materials requiring removal or treatment. The OU5 RI does not meet these FS requirements and will not meet these requirements until consensus has been attained on the aforementioned documents.

2. **Characterization of the main source of Acid rock drainage (ARD), the main cause of release and transport of COCs in both surface waters and sediments, has been omitted.** Kirschner (2008) demonstrates that the Mine discharges are responsible for major dissolved load during baseflow and increases dramatically during recharge and resaturation of mine workings which coincides with major runoff events.[4] Rationale for sampling the different portions of the hydrograph is described in Kirschner (2008)":

   3.2.1 Field Considerations

   One goal of surface water sampling (described in greater detail below) was to sample during baseflow conditions and during the peak of the hydrograph in the Douthat Bridge area. This area is of interest because Tar Creek gains flow and COCs from the mine pool via discharging shafts/air vents in that area. This relationship has been described during several historical investigations, including work performed by EPA while working toward a remedy on operable unit 1 (OU1, medium based OU, defined as ground water for the site).

   In general, early investigators noted that Tar Creek turns red in color as ferri-oxyhydroxides and other metals precipitate out of solution in the mixing zone formed by the confluence of mine-pool and Tar Creek flows (Figure 3). In order to understand loading or COCs, it is necessary to understand contribution of COCs in this area during peak and baseflow.

   Sampling during baseflow is required to understand transport under typical conditions. Depending on meteorologic conditions, baseflow

[4] Schaider, (2014), CH2M (2010), and CH2M (2017), the main reports relied upon to describe mine discharge, do not sample on the rising and falling limbs of the hydrograph and therefore, miss major release events.

for the site generally occurs in the spring, prior to the rainy season, and in late fall after the rainy season. Sampling during the spring baseflow period is preferred, because it generally follows a long period of minimal precipitation. Under such conditions, salts and other acid rock drainage byproducts are believed to build-up in pore waters of the unsaturated zones of both the bedrock aquifer and the chat pile aquifers. Such COC containing salts and ARD byproducts are typically released upon the first large meteorologic event or freshet.

Another goal of the surface-water sampling program was to obtain a near instantaneously sampled dataset or snapshot of the site. However, it was realized that it could be difficult to acquire a snapshot of baseflow conditions, as the rainy season approached. A two-scale monitoring network was developed to obtain snapshots on a coarse network grid (Figure 7). Three snapshots were made: (1) during baseflow, (2) near the peak of the hydrograph, and (3) on the trailing limb of the hydrograph.

Results depicted in Kirschner (2008) demonstrate that COCs sampled from the rising and trailing limbs of the hydrograph at the Douthat area are roughly the same, or slightly less, than during baseflow, even though flow was more than 1,000 times higher than baseflow.[5] This means that areas like Douthat are transmitting and introducing, for the first time to OU5[6], enormous volumes of COCs into the surface water/sediment system. To make matters worse, all of this occurs during annual high-flow events that result in flooding and contamination of riparian (OU5) and terrestrial soils (OU4).

Kirschner (2008) concludes:

Tables 5 and 6 summarize both the total and dissolved COCs that exceed the statistically or functionally supportable values of background as well as the maximum observed background values. From this, it is evident that at least one COC is exceeded at almost all locations. It is apparent that the mine-pool discharge in the vicinity of the Douthat Bridge area is contributing a disproportionate amount of COCs to the system. Equally important, is that there are no other loading sources to Tar Creek that are as significant as the mine pool at Douthat Bridge. [Emphasis added]

[5] Dilution of COCs is observed upstream of Douthat on the rising and trailing limbs of the hydrograph, demonstrating that the release from chat piles is less important than the release associated with discharge from the mine pool.

[6] Unlike stream sediments which are resuspended or eroded from OU4.

This omission in the RI is considered a fatal flaw since the FS design team will need to design for these conditions which occur annually—not conditions associated with baseflow.[7] For example, if not appropriately addressed via FS design, remediated riparian/terrestrial soils will be recontaminated during large storm events that cause the river/creeks to back-up, flood, and deposit sediments over large areas.

These issues are not new to EPA. Attached is the Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site (2007; Attachment 2). Section **3.1.3** ***"Hydrogeologic studies to determine strategic locations within mine pool for injection."*** should be re-consulted.[8]

3. **Potentially impacted ephemeral streams/creeks and all riparian soils have been omitted from all OUs.** Transition zone (TZ) soils are partially addressed in OU4[9]. OU5 covers perennially saturated sediments and surface waters. The 100 yr. floodplain is large and has been inundated several times during my 20+ years on the project. In some instances, the heart of the site becomes completely inundated, with solids being resuspended and redistributed. Along these lines is the fact that tornadoes clearly have redistributed solid materials in both volumes and directions that are not readily predictable using standard air-phase transport theories.

   Instead of spending 15-20 more years conducting piecemeal sampling campaigns of these areas, the Tribe recommends assuming that the 100yr floodplain is equally as contaminated as stream sediments. This makes practical sense, since riparian soils become sediments during annual runoff events. This means that the numeric PRGs/RAOs for upland or riparian soils cannot exceed those for sediments. Otherwise they are a source to OU4[10]. Again BTV's for sediments and soils are similar and should be used as the numeric PRG/RAO required by the FS designers to proceed.[11] Obviously, recontamination concerns would

[7] A rule of thumb particularly pertinent to soil/sediment transport is that "the majority of soils or sediments are transported and redistributed during one or two days in a given year, during major storm events." Based on Kirschner (2008), this rule of thumb also applies to surface water COC flux, due to the nature of interconnection between the mine pool and surface water at Tar Creek.

[8] This document was central to the proposed plan for OU4, which was cooperatively developed by the QTO, EPA, and the State of OK.

[9] The definition describing OU4 is incorrect: "addresses the undeveloped rural and urban areas of the site where mine and mill residues and smelter wastes have been placed, deposited, stored, or disposed of, or otherwise have come to be located as a result of mining, milling, smelting, or related operations." This "comes to be located" language covers sediments etc. and is much more expansive than OU4 which ends with TZ soils and chat in streams.

[10] This issue was raised with EPA during the Tribe's review of OU4.

[11] By definition these media are not affected by anomalous concentrations (i.e. contamination).

necessitate cleanup of upgradient riparian and upgradient upland soils prior to the downstream streambeds and banks.

4. **EPA demonstrates it lacks understanding of the geo-physical system while attempting to delineate the nature and extent of contamination.** EPA employed PIA to BTV point comparisons as well as PIA to background population distributions using a central tendency test. The latter approach is patently incorrect and provides no additional useful information. This approach should be removed from the following draft.[12]

5. **All results indicate that EPA has not delineated the N&E of sediments.** All PIA samples exceed at least one BTV by a large amount (generally 10x the BTV). The goal to delineating the N&E is to employ step-out sampling until two non exceedances are observed in all directions. From the FS standpoint, at least one of the measured COCs exceeds BTV throughout each area of interest. Therefore, ALL AOIs need to be addressed, by yet to be specified general response actions (GRAs). Exceedance maps tell the story. Exceedances are large and pervasive. All of the verbiage related to the N&E is a regurgitation of what the maps and tables already tell us, and is not very useful. It is clearly unnecessary filler.

6. **Criteria used to delineate the N&E of surface water is incorrect and not protective.** Unlike the sediments which employed BTV to evaluate the N&E, the RI employs KS, MO, and OK state surface water quality standards (SWQS) to evaluate water quality. These state SWQS are risk-based not pre-release conditions based, meaning that areas that do not exceed state SWQS are not necessarily clean. This means that the N&E of surface water has not been appropriately evaluated. BTV concentrations calculated in Kirschner (2008) are clearly lower than all state SWQS and should be used as the metric to compare to sampling points in the potentially impacted area (PIA) to delineate the N&E. This analysis will also conclude that COCs measured in surface water are numerous, pervasive, and the extent of contamination is not contained within the boundaries of OUs 4 or 5.

7. **Although SWQS are likely ARARs, they are not the only ARARs.** The Quapaw Nation has surface water quality standards that apply to their lands (Attachment No. 3). None of the "state standards" employ Harper (2018)[13] and therefore are not protective of Tribal uses. Therefore, this ARAR is not protective of Human health (FS design Threshold criteria under 40CFR300.430). EPA

[12] Some of the greatest gold discoveries would have been overlooked employing this approach.
[13] Tar Creek Superfund Site RME, Prepared by Dr. Barbara Harper, DABT, AESE Inc. August, 2018.

would save a lot of time and resources by calculating SWQS now, based on Harper (2018).

8. **Both COCs measured in sediments and soils are temporally variable,** and as demonstrated in Kirschner (2008), have a wide range of variability, especially during storm events. This means that all depictions of the nature and extent of contamination in the RI are not static—the maps change over time, depending on when and where sampling has occurred.

   As described above, the FS team requires knowledge related to worst case probable conditions. This draft does not reflect such conditions—only the conditions during sampling on a given date.

9. **In many instances, EPA only sampled 3 COCs which does not enable evaluation of risk or direct consequences to man or flora or fauna.** For example, Kirschner (2008) employed the full EPA Target Analyte List, plus molybdenum. Molybdenum was included specifically to evaluate copper deficiency in ruminants (cattle). The ability to use some of these lands for grazing will continue to be questionable. The Tribe has commented numerous times obviating the problems with EPA's approach. These problems continue to propagate through the RI/FS process.

10. **The BTVs for sediments have numerous concerns.** The Tribe concurs with using four-mile creek as an appropriate reference stream for sediments of Tar, Lytle, and Beaver Creeks, but we cannot support application of Four-mile derived BTVs to other areas, such as Neosho River whose watershed is much larger and drains much different geologic units.

    Kirschner's rationale for employing Fourmile Creek as a reference stream for Tar, Lytle, and Beaver Creeks is as follows (Kirschner, 2008):

    > "*Fourmile Creek and the upper reaches of Tar Creek (Upper Tar Creek) serve as provisional reference streams (Figures 2 and 3). These reference areas were selected based on bedrock geology, soil-types, stream gradient, stream size, and field reconnaissance of vegetation. Due to agricultural uses, housing development, and all other uses or anthropogenic actions occurring within the watersheds of these reference areas, these reference streams are not "perfect analogs of premining conditions", but they are analogous to conditions that would likely be present if past mining had not*

occurred. The reference areas that are upstream on Tar Creek may also be affected by upstream deposition of contaminants from the site via periodic backing-up of the stream behind Grand Lake and from wind-blown deposition. Both reference areas may also be affected by the use of chat in a variety of construction projects.

Comparison of values of COCs measured in media representing the reference areas to those obtained in the potentially impacted areas yield insight on the nature and extent of contamination within the Quapaw Indian Reservation. "

Table ES-1 has several issues:

a. The Tar Creek mining deposit is at depth with no observable geochemical anomalies (COCs) observable on the surface (i.e. blind deposit discovered by drilling). Appropriate reference streams/areas also should exhibit this blind behavior, meaning that there are no real surficial sources to contribute COCs to sediment/soils. Subsequently, both sieved and unsieved sediments, regardless of the sieve size should exhibit similar concentrations of COCs and should be relatively temporally static.[14] In fact concentrations are similar except MacDonald's max value of unsieved zinc is 100% higher than Kirschner's sieved max value.[15] All other specimens appear to be fairly close in concentration.[16] Since the highest values drive the BTV, we recommend censoring or culling MacDonald's high value of Zn. Doing so renders a more protective value and makes the dataset more internally logical.

b. The denominator of the Frequency of detection (FOD) reveals that the list of COCs are quite variable, meaning they were likely sampled by different investigators using different protocols designed to answer different DQO's. Regardless, exceedances of BTVs are pervasive.

c. All samples acquired from the potentially impacted area (PIA) contain COC's that exceed the BTVs. This only demonstrates that the EPA's reliance on the

[14] This relationship does not hold for the PIA, where ores have been brought to the surface and releases occur due to past mine waste management practice. In the PIA, sieve size can make a huge difference since transport and size reduction is occurring. PIA samples should be obtained just prior to the annual runoff event and samples should be sieved to a similar size to determine N&E. Also -63um should be used since its transport distance is much greater. Finally, Kirschner (2008) sieved samples to -63um—not -250 um as reported in Table 5-2 and elsewhere.

[15] Analysis of the dataset indicates that sample FCSD09 may be near a shaft our downstream from a chat-covered road crossing.

[16] Temporal variability cannot be evaluated. A q-q plot of Zn visually identifies this outlier.

administrative order on consent (AOC), to limit the future sampling suite, was erroneous and ultimately not protective of humans, flora, or fauna.

11. **Figure E-6 (CSM) has several problems:**
    a. The CSM attempt to compartmentalize by OU
    b. Many of the media cross OU boundaries
    c. Groundwater is not considered an exposure media
    d. Omits groundwater, soils, and the air pathways

12. **A retrospective datagap analysis has not been performed to evaluate the new data gathered post 2017.** Revelations on sampling associated with biota demonstrates that DQOs were not met. However, such revelations for other media are not as obvious. Also note that DQOs are not even described in the RI.

13. **Tables 5-3& 5-4.** Recommend reporting "n" as well as max value detected. Kirschner (2008) samples were sieved to -63 um—not 250 um

14. **Table 5-6.** Cd UTL95-95 appears to be over an order of magnitude higher than Kirschner (2008). Appears to be a problem with decimal placement. All maps/interpretation relying on this table needs to be checked.

15. **Figure 5-1 through 5-4**. The watershed polygons are not useful for interpretation. Reference areas must contain similar geology and soils. This requirement is basic to experimental design and selection of the reference areas. Recommend that geology or soil-type polygons be displayed instead of watershed polygons.

16. **Figures 6x (exceedance maps).** The lowest criterion of 10x background is not helpful. Recommend 2x or 3x—not 10x. Sieved and unsieved sediments of the PIA should not be pooled and compared to BTVs to determine the N&E. The -63um sieve size should be used to delineate the N&E. See footnote 10 above. If larger fractions are employed to map the N&E, a qualifying statement, such as "these comparisons are made using non-comparable values—the result depicted on the map is smaller than the actual size".

17. **Figure 7-1.** Omits ARD in unsaturated bedrock which is a major exogenous source today.

18. **Figure 7-2.** Fully omits underground workings and connection to upstream surface water that recharges the mine pool and controls the GW to SW pathway (flow and chemistry).

19. **Figure 7-3.** ARD source omitted. Ingestion, dermal, inhalation needs to be evaluated. Also need irrigation of plants with groundwater/surface water that is mine affected. Plant to cattle to human is omitted. Water to cattle to human is omitted. This CSM needs a major revision.

20. **Appendix F Statistics.** The exploratory data analysis (EDA) for the reference area samples is weak and poorly performed. Need q-q plots for sieved and unsieved sediments from the reference area. Once it has been determined that the area is relatively homogeneous for both sample types, these data can then be pooled. We know multiple populations creating gradients are present in the PIA; therefore, q-q plots are not useful for the PIA. Also, sieved and unsieved sediments of the PIA should not be pooled and compared to BTVs to determine the N&E. The -63um sieve size should be used to delineate the N&E. See footnote 10 above. If larger fractions are employed to map the N&E, a qualifying statement, such as "these comparisons are made using non-comparable values—like a re-view mirror, the result depicted on a given map is smaller than the actual size".

    The Tribe recommends the following process to determine PMB of sediments and surface water[17]:

    a. EDA (predominantly q-q plots) to ID any outliers (note MESL's high value of Zn is clearly an outlier). Since the deposit is blind, the distribution of each COC should be roughly normal (they are).
    b. Since the number of samples ("n") is low, the max observed for each COC (with outliers culled) should be used at the BTV.
    c. Delete all other UTL assumptions/attempts to qualify distribution as something other than normal, or retain them to show that it really does not matter[18]

    Comparison of concentrations of COCs in the PIA to BTVs should be point to point (or point to cutoff). EPA needs to delete all population-to-population or population-to-cutoff comparisons. Although these items provide good filler, the

[17] Since surface water is highly temporally variable and tied to mine discharges, surface water needs to be from same time period (if multiple time periods are to be characterized) or from the period likely to be highest (baseflow). This approach was followed by Kirschner (2008).

[18] The fact that other methods are close to the max value for each COC suggests that distribution is homogeneous.

approach is not correct and is not helpful. This and “c.” above only demonstrate the statisticians lack of understanding of the physical situation.

21. Appendix H: BERA General comment No. 3 applies to the entire BERA as well as the entire RI.

a. The RAOs/PRGs are qualitative at best and are not implementable and therefore not effective:

> ***“ • RAO for aquatic receptors: Minimize or prevent exposure to sediments and/or pore water that are sufficiently contaminated to pose moderate or high risks, respectively, to microbial, aquatic plant, benthic invertebrate, or fish communities (particularly for fish species that use sediment substrates for spawning).***
>
> ***• RAO for aquatic-dependent wildlife: Minimize risks to sediment-probing birds or omnivorous mammals associated with incidental ingestion of sediments during feeding activities.”***

It is clear that these broad aspirational statements are the goals of any CERCLA cleanup and therefore apply to any Superfund site. Therefore, they could have been developed without any prior knowledge of the site, saving millions of dollars. These aspirational statements are of no use to the FS team. As stated over the years on previous drafts produced by MacDonald, the Tribe does not agree with the method in which non-cumulative hazard indexes are employed and interpreted, when clearly there are numerous COCs adding to the risk to receptor groups. Again, the Tribe believes that the PRGs/RAOs will ultimately be determined based on Tribal uses, and will default to BTVs as described in Attachment No. 1. Therefore, we do not see the role of the BERA/ASLER/DERA in making FS and subsequently remedial decisions.

b. This is the first we have seen this document, even though it was published on April 10, 2019 (see General Comment No. 1)

c. The ASLERA and DERA are dated and have not been updated with the 2017 data and its interpretation. However, we are not sure that an update would matter—the ASLERA sampling is but just a snapshot in time that was not designed to characterize worst case conditions. Regardless, analysis of the snapshot concludes that nearly all of the perennial waterways and there sediments are clearly contaminated and require remediation.

d. The CSM (Figure 3) includes terrestrial and floodplain soils as exposure media; however, these media were never sampled and up-chain risk was never evaluated (See General Comment No. 3). The CSM also omits ARD and transport to SW via GW from the mine discharges as a primary release mechanism.

Attachment No 1. Berrey, J.[18], Kent, T.[19], Kirschner, F.E. [20] and, Harper, B. 2019[21], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[18] Chairman of the Quapaw Nation
[19] Environmental Director, Quapaw Nation
[20] Senior Scientist, AESE, Inc.
[21] Senior Scientist, AESE, Inc.

Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources

By

Chairman Berrey, Quapaw Nation

Tim Kent, Environmental Director, Quapaw Nation

Dr. Frederick Kirschner, Quapaw Nation

Dr. Barbara Harper, Quapaw Nation

Prior to delving into RI/FS studies, EPA needs to realize that the goal of any tribe is to restore its traditional cultural practices and lifeways, including returning to a subsistence level of hunting, gathering, and fishing. It is our experience that this reasonably anticipated future land use (RAFLU) is not contemplated by EPA, DOI, USDA, the State, and their consultants early in the Superfund Process.

By definition, a reservation is reserved by the Federal Government, the land owner, to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. In nearly all superfund cases, the current demography is highly influenced by contamination and subsequent advisories or other institutional controls that reflect reduced land uses that have resulted from current contaminated conditions. Therefore, current demographic conditions and land uses should not be considered as RAFLU in any of the risk assessments. Again, the lands were reserved by congress or executive order for traditional Tribal uses—not current uses that have evolved as a consequence of widespread contamination.

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land <u>must be cleaned up for Unrestricted Land Use</u>. This concept of identifying the RAFLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to attempt to compartmentalize a given problem, it is very important that EPA and the designer of the Remedial Action Alternatives realize that maximizing lands for RAFLU is an overarching goal—capping a lake bottom or capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.[1] Similarly, a brownfield remediation is, by definition, a land use restriction that should not be a final remedy unless the land owner is fully cognizant of the residual contamination and

[1] This discussion applies to Brownfield designation as well.

is in agreement that a brownfield land use is a permanent deed restriction with associated responsibilities of monitoring and informing its members/constituents.

This RAFLU goal does not only apply to lands held in trust by the federal government. Tribes are repatriating lands with the ultimate goal of re-acquiring all nearby non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect the Tribe's members for unrestricted uses (including but not limited to historical traditional cultural practices), these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

It is extremely important that EPA view the remediation of sites containing widespread contamination[2] in the broader context of the environmental justice initiatives that have been developing in the recent years. In the past, the implementation of CERCLA has predominantly focused on cleaning-up organic chemical-related sites that affected large populations of U.S. citizens. Remediation of these sites has been viewed from the narrow lens of protecting the "general public", without taking into account the needs of more sensitive populations. For the citizens of the Tribe, who have the right to "live close to the land" and are forced to live on a parcel of land termed a reservation, creating a remedy that is sufficiently protective of human health poses a new challenge—the resources affected by the site must be much more clean than lands used by members of the General Public, since the General Public is much less exposed than those who rely on the land for sustenance. This is particularly true of mine sites, because, unlike organic chemicals that can be expected to eventually degrade, metals and minerals do not degrade.

As discussed, above, If RAFLU is not contemplated by the parties, the initial preliminary remedial objectives/remedial action objectives (PRGs/RAOs) employed to evaluate the Remedial Action Alternatives (and all of their supporting documents) will not be protective of a Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. Again, in general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture.

It is our experience working with tribes on superfund issues throughout the U.S., that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of site contamination[3]. In essence, the Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. Our experience at more than 10 Tribal-related sites indicates that cleanups are being driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an applicable relevant or appropriate requirement (ARAR)[4]. In many cases, a true non-risk based cleanup is required (i.e. pre-mining baseline/background becomes the PRG/RAO/ARAR). This is clearly the case for mine sites in which a fingerprint of naturally

[2] For example mining-related Superfund sites such as Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, or Yerington.
[3] Contaminants released from the site that are in excess of natural pre-mining background (PMB).
[4] Non-Tribal ARARs are designed to protect the General Public, not Citizens of the Tribe.

occurring contaminants was present prior to mining[5]. In such instances, PMB is clearly the PRG/RAO, since PRPs cannot be forced to cleanup to conditions better than PMB. Finally, in practice, since excavators cannot "see the PRG/RAO contour line on the ground", and since excavators benefit more financially when more dirt is moved, all near-mine areas that do not rely on institutional controls are generally more protective than estimated.[6]

This concept of cleaning-up a site based on "what the site looked like prior to contamination" also is not new to the U.S. For example for uranium mill sites, the US Nuclear Regulatory Commission (NRC) employs the concept of cleaning-up to As Low as Reasonably Achievable (ALARA, 10 CFR 20) and at a minimum 25 mrem incremental risk above background. Since the difference between 25 mrem and background for a mill tailings pond is on the order of 1 foot of cover soil, the majority of sites are cleaned up to PMB. The DOI NRDAR regulations 43 CFR 11 revised in 2008 also acknowledge the restoration goal[7] for any site, regardless of Tribal involvement is pre-release baseline (PRB)[8]. Finally, when a reasonable U.S. citizen is asked what he or she believes to represent cleanup, the result is invariably "what the area looked like before it was contaminated"—not to a level that results in no more than risk 10^{-6} chance of premature cancer from residual contamination or exceeding hazard indices (HI) as specified under Superfund (40 CFR 300).

In Summary, for mine sites affecting Tribal resources, drawing the conclusion that PMB is the PRG/RAO early in the process enables the focus of work to shift from estimating risk and back-calculating PRG/RAOs, to determining PMB and mapping the nature and extent of contamination. This early realization will result in saving large sums of time and money, makes EPA to appear more credible to the public, speeds the cleanup process while not costing the responsible parties additional sums, and more rapidly brings closure to the RI/FS and NRDA processes. Aspects of the Baseline Human Health Risk Assessment may still be necessary to assess residual risk associated with each general action evaluated in the FS and to ensure that the proposed alternative is protective of human health and the environment. However, this work can come later.

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[5] This is the case for most mining-related superfund sites, including the Midnite Uranium Mine, Leviathan Mine, Sulphur Bank Mercury Mine, etc.

[6] Large sites Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, etc., where residual mine contamination and concomitant residual risk will occur in distal waterways for geologic time, require the pathway from source areas to be fully broken via removal action.

[7] From 43 CFR Part 11, Subpart A § 11.14 Definitions. (e) Baseline means the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred. (ll) Restoration or rehabilitation means actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided, when such actions are in addition to response actions completed or anticipated, and when such actions exceed the level of response actions determined appropriate to the site pursuant to the NCP.

[8] PRB and PMB are synonymous.

Attachment No 2. The Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site Prepared by AESE Inc. For The Quapaw Tribe of Oklahoma March 9, 2007

The Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site

Prepared by AESE Inc.

For

The Quapaw Tribe of Oklahoma

March 9, 2007

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1.0 Introduction

EPA developed and evaluated approximately 10 alternatives in the RI/FS process. A Draft Proposed Plan identified Alternative No. 4 as EPA's Preferred Alternative. The Preferred Alternative, as well as all other alternatives had major shortfalls with respect to protection of human health of Tribal members for the reasonably foreseeable land use as well as with other criteria used to evaluate alternatives under the NCP (40 CFR 300.430(e)(9), (f))

A Remedial Action Alternative, which includes three options is described below. This alternative is similar to the alternative proposed to EPA and the PRP on November 29, 2005. This alternative differs greatly from EPA's Proposed Remedial Action Alternatives in five important aspects:

1. This Alternative is designed to address site-wide wastes including those in the Treece Area of Kansas. EPA's alternatives focus only on surficial wastes in Oklahoma.

2. This Alternative is designed to consolidate wastes by addressing distal areas first, working toward the center of the site. EPA's alternatives rely predominantly on covering wastes in place.

3. This Alternative is designed to be protective of the Tribe's current and future residents for Tribe's designated Future Land Use. EPA's alternatives do not consider the Tribe's Future Land Use.

4. This Alternative is designed to address the ground water and surface water problems, positively affecting downstream interests. EPA's alternatives focus only on surficial wastes in Oklahoma.

5. This Alternative is much more prescriptive and more completely staged than EPA's alternatives. EPA's alternatives are poorly specified which increases the probability of realizing unintended consequences associated with not paying close attention to cumulative effects.

An outline of the proposed alternative is described followed by a detailed discussion of tasks. Although we do not believe that EPA choice of excavation and hauling equipment has been optimized, EPA's unit costs from: "***Feasibility Study Tar Creek Superfund Site Operable Unit No. 4 Ottawa County, Oklahoma***" are employed herein to enable comparisons.

Finally, the alternative as well as EPA's alternatives are evaluated or screened against the nine criteria of the NCP as well as other criteria EPA has used to compare its alternatives and develop its Draft Proposed Plan.

2.0 Outline for Tribal Alternative 1 (TA1)

To be consistent with EPA's Draft Proposed Plan, TA1 also consists of two main phases separated by approximately 10 years. The basic elements of each phase are:

Phase I

1. Chat Processing via Continued Sales (same as EPA's Proposed Plan); however, this Task is officially a portion of the CERCLA remedy. This assumes that 75% of all of the remaining chat is removed in 20 years via sales. This assumption is employed to be consistent with EPA's alternatives[1]. No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern (COC).

2. Removal of Chat and Chat base material from Distal Areas where chat is not currently marketable. This task consists of excavating, hauling, and delivering chat and chat base materials from distal areas to Chat Washers. This is cheaper than disposal in a repository and should help to bolster longevity of chat market.

   No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

[1] Unlike the EPA proposed Alternative, consolidation of chat bases and chat piles will result in "controlled management" of the hazardous substances via temporary institutional controls. This approach differs greatly from EPA's approach that employs "uncontrolled management" (actions are at the mercy of the market forces), reportedly necessitates the 20-year timeframe based on human health concerns. Controlled management as described herein should allow for sales to continue much longer. With time, non-marketable chat and chat bases could be wet-sieved by the governments, making the chat free for pickup to entities located beyond the market's "break-even" radius (reported to currently be approximately 200 miles).

3. Hydrogeologic studies to determine and identify strategic subsurface locations for injection. The study would also investigate interconnection with Commerce workings (if any).

4. Injection of Fine Wastes into strategic subsurface locations in order to change the hydrogeology. The goal is to minimize periodic oscillations of the water table thereby minimizing Acid Rock Drainage (ARD) Production in the Mine Pool (i.e. solve the problem). No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

5. Divert Tar Creek and install a headgate at the Treece Swimming Hole Dike to re-direct flow of Tar Creek into Treece Swimming Hole. This is designed to recharge the Mine Pool in KS. Install another headgate at the Cardin recharge area to re-direct flow of Tar Creek into Mine Pool. These actions are designed to flood pyrite bearing zones in the Pennsylvanian crown-pillar and to reduce the production of acid rock drainage (fix the main problem).

6. If necessary, Temporary Active Water Treatment of Mine Pool at Douthat using a Portable Plant; Discharge of Water Treatment Plant effluent at north end of channel liners (in KS) via pipe to restore river to clean flowing system that will support all future uses.

7. Excavation of Chat/Wastes in Tar, Lytle, and Beaver Creeks. Deliver the excavated chat to local chat washers or dispose of the wastes in one (or two) large lined and capped repository. The large repository will have a designated low-exposure beneficial use (e.g. golf course). No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

8. Install Flexible Membrane Liners (FML) in Tar and Lytle Creeks, from the Douthat Bridge area north past the Mine Workings in KS and over the mined-out areas in Beaver Creek . This is designed to immediately break the ground-water to Surface Water Pathway. Fines, chat, or relatively cleaner soils are used as Sub-Base for the FML. River substrate is purchased from mine Limestone quarry onsite or on the reservation (near Tribal HQ) and is placed on top of the FML and filter layer. This will remediate surface water, sediments, ground water, and riparian areas within the site as well as down gradient. This work and subsequent design is contingent on the findings of the aforementioned Hydrogeologic Studies.

9. Conduct education and community awareness throughout the site for the duration of the remedy. This has proved to be very effective at Tar Creek and other lead sites across the nation.

10. Remove or amend the transition zone soils to background conditions.

Phase II (after ~10 years)

1. Wet sieve remaining chat/chat bases, making the chat free for pickup to entities located beyond the "break-even" radius (reported to be approximately 200 miles). Compared to capping in place or disposal in designed repositories, this not for profit approach will enable subsurface disposal of all fines at a nominal unit cost.

3.0 Detailed Description of Tasks

A Remedial Action Alternative, in addition to those developed by EPA is provided below. This alternative is similar to that proposed to EPA and the PRP on November 29, 2005. This alternative differs greatly from EPA's Proposed Remedial Action Alternatives in several important aspects:

1. This Alternative is designed to address site-wide wastes including those in the Treece Area of Kansas.

2. This Alternative is designed to consolidate wastes by addressing distal areas first, working toward the center of the site.

3. This Alternative is designed to be protective of the Tribe's current and future residents for Tribe's designated Future Land Use.

4. This Alternative is designed to address the ground water and surface water problems, positively affecting downstream interests.

5. This Alternative is much more prescriptive and more completely staged than EPA's alternatives.

This broader, watershed-wide, approach is required because the ground water and surface waters of Kansas and Oklahoma in the Tar Creek area are inextricably linked. This means that Remedial Actions taken in the Treece, Kansas area will affect down gradient abiotic media, including, but not limited to ground water, surface water, sediments and riparian soils.

If not correctly implemented, actions taken by EPA in KS are likely to recontaminate downstream areas wasting time and monetary resources.

Besides the obvious benefit of reducing the footprint of the site early, consolidation of wastes via removals in distal areas first, has the added benefit of cleaning up the outlying watersheds early. Removals in these areas will cleanup these lands to be consistent with Tribal Land Uses. This means more lands will be available to the Tribe for subsistence hunting and gathering, taking pressure off of other reservation lands and resources.

Although not strictly a portion of OU4, this Alternative utilizes waste material to positively affect the ground water flow system by reestablishing the natural potentiometric surface of the Boone aquifer system. Doing so, in concert with other provisions, will break the ground water to surface water pathway currently responsible for the majority of release of soluble contaminants to downstream areas. A much more thorough discussion is provided below.

Finally, this Alternative is much more prescriptive and much more completely staged than any of EPA's alternatives. A prescriptive remedy is much more attractive to the governments, since uncertainties associated with funding or changes in the personalities of project personnel are minimized. A prescriptive remedy will also enable more accurate cost estimating, once construction methods and equipment are finally determined. Again, although we do not necessarily agree with EPA's selection of dir-moving equipment, EPA's unit costs are used herein, in order to be consistent with EPA's estimates.

3.1 Detailed Description and Staging of Phase I Tasks

Figure 1 represents the basic land features involved in the proposed remedial action Alternative. The basic elements of Phase I are:

1. Chat Processing via Continued Sales.

2. Removal of Chat and Chat Bases from Distal Areas.

3. Perform hydrogeologic studies to determine strategic locations within mine pool for injection. Study would also investigate interconnection with Commerce workings (if any).

4. Injection of Fine Wastes in Strategic Mined-out areas to change hydrogeology

5. Install hydraulic control systems to flood the pyrite-bearing zones in the Pennsylvanian crown-pillar and to reduce the production of mine drainage without creating any new discharges. These systems would be designed to recharge the mine pool in Kansas and to maintain and direct recharge at strategic locations in the Tar Creek site.

6. If necessary, Temporary Active Water Treatment of Mine Pool at Douthat.

7. Excavation of Chat/Wastes in Tar, Lytle, and Beaver Creeks.

8. Install Flexible Membrane Liners (FML) in Tar, Lytle, and Beaver Creeks from Southern Reservation Boundary North past Mine Workings in KS.

9. Implement public education plan.

Tasks 1-5 can be implemented concurrently and immediately. Initiation of Tasks 6-8 is contingent on the results of the Hydrogeologic Study (Task 3).

3.1.1. Chat Processing via Continued Sales

Chat Processing via Continued Sales is assumed to continue (Same as EPA's Proposed Plan). It is also assumed that introduction of distal chat and chat-base materials, described below, will not negatively affect the chat market.

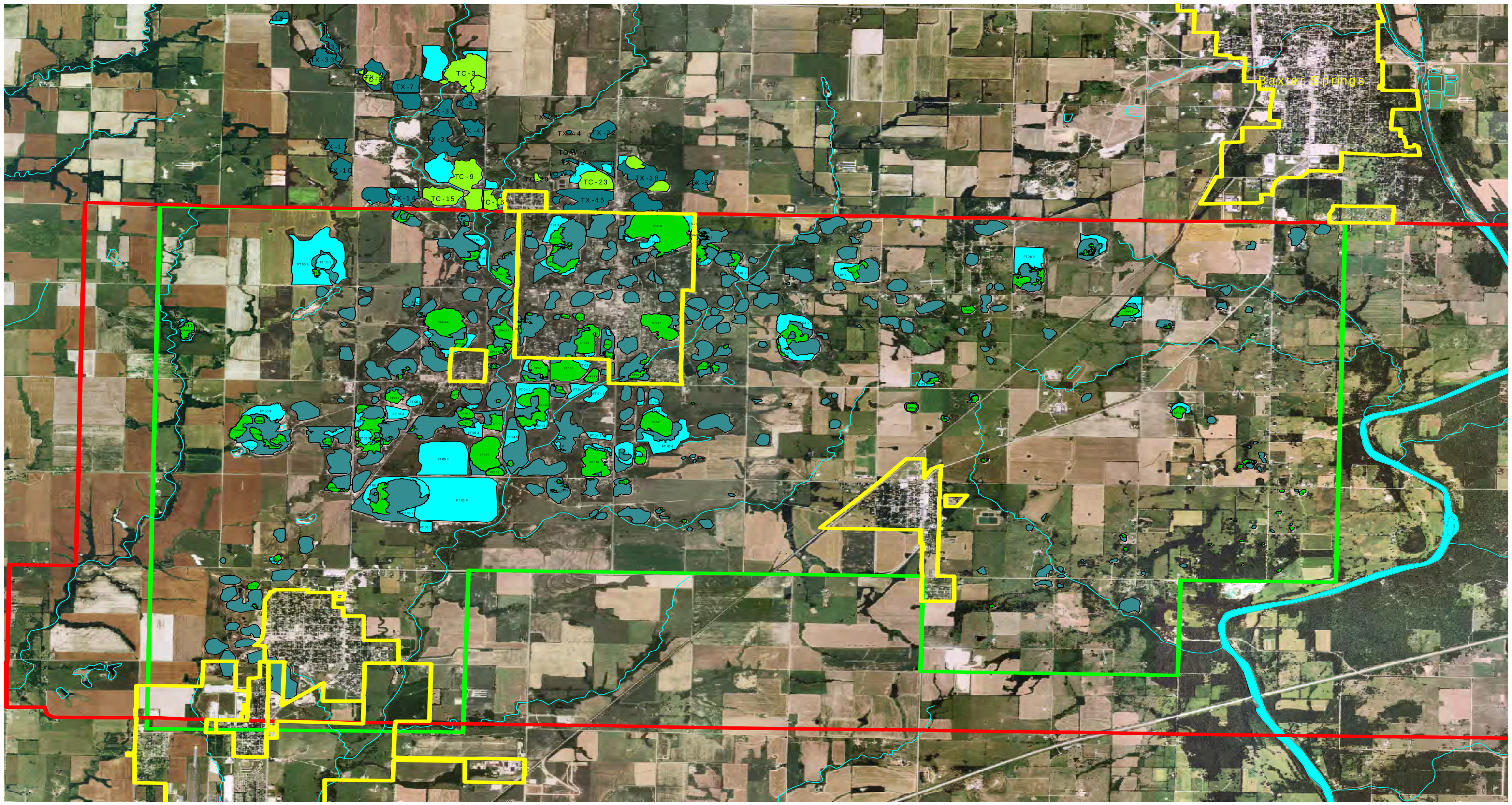


Figure 1. Map of the Superfund site showing chat piles (green polygons), chat bases (dark blue polygons), fine tailings ponds (light blue polygons), the QTO reservation boundary (red line), the NPL boundary (light green line), and town boundaries (yellow lines).

3.1.2. Removals of Chat and Chat Bases from Distal Areas

The disposition of chat and chat bases is determined using Decisional Flow Chart 1 (Figure 2). For the purposes of conservatively estimating costs, it is assumed that all of the chat and chat-base materials are excavated, hauled, and delivered to Chat Washers. Therefore the actual costs may be slightly less upon implementation.

For staging and cost estimating purposes, the NE and SE zones have been delineated (Figure 3). Each zone is terminated by a node or haul-point. These nodes are used only to allow flexibility and should not be construed as a drop-off or pick-up point.

Currently, all of the wastes in the NE zone are assumed to be delivered to the haul-point in Treece and all wastes in the SE zone are assumed to be delivered to the haul-point in east of Cardin (Figure 3). The total volumes of each zone based on EPA RI/FS data are:

NE = 2,263,163 combined cubic yards
SE = 725,379 combined cubic yards

These volumes do not include transition zone soils. The cost and duration of this portion of the project is directly affected by the types and numbers of excavation and hauling equipment. In order to facilitate comparison of this alternative to EPA's alternatives, EPA's unit costs are used herein. However, we would propose using low-ground pressure dozers (e.g. CAT D6) to rip, excavate, and push materials to a pile to feed a loading unit (e.g. CAT 988). The loader would then load off-road haul trucks (e.g. CAT 769). The number of trucks in the hauling unit will depend on the optimum production rate determined for a given pile or work area.

Delivery of wastes to Chat Washers is cheaper than disposal in a repository and should help to bolster longevity of chat market. Delivery of chat directly to the chat washers should enable the washers to remain in a given location for a longer period. Chat Washers will maintain the ability to set up an operation at a large pile. It is also assumed that introduction of distal chat and chat-base materials, described below, will not negatively affect the chat market.

No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

3.1.3 Hydrogeologic studies to determine strategic locations within mine pool for injection.

Work conducted by the Tribe indicates that during baseflow conditions, the discharge from the mine pool at the Douthat Bridge springs is responsible for the majority of loading of contaminants of concern in the entire Tar Creek watershed. USGS (2006) has demonstrated that the chat piles contribute COCs during other portions of the year. A generalized conceptual site model is provided in Figure 4. A more detailed analysis of the hydrogeology based on current information is provided in Appendix A

Modes of release and transport of COCs observed at Tar Creek are similar to those observed at other lead-zinc mining sites:

1. During baseflow and typical flow conditions, the majority of COCs are transported via the liquid phase, as dissolved COCs.

2. Compounds of COCs exhibiting lower solubility, such as $PbSO_4$ are transported predominantly during runoff events.

A rule of thumb is that 95% percent of the annual total load of a given for a relatively insoluble COC (e.g. anglesite or $PbSO_4$) from a given basin can occur during a single annual event. Since these events are so infrequent and very high energy, they are rarely adequately characterized via monitoring.

Another important aspect of these types of events is that they are characterized by concomitant large discharges and flows in surface water. This means that although large loads may be released and transported from piles or the mine pool during runoff, the impact to surface water is generally mitigated by natural dilution from the high flows in the streams. In fact waste treatment ponds at many mine sites and many water treatment plants are designed to overspill during high runoff events, taking advantage of dilution by high flowing streams.

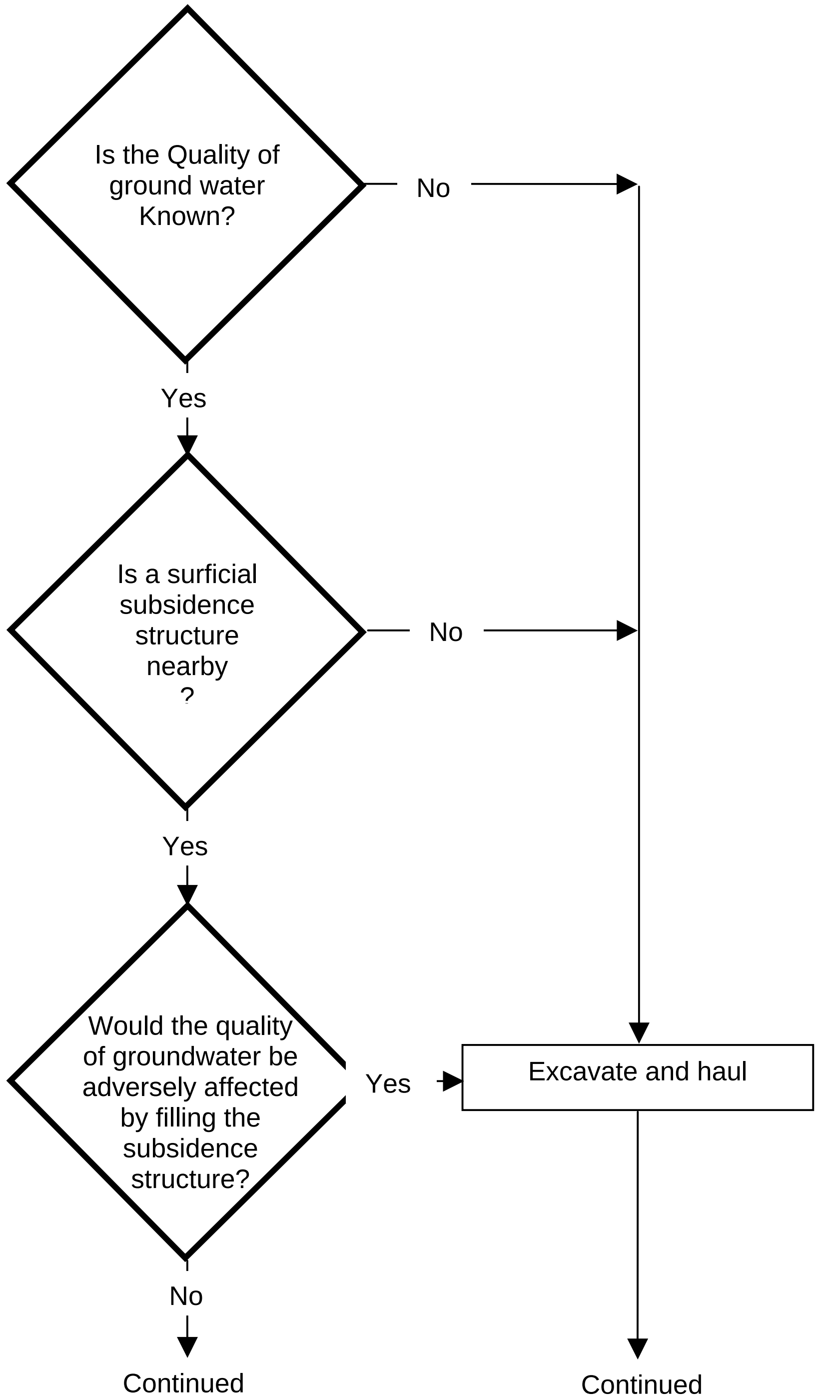
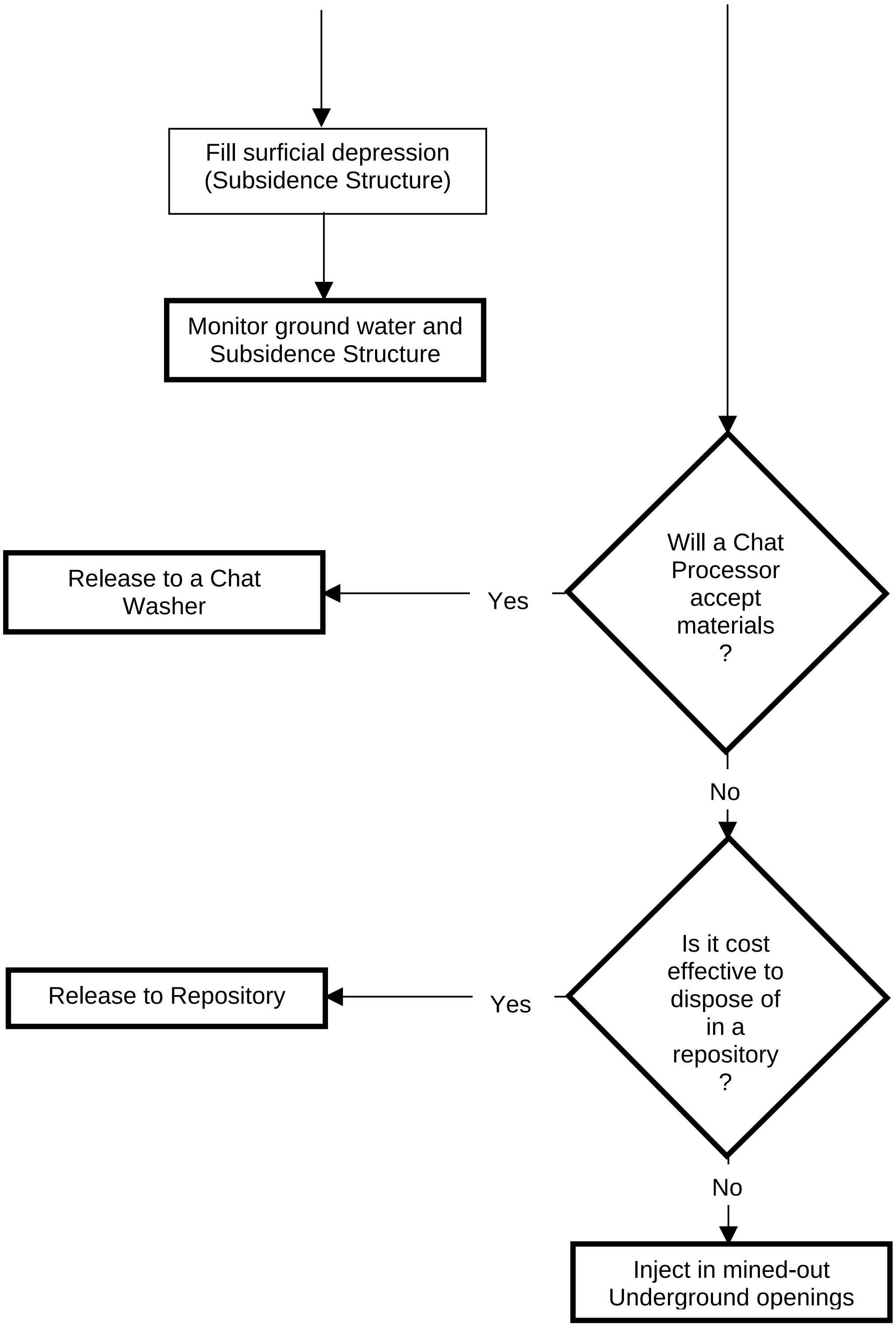


Figure 2. Decision flowchart for disposal of Chat/Chat Bases (continued on next page)


Fill surficial depression (Subsidence Structure)
Monitor ground water and Subsidence Structure
Release to a Chat Washer
Yes
Will a Chat Processor accept materials ?
No
Release to Repository
Yes
Is it cost effective to dispose of in a repository ?
No
Inject in mined-out Underground openings

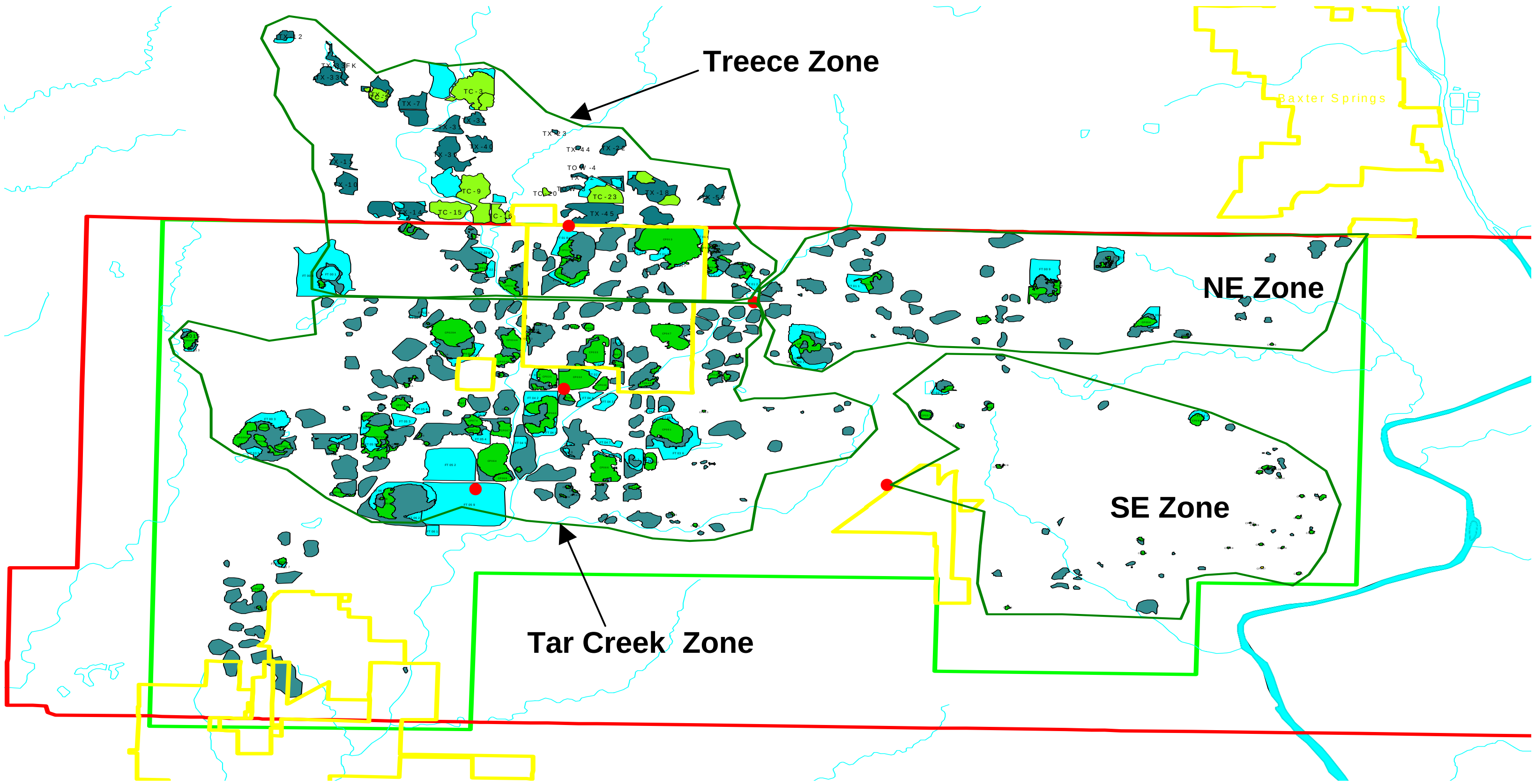


Figure 3. Map of the Tar Creek Superfund Site showing the NE, SE, Treece, Tar Creek staging zones and haul points (red dots), as well as chat piles (green polygons), chat bases (dark blue polygons), fine tailings ponds (light blue polygons), the QTO reservation boundary (red line), the NPL boundary (light green line), and town boundaries (yellow lines).

On the other hand, during baseflow conditions, when the creeks are flowing minimally, and the discharge from the minepool is relatively constant, the concentration of COCs in the mine pool water contribute the majority of COCs to the surface water system. Pb in the mine pool discharge at Douthat Bridge Springs is very low since the mine pool waters contain large amounts of SO4 released from ARD. However, all of the other COCs are indeed elevated above all other surface water qualities determined at other locations. Figures 3 and 4 are just two examples depicting concentrations of COCs measured in surface water vs. river mile obtained during a synoptic survey. Note that the elevated concentrations of these two COCs coincide with the discharge at the Douthat Bridge Springs. Figures 5 and 6 are just two examples depicting concentrations of COCs measured in sediments vs. river mile obtained during a synoptic survey. Note that the elevated concentrations of these two COCs also coincide with the discharge at the Douthat Bridge Springs.

Figure 7 is a conceptual site model of the site along the axis of Tar Creek. This CSM was developed through observations of water levels on several occasions. The water level in the well or vent pipe shown in Figure 7 is roughly 10 feet higher than the stream elevation during baseflow conditions in May-June of 2005. The water level observed in the well coincided with the level of water in the nearby ponds, south of the Douthat Road as well as the pond formed by the ring-dike constructed as part of EPA’s remedy (Figure 8).

Note that the Boone Aquifer (mine pool) is relatively flat lying and is artesian at Douthat Bridge area.

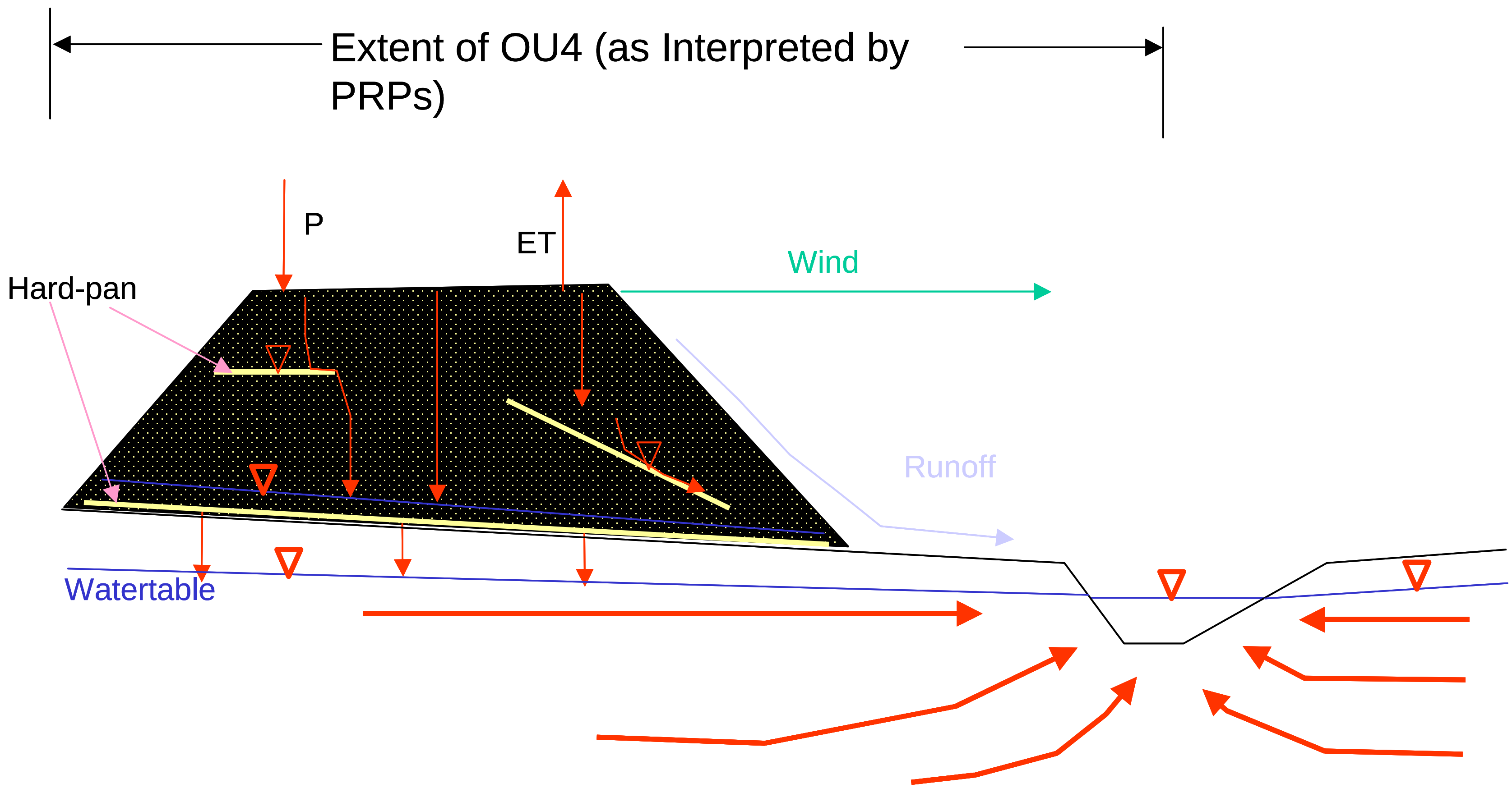


Figure 4. Generalized conceptual model of flow and transport of contaminants of concern from a given waste pile.

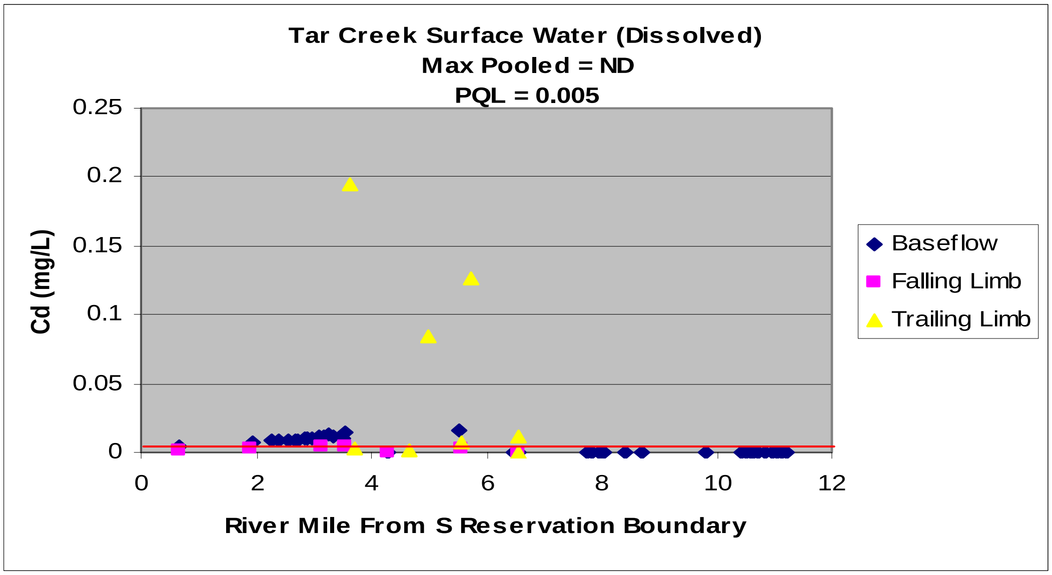


Figure 5. Concentration of Cd in surface water. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

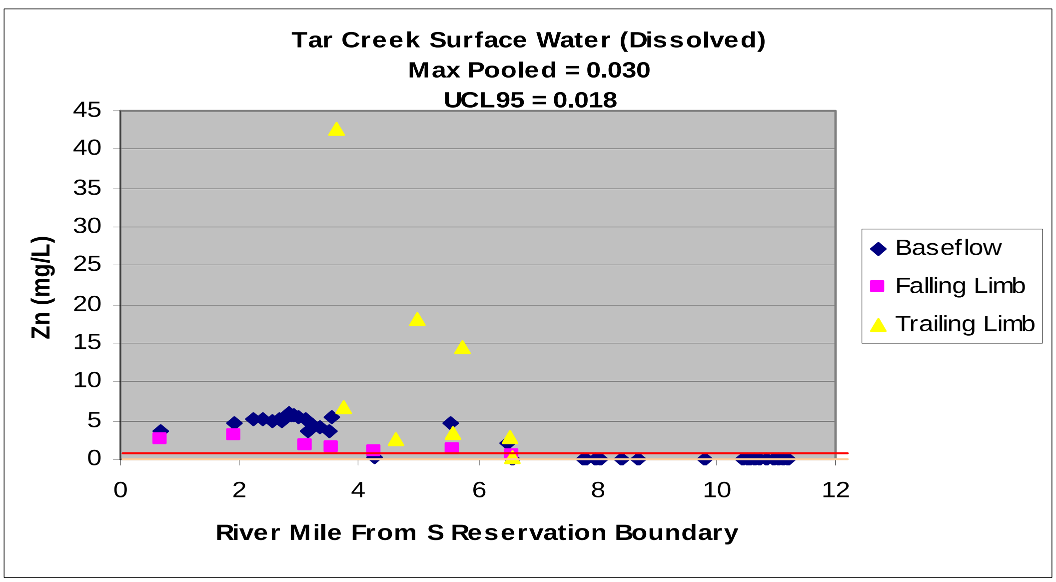


Figure 6. Concentration of Zn in surface water. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

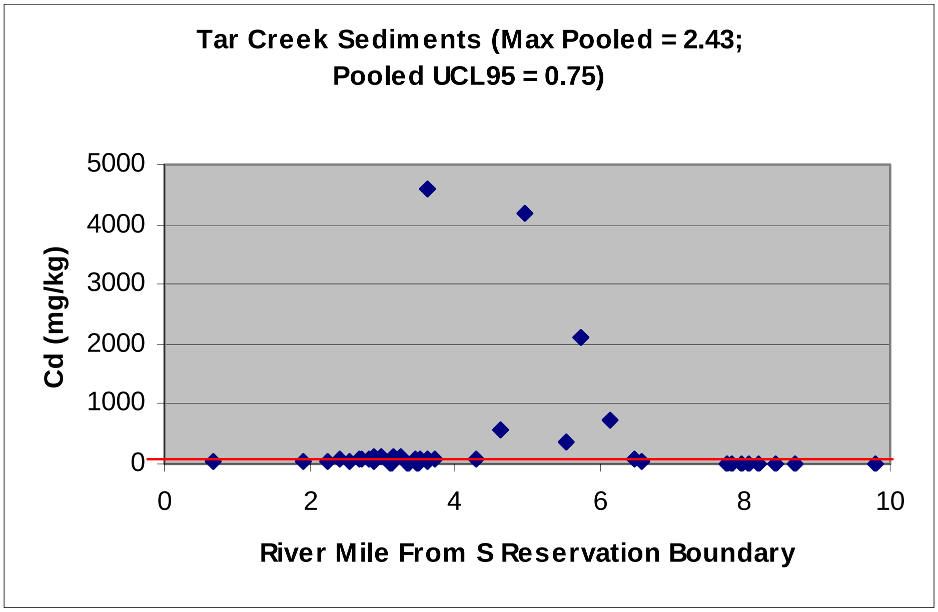


Figure 7. Concentration of Cd in sediments. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

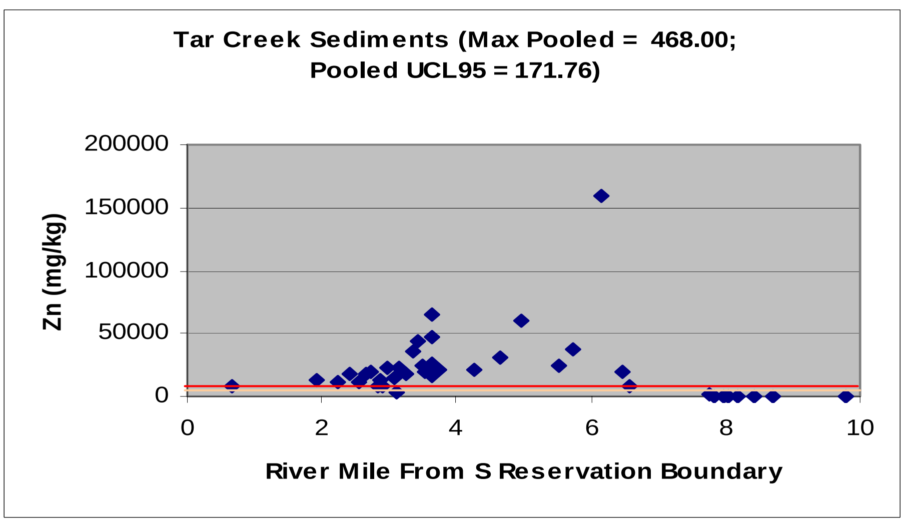


Figure 8. Concentration of Cd in sediments. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

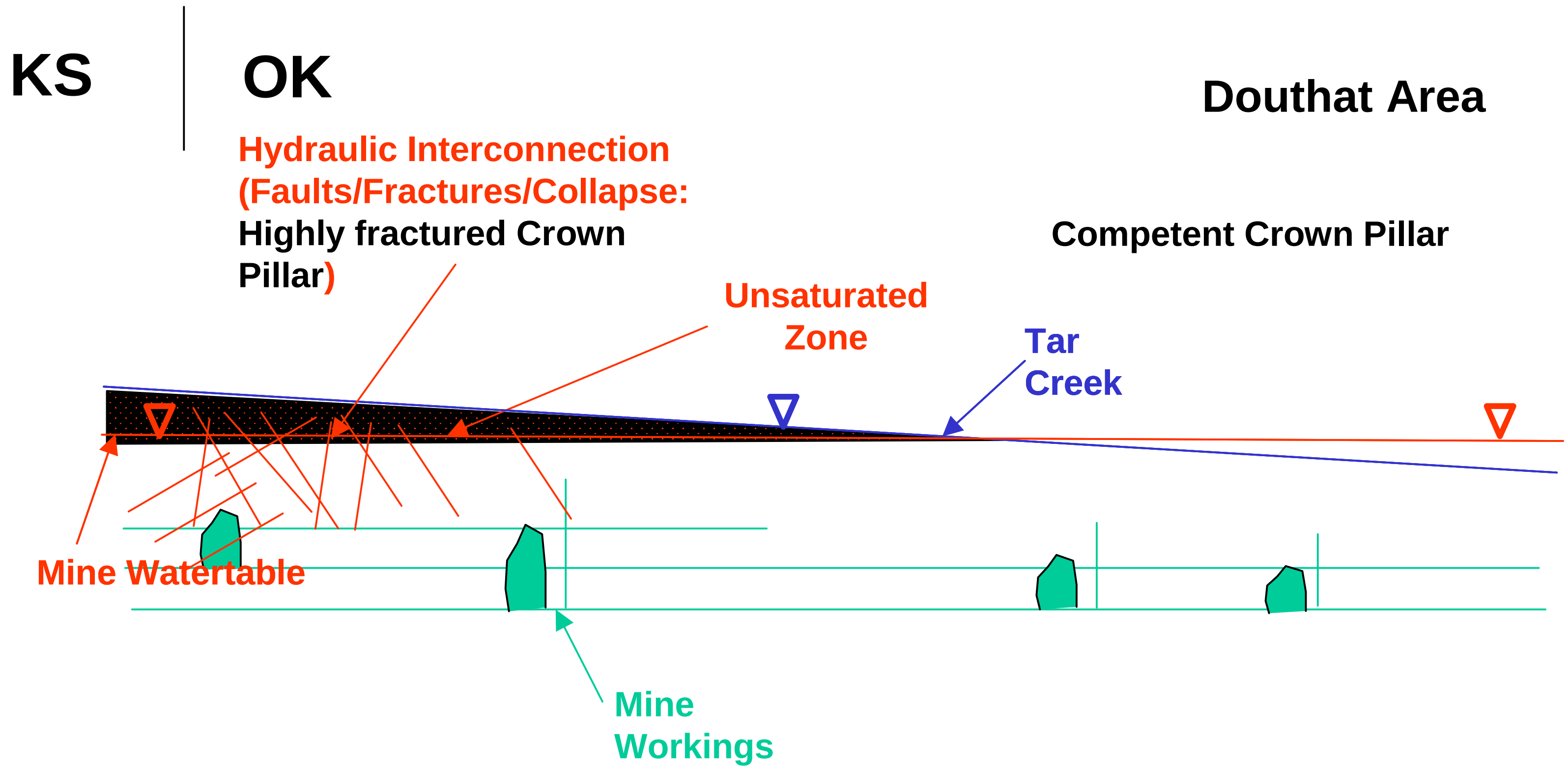


Figure 9. Conceptual N-S Cross-section along Tar Creek from Kansas (left) to the Douthat Area. Note that artesian conditions are observed near Douthat Bridge.

The goal of this task is to reduce the overall hydraulic conductivity of the Boone aquifer in the vicinity of the mine workings. Reducing the effective K of the Boone Aquifer, will:

1. Return the water table to its near natural surface which roughly paralleled, but was few feet lower than, the base of the stream channel. This will relieve artesian conditions, breaking the continued release from the site via ground-water to surface water pathway

2. Dampen and minimize periodic oscillations of the water table thereby minimizing Acid Rock Drainage (ARD) production in the crown pillar (i.e. solve the ARD problem).

3. Reduce flow and stream loss to the Boone Mine Pool, reducing flow of oxygenated waters into the system,

4. Promote stream flow, due to a reduction in storage in the Boone/mine pool aquifer system, and

5. Reduce ground water flow volumes and velocities controlling the geochemistry and facilitating injection of the fines.

Approximately 10 locations are tentatively identified as strategic candidate injection locations (Figure 9). The preliminary criteria for identifying these locations are:

1. Upstream of the relatively competent portion of the crown pillar;

2. Drifts that appear to be interconnectors to underground mine workings

Drifts are more attractive because they require less volume to fill and plug, and the crown pillar over the drifts are generally more competent and therefore less permeable.
Again, these locations will be better defined during the hydrogeologic characterization. These tentative locations are used in to estimate cost of this task.

3.1.4 Injection of Fines

This tasks has two goals: 1) removal of mine waste from the surface and 2) returning the water table to its near natural surface by reducing the overall hydraulic conductivity of the Boone aquifer in the vicinity of the mine workings This will be accomplished by injecting fine materials into strategic locations identified during the previous task. Approximately 10 locations are identified as strategic candidate injection locations (Figure 6).

Fines excavated and transported to the injection sites from the distal areas will be used for a portion of the task. Like the chat piles for distal areas, zones and haul-points or injection points have been developed for the fine materials (Figure 10). Again the haul points are used only to facilitate cost estimations and should not be construed as areas in which double handling occurs.

The disposition of the fine materials is determined using Decisional Flow Chart 2 (Figure 11). For the purposes of conservatively estimating costs, it is assumed that:

1. all fine materials located outside of the Tar Creek and Lytle Creek watersheds are excavated, hauled-in, and injected in strategic locations.

2. the remaining fines, located in the Tar Creek and Lytle Creek Watersheds are injected al the location of the accumulation.

In order to inject the fines, it will be necessary to resuspend the fines as a mixture. This will require excavation, and depending on the distance, could result in short-distance hauling. Several mobile large-scale wet-sieves or similar devices will be required. It is anticipated that the resuspension process will be the rate-limiting step in the injection process.

In order to facilitate comparison of this alternative to EPA's alternatives, EPA's unit costs are used herein. However, we would propose using low-ground pressure dozers (e.g. CAT D6) to rip, excavate, and push materials to a pile to feed a loading unit (e.g. CAT 988). The loader would then load off-road haul trucks (e.g. CAT 769). The number of trucks in the hauling unit will depend on the optimum production rate determined for a given pile or work area. The rate limiting step in the entire process is wet sieving and injecting. The rate-limiting step in the loading and hauling process is hauling; therefore, it would be necessary to have a sufficient number of trucks. The number of trucks depends on the haul distance for a given pile or work area.

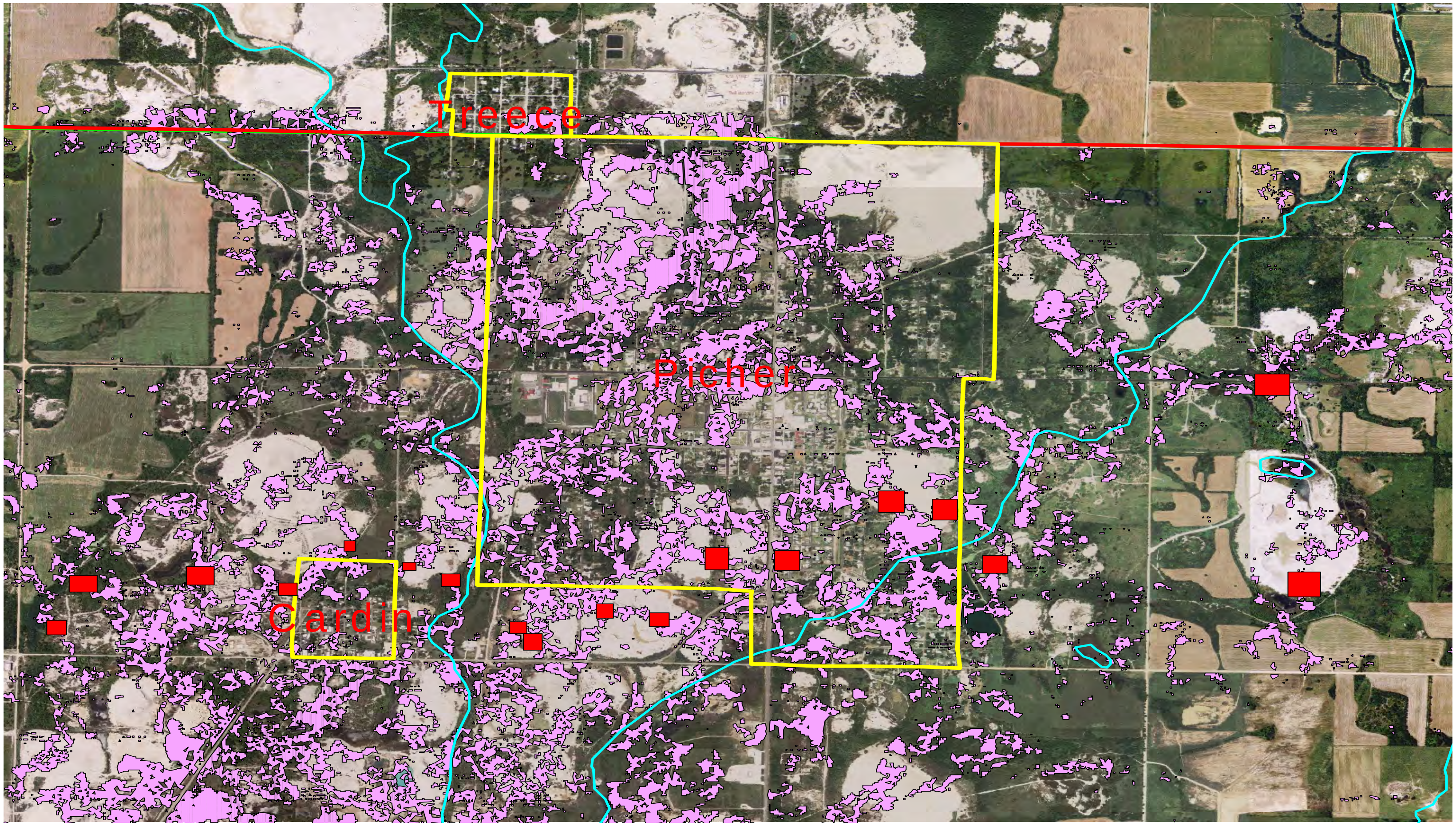


Figure 10. Map depicting the tentative strategic locations for injection of fines (red squares), the QTO reservation boundary (red line), and town boundaries (yellow lines).

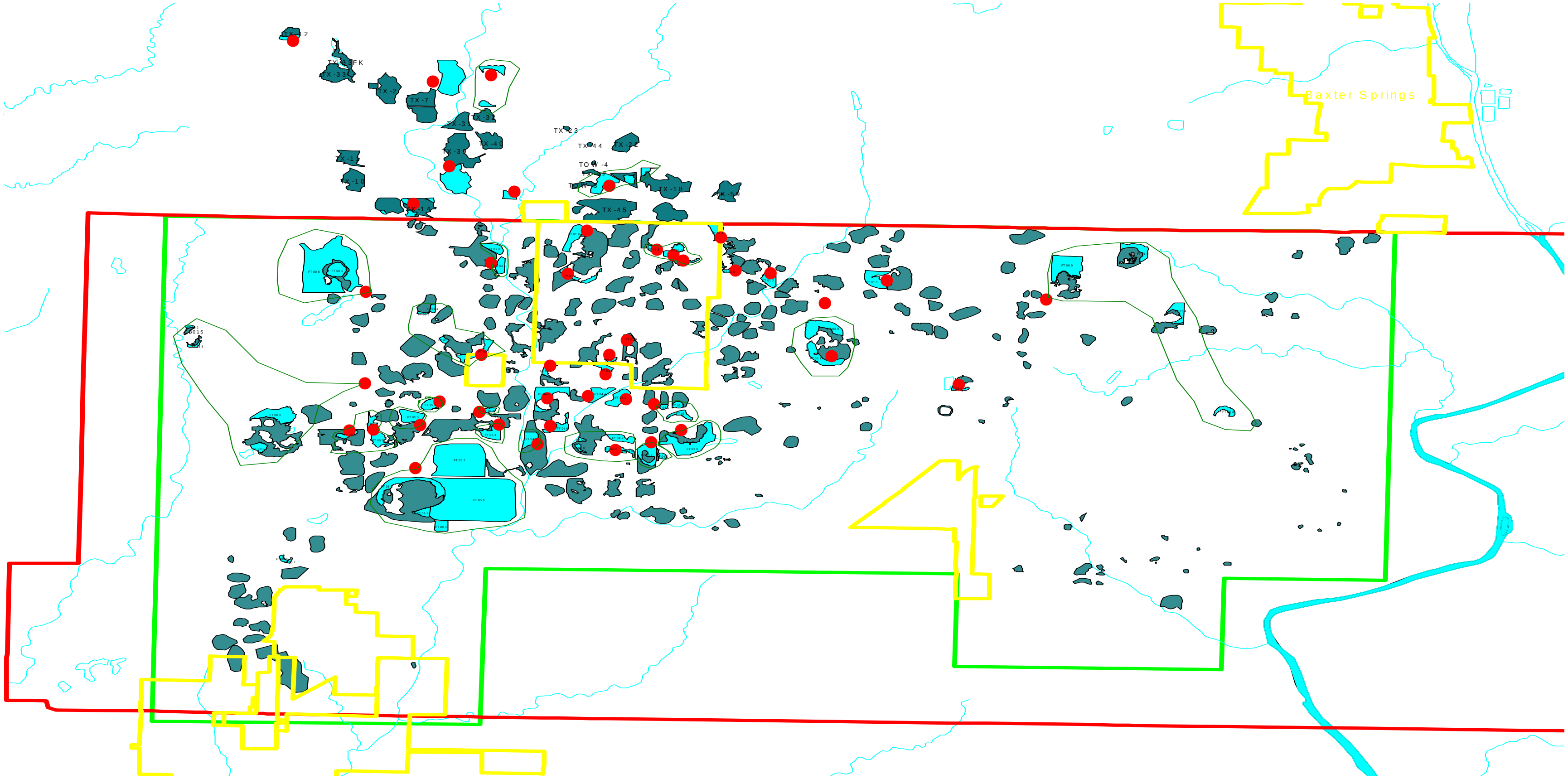


Figure 11. Injection points and zones used to estimate injection costs for the remaining fine materials and/or chat bases.

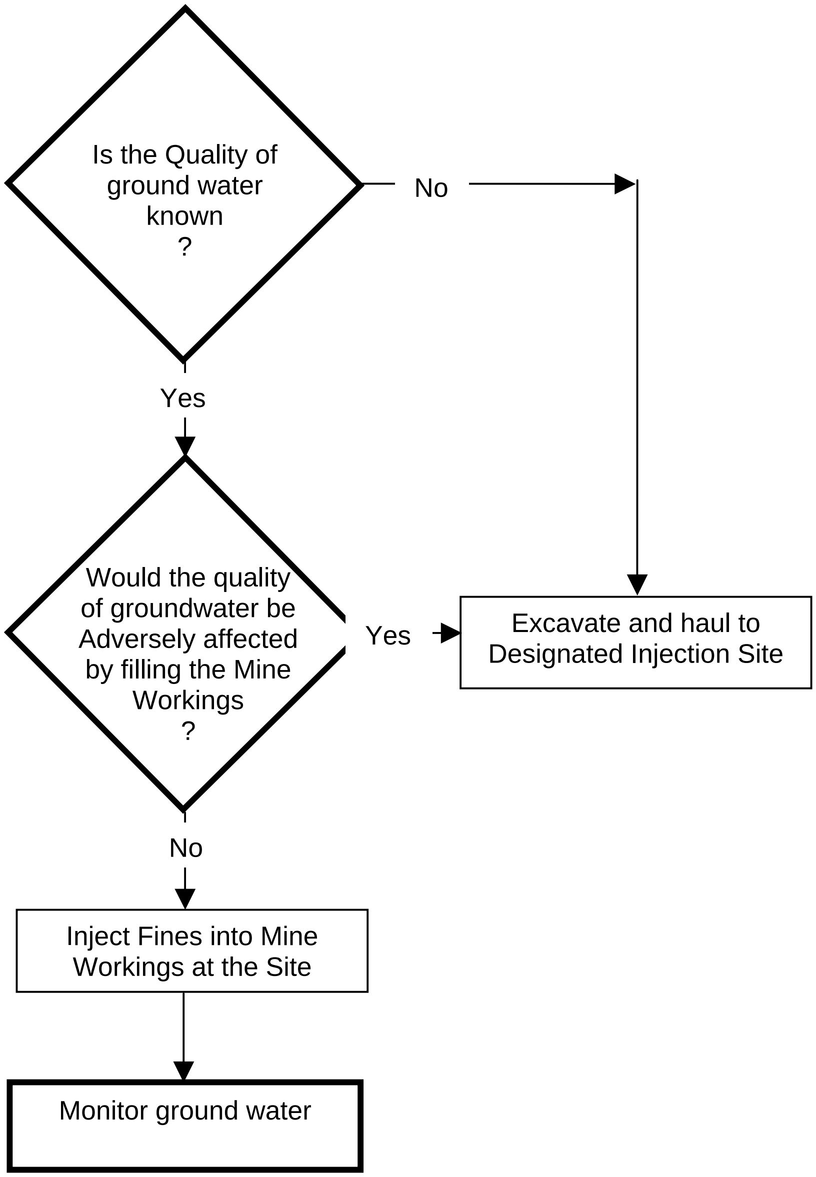


Figure 12. Decision flowchart for injecting fine materials.

Instances in which large volumes of fines are injected, such as the Central Mill Pond injected into the Blue-Goose mine workings, may employ cheaper traditional large volume sand-filling technologies typically employed in underground mines. However, In order to facilitate comparison of this alternative to EPA's alternatives, this approach has not been assumed in the following estimates of cost.

No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

3.1.5. Install Flexible Membrane Liners (FML) in Tar, Lytle, and Beaver Creeks (Contingency)

Installation of a system to immediately break the ground-water to surface water pathway. Previous work has determined that surface water in these creeks are contaminated by a combination of runoff, ground water discharge from chat aquifers, and discharge from the Boone Aquifer which has been impacted by mining. A conceptual site model of flow and transport is provided in Appendix A. The installation of Flexible Membrane Liners as a control system is used for cost estimating purposes.

FMLs have been used successfully at other mine site throughout the nation to contain wastes. A simplified conceptual model of a channel x-section of pre and post remediation conditions is provided in Figures 12 and 13.

For cost estimation purposes, it is assumed that the FMLs extend from the Douthat Bridge areanorth past Mine Workings in KS. In-place chat, fines, or relatively cleaner transition zone soils will be used as sub-base and filter material for the FMLs. Material to be used for river substrate would be purchased from a nearby limestone quarry or elsewhere on the reservation (near Tribal HQ) and is placed on top of the FML and filter layer. This will remediate surface water, sediments, ground water, and riparian areas within the site as well as down gradient. The engineering design related to this work should rely on the findings of the aforementioned Hydrogeologic Studies.

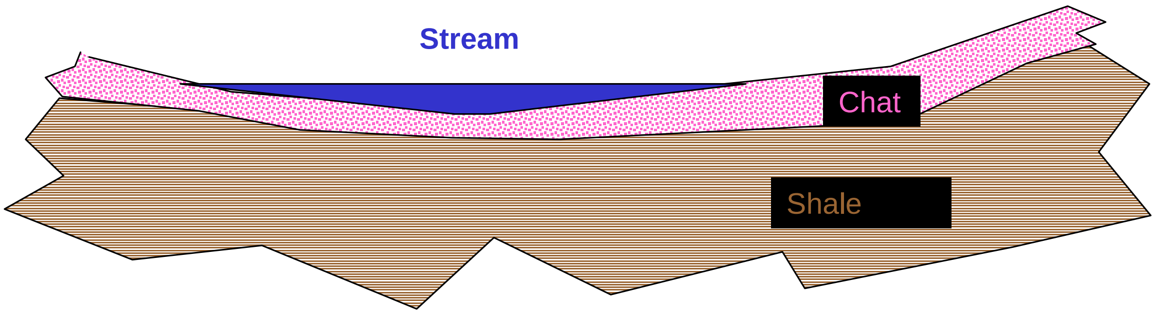


Figure 13. Conceptual pre-construction channel x-section.

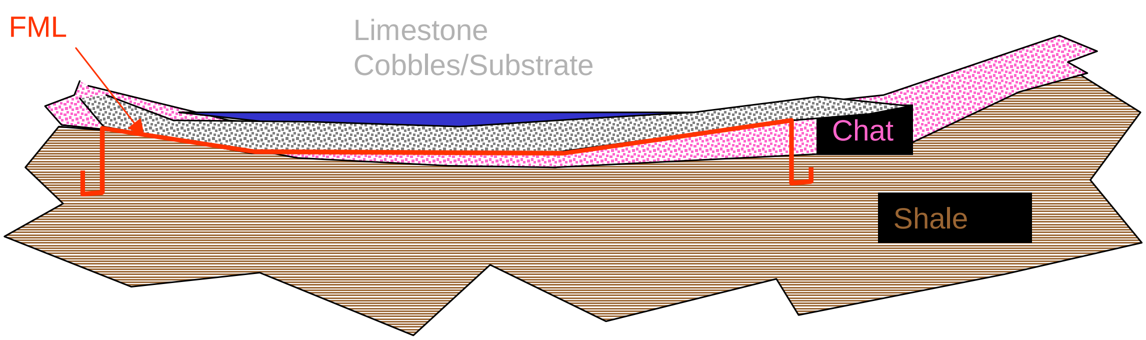


Figure 14. Conceptual post-construction x-section.

3.1.6. Control water level within the crown pillar via flow diversions and monitoring devices.

Again, the crown pillar is the current source of ARD production when periodically allowed to desaturate. Hydraulic alteration of the Boone aquifer via injection of fines will help to restore the water table to near natural conditions: however, the crown pillar will still be relatively higher permeability than similar Pennsylvanian rock outside of the mined are. In order to maintain and control saturation of the crown pillar to near natural conditions, it may be necessary to install headgates at the Treece Swimming Hole and Cardin Recharge areas to re-direct flow of Tar Creek into the crown pillar. These actions are designed to flood pyrite bearing zones in the Pennsylvanian crown-pillar and reduce production of acid rock drainage (fix the main problem).

Head in the crown pillar will be monitored in a near-real time manner. Results of monitoring will be used to tune the system, via the headgates, to minimize oscillating conditions in the crown pillar under a variety of hydrologic conditions.

3.1.7. Temporary Active Water Treatment of Mine Pool at Douthat (contingency)

Temporary active water treatment of the mine pool at the Douthat discharge is included in the proposal as a contingency in the event that ground water quality is temporarily impacted by chat washers or via remedial actions. A portable conventional lime precipitation plant is proposed. The water treatment plant effluent would be discharged at north end of channel liners (in KS) to remediate the river to a clean flowing system that will support all future uses.

3.2 Detailed Description of Phase II Tasks

3.2.1 Unmarketable chat/chat bases remaining after 10 years

Currently three options exist that are consistent with future land uses for disposal of these materials. These options are listed in the order of increasing expense, based on EPA's unit cost information:

Option 1: Excavation and onsite washing by the governments with small mobile wet sieves followed by direct injection of fines (Current best Management Practices for Chat Washers)

Option 2: Excavation, loading, and delivery to chat washers for processing;

Option 3: Excavation, loading, hauling and disposal in an engineered facility

The cost difference between the three options is quite large. All three options involve excavating approximately 15 million cubic yards of materials (EPA unit cost of $3.50 cubic yard[2]). Beyond that, Option 1 involves only wet sieving costs (estimated to be approximately $2.00 per cubic yard[3]). Additional costs for Options 2 and 3 involve hauling costs (EPA unit cost of $5.00 per cubic yard). Additional costs for Option 3 involves land purchase, construction, and long term operation and maintenance of one or two large-scale repositories. Options 1 and 2 currently comply with the Tribe's Future Land use plans. Option 3 would require other measures.

Unlike the EPA proposed Alternative, consolidation of chat bases and chat piles will result in "controlled management" of the hazardous substances via temporary institutional controls. This approach differs greatly from EPA's approach that employs "uncontrolled management" (actions are at the mercy of the market forces), and reportedly necessitates the 20-year timeframe based on human health concerns. Controlled management as described herein should allow for sales to continue much longer. With time, non-marketable chat and chat bases could be wet-sieved by the governments, making the chat free for pickup to entities located beyond the market's "break-even" point (reported currently to be approximately 200 miles away).

4.0 Estimated Costs

As discussed elsewhere herein, in order to facilitate comparison of this alternative and its three options to EPA's alternatives, EPA's unit costs are used herein. The detailed analysis of costs included the following assumptions:

1. EPA unit Costs
2. EPA Time frame
3. EPA construction concerns described above

[2] This unit cost is believed to be overestimated. The current cost of wet sieved chat picked-up at the pile is approximately $4.10 per cubic yard. Using EPA's value of $3.50 per yard would result in a negligible profit margin.

[3] The current cost of wet sieved chat picked-up at the pile is approximately $4.10 per cubic yard. The estimate of $2.00 per cubic yard processing fee assumes that the chat washers make slightly more than 100% profit)

Summary of costs for the three alternatives is provided in Table 1. Based on a percentage basis of the overall project, a major portion of the project requires a lot of dirt-work. Therefore, the overall cost is fairly sensitive to unit cost values. Detailed Costs are provided in Appendix B.

Table 1. Summary of Estimated Costs.

Awaiting new EPA unit costs

5.0 Conclusion

Remedy TA1 has a highest probability of all alternatives of meeting all nine criteria of NCP for OU1, OU4, and OU5. Onsite Surface water and sediments will be remediated. Downstream uses will return over short time. Monetary, ecological, and political costs associated with importing soils are mitigated.

Attachment No 3. RESOLUTION NO. 052105-APPROVING REGULATIONS CONTAINING WATER QUALITY STANDARDS FOR THE QUAPAW TRIBE OF OKLAHOMA

QUAPAW TRIBE OF OKLAHOMA

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

RESOLUTION NO. 052105-A

A RESOLUTION APPROVING REGULATIONS CONTAINING WATER QUALITY STANDARDS FOR THE QUAPAW TRIBE OF OKLAHOMA

WHEREAS, the Quapaw Tribe of Oklahoma is a federally recognized Indian Tribe and is governed by a Governing Resolution adopted by the Quapaw Indian Council on August 19, 1956, and approved by the Commissioner of Indian Affairs on September 20, 1957; and

WHEREAS, the Governing Resolution delegates authority to the Quapaw Tribal Business Committee to speak and act on the behalf of the Quapaw Tribe; and

WHEREAS, the Quapaw Tribal Business Committee is thus empowered and obligated to transact Tribal business, including adopting and implementing ordinances and regulations for the Tribe concerning the protection and regulation of the environment and waters on Tribal lands; and

WHEREAS, after public notice and comment and public release of preliminary water quality standards, the Environmental Department of the Tribe has prepared and finalized proposed Water Quality Standards for the Tribe to be applicable to lands within the jurisdiction of the Quapaw Tribe; and

WHEREAS, the Quapaw Tribal Business Committee desires to adopt and approve such Water Quality Standards, and to have them duly codified with other Tribal laws and regulations, and to authorize the Director of the Environmental Department to submit them to the Administrator of the United States Environmental Protection Agency, Region 6 (the "EPA"), for approval and to obtain treatment-as-a-state status for the Tribe pursuant to the federal Clean Water Act, 33 U.S.C. § 1377(e).

NOW THEREFORE BE IT RESOLVED by the Quapaw Tribal Business Committee that the proposed Water Quality Standards for the Tribe, a copy of the final version of which is attached hereto, are hereby approved and adopted to take effect immediately, and to be codified with other Tribal laws and regulations; and

BE IT FURTHER RESOLVED, that the Director of the Tribal Environmental Department is hereby authorized to apply to the EPA forthwith for approval of such Water Quality Standards and to make all applications to the EPA as are necessary to obtain treatment-as-a state status for the Tribe pursuant to the federal Clean Water Act.

CERTIFICATION

The foregoing resolution of the Quapaw Tribe of Oklahoma was presented and duly adopted at a regular meeting of the Quapaw Tribal Business Committee on May 21, 2005, with a vote reflecting 7 yes, ___ no, ___ abstaining, and ___ absent.

John L. Berrey, Chairman
Quapaw Tribal Business Committee

J.R Mathews, Vice-Chairman
Quapaw Tribal Business Committee

TITLE ____. Environmental Department, Quapaw Tribe of Oklahoma (O-Gah-Pah)

CHAPTER ____. SURFACE WATER QUALITY STANDARDS

Introduction:

These regulations were adopted by the Business Committee of the Quapaw Tribe of Oklahoma (O-Gah-Pah) effective May 21, 2005.

Subchapter **Section**

SUBCHAPTER 1. GENERAL PROVISIONS

Section

xxx:yy-1-1. Purpose

(a) By the Treaty of May 13, 1833, (Kappler, 1904, vol. 2, p. 395), the United States set aside the Quapaw Reservation for the purpose of providing a permanent homeland for the Quapaw People. Pursuant to that purpose, as well as the laws of the Quapaw Tribe, the Tribe's reserved water rights, and its sovereign rights to regulate its natural resources, and in recognition that water is a valuable resource of the Quapaw People, the Business Committee of the Tribe hereby establishes and adopts these water quality standards to apply to all surface waters on lands within the jurisdiction of the Tribe. These standards shall provide a mechanism for the Tribe to manage and regulate the quality and use of said waters by establishing standards for specific water bodies.

(b) These water quality standards shall serve to protect the public health, safety and welfare, to enhance and improve the quality of water, and to ensure that degradation of existing quality of surface waters of the Tribe does not occur. These standards are intended: to restore, maintain and protect the chemical, physical, biological, and cultural integrity of the surface waters; to promote the health, safety, welfare, and economic well-being of the Tribe and its people; to achieve a level of water quality that provides for the protection and propagation of fish and wildlife and for all existing and designated uses of the water; to promote the holistic watershed approach to management of the Tribe's water; and to provide for protection of threatened and endangered species.

(c) These standards are designed to establish the uses for which the surface waters of the Quapaw Tribe shall be protected. The water use and quality criteria set forth herein are established in general conformance with water uses of the surface waters of the Quapaw Tribe and in consideration of the natural water quality potential and limitations of the same.

(d) These standards specify numeric and narrative criteria to protect beneficial uses designated for certain surface waters of the Quapaw Tribe. Beneficial use designations can be found in Appendix A of this Chapter for listed surface waters and in xxx:yy-5-3 for unlisted surface waters. The numeric and narrative criteria assigned to protect surface water beneficial uses are shown in Subchapter 5 of this Chapter. The criteria that are the standards for a specific water of the Tribe do not consider cumulative affects associated with multiple contaminants, multiple pathways, nor multiple media. In the event that multiple contaminants, multiple pathways, or multiple media are involved, site-specific numerical standards must be calculated by a qualified toxicologist.

(e) These standards were prepared in preliminary form by the Environmental Department of the Quapaw Tribe. A public notice was issued in December 2003 concerning the proposed standards, and subsequently the preliminary proposal was released for public comment. A public hearing was conducted on the standards on January 29, 2004, and comments were received from various commenters, including the Oklahoma Department of Environmental Quality. After the comments were received, the standards were revised and placed into a final form by the Environmental Department. These standards shall become effective on the date of adoption, and shall be applicable and in force, to the full extent of the law, until repealed or replaced by the Business Committee of the Tribe.

xxx:yy-1-2. Definitions

The following words and terms, when used in this Chapter, shall have the following meaning unless the context clearly indicates otherwise:

"Abatement" means reduction of the degree or intensity of pollution.

"Acute test failure" means greater than or equal to 50% lethality to appropriate test organisms in 100% effluent in 48 hours.

"Acute toxicity" means greater than or equal to 50% lethality to appropriate test organisms in a test sample.

"Alpha particle" means a positively charged particle emitted by certain radioactive materials. It is the least penetrating of the three common types of radiation (alpha, beta and gamma).

"Ambient" means surrounding, especially of or pertaining to the environment about an entity, but undisturbed and unaffected by it.

"Appropriate reference site or region" means a site on the same water body or within the same basin or eco-region that has similar fish and wildlife habitat conditions and which is expected to represent the best attainable water quality and biological community within the area(s) of concern.

"Assimilative capacity" means the amount of pollution a water body can receive and still maintain the water quality standards designated for that water body.

"Attainable uses" means the best uses achievable for a particular water body given water of adequate quality. The process of use attainability analysis can, and in certain cases must, be used to determine attainable uses for a water body.

"BCF" means bioconcentration factor.

"Beneficial uses" means a classification of the surface waters of the Tribe, according to their best uses in the interest of Tribal members.

"Benthic macroinvertebrates" means invertebrate animals that are large enough to be seen by the unaided eye, can be retained by a U. S. Standard No. 30 sieve, and live at least part of their life cycles within (e.g. hyporheic zone) or upon available substrate in a body of water or water transport system.

"Best Available Technology" means the best proven technology, treatment techniques or other viable means which are commercially available.

"Best management practices" means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of surface waters of the Tribe or United Tribes. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

"Beta particle" means a negatively charged elementary particle emitted by radioactive decay that may cause skin burns. It is easily stopped by a thin sheet of metal.

"Bioconcentration factor" means the relative measure of the ability of a contaminant to be stored in tissues (usually fish) and thus to accumulate through the food chain and is shown as the following formula: BCF = Tissue Concentration divided by Water Concentration.

"BMPs" means best management practices.

"BOD" means biochemical oxygen demand.

"Carcinogenic" means cancer causing..

"Chronic test failure" is the statistically significant difference (at the 95% confidence level) between survival of the appropriate test organism in the chronic low flow dilution (LFD) after 7 or 21 days and a control. Statistical analyses shall be consistent with methods described in EPA's publication no. 600/14-89/001, "Short-Term Methods For Estimating The Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", or most recent revision.

"Chronic toxicity" means a statistically significant difference (at the 95% confidence level) between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity.

"Coliform group organisms" means all of the aerobic and facultative anaerobic gram-negative, non-spore-forming rod shaped bacteria that ferment lactose broth with gas formation within 48 hours at 35 C.

"Color" means true color as well as apparent color. True color is the color of the water from which turbidity has been removed. Apparent color includes not only the color due to substances in solution (true color), but also that color due to suspended matter.

"Conservation plan" means, but is not limited to, a written plan which lists activities, management practices and maintenance or operating procedures designed to promote natural resource conservation and is intended for the prevention and reduction of pollution of surface waters of the Tribe.

"Critical temperature" means the higher of the seven-day maximum temperature likely to occur with a 50% probability each year, or 29.4°C (85°F).

"Criterion" means a number or narrative statement assigned to protect a designated beneficial use.

"Degradation" means any condition caused by the activities of humans which result in the prolonged impairment of any constituent of the aquatic or riparian environment.

"Department" means the Environmental Department of the Tribe.

"Designated beneficial uses" means those uses specified for each water body or segment whether or not they are being attained.

"Dissolved oxygen (DO)" means the amount of oxygen dissolved in water at any given time, depending upon the water temperature, the partial pressure of oxygen in the atmosphere in contact with the water, the concentration of dissolved organic substances in the water, and the physical aeration of the water.

"DO" means dissolved oxygen.

"EPA" means the United States Environmental Protection Agency.

"Ephemeral stream" means an entire stream which flows only during or immediately after a rainfall event, and contains no refuge pools capable of sustaining a viable community of aquatic organisms.

"Epilimnion" means the uppermost homothermal region of a stratified lake.

"Eutrophication" means the process whereby the condition of a water body changes from one of low biologic productivity and clear water to one of high productivity and water made turbid by the accelerated growth of algae.

"Existing beneficial uses" means those uses listed in Title 40 CFR §131.3 actually attained by a water body on or after November 28, 1975. These uses may include public water supplies, fish and wildlife propagation, recreational uses, agriculture, industrial water supplies, navigation, and aesthetics.

"Fecal coliform" means a group of organisms common to the intestinal tracts of humans and of animals. The presence of fecal coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

"Geometric mean" means the nth root of the product of the samples.

"Ground water" means water in a saturated or unsaturated zone in stratum beneath the surface of land or water. Ground water is further defined herein to contain both dissolved solids and suspended solids. Dissolved solids are that fraction of the sample that passes 0.42 μm filter. Suspended solids are that fraction of the sample that is retained on the 0.42μm filter.

"HQW" means High Quality Water.

"Intolerant climax fish community" means habitat and water quality adequate to support game fishes or other sensitive species introduced or native to the biotic province or ecological region, which require specific or narrow ranges of high quality environmental conditions.

"Lake" means:

(A) An impoundment of surface waters of the Tribe over 50 acre-feet in volume.

(B) Licensed surface impoundments which are used as a treatment works for the purpose of treating stabilizing or holding wastes are excluded from this definition.

"LC_{50}" means lethal concentration and is the concentration of a toxicant in an external medium that is lethal to fifty percent of the test animals for a specified period of exposure.

"Long-term average flow" means an arithmetic average stream flow over a representative period of record.

"MDL" means the Method Detection Limit and is defined as the minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero (0). MDL is dependent upon the analyte of concern.

"Narrative criteria" means statements or other qualitative expressions of chemical, physical or biological parameters that are assigned to protect a beneficial use.

"Natural conditions" means the physico-chemical conditions that were present or would be present in the absence of man-made influences.

"Natural source" means source of contamination that is not human induced.

"NIW Impairment Study" means a scientific process of surveying the chemical, physical and biological characteristics of a nutrient threatened reservoir to determine whether the reservoir's beneficial uses are being impaired by human-induced eutrophication.

"Nonpoint source" means a source of pollution without a well defined point of origin.

"NTU" means Nephelometric Turbidity Unit, which is the unit of measure using the method based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension (formazin). The higher the intensity of scattered light, the higher the turbidity.

"Numerical criteria" means concentrations or other quantitative measures of chemical, physical or biological parameters that are assigned to protect a beneficial use.

"Numerical standard" means the most stringent of the numerical criteria assigned to the beneficial uses for a given stream.

"Nutrient impaired reservoir" means a reservoir with a beneficial use or uses determined by an NIW Impairment Study to be impaired by human-induced eutrophication.

"Nutrient-impacted watershed (NIW)" means a watershed of a water body with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's Trophic Tribe Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NIW" in Appendix A of this Chapter.

"Nutrients" means elements or compounds essential as raw materials for an organism's growth and development; these include carbon, oxygen, nitrogen and phosphorus.

"ORW" means Outstanding Resource Water.

"PCBs" means polychlorinated biphenyls.

"Picocurie (pCi) " means that quantity of radioactive material producing 2.22 nuclear transformations per minute.

"Point source" means any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, well, discrete fissure, container, rolling stock or concentrated animal feeding operation from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture.

"Pollutant" means any material, substance or property which may cause pollution.

"Pollution" means contamination or other alteration of the physical, chemical or biological properties of any natural surface waters of the Tribe, or such discharge of any liquid, gaseous or solid substance into any surface waters of the Tribe as will or is likely to create a nuisance or render such waters harmful, or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life".

" Primary Contact Ceremonial and spiritual" water use means activities involving Native American religious, spiritual and cultural practices which may involve primary and secondary contact with water, and immersion and intentional or incidental ingestion of water or steam. Such use also requires protection of sensitive and valuable aquatic life and riparian habitat.

"Primary contact recreation" means activities in which a person would have direct contact with water to the point of complete submergence, including but not limited to ceremonial, spiritual and cultural uses, and skin diving, swimming and water skiing.

"Polychlorinated biphenyls" means a group of organic compounds (209 possible) which are constructed of two phenyl rings and more than one chlorine atom.

"Put and take fishery" means the introduction of a fish species into a body of water for the express purpose of sport or subsistence fish harvest where existing conditions preclude a naturally reproducing population.

"Regulatory Variance" means a temporary (not to exceed three years) exclusion or waiver of a specific numerical criterion for a specific discharge to a specific water body.

"Salinity" means the concentration of salt in water.

"Seasonal base flow" means the fair-weather stream flow sustained by groundwater and normal surface water inputs such as tributaries.

"Seasonal seven-day, two-year low flow" means the design flow for determining allowable BOD load to a stream.

"Seasonal 7Q2" means the seasonal seven-day, two-year low flow.

"Sensitive representative species" means *Ceriodaphnia dubia, Daphnia magna, Daphnia pulex, Pimphales promelas* (Fathead minnow), *Lepomis macrochirus* (Bluegill sunfish), or other sensitive organisms indigenous to a particular water body.

"Seven-day, two-year low flow" means the design flow for determining allowable discharge load to a stream.

"7Q2" means the seven-day, two-year low flow.

"Standard deviation" means a statistical measure of the dispersion around the arithmetic mean of the data.

"Standard Methods" means the publication "Standard Methods for the Examination of Water and Wastewater", published jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation.

"Standards", when capitalized, means this Chapter, which constitutes the Quapaw Tribal Surface Water Quality Standards described herein. Whenever this term is not capitalized or is singular, it means the most stringent of the criteria assigned to protect the beneficial uses designated for a specified water of the Tribe.

"Storm water" means runoff from sheet flow or conveyance resulting from inclement weather conditions and snow melt .

"Subwatershed" means a smaller component of the larger watershed.

"Surface Waters of the Tribe" means all streams, lakes, ponds, marshes, wetlands, watercourses, waterways, springs, seeps, irrigation systems, drainage systems, and all other bodies or accumulations of surface water contained within, flow through, or border upon Tribal lands or any portion thereof.

"Synergistic effect" means the presence of cooperative pollutant action such that the total effect is greater than the sum of the effects of each pollutant taken individually.

"Thermal pollution" means degradation of water quality by the introduction of heated effluent.

"Thermal stratification" means horizontal layers of different densities produced in a lake caused by temperature differences.

"Tribe" means the Quapaw Tribe of Oklahoma (O-Gah-Pah).

"Warm Water Aquatic Community" means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support intolerant climax fish communities and includes an environment suitable for the full range of warm water benthos.

"Wastes" means industrial waste and all other liquid, gaseous or solid substances which may pollute or tend to pollute any surface waters of the Tribe.

"Water body" means any specified segment or body of surface waters of the Tribe, including but not limited to, an entire stream or lake or a portion thereof.

"Water quality" means physical, chemical, and biological characteristics of water which determine diversity, stability, and productivity of the climax biotic community or affect human health or use.

"Watershed" means the surface water drainage area of a water body including all direct or indirect tributaries.

"WWAC" means Warm Water Aquatic Community.

"Zone of passage" means a three dimensional zone expressed as a volume in the receiving stream through which mobile aquatic organisms may traverse the stream past a discharge without being affected by it.

xxx-yy-1-3. Adoption and enforceability of the standards

(a) Quapaw Tribal Surface Water Quality Standards adopted and promulgated by the Tribe shall be applicable to all activities that may affect the quality of waters of the Tribe and shall be utilized by all appropriate Tribal environmental agencies in implementing their respective duties to abate and prevent pollution to waters of the Tribe.

xxx-yy-1-4. GENERAL CONDITIONS

The following conditions shall apply to the water quality criteria and classifications set forth herein.

(a) All surface waters shall be free from pollutants and other materials in concentrations or combinations that do not protect the most sensitive existing or designated use of the water body.

(b) Whenever the natural conditions of any specific surface waters of the Tribe are of a lower quality than the criteria assigned to waters typical of that class, the Department may determine that the natural conditions shall constitute the water quality criteria.

(c) At the boundary between surface waters of different classifications, the more stringent water quality criteria shall prevail. If existing or designated uses of more than one resource are affected, the most protective criteria shall apply.

(d) The Department may revise the criteria on as to Tribal lands in general or on water body-specific basis as needed to protect aquatic life and human health and other existing and designated uses and to increase the technical accuracy of the criteria being applied. The Tribal Business Committee shall formally adopt any revised criteria following public review and comment, and shall submit revisions to EPA for review and approval.

(e) The analytical testing methods used to measure or otherwise evaluate Water Quality Standards shall to the extent practicable, be in accordance with the most recent editions of "Standard Methods for the Examination of Water and Wastewater," published by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, and "Methods for Chemical Analysis of Water and Wastes," published by the EPA, and other or superseding methods published and/or approved by the Department following consultation with and concurrence of the EPA.

xxx:yy-1-5. Revision procedures

(a) Any member may petition the Department to modify or repeal any criterion or beneficial use designation.

(b) The petitioner, through objective and acceptable scientific studies, data and other information, shall be required to show that the requested modification or repeal will be in accordance with the requirements of applicable Tribal and Federal law regarding water quality and in the best interest of the Tribe.

(c) Procedures required by applicable Tribal and Federal law for revising the designated beneficial uses and criteria or water quality shall be followed in any revision which is the subject of the petition.

xxx:yy-1-6. Errors and reparability

(a) Errors resulting from inadequate and erroneous data or human or clerical oversight will be subject to correction by the Department.

(b) The discovery of such errors does not render the remaining and unaffected Standards invalid.

(c) If any provision of these Standards, or the application of any provision of these Standards to any person or circumstances is held to be invalid, the application of such provisions to other persons and circumstances and the remainder of the Standards shall not be affected thereby.

SUBCHAPTER 2. ANTIDEGRADATION REQUIREMENTS

Section

xxx:yy-2-1. Purpose; antidegradation policy statement

(a) Waters of the Tribe constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the Department to protect all waters of the Tribe from degradation of water quality.

(c) The existing in-stream beneficial uses of each water body and the level of water quality necessary to protect those uses shall be maintained and protected.

(d) Where the quality and total maximum daily loads of the waters are at higher qualities than necessary to support propagation of fish, shellfish and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the Department finds, after full satisfaction of the intergovernmental coordination and public participation required by law, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the Department shall assure water quality adequate to protect existing uses fully. Further, the Department shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.

(e) Where high quality waters constitute an outstanding national or Tribal resource, or waters of exceptional recreational or ecological significance, the water quality and uses of those water bodies shall be maintained and protected.

(f) In those cases where potential water quality impairments associated with thermal discharge are involved, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act, as amended (33 U.S.C. § 1326).

xxx:yy-2-2. Applications of antidegradation policy

(a) **Application to Primary Body Contact Cultural and Spiritual waters (PBCC).** All waters of the Tribe constitute an outstanding resource or have exceptional significance. These waters include streams designated "PBCC" in Appendix A.

SUBCHAPTER 3. SURFACE WATER QUALITY STANDARDS

PART 1. GENERAL PROVISIONS

xxx:yy-3-1. Declaration of policy; authority of Department

(a) **General policy to protect, maintain and improve water quality.**

Whereas the pollution of the waters of this Tribe constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, it is hereby declared to be the public policy of the Tribe to conserve and utilize the waters of the Tribe and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses.

(b) **Department authority to promulgate Standards.**

(1) The Department, with the approval of the Tribal Business Committee, is authorized to develop, propose amendment to and otherwise promulgate rules to be known as the Quapaw Tribal Surface Water Quality Standards which establish classifications of uses of waters of the Tribe, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters. These Standards shall, at a minimum, be designed to maintain and protect the quality of the waters of the Tribe.

(2) Wherever the Department finds it is practical and in the public interest to do so, the rules may be amended to upgrade and improve progressively the quality of waters of the Tribe.

(3) Subject to the approval of the Tribal Business Committee, the Department may also amend the Standards to downgrade a designated use of any waters of this Tribe which is not an existing use, may establish subcategories of a use or may provide for less stringent criteria or other provisions thereof only in those limited circumstances permissible under the Federal Water Pollution Control Act as amended or federal rules which implement said act. As provided herein, and with the approval of the Tribal Business Committee, the Department may amend these Standards to downgrade a designated use, establish subcategories of a use or may provide for less stringent criteria or other provisions thereof only to the extent as will maintain or improve the existing uses and the water quality of the water affected.

xxx:yy-3-2. Beneficial uses: existing and designated

(a) Beneficial uses are designated for all waters of the Tribe. Such uses are protected through the restrictions imposed by the antidegradation policy statement, narrative criteria and numerical standards. Some uses require higher quality water than others. When multiple uses are assigned to the same waters, all such uses shall be protected. Beneficial uses are also protected by permits or other authorizations issued to meet these Standards for point sources and through practical management or regulatory programs for nonpoint sources. The criteria to protect the beneficial uses designated in Appendix A of this Chapter for certain surface waters of the Tribe are described in sections xxx:yy-5-10 through xxx:yy-5-20 of this Chapter.

(b) Beneficial uses designated in Appendix A of this Chapter for certain surface waters of the Tribe may be downgraded to a lower use or removed entirely, or subcategories of such designated uses may be established, if:

(1) the use, despite being designated, is not a use which is or has been actually attained in the water body on or after November 28, 1975; and

(2) for the use of Fish and Wildlife Propagation, Primary Body Contact Recreation or Secondary Body Contact Recreation, or any subcategory of such use or uses, it is demonstrated to the satisfaction of the Department and the EPA that attaining the designated use is not feasible because:

(A) naturally occurring pollutant concentrations prevent the attainment of the use, or

(B) natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating Tribe water conservation requirements to enable uses to be met, or

(C) human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place, or

(D) dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use, or

(E) physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses, or

(F) controls more stringent than those required by sections 301(b) and 306 of the federal Clean Water Act as amended would result in substantial and widespread economic and social impact; and

(3) such downgrade, removal, or establishment of a subcategory will maintain or improve the quality of water affected.

xxx:yy-3-3. Beneficial uses: default designations

(a) **Surface waters excluding lakes.**

(1) For those surface waters of the Tribe not listed in Appendix A of this Chapter, the following beneficial uses are designated:

(A) Primary Contact Ceremonial and spiritual

(2) Beneficial use determinations that follow use attainability analyses are subject to administrative rulemaking proceedings.

(b) **Lakes.**

(1) Lakes are assigned the following designations:

(A) Primary Contact Ceremonial and spiritual;

(B) Primary Body Contact Recreation;

(C) The Warm Water Aquatic Community subcategory of the beneficial use classification Fish and Wildlife Propagation;

(D) Agriculture;

(E) Industrial and Municipal Process and Cooling Water; and

(F) Aesthetics.

xxx:yy-3-4. Applicability of narrative and numerical criteria

(a) For purposes of permitting discharges for attainment of numerical criteria or establishing site specific criteria, streamflows of the greater of 1.0 cfs or 7Q2 shall be used to determine appropriate permit conditions.

(b) Narrative criteria listed in this Chapter shall be maintained at all times and apply to all surface waters of the Tribe.

(c) If more than one narrative or numerical criteria is assigned to a stream, the most stringent shall be maintained.

(d) A temporary regulatory variance may be granted at the sole discretion of the Department in limited circumstances only for specific numerical criteria listed in Table 2 of Appendix B of this Chapter addressing water column numerical criteria to protect human health for the consumption of fish and water, for specific numerical criteria listed in Appendix B Table 2 addressing numerical criteria for toxic substances, and for specific numerical criteria listed in Appendix B Table 2 addressing water column numerical criteria to protect human health for the consumption of fish flesh only.

PART 3. BENEFICIAL USES AND CRITERIA TO PROTECT USES

xxx:yy-3-5. General narrative criteria

All surface waters of the Tribe waters shall be free from pollutants and other materials attributable to point source discharges, nonpoint sources, or in-stream activities in accordance with the following:

(a) **Minerals.** Increased mineralization over natural conditions from elements such as, but not limited to, calcium, magnesium, sodium and their associated anions shall not impair any beneficial use.

(b) **Floating Solids, Oil and Grease.** All waters shall be free from visible oils, scum, foam, grease, and other floating and suspended materials of a persistent nature resulting from other than natural causes.

(c) **Color.** True color-producing materials resulting from other than natural causes shall not create an aesthetically undesirable condition; nor should color inhibit photosynthesis or otherwise impair the existing and designated uses of the water.

(d) **Odor and Taste.** Materials from other than natural causes shall be limited to concentrations that will not impart unpalatable flavor to fish, or result in offensive odor or taste arising from the water, or otherwise interfere with the existing and designated uses of the water.

(e) **Nuisance Conditions.** Nutrients or other materials from anthropogenic causes shall not be present in concentrations which will produce objectionable algal densities or nuisance aquatic vegetation, result in a dominance of nuisance species, or otherwise cause nuisance conditions.

(f) **Turbidity.** Turbidity shall not be at a level to threaten or impair existing and designated uses or aquatic biota.

(g) **Bottom Deposits.** All surface waters of the tribe shall be free from anthropogenic materials that may settle and have a deleterious effect on the aquatic biota or that will significantly alter the physical and chemical properties of the water or the bottom sediments.

(h) **Permits**. In issuing permits, Tribal authorities shall attempt to insure that to the extent practicable, all waters shall be free from soil particles resulting from erosion of land involved in earthwork, such as construction of public works, highways, or commercial or industrial developments, or the cultivation and management of agricultural or forested lands, or resulting from discharges from consumptive or nonconsumptive uses of water following surface water diversions or ground water pumping.

xxx:yy-3-6. TOXIC POLLUTANTS

(a) Toxic pollutants shall not be introduced into surface waters of the Tribe in concentrations which have the potential either singularly or cumulatively to adversely affect existing and designated uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the Department.

(b) The Department may employ or require chemical testing, acute and/or chronic toxicity testing, and biological assessments, as appropriate, to evaluate compliance with subsection (1) of this section. Where necessary, the Department may establish controls to ensure that aquatic communities and the existing and designated beneficial uses of waters are being fully protected.

(c) Criteria for toxic pollutants and other materials not currently listed in Table 2 shall be determined with consideration of *U.S. EPA Quality Criteria for Water, 1986*, as updated, and other relevant information as appropriate.

(d) Risk-based criteria for carcinogenic materials shall be applied such that the upper-bound excess cancer risk is less than or equal to one in one million, which means the probability of one excess cancer per one million people exposed.

(e) The guidelines set forth in 40 CFR Part 136 shall be used as guidance for analytical methodologies

(f) The criteria in Table 2, Appendix B shall be applied to all surface waters of the tribe for the protection of aquatic life and human health. The concentration for each compound listed in Table 2 is a criterion for aquatic life or human health protection. Selecting values for regulatory purposes will depend on the most sensitive beneficial use to be protected and the level of protection necessary for aquatic life and human health as specified within Table 2, Appendix B. Application for a reduction in the list of compounds or elements must be based on proof that one or more of the proposed compounds are not of concern. Authorization of such a reduction is at the discretion of the Department. All concentrations, except asbestos, are micrograms per liter (ug/L).

(A) Primary Contact Ceremonial and spiritual;

(B) Primary Body Contact Recreation;

(C) The Warm Water Aquatic Community subcategory of the beneficial use classification Fish and Wildlife Propagation;

(D) Agriculture;

(E) Industrial and Municipal Process and Cooling Water; and

(F) Aesthetics.

xxx:yy-3-7. Primary Contact Ceremonial and Spiritual

(a) **General.** Primary Contact Ceremonial and Spiritual is the highest and best use of the resource. The surface waters of this designated use shall be maintained so that toxicity does not inhibit ingestion of subsistence foods by humans including, but not limited to fish, shellfish, plants and terrestrial wildlife. The numerical criteria and values for substances listed in Appendix B, Table 2 of this Chapter shall apply to surface water designated as Warm Water Aquatic Community, Cool Water Aquatic Community, or Trout Fishery.

(b) **Water column criteria to protect for the consumption of fish and water.** Primary Contact Ceremonial and Spiritual use involves direct ingestion of water, flora, and fauna associated with daily subsistence practices as well as inhalation of vapors during sweat lodge ceremonies. In these cases the water shall not contain chemical, physical or biological substances in concentrations that:

1. toxic or cause illness or discomfort upon ingestion by human beings,
2. has the potential to bioaccumulate in subsistence foods; or
3. are irritating to skin or sense organs upon contact with water or vapor.

The water column numerical criteria (total recoverable) identified in the " Fish Consumption and Water " column in Appendix B, Table 2 protect human health for the consumption of fish, shellfish and aquatic life.

(c) **Radioactive materials.**

(1) There shall be no discharge of radioactive materials to Tribal waters.

(2) The concentration of gross alpha particles shall not exceed the criteria specified in (A) through (D) of this subparagraph, or the naturally occurring concentration, whichever is higher.

(A) The combined dissolved concentration of Radium-226 and Radium-228, and Strontium-90, shall not exceed 5 picocuries/liter, and 8 picocuries/liter, respectively.

(B) Gross alpha particle concentrations, including Radium-226 but excluding radon and uranium, shall not exceed 15 picocuries/liter.

(C) The gross beta concentration shall not exceed 50 picocuries/liter.

(D) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in waters having the designated use of Public and Private Water supply shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

(3) **Coliform bacteria.**

(A) The bacteria of the total coliform group shall not exceed a monthly geometric mean of 5,000/100 ml at a point of intake for public or private water supply.

(B) The geometric mean will be determined by multiple tube fermentation or membrane filter procedures based on a minimum of not less than five (5) samples taken over a period of not more than thirty (30) days.

(C) Further, in no more than 5% of the total samples during any thirty (30) day period shall the bacteria of the total coliform group exceed 20,000/100 ml.

(D) In cases where both public and private water supply and primary body contact recreation uses are designated, the primary body contact criteria will apply.

(4) **Oil and grease (petroleum and non-petroleum related).** Primary Contact Ceremonial and Spiritually designated surface waters of the Tribe shall be maintained free from oil and grease and taste and odors.

(5) **General criteria.**

(A) The quality of the surface waters of the Tribe which are designated as Primary Contact Ceremonial and Spiritual shall be protected, maintained, and improved when feasible, so that the waters can be used for all beneficial uses.

(B) These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans or flora and fauna.

xxx:yy-3-8. Public and private water supplies (PPWS)

The following criteria apply to surface waters of the Tribe having the designated beneficial use of Public and Private Water Supplies:

(1) **Raw water numerical criteria.** For surface water designated as public and private water supplies, the numerical criteria for substances identified under the "Public and Private Water Supply (Raw Water)" column in Table 2 of Appendix B of this Chapter shall not be exceeded. Raw water numerical criteria are considered long term average standards. For purposes of permitting discharges for attainment of these standards, the permitting authority shall use long term average receiving stream flows and complete mixing of effluent and receiving water to determine appropriate permit limits.

(2) **Radioactive materials.**

(A) There shall be no discharge of radioactive materials to Tribal waters.

(B) The concentration of gross alpha particles shall not exceed the criteria specified in (i) through (iv) of this subparagraph, or the naturally occurring concentration, whichever is higher.

(i) The combined dissolved concentration of Radium-226 and Radium-228, and Strontium-90, shall not exceed 5 picocuries/liter, and 8 picocuries/liter, respectively.

(ii) Gross alpha particle concentrations, including Radium-226 but excluding radon and uranium, shall not exceed 15 picocuries/liter.

(iii) The gross beta concentration shall not exceed 50 picocuries/liter.

(iv) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in waters having the designated use of Public and Private Water supply shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

(3) **Coliform bacteria.**

(A) The bacteria of the total coliform group shall not exceed a monthly geometric mean of 5,000/100 ml at a point of intake for public or private water supply.

(B) The geometric mean will be determined by multiple tube fermentation or membrane filter procedures based on a minimum of not less than five (5) samples taken over a period of not more than thirty (30) days.

(C) Further, in no more than 5% of the total samples during any thirty (30) day period shall the bacteria of the total coliform group exceed 20,000/100 ml.

(D) In cases where both public and private water supply and primary body contact recreation uses are designated, the primary body contact criteria will apply.

(4) **Oil and grease (petroleum and non-petroleum related).** For Public and Private Water Supplies, surface waters of the Tribe shall be maintained free from oil and grease and taste and odors.

(5) **General criteria.**

(A) The quality of the surface waters of the Tribe which are designated as public and private water supplies shall be protected, maintained, and improved when feasible, so that the waters can be used as sources of public and private raw water supplies.

(B) These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans or flora and fauna.

(6) **Water Column criteria to protect for the consumption of fish flesh and water.**

(A) Surface waters of the Tribe with the designated beneficial use of Public and Private Water Supply shall be protected to allow for the consumption of fish, shellfish, and water.

(B) The water column numerical criteria to protect human health for the consumption of fish flesh and water for the substances identified in Table 2 of Appendix B of this Chapter shall be as prescribed under the "Fish Consumption and Water" column in Table 2 of Appendix B in all surface waters designated with the beneficial use of Public and Private Water Supply. Water column numerical criteria to protect human health for the consumption of fish and water are considered long term average standards. For purposes of permitting discharges for attainment of these standards, the permitting authority shall use long term average receiving stream flows and complete mixing of effluent and receiving water to determine appropriate permit limits. Water column criteria to protect human health for the consumption of fish flesh only may be found in the column "Fish Consumption" in Table 2 of Appendix B of this Chapter.

xxx:yy-3-9. Emergency public and private water supplies

(a) During emergencies, those waters designated Emergency Public and Private Water Supplies may be put to use.

(b) Each emergency will be handled on a case-by-case basis, and be thoroughly evaluated by the appropriate Tribe agencies and/or local health authorities.

xxx:yy-3-10. Fish and wildlife propagation

(a) **List of subcategories.** The narrative and numerical criteria in this section are designed to maintain and protect the beneficial use classification of "Fish and Wildlife Propagation". This classification encompasses several subcategories which are capable of sustaining different climax communities of fish and shellfish. These subcategories are Habitat Limited Aquatic Community, Warm Water Aquatic Community, Cool Water Aquatic Community (Excluding Lake Waters), and Trout Fishery (Put and Take).

(b) **Warm Water Aquatic Community subcategory.** Warm Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support warm water climax fish communities.

(c) **Cool Water Aquatic Community subcategory.** Cool Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support cool water climax fish communities and includes an environment suitable for the full range of cool water benthos. Typical species may include smallmouth bass, certain darters and stoneflies.

(d) **Trout Fishery subcategory.** Trout Fishery (Put and Take) means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support a seasonal put and take trout fishery. Typical species may include trout.

(e) **Criteria used in protection of fish and wildlife propagation.** The narrative and numerical criteria to maintain and protect the use of "Fish and Wildlife Propagation" and its subcategories shall include:

(1) **Dissolved oxygen.**

(A) Dissolved oxygen (DO) criteria are designed to protect the diverse aquatic communities.

(ii) by comparison with pre-contamination historical data from the water body being evaluated.

(B) Compliance with the biological criteria to protect Fish and Wildlife Propagation set forth in this paragraph shall be based upon measures including, but not limited to, diversity, similarity, community structure, species tolerance, trophic structure, dominant species, indices of biotic integrity (IBI's), indices of well being (IWB's), or other measures.

(6) **Toxic substances (for protection of fish and wildlife).**

(A) Surface waters of the Tribe shall not exhibit acute toxicity and shall not exhibit chronic toxicity. The narrative criterion specified in this subparagraph (A) which prohibits acute toxicity shall be maintained at all times and shall apply to all surface waters of the Tribe. The narrative criterion specified in this subparagraph (A) which prohibits chronic toxicity shall apply at all times.

(B) Toxicants for which there are specific numerical criteria are listed in Table 1 of Appendix b of this Chapter.

(C) For toxicants not specified in Table 1 of Appendix b of this Chapter, concentrations of toxic substances with bio-concentration factors of 5 or less shall not exceed 0.1 of published LC_{50} value(s) for sensitive representative species using standard testing methods, giving consideration to site specific water quality characteristics.

(D) Concentrations of toxic substances with bio-concentration factors greater than 5 shall not exceed 0.01 of published LC_{50} value(s) for sensitive representative species using standard testing methods, giving consideration to site specific water quality characteristics.

(E) The acute and chronic numerical criteria listed in the "Fish and Wildlife Propagation" column in Table 2 of Appendix B of this Chapter apply to all waters of the Tribe designed with any of the beneficial use sub-categories of Fish and Wildlife Propagation. The numerical criteria which prohibit acute toxicity apply to all Tribal waters.

(i) The numerical criteria specified in Table 1 of Appendix b which prohibit chronic toxicity shall apply at all times.

(ii) Equations are presented in Table 1 of Appendix b for those substances whose toxicity varies with water chemistry. Metals listed in Table 1 of Appendix b are measured as total metals in the water column.

(7) **Turbidity.**

(A) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

(i) Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;

(ii) Lakes: 25 NTUs; and

(iii) Other surface waters: 50 NTUs.

(B) In waters where background turbidity exceeds these values, turbidity from point sources shall be restricted to not exceed ambient levels.

(C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

xxx:yy-3-11. Agriculture: livestock and irrigation

(a) The surface waters of the Tribe shall be maintained so that toxicity does not inhibit continued ingestion by livestock or irrigation of crops.

xxx:yy-3-12. Fish consumption

(a) **General.** The surface waters of the Tribe shall be maintained so that toxicity does not inhibit ingestion of subsistence foods by humans including, but not limited to fish, shellfish, plants and terrestrial wildlife. The numerical criteria and values for substances listed in column "Fish Consumption" in Table 2 of Appendix B of this Chapter shall apply to surface water designated as Warm Water Aquatic Community, Cool Water Aquatic Community, or Trout Fishery.

(b) **Water column criteria to protect for the consumption of fish flesh.** The water column numerical criteria (total recoverable) identified in the "Fish Consumption" column in Table 2 of Appendix b protect human health for the consumption of fish, shellfish and aquatic life.

APPENDIX A. DESIGNATED BENEFICIAL USES FOR SURFACE WATERS

(a) **Introduction.** The Tables that follow in this Appendix identify certain waterbodies throughout Tribal lands and designate beneficial uses for those waterbodies. The waterbodies are identified by their name (e.g., "Tar Creek") or other description (e.g., "Tributary of Tar Creek at Sec. 4) and a "WQM Segment" number.

(b) **Beneficial Use designations.** Designations of beneficial uses for a water body are reflected in the Tables by the presence of the following codes or a dot ("•") in the columns to the right of the water body name. An empty space in a column means that column's beneficial use or subcategory thereof is not designated for that water body. All water bodies of the Tribe are designated Primary contact Cultural Ceremonial Use

The criteria to protect the beneficial uses are provided in Appendix B of this Chapter.

TABLE 1. Designated Beneficial Uses of Surface Waters

Waterbody Name and Sequence	ODEQ WQM Segment	Designation [1]
Beaver Creek	121600	PCCS
Elm	121600	PCCS
Lytle	121600	PCCS
Spring River	121600	PCCS
Tar Creek	121600	PCCS

[1] The designated use is the highest and best use of surface water. This means that this use encompasses all lower-level designations. For example, water meeting the numeric criteria that are protective of Primary Contact Cultural and Spiritual uses (PCCS) which involves consumption of fish and water, will be protective of uses that involve only ingestion of fish or water.

TABLE 1.

Dissolved Oxygen Criteria to Protect Fish and Wildlife Propagation and All Subcategories Thereof

SUBCATEGORY OF FISH AND WILDLIFE PROPAGATION (FISHERY CLASS)	DATES APPLICABLE (MINIMUM)	D.O. CRITERIA (mg/L)	SEASONAL TEMP. (°C)
Habitat Limited Aquatic Community			
Early Life Stages	4/1 - 6/15	4.0	25[3]
Other Life Stages			
Summer Conditions	6/16 - 10/15	3.0	32
Winter Conditions	10/16 - 3/31	3.0	18
Warm Water Aquatic Community			
Early Life Stages	4/1 - 6/15	6.0[2]	25[3]
Other Life Stages			
Summer Conditions	6/16 - 10/15	5.0[2]	32
Winter Conditions	10/16 - 3/31	5.0	18
Cool Water Aquatic Community And Trout			
Early Life Stages	3/1 - 5/31	7.0[2]	22
Other Life Stages			
Summer Conditions	6/1 - 10/15	6.0[2]	29
Winter Conditions	10/16 - 2/28	6.0	18

1 For use in calculation of the allowable load.

2 Because of natural diurnal dissolved oxygen fluctuation, a 1.0 mg/l dissolved oxygen concentration deficit shall be allowed for not more than eight (8) hours during any twenty-four (24) hour period.

3 Discharge limits necessary to meet summer conditions will apply from June 1 of each year. However, where discharge limits based on Early Life Stage (spring) conditions are more restrictive, those limits may be extended to July 1.

TABLE 2.

Numerical Criteria to Protect Beneficial Uses and All Subcategories Thereof

PARAMETER	CAS #	Fish & Wildlife Propagation: ACUTE	Fish & Wildlife Propagation: CHRONIC	Public and Private Water Supply (Raw Water)	Fish Consumption and Water	Fish Consumption
		µg/L	µg/L	mg/L	µg/L	µg/L
INORGANICS						
Arsenic	7440382	360.0	190	0.04		205.0
Barium	7440393			1.00		
Cadmium	7440439	e(1.128[ln(hardness)] - 1.6774)	e(0.1002[ln(hardness)]-3.490)	0.020	14.49	84.13
Cadmium for trout streams		e(1.128[ln(hardness)] - 3.828)	e(0.1002[ln(hardness)]-3.490)	0.020	14.49	84.13
Chromium (total)			50	0.050	166.3	3365.0
Copper	7440508	e(0.9422[ln(hardness)]-1.3844)	e(0.8545[ln(hardness)]-1.386)	1.000		
Cyanide	57125	45.93	10.72	0.200		
Flouride @ 90°F				4.0		
Lead	7439921	e(1.273[ln(hardness)] - 1.460)	e(1.273[ln(hardness)] - 4.705)	0.100	5.0	25.0
Mercury	7439976	2.4	1.302	0.002	0.050	0.051
Nickel	7440020	e(0.8460[ln(hardness)]+3.3612)	e(0.846[ln(hardness)]+1.1645)		607.2	4583.0
Nitrates (as N)	14797558			10.000		

Selenium	7782492	20.0	5	0.010		
Silver	7440224	e(1.72[ln(hardness)] - 6.52)		0.050	104.8	64620.0
Thallium	7440280	1400.0			1.7	6.0
Zinc	7440666	e(0.8473[ln(hardness)]+0.8604)	e(0.8473[ln(hardness)]+ 0.7614	5.000		
ORGANICS						
1,1,1-TCE	71556				3094.0	173100.0
2,4,5-TP,Silvex	93721		10.0	0.010		
2,4,6-TNT		450.0				
2,4-D	94757			0.100		

PARAMETER	CAS #	Fish & Wildlife Propagation		Public and Private Water Supply (Raw Water)	Fish Consumption and Water	Fish Consumption
		ACUTE	CHRONIC			
		µg/L	µg/L	mg/L	µg/L	µg/L
Acrylonitrile	107131	7550.0			.59	6.7
Aldrin	309002	3.0			0.001273	0.001356
Benzene	71432		2200.0		11.87	714.1
Benzidine	92875			0.001		
Butylbenzyl Phthalate	85687			0.150		
Carbon Tetrachloride	56235				2.538	44.18
Chlordane	57749	2.4	0.17		0.00575	0.00587
Chloroform	67663				56.69	4708.0
Chlorpyrifos (Dursban)	2921882	0.083	0.041			
DDT		1.1	0.001		0.005876	0.0059
Demeton	8065483		0.1			
Detergents (total)				0.200		
Dichlorobromomethane	75274				1.9	157.0
Dieldrin	60571	2.5	0.0019		0.001352	0.00144
Dioxin	1746016				0.00000013	0.000000138
Endosulfan		0.22	0.056			
Endrin	72208	0.18	0.0023	0.0002	.7553	0.814
Ethylbenzene	100414				3120.0	28720.0

Table 3.

Conversion Factors for Total to Dissolved Fractions [H=hardness as $CaCO_3$ (mg/L)]

METAL	CAS #	ACUTE	CHRONIC
Arsenic	7440382	1.000	1.000
Cadmium	7440439	lnH 1.136672 - 0.041838	lnH1.101672 - 0.041838
Copper	7440508	0.960	0.960
Lead	7439921	lnH 1.46203 - 0.145712	lnH 1.46203 - 0.145712
Mercury	7439976	0.85	N/A
Nickel	7440020	0.998	0.997
Silver	7440224	0.85	N/A
Zinc	7440666	0.978	0.986

Attachment No 1. Berrey, J.[19], Kent, T.[20], Kirschner, F.E. [21] and, Harper, B. 2019[22], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[19] Chairman of the Quapaw Nation
[20] Environmental Director, Quapaw Nation
[21] Senior Scientist, AESE, Inc.
[22] Senior Scientist, AESE, Inc.

Attachment No.3 October 25, 2018 Memo entitled: Review of: Tar Creek Source Material Operable Unit 4 Remedial Action Exposure Scenario for Human Receptors in Riparian Areas September 26, 2018

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: October 25, 2018

SUBJECT: Review of: ***Tar Creek Source Material Operable Unit 4 Remedial Action Exposure Scenario for Human Receptors in Riparian Areas September 26, 2018***

CC: Katrina Coltrain (EPA-RPM)
Rafael Casanova (EPA-RPM)
File

The Quapaw Tribe of Oklahoma (QTO) provided comments on several earlier supporting document (Attachment No 1). The majority of concerns raised in this previous reviews pertinent to all aspects of the BHHRA and still are unresolved. The cover memo to the June 15, 2018 review states:

> ***"The QTO believes it would be much more expeditious and cost-effective for EPA to respond to these previous concerns (Attachment No. 1) as well as additional concerns provided herein before proceeding any further."***
>
> ***The QTO reiterates that OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable Maximal Exposure Scenario***

(RME) for each OU as soon as possible.[1] As demonstrated below, the information contained in this technical memorandum falls far short."

The QTO-specific HHRA RME, covering both OU4 (uplands) and OU5 (riparian areas) was transmitted to EPA on August 8, 2018 (Attachment No. 2). Upon review of the aforementioned EPA draft document, it became clear that the Tribal specific RME was not considered, nor was the request that EPA respond to all of the HHRA-based comments, before proceeding any further on the BHHRA.

As pointed-out in comments on the BHHRA over the past 10 years, the following pathways for a single COC (lead or cadmium) exceed acceptable risk levels:

1. Groundwater consumption
2. Surface water consumption
3. Soil consumption, and
4. Sediment consumption

All of which are abiotic media that are responsible for the elevated concentrations of COCs in fish, plants, and other biotic media relied by the QTO for sustenance.

Since soils are partially responsible for elevated concentrations of COCs in surface water and groundwater and since it is very costly to treat large volumes of ground water, let alone, surface water, EPA's focus is on stabilizing or removing sediments and soils.

From this discussion alone, it is clear that EPA does not, and cannot, treat or clean-up plants without first cleaning-up soils or sediments, and if soils and sediments are not returned to pre-mining concentrations in unrestricted use locations, OU4 and OU5 will never meet acceptable risk levels[2]. Therefore, the QTO cannot support wasting more time sampling flora and fauna, since pathways associated with the listed abiotic media (which is growth media for flora and fauna) already exceed acceptable risk levels.

The Tribe also wishes to inform EPA that the title of the subject document is clearly misleading, the memo contains numerous errors related to interpretation of exiting data and data quality, and appears to be more of a sales-pitch attempting to rationalize even more sampling that is not necessary for reasons described herein. The Quapaw Nation has elected to minimize further comments on this document, while awaiting response to all of the BHHRA-related comments described above.

[1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

[2] This situation is similar to a dentist advising that "your teeth are OK, but your gums have to go."

Attachment No 1 Review of: Technical Memorandum: Human Health Risk Assessment Process, Objectives, and Tribal Lifeways Scenarios Developed for Operable Unit 5, May 11, 2018

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: June 15, 2018

SUBJECT: Review of: ***Technical Memorandum: Human Health Risk Assessment Process, Objectives, and Tribal Lifeways Scenarios Developed for Operable Unit 5, May 11, 2018***

CC: Katrina Coltrain (EPA-RPM)
Rafael Casanova (EPA-RPM)
File

This memo constitutes a review of the aforementioned document. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

The Quapaw Tribe of Oklahoma (QTO) provided comments on an earlier supporting document (Attachment No 1). The majority of concerns raised in this previous review still are unresolved. The QTO believes it would be much more expeditious and cost-effective for EPA to respond to these previous concerns (Attachment No. 1) as well as additional concerns provided herein before proceeding any further.

The QTO reiterates that OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable

Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] As demonstrated below, the information contained in this technical memorandum falls far short.

General Comments (in addition to those raised in Attachment No. 1)

1. Aquatic-based and terrestrial-based variants of the RME for the QTO need to be developed as soon as possible (see Attachment No. 1)

2. From data presented in the Tech Memo, it is clear that the Tribes of the Tar Creek Trustee council (TCTC) rely on resources at much lower consumption rates, frequencies, and durations. Therefore the QTO is greatest exposed hedonistic receptor in the area. This means that tribes of the TCTC are much lower risk populations and should not be the subject of development of RMEs, since the QTO RME (terrestrial and aquatic variants) is protective of the TCTC Tribes. This also means that PRGs/RAOs and ultimately selection of the preferred alternative must be based on the QTO RME and not RME based on the TCTC tribes.

3. The General Objectives of the Tar Creek OU5 HHRA (Section 2.0) is misleading:

> *The objectives of the HHRA are two-fold: first, to estimate the level of risk to human health associated with concentrations of environmental contaminants detected in OU5 media (surface water, sediments, biota, and mine discharge);*

At this stage of the RI/FS, estimating PRGs/RAOs is the objective, followed by quantification of residual risk associated with each proposed alternative in the FS. The Hazard Ranking Score (HRS) has already demonstrated that Risk is excessive, even to the general public. Risk is clearly much greater for the QTO who "live close to the land".

> *Risks are estimated* ***for current exposures to OU5*** *media as well as reasonably foreseeable future uses. All contaminated media within OU5 are considered (such as sediment and surface water) if individuals are likely to be exposed to the media. All relevant* ***routes of exposure for OU5 are considered****, including direct contact (ingestion and dermal exposure) and indirect contact (exposure to food items that have accumulated contaminants through sediments).* [Emphasis added]

[1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

EPA cannot discount risk associated with the other OUs. In other words EPA needs to assess risk allocation from all OUs, from all COCs released, from all media, along all pathways to the QTO.

4. Sweatlodge usage was intentionally left ambiguous in the original QTO HHRA Scenario. The Traditional QTO frequency of sweatlodge use requires more research. This was included in the aforementioned proposal mentioned in Attachment No. 1.

   The downriver tribes may use a sweat lodge less than once per month, but research may reveal that the QTO use it at a higher frequency. This is important because the QTO reservation encompasses the most contaminated lands of all OUs.[2],[3] The QTO are the population representing the RME, and sweatlodge use is likely an important risk-driving activity. This means that PRGs/RAOs and subsequent remedies will be based on remedies that are protective for the Quapaw Tribe.

5. The distinction between ordinary surface water and mine discharge surface water is not clear.

   > *"Mine discharge occurs in three known locations of the Tar Creek Superfund Site in Ottawa County, Oklahoma"*

   It is not clear why there is any distinction at all, since any mine discharge becomes diluted with other water, and at some magical undefined point becomes ordinary surface water. The standard RME should be applied to these locations just as with any other location. This approach should save on risk calculation costs as well. Also, water quality standards are not dependent on the depth of the water (Section 3.4). The mine water media also needs to be connected to Surface Water in the wire-frame CSM**.**

[2] The Tribe also has the right to hunt fish and gather in areas downstream of their reservation.
[3] Many of the QTO members are dual citizens or have relatives of the downstream tribes that would result in the QTO to be exposed via diet during hunting, fishing, and gathering or via trade of contaminated resources.

Specific Comments

1. Section 1.0(1). While there is a logic to start by collecting all available data and then filling data gaps, a more complete process would be to: (Step 1) develop a whole-site human usage map and exposure scenario (the "exposome"), (Step 2) develop DQOs with detection limits based on total exposure and on background , (Step 3) review existing data for data usability according to EPA guidelines, (Step 4) develop a data gap report, (Step 5) collect new data, (Step 6) determine how to allocate risk among OUs and develop RMEs for as many OUs or sub-site areas as needed, and (Step 7) evaluate exposure and risk. These earlier documents cannot exist, since the RME(s) have not been developed and they are necessary to developing OU-specific DQOs and subsequently determine data usability. The allocation of risk among OUs means that the total allowable human risk (e.g., 1E-6 and HI = 1) will need to be subdivided among OUs so that individual OUs do not usurp the entire risk budget. Risk targets for individual OUs will need to be fractions of the total allowable risk. This comment is expanded in the next comment.

2. The "Overview of the Superfund HHRA Process" is incorrect.

> *1. The first step focuses on* data collection and analysis *to evaluate the characteristics of the site and support identification of the chemicals of potential concern (COPCs) in site media.*

This step is performed prior to listing in HRS and only identifies gross COPCs detrimental to the general public. The HHRAS/RME is required to determine necessary detection limits of COPCs. However, since Tribal populations use are the greatest exposed hedonistic receptor in the area, generally for mine sites, all EPA Target Analyte List (plus molybdenum) are COCs and the list of TAL+Mo cannot be screened-down. Regardless, COCs, necessary detection limits, and geographic scope are determined near Step 4. Data gaps cannot be determined until EPA knows what data are needed (DQOs) and if the exiting data meet these DQOs.

A later step is developing the SAP/FSP (or similar document(s)) that provides statistical design-level rationale for sampling biotic and abiotic media identified by EPA to be lacking from the historic database at the proper risk-based detection levels. This lacking information is termed data gaps. In order to determine what data are missing, EPA must first know what data they need to perform the BHHRA. The BHHRA is based on the reasonably anticipated future land use (RAFLU) of the target population. Note that land use is determined by the land owner first, and then the area is cleaned up to make that use safe, rather than forcing land use to be limited if the cleanup is not sufficient to reduce risk enough based on the RAFLU (i.e., if institutional controls are needed).

At TC, since these are Tribal lands, the QTO is the target of the BHHRA. Once the RAFLU and the target population have been identified, a plan is developed that specifies the data needs for the BHHRA. This is done in the HHRA work plan by using the conceptual site model as a visual accounting tool to derive the list of data that are needed. Next, the quality and quantity of those data are defined in a similar manner while the data quality objectives are being prepared. Once the DQOs have been prepared, the DQOs are used as a screening tool to evaluate the historical data. Data that meet the DQOs are retained for the BHHRA. Data that do not meet the DQO's are rejected and the data gap is recorded. Finally, a SAP and a FSP are developed using the DQOs and the HHRA WP to fill the gaps. This approach is detailed in the NCP.

3. Exposure parameters do not have "conservative safety factors" (Section 1.0(2)).

> . ….These assumptions, or default values, are assumed to be representative of a population, although they often include a conservative **safety factor**. These parameters include things such as time spent contacting surface water.

Exposure factors for the general population are based on actual data and statistical analysis, aiming at central tendency or upper percentiles, depending on the exposure pathway. For unstudied populations, the exposure parameters are extrapolated from actual data with professional judgment. A "reasonable maximum" is exactly that, reasonable.

4. An ecological determination of water body types (and therefore the specific boundaries of OU5) will probably be needed, because the sampling locations appear to include wetlands, streams, rivers, lakes, and springs. Perhaps the boundary of OU5 is a high water mark for a lake, but how is the boundary determined for a wetland or floodplain with seasonal discharges?

5. The relation between OU5 and the other OUs or other exposure areas is not clear. The floodplains are not included in the OU5 consideration. This is a systemic problem with the approach of subdividing a superfund site into OUs. While remedies may occur as separate engineering actions (e.g., pump and treat groundwater, excavate soil, cap sediments), the human body integrates all media, pathways, and contaminants into one cumulative set of doses with one single physiological response. A truly cumulative approach does not set a remedyfor one medium at a time, or one OU at a time unless the contributions from ALL OTHER media, pathways, chemicals, and OUs is treated as background exposures (the RSC or relative source contribution approach). Otherwise, 100% of exposure and risk must be assumed to be derived from each individual OU, and no exposure can occur from other OUs. As currently envisioned, for OU5 100% of time and exposure and food must come from

OU5. The only alternative to this is to allocate risk among OUs, such as allowing OU5 to contribute only 20% of the total risk, thus requiring, for instance, the total hazard index (summation of HQ's) from all COCs to be 0.2, not 1.0.

6. The body weight of 80 kg is acceptable only if all the dietary intake values are adjusted upward **(See General Comment 3, Attachment No. 1).** There are several ways to calculate this. A simple way is to multiply body weight (pounds) by 15-16 kcal/pound to maintain body weight.[4]

   The Harris-Benedict formula is based on total body weight, height, age, and sex and is a more accurate way to calculate basal metabolic rate.
   - Men: BMR = 66 + (13.7 x wt in kg) + (5 x ht in cm) - (6.8 x age in years)
   - Women: BMR = 655 + (9.6 x wt in kg) + (1.8 x ht in cm) - (4.7 x age in years)

   The BMR is then multiplied by a factor that considers the activity level of the person:

   - Sedentary = BMR x 1.2 (little or no exercise, desk job)
   - Lightly active = BMR x 1.375 (light exercise/ sports 1-3 days/week)
   - Moderately active = BMR x 1.55 (moderate exercise/ sports 6-7 days/week)
   - Very active = BMR x 1.725 (hard exercise every day, or exercising 2 xs/day)
   - Extra active = BMR x 1.9 (hard exercise 2 or more times per day, or training for marathon, or triathlon, etc.

   A similar approach is taken by the University of Maryland.[5] Men who are moderately active should multiply their weight in pounds by 15; women multiply by 12. The resulting number is the total calories per day needed to maintain weight. Relatively inactive men should multiply their weight by 13 and women, by 10. A moderately active woman who weighs 150 lbs. would need 1,800 calories per day to maintain her weight.

[4] https://www.k-state.edu/paccats/Contents/PA/control.htm.
[5] http://www.livestrong.com/article/307924-how-many-calories-are-needed-per-pound-to-maintain-a-body-weight/

The US Department of Health and Human Services provides age-specific guidelines in their publication, "Dietary Guidelines for Americans, 2015-2020, 8th edition." [6]

For use in this RME, a single simplified value of 2200 kcal/day will be used, for a lightly active to moderately active lifestyle. Note again that, based on the original QTO scenario, the aquatic ecosystem provides only 22% of total food. If OU5 is allowed to contribute 100% of allowable exposure and risk, then none of the other food can come from any other OU, and the person or family cannot live in those OUs and come into contact with them.

	Proposed IR based on 70 kg BW & 2000 kcal/day	**Adjusted IR based on 80 kg BW & 2200 kcal/day***	**kcal/100g**	**Total daily kcal**
Fish (catfish)	120 gpd	137 gpd	100	137
Shellfish (mussels)	30 gpd	34 gpd	182	63
Arrowroot root	133 gpd	152 gpd	66	100
Turtles, frogs	24 gpd	27 gpd	89	24
Semi-aquatic mammals (beaver)	69 gpd	79 gpd	212	166
Totals	***376 g (13 oz)***	***429 g (15 oz)***		***490 kcal 22% of 2200 kcal/d***
EF	365			
FC	1			
ED	64			
BW	80			
* A BW of 80 kg requires 2200 kcal/day, as opposed to 2000 for a 70kg body. IR is adjusted m \by the ratio of 70 kg to 80 kg, or multiplying the original IR by 1.14. NOTE: the original scenario did not evaluate upland versus in-water food or exposures.				

7. The rationale for the values in the separate document TCTC_RAGS_Table 4 from 2016 are not clear from the footnotes. For example, the Tribes proposed a shellfish IR of 30 gpd, while the proposed value was 12 gpd (not converted to g/kg-d), and the Tribes' IR for plants is 133 gpd while the proposed value was 40 gpd. The rates in the TCOU5RI (the current document under review) no longer have the lower proposed values, so please verify that the older RAGS_Table4 table is no longer the operative table. Again, the QTO is the RME in which PRGs/RAOs must be based.

[6] https://health.gov/dietaryguidelines/2015/

Comments provided by the TCTC demonstrate that that Tribes belonging to this entity are less likely to be exposed, even in the downstream areas than the QTO[7] (**Also See Comment No. 5…Attachment No. 1).**

8. The tribal worker scenario is not a useful scenario for two reasons. First, the tribal worker is assumed to spend fewer days per year (250 days) than the resident (312 days), and a shorter exposure duration (25 versus 70 years). It is not clear why the tribal worker's exposure is less than the ordinary resident. The only difference is that the skin surface might be reduced if the worker wears waders, but this difference alone seems unnecessary. Second, if the tribal worker's allowable risk is set at 1e-6 and HI=1, then this worker must live somewhere else, retire somewhere else, he cannot eat fish from the lake with his family members, and he cannot use the sweatlodge. It is more realistic that a regular tribal resident also works on the remedy, which does not change the total exposure in the scenario as described now.

9. Please remove the term "conservative" throughout the document and substitute the work "reasonable." The RME is reasonable, not a conservative worst case. For example, Section 3.1.4 says both that the RME does not include special high-contact water events, but implies that it still over-estimates total reasonable exposures. It would be more appropriate to say that the reasonable maximum may not include certain high-contact events; those events might not need to be addressed in a risk assessment, but special advice to members depending on exposure point concentrations might be warranted.

10. Section 3.1.1 The consideration of salve is good. It is not clear if any other aquatic plants will be sampled, or whether arrowroot represents all edible aquatic vegetation.

11. Section 3.3.2, Fish and shellfish ingestion. See comment on adjusting the intake rate. When the actual risk assessment is done, more attention to the method of preparation of various species may be needed, such as a crayfish boil, fish served skin on or off, and so on. A similar comment pertains to aquatic plants and how much sediment might remain on them (relevant to collection and sampling methods as well as to risk estimation).

12. From a public health perspective, past exposures (e.g., in the town of Picher) are relevant to providing appropriate biomedical intervention and specific health advice

[7] Pleased note that the exposure/dose history of the casual QTO downstream area is much greater than a TCTC user since the QTO citizen is exposed at higher durations, frequencies, and quantities at higher concentrations.

to individuals. While this is not part of a risk assessment document, it will be relevant when preparing advice based on sampling results, especially if institutional controls are part of the remedy. In point of fact, people who have had past exposures in Picher may already be carrying a high lead burden even if their blood lead levels are now below 5 ug/dl, and some consideration should be made of those past exposures. Remedies are developed for future people who start with no pre-existing body burden and no past exposures, so protecting the health of current tribal members who already have an exposure history should be considered.

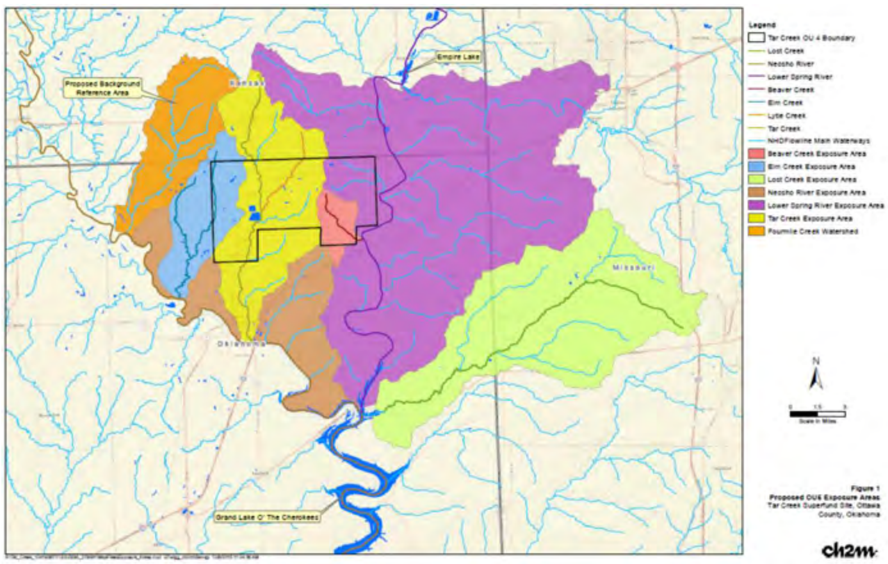


Figure 1. Map showing that OU5 includes the mine discharges within Tar Creek itself.

Attachment No 1 December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review: (RAGS Table 4 - Tribal Members - draft.xlsx)

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: January 8, 2018

SUBJECT: Review of December 13, 2017 Coltrain email requesting review of HHRA RAGS PartD Table 4 Review: (RAGS Table 4 - Tribal Members - draft.xlsx)

CC:

File

This memo constitutes a review of the aforementioned document. Tim Kent has directed us to send this directly to you. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

The OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] Because the RMEs were not developed, a piecemeal approach is resulting in a requirement for perpetual institutional controls and 5-year reviews, as well as an inability to reuse the lands and resources for

[1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

their intended uses.[2] Like the proposed plan and ROD, development of the OU5 RME should be a cooperative effort including EPA and the State, and needs to proceed without further delay. Ideally this will result in a cleanup where institutional controls and land use controls are not needed, and UU/UE can be achieved.[3]

General Comments:

1. **The QTO Traditional Scenario was developed to represent the general or average Traditional QTO citizen who relies on both aquatic AND terrestrial resources—it is not a Reasonable Maximal Exposure (RME) for a given OU.[4]** The RME should be a comprehensive site-wide exposure scenario, not an OU-specific exposure. As long as terrestrial and aquatic OUs are separated, the true OU-specific RME is one that describes individuals using either terrestrial OR aquatic OUs. The latter would be an RME for 100% time and 100% sustenance from each OU. For example the RME for a person who is more reliant on aquatic resources would require a greater aquatic diet, water from surface water or mine discharge (whichever is higher) and more aquatic area exposure time. As presented by EPA, the OU5 user is recreational, which is by definition not comprehensive. Further, limiting OU5 use to recreational use is inconsistent with the Tribes' plans for land use, and is in effect an institutional control. It also prevents a multi-OU cumulative exposure assessment. The options are to either (1) develop an RME for 100% of time and diet in OU5 and another for 100% OU4, or (2) develop a combined OU4/OU5 RME that uses resources from both areas simultaneously (in effect assuming a relative source contribution from each OU). As currently devised, the OU4 user cannot use resources from OU5 because his/her risk allocation has already been filled, and vice versa.

2. **Based solely on the approach used to build the RAGS Table 4, the Tribe still foresees major problems associated with the HHRA for the future traditional resident.** These problems are overarching and associated with balkanizing the site into OUs without reintegrating risk across the OUs to enable a comprehensive assessment of site risk as required by CERCLA. This concern has been raised by the Tribe previously and is clearly nothing new. The Tribe warned EPA on these issues as far back as 2004 and reiterated these concerns in no less than five memoranda. An early example first is General Comment 3, November 22, 2005

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[2] In effect, a non-congressionally approved taking of Tribal rights is slowly occurring.

[3] " Unrestricted Use/Unrestricted Exposure (UU/UE) - As discussed in EPA guidance documents, UU/UE generally refers to a situation when there are no exposure or use limitations required for the remedy at a site to be protective." https://www.epa.gov/sites/production/files/documents/final_pime_guidance_december_2012.pdf

[4] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

Memo from Tim Kent to Ursula Lennox (EPA-RPM) regarding REG and RAOs for OU4 (Attachment 1)

3. ***The PRGs/RAOs do not consider the exposure that ecological or human receptors receive from the Surface water pathway as well as riparian resources.***

   This is a major error and omission on the part of both the ecological and the Human Health Risk Assessments (this will be discussed in greater detail in comments on those reports). The residual exposure to humans from drinking surface water and using surface water in sweatlodge ceremonies alone exceed allowable risk. This risk is real and cannot be assumed away or managed via institutional controls such as signage or education— people are using these resources today. This means that that the allowable risk to Tribal members who use resources for traditional cultural practices will be exceeded even if the uplands are returned to background conditions.

   The concept of an Operable Unit was developed to partition remedial actions into workable or manageable units—not to balkanize risk assessments. The NCP requires protection of human health and the environment for the reasonably foreseeable land use of the site—not of an OU. In summary, as long as the residual risk from OU1 is measurable, the allowable risk from other OUs must be reduced by an amount so that the cumulative site-wide risk does not exceed the threshold criteria. In this instance, the risk allocated for all other OUs has been usurped by OU1. Therefore, the PRG for all media (e.g. surface water, ground water, soils, floodplain sediments, and air) must be pre-release baseline (background).

The following table is included as another early example (excerpted from Attachment No. 2). Pay particular attention to footnote No. 2 to the table.

Tribal Exposure Areas on Tribal lands

General Activity	Source Areas: Chat Piles/Bases/Flotation Tailings Ponds	Transition Zones	Wetlands/Streams [2]
Relative Potential for Tribal Residential Use	High	High	High
Relative Potential for Tribal Subsistence Fishing Use	NA	NA	High
Relative Potential for Tribal Gathering Use (Aquatic)	NA	NA	High
Relative Potential for Tribal Gathering Use (Terrestrial)	High	High	NA
Relative Potential for Tribal Hunting Use	High	High	High
Relative Potential for Tribal Recreational Use	High	High	High
General Population Exposure on Tribal lands [1]			
Relative Potential for General Public Sportfishing Use	NA	NA	Moderate-Low
Relative Potential for General Public Bathing Use	NA	NA	Moderate-Low

NA = Not Applicable

[1] If members of the General Public (GP) reside on Tribal Lands, the residential recreational doses for the GP must also be determined.

[2] although this EA is not officially part of OU4, the dose from these areas must be considered in the Risk Assessment. If the Dose allocation from this EA equals or exceeds Risk Criteria defined by the NCP, then all other EAs must be cleaned-up to pre-release background conditions.

3. **Conversion to g/kg-d. This seems to be a systemic problem.**

An example for fish from Table 3-1 is that the fish daily ingestion rate = 120 g/d; (mistakenly converted to 15 g/kg-d by EPA). This is simply a dilution of the 120 g/d estimate by a 70 kg person into an 80kg person because EPA assumes that the same amount is eaten by both a 70 kg person and an 80 kg person.

(120 g/d)/70 kg = 1.714 g/kg/d, not 1.5 g/kd-d.

EPA's value of 1.5 g/kg-d comes from dividing the 120 g/d by 80 kg, which means that the larger person is eating less per body weight than the original 70 kg person. 2000 kcal (1526 g/d) is not enough to sustain an 80 kg person, as shown below (See Attachment).

We do not dispute that the average American is now 80 kg. But this means that everyone is eating more. If EPA wants to assume that people are heavier today, then they also have to recognize that they eat more, i.e., every intake factor needs to be multiplied by 1.14[5].

The goal for Tribes is to recapture its old lifestyle that leads to non-supersized people. The Traditional Scenario was developed for when people were a traditional size. If

[5] Accordingly the surface area for dermal calculations also would need to be revised as well.

EPA wants to adjust to new super-sized people to assess risk for current conditions they must scale all of the aforementioned exposure factors. However, the goal of the Tribe goal is for our future citizens to reach 70 kg once again. This means that the future traditional Tribal resident needs to be assessed assuming a traditional body weight of 70 kg, or alternately that the 80 kg person eats proportionally more.

- ***We recommend that EPA also examines the total caloric intake for the whole diet and compare it to the caloric needs per kg of body weight, rather than simply diluting a 70-kg diet into an 80-kg body.***

4. Use of two Canadian studies for reducing the soil ingestion rate

These two fecal tracer studies were conducted with the Nemiah Band, a traditional community; all food was provided to the participants by the investigators in the Davis et al. (2012) study, and participants were engaged in fisheries activities. A similar study of the same community was conducted by the same investigators (Irvine et al., 2014), with participants engaged in traditional activities; all food was provided to the participants by the investigators. As explained in Attachment No. 4: "Soil Ingestion for Oklahoma," these two studies are not considered to be applicable to the Quapaw exposure scenario. QTO believes that decades of previous work with multiple lines of evidence is not invalidated by these two studies, The approved Quapaw scenario uses a soil/sediment ingestion of 400 mg/d; the attachment presents the rationale for reducing the soil ingestion rate for another Tribe that behaves differently to 330 mg/d if the other Tribe(s) so desire.

5. **Geographic scope of OU5 needs to be revised.** We see several problems:

   a. We cannot ascertain the geographic scope from the provided information. Does OU5 extend all the way to Grand Lake. Or is it solely within the OU4 boundary?

   b. It is not clear whether riparian and flood-plain soils are included and whether the nature and extent of contamination has been characterized downstream of the source area on the QTO reservation.

   c. Downstream Tribes who are not using the source area uplands should perhaps have a separate OU and subsequent RME based on that OU. That RME would include the floodplains where residences occur.

6. **Frequency of sweat lodge use.** The Quapaw scenario includes daily use of a sweat lodge. We note that asking one tribal member about a lower rate does not invalidate the value used in the officially approved scenario. However, if the downriver tribes wish to use a lower frequency, they may do so.

Specific comments:

The frequency and duration of contact with streams is reasonable and acceptable.

Table 3-1

- Does waterfowl data already exist (so it is not a data gap)?
- Cell 8j: "Two plant types (duckweed and arrowhead root); duckweed = washed whole plant; arrowhead = washed tuber only, washed fine roots only, and washed leaves/stalk only." (OK, but duckweed is not listed in Table 4-1.)
- Cell 11j: What grain size will be used in sieving? As EPA knows, more contaminants are adsorbed as the surface area increases with smaller grain sizes, and stream silt would have smaller grain sizes. Additionally, the sand-silt cutoff (63 um) is the point at which grittiness is detected and spit out. See the Soil Ingestion attachment for a longer discussion.

Table 4-1 - Food

- Footnote 3 – 10% of aquatic food is shellfish, which is reasonable, but what % of the total diet is aquatic?
- Footnote 4 – 20% of aquatic food is amphibian and reptile; 20% is plants. This leaves 50% for fish if small mammals are kept separate; again, what % of the total diet is comprised of aquatic-sourced foods, and what assumption are made about where the rest of the food comes from? It cannot come from OU4, because OU4 has already filled the entire risk allocation.
- It is not clear whether EPA intends to use a fish ingestion rate of 120 g/d plus shellfish (12 g/d), aquatic tubers (40 g/d), plus herps (24 g/d). or whether EPA intends to divide 120 g/d into different fractions.
- Aquatic tubers = 40 g/d (no duckweed?)
- Again, EPA should not convert a 70kg person diet into an 80kg person unless the values are raised to account for a larger person eating more.

Table 4-2 – Sediment

- The exposure frequency of 126 days per year is reasonable for recreational use, but the QTO has not agreed that OU4 is solely recreational or that it is off-limits to users of other OUs (due to unacceptable cumulative risk).

Table 4.3 – SW Potable (surface water in creeks), and Table 4.4 – SW (also in surface water creeks)

- It is not clear how these two tables are different. If the difference is expected to be related to exposure point concentration, then it would seem that a single set of exposure assumption should be used with several different exposure point concentrations (the creek, the mine drainage, the river, and groundwater).
- The drinking/swimming/sweatlodge RME should use maximum concentration of whatever resource is more contaminated. This will provide the upper bound of risk. Then, several mixes of the various sources would provide a more central tendency of risks (e.g., 50:50 GW and SW for 365 days/year, plus swimming during 126 days/year).

Table 4.5 – SW sweat lodge

- Infants (0-24 months) have no sweat lodge use (OK).
  See note above about frequency.

Table 4.6 Arrowhead – medical salve (in addition to ingestion in Table 4-1)

- Includes dermal while digging, 12 d/yr x 64 yrs (adult) or 6 yrs (child).
  This is OK, but the same exposure is received when gathering for food use.

Table 4.7 – discharge

- Dermal exposure 1 hr/event (washing) x 10 events/yr. – adult and child. The exposure frequency should be the same as for the other water bodies, even if the drainage is intermittent.
- The RME should use the maximum concentration from whatever resource is more contaminated. Thus, this is a question of exposure point concentration, not exposure frequency

References Cited

Harper, Barbara, AESE, Inc. 2008. *Quapaw Traditional Lifeways Scenario*. Quapaw, Oklahoma.

Kirschner, F.E., AESE, Inc. 2008. *Site Characterization Report: Sediments, Surface Water, and Vegetation of Tar Creek, Lytle Creek, and Beaver Creek, Oklahoma.*

Attachment No 1. November 22, 2005 Memo to EPA entitled: Expedited Review of Draft Final RAO's (FK_AESE_PRG_RAO_Comments.pdf)

Quapaw Tribe of Oklahoma

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

November 22, 2005

Ursula Lennox
Remedial Project Manager
U. S. EPA (6SF-LP)
14445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Lennox:

Please find enclosed, the Quapaw Tribe's comments regarding the Preliminary Remedial Goals (PRGs) and the Remedial Action Objectives (RAOs) currently being developed for OU4 at the Tar Creek site. These comments are a result of what was presented in the November 17-18 meetings held in Tulsa, Oklahoma regarding the RI/S for OU4. These enclosed comments were prepared by the Tribe's consultant, Dr. Fred Kirschner in consultation with me and the Tribal leadership. Establishment of the PRGs and RAOs are critical to the development of the Proposed (remediation) Plan. The Tribe believes that addressing the Tribe's concerns now will be much more productive than proceeding with the development of the Proposed Plan and attempting to address the Tribe's concerns after it has been released to the public.

Please read over the enclosed comments and let me know how you would like to proceed in working together to address them. Moreover, if you have any questions regarding these comments, or if you would like to discuss them, please don't hesitate to call.

Sincerely,

Tim Kent, PG
Environmental Director
Quapaw Tribe of Oklahoma

cc: Honorable John Berrey
Mr. Steve Ward, Esq
Dr. Fred Kirschner

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-924-0184
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Environmental Division Director,
Quapaw Tribe of Oklahoma (O-Gah-Pah)

FEK

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: November 22, 2005

SUBJECT: Expedited Review of Draft Final RAO's

CC: Chairman John Berrey
File

During the November 17-18 meeting in Tulsa, Ursula Lennox, the RPM for the Tar Creek Superfund Site, described how the RI/FS process was following a "deviated approach". This deviation from the typical EPA guidance and procedures enumerated in the National Contingency Plan, surrounds how EPA will incorporate comments and suggestions in the RI/FS process. Due to the compressed time-frame depicted in the "Super Sonic Schedule" (Attachment 1), EPA or the Respondents will not be able to address comments from governmental entities until comments have been received after the Proposed Plan has been published. In essence, the governmental entities, including the Tribe, have been relegated to the status of the "Public".

As you know, we raised concern to the EPA that the Tribe would be unable to provide "meaningful comment" or "comment that could change the outcome of the preferred alternative". The Respondents replied that *if you want to make meaningful comments on the FS, then we need the comments very soon* (paraphrasing).

In response to this statement, this memo identifies major fatal flaws regarding the Draft Final RAO's. Many of which do not meet the requirements specified at 40 CFR 430(e). We believe it is important to express these comments/concerns (again) to EPA and the Respondents very early because the RAO's define the design goals of the Remedial Alternatives—much of which have been already drafted, without the benefit of meaningful comment.

As pointed-out in AESE's October 29,2004 set of comments on the RIFS workplan, the RI/FS process is a "house of cards" with each "floor" relying on the foundation and structural integrity of the previous "floors". The Remedial Action Alternatives rely on the RAOs/PRGs. As pointed-out below, the PRGs/RAOs for this site will ultimately depend on the outcome of the human health risk assessment. General comments on the Human Health Risk Assessment will follow shortly. The Tribe will also prepare comments on the draft Remedial Action Alternatives. These comments will include a new alternative that has not been evaluated at this point.

Again, in preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Preferred Plan.

General Comments

1. Future Land Use (FLU) for the Site was not seriously contemplated prior to development of the PRGs/RAOs as well as the draft Remedial Action Alternatives.

   Webster defines "alternative" as

   > *"an opportunity for deciding between two or more **courses or propositions** to be chosen".*

   The presumption underlying this definition is that the courses or propositions ultimately "take one to the same place", much like an "alternate route". In the context of CERCLA, the "place" being strived to attain, is achieving a remedy that is protective of Human Health and the Environment for the reasonably foreseeable future land use (FLU).

   Although not specifically enumerated in the NCP, it is presumed that each "Alternative" meets the ultimate goal of protection of Human Health and the Environment ***for the intended future land use***. It would be ludicrous to expect to design anything without an end-state in mind. Like building a house, at a minimum, the client must first specify the number of bedrooms (equivalent to specifying future use). The number of bedrooms dictates his/her septic system needs and other technical specifications so the house functions properly when it is completed and allows the client to use the house as it was intended.

   This concern was brought to the attention of EPA and the Respondents very early in the process. Specifically, within comments provided in the September 30, 2004 memo to EPA (Attachment No. 2) as well as in the August 7, 2004 memo from AESE to QTO. These have been excerpted (once again):

   > "1. The need for a more comprehensive risk assessment was not realized, until recently, when the Tribe secured the services of a technical contractor that specializes in quantifying risk to Native American populations. This increased need and subsequent increase in the Scope of the human health risk assessment (above and beyond that described by the AOC and SOW) stems from the Tribe's traditionally heavy reliance and use of natural resources associated with the site.
   >
   > General Comment No. 2 of the 49 page, August 7, 2004 memo from our technical consultant that was forwarded on to you entitled "Review of ***DRAFT Data Gap Analysis Report Tar Creek OU4 RI/FS Program Prepared for the Tar Creek Respondents and the U.S. Environmental Protection Agency by AATA International, Inc.,***

June 2004" identifies the cleanup goal or post remediation land use (PRLU) for your risk managers.

> ***"2. The reservation is intended to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. The current demography is highly influenced by contamination and subsequent advisories and institutional controls designed to mitigate for current conditions. Therefore, current demographic conditions should not be considered as post-remediation land use (PRLU) in any of the risk assessments."***

Again, this statement provides the goal for the cleanup—a goal very different from that used at the Cherokee and Jasper County sites." [Emphasis added.]

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land must be cleaned up for Unrestricted Land Use. This concept of identifying the FLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to balkanize and compartmentalize a given problem, it is very important that EPA and the Designer of the Remedial Action Alternatives to realize that capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.

This FLU goal does not only apply to lands held in trust by the federal government. The Tribal government is currently repatriating lands within the reservation boundary with the ultimate goal of re-acquiring all non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect Tribal members for unrestricted uses (including but not limited to historical traditional cultural practices) these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

2. The Draft RAOs are not protective of the Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. As stated during the meeting November 17-18, 2005 meetings held in Tulsa:

> "In general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. It is our experience working with tribes throughout the US, that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of contamination. In essence, Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. As a result, our experience at other sites indicates that cleanups will be driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an ARAR.

General Comment 6 of the 49 page August 7, 2004 AESE memo to QTO (Attachment No. 2) identified this issue for EPA risk managers as well.

> *"6. For this site, which involves several Native American Tribes, typical PRG's/RAOs/ARARs will not be protective. Therefore, any sample designs based on the attainability of PRG's/RAOs/ARARs that are designed to protect the general population will not be applicable here (i.e. any study that uses these "standards", designed for the general population, to falsely and incorrectly screen-out COCs, media, pathways, or exposure areas) and will only complicate matters later on in the process when the BHHRA has been completed and it is "discovered" that ARARs, PRGs, and PRAOs are not protective of the Tribes."*

Stated another way, if EPA proceeds to clean-up the site using these PRG's/RAOs/ARARs as design criteria, they will be cleaning-up the site for a population that does not live there today and will probably not live there in the future.

3. The PRGs/RAOs do not consider the exposure that ecological or human receptors receive from the Surface water pathway as well as riparian resources. This is a major error and omission on the part of both the ecological and the Human Health Risk Assessments (this will be discussed in greater detail in comments on those reports).

The residual exposure to humans from drinking surface water and using surface water in sweatlodge ceremonies alone exceed allowable risk. This risk is real and cannot be assumed away or managed via institutional controls such as signage or education—people are using these resources today. This means that that the allowable risk to Tribal members who use resources for traditional cultural practices will be exceeded even if the uplands are returned to background conditions.

The concept of an Operable Unit was developed to partition remedial actions into workable or manageable units—not to balkanize risk assessments. The NCP requires protection of human health and the environment for the reasonably foreseeable land use of the *site*—not of an *OU*. In summary, as long as the residual risk from OU1 is measurable, the allowable risk from other OUs must be reduced by an amount so that the cumulative site-wide risk does not exceed the threshold criteria. In this instance, the risk allocated for all other OUs has been usurped by OU1. Therefore, the PRG for all media (e.g. surface water, ground water, soils, floodplain sediments, and air) must be pre-release baseline (background).

Attachment No. 1: Super Sonic Schedule, Nov 15, 2005.

Attachment No. 1: Super Sonic Schedule, Nov 15, 2005.

Tar Creek OU4 Schedule
November 15, 2005

Critical Path Activities	Super Sonic Schedule
Site Characterization	September 29, 2005
Risk Assessments, risk decisions & RAOs	October 30, 2005
Meeting with partners	November 17-18, 2005
Draft Proposed Plan to partners	December 2005
Remedy Review Board – Dallas, TX	January 18,2006
Release Proposed Plan for public review	January 2006
Public meeting	February 2006
Response to comments	April 2006
Issue ROD	May 2006
Start Remedial Design	October 2006
Complete Remedial Action	December 2020

FS = Sametime as PP

Attachment No. 2: August 7, 2004 memo from AESE to QTO.

Attachment No. 2 November 9, 2004 Memo to EPA entitled:

*Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site (*D3R3_FK_HHRA_DataNeeds_Memo.pdf)

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
702-458-2025
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Director QTI-RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: November 9, 2004

SUBJECT: Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site

CC: Chairman Berrey

Please find attached: (1) a Draft Conceptual Site Model (CSM) depicting pathways, media, transport-specific COC pathways, and human receptors (HHRA-CSM) and (2) a Draft tabulation of proposed sampling needs associated with performing the Human Health Risk Assessment. A brief discussion of each file follows.

Please note that this package is quite similar to the package prepared by AESE on September 20, 2004 except for two general areas: (1) a sheet including Tribal Exposure areas has been included and (2) the data needs summary has been recalculated to reflect a composite-source exposure area and a composite transition zone exposure area. Recall that the earlier draft assumed that five separate Exposure Areas (EAs) would require characterization:

(1) Chat Pile Source Area;
(2) Chat Pile Transition Zone;
(3) Tailings Pond Source Area;
(4) Tailings Pond Transition Zone; and
(5) Riparian/Wetland/Surface water area that is common to both source terms.

In order to reduce sample costs, this draft has commingled the Source Terms and the Transition Zones resulting in only three EAs:

(1) Combined Chat Pile/Tailings Pond Source Area;
(2) Combined Chat Pile/Tailings Pond Transition Zone;
(3) Riparian/Wetland/Surface water area that is common to both source terms.

The result is briefly described in the following Tables and Attachments. Note that this alternative approach was developed to reduce sampling and analytical costs; however, it does so at the expense of specificity. This change from previous submittals will affect the previously designed false positive/false negative error rate and will shift that rate by increasing the probability of incurring false positives—a shift that is detrimental to the Tribe because more areas will be falsely identified as currently causing a significant risk to the Tribe.

Table 1. Non-stationary media.

Phase 1: Temporal Sampling				
Reference Locations	20			
SW/Sed Monitoring Nodes	**20**			
SW Sampling Annual Frequency	12			
Sed Sampling Annual Frequency	4			
Exposure Area (EA)				
20 SW Loc and 20 Reference Areas			**Sample/year "n" [1]**	
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
Surface Water	Total/Acidify in field	12	12	12
	Field Filtered .45 um	12	12	12
	Total/Year/Location	**24**	**24**	**24**
	Total/Year	**960**	**960**	**960**
Sediment	<62 um	4	4	4
	<250 um	4	4	4
	Total/Year/Location	**8**	**8**	**8**
	Total/Year	**320**	**320**	**320**

Table 2. Stationary Media and Flora

Phase 1: "Stationary media": One time Sampling event				
No. Exposure Areas		2 TP/CP, TP/CP-TZ, Aquatic		
Ref EA		1		
Total		3		
			Sample "n" [1]	
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
Ground Water [2]	Total/Acidify in field	60	60	60
	Total	**60**	**60**	**60**
Air [2]	Cannister	60	60	60
	Total	**60**	**60**	**60**
Soils	<62 um	60	60	60
	<250 um	60	60	60
	Total	**120**	**120**	**120**
Terrestrial Plant (3 plants: **2EAs**: Roots: Leaves: Washed: Unwashed)				
	Total	**480**	**480**	**480**
Terrestrial Plant (3 plants: **REF Area**: Roots: Leaves: Washed: Unwashed)				
	Total	**240**	**240**	**240**
Riparian Plant (3 plants: **1 EA:** Roots: Leaves: Washed: Unwashed)				
	Total	**240**	**240**	**240**
Riparian Plant (3 plants: **1 Ref. Area**: Roots: Leaves: Washed: Unwashed)				
	Total	**240**	**240**	**240**
	Total Plants	**1200**	**1200**	**1200**

HHRA-Conceptual Site Model (CSM: Attachment No. 1)

This Attachment contains four separate sheets and was sent to most of the group with the following discussion:

> *Attached is a fairly intricate CSM being used for the Washoe Tribe at the Leviathan Mine Superfund site* ***[that has been tailored to reflect differences at the Tar Creek Superfund site]****. Note that currently all of the pathways are considered "complete". We may be able to "deactivate" some of these pathways in an attempt to collapse the CSM into something a little more manageable. However, I agree with the approach Mark described today of starting with a robust CSM and if we do not have the data to calculate risk from that pathway, medium, or COC, then at least it still gets "addressed" in the uncertainties section of the BHHRA/BERA.*

Please look this over. We can discuss this sometime next week if you have questions.

I plan on using the CSM as a visual accounting tool to determine the gross data needs. I will probably color code the CSM to indicate which pathway and transfer to secondary media will be modeled, and which media should be measured.

I'll begin working on the "list" of data needs sometime early next week. Call if you have questions.

PS: I did a little research on sieve size as well. One TRW guidance suggests a <250 um OR less. This may give us a little flexibility in the event that the ERA may require <63 um or some other PSD cutoff. I have a call into Art Johnson of the USGS, an international expert on sediments.

The only real change from the previous draft is that we have identified primary and secondary media that should be sampled. These values are portrayed on each of the four sheets in "red font".

Data Needs Tables (Attachment No. 2)

This attachment contains five different spreadsheets. The "Tribal Exposure Areas" was generated using the HHRA-CSM (attachment No. 1) as a visual accounting tool.

One premise basic to development of these tables is that there are essentially three exposure areas (EA's) and an appropriate reference area (RA) required to determine pre-mining baseline conditions (4 areas total). These areas are:

- Combined Jig Tailings Piles/ Flotation Tailings Ponds EA (COC Source Area);
- Transition Zone EA for the combined Jig Tailings Piles/ Flotation Tailings Ponds;
- Riparian Area EA; and
- Reference Areas RA

Each sheet is described below:

1. Tribal Exposure Areas. This sheet summarizes the generalized types of exposures likely to occur to Tribal Members and the General Public within each Tribally owned EA;

2. Sampling Requirement Summary: This sheet summarizes all needs for all EA's and the Reference Areas.

3. SW_Sediment_Riparian_Veg: This area represents the Riparian Zone. Due to the spatial and temporal variability of surface water and sediments, these two media are sampled periodically at 20 locations. Total and dissolved surface water is sampled at a frequency of once per month (12/year). Sediments sieved at two different cut-offs are sampled quarterly (4/year), contemporaneously, and collocated with surface water sediments.

   COCs within the vegetative tissue and within rooting soils and fugitive dust located on leaves is probably much less temporally variable than the surface water of sediments; therefore, a synoptic survey is employed for these secondary media. Both washed and unwashed roots and leaves are sampled for three plant types used by the Tribe at 20 locations that are collocated with the other media. This design should allow for determination of plant tissue-specific transfer coefficients between sediment/surface water and the specific plant part used by the Tribe. Washed and unwashed samples are required to determine the concentration of COCs on plant leaves ingested by the Tribe as well as on plant roots ingested by the Tribe.

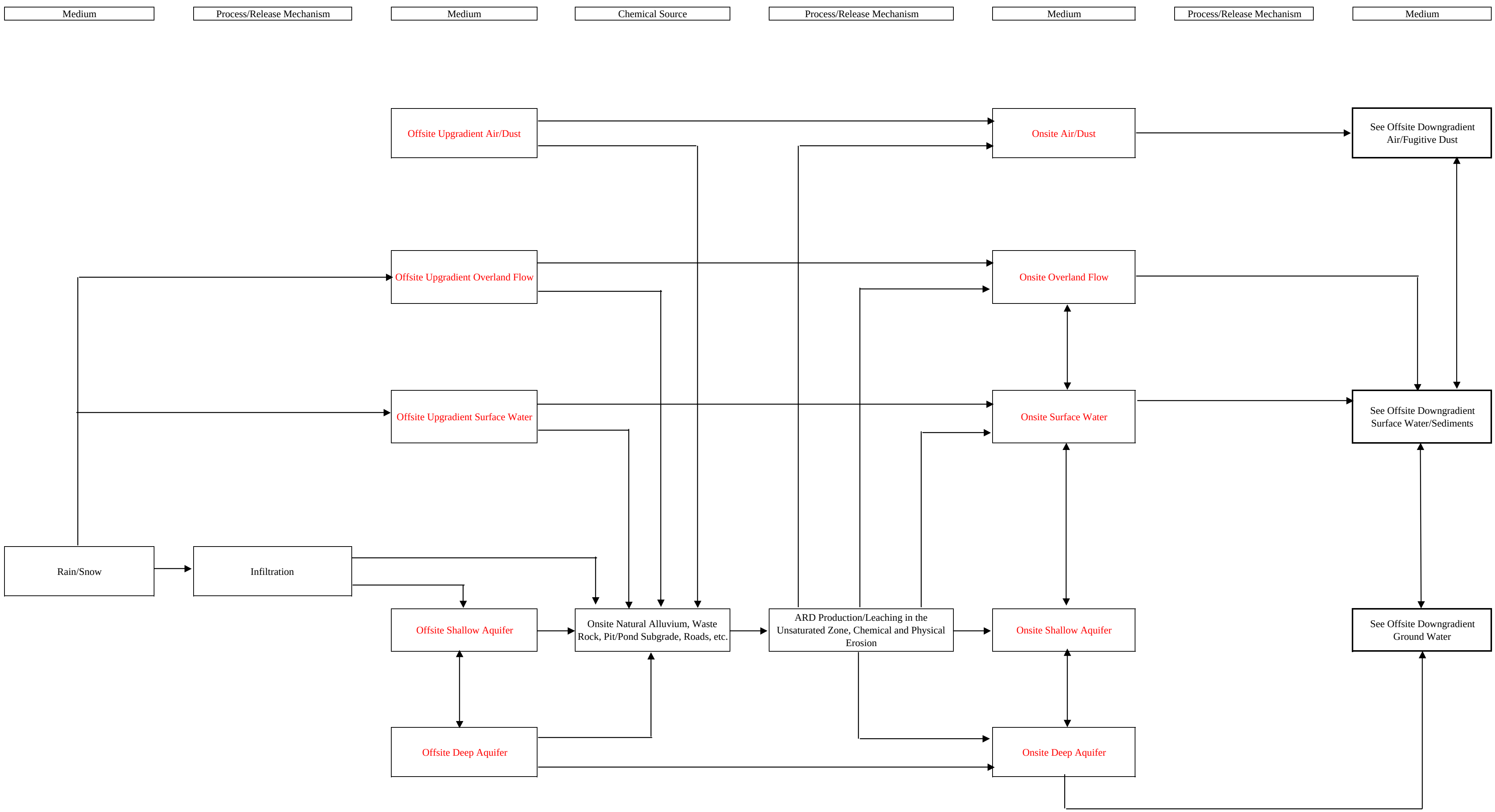
4. Tables 1A through Table 1C are the proposed analytical methods along with the proposed method detection limits. Note that isotopic uranium was included in this phase. Should results of this phase indicate that isotopic uranium is not a COC, this analyte will be dropped from the list of COCs.

Attachment No. 1

DATE: **November 9, 2004**

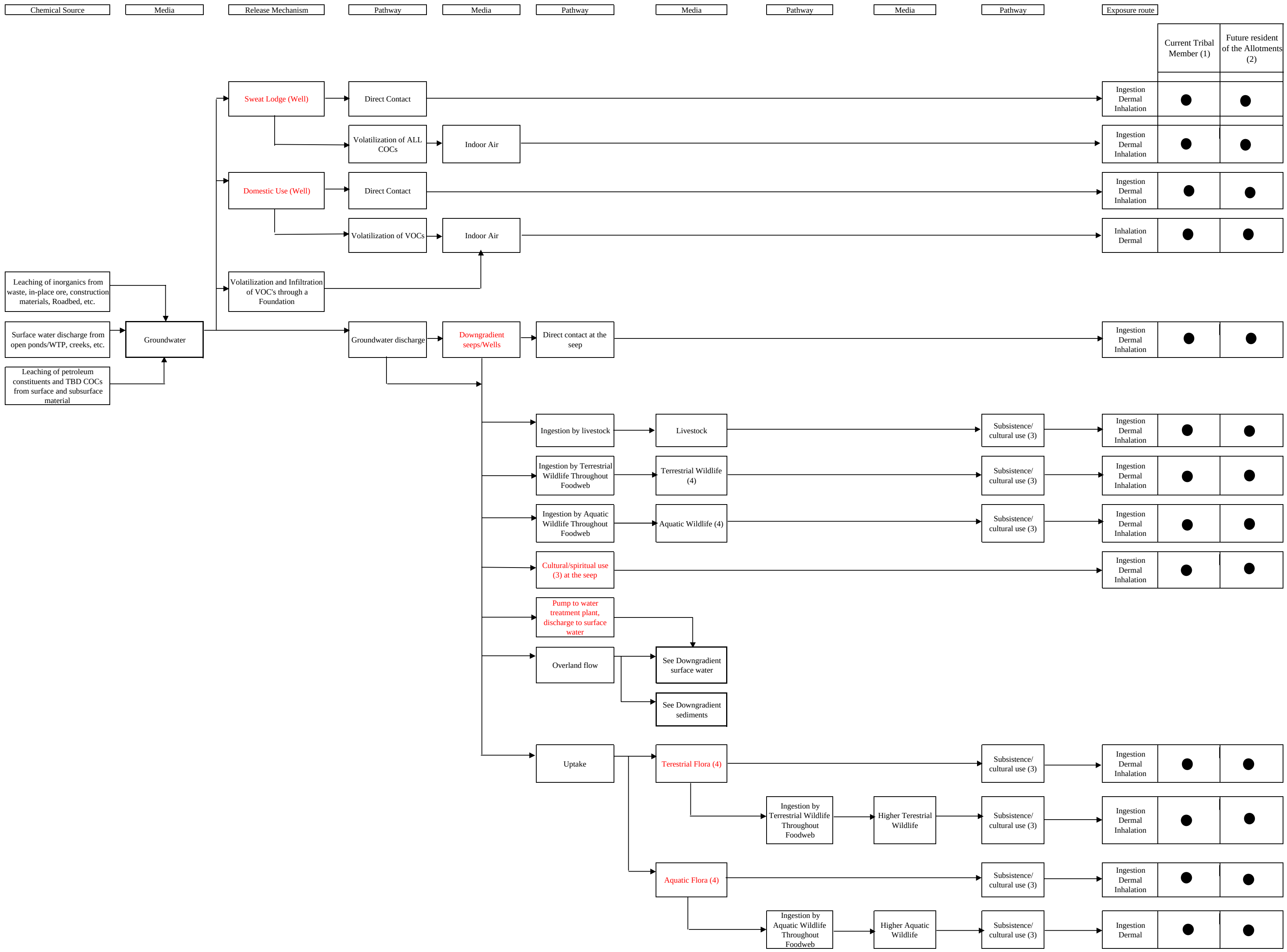
SUBJECT: ***Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site***

Minesite



Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

Downgradient Groundwater



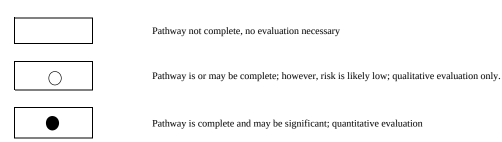
Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine

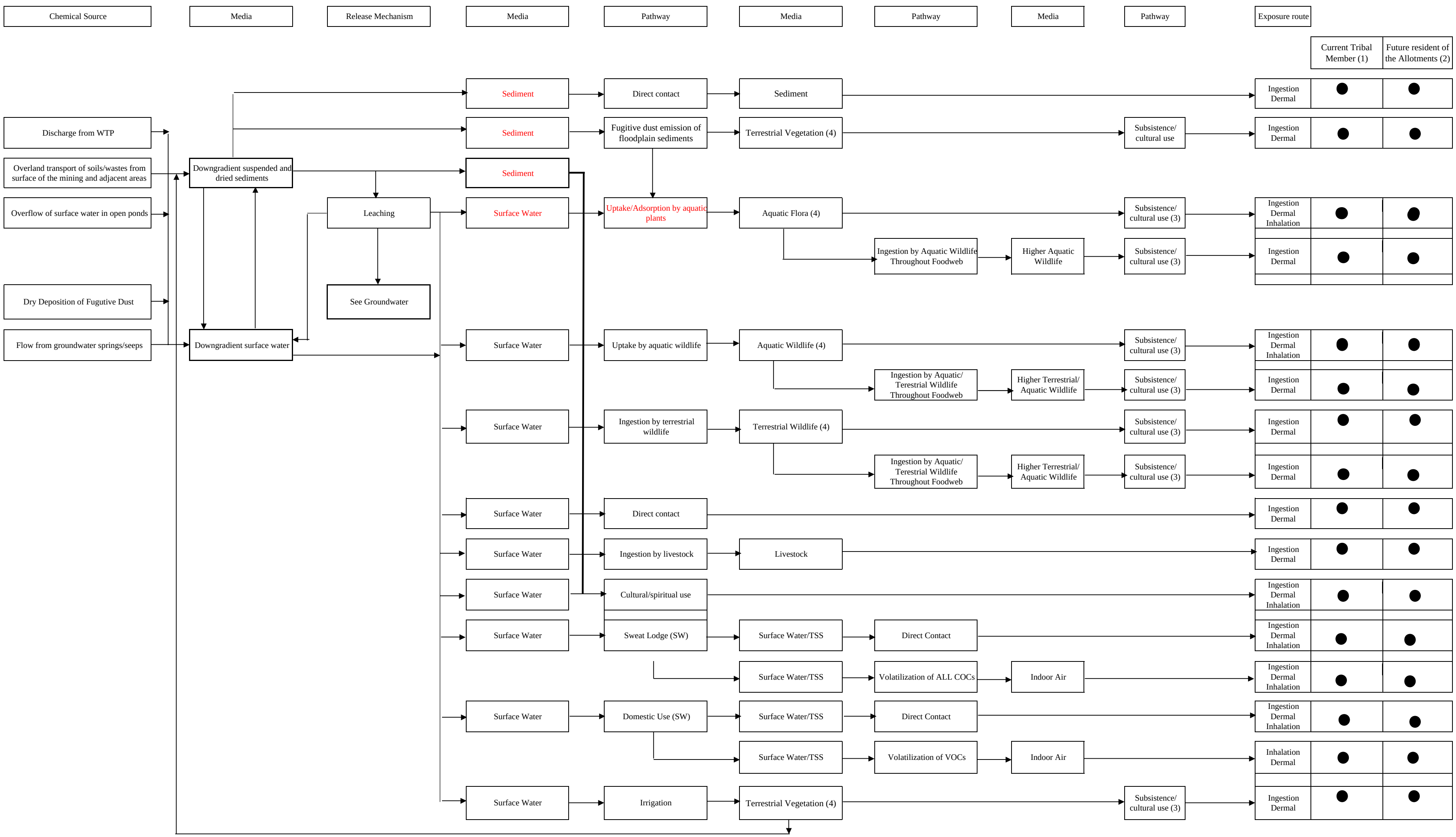
(2) Future resident of the Allotments who lives on areas impacted by the mine

(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.

(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air



Surface Water-Sediments



Pathway not complete, no evaluation necessary

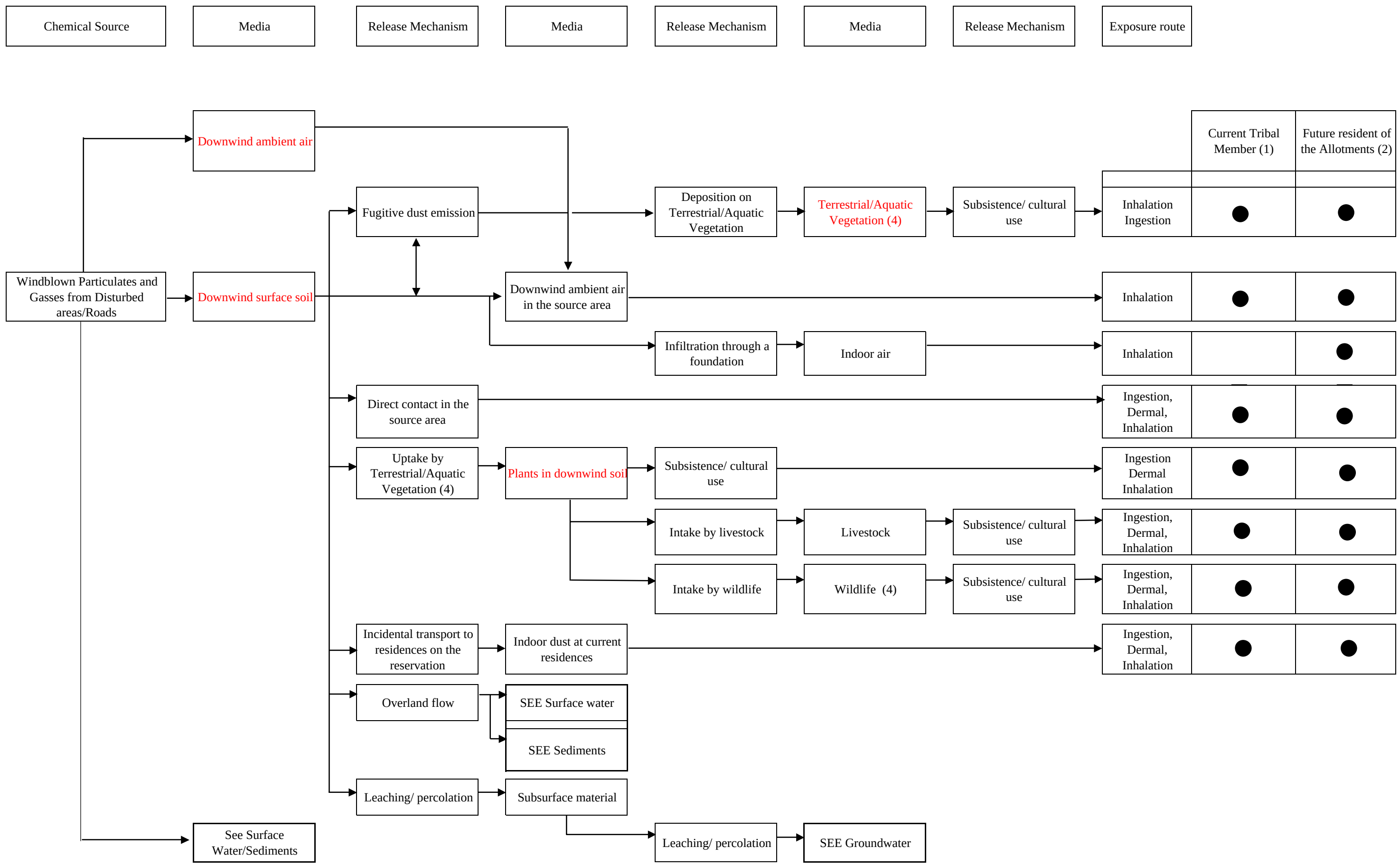
○ Pathway is or may be complete; however, risk is likely low; qualitative evaluation only.

● Pathway is complete and may be significant; quantitative evaluation

Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine
(2) Future resident of the Allotments who lives on areas impacted by the mine
(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.
(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air

AIR



Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine
(2) Future resident of the Allotments who lives on areas impacted by the mine
(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.
(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air

Pathway not complete, no evaluation necessary

○ Pathway is or may be complete; however, risk is likely low; qualitative evaluation only.

● Pathway is complete and may be significant; quantitative evaluation

Attachment No. 2

DATE: **November 9, 2004**

SUBJECT: ***Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site***

Tribal Exposure Areas on Tribal lands

General Activity	Source Areas: Chat Piles/Bases/Flotation Tailings Ponds	Transition Zones	Wetlands/Streams [2]
Relative Potential for Tribal Residential Use	High	High	High
Relative Potential for Tribal Subsistence Fishing Use	NA	NA	High
Relative Potential for Tribal Gathering Use (Aquatic)	NA	NA	High
Relative Potential for Tribal Gathering Use (Terrestrial)	High	High	NA
Relative Potential for Tribal Hunting Use	High	High	High
Relative Potential for Tribal Recreational Use	High	High	High
General Population Exposure on Tribal lands [1]			
Relative Potential for General Public Sportfishing Use	NA	NA	Moderate-Low
Relative Potential for General Public Bathing Use	NA	NA	Moderate-Low

NA = Not Applicable

[1] If members of the General Public (GP) reside on Tribal Lands, the residential recreational doses for the GP must also be determined.

[2] although this EA is not officially part of OU4, the dose from these areas must be considered in the Risk Assessment. If the Dose allocation from this EA equals or exceeds Risk Criteria defined by the NCP, then all other EAs must be cleaned-up to pre-release background conditions.

Phase 1: Temporal Sampling				
Reference Locations		20		
SW/Sed Monitoring Nodes		**20**		
SW Sampling Annual Frequenc		12		
Sed Sampling Annual Frequen		4		
Exposure Area (EA)				
20 SW Loc and 20 Reference Areas		**Sample/year "n" [1]**		
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
Surface Water	Total/Acidify in field	12	12	12
	Field Filtered .45 um	12	12	12
	Total/Year/Location	**24**	**24**	**24**
	Total/Year	**960**	**960**	**960**
Sediment	<62 um	4	4	4
	<250 um	4	4	4
	Total/Year/Location	**8**	**8**	**8**
	Total/Year	**320**	**320**	**320**

Phase 1: "Stationary media": One time Sampling event					
No. Exposure Areas		2 TP/CP, TP/CP-TZ, Aquatic			
Ref EA		1			
Total		3			
		Sample "n" [1]			
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**	
Ground Water [2]	Total/Acidify in field	60	60	60	
	Total	**60**	**60**	**60**	
Air [2]	Cannister	60	60	60	
	Total	**60**	**60**	**60**	
Soils	<62 um	60	60	60	
	<250 um	60	60	60	
	Total	**120**	**120**	**120**	
Terrestrial Plant 1: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
	Roots uwashed, pulverized	40	40	40	
	Roots washed, pulverized	40	40	40	
	Leaves uwashed, pulverized	40	40	40	
	Leaves washed, pulverized	40	40	40	
Terrestrial Plant 2: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
	Roots uwashed, pulverized	40	40	40	
	Roots washed, pulverized	40	40	40	
	Leaves uwashed, pulverized	40	40	40	
	Leaves washed, pulverized	40	40	40	
Terrestrial Plant 3: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
	Roots uwashed, pulverized	40	40	40	
	Roots washed, pulverized	40	40	40	
	Leaves uwashed, pulverized	40	40	40	
	Leaves washed, pulverized	40	40	40	
	Total	**480**	**480**	**480**	

Terrestrial Plant 1 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Terrestrial Plant 2 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Terrestrial Plant 3 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
Riparian Plant 1: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 2: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 3: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
Riparian Plant 1 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 2 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	

Riparian Plant 3 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
Total		**1440**	**1440**	**1440**	

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely that more samples will be required to meet statistical design goals. Number of specimens (n) assumes intial CV of 0.20, a = .05; b =.90

[2] Like SW and sediments, these media also should be sampled at an appropriate frequency and duration. However, for the puposes of this phase a synoptic survey approach is utilized

[3] The goal is to determine the relationship (e.g. transfer coefficient) between media (soil/sed/surface water) and the plant tissue. Samples from the sources (Tailings Ponds and Chat Piles), the two Transitions Zones (TZs), and Baseline Reference Areas will be used to generate these relationships.

[4] It is assumed that all three terrestrial/aquatic plant species are collocated with the SW/SED/Soil sample

Reference Locations	20
SW/Sed Monitoring Nodes	**20**
SW Sampling Annual Frequency	12
Sed Sampling Annual Frequency	4

Exposure Area (EA)	Medium	Preparation	Sample/year "n" [1] TAL-Metals	Radionuclides	Anions
SW Loc 1	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<63 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**

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Exposure Area (EA)	Medium	Preparation	Sample/year "n" [1] TAL-Metals	Radionuclides	Anions
SW Loc 20	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<63 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/yr	**32**	**32**	**32**
		Total Analyses/yr	**640**	**640**	**640**

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely that more samples will be required to meet statistical design goals.

Exposure Area (EA)	Medium	Preparation	Sample/year "n" [1] TAL-Metals	Radionuclides	Anions
SW REF Loc 1	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<62 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**

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Exposure Area (EA)	Medium	Preparation	Sample/year "n" [1] TAL-Metals	Radionuclides	Anions
SW REF 20	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<62 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**
		Total Analyses/yr	**640**	**640**	**640**
		Grand Total/yr	**1280**	**1280**	**1280**

Exposure Area (EA)	Medium		Preparation	Sample "n" [1] TAL-Metals	Radionuclides	Anions	
	Riparian Plant 1						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
	Riparian Plant 2						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
	Riparian Plant 3						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
			Total	**240**	**240**	**240**	

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using
an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely
that more samples will be required to meet statistical design goals.

Analyte	Reporting Limit Requirement [1]	Proposed Analysis Method*	Laboratory MDL
Radionuclides	**pCi/L**		**pCi/L**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom Alpha Spec	0.2
Cations	**mg/L**		**mg/L**
Aluminum	0.03	EPA 200.7, ICP	0.03
Antimony	0.00005	EPA 200.8, ICP-MS	0.00005
Arsenic	0.005	EPA 200.8, ICP-MS	0.005
Barium	0.003	EPA 200.7, ICP	0.003
Beryllium	0.002	EPA 200.7, ICP	0.002
Cadmium	0.3	EPA 200.8, ICP-MS	0.3
Calcium	0.2	EPA 200.7, ICP	0.2
Chromium	0.01	EPA 200.7, ICP	0.01
Cobalt	0.01	EPA 200.7, ICP	0.01
Copper	0.01	EPA 200.7, ICP	0.01
Iron	0.01	EPA 200.7, ICP	0.01
Lead	0.0001	EPA 200.8, ICP-MS	0.0001
Magnesium	0.2	EPA 200.7, ICP	0.2
Manganese	0.005	EPA 200.7, ICP	0.005
Mercury	0.0002	EPA 245.1, CVAA	0.0002
Molybdenum	0.01	EPA 200.7, ICP	0.01
Nickel	0.0	EPA 200.7, ICP	0.0
Potassium	0.3	EPA 200.7, ICP	0.3
Selenium	0.001	SM 3500, Se Hydride AA	0.001
Silica	0.2	EPA 200.7, ICP	0.2
Silver	0.005	EPA 200.7, ICP	0.005
Sodium	0.3	EPA 200.7, ICP	0.3
Thallium	0.2	EPA 200.8, ICP-MS	0.2
Uranium	0.00005	EPA 200.7, ICP	0.00005
Vanadium	1.0	EPA 200.8, ICP-MS	1.0
Zinc	1.0	EPA 200.7, ICP	1.0
Anions	**mg/L**		**mg/L**
Sulfate	0.3	EPA 300.0	0.3
Chloride	0.2	EPA 300.0	0.2
Other			
TDS		EPA 160.1	
Hardness		SM 2340 B Calc	
Alkalinity	10	SM 2320B	10
Ammonia			
TDS			
TSS			
TOC			

Analyte	Reporting Limit Requirement	Proposed Analysis Method*	Laboratory MDL
Sample Prep			
Sieve (-63 um)	NA	ASA9-15.4.2.2	NA
Digestion	NA	3050b	NA
Radionuclides	**pCi/g**		**pCi/g**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom ACW 3	0.2
Cations	**mg/kg**		**mg/kg**
Aluminum	3	EPA 6010, ICP	3
Antimony	0.05	EPA 6020, ICP-MS	0.05
Arsenic	0.5	EPA 6020, ICP-MS	0.5
Barium	0.3	EPA 6010, ICP	0.3
Beryllium	0.2	EPA 6010, ICP	0.2
Cadmium	0.01	EPA 6020, ICP-MS	0.01
Calcium	1	EPA 6010, ICP	1
Chromium	1	EPA 6010, ICP	1
Cobolt	1	EPA 6010, ICP	1
Copper	1	EPA 6010, ICP	1
Iron	1	EPA 6010, ICP	1
Lead	0.01	EPA 6020, ICP-MS	0.01
Magnesium	20	EPA 6010, ICP	20
Manganese	0.5	EPA 6010, ICP	0.5
Mercury	0.02	EPA 7470, CVAA	0.02
Molybdenum	1	EPA 6010, ICP	1
Nickel	1	EPA 6010, ICP	1
Potassium	30	EPA 6010, ICP	30
Selenium	0.1	SM 3500, Se Hydride A	0.1
Silica	20	EPA 6010, ICP	20
Silver	0.5	EPA 6010, ICP	0.5
Sodium	30	EPA 6010, ICP	30
Thallium	0.05	EPA 6020, ICP-MS	0.05
Uranium	0.5	EPA 6010, ICP	0.5
Vanadium	0.05	EPA 6020, ICP-MS	0.05
Zinc	1	EPA 6010, ICP	1

Analyte	Reporting Limit Requirement	Proposed Analysis Method*	Laboratory MDL
Sample Prep			
Tissue Pulverization	NA	ASA9-15.4.2.2	NA
Digestion	NA	3050b	NA
Radionuclides	**pCi/g**		**pCi/g**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom ACW 3	0.2
Cations	**mg/kg**		**mg/kg**
Aluminum	3	EPA 6010, ICP	3
Antimony	0.05	EPA 6020, ICP-MS	0.05
Arsenic	0.5	EPA 6020, ICP-MS	0.5
Barium	0.3	EPA 6010, ICP	0.3
Beryllium	0.2	EPA 6010, ICP	0.2
Cadmium	0.01	EPA 6020, ICP-MS	0.01
Calcium	1	EPA 6010, ICP	1
Chromium	1	EPA 6010, ICP	1
Cobolt	1	EPA 6010, ICP	1
Copper	1	EPA 6010, ICP	1
Iron	1	EPA 6010, ICP	1
Lead	0.01	EPA 6020, ICP-MS	0.01
Magnesium	20	EPA 6010, ICP	20
Manganese	0.5	EPA 6010, ICP	0.5
Mercury	0.02	EPA 7470, CVAA	0.02
Molybdenum	1	EPA 6010, ICP	1
Nickel	1	EPA 6010, ICP	1
Potassium	30	EPA 6010, ICP	30
Selenium	0.1	SM 3500, Se Hydride	0.1
Silica	20	EPA 6010, ICP	20
Silver	0.5	EPA 6010, ICP	0.5
Sodium	30	EPA 6010, ICP	30
Thallium	0.05	EPA 6020, ICP-MS	0.05
Uranium	0.5	EPA 6010, ICP	0.5
Vanadium	0.05	EPA 6020, ICP-MS	0.05
Zinc	1	EPA 6010, ICP	1

Attachment No. 3 Discussion on Nutritional requirements and body-weight

Discussion on Nutritional requirements and body-weight.

A normal healthy person needs 25-30 kcals/kg/d.

70 kg body weight: 1750 - 2100 kcal/d. Or 2000 kcal for simplicity.

80 kg body weight: 2000 - 2400 kcal/d. Or 2285 kcal/d for simplicity.

Therefore, the 80 kg person needs 2285 calories, whereas the 70 kg person needs 2000 kcal. (http://www.o-wm.com/content/calculating-your-patients%E2%80%99-caloric-needs).

Examples of change in Average caloric intake (generally reflects 2014 intakes and various interpretations):

a. The average American consumes more than 3,600 calories daily – a 24% increase from 1961, when the average was just 2,880 calories. http://www.businessinsider.com/american-calorie-intake-last-52-years-diet-food-eating-increase-science-2017-6

b. By 2010, Americans consumed 20 percent more calories compared to 1970. The average American adult woman needs between 1,800 and 2,400 calories per day, while the average American adult man needs between 2,400 and 3,000, according to the U.S. Department of Agriculture's 2010 Dietary Guidelines, but Americans may be consuming 2,231 to 3,300 calories per day (based on self-reporting and a correction for known under-reporting). https://www.livestrong.com/article/272696-healthy-juice-mixes/

c. Calorie intake data released by The Food and Agriculture Organization shows that Americans eat an average of over 3,600 calories a day, according to the report. This is well above the U.S. Department of Agriculture recommendations. http://healthyeating.sfgate.com/average-calorie-intake-human-per-day-versus-recommendation-1867.html

Average quantity of daily food eaten

In 2014, Americans ate

- Fruits = 261.4 lbs/yr
- Vegetables. = 383.6 pounds

- Dairy = 614.3 pounds
- Grains = 174.4 pounds
- Protein foods = 226.6 pounds (including 7.1 ounce-equivalent of meat, poultry, fish, shellfish eggs, and nuts per person per day).
- Added sugars and sweeteners = 131 pounds per person
- Added fats and oils = 82.2 pounds per person
- Total average annual pounds = 1873.5 pounds, or 5.13 pounds per day, or 82.1 ounces/day.   Average total food intake is 2327 g/d (at 28.3495 grams/ounce). Because the average weight is 80 kg, this converts to 29 g/kg-d. This is the mean cited in Table 14-1 of the Exposure Factors Handbook (2011).
- ***We recommend that EPA also examines the total caloric intake for the whole diet and compare it to the caloric needs per kg of body weight, rather than simply diluting a 70-kg diet into an 80-kg body.***

Source material:
"What We Eat in America"
https://www.ars.usda.gov/northeast-area/beltsville-md/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wweianhanes-overview/

https://www.ars.usda.gov/northeast-area/beltsville-md/beltsville-human-nutrition-research-center/food-surveys-research-group/

https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/

NHANES https://www.cdc.gov/nchs/nhanes/wweia.htm

Attachment No. 4 Soil Ingestion for Oklahoma

SOIL INGESTION RATE (revised 2017)

Indigenous Soil Ingestion Rate = 330 mg/d (all ages, all scenarios)
Sieved to grain sizes < 63 µm

Applies to the Tribal Homesteader and Traditional Use Scenarios

SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust Indoor and outdoor), swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The soil ingestion rate is based on a review of EPA guidance, soil ingestion studies in suburban, rural, and indigenous settings, pica and geophagia, and dermal adherence studies. It is also based on homesteading (farming, ranching, gardening) and traditional resource use scenarios use with their higher environmental contact rates and local climatic and geologic conditions.

A soil ingestion rate of 400 mg/d for all ages is the upper bound for suburban children (EPA, 1997), and within the range of outdoor activity rates for adults. Farming, ranching, and traditional Native American lifestyles and natural resource use were not considered by the EPA guidance, but could logically be considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. The current EPA recommended rate of 330 mg/d is lower than the previous high-contact rate of 480 mg/d to allow for some low-contact days, but it should not be lower because there are many "1-gram" days and events such as tilling soil, wrangling livestock, gardening, root digging, plant and material gathering, basketmaking and other use of natural materials, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, firewood splitting, hide tanning, and similar activities. Based on professional judgment, we do not believe that data are adequate to distinguish between homesteading and traditional natural resource-based soil contact rates, and therefore use a single rate for both homesteader and traditional practitioner scenarios.

An updated review (2017) is added at the end of this review, with the conclusion that 330 md/d for all ages is now recommended, based on mass-balance studies of Al and Si, but recognizing that there is still a tremendous variance and uncertainty about true soil ingestion rates as reflected by different trace elements. The gastrointestinal absorption or bioavailability of trace elements needs further investigation, whether from food or other sources, and whether in solid, dissolved, or nanoparticle form, since soil ingestion rates are based on the ingestion/ excretion ratios of

various trace elements. It should also be recognized that the older references (Haywood and Smith 1993; La Goy 1987; Haywood 1985) made measurements and assumptions that are still as valid now as when they were made, and high-contact activities such as wilderness sports, ranching, or certain rural settings have never been fully measured.

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle and the farming-ranching lifestyle are lived in closer contact with the environment than a suburban or urban lifestyle from which most of the soil ingestion data are derived.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat. Rural and farm roads are often unpaved.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater. Similar events for farming, ranching, and homesteading are assumed.
- 400 mg/d is the upper bound for suburban children (EPA, 1997); traditional or subsistence activities are not suburban in environs or activities
- This rate is within the range of outdoor activity rates for adults (between 330 and 480). However, the recommended level is lower than 480 to allow for some low-contact days.
- The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999) such as root gathering days, tule-camas-wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
- This rate does not account for pica or geophagy.
- Primary data is supported by dermal adherence data in gatherers and ‘kids in mud’.
- This rate includes a consideration of residual soil on roots through observation and anecdote, but there is no quantitative data.

1. EPA Guidance (through 2009)

EPA has reviewed the studies relevant to suburban populations and has published summaries in its Exposure Factors Handbook (1989, 1991, 1997, and 2011). In the 1997 iteration of the

Exposure Factors Handbook[1], EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion.

In 1997, EPA recommended 100 mg/d as a central tendency for children, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an “upper bound” value (exact percentile not specified), and 10 mg/d for pica children. Most state and federal guidance uses 200 mg/d for children. In 2011, EPA recommended an unspecified upper percentile soil ingestion rate for the general population of children of 200 mg/d for both soil-only and soil plus dust, 1000 mg/d for pica children, and 50,000 mg for geophagy. There are no recommendations for other populations of children. The “general population” refers primarily to the groups of children studied in suburban settings (home, daycare), including several Superfund sites. No studies of indigenous or rural children were used; either they have not been studied, or the ingestion rates were not mass-balance studies.

Other EPA guidance such as the Soil Screening Level Guidance[2] recommends using 200 mg/d for children and 100 mg/d for adults, based on RAGS HHEM, Part B (EPA, 1991) or an age-adjusted rate of 114 mg-y/kg-d. A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as “too speculative.” However, the soil screening guidance still recommends 330 mg/d for a construction or other outdoor worker, and risk assessments for construction workers oftenuse a rate of 480 mg/d (EPA, 1997; Hawley, 1985). Other soil ingestion rates are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event[3] to approximate a non-average day for children, such as an outdoor day. This ingestion rate is now (2011) limited to pica children <6 years of age.

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[1] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.
[2] EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (http://www.epa.gov/superfund/resources/soil/toc.htm#p2), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 (http://www.epa.gov/superfund/resources/soil/ssg_main.pdf),
[3] MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

2. Military Guidance

The US military originally assumed 480 mg per exposure event[4] or per field day. For military risk assessment, the US Army used the Technical Guide 230 (TG) as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.[5] No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental U.S. facilities or during deployment. Department Of Defense (2002)[6] recommendations for certain activities such as construction or landscaping which involve a greater soil contact rate was formerly a soil ingestion rate of 480 mg/day. This value sis based on the assumption that the ingested soil comes from a 50 µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50 mg/d) for a chronic average rate of 265 mg/d.

The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[7].

3. Studies in suburban or urban populations

Written knowledge that humans often ingest soil or clay dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high inadvertent, based on studies of pica children (e.g., Kimbrough, 1984). This triggered a great deal of research with industry (e.g., the Calabrese series) or federal funding (e.g., the DOE-funded studies of fallout and bomb test contamination).

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[4] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[5] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine.
Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[6] Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for Deployed Military Personnel", January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

[7] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.unep.ch/btf/missions/september/dufinal.pdf

Some of the key studies are summarized here. Other agencies (including the EPA[8] and California OEHHA) have reviewed more studies and provide more detail. To quote form OEHHA:

> "There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil."[9]

In general, two approaches to estimating soil ingestion rates have been taken. The first method of involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are associated with large uncertainty due to their somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

3.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. In particular, one study of soil ingestion from "sticky sweets" was estimated at 10 mg to 1 g/d (Day et al, 1975).

Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250 mg/d. For outdoor activities from May through October, Hawley estimated the ingestion amount as 480 mg per active day, assuming that 8 hours is spent outdoors per day, 2 d/week.

Other early tracer studies in American children (Binder, et al., 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in all subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch children. Neither study included the trace minerals from food or medicine. A third study (Van Wijnen et al., 1990) used the same approach, and was the first to include a consideration of camping and the presence or absence of gardens.

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[8] http://www.epa.gov/ncea/pdfs/efh/sect4.pdf.

[9] California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion. http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicates a mean soil ingestion rate of 91 mg/d, and a 90th percentile of 143 mg/d.

Davis et al. (1990), in Calabrese's laboratory, included an evaluation of food, medicine, and house dust as a better approximation of a total mass balance. As with the earlier studies, using titanium as the tracer results in estimates of extremely large soil ingestion rates (titanium is a common additive in food and commercial products), while Al and Si tracers resulted in a much lower and narrower range of soil ingestion rates. Titanium, however, is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). This illustrates the difficulty of using mineral tracers to calculate mass balance and soil ingestion, but trace studies nevertheless provide the most quantitative estimates.

Calabrese et al. (1989) based estimates of soil ingestion rate in children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in the Amherst, Massachusetts. They used a method similar to Binder et al. (1986) but included an improved mass balance approach. They evaluated soil ingestion over eight days rather than three days, and collected duplicate samples of food, medicine, and house dust. In addition, the children used tracer-free toothpaste and ointment. The adult (n = 6) validation portion of the study indicated that study methodology could adequately detect soil ingestion at rates expected by children. Recovery data from the adult study indicated that Al, Si, Y, and Zr had the best recoveries (closest to 100%). Zirconium as a tracer was highly variable and Ti was not reliable in the adult studies. The investigators conclude that Al, Si, and Y are the most reliable tracers for soil ingestion. This was also the first study to evaluate whether pica children were present in the sampled population; one diagnosed pica child was found.

Stanek and Calabrese (1995a) adjusted their 1989 data for the 64 children. The primary adjustment was related to intestinal transit time, which allowed an adjustment for clearance of minerals on days when fecal samples were not collected. They concluded that daily intake based on the "overall" multi-tracer estimates is 45 mg/day or less for 50 percent of the children and 208 mg/day or less for 95 percent of the children. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1 – 2268 mg/d; the median (lognormal) was 75 mg/d, the 90th % was 1190 mg/d, and the 95th% was 1751 mg/d. The known pica child was not included, and individual "outlier" results for individual tracers were also omitted. Even so, the range of rates is so large that it is evident that there are still methodological difficulties.

Stanek and Calabrese (1995a) also evaluated the number of days a child might have excessive soil ingestion events. An estimated 16% of children are predicted to ingest more than 1 gram of soil per day on 35-40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35-40 days per year.

Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study with data from Davis et al. (1990) and using a different methodology. This methodology, the Best Tracer Method (BTM), is designed to overcome inter-tracer inconsistencies in the estimation of soil ingestion rates. The two data sets were combined, with estimates as follows: 50th = 37 mg/d, 90th = 156mg/d, 95th = 217mg/d, 99th = 535mg/d, mean = 104mg/d. Even with this method, they conclude that the large standard deviation indicates that there are still large problems with "input-output misalignment." They also says that soil ingestion cannot even be detected, in comparison to food, unless more than 200 mg/d is ingested, rather than lower rates as they indicated in 1989.

Stanek et al. (2000) conducted a second study of 64 children aged 1-4 at a Superfund site in Montana, using the same methods as they did in their earlier study, with 3 additional tracers. Soil, food and fecal samples were collected for a total mass balance estimate. The home or daycare settings were not described, nor were the community conditions or the typical daily activities of the children, and 32% of the soil ingestion estimates were excluded as outliers. In addition, only soil with a grain size of 250 um or less was used; no explanation of concentration differences between large and small grain sizes were given (see discussion on dermal adherence) and no concentration data were included.

3.2 Studies in Adults

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese and co-authors (1997) conducted a second adult pilot study (n = 10) to compare tracers. This study was done as a method validation, and was "not designed to estimate the amount of soil normally ingested by adults." Each adult was followed for 4 weeks. The median, 75th percentile, and 95th percentile soil ingestion estimates were 1, 49, and 331 mg/day, with estimates calculated as the median of the three trace elements Al, Si, and Y.

4. Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1992) evaluated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. Annual doses to individuals following an aboriginal lifestyle could result in an annual effective dose equivalent of several mSv within contours enclosing areas of several hundred square kilometers. The most significant dose pathways are inhalation of resuspended dust and ingestion of soil by infants based on measurements of dust in air, activity diaries, and modeling. Haywood and Smith constructed a table showing hours per week sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

> "*virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1 gpd was estimated based on fecal samples of nonaboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aboriginals under camp conditions. In the absence of better information, a soil intake of 10 gpd has been assumed in the assessment for all age groups."*

They noted a "very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent. "

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of 500 mg/d. This was based on the primary work of Haywood and Smith who "reported an average soil intake of 10,000 mg/d in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia." The authors state that:

> "*Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of 1,000 mg/d was established from the fecal samples of the investigators who made field trips to the affected areas*."

"*It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported a maximum intake of 500 mg/d for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average for the Marshallese people. Therefore, this work adopts 500 mg/d as the average life-time intake of soil by the Marshallese*."

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5 g/d. These are all geometric means (lognormal) or modes (triangular distribution), not maxima.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that "*the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined*."

5. Geophagia

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the Philippines, New Guinea, Costa Rica, Guatemala, the Amazon and Orinoco basins of South

America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991).

There are two types of edible clays, sodium and calcium montmorillonite[10]. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite, the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid, 1992; Krishnamani and Mahaney, 2000).

Krishnamani and Mahaney (2000) propose several hypotheses that may contribute to the prevalence of geophagy:

(1) soils adsorb toxins.

(2) soil ingestion has an antacid action.

(3) soils act as an antidiarrheal agent.

(4) soils counteract the effects of endoparasites.

(5) geophagy may satiate olfactory senses.

(6) soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette, 1991). This is especially important in pregnancy and at high altitudes.

Several studies of geophagia in pregnancy have been done. In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may

[10] http://www.the-vu.com/edible_clay.htm

be very important as a mineral supplement, particularly iron and calcium during pregnancy (Abrahams, 1997). One widely held theory suggests that iron deficiency is a major cause of geophagia[11]. Several reports have described an extreme form of geophagy (pica) in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of pica or a result of it. Because some substances, such as clay, are believed to block the absorption of iron into the bloodstream, it was thought that low blood levels of iron could be the direct result of pica. Some studies have shown that pica cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces pica (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C.. Serum ferritin concentrations of pica women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their nonpica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less those of nonpica women. Again, low ferritin and hemoglobin are hypothesized to result in pica.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother's secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines. Adjuvants are compounds that nonspecifically amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al is one of Calabrese's preferred tracers due to the assumption that it is not adsorbed and inert at trace levels (it is quite toxic at high levels).

6. Acute Soil Ingestion and Pica

There is a gradient between geophagy and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide

[11] http://www.ehendrick.org/healthy/001609.htm

variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails, paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults, with 10-32% of children aged 1 to 6 may exhibit pica behavior at some point[12]. LaGoy (1987) estimated that a value of 5 gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 5000 mg of soil per day but cautioned that the amount selected was arbitrary[13]. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25-60 g soil during a single day. When a set of 13 chemicals were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

(1) EPA (1997) recommends a value of 10g/d for a pica child.

(2) Florida recommends 10g per event for acute toxicity evaluation[14].

(3) ATSDR uses 5 g/day for a pica child[15].

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[12] http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors

[13] Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: http://www.atsdr.cdc.gov/NEWS/soilpica.html

[14] Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf .

[15] For Example: El Paso Metals Survey, Appendix B, www.atsdr.cdc.gov/HAC/PHA/**elpaso**/epc_toc.html.

(4) EPA (2011) now uses a cutoff of 1000 mg/d as the definition of pica. Note that this skews ingestion rates lower because any child ingesting over 1000 mg/d is assumed to be pica, and therefore can be removed from the 'normal' population.

7. Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Although this body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers from Kissel's laboratory are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings, up to 27 mg/cm^2. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). Since reed gatherers, farmers, and gardeners had higher skin loadings, this is supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) said that variability in estimating soil ingestion rates using tracer elements was reduced when a grain size less than 250 um were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size, with particles above the sand-silt size division (0.075 mm) adhering less than smaller sizes. Average adherences of 1.40 mg/cm^2 for particle sizes less than 150 µm, 0.95 mg/cm^2 for particle sizes less than 250 µm and 0.58 mg/cm^2 for unsieved soils were measured (see EPA, 1992[16] for more details). Soil samples should be sieved and concentrations should be evaluated for sizes below 0.075 mm.

A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and

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[16] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil. Soil loading on various parts of the body is collected with wipes, tape, or rinsing in dilute solvents, which would generally collect the smaller particle sizes[17]. Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size <0.044 cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size.

8. Data from washed or unwashed vegetables.

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is important source of radionuclides to grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

[17] Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2 mm; silt = 1/256 to 1/16 mm; clay = <1/256 mm.

9. Homesteader and Traditional Practitioner rationale for soil ingestion rate

In brief, the homesteader is a residential farming and ranching scenario with a kitchen garden, row crops, and hay production. The homesteader may leave the homestead for short hunting excursions, but the exposure frequency is left at 365 days per year as an upper bound. The traditional practitioner lives in the community but spends his snow-free days at developed or undeveloped camps hunting, fishing, and gathering.

The soil ingestion rate of 330 mg/d is based on the following points:

- It conforms to EPA recommendations for higher soil contact situations.
- Low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999).
- This rate is lower than Simon estimate of 500 mg/d and lower than the recommendations of 3 g/d for indigenous children and 2 g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles.
- This rate includes a consideration of the number of windy-dusty days, but without further quantification of air particulates.

10. Soil and Dust Ingestion Update (2017)

The emphasis of soil ingestion studies is on children, and rightly so. It is generally (but not always) true that setting cleanup levels based on children's exposures will also protect adults. But much less has been published for adults, so risk assessors may at times fail to recognize situations where adults have high exposures, and, lacking data, overlook or underestimate those exposures. A brief update of adult rates for use in risk assessment is given below.

The questions that the risk assessor must answer are: (1) Are there people who may have higher exposures and/or who are more sensitive, and (2) Is there data to describe a Central Tendency Exposure (CTE) and RME for these scenarios? For the **Tribal Homesteader** (residential farming and ranching) scenario and the **Traditional Practitioner** (non-residential hunting, fishing, gathering), which are quite different from the suburban lifestyles used to develop default values, the questions can be restated as, (1) Are the generic default exposure parameters reflective of a mean and 90th or 95th percentile for each of the two scenarios, and (2) Is professional judgment needed to justify a more appropriate set of exposure parameters?

EPA CERCLA baseline risk assessments are required to use exposure scenarios that are selected to reflect both "average" or Central Tendency Exposure (CTE) and Reasonable Maximum

Exposure (RME).[18] The document "Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final" originally dated EPA/540/1-89/002 December 1989 and re-posted in 2015[19] directs project managers to:

> *Review information on the site area to determine if any subpopulations may be at increased risk from chemical exposures due to increased sensitivity, behavior patterns that may result in high exposure, and/or current or past exposures from other sources. Those potentially at higher risk due to behavior patterns include children, who are more likely to contact soil, and persons who may eat large amounts of locally caught fish or locally grown produce (e.g., home-grown vegetables).*
>
> *Recommendations are based on EPA's determination of what would result in an estimate of the RME. As discussed previously, a determination of "reasonable" cannot be based solely on quantitative information, but also requires the use of professional judgment. Accordingly, the recommendations below are based on a combination of quantitative information and professional judgment.*
>
> *Contact rate reflects the amount of contaminated medium contacted per unit time or event. If statistical data are available for a contact rate, use the 95th percentile value for this variable. (In this case and throughout this chapter, the 90th percentile value can be used if the 95th percentile value is not available.) If statistical data are not available, professional judgment should be used to estimate a value which approximates the 95th percentile value. (It is recognized that such estimates will not be precise. They should, however, reflect a reasonable estimate of an upper-bound value.)*

It is not clear what the current default soil ingestion rate should be, since EPA documents are constantly being updated and old documents are re-posted (presumably after review to ensure that they represent the latest policy), and are not always consistent with each other. For the purposes of CERCLA risk assessment, OSWER Directive 9200.1-120 February 6, 2014 ("Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors") uses a soil ingestion rate 100 mg/d for adults. Soil screening levels (OSWER 9355.4-24, 2002) are based on 100 mg/d for residential adults and 330 mg/d for short-term non-residential construction work, with the admonition that a full risk assessment should be more comprehensive.

USEPA's 2011 revision of the Exposure Factors Handbook ("EFH 2011") presents default values for national soil ingestion rates. Based primarily on reanalysis of older data plus three

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[18] "Because of the uncertainty associated with any estimate of exposure concentration, the upper confidence limit (i.e., the 95 percent upper confidence limit) on the arithmetic average will be used for this variable. USEPA RAGS-A; https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf, page 6-19.

[19] https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf

studies published after 1997, the current default soil ingestion rate for all adults, whether indoor resident or outdoor worker, appears to be 100 mg/d, with 50 mg/d for the indoor worker (USEPA 2015 (Human Health Evaluation Manual); EPA 1989 (RAGS A)), although EFH 2011 gives the central tendency of soil plus dust ingestion for adults as 50 mg/d based on the Davis and Mirick 2006 study. No upper percentile is given, leaving that to the risk assessors for a particular site. Thus, the questions are (1) is 100 mg/d or another number intended to be a number a 90th or 95th percentile, (2) why are the soil and soil + dust upper percentiles the same for children aged 3 to <6 years of age, and (3) are they even relevant to either tribal scenario if the tribal scenario is not a 'general population' lifestyle?

Table 5-1. Recommended Values for Daily Soil, Dust, and Soil + Dust Ingestion (mg/day)

	Soil[a]		High End		Dust[b]		Soil + Dust	
Age Group	General Population Central Tendency [c]	General Population Upper Percentile [d]	Soil-Pica[e]	Geophagy [f]	General Population Central Tendency [g]	General Population Upper Percentile [h]	General Population Central Tendency [c]	General Population Upper Percentile [h]
6 weeks to <1 year	30				30		60	
1 to <6 years	50		1,000	50,000	60		100[i]	
3 to <6 years		200				100		200
6 to <21 years	50		1,000	50,000	60		100[i]	
Adult	20[j]			50,000	30[j]		50	

a Includes soil and outdoor settled dust.
b Includes indoor settled dust only.
c Davis and Mirick (2006); Hogan et al. (1998); Davis et al. (1990); van Wijnen et al. (1990); Calabrese and Stanek (1995).
d Özkaynak et al. (2011); Stanek and Calabrese (1995b); rounded to one significant figure.
e ATSDR (2001); Stanek et al. (1998); Calabrese et al. (1997b; 1997a; 1991; 1989); Calabrese and Stanek (1993); Barnes (1990); Wong (1988); Vermeer and Frate (1979).
f Vermeer and Frate (1979).
g Hogan et al. (1998).
h Özkaynak et al. (2011); rounded to one significant figure.
i Total soil and dust ingestion rate is 110 mg/day; rounded to one significant figure it is 100 mg/day.
j Estimates of soil and dust were derived from the soil + dust and assuming 45% soil and 55% dust.

USEPA (EFH 2011, chapter 5) discusses soil ingestion rates and uses one study (Davis and Mirick, 2006), supported by other studies (Hogan, Ozkaynak), to support the adult soil ingestion rate. The Davis and Mirick study used a mass balance method that measured quantities of specific elements present in feces, urine, food and medications. Thirty-three adults from a suburban area in southeast Washington during summer and fall months in 1988. This is a hot arid area, sometimes dusty, with summer temperatures sometimes exceeding 100 degrees. No garden vegetables were consumed. For the aluminum and silicon tracers, soil ingestion rates ranged from 23−92 mg/day (mean), 0−23 mg/day (median), and 138−814 mg/day (maximum), with an overall mean value of 52 mg/day for the adults in the study. The large range of maximum values suggests that there are some people even in suburban settings with significantly higher soil contact and ingestion.

The most commonly used soil ingestion values for occupational and outdoor exposures are 330 mg/d and 480 mg/d while the worker is engaged in those activities. Single high-contact events are not included.

Soil Ingestion Rate for Construction Worker - 480 mg/day (USEPA 1996, 2002)
Soil Ingestion Rate for Industrial Worker - 136 mg/day (USACE 1998)
Sediment Ingestion Rate for Sewer Maintenance Worker - 330 mg/day (USACE 1996, 2002)
Soil Ingestion Rate for Utility Worker - 480 mg/day (USEPA 1996, 2002)

EPA (2002) in the Soil Screening Levels Directive 9355.4-24, gives a soil ingestion rate for construction workers as 330 mg/d, and says that the soil ingestion rate was revised from the previous default ingestion rate of 480 mg/d, albeit without any new data. The activities for this receptor typically involve substantial on-site exposures to surface and subsurface soils. The construction worker is assumed to be exposed to contaminants via incidental soil ingestion, dermal absorption, inhalation of volatiles outdoors, and inhalation of fugitive dust. The default value of 330 mg/day (Stanek et al., 1997) replaces the previous default 95th percentile ingestion rate of 480 mg/day (Hawley, 1985). While the Hawley value was based on a theoretical calculation for adults engaged in outdoor physical activity, the revised default ingestion rate is based on the 95th percentile value for adult soil intake rates reported in a soil ingestion mass-balance study that was not in dusty or outdoor settings other than a suburban backyard.

Hawley (1985) used a set of assumptions to estimate total dust exposure (ingestion, inhalation, and dermal) while entering dusty attics (12 hrs/yr) and outdoor work (80 hrs/yr) based on skin adherence and surface area, the ratio of indoor to outdoor dust, and similar factors. These remain reasonable assumptions. Other investigators have studied dermal loading of soil residues in various activities such as children playing in the mud and adults playing rugby, gathering reed, or digging clams (Kissel et al., 1996; Shoaf et al., 2005). The Stanek et al, (1997) study administered measured soil aliquots in gelatin capsules to 10 volunteers and collected food and feces over 7-day intervals spread over several months, for a total of 280 collection days. No information is provided about the activities of the participants while they were collecting all of their fecal output.

The military follows EPA guidance on exposure factors if they are relevant to military situations (US Army, 2010). The National Research Council (2004) reviewed the Army's exposure parameters. In RD-230 (2003) an average soil ingestion was derived by assuming that soldiers have an equal number of high-contact days (at 480 mg/d) and low-contact days (50 mg/d), for an average of 265 mg/d. In RD-230 (2003), the US Army gives the rationale that the EPA recommendation for construction or landscaping was 480 mg/d at that time, and that soldiers' field activities may include digging or crawling on the ground. Following EPA's recommendation of using the high-contact rate for limited exposure frequencies, the Army averaged the two rates. Subsequently, the Army lowered the high-contact rate to 330 mg/d (US Army 2010).

Two recent papers have appeared that evaluate native peoples engaged in some traditional activities using a mass-balance approach consisting of measuring trace elements that are not well-absorbed in the intestinal tract in food and feces, and assuming certain intestinal absorption, and that any increase over expected values comes from other sources such as soil ingestion or possibly other consumer products.

The first study was a pilot study of 7 subjects living in British Columbia was conducted over a 3-week period (Doyle et al., 2012). During most of this time the subjects were conducting fisheries-related activities. Daily activities included clearing deadfall from spawning streams, collecting Sockeye salmon using traditional methods, such as "dip nets" or seine nets along the shore, weighing, bleeding and cleaning each fish, and storing the catch in a mixture of brine and ice. The late afternoon and evening involved scouting of new dip net locations by hiking up the shore of the river or fishing for Sockeye and Chinook salmon with rod and reel, in addition to routine camp activities (e.g., eating and clean-up, collecting and cutting firewood, etc.). All foods (breakfast, lunch, dinner and snacks) were provided. The study did not include ingestion related to "high contact" activities and/or ingestion of soil in traditional foods, and the authors state that soil ingestion studies for potentially higher soil contact activities (e.g., root digging, attending and/or participating in rodeos, plowing, etc.) are warranted. The mean soil ingestion rate estimated in this study using the 4 elemental tracers with the lowest food-to-soil ratios (i.e., Al, Ce, La, Si), was observed to be approximately 75 mg/d, the median soil ingestion rate was 50 mg/d, and the 90th percentile was 211 mg/d. The second paper (Irvine et al., 2014) recalculated the 90th percentile of the first study to 193 mg/d, all with very large standard deviations and vastly different rates for different tracers. It is a point of discussion whether this is an actual "wilderness" setting, as opposed to a rural setting with fisheries activities, and also whether so much water contact resulted in lack of adherence of soil to skin.

The second study was by the same investigators and evaluated 9 subjects over a 13 day period in Cold Lake, Alberta (Irvine et al., 2014). The purpose was to determine if soil ingestion in a community with a 'wilderness' lifestyle is greater than soil ingestion values used in Canadian human health risk assessments. The area has a humid continental climate, with a lower than average rainfall compared to other Canadian cities, and contains many unpaved roads that can contribute to airborne dust particles. An outdoor base camp was established and all participants remained at the base camp for the duration of the study, and engaged in a variety of outdoor wilderness activities during the day (e.g., fishing, hunting, food gathering). All food was provided and prepared for study participants, and the exact amount of food consumed by each participant was pre-weighed. Activities included hunting and setting traps and snares on the reserve, fishing and setting fishing nets, collection of medicinal plants on the reserve and surrounding traditional lands, and collection of foods and spices such as blueberries, bear berries, and mint. Although this study did not detect a statistically significant effect of activities on soil ingestion rate, the authors recommended follow-up studies that include higher soil contact activities (i.e., rodeo participation, root harvesting) and other seasons. This study found a mean (Al, Ce, La, Si) of 32 mg/d and a 90th percentile of 152 mg/d.

At the request of USEPA[20], the authors combined the results of the two studies for the two most commonly used tracers as follows (units in mg/d):

Tracer	*Mean*	*50th*	*90th*	*95th*
Al	37	19	155	213
Si	59	39	213	264
Average of Al and Si	**48**	**29**	**184**	**239**

The results from the Irvine report are reproduced below. The means are similar but not identical when calculated first by combining all data for each element (Table 5) or calculated per person first (Table 6). This may be a statistical artifact of the sequence of data combination. The trace elements Al and Si are generally used as the most suitable tracers according to generally accepted criteria of being poorly absorbed, having a low food/soil ratio, and being within accurate instrument measurement ranges. Even so, the variances are large considering that all the food was pre-weighed and analyzed, suggesting that either different participants had different behaviors, the sources were not homogeneous, or there were inconsistencies in fecal collection.

Table 5
Summary of soil ingestion rates calculated for each of the 12 elemental tracers examined. Soil ingestion rate is expressed as mg d^{-1}.

	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
Mean	36	318	12	12	1998	68	−378	3215	−183	196	−7	19
Standard deviation	117	1662	72	78	10,107	152	461	5622	238	626	145	407
Standard error	12	176	8	8	1071	16	49	597	25	66	15	43
Median	7	467	−4	−2	1034	37	−390	759	−185	143	−17	−30
90th percentile	165	1744	111	97	11,555	231	109	9325	111	1032	159	211
95th percentile	268	2405	132	156	18,226	361	217	16,459	169	1226	230	301
Upper 95% CI[a]	65	650	29	32	4075	104	−283	4662	−129	328	27	196
Lower 95% CI[a]	15	−26	−1	−1	−164	40	−479	2242	−230	69	−34	−34
n	87	87	87	87	87	87	87	87	87	87	87	87

[a] Upper and lower 95% confidence intervals are bootstrapped confidence intervals with 5000 bootstrapped replicates.

[20] M. Stifelman, Region 10 Office of Environmental Assessment and Review, March 9, 2017

Table 6
Soil ingestion rate values calculated for each participant. Mean, standard deviation (SD), median, and sample size are given for each participant over the study duration. Soil ingestion rate is expressed as mg d^{-1}.

Subject	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
A	18	384	19	16	2346	119	−244	5314	−197	117	16	64
B	−47	−1005	−41	−42	−2820	−19	−790	163	−400	−295	−157	−38
C	152	485	82	92	6665	267	−725	13,574	−352	260	78	616
D	32	37	−2	−1	−1697	3	−195	839	−185	−103	−60	−57
E	55	8	−8	0	−875	61	−544	1861	−179	290	27	−109
F	32	394	34	25	10,137	58	−406	2343	−252	166	25	−13
H	60	631	13	11	4714	72	−111	5055	−30	582	−15	−30
I	−11	620	−9	−7	1408	87	−349	443	45	54	−34	−38
J	6	1759	10	13	−7612	25	−307	719	−86	601	1	−12
Mean	33	368	11	12	1363	75	−408	3368	−182	186	−13	43
SD	55	725	34	36	5359	84	234	4277	144	292	67	220
Median	32	394	10	11	1408	61	−349	1861	−185	166	1	−30
n	9	9	9	9	9	9	9	9	9	9	9	9

One explanation for the vastly different input-output differences for some elements, such as titanium, has been that some elements are present in relatively high quantities in consumer products, since the content in foods were all accounted for. However, titanium (always high in excreta measurements) is a common food additive and is poorly absorbed in nanoparticle form (Cho et al., 2013), so it is possible that elements other than Al and Si may reflect unrecognized ingestion sources that might or might not be related to soil ingestion. For example, aluminum is poorly absorbed following either oral or inhalation exposure and is essentially not absorbed dermally. Approximately 1.5–2% of inhaled and 0.01–5% of ingested aluminum is absorbed. The absorption efficiency is dependent on chemical form, particle size (inhalation), and concurrent dietary exposure to chelators such as citric acid or lactic acid (oral), and is primarily excreted in the urine, with a lesser amount in the bile, but it binds to various ligands in the blood and distributes to every organ, with highest concentrations ultimately found in bone and lung tissues.[21] The general assumption that 100% of poorly-absorbed trace elements occurs within 24 hours may need to be revisited. Ultimately, titanium must be explained, along with inter-individual differences and the negative results for some subjects (assumed to be due to missed sample collection).

11. Grain or Particle Size

It has been known for decades that greater concentration of contaminants measured in smaller particles is due to increased surface area. For example, Parizanganeh (2008) found that the majority of trace elements were present in the 63 µm fraction. Zhao et al. (2003) found that particles with smaller grain size (<250µm) contributed more than 80% of the total metal loads in road runoff, while suspended solids with a grain size <44µm in runoff water accounted for greater than 70% of the metal mass in the total suspended solids. Sutherland (2003) found that sediment <63µm accounted for 51% of the total Pb load in road sediments. Wang et al. (2006) found that higher concentrations of anthropogenic heavy metals (Cu, Zn, Mo, As, Hg, Bi, Ag)

[21] https://www.atsdr.cdc.gov/toxguides/toxguide-22.pdf

are observed in the finest particle grain size fraction (i.e. < 45µm) of road dust. Some heavy metals (Se, Sb and Ba) behave independently of selected grain size fractions, but more than 30% of the concentrations for all anthropogenic heavy metals are contributed by the particle grain size fractions of 45–74µm and more than 70% of the concentrations for all heavy metals are contributed by the particle grain size fractions of 45–74 and 74–125µm.

The concern about health risks centers on adherence of small particles to the skin, where it is available for hand-to-mouth ingestion. Smaller grain sizes that comprise respirable fractions of dust whence they deposit in different areas of the respiratory system, including clearance by the mucociliary system and then swallowed. Air quality regulations focus on aerosols, PM10 (<10µm), PM 2.5, and recently on nanoparticles. Natusch et al. (1974) investigated the distribution of trace elements among fly ash grain sizes. Particles less than about 1 µm deposit predominantly in the alveolar regions of the lung where the absorption efficiency for most trace elements is 50 to 80 percent. Larger particles, on the other hand, deposit in the nasal, pharyngeal, and bronchial regions of the respiratory system and are removed by cilial action to the stomach. Natusch found that the size distribution of certain trace elements in ambient air can be influenced, at least in part, by their particle size distribution in the source emission, although this varies considerably between elements, and that the highest concentrations of many toxic elements are emitted in the smallest, lung-depositing particles. Particles larger than PM10 are intercepted in the nasopharyngeal area (Stuart 1984; Heyder et al. 1986).

The general cutoff for adherence is 63µm, the silt/sand boundary, with greater adherence of the smaller grain sizes, Soil adherence has been reviewed by EPA.[22] Grain size is the key parameter in dermal adherence, with moisture only a factor for very moist soils (Choate et al., 2006). These authors found that the adhered fractions of dry or moderately moist soils with wide distributions of particle sizes generally consist of particles of diameters <63 µm. Finer particles are less likely to be rejected/screened by the consumer (children). 63µm is the sand/silt break-point on the Wentworth scale[23] and is defined in the field based on oral "grittiness test". The clay/silt breakpoint is the first detection of grit when lightly ground between front teeth. Consequently, dermal absorption experiments using larger size fractions may be of limited relevance to actual situations of soil exposure.

Regardless of the source, due to gravity separation alone, finer particles are transported longer distances than larger particles. Finer particles are also less filterable via canopy, aquatic system, or household HVAC systems. Therefore, the nature and extent of the distribution of finer particles are much larger than coarser fractions, spreading contamination further. Finer particles

[22] https://www.epa.gov/sites/production/files/2015-09/documents/part_e_final_revision_10-03-07.pdf
[23] The simplified Wentworth scale is: Gravel gradations (>2mm); Sand gradations (62.5-125 µm); Silt (3.9–62.5 µm); Clay (0.98–3.9 µm). Soils are typed according to physical (e.g., grain size, color, moisture), chemical (e.g., minerals, pH), and biological attributes (e.g., organic matter).

are produced by more industrial sources (range from stack or tail-pipe air-emitters to sediment dischargers associated with mining)

One goal of the risk assessor is to employ an exposure point concentration that represents the pertinent pathway of interest (*direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact).* For example when evaluating ingestion of soils EPA recommends a particle size distribution (PSD) cutoff of 250µm because EPA believes this is the largest size that adheres to the hand which subsequently affects hand to mouth intake. This is not a conservative value.

Another goal is to employ an exposure point concentration that represent the thermodynamically effective (TDE) concentration of contaminants of concern associated with the particle size cutoff. The cutoff is directly related to: (1) the process that was responsible for genesis of the TDE contaminant, and (2) sorption of the contaminant on native particulates during transport. Native clay-sized materials (< 4µm) are the dominant media providing sites for active sorption. Falsely low values for exposure point concentrations occur when the incorrect cutoff is employed. For example, if an EPA defined size of 250µm (relatively coarse) is employed for ingestion of soils related to smelter stack emission exposure point concentration (an aerosol of 0.001µm to 100µm), the analytical result and exposure point concentration will be falsely low due to dilution of the aerosol-sized particle with larger naturally occurring materials occupying the greater than aerosol to 250µm range of the distribution. In other words, employing the larger cutoff relies on the assumption that TDE contaminants are homogenously distributed in the particle size distribution. This assumption is only valid for very rare cases where the particle size distribution of a manufacturing process is coincident with the 250µm cutoff.

Multiple pathways from multiple sources requiring different cutoffs for different thermodynamically effective contaminants, further complicate matters because sampling can become cumbersome and quite costly. In summary, for such situations, since wastes from manufacturing processes are governed by less-than particle size cutoffs associated with design of settling basins, air/water filtration, etc., the finer (<63 µm) fraction is present in all the aforementioned pathways (direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact), we recommend a much finer PSD cutoff of 63µm to represent all pathways. Employing a coarser cutoff of the particles sizes likely results in dilution of the exposure point concentration resulting in a falsely low exposure point concentration. Since quantitative estimates of risk are directly proportional to the exposure point concentration, risk is also estimated to be falsely lower than actual conditions.

For these reasons, we recommend sieving soil and dust samples along the sand/silt and silt/clay size boundaries, and using fractions <63µm for risk assessment.

12. Fugitive Dust

Fugitive dust may be an under-appreciated route of exposure for dust and soil. For example, asbestos can cause gastrointestinal tumors due to swallowing, and the clearance of coal dust by the mucociliary tract has been linked to gastric cancer.

Fugitive dust consists of geological material that is injected into the atmosphere by natural wind and by anthropogenic sources such as paved and unpaved roads, construction and demolition of buildings and roads, storage piles, wind erosion, and agricultural activities (Watson 1996). The largest sources of regional dust are roads and agriculture. There are more than 4 million miles of roads in the United States with about 2.5 million miles paved roads and 1.5 million miles unpaved. There are about 350 million acres of tilled farmland in the continental US and 188 million acres of range and pasture land.[24]

Unpaved Roads

Nearly 50 percent of America's roads are unpaved, not counting private roads, agricultural roads, and parking lots.[25] The practice of converting paved roads to unpaved is relatively widespread; recent road conversion projects were identified in 27 states. These are primarily rural, low-volume roads that were paved when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are rapidly deteriorating, and are both difficult and expensive to maintain. Instead, many local road agencies are converting these deteriorated paved roads to unpaved as a more sustainable solution.[26]

Oklahoma has 234,633 miles of roads, of which 12,000 miles are paved.

Nation-wide, counties spend approximately 31 percent of their budget on gravel road maintenance (Birst and Hough 1999). Gravel road maintenance includes roadside maintenance, grading, ditching, snow and ice control, signing, dust control, rehabilitation/regrading, and other steps. Results of a study conducted by *Better Roads*[27], identified that more engineers called dust their most serious gravel road maintenance problem than any other. A car traveling 35 mph on a moderately dusty road generates the concentration of silt-sized particles equal to that of about 100 times the pollution concentration in the air of an industrial city (Birst and Hough 1999). For

[24] https://www.westernwatersheds.org/watmess/watmess_2002/2002html_summer/article6.htm
[25] www.equipmentworld.com/celebrating-80-years-of-better-roads (data from 2011).
[26] http://www.montana.edu/ltap/resources/publications/nchrp_syn_485.pdf (data from 2016).
[27] http://www.equipmentworld.com/better-roads-magazine-archive/

every vehicle traveling one mile of unpaved roadway once a day, every day for a year, one ton of dust is deposited along a 1,000-foot corridor centered on the road (Sanders and Addo 1993).

Risk assessments often do not quantify the risk associated with soil inhalation. However, in areas with unpaved roads, this is a relevant exposure pathway. To determine the inhalation exposure, James et al. (2013) collected three size fractions of airborne particulate matter (total suspended particulates [TSP], particulate matter with an aerodynamic diameter less than 10µm [PM10], and particulate matter with an aerodynamic diameter less than 2.5µm [PM2.5]) before and after roads were paved. Road paving reduced the concentration of many airborne contaminants by 25 to 75% (James et al. 2012).

Off-road vehicles, such as might occur during homesteading activities, while perhaps trivial in a regional context, could be locally significant. Goossens and Buck (2009 a,b) examined the type of surface (sand, silt, gravel, drainage) with respect to dust emission from off-road use. As predicted by grain size, the increase in PM10 emission resulting from ATV use in arid areas are: for sandy areas, 30–40 g km−1 (PM10) and 150–250 g km−1 (TSP); for silty areas, 100–200 g km−1 (PM10) and 600–2000 g km−1 (TSP); and for mixed terrain, 60–100 g km−1 (PM10) and 300–800 g km−1 (TSP). These values are for the types of vehicles tested in this study and do not refer to cars or trucks, which produce significantly more dust (Goossens and Buck 2009 a,b). Predictions of aeolian (wind-caused) erodibility can be made based on climate, wind speed, elevation, vegetative cover, slope, and soil type (USACE 2008), as well as grazing intensity (Goossens 2001).

Agricultural Dust Production

Tillage has been shown to be a significant source of dust (particles and any contaminants adsorbed onto them such as fertilizers and pesticides) as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001; Clausnitzer and Singer, 1996; Cassel et al., 2016). A long history of research focusing on tillage and dust emission exists for the USA. On the local scale, wind erosion and agricultural activity remain the major sources of dust after vehicle driving on paved or unpaved roads. Tillage has been shown to be a significant source of dust as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001). For example, the San Joaquin Valley of California is in non-attainment of National Ambient Air Quality Standards for PM10. The occurrence of 24-hour exceedences during periods of intense agricultural activity in the post-harvest months of October and November, as well as the composition of ambient PM10 at that time, indicates the importance of row crop agriculture in the region's air quality. Road dust and farming were the sources of the bulk of PM10 (Cassel et al., 2016). Clausnitzer and Singer (1996) measured respirable dust generated during agricultural operations related to corn, tomatoes, and wheat in the Sacramento Valley. The highest amount of respirable dust was generated form soil ripping and plant into dry surface soil, and the lowest was generated by disking corn stubble during the wet season. Approximately 64% of all operations were performed during the dry season and generated 83% of the respirable dust. Areas of abandoned agricultural land in the Antelope Valley, western Mojave (high) desert of California are recalcitrant to conventional tillage and revegetation strategies designed to suppress wind erosion of soil and transport of sediment and fugitive dust. These areas represented a continuing source of drifting sand and of coarse and respirable suspended particulate matter (Grantz et al., 1997).

Homesteading, farming, and ranching risk assessment must consider (1) past spread of mining-generated particles at the mine sites and much larger depositional areas, (2) newly generated particles during farming and ranching, and (3) particles generated as road dust, including a consideration of past spillage of mined materials onto haul roads.

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Attachment No 2 Tar Creek Superfund Site RME Prepared by Dr. Barbara Harper, DABT, AESE Inc. August, 2018

Tar Creek Superfund Site RME

Prepared by Dr. Barbara Harper, DABT, AESE Inc.
August, 2018.

1.0 SUMMARY

This report presents the RME for the Tar Creek superfund Site, based on the Quapaw Traditional Lifeways Scenario (Harper 2008). The Quapaw Traditional Lifeways Scenario is a regional scenario, drawing on all the natural resources originally available to the Quapaw Tribe. The RME is a more localized scenario that reflects the same self-sufficient lifestyle (essentially a homestead), but is modified for the more limited area of the Tar Creek Superfund Site. The RME scenario assumes that the RME family has access to the entire Tar Creek site and all media simultaneously, irrespective of Operable Unit boundaries, previous risk assessment assumptions, land use planning, or institutional controls. It is our experience that when upland game or aquatic resources are plentiful, as they are at Tar Creek, traditional tribal users relied on resources that each individual preferred, much like what occurs today when shopping for an extended family. In order to capture these variations in the diet, two dietary variants are described: a terrestrial-focused diet and an aquatic-focused diet. The direct exposure factors (e.g., soil ingestion rate) derived from activities associated with hunting, fishing, or gathering each diet are not varied, since these activities are typically conducted by specific groups within the tribe, clan, or family regardless of the individual's preference for diet.

2.0 REASONABLE MAXIMUM EXPOSURE

> *"Actions at Superfund sites should be based on an estimate of the* ***reasonable maximum exposure*** *(RME) expected to occur under both current and future land-use conditions. The reasonable maximum exposure is defined [by EPA] as the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual pathways. If a population is exposed via more than one pathway, the combination of exposures across pathways also must represent an RME. The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures."* (EPA, 1989)

The Quapaw Tribe notes that this definition includes several very important statements. First, this definition applies to a site, not to portions of a site (operable units) or individual media (e.g., soil or groundwater). Second, "the combination of exposures across pathways also must represent an RME." Subdividing a site merely creates smaller sites, each of which requires a complete RME, according to the requirement to include all pathways in the RME. According to the site-wide perspective, if only one OU is considered at a time, the simultaneous exposures from the other OUs must be included in the exposure assessment. While a remedy may be selected for individual media or locations, the human body integrates all exposures from all sources, into total daily doses, which is the basis for estimating cumulative risk.

The goal of selecting a remedy at a Superfund site is to ensure that the future land use is safe, without the need for land use restrictions designed or assumed to reduce exposure to allowable levels. In selecting a remedy that will include institutional controls, "site managers should consider whether the site would meet unlimited use and unrestricted exposure (UU/UE) as one of the factors in deciding when an Institutional Control (IC) is appropriate at a site. UU/UE generally is the level of cleanup at which all exposure pathways present an acceptable level of risk for all land uses" (EPA 2012). EPA's Five-year review guidance states:

> *"In general, if the selected remedy relies on restrictions of land, ground water, or surface water use by humans or if any physical or engineered barrier is part of the remedy, then the use has been limited and a Five-Year Review should be conducted.* " (EPA 2001)

Cumulative Risk. Cumulative risk refers to the sum of risks from all media, all contaminants, and all pathways of exposure associated with the site. This cumulative approach should also be used in the identification of contaminants of concern. This means that a contaminant should not be screened out based on its concentration in a single medium if it is present in more than one medium (e.g., present in both soil and water). Thus, it should be noted that Region 9 soil PRGs do not consider all media, and were not developed with a tribal lifestyle in mind.

> *"The practice of risk assessment within the Environmental Protection Agency (EPA) is evolving away from a focus on the potential of a single pollutant in one environmental medium for causing cancer toward integrated assessments involving suites of pollutants in several media that may cause a variety of adverse effects on humans, plants, animals, or even effects on ecological systems and their processes and functions." "In recent years, EPA's risk assessment emphasis has shifted increasingly to a more broadly based approach characterized by greater consideration of multiple endpoints, sources, pathways and routes of exposure; community-based decision making; flexibility in achieving goals; case-specific responses; a focus on all of the environmental media; and significantly, holistic reduction of risk. This more complex assessment involves cumulative risk assessment. It is defined in each case according to who or what is at risk of adverse effects—from identifiable sources and stressors—through several routes of exposure over varied time frames."* (EPA 1997).

3.0 THE RME IS USED TO CALCULATE TOTAL DAILY DOSE

The Tar Creek RME must be used to calculate and report total daily intakes for all three COPCs (Pb, Cd, Zn) using the same set of exposure parameters for each. EPA has not set a RfD for Pb. The toxicity of lead is not completely separate from other contaminants (Cd and Zn), because Cd has neurotoxic effects that should be considered in combination with the neurotoxicity of Pb. At Tar Creek, the total daily intake of each and every COPC must be calculated and reported. Simply running the IEUBK for Pb and a separate conventional dose estimate for Cd and Zn is inadequate. The Quapaw Tribe expects the HHRA to include a table of U.S. and international provisional tolerable daily and weekly intake (PTWI) values for Pb in addition to any IEUBK results. Please also note that QTO Resolution No 122005-C (December 201, 2005; Attached) specifies:

> ***"BE IT FURTHER RESOLVED****, that the goal for Children's Blood Lead (PbB) from a combination of all sources (pathways) should result in PbB levels at or below 10 ug/dL for 99% of children, at or below 7.5 ug/dL Tor 95% of children, and at or below 5 ug/dL for 90% of children."*

The IEUBK may be run separately using the same exposure factors or input parameters as the RME. For IEUBK-specific default assumptions, such as the ratio of concentration in outdoor soil to indoor dust, the Quapaw Tribe must be consulted. For example, a rural setting with dusty agriculture may warrant setting the indoor dust concentration of Pb equal to the outdoor soil concentration. Assumptions about the domestic worker portion of the IEUBK also require consultation.

QTO notes that the IEUBK is not conservative because (1) not all pathways are automatically considered and tribal exposure factors are not (or were not) used in the 2005 assessment for OU4, and (2) the blood lead level is modeled based on frank effects seen in human studies without any safety factor, unlike a RfD which does have safety factors. In 2012, CDC concluded that no safe level of lead in children's blood has been identified. It replaced its Level of Concern with a reference level set at 5 μg/dL to represent the levels in the 97.5th percentile of children. CDC has discussed whether the level should be further reduced to 3.5 μg/d.[1]

[1] https://www.edf.org/sites/default/files/edf_lead_food_report_final.pdf. https://www.atsdr.cdc.gov/science/lpp/docs/lead_subcommittee_minutes_9_19_2016_508.pdf

4.0 QUAPAW REGIONAL EXPOSURE SCENARIO (QRES)

A regional traditional exposure scenario was developed for the Quapaw Tribe (Harper 2008). It is based on the traditional lifestyle and diet specific to the local ecology and the natural resources that are or were present prior to the releases. The eastern Oklahoma culture area is located along the intersection of the oak-hickory savanna of the Ozark Highlands broadleaf woodland, and the tallgrass prairie of the eastern Great Plains, along with aquatic and riparian zones, river bottom or floodplain forests, wetlands, and farmlands (e.g., extensive corn fields were maintained by the Tribe) with field margins of nuts, berries, and fruits. During the settlement era, western foods and livestock were incorporated into the Quapaw lifestyle, while maintaining hunting, gathering, fishing, medicines, pottery, basketmaking, wood gathering, and associated survival practices. The Reservation includes cultivated as well as wild plants, and domestic livestock as well as fish, fowl, and game, which is carried through to the RME.

Based on the literature and the other information presented above, the baseline average Quapaw diet in Oklahoma is estimated as roughly: 1/3 of calories from corn; 1/3 from meat, fowl, and fish, and 1/3 from all other plants (nuts, roots, beans, squash, other seeds, fruits, leaves and greens), and sweeteners.

Table 1. Exposure Factors from the Quapaw Regional Exposure Scenario. This table is used as the basis for the RME factors (Table 2).

Exposure Factor[2]	***Daily Rate***
Soil ingestion	400 mg/d
Water ingestion[3]	2L/d
Inhalation	25 m^3/d
Corn	267 gpd
Large game	267 gpd
Small game	69 gpd
Fowl & eggs	53 gpd
Aquatic & Fish	120 gpd
Legumes	92 gpd
Squash, other veg	133 gpd
Nuts, grains, seeds	24 gpd
Roots & Bulbs	133 gpd
Fruits & berries	167 gpd
Greens & sweets	200 gpd

[2] All exposure factors in this table are based on a the older default body weight of 70 kg. If a higher body weight is used, the caloric intake and daily food ingestion rates need to be raised accordingly.
[3] This water ingestion rate does not include water consumed during sweatlodge ceremonies.

5.0 TAR CREEK RME

The RME is the practical application of the traditional scenario to the Superfund site within the traditional homeland area. The RME describes the same lifestyle goals, but in a more constricted area, namely, how a tribal homesteader can be self-reliant and self-sufficient within the study area. To accommodate current practices and activities, contemporary homesteading activities are substituted for some of the subsistence practices. The goal of the Tar Creek RME is to identify the people who are reasonably maximally exposed via all media (water, soil, biota, food, natural materials) in combination, and/or each activity (the fisherman, or the hunter/ farmer/ rancher/gatherer). For this report, we are using the term "Tribal Homestead."

The **Tribal Homesteader** is a person (or family) who lives on and supports himself (and his family) on the homestead, raising crops and livestock, and obtaining water from surface water or a well for domestic use, irrigating crops, and watering livestock[4], augmented with wild foods. Activities include farming, ranching, and similar agriculturally-oriented activities as well as traditional tribal activities. The diet includes both homegrown crops (kitchen garden, row crops, hay or alfalfa for the livestock, fruit) and wild foods and medicines obtained through hunting, fishing, gathering, and trade. The homesteader uses firewood for winter heating, obtained from the study area. This report presents a general Homesteader RME with two variants: (1) Upland-intensive with a terrestrial-based diet, and (2) Aquatic-intensive with a river/lake-based diet. The RME generally represents an upper percentile of possible exposure that is unspecified because some of the exposure factors (such as inhalation rates) are central tendency or are representative "averages."

For this report, there are two variants of the RME:

1. First RME ("**Land-intensive Homesteader**") is the family living within the Superfund Site boundaries, growing all of their food with livestock and wild foods obtained from the wetlands, lake, and uplands. The fish ingestion rate for this RME is taken from the Regional Quapaw Scenario (120 gpd).

2. Second RME ("**Lake-intensive Homesteader**") is the family that fishes for much of their protein for themselves, their family, and other families. Sediment concentrations are applied to the soil ingestion rate for this RME.

[4] All water uses should assume either ground water or surface water as the source. The HHRA should employ 100 percent of the water that is more contaminated in order to evaluate the RME.

Assumptions for both RME variants:

1. All families utilize the wetlands for plant food and materials and small wetlands game and fowl, utilize the floodplain and uplands for small game and fowl, and utilize the lake for fish and water fowl.

2. All RME families have an individual garden with a few fruit trees irrigated with lake water or groundwater.

3. Total vegetation intake is the same for each variant, with the locations (i.e., exposure point concentration) to be discussed with QTO before application. For example, the exposures should be estimated separately for 100% cultivated produce (irrigated with groundwater or surface water), 100% wild-gathered upland vegetation, 100% floodplain vegetation, 100% wetland, and 100% aquatic. Combinations of vegetation sources and representative species must be discussed with QTO before application.

4. Protein is from beef (including a water-to-pasture-to cow pathway). While cattle graze and deer browse, it may be assumed for simplicity that they are essentially the same, obtaining all of their forage from the site.

5. Drinking water is from the shallow aquifer or surface water (in each case 2 L/d plus other domestic and garden use), plus 1 L per sweat lodge use.

6. Soil ingestion is 400 gpd for all ages, composed of 100% soil for the terrestrial variant, and 100% sediment for the aquatic variant. The actual exposure point concentrations must be discussed with QTO before application.

7. All RME families have children who engage in beach play, and are exposed to sediment. Since surface water of the site is slow moving slack-water, beach play must include well mixed sediment and surface water.

8. Sweat lodge use was not quantified in the Regional Scenario. In the RME it is provisionally assumed to be weekly, pending other input from QTO. This is a reasonable maximum, lower than daily use but higher than monthly as indicated by the downriver tribes. The specific location and water source will be based on input from QTO.

9. Exposure specific to basket-makers is a well-recognized problem, but it has not been fully researched with respect to environmental contact rates. Gathering of some plants (e.g., willows, cattails, reeds and rushes) can be very muddy, and river shore or lakeshore activities with sediment exposure may be underestimated. Washing, peeling, weaving rushes, and other activities results in additional exposure, such as dust deposited on

leaves or soil adhered to roots. Some of the materials are held in the mouth for splitting, and cuts on the fingers are common. As more information becomes available, it will be evaluated to ensure that the exposure factors for each route of exposure account for this particular activity. In the interim, the soil ingestion of 400 mg/d is used for all people over the age of 6.

10. The QTO is aware of the Tar Creek fish advisory.[5] The advisory estimates an allowable fish consumption rate assuming that lead is the only COC and the human receptor is not obtaining a dose from other pathways (e.g. sediment, soil, surface water, ground water, ingestion, dietary plant or animal ingestion, sweat lodge use, etc.) within Tar Creek at the rates used in the RME. For example, while an average Tar Creek residential yard soil concentration was used, other pathways and site-specific doses were generally not considered.

Body Weight and Daily Calories. If a BW of 80 kg is used, the following information is relevant. A body weight of 80 kg (176 lbs.) is now often used for risk assessments (raised from the older default value of 70 kg). USDA suggests that a maintenance caloric intake for a 176 pound person is 2640 kcal/d. A moderately active man needs 176 lbs x 15 kcal/lb = 2640 kcal/d; a woman needs 2000-2200. The conclusion is that if a higher body weight is used, the caloric intake and daily food ingestion rates need to be raised accordingly.

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[5] Oklahoma Department of Environmental Quality (DEQ) (2006). Fish Tissue Metals Analysis in the Tri-State Mining Area Follow-up Study FY 2006 Final Report. OK DEQ Section 106 Water Quality Management Program. Posted at:
http://www.deq.state.ok.us/CSDnew/fish/PDFs/PDFs/TabLinks/TarCreekInformation/2007TarCreekStudy.pdf

[5] A Guide to Healthy Fish Consumption in Oklahoma, posted at:.
www.deq.state.ok.us/csdnew/fish/PDFs/2017_MercuryinFish.pdf

Table 2. Traditional and Homestead RME Diets

	Traditional Regional (Upland + Aquatic) 2007	Homestead RME - Upland	Homestead RME - Aquatic
Fish, shellfish	6%, 120 gpd	120 gpd Consult Tribe for species, ratios	389 gpd Consult Tribe for species, ratios
Game (large and small) and waterfowl, eggs	32%, 389 gpd	389 gpd beef and large game. May substitute negotiated amounts of small game, fowl, eggs.	120 gpd May substitute negotiated amounts of wetland small game, waterfowl, eggs.
Corn	30%, 267 gpd	Either species-specific uptake rates, or combine with "other aboveground"	Either species-specific uptake rates, or combine with "other aboveground"
Roots, tubers, bulbs, rhizomes, corms (below ground)	5%, 133 gpd	133 gpd (assume 100% terrestrial vegetation)	133 gpd (100% aquatic; may use cattail root as representative)
Nuts, seeds, other grain	6%, 24 gpd	24 gpd	24 gpd
Fruits and berries	5%, 167 gpd	167 gpd	167 gpd
Other aboveground vegetation, greens, shoots, teas, medicines, sweeteners	16%, 245 gpd	245 gpd (assume 100% terrestrial split among asparagus, willow, and cattail, or whichever is more contaminated	245 gpd (100% aquatic, may cattail shoots as representative)
Dietary totals	*100%, 2000kcal/d, 1345 gpd (3 lbs)*	*100%*	*100%*
Soil Ingestion	400 mg/d	400 mg/d, soil concentration TBD	400 mg/d, sediment concentration TBD
Water Ingestion from surface and groundwater	2 L/d + 1L/sweat	Combination of sources or 100% of each source calculated separately	Combination of sources or 100% of each source calculated separately
Other water use	yes	domestic, irrigation	domestic, irrigation
Sweat Lodge	Not specified	1 per week (provisional)	1 per week (provisional)
EF, ED	365 d/yr , 70 yrs	365 d/yr , 70 yrs	365 d/yr , 70 yrs
BW	70 kg	70 kg	70 kg

Note: the specific species of plants, animals, fish, and shellfish, and the representative species used for each category requires consultation with QTO before application.

REFERENCES

EPA (1989). Risk Assessment Guidance for Superfund, Part A, Chapter 6, section 6.2.1. http://www.epa.gov/oswer/riskassessment/ragsa/pdf/ch6-1.pdf.

EPA (1997). Guidance on Cumulative Risk Assessment, Part 1. Planning and Scoping. https://www.epa.gov/sites/production/files/2015-01/documents/cumrisk2_0.pdf

EPA (2001). Comprehensive Five-Year Review Guidance (EPA 540-R-01-007), June 2001.

EPA (2012). "Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites." OSWER 9355.0-89 EPA-540-R-09-001 December, 2012. https://www.epa.gov/sites/production/files/documents/final_pime_guidance_december_2012.pdf

Harper (2008). Quapaw Traditional Lifeways Scenario. Prepared for the Quapaw Tribe of Oklahoma.

Attachment: RESOLUTION NO. 122005-C:

A RESOLUTION ESTABLISHING HUMAN HEALTH REQUIREMENTS AND RELATED PROCESSES FORTHE QUAPAW RESERVATION

QUAPAW TRIBE OF OKLAHOMA

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

RESOLUTION NO. 122005-C

A RESOLUTION ESTABLISHING HUMAN HEALTH REQUIREMENTS AND RELATED PROCESSES FOR THE QUAPAW RESERVATION

WHEREAS, the Quapaw Tribe of Oklahoma is a federally recognized Indian Tribe and is governed by a Governing Resolution adopted by the Quapaw Indian Council on August 19, 1956, and approved by the Commissioner of Indian Affairs on September 20, 1957; and

WHEREAS, the Governing Resolution delegates authority to the Quapaw Tribal Business Committee to speak and act on the behalf of the Quapaw Tribe; and

WHEREAS, the Quapaw Tribal Business Committee is thus empowered and obligated to take actions to protect the health, security, and general welfare of the Tribe as a whole and of all residents of the Quapaw Reservation; and

WHEREAS, the Quapaw Reservation was created and set aside by a treaty between the Quapaw Tribe and the United States to forever serve as the homeland for the Quapaw Nation, the boundaries of the Reservation being formally established by the Treaty of May 13, 1833 (Kappler, 1904, vol. 2, p. 395, 7 Stat. 424) and which have never been diminished; and

WHEREAS, the Quapaw Reservation, when reserved as a permanent homeland for the Quapaw Nation, was intended to support the Quapaw People's subsistence, medicinal, spiritual, and other cultural needs by providing sufficient and healthy quantities of land, water, fish, wildlife, plants, and other natural resources, as had been available to and used by the Tribe from time immemorial; and

WHEREAS, it is the desire of the Quapaw People and the policy of the Quapaw Tribe to honor the vision of our ancestors by protecting the Quapaw Reservation and its resources to ensure their healthy and safe use by all future generations to fulfill their subsistence, medicinal, spiritual, and other cultural needs; and

WHEREAS, it is the desire of the Quapaw People and the policy of the Quapaw Tribe to evaluate risk at both the individual and community level; and

WHEREAS, it is the desire of the Quapaw People and the policy of the Quapaw Tribe to remain at or regain uncontaminated, background conditions, to keep risks as low as technologically achievable (ALATA), and to use caution in making decisions if the risks are uncertain (the Precautionary Principle); and

WHEREAS, healthy quantities of the Quapaw Reservation's land, water, fish, wildlife, plants, and other natural resources continue today to be critical to the physical, spiritual and cultural survival of the Quapaw People, representing a mutually dependent relationship between the Tribe and Reservation resources; and

WHEREAS, the Quapaw Reservation has been and will continue to be exposed to contaminants through trade, through sharing of natural resources with other cultures, and through the interaction of Reservation and off-Reservation migratory resources; and

WHEREAS, lands historically held by the Quapaw Tribe are currently being repatriated through the Tribe's land consolidation program; and

WHEREAS, repatriated lands must be clean and free of contamination to support use by the Quapaw Tribe and the Quapaw People as well as to enable the land to go back into federal trust status; and

WHEREAS, the United States Environmental Protection Agency (the "EPA") has placed the former mining district within the Quapaw Reservation (the so-called "Tar Creek Superfund Site") on the National Priorities List and is proceeding with response activities at the district and impacted areas; and

WHEREAS, the EPA has requested the Quapaw Tribe to identify Applicable Relevant and Appropriate Requirement ("ARARs") to facilitate selection of the Preferred Remedial Action Alternative under the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"); and

WHEREAS, the upon completion of the CERCLA remedy at the Tar Creek Superfund Site, the Quapaw Reservation lands shall be used to support unrestricted land use; and

WHEREAS, the Quapaw Tribe has consistently represented to the EPA and other federal agencies and bureaus the need for the historical agreement by the United States to reserve and protect the Quapaw Reservation as a permanent homeland to be honored and upheld and continues to hold this position.

NOW, THEREFORE, BE IT RESOLVED by the Quapaw Tribal Business Committee, that actions taken within the Quapaw Reservation which affect Tribal natural resources will, to the greatest extent possible, be consistent with the health and safety requirements of Quapaw People, who honor our ancestors by preserving our culture and health through practicing our traditional ways.

BE IT FURTHER RESOLVED, that to ensure the health and safety of the Quapaw People practicing our traditional ways, actions taken within the Quapaw Reservation which affect Tribal natural resources will, to the greatest extent possible, achieve or surpass the most stringent standards for risk to human health documented in federal law, taking into account the total cumulative multipathway risk, both to individuals and community, inherent in the traditional practices of our people.

BE IT FURTHER RESOLVED, that the measure of exposure to the Quapaw People practicing our traditional ways shall be based on a Tribally sanctioned or generated risk scenario, approved by the Quapaw Tribal Business Committee, which identifies and analyzes the multiple pathways for exposure to our people who practice our traditional ways.

BE IT FURTHER RESOLVED, that the goal for Children's Blood Lead (PbB) from a combination of all sources (pathways) should result in PbB levels at or below 10 ug/dL for 99% of children, at or below 7.5 ug/dL for 95% of children, and at or below 5 ug/dL for 90% of children.

CERTIFICATION

The foregoing resolution of the Quapaw Tribe of Oklahoma was presented and duly adopted at a reconvened meeting of the Quapaw Tribal Business Committee on December 20, 2005, with a vote reflecting 6 yes, 0 no, 0 abstaining, and 0 absent and 1 vacancy.

J.R. Mathews, Vice-Chairman
Quapaw Tribal Business Committee

Tamara Summerfield, Sec./Treas.
Quapaw Tribal Business Committee

Attachment No. 4 June 15, 2018 Memo entitled: Review of: Technical Memorandum: Human Health Risk Assessment Process, Objectives, and Tribal Lifeways Scenarios Developed for Operable Unit 5, May 11, 2018

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: June 15, 2018

SUBJECT: Review of: ***Technical Memorandum: Human Health Risk Assessment Process, Objectives, and Tribal Lifeways Scenarios Developed for Operable Unit 5, May 11, 2018***

CC: Katrina Coltrain (EPA-RPM)
Rafael Casanova (EPA-RPM)
File

This memo constitutes a review of the aforementioned document. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

The Quapaw Tribe of Oklahoma (QTO) provided comments on an earlier supporting document (Attachment No 1). The majority of concerns raised in this previous review still are unresolved. The QTO believes it would be much more expeditious and cost-effective for EPA to respond to these previous concerns (Attachment No. 1) as well as additional concerns provided herein before proceeding any further.

The QTO reiterates that OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable

Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] As demonstrated below, the information contained in this technical memorandum falls far short.

General Comments (in addition to those raised in Attachment No. 1)

1. Aquatic-based and terrestrial-based variants of the RME for the QTO need to be developed as soon as possible (see Attachment No. 1)

2. From data presented in the Tech Memo, it is clear that the Tribes of the Tar Creek Trustee council (TCTC) rely on resources at much lower consumption rates, frequencies, and durations. Therefore the QTO is greatest exposed hedonistic receptor in the area. This means that tribes of the TCTC are much lower risk populations and should not be the subject of development of RMEs, since the QTO RME (terrestrial and aquatic variants) is protective of the TCTC Tribes. This also means that PRGs/RAOs and ultimately selection of the preferred alternative must be based on the QTO RME and not RME based on the TCTC tribes.

3. The General Objectives of the Tar Creek OU5 HHRA (Section 2.0) is misleading:

> *The objectives of the HHRA are two-fold: first, to estimate the level of risk to human health associated with concentrations of environmental contaminants detected in OU5 media (surface water, sediments, biota, and mine discharge);*

At this stage of the RI/FS, estimating PRGs/RAOs is the objective, followed by quantification of residual risk associated with each proposed alternative in the FS. The Hazard Ranking Score (HRS) has already demonstrated that Risk is excessive, even to the general public. Risk is clearly much greater for the QTO who "live close to the land".

> *Risks are estimated **for current exposures to OU5** media as well as reasonably foreseeable future uses. All contaminated media within OU5 are considered (such as sediment and surface water) if individuals are likely to be exposed to the media. All relevant **routes of exposure for OU5 are considered**, including direct contact (ingestion and dermal exposure) and indirect contact (exposure to food items that have accumulated contaminants through sediments).* [Emphasis added]

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[1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

EPA cannot discount risk associated with the other OUs. In other words EPA needs to assess risk allocation from all OUs, from all COCs released, from all media, along all pathways to the QTO.

4. Sweatlodge usage was intentionally left ambiguous in the original QTO HHRA Scenario. The Traditional QTO frequency of sweatlodge use requires more research. This was included in the aforementioned proposal mentioned in Attachment No. 1.

   The downriver tribes may use a sweat lodge less than once per month, but research may reveal that the QTO use it at a higher frequency. This is important because the QTO reservation encompasses the most contaminated lands of all OUs.[2],[3] The QTO are the population representing the RME, and sweatlodge use is likely an important risk-driving activity. This means that PRGs/RAOs and subsequent remedies will be based on remedies that are protective for the Quapaw Tribe.

5. The distinction between ordinary surface water and mine discharge surface water is not clear.

   > *"Mine discharge occurs in three known locations of the Tar Creek Superfund Site in Ottawa County, Oklahoma"*

   It is not clear why there is any distinction at all, since any mine discharge becomes diluted with other water, and at some magical undefined point becomes ordinary surface water. The standard RME should be applied to these locations just as with any other location. This approach should save on risk calculation costs as well. Also, water quality standards are not dependent on the depth of the water (Section 3.4). The mine water media also needs to be connected to Surface Water in the wire-frame CSM**.**

[2] The Tribe also has the right to hunt fish and gather in areas downstream of their reservation.
[3] Many of the QTO members are dual citizens or have relatives of the downstream tribes that would result in the QTO to be exposed via diet during hunting, fishing, and gathering or via trade of contaminated resources.

Specific Comments

1. Section 1.0(1). While there is a logic to start by collecting all available data and then filling data gaps, a more complete process would be to: (Step 1) develop a whole-site human usage map and exposure scenario (the "exposome"), (Step 2) develop DQOs with detection limits based on total exposure and on background , (Step 3) review existing data for data usability according to EPA guidelines, (Step 4) develop a data gap report, (Step 5) collect new data, (Step 6) determine how to allocate risk among OUs and develop RMEs for as many OUs or sub-site areas as needed, and (Step 7) evaluate exposure and risk. These earlier documents cannot exist, since the RME(s) have not been developed and they are necessary to developing OU-specific DQOs and subsequently determine data usability. The allocation of risk among OUs means that the total allowable human risk (e.g., 1E-6 and HI = 1) will need to be subdivided among OUs so that individual OUs do not usurp the entire risk budget. Risk targets for individual OUs will need to be fractions of the total allowable risk. This comment is expanded in the next comment.

2. The "Overview of the Superfund HHRA Process" is incorrect.

> *1. The first step focuses on* data collection and analysis *to evaluate the characteristics of the site and support identification of the chemicals of potential concern (COPCs) in site media.*

This step is performed prior to listing in HRS and only identifies gross COPCs detrimental to the general public. The HHRAS/RME is required to determine necessary detection limits of COPCs. However, since Tribal populations use are the greatest exposed hedonistic receptor in the area, generally for mine sites, all EPA Target Analyte List (plus molybdenum) are COCs and the list of TAL+Mo cannot be screened-down. Regardless, COCs, necessary detection limits, and geographic scope are determined near Step 4. Data gaps cannot be determined until EPA knows what data are needed (DQOs) and if the exiting data meet these DQOs.

A later step is developing the SAP/FSP (or similar document(s)) that provides statistical design-level rationale for sampling biotic and abiotic media identified by EPA to be lacking from the historic database at the proper risk-based detection levels. This lacking information is termed data gaps. In order to determine what data are missing, EPA must first know what data they need to perform the BHHRA. The BHHRA is based on the reasonably anticipated future land use (RAFLU) of the target population. Note that land use is determined by the land owner first, and then the area is cleaned up to make that use safe, rather than forcing land use to be limited if the cleanup is not sufficient to reduce risk enough based on the RAFLU (i.e., if institutional controls are needed).

At TC, since these are Tribal lands, the QTO is the target of the BHHRA. Once the RAFLU and the target population have been identified, a plan is developed that specifies the data needs for the BHHRA. This is done in the HHRA work plan by using the conceptual site model as a visual accounting tool to derive the list of data that are needed. Next, the quality and quantity of those data are defined in a similar manner while the data quality objectives are being prepared. Once the DQOs have been prepared, the DQOs are used as a screening tool to evaluate the historical data. Data that meet the DQOs are retained for the BHHRA. Data that do not meet the DQO's are rejected and the data gap is recorded. Finally, a SAP and a FSP are developed using the DQOs and the HHRA WP to fill the gaps. This approach is detailed in the NCP.

3. Exposure parameters do not have "conservative safety factors" (Section 1.0(2)).

> . ....These assumptions, or default values, are assumed to be representative of a population, although they often include a conservative **safety factor**. These parameters include things such as time spent contacting surface water.

Exposure factors for the general population are based on actual data and statistical analysis, aiming at central tendency or upper percentiles, depending on the exposure pathway. For unstudied populations, the exposure parameters are extrapolated from actual data with professional judgment. A "reasonable maximum" is exactly that, reasonable.

4. An ecological determination of water body types (and therefore the specific boundaries of OU5) will probably be needed, because the sampling locations appear to include wetlands, streams, rivers, lakes, and springs. Perhaps the boundary of OU5 is a high water mark for a lake, but how is the boundary determined for a wetland or floodplain with seasonal discharges?

5. The relation between OU5 and the other OUs or other exposure areas is not clear. The floodplains are not included in the OU5 consideration. This is a systemic problem with the approach of subdividing a superfund site into OUs. While remedies may occur as separate engineering actions (e.g., pump and treat groundwater, excavate soil, cap sediments), the human body integrates all media, pathways, and contaminants into one cumulative set of doses with one single physiological response. A truly cumulative approach does not set a remedyfor one medium at a time, or one OU at a time unless the contributions from ALL OTHER media, pathways, chemicals, and OUs is treated as background exposures (the RSC or relative source contribution approach). Otherwise, 100% of exposure and risk must be assumed to be derived from each individual OU, and no exposure can occur from other OUs. As currently envisioned, for OU5 100% of time and exposure and food must come from

OU5. The only alternative to this is to allocate risk among OUs, such as allowing OU5 to contribute only 20% of the total risk, thus requiring, for instance, the total hazard index (summation of HQ's) from all COCs to be 0.2, not 1.0.

6. The body weight of 80 kg is acceptable only if all the dietary intake values are adjusted upward **(See General Comment 3, Attachment No. 1).** There are several ways to calculate this. A simple way is to multiply body weight (pounds) by 15-16 kcal/pound to maintain body weight.[4]

   The Harris-Benedict formula is based on total body weight, height, age, and sex and is a more accurate way to calculate basal metabolic rate.
   - Men: BMR = 66 + (13.7 x wt in kg) + (5 x ht in cm) - (6.8 x age in years)
   - Women: BMR = 655 + (9.6 x wt in kg) + (1.8 x ht in cm) - (4.7 x age in years)

   The BMR is then multiplied by a factor that considers the activity level of the person:

   - Sedentary = BMR x 1.2 (little or no exercise, desk job)
   - Lightly active = BMR x 1.375 (light exercise/ sports 1-3 days/week)
   - Moderately active = BMR x 1.55 (moderate exercise/ sports 6-7 days/week)
   - Very active = BMR x 1.725 (hard exercise every day, or exercising 2 xs/day)
   - Extra active = BMR x 1.9 (hard exercise 2 or more times per day, or training for marathon, or triathlon, etc.

   A similar approach is taken by the University of Maryland.[5] Men who are moderately active should multiply their weight in pounds by 15; women multiply by 12. The resulting number is the total calories per day needed to maintain weight. Relatively inactive men should multiply their weight by 13 and women, by 10. A moderately active woman who weighs 150 lbs. would need 1,800 calories per day to maintain her weight.

[4] https://www.k-state.edu/paccats/Contents/PA/control.htm.
[5] http://www.livestrong.com/article/307924-how-many-calories-are-needed-per-pound-to-maintain-a-body-weight/

The US Department of Health and Human Services provides age-specific guidelines in their publication, "Dietary Guidelines for Americans, 2015-2020, 8th edition." [6]

For use in this RME, a single simplified value of 2200 kcal/day will be used, for a lightly active to moderately active lifestyle. Note again that, based on the original QTO scenario, the aquatic ecosystem provides only 22% of total food. If OU5 is allowed to contribute 100% of allowable exposure and risk, then none of the other food can come from any other OU, and the person or family cannot live in those OUs and come into contact with them.

	Proposed IR based on 70 kg BW & 2000 kcal/day	**Adjusted IR based on 80 kg BW & 2200 kcal/day***	**kcal/100g**	**Total daily kcal**
Fish (catfish)	120 gpd	137 gpd	100	137
Shellfish (mussels)	30 gpd	34 gpd	182	63
Arrowroot root	133 gpd	152 gpd	66	100
Turtles, frogs	24 gpd	27 gpd	89	24
Semi-aquatic mammals (beaver)	69 gpd	79 gpd	212	166
Totals	*376 g (13 oz)*	*429 g (15 oz)*		*490 kcal* *22% of 2200 kcal/d*
EF	365			
FC	1			
ED	64			
BW	80			
* A BW of 80 kg requires 2200 kcal/day, as opposed to 2000 for a 70kg body. IR is adjusted m \by the ratio of 70 kg to 80 kg, or multiplying the original IR by 1.14. NOTE: the original scenario did not evaluate upland versus in-water food or exposures.				

7. The rationale for the values in the separate document TCTC_RAGS_Table 4 from 2016 are not clear from the footnotes. For example, the Tribes proposed a shellfish IR of 30 gpd, while the proposed value was 12 gpd (not converted to g/kg-d), and the Tribes' IR for plants is 133 gpd while the proposed value was 40 gpd. The rates in the TCOU5RI (the current document under review) no longer have the lower proposed values, so please verify that the older RAGS_Table4 table is no longer the operative table. Again, the QTO is the RME in which PRGs/RAOs must be based.

[6] https://health.gov/dietaryguidelines/2015/

Comments provided by the TCTC demonstrate that that Tribes belonging to this entity are less likely to be exposed, even in the downstream areas than the QTO[7] (**Also See Comment No. 5…Attachment No. 1).**

8. The tribal worker scenario is not a useful scenario for two reasons. First, the tribal worker is assumed to spend fewer days per year (250 days) than the resident (312 days), and a shorter exposure duration (25 versus 70 years). It is not clear why the tribal worker's exposure is less than the ordinary resident. The only difference is that the skin surface might be reduced if the worker wears waders, but this difference alone seems unnecessary. Second, if the tribal worker's allowable risk is set at 1e-6 and HI=1, then this worker must live somewhere else, retire somewhere else, he cannot eat fish from the lake with his family members, and he cannot use the sweatlodge. It is more realistic that a regular tribal resident also works on the remedy, which does not change the total exposure in the scenario as described now**.**

9. Please remove the term "conservative" throughout the document and substitute the work "reasonable." The RME is reasonable, not a conservative worst case. For example, Section 3.1.4 says both that the RME does not include special high-contact water events, but implies that it still over-estimates total reasonable exposures. It would be more appropriate to say that the reasonable maximum may not include certain high-contact events; those events might not need to be addressed in a risk assessment, but special advice to members depending on exposure point concentrations might be warranted.

10. Section 3.1.1 The consideration of salve is good. It is not clear if any other aquatic plants will be sampled, or whether arrowroot represents all edible aquatic vegetation.

11. Section 3.3.2, Fish and shellfish ingestion. See comment on adjusting the intake rate. When the actual risk assessment is done, more attention to the method of preparation of various species may be needed, such as a crayfish boil, fish served skin on or off, and so on. A similar comment pertains to aquatic plants and how much sediment might remain on them (relevant to collection and sampling methods as well as to risk estimation).

12. From a public health perspective, past exposures (e.g., in the town of Picher) are relevant to providing appropriate biomedical intervention and specific health advice

[7] Pleased note that the exposure/dose history of the casual QTO downstream area is much greater than a TCTC user since the QTO citizen is exposed at higher durations, frequencies, and quantities at higher concentrations.

to individuals. While this is not part of a risk assessment document, it will be relevant when preparing advice based on sampling results, especially if institutional controls are part of the remedy. In point of fact, people who have had past exposures in Picher may already be carrying a high lead burden even if their blood lead levels are now below 5 ug/dl, and some consideration should be made of those past exposures. Remedies are developed for future people who start with no pre-existing body burden and no past exposures, so protecting the health of current tribal members who already have an exposure history should be considered.

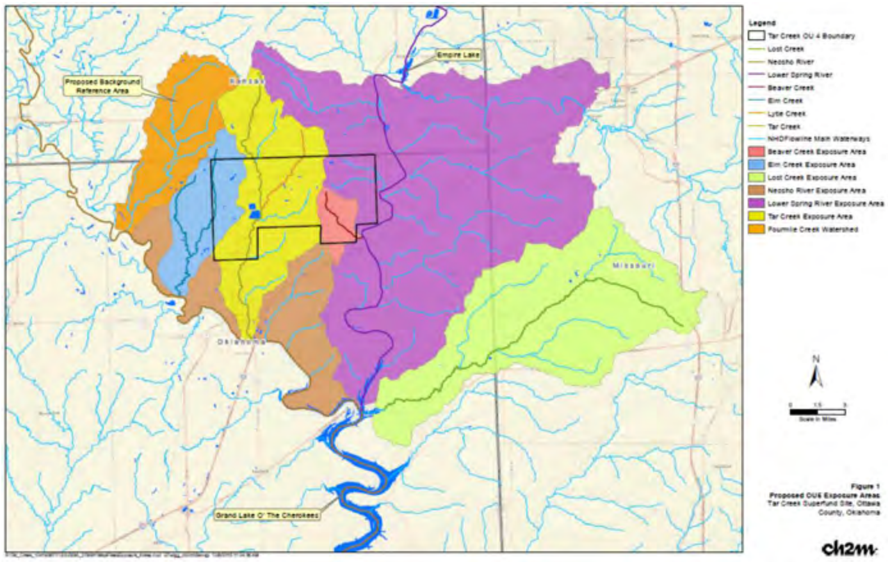


Figure 1. Map showing that OU5 includes the mine discharges within Tar Creek itself.

Attachment No 1 December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review: (RAGS Table 4 - Tribal Members - draft.xlsx)

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

Dr. Harper, DABT Senior Scientist

DATE: January 8, 2018

SUBJECT: Review of December 13, 2017 Coltrain email requesting review of HHRA RAGS PartD Table 4 Review: (RAGS Table 4 - Tribal Members - draft.xlsx)

CC:

File

This memo constitutes a review of the aforementioned document. Tim Kent has directed us to send this directly to you. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

The OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] Because the RMEs were not developed, a piecemeal approach is resulting in a requirement for perpetual institutional controls and 5-year reviews, as well as an inability to reuse the lands and resources for

[1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

their intended uses.[2] Like the proposed plan and ROD, development of the OU5 RME should be a cooperative effort including EPA and the State, and needs to proceed without further delay. Ideally this will result in a cleanup where institutional controls and land use controls are not needed, and UU/UE can be achieved.[3]

General Comments:

1. **The QTO Traditional Scenario was developed to represent the general or average Traditional QTO citizen who relies on both aquatic AND terrestrial resources—it is not a Reasonable Maximal Exposure (RME) for a given OU.[4]** The RME should be a comprehensive site-wide exposure scenario, not an OU-specific exposure. As long as terrestrial and aquatic OUs are separated, the true OU-specific RME is one that describes individuals using either terrestrial OR aquatic OUs. The latter would be an RME for 100% time and 100% sustenance from each OU. For example the RME for a person who is more reliant on aquatic resources would require a greater aquatic diet, water from surface water or mine discharge (whichever is higher) and more aquatic area exposure time. As presented by EPA, the OU5 user is recreational, which is by definition not comprehensive. Further, limiting OU5 use to recreational use is inconsistent with the Tribes' plans for land use, and is in effect an institutional control. It also prevents a multi-OU cumulative exposure assessment. The options are to either (1) develop an RME for 100% of time and diet in OU5 and another for 100% OU4, or (2) develop a combined OU4/OU5 RME that uses resources from both areas simultaneously (in effect assuming a relative source contribution from each OU). As currently devised, the OU4 user cannot use resources from OU5 because his/her risk allocation has already been filled, and vice versa.

2. **Based solely on the approach used to build the RAGS Table 4, the Tribe still foresees major problems associated with the HHRA for the future traditional resident.** These problems are overarching and associated with balkanizing the site into OUs without reintegrating risk across the OUs to enable a comprehensive assessment of site risk as required by CERCLA. This concern has been raised by the Tribe previously and is clearly nothing new. The Tribe warned EPA on these issues as far back as 2004 and reiterated these concerns in no less than five memoranda. An early example first is General Comment 3, November 22, 2005

[2] In effect, a non-congressionally approved taking of Tribal rights is slowly occurring.

[3] " Unrestricted Use/Unrestricted Exposure (UU/UE) - As discussed in EPA guidance documents, UU/UE generally refers to a situation when there are no exposure or use limitations required for the remedy at a site to be protective." https://www.epa.gov/sites/production/files/documents/final_pime_guidance_december_2012.pdf

[4] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.

Memo from Tim Kent to Ursula Lennox (EPA-RPM) regarding REG and RAOs for OU4 (Attachment 1)

3. ***The PRGs/RAOs do not consider the exposure that ecological or human receptors receive from the Surface water pathway as well as riparian resources.***

   This is a major error and omission on the part of both the ecological and the Human Health Risk Assessments (this will be discussed in greater detail in comments on those reports). The residual exposure to humans from drinking surface water and using surface water in sweatlodge ceremonies alone exceed allowable risk. This risk is real and cannot be assumed away or managed via institutional controls such as signage or education— people are using these resources today. This means that that the allowable risk to Tribal members who use resources for traditional cultural practices will be exceeded even if the uplands are returned to background conditions.

   The concept of an Operable Unit was developed to partition remedial actions into workable or manageable units—not to balkanize risk assessments. The NCP requires protection of human health and the environment for the reasonably foreseeable land use of the site—not of an OU. In summary, as long as the residual risk from OU1 is measurable, the allowable risk from other OUs must be reduced by an amount so that the cumulative site-wide risk does not exceed the threshold criteria. In this instance, the risk allocated for all other OUs has been usurped by OU1. Therefore, the PRG for all media (e.g. surface water, ground water, soils, floodplain sediments, and air) must be pre-release baseline (background).

The following table is included as another early example (excerpted from Attachment No. 2). Pay particular attention to footnote No. 2 to the table.

Tribal Exposure Areas on Tribal lands

General Activity	Source Areas: Chat Piles/Bases/Flotation Tailings Ponds	Transition Zones	Wetlands/Streams [2]
Relative Potential for Tribal Residential Use	High	High	High
Relative Potential for Tribal Subsistence Fishing Use	NA	NA	High
Relative Potential for Tribal Gathering Use (Aquatic)	NA	NA	High
Relative Potential for Tribal Gathering Use (Terrestrial)	High	High	NA
Relative Potential for Tribal Hunting Use	High	High	High
Relative Potential for Tribal Recreational Use	High	High	High
General Population Exposure on Tribal lands [1]			
Relative Potential for General Public Sportfishing Use	NA	NA	Moderate-Low
Relative Potential for General Public Bathing Use	NA	NA	Moderate-Low

NA = Not Applicable

[1] If members of the General Public (GP) reside on Tribal Lands, the residential recreational doses for the GP must also be determined.

[2] although this EA is not officially part of OU4, the dose from these areas must be considered in the Risk Assessment. If the Dose allocation from this EA equals or exceeds Risk Criteria defined by the NCP, then all other EAs must be cleaned-up to pre-release background conditions.

3. **Conversion to g/kg-d. This seems to be a systemic problem.**

An example for fish from Table 3-1 is that the fish daily ingestion rate = 120 g/d; (mistakenly converted to 15 g/kg-d by EPA). This is simply a dilution of the 120 g/d estimate by a 70 kg person into an 80kg person because EPA assumes that the same amount is eaten by both a 70 kg person and an 80 kg person.

(120 g/d)/70 kg = 1.714 g/kg/d, not 1.5 g/kd-d.

EPA's value of 1.5 g/kg-d comes from dividing the 120 g/d by 80 kg, which means that the larger person is eating less per body weight than the original 70 kg person. 2000 kcal (1526 g/d) is not enough to sustain an 80 kg person, as shown below (See Attachment).

We do not dispute that the average American is now 80 kg. But this means that everyone is eating more. If EPA wants to assume that people are heavier today, then they also have to recognize that they eat more, i.e., every intake factor needs to be multiplied by 1.14[5].

The goal for Tribes is to recapture its old lifestyle that leads to non-supersized people. The Traditional Scenario was developed for when people were a traditional size. If

[5] Accordingly the surface area for dermal calculations also would need to be revised as well.

EPA wants to adjust to new super-sized people to assess risk for current conditions they must scale all of the aforementioned exposure factors. However, the goal of the Tribe goal is for our future citizens to reach 70 kg once again. This means that the future traditional Tribal resident needs to be assessed assuming a traditional body weight of 70 kg, or alternately that the 80 kg person eats proportionally more.

- ***We recommend that EPA also examines the total caloric intake for the whole diet and compare it to the caloric needs per kg of body weight, rather than simply diluting a 70-kg diet into an 80-kg body.***

4. Use of two Canadian studies for reducing the soil ingestion rate

These two fecal tracer studies were conducted with the Nemiah Band, a traditional community; all food was provided to the participants by the investigators in the Davis et al. (2012) study, and participants were engaged in fisheries activities. A similar study of the same community was conducted by the same investigators (Irvine et al., 2014), with participants engaged in traditional activities; all food was provided to the participants by the investigators. As explained in Attachment No. 4: "Soil Ingestion for Oklahoma," these two studies are not considered to be applicable to the Quapaw exposure scenario. QTO believes that decades of previous work with multiple lines of evidence is not invalidated by these two studies, The approved Quapaw scenario uses a soil/sediment ingestion of 400 mg/d; the attachment presents the rationale for reducing the soil ingestion rate for another Tribe that behaves differently to 330 mg/d if the other Tribe(s) so desire.

5. **Geographic scope of OU5 needs to be revised.** We see several problems:

   a. We cannot ascertain the geographic scope from the provided information. Does OU5 extend all the way to Grand Lake. Or is it solely within the OU4 boundary?

   b. It is not clear whether riparian and flood-plain soils are included and whether the nature and extent of contamination has been characterized downstream of the source area on the QTO reservation.

   c. Downstream Tribes who are not using the source area uplands should perhaps have a separate OU and subsequent RME based on that OU. That RME would include the floodplains where residences occur.

6. **Frequency of sweat lodge use.** The Quapaw scenario includes daily use of a sweat lodge. We note that asking one tribal member about a lower rate does not invalidate the value used in the officially approved scenario. However, if the downriver tribes wish to use a lower frequency, they may do so.

Specific comments:

The frequency and duration of contact with streams is reasonable and acceptable.

Table 3-1

- Does waterfowl data already exist (so it is not a data gap)?
- Cell 8j: "Two plant types (duckweed and arrowhead root); duckweed = washed whole plant; arrowhead = washed tuber only, washed fine roots only, and washed leaves/stalk only." (OK, but duckweed is not listed in Table 4-1.)
- Cell 11j: What grain size will be used in sieving? As EPA knows, more contaminants are adsorbed as the surface area increases with smaller grain sizes, and stream silt would have smaller grain sizes. Additionally, the sand-silt cutoff (63 um) is the point at which grittiness is detected and spit out. See the Soil Ingestion attachment for a longer discussion.

Table 4-1 - Food

- Footnote 3 – 10% of aquatic food is shellfish, which is reasonable, but what % of the total diet is aquatic?
- Footnote 4 – 20% of aquatic food is amphibian and reptile; 20% is plants. This leaves 50% for fish if small mammals are kept separate; again, what % of the total diet is comprised of aquatic-sourced foods, and what assumption are made about where the rest of the food comes from? It cannot come from OU4, because OU4 has already filled the entire risk allocation.
- It is not clear whether EPA intends to use a fish ingestion rate of 120 g/d plus shellfish (12 g/d), aquatic tubers (40 g/d), plus herps (24 g/d). or whether EPA intends to divide 120 g/d into different fractions.
- Aquatic tubers = 40 g/d (no duckweed?)
- Again, EPA should not convert a 70kg person diet into an 80kg person unless the values are raised to account for a larger person eating more.

Table 4-2 – Sediment

- The exposure frequency of 126 days per year is reasonable for recreational use, but the QTO has not agreed that OU4 is solely recreational or that it is off-limits to users of other OUs (due to unacceptable cumulative risk).

Table 4.3 – SW Potable (surface water in creeks), and Table 4.4 – SW (also in surface water creeks)

- It is not clear how these two tables are different. If the difference is expected to be related to exposure point concentration, then it would seem that a single set of exposure assumption should be used with several different exposure point concentrations (the creek, the mine drainage, the river, and groundwater).
- The drinking/swimming/sweatlodge RME should use maximum concentration of whatever resource is more contaminated. This will provide the upper bound of risk. Then, several mixes of the various sources would provide a more central tendency of risks (e.g., 50:50 GW and SW for 365 days/year, plus swimming during 126 days/year).

Table 4.5 – SW sweat lodge

- Infants (0-24 months) have no sweat lodge use (OK).
  See note above about frequency.

Table 4.6 Arrowhead – medical salve (in addition to ingestion in Table 4-1)

- Includes dermal while digging, 12 d/yr x 64 yrs (adult) or 6 yrs (child).
  This is OK, but the same exposure is received when gathering for food use.

Table 4.7 – discharge

- Dermal exposure 1 hr/event (washing) x 10 events/yr. – adult and child. The exposure frequency should be the same as for the other water bodies, even if the drainage is intermittent.
- The RME should use the maximum concentration from whatever resource is more contaminated. Thus, this is a question of exposure point concentration, not exposure frequency

References Cited

Harper, Barbara, AESE, Inc. 2008. *Quapaw Traditional Lifeways Scenario*. Quapaw, Oklahoma.

Kirschner, F.E., AESE, Inc. 2008. *Site Characterization Report: Sediments, Surface Water, and Vegetation of Tar Creek, Lytle Creek, and Beaver Creek, Oklahoma.*

Attachment No 1. November 22, 2005 Memo to EPA entitled: Expedited Review of Draft Final RAO's (FK_AESE_PRG_RAO_Comments.pdf)

QUAPAW TRIBE OF OKLAHOMA

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

November 22, 2005

Ursula Lennox
Remedial Project Manager
U. S. EPA (6SF-LP)
14445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Lennox:

Please find enclosed, the Quapaw Tribe's comments regarding the Preliminary Remedial Goals (PRGs) and the Remedial Action Objectives (RAOs) currently being developed for OU4 at the Tar Creek site. These comments are a result of what was presented in the November 17-18 meetings held in Tulsa, Oklahoma regarding the RI/S for OU4. These enclosed comments were prepared by the Tribe's consultant, Dr. Fred Kirschner in consultation with me and the Tribal leadership. Establishment of the PRGs and RAOs are critical to the development of the Proposed (remediation) Plan. The Tribe believes that addressing the Tribe's concerns now will be much more productive than proceeding with the development of the Proposed Plan and attempting to address the Tribe's concerns after it has been released to the public.

Please read over the enclosed comments and let me know how you would like to proceed in working together to address them. Moreover, if you have any questions regarding these comments, or if you would like to discuss them, please don't hesitate to call.

Sincerely,

Tim Kent, PG
Environmental Director
Quapaw Tribe of Oklahoma

cc: Honorable John Berrey
Mr. Steve Ward, Esq
Dr. Fred Kirschner

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-924-0184
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Environmental Division Director,
Quapaw Tribe of Oklahoma (O-Gah-Pah)

FEK

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: November 22, 2005

SUBJECT: Expedited Review of Draft Final RAO's

CC: Chairman John Berrey
File

During the November 17-18 meeting in Tulsa, Ursula Lennox, the RPM for the Tar Creek Superfund Site, described how the RI/FS process was following a "deviated approach". This deviation from the typical EPA guidance and procedures enumerated in the National Contingency Plan, surrounds how EPA will incorporate comments and suggestions in the RI/FS process. Due to the compressed time-frame depicted in the "Super Sonic Schedule" (Attachment 1), EPA or the Respondents will not be able to address comments from governmental entities until comments have been received after the Proposed Plan has been published. In essence, the governmental entities, including the Tribe, have been relegated to the status of the "Public".

As you know, we raised concern to the EPA that the Tribe would be unable to provide "meaningful comment" or "comment that could change the outcome of the preferred alternative". The Respondents replied that *if you want to make meaningful comments on the FS, then we need the comments very soon* (paraphrasing).

In response to this statement, this memo identifies major fatal flaws regarding the Draft Final RAO's. Many of which do not meet the requirements specified at 40 CFR 430(e). We believe it is important to express these comments/concerns (again) to EPA and the Respondents very early because the RAO's define the design goals of the Remedial Alternatives—much of which have been already drafted, without the benefit of meaningful comment.

As pointed-out in AESE's October 29,2004 set of comments on the RIFS workplan, the RI/FS process is a "house of cards" with each "floor" relying on the foundation and structural integrity of the previous "floors". The Remedial Action Alternatives rely on the RAOs/PRGs. As pointed-out below, the PRGs/RAOs for this site will ultimately depend on the outcome of the human health risk assessment. General comments on the Human Health Risk Assessment will follow shortly. The Tribe will also prepare comments on the draft Remedial Action Alternatives. These comments will include a new alternative that has not been evaluated at this point.

Again, in preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Preferred Plan.

General Comments

1. Future Land Use (FLU) for the Site was not seriously contemplated prior to development of the PRGs/RAOs as well as the draft Remedial Action Alternatives.

   Webster defines "alternative" as

   > *"an opportunity for deciding between two or more* ***courses or propositions*** *to be chosen".*

   The presumption underlying this definition is that the courses or propositions ultimately "take one to the same place", much like an "alternate route". In the context of CERCLA, the "place" being strived to attain, is achieving a remedy that is protective of Human Health and the Environment for the reasonably foreseeable future land use (FLU).

   Although not specifically enumerated in the NCP, it is presumed that each "Alternative" meets the ultimate goal of protection of Human Health and the Environment ***for the intended future land use***. It would be ludicrous to expect to design anything without an end-state in mind. Like building a house, at a minimum, the client must first specify the number of bedrooms (equivalent to specifying future use). The number of bedrooms dictates his/her septic system needs and other technical specifications so the house functions properly when it is completed and allows the client to use the house as it was intended.

   This concern was brought to the attention of EPA and the Respondents very early in the process. Specifically, within comments provided in the September 30, 2004 memo to EPA (Attachment No. 2) as well as in the August 7, 2004 memo from AESE to QTO. These have been excerpted (once again):

   > "1. The need for a more comprehensive risk assessment was not realized, until recently, when the Tribe secured the services of a technical contractor that specializes in quantifying risk to Native American populations. This increased need and subsequent increase in the Scope of the human health risk assessment (above and beyond that described by the AOC and SOW) stems from the Tribe's traditionally heavy reliance and use of natural resources associated with the site.
   >
   > General Comment No. 2 of the 49 page, August 7, 2004 memo from our technical consultant that was forwarded on to you entitled "Review of ***DRAFT Data Gap Analysis Report Tar Creek OU4 RI/FS Program Prepared for the Tar Creek Respondents and the U.S. Environmental Protection Agency by AATA International, Inc.,***

June 2004" identifies the cleanup goal or post remediation land use (PRLU) for your risk managers.

> ***"2. The reservation is intended to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. The current demography is highly influenced by contamination and subsequent advisories and institutional controls designed to mitigate for current conditions. Therefore, current demographic conditions should not be considered as post-remediation land use (PRLU) in any of the risk assessments."***

Again, this statement provides the goal for the cleanup—a goal very different from that used at the Cherokee and Jasper County sites." [Emphasis added.]

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land must be cleaned up for Unrestricted Land Use. This concept of identifying the FLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to balkanize and compartmentalize a given problem, it is very important that EPA and the Designer of the Remedial Action Alternatives to realize that capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.

This FLU goal does not only apply to lands held in trust by the federal government. The Tribal government is currently repatriating lands within the reservation boundary with the ultimate goal of re-acquiring all non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect Tribal members for unrestricted uses (including but not limited to historical traditional cultural practices) these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

2. The Draft RAOs are not protective of the Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. As stated during the meeting November 17-18, 2005 meetings held in Tulsa:

> "In general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. It is our experience working with tribes throughout the US, that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of contamination. In essence, Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. As a result, our experience at other sites indicates that cleanups will be driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an ARAR.

General Comment 6 of the 49 page August 7, 2004 AESE memo to QTO (Attachment No. 2) identified this issue for EPA risk managers as well.

> *"6. For this site, which involves several Native American Tribes, typical PRG's/RAOs/ARARs will not be protective. Therefore, any sample designs based on the attainability of PRG's/RAOs/ARARs that are designed to protect the general population will not be applicable here (i.e. any study that uses these "standards", designed for the general population, to falsely and incorrectly screen-out COCs, media, pathways, or exposure areas) and will only complicate matters later on in the process when the BHHRA has been completed and it is "discovered" that ARARs, PRGs, and PRAOs are not protective of the Tribes."*

Stated another way, if EPA proceeds to clean-up the site using these PRG's/RAOs/ARARs as design criteria, they will be cleaning-up the site for a population that does not live there today and will probably not live there in the future.

3. The PRGs/RAOs do not consider the exposure that ecological or human receptors receive from the Surface water pathway as well as riparian resources. This is a major error and omission on the part of both the ecological and the Human Health Risk Assessments (this will be discussed in greater detail in comments on those reports).

   The residual exposure to humans from drinking surface water and using surface water in sweatlodge ceremonies alone exceed allowable risk. This risk is real and cannot be assumed away or managed via institutional controls such as signage or education—people are using these resources today. This means that that the allowable risk to Tribal members who use resources for traditional cultural practices will be exceeded even if the uplands are returned to background conditions.

   The concept of an Operable Unit was developed to partition remedial actions into workable or manageable units—not to balkanize risk assessments. The NCP requires protection of human health and the environment for the reasonably foreseeable land use of the *site*—not of an *OU*. In summary, as long as the residual risk from OU1 is measurable, the allowable risk from other OUs must be reduced by an amount so that the cumulative site-wide risk does not exceed the threshold criteria. In this instance, the risk allocated for all other OUs has been usurped by OU1. Therefore, the PRG for all media (e.g. surface water, ground water, soils, floodplain sediments, and air) must be pre-release baseline (background).

Attachment No. 1: Super Sonic Schedule, Nov 15, 2005.

Attachment No. 2: August 7, 2004 memo from AESE to QTO.

Attachment No. 2 November 9, 2004 Memo to EPA entitled:

*Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site (*D3R3_FK_HHRA_DataNeeds_Memo.pdf)

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
702-458-2025
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Director QTI-RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: November 9, 2004

SUBJECT: Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site

CC: Chairman Berrey

Please find attached: (1) a Draft Conceptual Site Model (CSM) depicting pathways, media, transport-specific COC pathways, and human receptors (HHRA-CSM) and (2) a Draft tabulation of proposed sampling needs associated with performing the Human Health Risk Assessment. A brief discussion of each file follows.

Please note that this package is quite similar to the package prepared by AESE on September 20, 2004 except for two general areas: (1) a sheet including Tribal Exposure areas has been included and (2) the data needs summary has been recalculated to reflect a composite-source exposure area and a composite transition zone exposure area. Recall that the earlier draft assumed that five separate Exposure Areas (EAs) would require characterization:

(1) Chat Pile Source Area;
(2) Chat Pile Transition Zone;
(3) Tailings Pond Source Area;
(4) Tailings Pond Transition Zone; and
(5) Riparian/Wetland/Surface water area that is common to both source terms.

In order to reduce sample costs, this draft has commingled the Source Terms and the Transition Zones resulting in only three EAs:

(1) Combined Chat Pile/Tailings Pond Source Area;
(2) Combined Chat Pile/Tailings Pond Transition Zone;
(3) Riparian/Wetland/Surface water area that is common to both source terms.

The result is briefly described in the following Tables and Attachments. Note that this alternative approach was developed to reduce sampling and analytical costs; however, it does so at the expense of specificity. This change from previous submittals will affect the previously designed false positive/false negative error rate and will shift that rate by increasing the probability of incurring false positives—a shift that is detrimental to the Tribe because more areas will be falsely identified as currently causing a significant risk to the Tribe.

Table 1. Non-stationary media.

Phase 1: Temporal Sampling				
Reference Locations	20			
SW/Sed Monitoring Nodes	**20**			
SW Sampling Annual Frequency	12			
Sed Sampling Annual Frequency	4			
Exposure Area (EA)				
20 SW Loc and 20 Reference Areas			**Sample/year "n" [1]**	
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
Surface Water	Total/Acidify in field	12	12	12
	Field Filtered .45 um	12	12	12
	Total/Year/Location	**24**	**24**	**24**
	Total/Year	**960**	**960**	**960**
Sediment	<62 um	4	4	4
	<250 um	4	4	4
	Total/Year/Location	**8**	**8**	**8**
	Total/Year	**320**	**320**	**320**

Table 2. Stationary Media and Flora

Phase 1: "Stationary media": One time Sampling event					
No. Exposure Areas		2	TP/CP, TP/CP-TZ, Aquatic		
Ref EA		1			
Total		3			
				Sample "n" [1]	
Medium	**Preparation**		**TAL-Metals**	**Radionuclides**	**Anions**
Ground Water [2]	Total/Acidify in field		60	60	60
		Total	**60**	**60**	**60**
Air [2]	Cannister		60	60	60
		Total	**60**	**60**	**60**
Soils	<62 um		60	60	60
	<250 um		60	60	60
		Total	**120**	**120**	**120**
Terrestrial Plant (3 plants: **2EAs**: Roots: Leaves: Washed: Unwashed)					
		Total	**480**	**480**	**480**
Terrestrial Plant (3 plants: **REF Area**: Roots: Leaves: Washed: Unwashed)					
		Total	**240**	**240**	**240**
Riparian Plant (3 plants: **1 EA:** Roots: Leaves: Washed: Unwashed)					
		Total	**240**	**240**	**240**
Riparian Plant (3 plants: **1 Ref. Area**: Roots: Leaves: Washed: Unwashed)					
		Total	**240**	**240**	**240**
		Total Plants	**1200**	**1200**	**1200**

HHRA-Conceptual Site Model (CSM: Attachment No. 1)

This Attachment contains four separate sheets and was sent to most of the group with the following discussion:

> *Attached is a fairly intricate CSM being used for the Washoe Tribe at the Leviathan Mine Superfund site* ***[that has been tailored to reflect differences at the Tar Creek Superfund site]****. Note that currently all of the pathways are considered "complete". We may be able to "deactivate" some of these pathways in an attempt to collapse the CSM into something a little more manageable. However, I agree with the approach Mark described today of starting with a robust CSM and if we do not have the data to calculate risk from that pathway, medium, or COC, then at least it still gets "addressed" in the uncertainties section of the BHHRA/BERA.*

Please look this over. We can discuss this sometime next week if you have questions.

I plan on using the CSM as a visual accounting tool to determine the gross data needs. I will probably color code the CSM to indicate which pathway and transfer to secondary media will be modeled, and which media should be measured.

I'll begin working on the "list" of data needs sometime early next week. Call if you have questions.

PS: I did a little research on sieve size as well. One TRW guidance suggests a <250 um OR less. This may give us a little flexibility in the event that the ERA may require <63 um or some other PSD cutoff. I have a call into Art Johnson of the USGS, an international expert on sediments.

The only real change from the previous draft is that we have identified primary and secondary media that should be sampled. These values are portrayed on each of the four sheets in "red font".

Data Needs Tables (Attachment No. 2)

This attachment contains five different spreadsheets. The "Tribal Exposure Areas" was generated using the HHRA-CSM (attachment No. 1) as a visual accounting tool.

One premise basic to development of these tables is that there are essentially three exposure areas (EA's) and an appropriate reference area (RA) required to determine pre-mining baseline conditions (4 areas total). These areas are:

- Combined Jig Tailings Piles/ Flotation Tailings Ponds EA (COC Source Area);
- Transition Zone EA for the combined Jig Tailings Piles/ Flotation Tailings Ponds;
- Riparian Area EA; and
- Reference Areas RA

Each sheet is described below:

1. Tribal Exposure Areas. This sheet summarizes the generalized types of exposures likely to occur to Tribal Members and the General Public within each Tribally owned EA;

2. Sampling Requirement Summary: This sheet summarizes all needs for all EA's and the Reference Areas.

3. SW_Sediment_Riparian_Veg: This area represents the Riparian Zone. Due to the spatial and temporal variability of surface water and sediments, these two media are sampled periodically at 20 locations. Total and dissolved surface water is sampled at a frequency of once per month (12/year). Sediments sieved at two different cut-offs are sampled quarterly (4/year), contemporaneously, and collocated with surface water sediments.

   COCs within the vegetative tissue and within rooting soils and fugitive dust located on leaves is probably much less temporally variable than the surface water of sediments; therefore, a synoptic survey is employed for these secondary media. Both washed and unwashed roots and leaves are sampled for three plant types used by the Tribe at 20 locations that are collocated with the other media. This design should allow for determination of plant tissue-specific transfer coefficients between sediment/surface water and the specific plant part used by the Tribe. Washed and unwashed samples are required to determine the concentration of COCs on plant leaves ingested by the Tribe as well as on plant roots ingested by the Tribe.

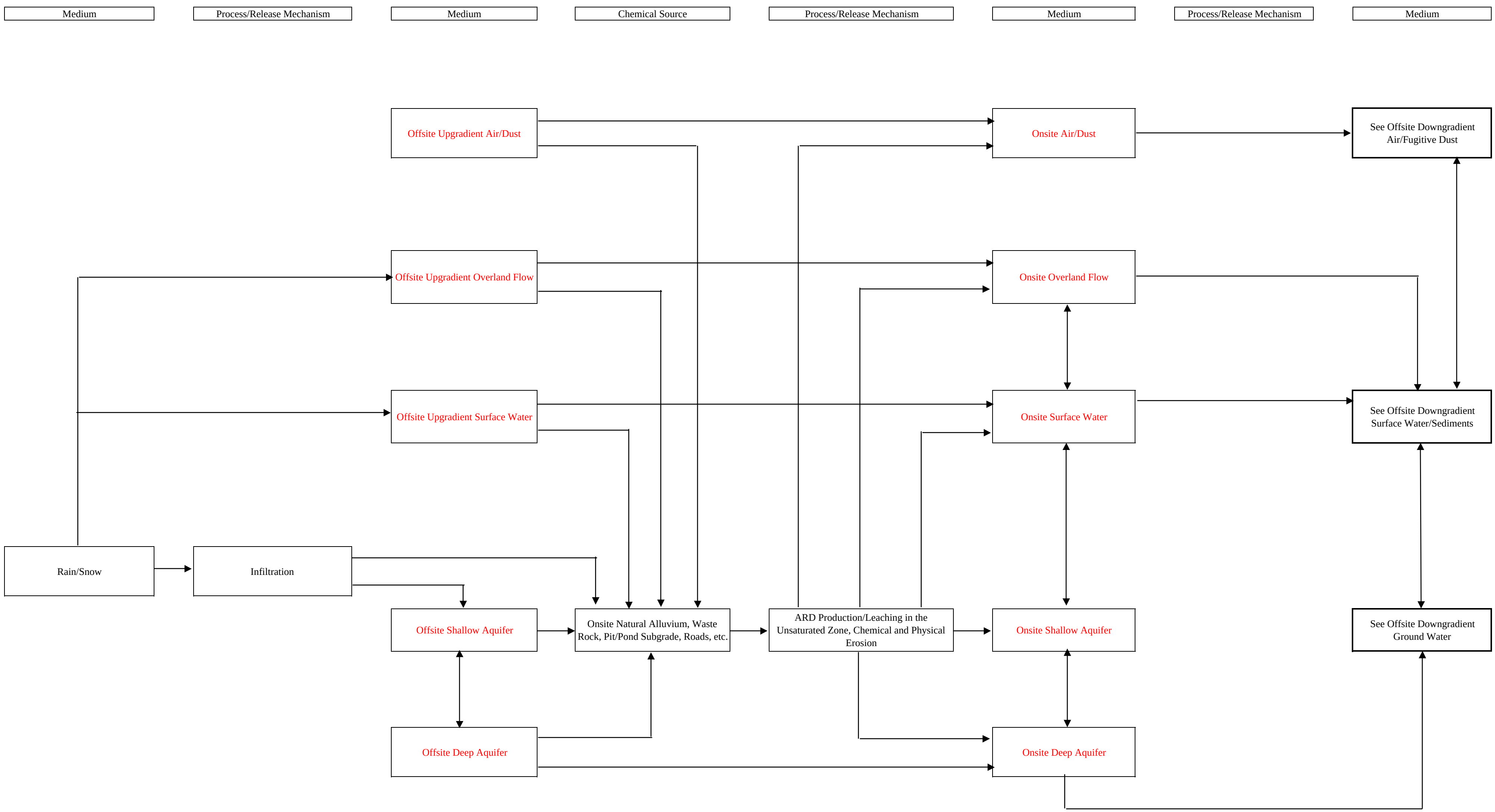
4. Tables 1A through Table 1C are the proposed analytical methods along with the proposed method detection limits. Note that isotopic uranium was included in this phase. Should results of this phase indicate that isotopic uranium is not a COC, this analyte will be dropped from the list of COCs.

Attachment No. 1

DATE: **November 9, 2004**

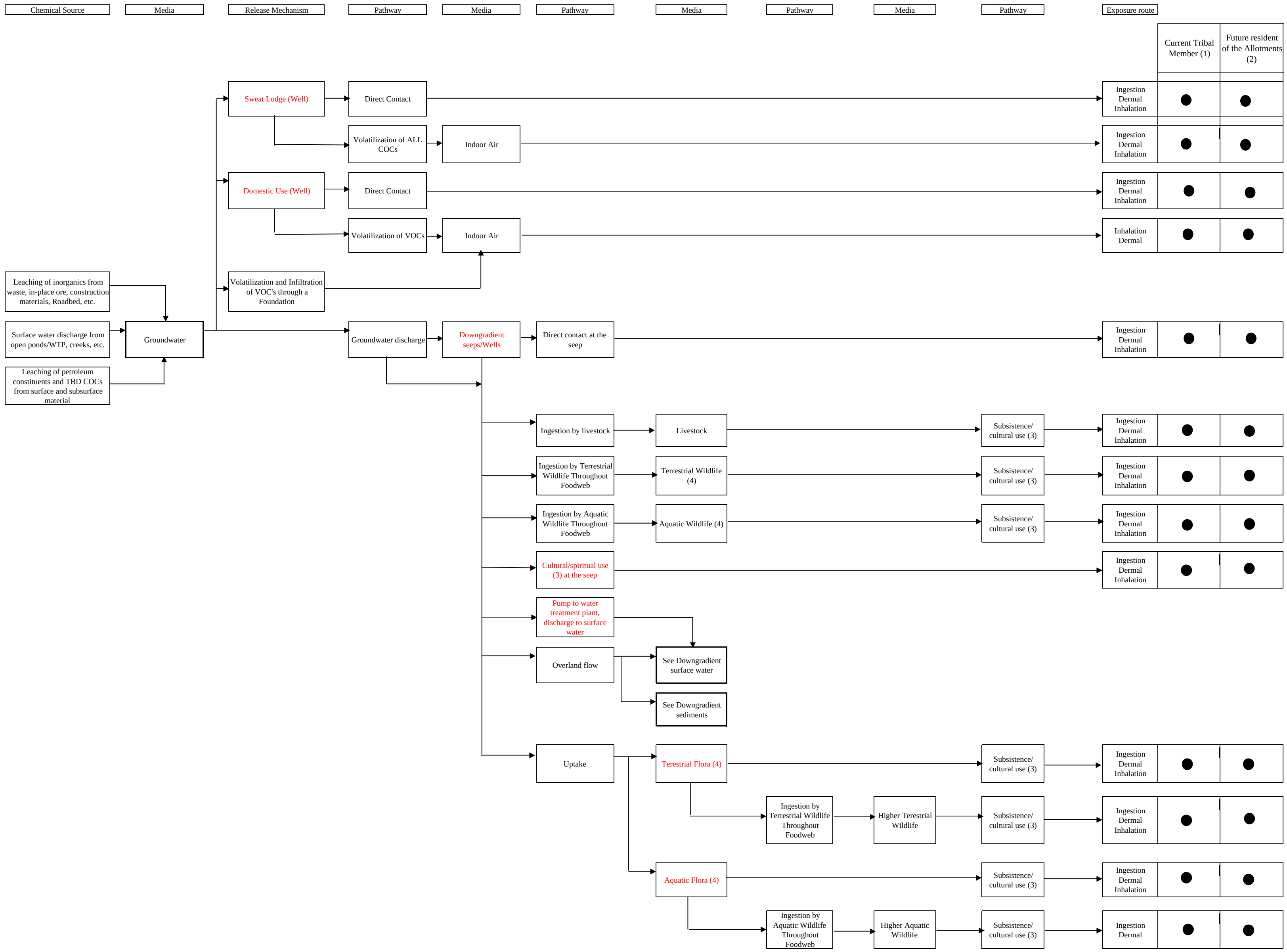
SUBJECT: ***Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site***

Minesite



Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

Downgradient Groundwater



Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine

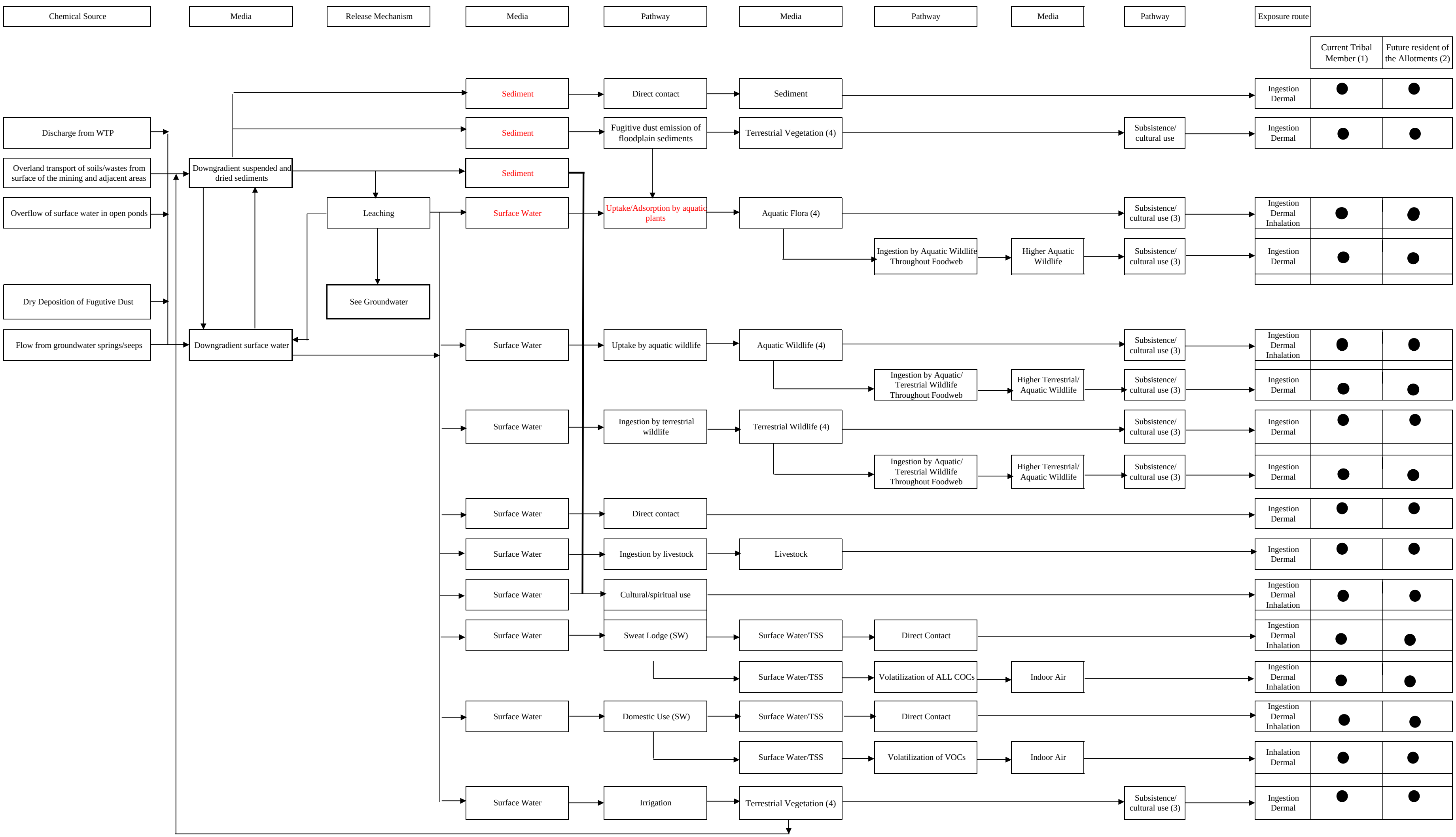
(2) Future resident of the Allotments who lives on areas impacted by the mine

(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.

(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air

(empty box)	Pathway not complete, no evaluation necessary
○	Pathway is or may be complete; however, risk is likely low; qualitative evaluation only.
●	Pathway is complete and may be significant; quantitative evaluation

Surface Water-Sediments



Pathway not complete, no evaluation necessary

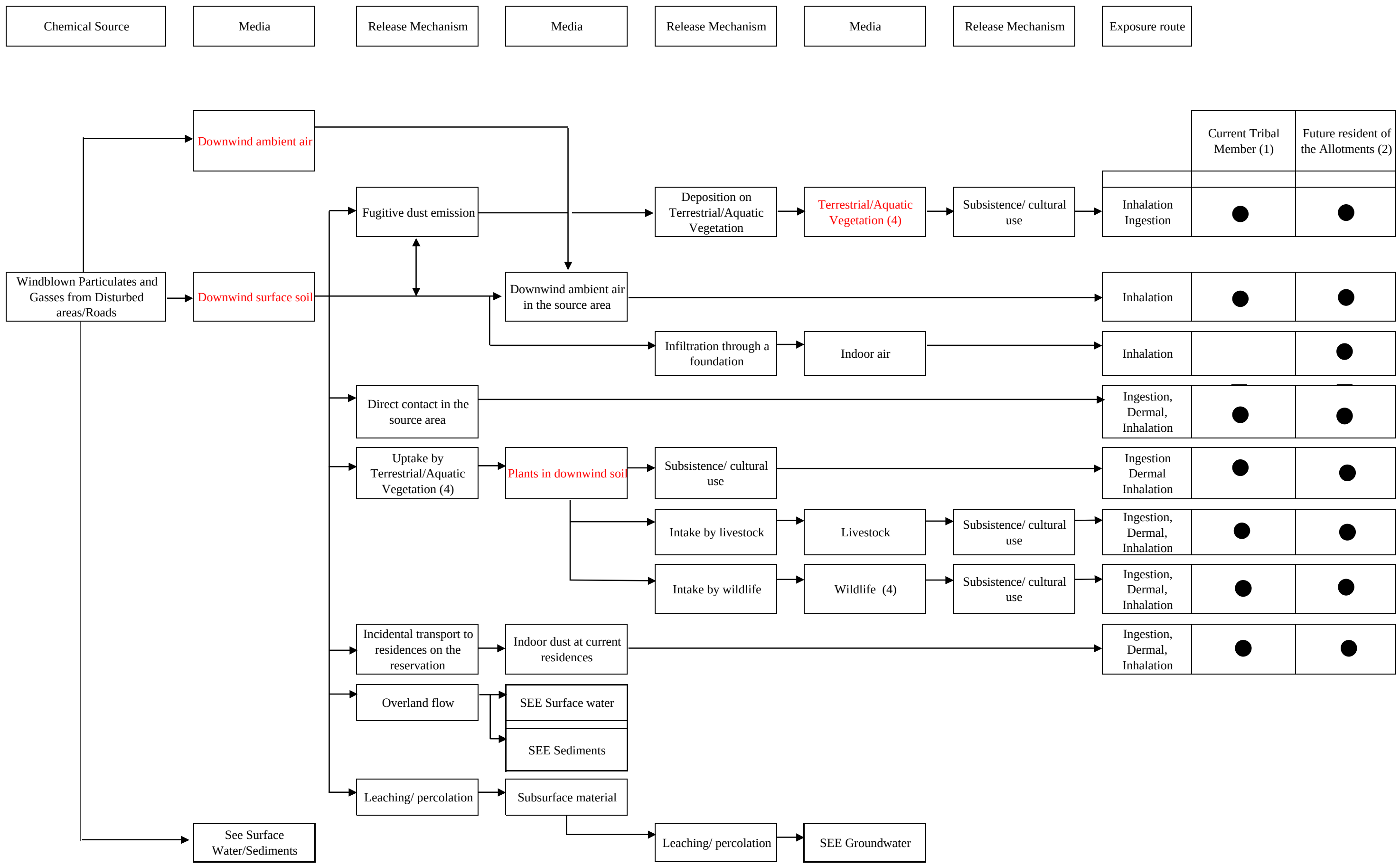
Pathway is or may be complete; however, risk is likely low; qualitative evaluation only.

Pathway is complete and may be significant; quantitative evaluation

Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

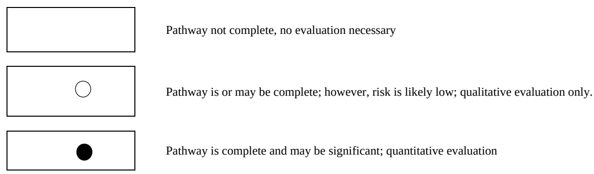
(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine
(2) Future resident of the Allotments who lives on areas impacted by the mine
(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.
(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air

AIR



Media listed in red currently proposed for sampling. Transfer along all other pathways, secondary media, etc. will be modeled.

(1) Current Tribal Member who regularly visits, but does not live on, areas impacted by the mine
(2) Future resident of the Allotments who lives on areas impacted by the mine
(3) Subsistence/Cultural use includes, but is not limited to exposures associated with diet, resource preparation, and other activities associated with the medium for a specific use.
(4) Through death and subsequent erosion and/or leaching, this medium may also be a source to Ground Water, Surface Water, Sediment, or Air



Attachment No. 2

DATE: **November 9, 2004**

SUBJECT: ***Transmittal of Documents/presentations associated with Quapaw Data Needs for OU4 of the Tar Creek Superfund Site***

Tribal Exposure Areas on Tribal lands

General Activity	Source Areas: Chat Piles/Bases/Flotation Tailings Ponds	Transition Zones	Wetlands/Streams [2]
Relative Potential for Tribal Residential Use	High	High	High
Relative Potential for Tribal Subsistence Fishing Use	NA	NA	High
Relative Potential for Tribal Gathering Use (Aquatic)	NA	NA	High
Relative Potential for Tribal Gathering Use (Terrestrial)	High	High	NA
Relative Potential for Tribal Hunting Use	High	High	High
Relative Potential for Tribal Recreational Use	High	High	High
General Population Exposure on Tribal lands [1]			
Relative Potential for General Public Sportfishing Use	NA	NA	Moderate-Low
Relative Potential for General Public Bathing Use	NA	NA	Moderate-Low

NA = Not Applicable

[1] If members of the General Public (GP) reside on Tribal Lands, the residential recreational doses for the GP must also be determined.

[2] although this EA is not officially part of OU4, the dose from these areas must be considered in the Risk Assessment. If the Dose allocation from this EA equals or exceeds Risk Criteria defined by the NCP, then all other EAs must be cleaned-up to pre-release background conditions.

Phase 1: Temporal Sampling				
Reference Locations		20		
SW/Sed Monitoring Nodes		**20**		
SW Sampling Annual Frequenc		12		
Sed Sampling Annual Frequen		4		
Exposure Area (EA)				
20 SW Loc and 20 Reference Areas		**Sample/year "n" [1]**		
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
Surface Water	Total/Acidify in field	12	12	12
	Field Filtered .45 um	12	12	12
	Total/Year/Location	**24**	**24**	**24**
	Total/Year	**960**	**960**	**960**
Sediment	<62 um	4	4	4
	<250 um	4	4	4
	Total/Year/Location	**8**	**8**	**8**
	Total/Year	**320**	**320**	**320**

Phase 1: "Stationary media": One time Sampling event					
No. Exposure Areas		2 TP/CP, TP/CP-TZ, Aquatic			
Ref EA		1			
Total		3			
		Sample "n" [1]			
Medium	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**	
Ground Water [2]	Total/Acidify in field	60	60	60	
	Total	**60**	**60**	**60**	
Air [2]	Cannister	60	60	60	
	Total	**60**	**60**	**60**	
Soils	<62 um	60	60	60	
	<250 um	60	60	60	
	Total	**120**	**120**	**120**	
Terrestrial Plant 1: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	40	40	40	
Roots	washed, pulverized	40	40	40	
Leaves	uwashed, pulverized	40	40	40	
Leaves	washed, pulverized	40	40	40	
Terrestrial Plant 2: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	40	40	40	
Roots	washed, pulverized	40	40	40	
Leaves	uwashed, pulverized	40	40	40	
Leaves	washed, pulverized	40	40	40	
Terrestrial Plant 3: 2EAs					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	40	40	40	
Roots	washed, pulverized	40	40	40	
Leaves	uwashed, pulverized	40	40	40	
Leaves	washed, pulverized	40	40	40	
	Total	**480**	**480**	**480**	

Terrestrial Plant 1 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Terrestrial Plant 2 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Terrestrial Plant 3 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
Riparian Plant 1: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 2: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 3: Onsite					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
Riparian Plant 1 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
Riparian Plant 2 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	

Riparian Plant 3 Ref. Area					Samples Collocated and Contemporaneous with SW/SED/Soils [3,4]
Roots	uwashed, pulverized	20	20	20	
Roots	washed, pulverized	20	20	20	
Leaves	uwashed, pulverized	20	20	20	
Leaves	washed, pulverized	20	20	20	
	Total	**240**	**240**	**240**	
	Total	**1440**	**1440**	**1440**	

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely that more samples will be required to meet statistical design goals. Number of specimens (n) assumes intial CV of 0.20, a = .05; b =.90

[2] Like SW and sediments, these media also should be sampled at an appropriate frequency and duration. However, for the puposes of this phase a synoptic survey approach is utilized

[3] The goal is to determine the relationship (e.g. transfer coefficient) between media (soil/sed/surface water) and the plant tissue. Samples from the sources (Tailings Ponds and Chat Piles), the two Transitions Zones (TZs), and Baseline Reference Areas will be used to generate these relationships.

[4] It is assumed that all three terrestrial/aquatic plant species are collocated with the SW/SED/Soil sample

Reference Locations	20
SW/Sed Monitoring Nodes	**20**
SW Sampling Annual Frequency	12
Sed Sampling Annual Frequency	4

			Sample/year "n" [1]		
Exposure Area (EA)	**Medium**	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
SW Loc 1	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<63 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**

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			Sample/year "n" [1]		
Exposure Area (EA)	**Medium**	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
SW Loc 20	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<63 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/yr	**32**	**32**	**32**
		Total Analyses/yr	**640**	**640**	**640**

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely that more samples will be required to meet statistical design goals.

			Sample/year "n" [1]		
Exposure Area (EA)	**Medium**	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
SW REF Loc 1	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<62 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**

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			Sample/year "n" [1]		
Exposure Area (EA)	**Medium**	**Preparation**	**TAL-Metals**	**Radionuclides**	**Anions**
SW REF 20	Surface Water	Total/Acidify in field	12	12	12
		Field Filtered .45 um	12	12	12
		Total	**24**	**24**	**24**
	Sediment	<62 um	4	4	4
		<250 um	4	4	4
		Total	**8**	**8**	**8**
		Total analyses/EA	**32**	**32**	**32**
		Total Analyses/yr	**640**	**640**	**640**
		Grand Total/yr	**1280**	**1280**	**1280**

Exposure Area (EA)	Medium		Preparation	Sample "n" [1] TAL-Metals	Radionuclides	Anions	
	Riparian Plant 1						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
	Riparian Plant 2						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
	Riparian Plant 3						Samples Collocated and Contemporaneous with SW/SED/Soils
		Roots	uwashed, pulverized	20	20	20	
		Roots	washed, pulverized	20	20	20	
		Leaves	uwashed, pulverized	20	20	20	
		Leaves	washed, pulverized	20	20	20	
			Total	**240**	**240**	**240**	

[1] Actual number of samples "n" depends on the COC having the greatest CV determined from samples using an apriori specified a and b. Since CV will not be known until sampling for this phase has been concluded, it is likely that more samples will be required to meet statistical design goals.

Analyte	Reporting Limit Requirement [1]	Proposed Analysis Method*	Laboratory MDL
Radionuclides	**pCi/L**		**pCi/L**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom Alpha Spec	0.2
Cations	**mg/L**		**mg/L**
Aluminum	0.03	EPA 200.7, ICP	0.03
Antimony	0.00005	EPA 200.8, ICP-MS	0.00005
Arsenic	0.005	EPA 200.8, ICP-MS	0.005
Barium	0.003	EPA 200.7, ICP	0.003
Beryllium	0.002	EPA 200.7, ICP	0.002
Cadmium	0.3	EPA 200.8, ICP-MS	0.3
Calcium	0.2	EPA 200.7, ICP	0.2
Chromium	0.01	EPA 200.7, ICP	0.01
Cobalt	0.01	EPA 200.7, ICP	0.01
Copper	0.01	EPA 200.7, ICP	0.01
Iron	0.01	EPA 200.7, ICP	0.01
Lead	0.0001	EPA 200.8, ICP-MS	0.0001
Magnesium	0.2	EPA 200.7, ICP	0.2
Manganese	0.005	EPA 200.7, ICP	0.005
Mercury	0.0002	EPA 245.1, CVAA	0.0002
Molybdenum	0.01	EPA 200.7, ICP	0.01
Nickel	0.0	EPA 200.7, ICP	0.0
Potassium	0.3	EPA 200.7, ICP	0.3
Selenium	0.001	SM 3500, Se Hydride AA	0.001
Silica	0.2	EPA 200.7, ICP	0.2
Silver	0.005	EPA 200.7, ICP	0.005
Sodium	0.3	EPA 200.7, ICP	0.3
Thallium	0.2	EPA 200.8, ICP-MS	0.2
Uranium	0.00005	EPA 200.7, ICP	0.00005
Vanadium	1.0	EPA 200.8, ICP-MS	1.0
Zinc	1.0	EPA 200.7, ICP	1.0
Anions	**mg/L**		**mg/L**
Sulfate	0.3	EPA 300.0	0.3
Chloride	0.2	EPA 300.0	0.2
Other			
TDS		EPA 160.1	
Hardness		SM 2340 B Calc	
Alkalinity	10	SM 2320B	10
Ammonia			
TDS			
TSS			
TOC			

Analyte	Reporting Limit Requirement	Proposed Analysis Method*	Laboratory MDL
Sample Prep			
Sieve (-63 um)	NA	ASA9-15.4.2.2	NA
Digestion	NA	3050b	NA
Radionuclides	**pCi/g**		**pCi/g**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom ACW 3	0.2
Cations	**mg/kg**		**mg/kg**
Aluminum	3	EPA 6010, ICP	3
Antimony	0.05	EPA 6020, ICP-MS	0.05
Arsenic	0.5	EPA 6020, ICP-MS	0.5
Barium	0.3	EPA 6010, ICP	0.3
Beryllium	0.2	EPA 6010, ICP	0.2
Cadmium	0.01	EPA 6020, ICP-MS	0.01
Calcium	1	EPA 6010, ICP	1
Chromium	1	EPA 6010, ICP	1
Cobolt	1	EPA 6010, ICP	1
Copper	1	EPA 6010, ICP	1
Iron	1	EPA 6010, ICP	1
Lead	0.01	EPA 6020, ICP-MS	0.01
Magnesium	20	EPA 6010, ICP	20
Manganese	0.5	EPA 6010, ICP	0.5
Mercury	0.02	EPA 7470, CVAA	0.02
Molybdenum	1	EPA 6010, ICP	1
Nickel	1	EPA 6010, ICP	1
Potassium	30	EPA 6010, ICP	30
Selenium	0.1	SM 3500, Se Hydride A	0.1
Silica	20	EPA 6010, ICP	20
Silver	0.5	EPA 6010, ICP	0.5
Sodium	30	EPA 6010, ICP	30
Thallium	0.05	EPA 6020, ICP-MS	0.05
Uranium	0.5	EPA 6010, ICP	0.5
Vanadium	0.05	EPA 6020, ICP-MS	0.05
Zinc	1	EPA 6010, ICP	1

Analyte	Reporting Limit Requirement	Proposed Analysis Method*	Laboratory MDL
Sample Prep			
Tissue Pulverization	NA	ASA9-15.4.2.2	NA
Digestion	NA	3050b	NA
Radionuclides	**pCi/g**		**pCi/g**
Isotopic U (238, 235, 234, Total)	0.2	Ei Chrom ACW 3	0.2
Cations	**mg/kg**		**mg/kg**
Aluminum	3	EPA 6010, ICP	3
Antimony	0.05	EPA 6020, ICP-MS	0.05
Arsenic	0.5	EPA 6020, ICP-MS	0.5
Barium	0.3	EPA 6010, ICP	0.3
Beryllium	0.2	EPA 6010, ICP	0.2
Cadmium	0.01	EPA 6020, ICP-MS	0.01
Calcium	1	EPA 6010, ICP	1
Chromium	1	EPA 6010, ICP	1
Cobolt	1	EPA 6010, ICP	1
Copper	1	EPA 6010, ICP	1
Iron	1	EPA 6010, ICP	1
Lead	0.01	EPA 6020, ICP-MS	0.01
Magnesium	20	EPA 6010, ICP	20
Manganese	0.5	EPA 6010, ICP	0.5
Mercury	0.02	EPA 7470, CVAA	0.02
Molybdenum	1	EPA 6010, ICP	1
Nickel	1	EPA 6010, ICP	1
Potassium	30	EPA 6010, ICP	30
Selenium	0.1	SM 3500, Se Hydride	0.1
Silica	20	EPA 6010, ICP	20
Silver	0.5	EPA 6010, ICP	0.5
Sodium	30	EPA 6010, ICP	30
Thallium	0.05	EPA 6020, ICP-MS	0.05
Uranium	0.5	EPA 6010, ICP	0.5
Vanadium	0.05	EPA 6020, ICP-MS	0.05
Zinc	1	EPA 6010, ICP	1

Attachment No. 3 Discussion on Nutritional requirements and body-weight

Discussion on Nutritional requirements and body-weight.

A normal healthy person needs 25-30 kcals/kg/d.

70 kg body weight: 1750 - 2100 kcal/d. Or 2000 kcal for simplicity.

80 kg body weight: 2000 - 2400 kcal/d. Or 2285 kcal/d for simplicity.

Therefore, the 80 kg person needs 2285 calories, whereas the 70 kg person needs 2000 kcal. (http://www.o-wm.com/content/calculating-your-patients%E2%80%99-caloric-needs).

Examples of change in Average caloric intake (generally reflects 2014 intakes and various interpretations):

a. The average American consumes more than 3,600 calories daily – a 24% increase from 1961, when the average was just 2,880 calories. http://www.businessinsider.com/american-calorie-intake-last-52-years-diet-food-eating-increase-science-2017-6

b. By 2010, Americans consumed 20 percent more calories compared to 1970. The average American adult woman needs between 1,800 and 2,400 calories per day, while the average American adult man needs between 2,400 and 3,000, according to the U.S. Department of Agriculture's 2010 Dietary Guidelines, but Americans may be consuming 2,231 to 3,300 calories per day (based on self-reporting and a correction for known under-reporting). https://www.livestrong.com/article/272696-healthy-juice-mixes/

c. Calorie intake data released by The Food and Agriculture Organization shows that Americans eat an average of over 3,600 calories a day, according to the report. This is well above the U.S. Department of Agriculture recommendations. http://healthyeating.sfgate.com/average-calorie-intake-human-per-day-versus-recommendation-1867.html

Average quantity of daily food eaten

In 2014, Americans ate

- Fruits = 261.4 lbs/yr
- Vegetables. = 383.6 pounds

- Dairy = 614.3 pounds
- Grains = 174.4 pounds
- Protein foods = 226.6 pounds (including 7.1 ounce-equivalent of meat, poultry, fish, shellfish eggs, and nuts per person per day).
- Added sugars and sweeteners = 131 pounds per person
- Added fats and oils = 82.2 pounds per person
- Total average annual pounds = 1873.5 pounds, or 5.13 pounds per day, or 82.1 ounces/day. Average total food intake is 2327 g/d (at 28.3495 grams/ounce). Because the average weight is 80 kg, this converts to 29 g/kg-d. This is the mean cited in Table 14-1 of the Exposure Factors Handbook (2011).
- ***We recommend that EPA also examines the total caloric intake for the whole diet and compare it to the caloric needs per kg of body weight, rather than simply diluting a 70-kg diet into an 80-kg body.***

Source material:
"What We Eat in America"
https://www.ars.usda.gov/northeast-area/beltsville-md/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wweianhanes-overview/

https://www.ars.usda.gov/northeast-area/beltsville-md/beltsville-human-nutrition-research-center/food-surveys-research-group/

https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/

NHANES https://www.cdc.gov/nchs/nhanes/wweia.htm

Attachment No. 4 Soil Ingestion for Oklahoma

SOIL INGESTION RATE (revised 2017)

Indigenous Soil Ingestion Rate = 330 mg/d (all ages, all scenarios)
Sieved to grain sizes < 63 µm

Applies to the Tribal Homesteader and Traditional Use Scenarios

SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust Indoor and outdoor), swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The soil ingestion rate is based on a review of EPA guidance, soil ingestion studies in suburban, rural, and indigenous settings, pica and geophagia, and dermal adherence studies. It is also based on homesteading (farming, ranching, gardening) and traditional resource use scenarios use with their higher environmental contact rates and local climatic and geologic conditions.

A soil ingestion rate of 400 mg/d for all ages is the upper bound for suburban children (EPA, 1997), and within the range of outdoor activity rates for adults. Farming, ranching, and traditional Native American lifestyles and natural resource use were not considered by the EPA guidance, but could logically be considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. The current EPA recommended rate of 330 mg/d is lower than the previous high-contact rate of 480 mg/d to allow for some low-contact days, but it should not be lower because there are many "1-gram" days and events such as tilling soil, wrangling livestock, gardening, root digging, plant and material gathering, basketmaking and other use of natural materials, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, firewood splitting, hide tanning, and similar activities. Based on professional judgment, we do not believe that data are adequate to distinguish between homesteading and traditional natural resource-based soil contact rates, and therefore use a single rate for both homesteader and traditional practitioner scenarios.

An updated review (2017) is added at the end of this review, with the conclusion that 330 md/d for all ages is now recommended, based on mass-balance studies of Al and Si, but recognizing that there is still a tremendous variance and uncertainty about true soil ingestion rates as reflected by different trace elements. The gastrointestinal absorption or bioavailability of trace elements needs further investigation, whether from food or other sources, and whether in solid, dissolved, or nanoparticle form, since soil ingestion rates are based on the ingestion/ excretion ratios of

various trace elements. It should also be recognized that the older references (Haywood and Smith 1993; La Goy 1987; Haywood 1985) made measurements and assumptions that are still as valid now as when they were made, and high-contact activities such as wilderness sports, ranching, or certain rural settings have never been fully measured.

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle and the farming-ranching lifestyle are lived in closer contact with the environment than a suburban or urban lifestyle from which most of the soil ingestion data are derived.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat. Rural and farm roads are often unpaved.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater. Similar events for farming, ranching, and homesteading are assumed.
- 400 mg/d is the upper bound for suburban children (EPA, 1997); traditional or subsistence activities are not suburban in environs or activities
- This rate is within the range of outdoor activity rates for adults (between 330 and 480). However, the recommended level is lower than 480 to allow for some low-contact days.
- The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999) such as root gathering days, tule-camas-wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
- This rate does not account for pica or geophagy.
- Primary data is supported by dermal adherence data in gatherers and 'kids in mud'.
- This rate includes a consideration of residual soil on roots through observation and anecdote, but there is no quantitative data.

1. EPA Guidance (through 2009)

EPA has reviewed the studies relevant to suburban populations and has published summaries in its Exposure Factors Handbook (1989, 1991, 1997, and 2011). In the 1997 iteration of the

Exposure Factors Handbook[1], EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion.

In 1997, EPA recommended 100 mg/d as a central tendency for children, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an "upper bound" value (exact percentile not specified), and 10 mg/d for pica children. Most state and federal guidance uses 200 mg/d for children. In 2011, EPA recommended an unspecified upper percentile soil ingestion rate for the general population of children of 200 mg/d for both soil-only and soil plus dust, 1000 mg/d for pica children, and 50,000 mg for geophagy. There are no recommendations for other populations of children. The "general population" refers primarily to the groups of children studied in suburban settings (home, daycare), including several Superfund sites. No studies of indigenous or rural children were used; either they have not been studied, or the ingestion rates were not mass-balance studies.

Other EPA guidance such as the Soil Screening Level Guidance[2] recommends using 200 mg/d for children and 100 mg/d for adults, based on RAGS HHEM, Part B (EPA, 1991) or an age-adjusted rate of 114 mg-y/kg-d. A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as "too speculative." However, the soil screening guidance still recommends 330 mg/d for a construction or other outdoor worker, and risk assessments for construction workers oftenuse a rate of 480 mg/d (EPA, 1997; Hawley, 1985). Other soil ingestion rates are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event[3] to approximate a non-average day for children, such as an outdoor day. This ingestion rate is now (2011) limited to pica children <6 years of age.

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[1] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.
[2] EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (http://www.epa.gov/superfund/resources/soil/toc.htm#p2), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 (http://www.epa.gov/superfund/resources/soil/ssg_main.pdf),
[3] MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

2. Military Guidance

The US military originally assumed 480 mg per exposure event[4] or per field day. For military risk assessment, the US Army used the Technical Guide 230 (TG) as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.[5] No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental U.S. facilities or during deployment. Department Of Defense (2002)[6] recommendations for certain activities such as construction or landscaping which involve a greater soil contact rate was formerly a soil ingestion rate of 480 mg/day. This value sis based on the assumption that the ingested soil comes from a 50 µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50 mg/d) for a chronic average rate of 265 mg/d.

The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[7].

3. Studies in suburban or urban populations

Written knowledge that humans often ingest soil or clay dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high inadvertent, based on studies of pica children (e.g., Kimbrough, 1984). This triggered a great deal of research with industry (e.g., the Calabrese series) or federal funding (e.g., the DOE-funded studies of fallout and bomb test contamination).

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[4] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[5] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine.
Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[6] Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for Deployed Military Personnel", January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

[7] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.unep.ch/btf/missions/september/dufinal.pdf

Some of the key studies are summarized here. Other agencies (including the EPA[8] and California OEHHA) have reviewed more studies and provide more detail. To quote form OEHHA:

> "There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil."[9]

In general, two approaches to estimating soil ingestion rates have been taken. The first method of involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are associated with large uncertainty due to their somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

3.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. In particular, one study of soil ingestion from "sticky sweets" was estimated at 10 mg to 1 g/d (Day et al, 1975).

Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250 mg/d. For outdoor activities from May through October, Hawley estimated the ingestion amount as 480 mg per active day, assuming that 8 hours is spent outdoors per day, 2 d/week.

Other early tracer studies in American children (Binder, et al., 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in all subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch children. Neither study included the trace minerals from food or medicine. A third study (Van Wijnen et al., 1990) used the same approach, and was the first to include a consideration of camping and the presence or absence of gardens.

[8] http://www.epa.gov/ncea/pdfs/efh/sect4.pdf.
[9] California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion. http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicates a mean soil ingestion rate of 91 mg/d, and a 90th percentile of 143 mg/d.

Davis et al. (1990), in Calabrese's laboratory, included an evaluation of food, medicine, and house dust as a better approximation of a total mass balance. As with the earlier studies, using titanium as the tracer results in estimates of extremely large soil ingestion rates (titanium is a common additive in food and commercial products), while Al and Si tracers resulted in a much lower and narrower range of soil ingestion rates. Titanium, however, is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). This illustrates the difficulty of using mineral tracers to calculate mass balance and soil ingestion, but trace studies nevertheless provide the most quantitative estimates.

Calabrese et al. (1989) based estimates of soil ingestion rate in children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in the Amherst, Massachusetts. They used a method similar to Binder et al. (1986) but included an improved mass balance approach. They evaluated soil ingestion over eight days rather than three days, and collected duplicate samples of food, medicine, and house dust. In addition, the children used tracer-free toothpaste and ointment. The adult (n = 6) validation portion of the study indicated that study methodology could adequately detect soil ingestion at rates expected by children. Recovery data from the adult study indicated that Al, Si, Y, and Zr had the best recoveries (closest to 100%). Zirconium as a tracer was highly variable and Ti was not reliable in the adult studies. The investigators conclude that Al, Si, and Y are the most reliable tracers for soil ingestion. This was also the first study to evaluate whether pica children were present in the sampled population; one diagnosed pica child was found.

Stanek and Calabrese (1995a) adjusted their 1989 data for the 64 children. The primary adjustment was related to intestinal transit time, which allowed an adjustment for clearance of minerals on days when fecal samples were not collected. They concluded that daily intake based on the "overall" multi-tracer estimates is 45 mg/day or less for 50 percent of the children and 208 mg/day or less for 95 percent of the children. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1 – 2268 mg/d; the median (lognormal) was 75 mg/d, the 90th % was 1190 mg/d, and the 95th% was 1751 mg/d. The known pica child was not included, and individual "outlier" results for individual tracers were also omitted. Even so, the range of rates is so large that it is evident that there are still methodological difficulties.

Stanek and Calabrese (1995a) also evaluated the number of days a child might have excessive soil ingestion events. An estimated 16% of children are predicted to ingest more than 1 gram of soil per day on 35-40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35-40 days per year.

Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study with data from Davis et al. (1990) and using a different methodology. This methodology, the Best Tracer Method (BTM), is designed to overcome inter-tracer inconsistencies in the estimation of soil ingestion rates. The two data sets were combined, with estimates as follows: 50th = 37 mg/d, 90th = 156mg/d, 95th = 217mg/d, 99th = 535mg/d, mean = 104mg/d. Even with this method, they conclude that the large standard deviation indicates that there are still large problems with "input-output misalignment." They also says that soil ingestion cannot even be detected, in comparison to food, unless more than 200 mg/d is ingested, rather than lower rates as they indicated in 1989.

Stanek et al. (2000) conducted a second study of 64 children aged 1-4 at a Superfund site in Montana, using the same methods as they did in their earlier study, with 3 additional tracers. Soil, food and fecal samples were collected for a total mass balance estimate. The home or daycare settings were not described, nor were the community conditions or the typical daily activities of the children, and 32% of the soil ingestion estimates were excluded as outliers. In addition, only soil with a grain size of 250 um or less was used; no explanation of concentration differences between large and small grain sizes were given (see discussion on dermal adherence) and no concentration data were included.

3.2 Studies in Adults

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese and co-authors (1997) conducted a second adult pilot study (n = 10) to compare tracers. This study was done as a method validation, and was "not designed to estimate the amount of soil normally ingested by adults." Each adult was followed for 4 weeks. The median, 75th percentile, and 95th percentile soil ingestion estimates were 1, 49, and 331 mg/day, with estimates calculated as the median of the three trace elements Al, Si, and Y.

4. Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1992) evaluated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. Annual doses to individuals following an aboriginal lifestyle could result in an annual effective dose equivalent of several mSv within contours enclosing areas of several hundred square kilometers. The most significant dose pathways are inhalation of resuspended dust and ingestion of soil by infants based on measurements of dust in air, activity diaries, and modeling. Haywood and Smith constructed a table showing hours per week sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

> "*virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1 gpd was estimated based on fecal samples of nonaboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aboriginals under camp conditions. In the absence of better information, a soil intake of 10 gpd has been assumed in the assessment for all age groups."*

They noted a "very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent. "

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of 500 mg/d. This was based on the primary work of Haywood and Smith who "reported an average soil intake of 10,000 mg/d in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia." The authors state that:

> "*Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of 1,000 mg/d was established from the fecal samples of the investigators who made field trips to the affected areas*."

"*It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported a maximum intake of 500 mg/d for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average for the Marshallese people. Therefore, this work adopts 500 mg/d as the average life-time intake of soil by the Marshallese*."

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5 g/d. These are all geometric means (lognormal) or modes (triangular distribution), not maxima.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that "*the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined*."

5. Geophagia

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the Philippines, New Guinea, Costa Rica, Guatemala, the Amazon and Orinoco basins of South

America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991).

There are two types of edible clays, sodium and calcium montmorillonite[10]. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite, the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid, 1992; Krishnamani and Mahaney, 2000).

Krishnamani and Mahaney (2000) propose several hypotheses that may contribute to the prevalence of geophagy:

(1) soils adsorb toxins.

(2) soil ingestion has an antacid action.

(3) soils act as an antidiarrheal agent.

(4) soils counteract the effects of endoparasites.

(5) geophagy may satiate olfactory senses.

(6) soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette, 1991). This is especially important in pregnancy and at high altitudes.

Several studies of geophagia in pregnancy have been done. In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may

[10] http://www.the-vu.com/edible_clay.htm

be very important as a mineral supplement, particularly iron and calcium during pregnancy (Abrahams, 1997). One widely held theory suggests that iron deficiency is a major cause of geophagia[11]. Several reports have described an extreme form of geophagy (pica) in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of pica or a result of it. Because some substances, such as clay, are believed to block the absorption of iron into the bloodstream, it was thought that low blood levels of iron could be the direct result of pica. Some studies have shown that pica cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces pica (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C.. Serum ferritin concentrations of pica women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their nonpica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less those of nonpica women. Again, low ferritin and hemoglobin are hypothesized to result in pica.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother's secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines. Adjuvants are compounds that nonspecifically amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al is one of Calabrese's preferred tracers due to the assumption that it is not adsorbed and inert at trace levels (it is quite toxic at high levels).

6. Acute Soil Ingestion and Pica

There is a gradient between geophagy and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide

[11] http://www.ehendrick.org/healthy/001609.htm

variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails, paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults, with 10-32% of children aged 1 to 6 may exhibit pica behavior at some point[12]. LaGoy (1987) estimated that a value of 5 gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 5000 mg of soil per day but cautioned that the amount selected was arbitrary[13]. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25-60 g soil during a single day. When a set of 13 chemicals were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

(1) EPA (1997) recommends a value of 10g/d for a pica child.

(2) Florida recommends 10g per event for acute toxicity evaluation[14].

(3) ATSDR uses 5 g/day for a pica child[15].

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[12] http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors

[13] Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: http://www.atsdr.cdc.gov/NEWS/soilpica.html

[14] Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf .

[15] For Example: El Paso Metals Survey, Appendix B, www.atsdr.cdc.gov/HAC/PHA/**elpaso**/epc_toc.html.

(4) EPA (2011) now uses a cutoff of 1000 mg/d as the definition of pica. Note that this skews ingestion rates lower because any child ingesting over 1000 mg/d is assumed to be pica, and therefore can be removed from the 'normal' population.

7. Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Although this body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers from Kissel's laboratory are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings, up to 27 mg/cm^2. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). Since reed gatherers, farmers, and gardeners had higher skin loadings, this is supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) said that variability in estimating soil ingestion rates using tracer elements was reduced when a grain size less than 250 um were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size, with particles above the sand-silt size division (0.075 mm) adhering less than smaller sizes. Average adherences of 1.40 mg/cm^2 for particle sizes less than 150 µm, 0.95 mg/cm^2 for particle sizes less than 250 µm and 0.58 mg/cm^2 for unsieved soils were measured (see EPA, 1992[16] for more details). Soil samples should be sieved and concentrations should be evaluated for sizes below 0.075 mm.

A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and

[16] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil. Soil loading on various parts of the body is collected with wipes, tape, or rinsing in dilute solvents, which would generally collect the smaller particle sizes[17]. Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size <0.044 cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size.

8. Data from washed or unwashed vegetables.

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is important source of radionuclides to grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

[17] Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2 mm; silt = 1/256 to 1/16 mm; clay = <1/256 mm.

9. Homesteader and Traditional Practitioner rationale for soil ingestion rate

In brief, the homesteader is a residential farming and ranching scenario with a kitchen garden, row crops, and hay production. The homesteader may leave the homestead for short hunting excursions, but the exposure frequency is left at 365 days per year as an upper bound. The traditional practitioner lives in the community but spends his snow-free days at developed or undeveloped camps hunting, fishing, and gathering.

The soil ingestion rate of 330 mg/d is based on the following points:

- It conforms to EPA recommendations for higher soil contact situations.
- Low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999).
- This rate is lower than Simon estimate of 500 mg/d and lower than the recommendations of 3 g/d for indigenous children and 2 g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles.
- This rate includes a consideration of the number of windy-dusty days, but without further quantification of air particulates.

10. Soil and Dust Ingestion Update (2017)

The emphasis of soil ingestion studies is on children, and rightly so. It is generally (but not always) true that setting cleanup levels based on children's exposures will also protect adults. But much less has been published for adults, so risk assessors may at times fail to recognize situations where adults have high exposures, and, lacking data, overlook or underestimate those exposures. A brief update of adult rates for use in risk assessment is given below.

The questions that the risk assessor must answer are: (1) Are there people who may have higher exposures and/or who are more sensitive, and (2) Is there data to describe a Central Tendency Exposure (CTE) and RME for these scenarios? For the **Tribal Homesteader** (residential farming and ranching) scenario and the **Traditional Practitioner** (non-residential hunting, fishing, gathering), which are quite different from the suburban lifestyles used to develop default values, the questions can be restated as, (1) Are the generic default exposure parameters reflective of a mean and 90th or 95th percentile for each of the two scenarios, and (2) Is professional judgment needed to justify a more appropriate set of exposure parameters?

EPA CERCLA baseline risk assessments are required to use exposure scenarios that are selected to reflect both "average" or Central Tendency Exposure (CTE) and Reasonable Maximum

Exposure (RME).[18] The document "Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final" originally dated EPA/540/1-89/002 December 1989 and re-posted in 2015[19] directs project managers to:

> *Review information on the site area to determine if any subpopulations may be at increased risk from chemical exposures due to increased sensitivity, behavior patterns that may result in high exposure, and/or current or past exposures from other sources. Those potentially at higher risk due to behavior patterns include children, who are more likely to contact soil, and persons who may eat large amounts of locally caught fish or locally grown produce (e.g., home-grown vegetables).*
>
> *Recommendations are based on EPA's determination of what would result in an estimate of the RME. As discussed previously, a determination of "reasonable" cannot be based solely on quantitative information, but also requires the use of professional judgment. Accordingly, the recommendations below are based on a combination of quantitative information and professional judgment.*
>
> *Contact rate reflects the amount of contaminated medium contacted per unit time or event. If statistical data are available for a contact rate, use the <u>95th percentile</u> value for this variable. (In this case and throughout this chapter, <u>the 90th percentile</u> value can be used if the 95th percentile value is not available.) If statistical data are not available, professional judgment should be used to estimate a value which approximates the 95th percentile value. (It is recognized that such estimates will not be precise. They should, however, reflect a reasonable estimate of an upper-bound value.)*

It is not clear what the current default soil ingestion rate should be, since EPA documents are constantly being updated and old documents are re-posted (presumably after review to ensure that they represent the latest policy), and are not always consistent with each other. For the purposes of CERCLA risk assessment, OSWER Directive 9200.1-120 February 6, 2014 ("Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors") uses a soil ingestion rate 100 mg/d for adults. Soil screening levels (OSWER 9355.4-24, 2002) are based on 100 mg/d for residential adults and 330 mg/d for short-term non-residential construction work, with the admonition that a full risk assessment should be more comprehensive.

USEPA's 2011 revision of the Exposure Factors Handbook ("EFH 2011") presents default values for national soil ingestion rates. Based primarily on reanalysis of older data plus three

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[18] "Because of the uncertainty associated with any estimate of exposure concentration, the upper confidence limit (i.e., the 95 percent upper confidence limit) on the arithmetic average will be used for this variable. USEPA RAGS-A; https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf, page 6-19.
[19] https://www.epa.gov/sites/production/files/2015-09/documents/rags_a.pdf

studies published after 1997, the current default soil ingestion rate for all adults, whether indoor resident or outdoor worker, appears to be 100 mg/d, with 50 mg/d for the indoor worker (USEPA 2015 (Human Health Evaluation Manual); EPA 1989 (RAGS A)), although EFH 2011 gives the central tendency of soil plus dust ingestion for adults as 50 mg/d based on the Davis and Mirick 2006 study. No upper percentile is given, leaving that to the risk assessors for a particular site. Thus, the questions are (1) is 100 mg/d or another number intended to be a number a 90th or 95th percentile, (2) why are the soil and soil + dust upper percentiles the same for children aged 3 to <6 years of age, and (3) are they even relevant to either tribal scenario if the tribal scenario is not a 'general population' lifestyle?

Table 5-1. Recommended Values for Daily Soil, Dust, and Soil + Dust Ingestion (mg/day)

	Soil[a]				Dust[b]		Soil + Dust	
			High End					
Age Group	General Population Central Tendency[c]	General Population Upper Percentile[d]	Soil-Pica[e]	Geophagy[f]	General Population Central Tendency[g]	General Population Upper Percentile[h]	General Population Central Tendency[c]	General Population Upper Percentile[h]
6 weeks to <1 year	30				30		60	
1 to <6 years	50		1,000	50,000	60		100[i]	
3 to <6 years		200				100		200
6 to <21 years	50		1,000	50,000	60		100[i]	
Adult	20[j]			50,000	30[j]		50	

[a] Includes soil and outdoor settled dust.
[b] Includes indoor settled dust only.
[c] Davis and Mirick (2006); Hogan et al. (1998); Davis et al. (1990); van Wijnen et al. (1990); Calabrese and Stanek (1995).
[d] Özkaynak et al. (2011); Stanek and Calabrese (1995b); rounded to one significant figure.
[e] ATSDR (2001); Stanek et al. (1998); Calabrese et al. (1997b; 1997a; 1991; 1989); Calabrese and Stanek (1993); Barnes (1990); Wong (1988); Vermeer and Frate (1979).
[f] Vermeer and Frate (1979).
[g] Hogan et al. (1998).
[h] Özkaynak et al. (2011); rounded to one significant figure.
[i] Total soil and dust ingestion rate is 110 mg/day; rounded to one significant figure it is 100 mg/day.
[j] Estimates of soil and dust were derived from the soil + dust and assuming 45% soil and 55% dust.

USEPA (EFH 2011, chapter 5) discusses soil ingestion rates and uses one study (Davis and Mirick, 2006), supported by other studies (Hogan, Ozkaynak), to support the adult soil ingestion rate. The Davis and Mirick study used a mass balance method that measured quantities of specific elements present in feces, urine, food and medications. Thirty-three adults from a suburban area in southeast Washington during summer and fall months in 1988. This is a hot arid area, sometimes dusty, with summer temperatures sometimes exceeding 100 degrees. No garden vegetables were consumed. For the aluminum and silicon tracers, soil ingestion rates ranged from 23−92 mg/day (mean), 0−23 mg/day (median), and 138−814 mg/day (maximum), with an overall mean value of 52 mg/day for the adults in the study. The large range of maximum values suggests that there are some people even in suburban settings with significantly higher soil contact and ingestion.

The most commonly used soil ingestion values for occupational and outdoor exposures are 330 mg/d and 480 mg/d while the worker is engaged in those activities. Single high-contact events are not included.

Soil Ingestion Rate for Construction Worker - 480 mg/day (USEPA 1996, 2002)
Soil Ingestion Rate for Industrial Worker - 136 mg/day (USACE 1998)
Sediment Ingestion Rate for Sewer Maintenance Worker - 330 mg/day (USACE 1996, 2002)
Soil Ingestion Rate for Utility Worker - 480 mg/day (USEPA 1996, 2002)

EPA (2002) in the Soil Screening Levels Directive 9355.4-24, gives a soil ingestion rate for construction workers as 330 mg/d, and says that the soil ingestion rate was revised from the previous default ingestion rate of 480 mg/d, albeit without any new data. The activities for this receptor typically involve substantial on-site exposures to surface and subsurface soils. The construction worker is assumed to be exposed to contaminants via incidental soil ingestion, dermal absorption, inhalation of volatiles outdoors, and inhalation of fugitive dust. The default value of 330 mg/day (Stanek et al., 1997) replaces the previous default 95th percentile ingestion rate of 480 mg/day (Hawley, 1985). While the Hawley value was based on a theoretical calculation for adults engaged in outdoor physical activity, the revised default ingestion rate is based on the 95th percentile value for adult soil intake rates reported in a soil ingestion mass-balance study that was not in dusty or outdoor settings other than a suburban backyard.

Hawley (1985) used a set of assumptions to estimate total dust exposure (ingestion, inhalation, and dermal) while entering dusty attics (12 hrs/yr) and outdoor work (80 hrs/yr) based on skin adherence and surface area, the ratio of indoor to outdoor dust, and similar factors. These remain reasonable assumptions. Other investigators have studied dermal loading of soil residues in various activities such as children playing in the mud and adults playing rugby, gathering reed, or digging clams (Kissel et al., 1996; Shoaf et al., 2005). The Stanek et al, (1997) study administered measured soil aliquots in gelatin capsules to 10 volunteers and collected food and feces over 7-day intervals spread over several months, for a total of 280 collection days. No information is provided about the activities of the participants while they were collecting all of their fecal output.

The military follows EPA guidance on exposure factors if they are relevant to military situations (US Army, 2010). The National Research Council (2004) reviewed the Army's exposure parameters. In RD-230 (2003) an average soil ingestion was derived by assuming that soldiers have an equal number of high-contact days (at 480 mg/d) and low-contact days (50 mg/d), for an average of 265 mg/d. In RD-230 (2003), the US Army gives the rationale that the EPA recommendation for construction or landscaping was 480 mg/d at that time, and that soldiers' field activities may include digging or crawling on the ground. Following EPA's recommendation of using the high-contact rate for limited exposure frequencies, the Army averaged the two rates. Subsequently, the Army lowered the high-contact rate to 330 mg/d (US Army 2010).

Two recent papers have appeared that evaluate native peoples engaged in some traditional activities using a mass-balance approach consisting of measuring trace elements that are not well-absorbed in the intestinal tract in food and feces, and assuming certain intestinal absorption, and that any increase over expected values comes from other sources such as soil ingestion or possibly other consumer products.

The first study was a pilot study of 7 subjects living in British Columbia was conducted over a 3-week period (Doyle et al., 2012). During most of this time the subjects were conducting fisheries-related activities. Daily activities included clearing deadfall from spawning streams, collecting Sockeye salmon using traditional methods, such as "dip nets" or seine nets along the shore, weighing, bleeding and cleaning each fish, and storing the catch in a mixture of brine and ice. The late afternoon and evening involved scouting of new dip net locations by hiking up the shore of the river or fishing for Sockeye and Chinook salmon with rod and reel, in addition to routine camp activities (e.g., eating and clean-up, collecting and cutting firewood, etc.). All foods (breakfast, lunch, dinner and snacks) were provided. The study did not include ingestion related to "high contact" activities and/or ingestion of soil in traditional foods, and the authors state that soil ingestion studies for potentially higher soil contact activities (e.g., root digging, attending and/or participating in rodeos, plowing, etc.) are warranted. The mean soil ingestion rate estimated in this study using the 4 elemental tracers with the lowest food-to-soil ratios (i.e., Al, Ce, La, Si), was observed to be approximately 75 mg/d, the median soil ingestion rate was 50 mg/d, and the 90th percentile was 211 mg/d. The second paper (Irvine et al., 2014) recalculated the 90th percentile of the first study to 193 mg/d, all with very large standard deviations and vastly different rates for different tracers. It is a point of discussion whether this is an actual "wilderness" setting, as opposed to a rural setting with fisheries activities, and also whether so much water contact resulted in lack of adherence of soil to skin.

The second study was by the same investigators and evaluated 9 subjects over a 13 day period in Cold Lake, Alberta (Irvine et al., 2014). The purpose was to determine if soil ingestion in a community with a 'wilderness' lifestyle is greater than soil ingestion values used in Canadian human health risk assessments. The area has a humid continental climate, with a lower than average rainfall compared to other Canadian cities, and contains many unpaved roads that can contribute to airborne dust particles. An outdoor base camp was established and all participants remained at the base camp for the duration of the study, and engaged in a variety of outdoor wilderness activities during the day (e.g., fishing, hunting, food gathering). All food was provided and prepared for study participants, and the exact amount of food consumed by each participant was pre-weighed. Activities included hunting and setting traps and snares on the reserve, fishing and setting fishing nets, collection of medicinal plants on the reserve and surrounding traditional lands, and collection of foods and spices such as blueberries, bear berries, and mint. Although this study did not detect a statistically significant effect of activities on soil ingestion rate, the authors recommended follow-up studies that include higher soil contact activities (i.e., rodeo participation, root harvesting) and other seasons. This study found a mean (Al, Ce, La, Si) of 32 mg/d and a 90th percentile of 152 mg/d.

At the request of USEPA[20], the authors combined the results of the two studies for the two most commonly used tracers as follows (units in mg/d):

Tracer	*Mean*	*50th*	*90th*	*95th*
Al	37	19	155	213
Si	59	39	213	264
Average of Al and Si	**48**	**29**	**184**	**239**

The results from the Irvine report are reproduced below. The means are similar but not identical when calculated first by combining all data for each element (Table 5) or calculated per person first (Table 6). This may be a statistical artifact of the sequence of data combination. The trace elements Al and Si are generally used as the most suitable tracers according to generally accepted criteria of being poorly absorbed, having a low food/soil ratio, and being within accurate instrument measurement ranges. Even so, the variances are large considering that all the food was pre-weighed and analyzed, suggesting that either different participants had different behaviors, the sources were not homogeneous, or there were inconsistencies in fecal collection.

Table 5
Summary of soil ingestion rates calculated for each of the 12 elemental tracers examined. Soil ingestion rate is expressed as mg d^{-1}.

	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
Mean	36	318	12	12	1998	68	−378	3215	−183	196	−7	19
Standard deviation	117	1662	72	78	10,107	152	461	5622	238	626	145	407
Standard error	12	176	8	8	1071	16	49	597	25	66	15	43
Median	7	467	−4	−2	1034	37	−390	759	−185	143	−17	−30
90th percentile	165	1744	111	97	11,555	231	109	9325	111	1032	159	211
95th percentile	268	2405	132	156	18,226	361	217	16,459	169	1226	230	301
Upper 95% CI[a]	65	650	29	32	4075	104	−283	4662	−129	328	27	196
Lower 95% CI[a]	15	−26	−1	−1	−164	40	−479	2242	−230	69	−34	−34
n	87	87	87	87	87	87	87	87	87	87	87	87

[a] Upper and lower 95% confidence intervals are bootstrapped confidence intervals with 5000 bootstrapped replicates.

[20] M. Stifelman, Region 10 Office of Environmental Assessment and Review, March 9, 2017

Table 6
Soil ingestion rate values calculated for each participant. Mean, standard deviation (SD), median, and sample size are given for each participant over the study duration. Soil ingestion rate is expressed as mg d^{-1}.

Subject	Al	Ba	Ce	La	Mn	Si	Th	Ti	V	U	Y	Zr
A	18	384	19	16	2346	119	−244	5314	−197	117	16	64
B	−47	−1005	−41	−42	−2820	−19	−790	163	−400	−295	−157	−38
C	152	485	82	92	6665	267	−725	13,574	−352	260	78	616
D	32	37	−2	−1	−1697	3	−195	839	−185	−103	−60	−57
E	55	8	−8	0	−875	61	−544	1861	−179	290	27	−109
F	32	394	34	25	10,137	58	−406	2343	−252	166	25	−13
H	60	631	13	11	4714	72	−111	5055	−30	582	−15	−30
I	−11	620	−9	−7	1408	87	−349	443	45	54	−34	−38
J	6	1759	10	13	−7612	25	−307	719	−86	601	1	−12
Mean	33	368	11	12	1363	75	−408	3368	−182	186	−13	43
SD	55	725	34	36	5359	84	234	4277	144	292	67	220
Median	32	394	10	11	1408	61	−349	1861	−185	166	1	−30
n	9	9	9	9	9	9	9	9	9	9	9	9

One explanation for the vastly different input-output differences for some elements, such as titanium, has been that some elements are present in relatively high quantities in consumer products, since the content in foods were all accounted for. However, titanium (always high in excreta measurements) is a common food additive and is poorly absorbed in nanoparticle form (Cho et al., 2013), so it is possible that elements other than Al and Si may reflect unrecognized ingestion sources that might or might not be related to soil ingestion. For example, aluminum is poorly absorbed following either oral or inhalation exposure and is essentially not absorbed dermally. Approximately 1.5–2% of inhaled and 0.01–5% of ingested aluminum is absorbed. The absorption efficiency is dependent on chemical form, particle size (inhalation), and concurrent dietary exposure to chelators such as citric acid or lactic acid (oral), and is primarily excreted in the urine, with a lesser amount in the bile, but it binds to various ligands in the blood and distributes to every organ, with highest concentrations ultimately found in bone and lung tissues.[21] The general assumption that 100% of poorly-absorbed trace elements occurs within 24 hours may need to be revisited. Ultimately, titanium must be explained, along with inter-individual differences and the negative results for some subjects (assumed to be due to missed sample collection).

11. Grain or Particle Size

It has been known for decades that greater concentration of contaminants measured in smaller particles is due to increased surface area. For example, Parizanganeh (2008) found that the majority of trace elements were present in the 63 µm fraction. Zhao et al. (2003) found that particles with smaller grain size (<250µm) contributed more than 80% of the total metal loads in road runoff, while suspended solids with a grain size <44µm in runoff water accounted for greater than 70% of the metal mass in the total suspended solids. Sutherland (2003) found that sediment <63µm accounted for 51% of the total Pb load in road sediments. Wang et al. (2006) found that higher concentrations of anthropogenic heavy metals (Cu, Zn, Mo, As, Hg, Bi, Ag)

[21] https://www.atsdr.cdc.gov/toxguides/toxguide-22.pdf

are observed in the finest particle grain size fraction (i.e. < 45µm) of road dust. Some heavy metals (Se, Sb and Ba) behave independently of selected grain size fractions, but more than 30% of the concentrations for all anthropogenic heavy metals are contributed by the particle grain size fractions of 45–74µm and more than 70% of the concentrations for all heavy metals are contributed by the particle grain size fractions of 45–74 and 74–125µm.

The concern about health risks centers on adherence of small particles to the skin, where it is available for hand-to-mouth ingestion. Smaller grain sizes that comprise respirable fractions of dust whence they deposit in different areas of the respiratory system, including clearance by the mucociliary system and then swallowed. Air quality regulations focus on aerosols, PM10 (<10µm), PM 2.5, and recently on nanoparticles. Natusch et al. (1974) investigated the distribution of trace elements among fly ash grain sizes. Particles less than about 1 µm deposit predominantly in the alveolar regions of the lung where the absorption efficiency for most trace elements is 50 to 80 percent. Larger particles, on the other hand, deposit in the nasal, pharyngeal, and bronchial regions of the respiratory system and are removed by cilial action to the stomach. Natusch found that the size distribution of certain trace elements in ambient air can be influenced, at least in part, by their particle size distribution in the source emission, although this varies considerably between elements, and that the highest concentrations of many toxic elements are emitted in the smallest, lung-depositing particles. Particles larger than PM10 are intercepted in the nasopharyngeal area (Stuart 1984; Heyder et al. 1986).

The general cutoff for adherence is 63µm, the silt/sand boundary, with greater adherence of the smaller grain sizes, Soil adherence has been reviewed by EPA.[22] Grain size is the key parameter in dermal adherence, with moisture only a factor for very moist soils (Choate et al., 2006). These authors found that the adhered fractions of dry or moderately moist soils with wide distributions of particle sizes generally consist of particles of diameters <63 µm. Finer particles are less likely to be rejected/screened by the consumer (children). 63µm is the sand/silt break-point on the Wentworth scale[23] and is defined in the field based on oral "grittiness test". The clay/silt breakpoint is the first detection of grit when lightly ground between front teeth. Consequently, dermal absorption experiments using larger size fractions may be of limited relevance to actual situations of soil exposure.

Regardless of the source, due to gravity separation alone, finer particles are transported longer distances than larger particles. Finer particles are also less filterable via canopy, aquatic system, or household HVAC systems. Therefore, the nature and extent of the distribution of finer particles are much larger than coarser fractions, spreading contamination further. Finer particles

[22] https://www.epa.gov/sites/production/files/2015-09/documents/part_e_final_revision_10-03-07.pdf
[23] The simplified Wentworth scale is: Gravel gradations (>2mm); Sand gradations (62.5-125 µm); Silt (3.9–62.5 µm); Clay (0.98–3.9 µm). Soils are typed according to physical (e.g., grain size, color, moisture), chemical (e.g., minerals, pH), and biological attributes (e.g., organic matter).

are produced by more industrial sources (range from stack or tail-pipe air-emitters to sediment dischargers associated with mining)

One goal of the risk assessor is to employ an exposure point concentration that represents the pertinent pathway of interest (*direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact).* For example when evaluating ingestion of soils EPA recommends a particle size distribution (PSD) cutoff of 250µm because EPA believes this is the largest size that adheres to the hand which subsequently affects hand to mouth intake. This is not a conservative value.

Another goal is to employ an exposure point concentration that represent the thermodynamically effective (TDE) concentration of contaminants of concern associated with the particle size cutoff. The cutoff is directly related to: (1) the process that was responsible for genesis of the TDE contaminant, and (2) sorption of the contaminant on native particulates during transport. Native clay-sized materials (< 4µm) are the dominant media providing sites for active sorption. Falsely low values for exposure point concentrations occur when the incorrect cutoff is employed. For example, if an EPA defined size of 250µm (relatively coarse) is employed for ingestion of soils related to smelter stack emission exposure point concentration (an aerosol of 0.001µm to 100µm), the analytical result and exposure point concentration will be falsely low due to dilution of the aerosol-sized particle with larger naturally occurring materials occupying the greater than aerosol to 250µm range of the distribution. In other words, employing the larger cutoff relies on the assumption that TDE contaminants are homogenously distributed in the particle size distribution. This assumption is only valid for very rare cases where the particle size distribution of a manufacturing process is coincident with the 250µm cutoff.

Multiple pathways from multiple sources requiring different cutoffs for different thermodynamically effective contaminants, further complicate matters because sampling can become cumbersome and quite costly. In summary, for such situations, since wastes from manufacturing processes are governed by less-than particle size cutoffs associated with design of settling basins, air/water filtration, etc., the finer (<63 µm) fraction is present in all the aforementioned pathways (direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact), we recommend a much finer PSD cutoff of 63µm to represent all pathways. Employing a coarser cutoff of the particles sizes likely results in dilution of the exposure point concentration resulting in a falsely low exposure point concentration. Since quantitative estimates of risk are directly proportional to the exposure point concentration, risk is also estimated to be falsely lower than actual conditions.

For these reasons, we recommend sieving soil and dust samples along the sand/silt and silt/clay size boundaries, and using fractions <63µm for risk assessment.

12. Fugitive Dust

Fugitive dust may be an under-appreciated route of exposure for dust and soil. For example, asbestos can cause gastrointestinal tumors due to swallowing, and the clearance of coal dust by the mucociliary tract has been linked to gastric cancer.

Fugitive dust consists of geological material that is injected into the atmosphere by natural wind and by anthropogenic sources such as paved and unpaved roads, construction and demolition of buildings and roads, storage piles, wind erosion, and agricultural activities (Watson 1996). The largest sources of regional dust are roads and agriculture. There are more than 4 million miles of roads in the United States with about 2.5 million miles paved roads and 1.5 million miles unpaved. There are about 350 million acres of tilled farmland in the continental US and 188 million acres of range and pasture land.[24]

Unpaved Roads

Nearly 50 percent of America's roads are unpaved, not counting private roads, agricultural roads, and parking lots.[25] The practice of converting paved roads to unpaved is relatively widespread; recent road conversion projects were identified in 27 states. These are primarily rural, low-volume roads that were paved when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are rapidly deteriorating, and are both difficult and expensive to maintain. Instead, many local road agencies are converting these deteriorated paved roads to unpaved as a more sustainable solution.[26]

Oklahoma has 234,633 miles of roads, of which 12,000 miles are paved.

Nation-wide, counties spend approximately 31 percent of their budget on gravel road maintenance (Birst and Hough 1999). Gravel road maintenance includes roadside maintenance, grading, ditching, snow and ice control, signing, dust control, rehabilitation/regrading, and other steps. Results of a study conducted by *Better Roads*[27], identified that more engineers called dust their most serious gravel road maintenance problem than any other. A car traveling 35 mph on a moderately dusty road generates the concentration of silt-sized particles equal to that of about 100 times the pollution concentration in the air of an industrial city (Birst and Hough 1999). For

[24] https://www.westernwatersheds.org/watmess/watmess_2002/2002html_summer/article6.htm
[25] www.equipmentworld.com/celebrating-80-years-of-better-roads (data from 2011).
[26] http://www.montana.edu/ltap/resources/publications/nchrp_syn_485.pdf (data from 2016).
[27] http://www.equipmentworld.com/better-roads-magazine-archive/

every vehicle traveling one mile of unpaved roadway once a day, every day for a year, one ton of dust is deposited along a 1,000-foot corridor centered on the road (Sanders and Addo 1993).

Risk assessments often do not quantify the risk associated with soil inhalation. However, in areas with unpaved roads, this is a relevant exposure pathway. To determine the inhalation exposure, James et al. (2013) collected three size fractions of airborne particulate matter (total suspended particulates [TSP], particulate matter with an aerodynamic diameter less than 10µm [PM10], and particulate matter with an aerodynamic diameter less than 2.5µm [PM2.5]) before and after roads were paved. Road paving reduced the concentration of many airborne contaminants by 25 to 75% (James et al. 2012).

Off-road vehicles, such as might occur during homesteading activities, while perhaps trivial in a regional context, could be locally significant. Goossens and Buck (2009 a,b) examined the type of surface (sand, silt, gravel, drainage) with respect to dust emission from off-road use. As predicted by grain size, the increase in PM10 emission resulting from ATV use in arid areas are: for sandy areas, 30–40 g km−1 (PM10) and 150–250 g km−1 (TSP); for silty areas, 100–200 g km−1 (PM10) and 600–2000 g km−1 (TSP); and for mixed terrain, 60–100 g km−1 (PM10) and 300–800 g km−1 (TSP). These values are for the types of vehicles tested in this study and do not refer to cars or trucks, which produce significantly more dust (Goossens and Buck 2009 a,b). Predictions of aeolian (wind-caused) erodibility can be made based on climate, wind speed, elevation, vegetative cover, slope, and soil type (USACE 2008), as well as grazing intensity (Goossens 2001).

Agricultural Dust Production

Tillage has been shown to be a significant source of dust (particles and any contaminants adsorbed onto them such as fertilizers and pesticides) as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001; Clausnitzer and Singer, 1996; Cassel et al., 2016). A long history of research focusing on tillage and dust emission exists for the USA. On the local scale, wind erosion and agricultural activity remain the major sources of dust after vehicle driving on paved or unpaved roads. Tillage has been shown to be a significant source of dust as it is able to emit higher amounts of dust than wind erosion alone (Goossens et al., 2001). For example, the San Joaquin Valley of California is in non-attainment of National Ambient Air Quality Standards for PM10. The occurrence of 24-hour exceedences during periods of intense agricultural activity in the post-harvest months of October and November, as well as the composition of ambient PM10 at that time, indicates the importance of row crop agriculture in the region's air quality. Road dust and farming were the sources of the bulk of PM10 (Cassel et al., 2016). Clausnitzer and Singer (1996) measured respirable dust generated during agricultural operations related to corn, tomatoes, and wheat in the Sacramento Valley. The highest amount of respirable dust was generated form soil ripping and plant into dry surface soil, and the lowest was generated by disking corn stubble during the wet season. Approximately 64% of all operations were performed during the dry season and generated 83% of the respirable dust. Areas of abandoned agricultural land in the Antelope Valley, western Mojave (high) desert of California are recalcitrant to conventional tillage and revegetation strategies designed to suppress wind erosion of soil and transport of sediment and fugitive dust. These areas represented a continuing source of drifting sand and of coarse and respirable suspended particulate matter (Grantz et al., 1997).

Homesteading, farming, and ranching risk assessment must consider (1) past spread of mining-generated particles at the mine sites and much larger depositional areas, (2) newly generated particles during farming and ranching, and (3) particles generated as road dust, including a consideration of past spillage of mined materials onto haul roads.

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Attachment No. 5 Annotated review Appendix A Response to Comments on Interim HHRA Deliverables, Human Health Risk Assessment Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma

Table 1b. Response to Comments Provided by AESE, Inc., on behalf of Quapaw Nation, on Document No. 1

Item	Section	Page	Comment	Response
1	Figure 7-3		ARD source omitted. Ingestion, dermal, inhalation needs to be evaluated. Also need irrigation of plants with groundwater/surface water that is mine affected. Plant to cattle to human is omitted. Water to cattle to human is omitted. This CSM needs a major revision.	Acid rock drainage (ARD), in the form of mine discharge, was added as a source to surface water on the CEM. Mine discharge is accessible for contact at two locations, which are conservatively addressed in Appendix F3 using the same exposure assumptions as surface water. Locations where mine discharge enters and mixes with surface water were sampled. Irrigation of plants with surface water that is affected by the mine was added as a potential exposure route on the CEM and is discussed in the HHRA. Plants (arrowhead and duckweed) growing in surface water (which is more exposure than irrigation) were sampled during the RI and associated exposures are addressed in the HHRA. Vegetation (and incidental soil) exposures by grazing cattle (and subsequent human consumption of meat and milk) are terrestrial exposures addressed under Tar Creek OU4 and were further evaluated in the memorandum titled, *Tar Creek Source Material Operable Unit 4 Remedial Action: Results of Bioaccumulation Study of Chemicals of Concern in Row Crop and Pasture Grasses,* prepared by CH2M, dated November 12, 2019; risks were within EPA's acceptable risk levels.

Table 1c. Response to Comments Provided by the ODEQ on Document No. 1

Item	Section	Page	Comment	Response
1			Does EPA plan to use sieved or un-sieved sediment sample data in its risk models. Does EPA plan to use total or dissolved surface water sample data in its risk models?	Both unsieved and sieved sediment data were used in the HHRA. Total metals surface water data were used in the quantitative risk estimates. An evaluation of potential risk based on dissolved metals surface water data is included in the uncertainty analysis of the HHRA.
2			DEQ has concerns about using only one aquatic plant sample as the background reference sample for all aquatic plants in the entire study area and using a dry weight to wet weight conversion factor on this one sample. DEQ would prefer that additional sampling be conducted to increase the sample size for background reference and that those samples be analyzed appropriately so that a conversion factor is not required. This data could be evaluated in the Feasibility Study (FS) stage of the Super-fund Process. In lieu of conducting additional sampling, DEQ requests that EPA include a reference document into the Rl for using the dry to wet weight conversion factor and provide guidance stating that one sample is adequate for background reference.	The background reference concentration in the aquatic plant sample was not used to eliminate COPCs in the HHRA. After the risk estimates were calculated, sediment background comparisons were considered when identifying preliminary COCs in aquatic plants. Because dietary consumption rates are provided on a wet weight basis, all biota datasets used in the HHRA are presented on a wet weight basis. Some of the historical data (e.g., mussels and aquatic plants) were reported as dry weight, and a dry-weight-to-wet-weight conversion was needed to provide consistent reporting format in the dataset. The conversion from dry weight to wet weight was performed using the moisture content of the samples. Chapter 11 of EPA's Exposure Factors Handbook (2011) provides the equation for the conversion.

Table 1c. Response to Comments Provided by the ODEQ on Document No. 1

Item	Section	Page	Comment	Response
3			It appears as if there are different approaches to determining how chemicals of potential concern (COPC) are carried forward in a risk assessment. Although not yet released, the human health risk assessment appears as if it will use BTV (discussed in Section 5 of RI) while the BERA appears to use toxicity threshold values. Is this accurate? If so, why use different approaches?	The background threshold values (BTVs) were not used to identify COPCs. Rather, COPCs for general public direct contact exposure pathways were identified by comparison to EPA's Regional Screening Levels. However, for biota consumption pathways and Tribal Lifeway exposure scenarios, all detected chemicals in a given dataset were conservatively identified as COPCs.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
1	Topic #1a: Consultation process – TCTCIT participation in the consultation process should not be construed as an "endorsement" of EPA's HHRA approach for OU5.	2	The HHRA memo (CH2M HILL, 2018) indicates that EPA has consulted with the nine Tribes in the ongoing HHRA, including, for example, providing documents such as the Remedial Investigation Data Gap Summary Report (CH2M HILL, 2016) for the Tribes for review. We agree that EPA has provided such HHRA work products to the Tribes, in addition to holding periodic check-in teleconferences/meetings, during which EPA has provided general updates to the Tribes on the status of EPA's ongoing HHRA. The TCTCIT appreciate that EPA undertakes these check-ins, consistent with EPA's Indian Policy (Ruckelshaus, 1984; McCarthy, 2014) and trust responsibilities. However, the TCTCIT's participation should not be construed as a blanket "endorsement" of EPA's proposed HHRA approach, and EPA's eventual HHRA results. This is particularly true since some of the main overarching comments and concerns raised by the TCTCIT on the HHRA throughout this government-to-government consultation process have yet to be addressed by EPA (see Topic #4 below).	Comment noted; the exposure scenarios and exposure factor values (and ranges) included in the draft OU5 HHRA prepared by TCTCIT's consultant (Abt Associates) in June 2019 were taken into consideration when developing this HHRA.
2a	Topic #1b: Consultation process – the process should inform, but not be a substitute for, EPA conducting the work needed to delineate RME values.	2	As a part of the HHRA consultation process, EPA has requested information on exposure pathways and levels, and some of the information provided by the TCTCIT has been incorporated into the RME tables in the HHRA memo. In particular, EPA provided the Tribes with draft RME tables via email on November 7, 2017, and requested that the Tribes confirm/review some of the proposed exposure parameters, such as number of days per year and hours per day that Tribal adults and children are exposed to surface water and sediment in OU5. In an effort to facilitate the HHRA process, the TCTCIT technical representatives provided feedback on these values, to the best of their ability and knowledge. However, as communicated to EPA by the TCTCIT in subsequent conversations, including a conference call held on March 16, 2018, the TCTCIT technical representatives do not formally gather, nor do they have access to data on Tribal population exposure metrics, as a part of their respective Tribal departmental duties. Therefore, the provided information should be viewed as estimates that may inform, but should not be a substitute for, whatever process EPA may need to complete to formally and accurately delineate these parameters. This might include consulting with other governmental entities that may gather relevant information, or conducting Tribal population surveys, if needed. For example, EPA guidance on exposure assessment states that site-specific exposure factors can be developed by collecting behavior and activity patterns through surveys, which can be implemented via several methods, including activity diaries and questionnaires (EPA 1992).	Comment noted; the exposure scenarios and exposure factor values (and ranges) included in the draft OU5 HHRA prepared by TCTCIT's consultant (Abt Associates) in June 2019 were taken into consideration when developing this HHRA.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
2b	Topic #1b: Consultation process – the process should inform, but not be a substitute for, EPA conducting the work needed to delineate RME values.	3	We further note that EPA appears to be using values provided by the TCTCIT as inputs for all exposed Tribes. This may not be appropriate, as the TCTCIT includes only seven of the nine Tribes in OU5, and TCTCIT exposure values may not be representative, even as estimates, for the other two Tribes. Finally, in numerous instances, EPA is incorrectly citing the TCTCIT for exposure values in the HHRA memo and accompanying RME tables (see Topic #1c below for further discussion of this topic). EPA should remove reference to the TCTCIT in instances where they are incorrectly cited as the source of information (see Topic #1c), and EPA should complete the work needed to comprehensively delineate exposure parameters, rather than solely relying upon TCTCIT estimates.	Comment noted; the exposure scenarios and exposure factor values (and ranges) included in the draft OU5 HHRA prepared by TCTCIT's consultant (Abt Associates) in June 2019 were taken into consideration when developing this HHRA. Input from the Quapaw Nation and ODEQ was also considered, and the final HHRA exposure scenarios and exposure factor values reflect input from all sources. The reference for each final exposure factor value indicates the source of the value.
3a	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	3	As noted above, EPA circulated draft RME tables via email on November 7, 2017, and requested the Tribes' input on a number of parameters. Also noted above, the TCTCIT do not formally compile the type of requested information (such as the number of days per year that Tribal members and citizens are exposed to surface water and sediment in OU5). However, in an effort to facilitate the HHRA process, the TCTCIT provided EPA with some estimates, based on their existing knowledge of Tribal activities. These values were provided to EPA via email by the TCTCIT on January 24, 2018. It appears that some of this information has been used by EPA in the HHRA memo in a manner that is inconsistent with the TCTCIT's original intent. In other instances, EPA is incorrectly citing the TCTCIT as the source of exposure parameters that the TCTCIT did not provide, or for which the TCTCIT provided a different value. For example:	Comment noted; the exposure scenarios and exposure factor values (and ranges) included in the draft OU5 HHRA prepared by TCTCIT's consultant (Abt Associates) in June 2019 were taken into consideration when developing this HHRA. Input from the Quapaw Nation and ODEQ was also considered, and the final HHRA exposure scenarios and exposure factor values reflect input from all sources. The reference for each final exposure factor value indicates the source of the value.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
3b	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	3, Bullet 1	"Tribal Lifeway" vs "Tribal Worker" scenarios – the TCTCIT estimated that many Tribal adults are exposed to surface water and sediment 312 days/year, through a combination of all activities involving contact with OU5 streams and creeks. This includes fishing, hunting, gathering, ceremonial and other cultural practices, recreating, and work (e.g., hatchery employees who are exposed to OU5 stream water as a part of their daily work duties, or staff from environmental departments who are exposed when collecting environmental samples). The TCTCIT provided this value of 312 days/year to EPA in their January 24, 2018 response to EPA's request. In the HHRA memo, EPA now describes separate "Tribal Lifeway" and "Tribal Worker" exposure scenarios (these separate scenarios did not exist in the November 7, 2017 version of the RME tables). The value of 312 days/year provided by the TCTCIT has been assigned to the "Tribal Lifeway" exposure scenario for the surface water and sediment exposure frequency (see Table 4.2 and page 4/26 of the HHRA memo), and a separate value of 250 days/year is assigned for the "Tribal worker" exposure frequency. The latter value is based on EPA standard exposure factors (see Table 4.3 and page 5/26 of the HHRA memo). This approach raises at least two questions of concern to the TCTCIT: Is EPA intentionally incorporating work-related exposure into both scenarios? Why is a separate "Tribal Worker" scenario needed, if work-related exposure is already incorporated into the "Tribal Lifeway" exposure scenario?	The final exposure frequency for surface water and sediment exposures by Tribal Adults is 312 days/year in this HHRA; this exposure frequency is intended to cover members who (1) work and perform other activities in surface water and sediment outside of work, and (2) do not "work" in surface water but who conduct other Tribal Lifeway activities in or using surface water and sediment. A separate Aquatic Worker scenario is provided to address surface water and sediment exposures by tribal members and citizens who may have minimal surface water or sediment exposure outside of their work exposure. This scenario was also described and emphasized as an important scenario by a TCTCIT entity.
3c	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	4, Bullet 1	Tribal children exposure frequency for surface water and sediment – the TCTCIT estimated that children are exposed to surface water 234 days/year and to sediment 312 days/year in their January 24, 2018 response to EPA. In the HHRA memo RME tables, the exposure frequency for children is set to 244 days/year for both sediment and surface water, and EPA incorrectly sites the TCTCIT for this value (see Tables 4.2 and 4.5, and pages 4/26 and 6/26). Further, EPA states on page 6/26 of the HHRA memo that it is not possible for children to be more exposed to sediment than to surface water because "sediments are below surface water" (page 6/216 of the HHRA memo). The TCTCIT understand that sediments are generally located below surface water. However, the TCTCIT believe it is possible for sediment exposure to be greater than surface water exposure, and would like to clarify that the estimate of 312 days/year includes exposure to sediment that does not involve contact with water. This includes, for example, through contact with sediment-laden clothing and footwear of children's parents, or other sediment-laden items, such as aquatic plants, mussels, etc., collected by family or other members of the community. EPA should remove the TCTCIT as the source for their 244 days/year exposure value in Tables 4.2 and 4.5. We request that EPA reconsider their assertion regarding the impossibility of sediment exposure being higher than surface water exposure for children.	For tribal children, exposure frequencies of 312 days/year (sediment) and 234 days/year (surface water) are used in the HHRA. These exposure frequencies are in addition to evaluation of surface water for potable use and surface water in sweat lodges.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
3d	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	4, Bullet 2	Tribal children swimming and wading event time for surface water and sediment – the TCTCIT estimated that children swim for 6 hours/day and wade for 6 hours/day in their January 24, 2018 reply to EPA. These event times have been set to 1 hour/day and 5 hours/day, respectively, in the HHRA memo (see Table 4.2 and page 4/26 in the HHRA memo). Again, the HHRA memo incorrectly cites the TCTCIT as the source of these values and EPA should remove the TCTCIT as the source for these values. Further, we are concerned that one hour/day does not accurately reflect the duration of children's time swimming (particularly in warmer months, when TCTCIT representatives report that children swim many hours per day each day). However, we acknowledge that we do not have quantitative data on childhood time spent swimming and wading. EPA may therefore need to conduct additional data collection efforts to determine a value for these parameters.	For tribal children, an event time of 6 hours is assumed for a combination of swimming and wading in the HHRA; as a conservative approach, exposure factor values for a swimming scenario are used in the risk estimates to account for a child swimming 6 hours per event.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
3e	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	4, Bullet 3	Exposure to mine discharge – the TCTCIT estimated that adults spend 6 hours/day, 156 days/year; and children spend 1 hour/day, 48 days/year in contact with mine discharge in the information they provided to EPA on January 24, 2018. The HHRA memo states that these exposure times and frequencies were not incorporated into exposure scenarios because EPA believes the TCTCIT was providing estimates of contact with "water bodies that have received mine discharge, rather than direct contact with the shallow mine discharges in the two areas, prior to entering water bodies" (page 8/26 of the HHRA memo). (We note that page 7 of the HHRA memo describes three mine discharge areas, and so we assume the reference to two areas in the quoted text is a typographical error). The TCTCIT would like to affirm that they understand the definition of the term "mine discharge," and the estimates provided by the TCTCIT indeed reflect their estimates for adult and child exposure to the mine drainage areas described in the HHRA memo. These include (1) the area in Commerce, Oklahoma where discharges led to the eventual inclusion of the Tar Creek Superfund Site on the National Priorities List; (2) the area by East 40 Road, where Tar Creek and the old creek bed of Lytle Creek converge; and (3) the area on Beaver Creek, immediately north and south of East 50 Road. However, we acknowledge that these are best estimates, and not quantitative data. EPA may therefore need to conduct additional data collection efforts to determine the value of these parameters.	The mine discharges sampled are representative of those that people could contact outside of creeks, rivers, and tributaries. Mine discharges in one area of the Tar Creek watershed (in Commerce) are currently being treated by passive treatment systems at the point of discharge. The mine discharges within the remaining two areas occur intermittently, have a typically low flow rate, flow over very short distances before reaching a creek, are not wide or deep (typically shallow flow of less than 3 to 5 feet across), and are not easily accessible or are restricted by physical structures such as fences or heavy overgrowth. Although exposure is expected to be infrequent, mine discharge was conservatively evaluated for tribal lifeway hunting/ fishing/gathering and recreational activities (incidental ingestion and dermal contact), tribal lifeway potable use (ingestion and dermal contact), tribal lifeway sweat lodge (ingestion, dermal contact, and inhalation of water vapors), and general public wading (dermal contact) using the same exposure assumptions as surface water in Appendix F3.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
3f	Topic 1c: Consultation process – in many instances, EPA's incorporation of information provided by the TCTCIT is inaccurate and EPA incorrectly cites the TCTCIT as the source of numerous exposure parameters.	5, Bullet 1	The TCTCIT did not provide the ingestion rates for turtles/frogs and for aquatic mammals in Table 4.7 (and discussed on page 7/26 of the HHRA memo), and thus EPA should remove the TCTCIT as the cited source for this information. The TCTCIT did provide the value of 133 g/day for the arrowhead root consumption rate listed in Table 4.7. However, this value is directly derived from the value provided in Harper (2008) for the daily consumption rate for "roots and bulbs." EPA should therefore cite Harper (2008) and not the TCTCIT for this value. Further, when originally providing this value, the TCTCIT did not fully understand the context in which it was to be used. This value represents only a fraction of the total daily plant intake in the Tribal diet described by Harper (2008). In a risk assessment, it is typical to conservatively assume that the total intake of dietary items is from the contaminated source area (see, for example, the HHRA EPA (URS, 2005) conducted for the Midnite Mine Superfund Site). In which case, the daily intake value for plants reported in the HHRA memo and RME tables should be the total plant intake from Harper (2008) of 558 g/day (consisting of legumes, squash and other vegetables, roots and bulbs, greens, and sweets).	The reference for the adult ingestion rate for turtles/frogs, semi-aquatic mammals, and aquatic plants was changed to Harper (2008). This HHRA addresses exposures from the aquatic environment (OU5) only, and not terrestrial sources (OU4). Therefore, the total plant intake from Harper (2008) of 558 g/day (which includes both terrestrial and aquatic sources) is not applicable to OU5.
4	Topic #1d: Consultation process – many of the Tribes are incorrectly identified in the HHRA memo.	5	In general, please correctly refer to the Tribes in communications, and specifically for the HHRA memo, please make the following corrections on page 1/26: • Miami Tribe of Oklahoma (not Miami Nation of Oklahoma) • Seneca-Cayuga Nation (not Seneca-Cayuga Tribe of Oklahoma) • Wyandotte Nation (not Wyandotte Nation of Oklahoma).	The names of the Tribes have been corrected to those indicated in the comment.
5a	Topic #2a: Tribal Lifeways characterization – the characterization of Tribal exposure scenarios in the HHRA memo is confusing and inconsistent across the memorandum and attachments.	5	The HHRA memo describes "Tribal Lifeway," "Worker," and "Sweat Lodge" exposures. However, the relationship between the three is inconsistently described, and it is therefore unclear how the "combined risk" mentioned in the memorandum will be calculated by EPA.	Potential risks associated with each exposure pathway (e.g., ingestion of fish, ingestion of aquatic plants, potable use of surface water) are presented separately. Potential risks associated with aquatic worker exposures are also presented separately. However, cumulative risks from sediment (ingestion and dermal contact), surface water (incidental ingestion, dermal contact, potable use, sweat lodge ingestion, sweat lodge dermal contact, and sweat lodge inhalation), aquatic animal (ingestion), and aquatic plants (ingestion and dermal) exposures are presented to provide a combined risk estimate for OU5 media.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
5b	Topic #2a: Tribal Lifeways characterization – the characterization of Tribal exposure scenarios in the HHRA memo is confusing and inconsistent across the memorandum and attachments.	5, Bullet 1	Section 3 of the HHRA memo (page 3/26) provides a narrative description of the exposure scenarios and is titled "Tribal Lifeway Exposure Scenarios." This section is divided by media and within each media is further subdivided into "Tribal Lifeways Exposures," "Worker Exposures," and "Sweat Lodge Exposure." This structural organization would imply that worker exposure and sweat lodge exposure are subcategories of an overall "Tribal Lifeways Exposure" receptor population.	As presented in the HHRA, a complete "Tribal Lifeway Exposure Scenario" for OU5 consists of potential exposures to sediment (ingestion and dermal contact), surface water (incidental ingestion, dermal contact, potable use, sweat lodge water ingestion, sweat lodge water dermal contact, and sweat lodge water inhalation), aquatic animals (ingestion), and aquatic plants (ingestion and dermal). The adult exposure frequency (312 days/ year) used for sediment and surface water exposures is high enough to account for exposures that may occur at work or while performing Tribal Lifeway activities. A separate "Aquatic Worker" scenario is also presented in the HHRA to address people who work in surface water and sediment (250 days/year) but do not participate in other Tribal Lifeway scenarios.
5c	Topic #2a: Tribal Lifeways characterization – the characterization of Tribal exposure scenarios in the HHRA memo is confusing and inconsistent across the memorandum and attachments.	5, Bullet 2	However, the CEM presented in Attachment one (page 11/26 of the HHRA memo) only shows two Tribal "potential receptor" groups ("Tribal Lifeway" and "Tribal Worker"), and sweat lodges are depicted as an "Exposure Point" (not a receptor). The RME tables in Attachment two (beginning on page 15 of the HHRA memo) similarly list "Tribal Lifeway" and "Tribal Worker" as "Receptor Populations," and sweat lodges as an "Exposure Point."	In the HHRA, sweat lodge exposures are included as part of the Tribal Lifeway scenarios, and include surface water exposures during sweat lodge use (water ingestion, dermal contact with water, and inhalation of steam).

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
5d	Topic #2a: Tribal Lifeways characterization – the characterization of Tribal exposure scenarios in the HHRA memo is confusing and inconsistent across the memorandum and attachments.	6	The TCTCIT recommends that EPA clarify what are considered receptor populations vs exposure points in the HHRA. Further, EPA should clarify the relationship among these exposure populations and, specifically, how EPA intends to determine the "combined risk" (page 3/6 and 11/26 of the HHRA memo), for these exposure groups. Without such changes, the TCTCIT question, for example, how will EPA assess the "combined risk" for a Tribal member or citizen who practices traditional lifeways and also has work-related exposures?	The receptor populations addressed in the HHRA are presented in RAGS Table 1: Tribal Lifeway (adults and children) and General Public (adults and children). Exposure points are indicated in RAGS Table 1 for all media. Potential risks from sediment (ingestion and dermal contact), surface water (incidental ingestion, dermal contact, potable use, sweat lodge ingestion, sweat lodge dermal contact, and sweat lodge inhalation), aquatic animal (ingestion), and aquatic plants (ingestion and dermal) exposures are presented in the HHRA separately and combined to provide a cumulative risk estimate for exposure to OU5 media. Aquatic workers are presented separately to address people who work in surface water and sediment (250 days/year) but may not participate in other Tribal Lifeway scenarios. For those tribal members or citizens who practice traditional lifeways and have work-related exposures, their potential risks are addressed in the Tribal Lifeway scenario.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
6	Topic #2b: Tribal Lifeways characterization – EPA's characterization of Tribal wading and swimming exposure routes is confusing and potentially misleading/inaccurate	6, Para. 1 to 3	The HHRA memo makes statements (page 4/26) regarding the relative frequencies of exposure of Tribal members and citizens engaged in different Tribal Lifeways activities: *Exposure to surface water while wading and swimming consists of both dermal exposure and incidental ingestion. For the purpose of the risk assessment, these exposures for a tribal lifeways scenario with surface water will be evaluated by assessing exposure during wading and swimming activities. Wading and swimming may also occur as a recreational or ceremonial activity, but these exposures are expected to occur at a lower frequency than during hunting and gathering activities, and are therefore addressed by this more conservative exposure scenario. (page 4/26)* Statements are also made in the HHRA memo on pages 5/26 and 6/26 regarding relative frequencies of surface water and sediment exposure during Tribal Lifeway activities: *The tribal lifeways scenario associated with surface water is a conservative representation of many other surface water [sediment] exposures that tribal members and citizens may encounter on a frequent or occasional basis, such as when Entering cold surface water during challenges…Occasional visitors contact surface water during tribal festivals or ceremonies, or recreational activities such as swimming, fishing, or hunting. (page 5/26 and 6/26)* These statements are confusing and the intended significance to the Tribal Lifeways exposure scenario is unclear. We recommend removing the language and replacing with "Tribal members are exposed to surface water and sediment when wading and swimming, which may take place during hunting, fishing, gigging, gathering, ceremonial, and recreational activities that are part of typical cultural practices." Also, EPA should explain or provide sources for the basis of their statements regarding relative frequencies for the different listed Tribal activities. If sources cannot be provided, then these assertions should be removed from the HHRA memo and not incorporated into the OU5 HHRA.	The language referencing these activities has been modified for the HHRA. The HHRA text states that tribal members are exposed to surface water and sediment when wading and swimming, which may take place during hunting, fishing, gigging, gathering, ceremonial, and recreational activities that are part of typical cultural practices.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
7	Topic #2c: Tribal Lifeways characterization – EPA's characterization of Tribal use of plants is confusing and potentially misleading/inaccurate.	7	The HHRA memo states that: *Aquatic plants may also be used for ceremonial practices involving dermal contact or ingestion, but assessment of medicinal use on skin, and direct ingestion of plants as discussed further below, address ceremonial use of plants. (page 6/26)* The HHRA memo then states: *The tribal lifeway scenario associated with aquatic plants is a conservative representation of other aquatic plant ingestion exposures that tribal members and citizens encounter on an occasional basis, such as when ingesting aquatic plants for medicinal purposes. (page 7/26)* Ceremonial and medicinal use of plants should be considered in addition to (not subsumed within) consuming plants as a part of the Tribal diet. EPA should provide the basis (i.e., cite sources) for their statement regarding the "occasional basis" of ingesting aquatic plants for medicinal purposes, and implied relative consumption rates of plants for dietary vs medicinal/ceremonial purposes. If EPA cannot provide a source, these statements should be removed from the HHRA memo and not incorporated into the OU5 HHRA.	Ceremonial and medicinal use of aquatic plants was considered, and potential risks from medicinal use of plants as salve (based on total arrowhead plant data) are included in the HHRA based on the knowledge of use of arrowhead for this purpose. Regarding the statements in the HHRA memo, they will not be included in the OU5 HHRA without sufficient evidence to support the argument.
8	Topic #2d: Tribal Lifeways characterization – EPA's exposure route assumptions for sweat lodge participation should be re-evaluated and adjusted.	7	The HHRA memo states that: *Adults may use a sweat lodge for ceremonial purposes, and the water used in this ceremony comes from surface water, leading to a dermal exposure to surface water. (page 5/26)* Exposure during a sweat lodge ceremony includes inhalation or oral ingestion of water as steam, in addition to dermal contact. In a sweat lodge, water is turned to steam and the participants sit in a steam bath, during which time they are breathing and potentially talking, which means that exposure could be through inhalation or ingestion, in addition to dermal contact. There may also be exposure to sediment during sweat lodge use. EPA should re-evaluate their exposure assumptions and adjust accordingly.	Inhalation, ingestion (1 L/day by adults and children), and dermal contact exposures (whole body) to surface water are included in the HHRA for sweat lodge use.
9	Topic #2e: Tribal Lifeways characterization – the exposure scenarios described in the HHRA memo do not include Tribal use of groundwater springs.	7	Many Tribal members and citizens visit groundwater springs within OU5 to gather plants for consumption (e.g., watercress) and to engage in cultural practices. During these visits, they are exposed via ingestion and dermal contact with the water and sediment. Exposure at groundwater springs should be included in the HHRA.	Groundwater is not a medium addressed under OU5. However, while water from groundwater springs are not specifically addressed in the HHRA, exposures to direct mine discharge are evaluated as a worst-case scenario in Appendix F3.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

Item	Section	Page	Comment	Response
10a	Additional details – EPA's body surface area exposure parameter values may underestimate the exposure for both adult workers and children.	8, Bullet 1	Worker skin surface area exposed to surface water and sediment – the HHRA memo states that only the hands and forearms of workers come into contact with surface water and sediment (see pages 5/26 and 6/26 of the HHRA memo). The TCTCIT understand from conversations with Tribal workers that this is not necessarily true. Tribal workers normally wear protective gear when in contact with surface water and sediment, but the nature of the work can be variable and it is common to have contact with water and sediment on the face, legs, and sometimes body as a result of normal work conditions in the field. Figure 1 provides an illustration of this point, showing Tribal hatchery workers directly exposed up to their chests to surface water and sediments pumped from the Spring River. Therefore, it would be appropriate to expand the exposed skin surface area for workers to ensure that the HHRA estimates are protective of all Tribal community members. This would affect the "skin surface area available for contact" parameter in Tables 4.3 and 4.6.	It is conservatively assumed in the HHRA that an aquatic worker has their entire body exposed to surface water and sediment every work day (250 days/year) for 25 years.
10b	Additional details – EPA's body surface area exposure parameter values may underestimate the exposure for both adult workers and children.	8, Bullet 2	Child skin surface area exposed to surface water and sediment when wading – the HHRA memo assumes that when wading, children's hands, forearms, lower legs, and feet are exposed to surface water and sediment. This may be an underestimate of the portions of the body that get wet and come into contact with sediment, particularly for young children (up to 6 years). It may be appropriate to expand the exposed skin surface area to the "total skin area" used for swimming for this age group. This would affect the "skin surface area available for contact" parameter in Tables 4.2 and 4.5.	It is conservatively assumed in the HHRA that a tribal child has their entire body exposed to surface water and sediment during every swimming/wading event.
11a	Topic #3b: Additional details – there are minor unexplained numerical discrepancies between the HHRA memo and the November 7, 2018 version of the RME tables.	8, Bullet 1	Text on page 15/26, Table 4.1: Adult dermal contact is identified as 0.72 hours/event. This value is slightly different than the value in an earlier version of the RME tables that EPA shared with the TCTCIT via email on November 7, 2017 (previous estimate was 0.71 hours/event). What is the reason for this slight difference?	The HHRA uses a water dermal contact event time of 0.71 hour/event for adults, which is the default value provided by EPA for daily potable water dermal contact.
11b	Topic #3b: Additional details – there are minor unexplained numerical discrepancies between the HHRA memo and the November 7, 2018 version of the RME tables.	8, Bullet 2	Text on page 16/26, Table 4.1: Child dermal contact is identified as 0.53 hours/event. This value is slightly different than the value in an earlier version of the RME tables that EPA shared with the TCTCIT via email on November 7, 2017 (previous estimate was 0.54 hours/event). What is the reason for this slight difference?	The HHRA uses a water dermal contact event time of 0.54 hour/event for children, which is the default value provided by EPA for daily potable water dermal contact.

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Item	Section	Page	Comment	Response
12	Topic #3c: Additional details – incorrect spelling of Tribal activities.	8	On pages 5/26 and 6/26, under "Applicability of Evaluated Exposure Scenarios to Other Surface Water (Sediment) Scenarios," the HHRA memo lists "*Jigging or spearing fish….*" We believe this is a typographical error that should be corrected to "*Gigging or spearing fish….*"	The spelling of "gigging" is correct in the HHRA.
13	Topic #4a: Overall nature and extent – the HHRA may underestimate the risk if cumulative effects across multiple exposure pathways and multiple contaminants are not adequately characterized.	10	The HHRA memo indicates, "The HHRA will present exposure and risk estimates for each sampled medium separately and will also provide risk estimates for all exposure media (surface water, sediments and aquatic biota) and pathways combined at OU5" (page 11/26 of the HHRA memo). However, EPA does not describe how they intend to assess risk from all pathways combined. Further, EPA does not describe how the HHRA will address the combined risk associated with the multiple metal contaminants that are present within OU5. It is therefore difficult for the TCTCIT to evaluate the adequacy of EPA's "combined" approach for all exposure media and pathways, and whether EPA intends to assess cumulative risk. EPA (U.S. EPA, 2003) defines cumulative risk as the combined risks from aggregate exposures to multiple agents or stressors, and further states that: *this definition requires that the risks from multiple agents or stressors be combined. This does not necessarily mean that the risks should be "added," but rather that some analysis should be conducted to determine how the risks from the various agents or stressors interact. It also means that an assessment that covers a number of chemicals or other stressors but that merely lists each chemical with a corresponding risk without consideration of the other chemicals present is not an assessment of cumulative risk. (U.S. EPA, 2003, p.17)* The description of EPA's HHRA approach for OU5 is incomplete because it does not adequately describe how cumulative risk will be determined, particularly given the multiple contaminants present at this site.	The HHRA provides cumulative risk estimates assuming additivity for chemicals with the same target organ. The HHRA presents cumulative risk estimates for each exposure scenario, based on risks from surface water and sediment in each waterway separately and combined watershed-wide risks from biota consumption. To understand potential vulnerability of communities around Tar Creek Superfund Site, a discussion of demographic data (as indicators of additional stressors) in these communities will be included in the HHRA.
14	Topic #4b: Overall nature and extent – underestimation of risk – the HHRA may underestimate risk due to the inadequate consideration of "background" contaminant exposure levels.	10-11	The TCTCIT has previously commented on this topic [see, for example, Abt Associates (2016)]. The HHRA is focused on OU5, which consists of surface water and sediment located downstream of mined areas. Because of this focus, EPA is only considering exposure to contaminants through dermal contact and ingestion of surface water, sediments, and aquatic biota within OU5. However, members and citizens of the TCTCIT are not only exposed to metal contaminants of the Tar Creek Superfund Site through these exposure pathways. TCTCIT members and citizens also engage in other activities that may expose them to these metals. For example, they may be exposed while gathering and ingesting terrestrial plants, and while hunting and ingesting big game in other parts of the Tar Creek Superfund Site. By not taking into account these other "background" contaminant exposure pathways and levels, EPA may over-estimate levels that are considered "safe" within OU5, which may ultimately lead to cleanup levels that are not protective of human health.	EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) indicates that when a site is divided into operable units (OUs), a risk assessment should be performed for each unit separately. During the remedial alternatives process, the alternatives should be evaluated to ensure that they protect human health and the environment from each potential pathway of concern at the site or those areas of the site being addressed as part of an OU.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

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			Disregarding other sources of contaminant exposure and contaminant background levels when assessing risk and setting "safe" exposure levels is at direct odds with EPA's own risk assessment guidance. For example: EPA guidance for metals risk assessment, children's risk assessment, and for setting safe consumption limits indicate that, to properly address the risk of a contaminant to human health, assessors need to consider all exposure sources in their assessments (U.S. EPA, 2000a, 2000b, 2007). EPA's *Framework for Metals Risk Assessment* states: *In Exposure Assessment, the risk assessor quantifies the total exposure to a toxic agent in the environment based on amount taken into the body, including any combination of the oral, inhalation, and dermal routes of exposure* (U.S. EPA, 2007, p. 4-1). EPA guidance is clear that when establishing safe consumption levels, a comprehensive evaluation of all sources of exposure should be conducted (U.S. EPA, 2000a). For example, when setting fish consumption advisories (FCAs), EPA states that it is important to consider all exposure routes because even though exposure through the consumption of fish alone may be safe, the total exposure to a contaminant, when including sources other than the fish, may cause an individual to exceed a safe exposure level, thus requiring issuance of an FCA (U.S. EPA, 2000a). EPA's guidance for deriving ambient water quality criteria (AWQC) also recommends considering all sources of exposure when assessing risk, by applying a relative source contribution (RSC; U.S. EPA, 2000b). The 2015 AWQC update recommends the inclusion of an RSC ranging from 20% to 80%, to account for contaminant exposure from other sources, including food consumption (e.g., meats, poultry, fruits, vegetables, grains), dermal exposure, and respiratory exposure (U.S. EPA, 2015). While the AWQC is obviously focused on water criteria, the guidance includes broader statements about EPA-wide policy on characterizing exposure and human health risk. Throughout this guidance, EPA stresses that assessors should consider all sources of contaminant exposure when evaluating human health risk, and states that this approach is an Agency-wide priority: *The policy of considering multiple sources of exposure when deriving health-based criteria has become common in EPA's program office risk characterizations and criteria and standard-setting actions. Numerous EPA workgroups have evaluated the appropriateness of factoring in such exposures, and the Agency concludes that it is important for adequately protecting human health* (U.S. EPA, 2000b, p. 4-4). Even if risk assessors focus on a particular exposure scenario, EPA guidance is clear that assessors need to characterize all "background" exposure values and include them in the assessment (U.S. EPA, 2003, 2007). Within this context, EPA defines "background" as all existing metal sources other than the targeted source. Therefore, even if EPA is focusing their HHRA on aquatic exposure pathways within OU5, they still need to consider other "background" sources of exposure, which for Tribal members and citizens in OU5	If separate alternatives have been developed for different areas or media of the site, it is recommended that they be combined during the detailed analysis phase to present comprehensive options addressing all potential threats posed by the site or that area being addressed by the OU. EPA's *Risk Assessment Guidance for Superfund (RAGS) Part A* (EPA, 1989) states: "The human health evaluation should focus on the subject of the RI/FS [remedial investigation/feasibility study], whether that is an operable unit or the site as a whole. The baseline risk assessment and other risk information gathered will provide the justification for taking the action for the operable unit. At the same time, personnel involved in conducting the human health evaluation for a focused RI/FS must be mindful of other potential exposure pathways, and other actions that are being contemplated for the site to address other potential exposures. Risk analysts should foresee that exposure pathways outside the scope of the focused RI/FS may ultimately be combined with exposure pathways that are directly addressed by the focused RI/FS. Considering risks from all related operable units should prevent the unexpected discovery of high multiple pathway risks during the human health evaluation for the last operable unit." The HHRA risk estimates address potential exposures to media within OU5 only. The risk estimates associated with terrestrial exposures were presented in the HHRA for OU4.

Table 2a. Response to Comments Provided by TCTCIT on Document No. 2

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			include, for example, contaminated air and soil, large game, small game, and terrestrial plants in other parts of the Tar Creek Superfund Site. If EPA does not consider these sources, EPA may underestimate the risk and set exposure and cleanup levels that are in fact not protective of human health.	The approach for development of preliminary remediation goals (PRGs) and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level), including considerations for other OUs, have not yet been established and will be developed after the HHRA for OU5.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
1	Introduction	1 Para. 2 and 3	The Quapaw Tribe of Oklahoma (QTO) provided comments on an earlier supporting document (Attachment No 1). The majority of concerns raised in this previous review still are unresolved. The QTO believes it would be much more expeditious and cost-effective for EPA to respond to these previous concerns (Attachment No. 1) as well as additional concerns provided herein before proceeding any further. The QTO reiterates that OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] As demonstrated below, the information contained in this technical memorandum falls far short. [1] In early 2016 the Tribe proposed to EPA to develop RME's for each OU type; however, funding was not received.	The HHRA risk estimates address potential exposures to media within OU5 only; the RME exposure scenarios and assumptions are based on input received from the QTO and TCTCIT. The risk estimates associated with terrestrial exposures were presented in the HHRA for OU4. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.
2	General Comments (in addition to those raised in Attachment No. 1)	2, Bullet 1	Aquatic-based and terrestrial-based variants of the RME for the QTO need to be developed as soon as possible (see Attachment No. 1)	The HHRA risk estimates address potential exposures to media within OU5 only; the RME exposure scenarios and assumptions are based on input received from the QTO and TCTCIT. The risk estimates associated with terrestrial exposures were presented in the HHRA for OU4.
3	General Comments (in addition to those raised in Attachment No. 1)	2, Bullet 2	From data presented in the Tech Memo, it is clear that the Tribes of the Tar Creek Trustee council (TCTC) rely on resources at much lower consumption rates, frequencies, and durations. Therefore the QTO is greatest exposed hedonistic receptor in the area. This means that tribes of the TCTCIT are much lower risk populations and should not be the subject of development of RMEs, since the QTO RME (terrestrial and aquatic variants) is protective of the TCTCIT Tribes. This also means that PRGs/RAOs and ultimately selection of the preferred alternative must be based on the QTO RME and not RME based on the TCTCIT tribes.	The final biota consumption rates used in the HHRA were obtained from Harper (2008) (see RAGS Table 4.6). The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
4	General Comments (in addition to those raised in Attachment No. 1)	2, Bullet 3	The General Objectives of the Tar Creek OU5 HHRA (Section 2.0) is misleading: *The objectives of the HHRA are two-fold: first, to estimate the level of risk to human health associated with concentrations of environmental contaminants detected in OU5 media (surface water, sediments, biota, and mine discharge);* At this stage of the RI/FS, estimating PRGs/RAOs is the objective, followed by quantification of residual risk associated with each proposed alternative in the FS. The Hazard Ranking Score (HRS) has already demonstrated that Risk is excessive, even to the general public. Risk is clearly much greater for the QTO who "live close to the land". *Risks are estimated **for current exposures to OU5** media as well as reasonably foreseeable future uses. All contaminated media within OU5 are considered (such as sediment and surface water) if individuals are likely to be exposed to the media. All relevant **routes of exposure for OU5 are considered**, including direct contact (ingestion and dermal exposure) and indirect contact (exposure to food items that have accumulated contaminants through sediments).* [Emphasis added] EPA cannot discount risk associated with the other OUs. In other words EPA needs to assess risk allocation from all OUs, from all COCs released, from all media, along all pathways to the QTO.	EPA's *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (EPA, 1991) indicates that the primary purpose of the baseline risk assessment is to provide risk managers with an understanding of the actual and potential risks to human health and the environment posed by the site and any uncertainties associated with the assessment. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.
5	General Comments (in addition to those raised in Attachment No. 1)	3, Bullet 4	Sweatlodge usage was intentionally left ambiguous in the original QTO HHRA Scenario. The Traditional QTO frequency of sweatlodge use requires more research. This was included in the aforementioned proposal mentioned in Attachment No. 1. The downriver tribes may use a sweat lodge less than once per month, but research may reveal that the QTO use it at a higher frequency. This is important because the QTO reservation encompasses the most contaminated lands of all OUs.[2,3] The QTO are the population representing the RME, and sweatlodge use is likely an important risk-driving activity. This means that PRGs/RAOs and subsequent remedies will be based on remedies that are protective for the Quapaw Tribe. [2] The Tribe also has the right to hunt fish and gather in areas downstream of their reservation. [3] Many of the QTO members are dual citizens or have relatives of the downstream tribes that would result in the QTO to be exposed via diet during hunting, fishing, and gathering or via trade of contaminated resources.	A sweat lodge exposure frequency of 365 days/year, exposure time of 1 hour/event, and exposure duration of 64 years is used for adults in the HHRA based on *Shoshone-Bannock Exposure Scenario for Use in Risk Assessment: Traditional Subsistence Lifeways*. (S-B EWMP, 2016). These exposure assumptions are more conservative than input provided by Quapaw and TCTCIT. A sweat lodge exposure frequency of 365 days/year, exposure time of 1 hour/event, and exposure duration of 4 years (children ages 2 to 6) is used for children in the HHRA based on input from QTO since TCTCIT indicated that children do not use the sweat lodge.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
6	General Comments (in addition to those raised in Attachment No. 1)	3, Bullet 5	The distinction between ordinary surface water and mine discharge surface water is not clear. *"Mine discharge occurs in three known locations of the Tar Creek Superfund Site in Ottawa County, Oklahoma"* It is not clear why there is any distinction at all, since any mine discharge becomes diluted with other water, and at some magical undefined point becomes ordinary surface water. The standard RME should be applied to these locations just as with any other location. This approach should save on risk calculation costs as well. Also, water quality standards are not dependent on the depth of the water (Section 3.4). The mine water media also needs to be connected to Surface Water in the wire-frame CSM.	The mine discharges sampled are representative of those that people could contact outside of creeks, rivers, and tributaries. Mine discharges in one area of the Tar Creek Watershed (in Commerce) are currently being treated by passive treatment systems at the point of discharge. The mine discharges within the remaining two areas occur intermittently, have a typically low flow rate, and are not easily accessible. Although exposure is expected to be infrequent, mine discharge was conservatively evaluated using the same exposure scenarios and assumptions as surface water in Appendix F3. Mine discharge media is connected to surface water in the conceptual site model (CSM) figure provided in the HHRA.
7	Specific Comments	4, Bullet 1	Section 1.0(1). While there is a logic to start by collecting all available data and then filling data gaps, a more complete process would be to: (Step 1) develop a whole-site human usage map and exposure scenario (the "exposome"), (Step 2) develop DQOs with detection limits based on total exposure and on background , (Step 3) review existing data for data usability according to EPA guidelines, (Step 4) develop a data gap report, (Step 5) collect new data, (Step 6) determine how to allocate risk among OUs and develop RMEs for as many OUs or sub-site areas as needed, and (Step 7) evaluate exposure and risk. These earlier documents cannot exist, since the RME(s) have not been developed and they are necessary to developing OU-specific DQOs and subsequently determine data usability. The allocation of risk among OUs means that the total allowable human risk (e.g., 1E-6 and HI = 1) will need to be subdivided among OUs so that individual OUs do not usurp the entire risk budget. Risk targets for individual OUs will need to be fractions of the total allowable risk. This comment is expanded in the next comment.	This HHRA addresses potential exposures to media within OU5 only. The risk estimates associated with terrestrial exposures were presented in the HHRA for OU4 and residential exposures in the HHRA for OU2. The preliminary CSM was developed at the beginning of the OU5 study in 2016 and continued to be refined with input from QTO and TCTCIT, and has informed the OU5 HHRA. Step 1 is not necessary as each OU has allocated risk (Step 6) and each OU has completed Steps 2 through Step 7. The RME for OU5 scenarios and exposure assumptions were identified through input from TCTCIT and QTO. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
8	Specific Comments	4, Bullet 2	The "Overview of the Superfund HHRA Process" is incorrect. *1. The first step focuses on data collection and analysis to evaluate the characteristics of the site and support identification of the chemicals of potential concern (COPCs) in site media.* This step is performed prior to listing in HRS and only identifies gross COPCs detrimental to the general public. The HHRAS/RME is required to determine necessary detection limits of COPCs. However, since Tribal populations use are the greatest exposed hedonistic receptor in the area, generally for mine sites, all EPA Target Analyte List (plus molybdenum) are COCs and the list of TAL+Mo cannot be screened-down. Regardless, COCs, necessary detection limits, and geographic scope are determined near Step 4. Data gaps cannot be determined until EPA knows what data are needed (DQOs) and if the exiting data meet these DQOs. A later step is developing the SAP/FSP (or similar document(s)) that provides statistical design-level rationale for sampling biotic and abiotic media identified by EPA to be lacking from the historic database at the proper risk-based detection levels. This lacking information is termed data gaps. In order to determine what data are missing, EPA must first know what data they need to perform the BHHRA. The BHHRA is based on the reasonably anticipated future land use (RAFLU) of the target population. Note that land use is determined by the land owner first, and then the area is cleaned up to make that use safe, rather than forcing land use to be limited if the cleanup is not sufficient to reduce risk enough based on the RAFLU (i.e., if institutional controls are needed). At TC, since these are Tribal lands, the QTO is the target of the BHHRA. Once the RAFLU and the target population have been identified, a plan is developed that specifies the data needs for the BHHRA. This is done in the HHRA work plan by using the conceptual site model as a visual accounting tool to derive the list of data that are needed. Next, the quality and quantity of those data are defined in a similar manner while the data quality objectives are being prepared. Once the DQOs have been prepared, the DQOs are used as a screening tool to evaluate the historical data. Data that meet the DQOs are retained for the BHHRA. Data that do not meet the DQO's are rejected and the data gap is recorded. Finally, a SAP and a FSP are developed using the DQOs and the HHRA WP to fill the gaps. This approach is detailed in the NCP.	The first step of the baseline HHRA process, as presented in EPA's RAGS Part A, is Data Evaluation, which includes screening site data for chemicals exceeding risk-based concentrations. The chemicals exceeding screening levels are termed chemicals of potential concern (COPCs), and those that are risk drivers based on the HHRA results are termed chemicals of concern (COCs). The data usability evaluation that was conducted on the existing dataset in 2016 is documented in the Data Gap Summary Report (CH2M, 2016). The data that were concluded to be usable for the HHRA have been incorporated into the HHRA dataset. Significant historical studies and associated datasets have focused on only cadmium, lead, and zinc. New data gap samples were analyzed for all metals, not an abbreviated list. The analyte list and the detection limits needed from a risk-based standpoint were identified in the Quality Assurance Project Plan (2017), which included the data quality objectives (DQOs). The HHRA evaluates a Tribal Lifeway scenario in OU5. The preliminary CSM was developed at the beginning of the OU5 study in 2016 and continued to be refined with input from QTO and TCTCIT. The exposure scenarios and assumptions were identified with input from QTO and TCTCIT.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

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9	Specific Comments	5, Bullet 3	Exposure parameters do not have "conservative safety factors" (Section 1.0(2)). *….These assumptions, or default values, are assumed to be representative of a population, although they often include a conservative safety factor. These parameters include things such as time spent contacting surface water.* Exposure factors for the general population are based on actual data and statistical analysis, aiming at central tendency or upper percentiles, depending on the exposure pathway. For unstudied populations, the exposure parameters are extrapolated from actual data with professional judgment. A "reasonable maximum" is exactly that, reasonable.	The specific section of the Technical Memorandum cited in the comment was a general discussion of the Superfund HHRA process. In the HHRA for OU5, the exposure scenarios and assumptions for the Tribal Lifeway scenarios were identified with input from the Quapaw Nation and TCTCIT.
10	Specific Comments	5, Bullet 4	An ecological determination of water body types (and therefore the specific boundaries of OU5) will probably be needed, because the sampling locations appear to include wetlands, streams, rivers, lakes, and springs. Perhaps the boundary of OU5 is a high water mark for a lake, but how is the boundary determined for a wetland or floodplain with seasonal discharges?	OU5 is defined as the wet-bank-to-wet-bank boundaries of perennial flowing streams. Wetlands and riparian areas were included in OU4. All samples used in the OU5 HHRA were collected within the OU5 study area and specifically within the wet-bank-to-wet-bank boundaries of the perennial flowing creeks, with limited exception to select biota such as frogs and raccoons.
11	Specific Comments	5, Bullet 5	The relation between OU5 and the other OUs or other exposure areas is not clear. The floodplains are not included in the OU5 consideration. This is a systemic problem with the approach of subdividing a superfund site into OUs. While remedies may occur as separate engineering actions (e.g., pump and treat groundwater, excavate soil, cap sediments), the human body integrates all media, pathways, and contaminants into one cumulative set of doses with one single physiological response. A truly cumulative approach does not set a remedy for one medium at a time, or one OU at a time unless the contributions from ALL OTHER media, pathways, chemicals, and OUs is treated as background exposures (the RSC or relative source contribution approach). Otherwise, 100% of exposure and risk must be assumed to be derived from each individual OU, and no exposure can occur from other OUs. As currently envisioned, for OU5 100% of time and exposure and food must come from OU5. The only alternative to this is to allocate risk among OUs, such as allowing OU5 to contribute only 20% of the total risk, thus requiring, for instance, the total hazard index (summation of HQ's) from all COCs to be 0.2, not 1.0.	EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) indicates that when a site is divided into OUs, a risk assessment should be performed for each unit separately. During the remedial alternatives process, the alternatives should be evaluated to ensure that they protect human health and the environment from each potential pathway of concern at the site or those areas of the site being addressed as part of an OU. If separate alternatives have been developed for different areas or media of the site, it is recommended that they be combined during the detailed analysis phase to present comprehensive options addressing all potential threats posed by the site or that area being addressed by the OU.

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				EPA's *Risk Assessment Guidance for Superfund (RAGS) Part A* (EPA, 1989) states: "The human health evaluation should focus on the subject of the RI/FS, whether that is an operable unit or the site as a whole. The baseline risk assessment and other risk information gathered will provide the justification for taking the action for the operable unit. At the same time, personnel involved in conducting the human health evaluation for a focused RI/FS must be mindful of other potential exposure pathways, and other actions that are being contemplated for the site to address other potential exposures. Risk analysts should foresee that exposure pathways outside the scope of the focused RI/FS may ultimately be combined with exposure pathways that are directly addressed by the focused RI/FS. Considering risks from all related operable units should prevent the unexpected discovery of high multiple pathway risks during the human health evaluation for the last operable unit." The HHRA risk estimates address potential exposures to media within OU5 only; floodplains were addressed as riparian areas in the OU4 HHRA. In the OU5 HHRA, the following is assumed: • All sediment and surface water exposures occur within OU5. • All drinking water and sweat lodge water is obtained from surface water in OU5. • All fish and shellfish food (100% of the "aquatic and fish" food category in Harper [2008]) is from OU5.

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				• All small game food (135% of the "small game" food category in Harper [2008]) is from OU5. • All roots and bulbs food (100% of the "roots & bulbs" food category in Harper [2008]) is from OU5. • All plants used for salve (45 days/year) are from OU5. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.
12	Specific Comments	6, Bullet 6	The body weight of 80 kg is acceptable only if all the dietary intake values are adjusted upward (See General Comment 3, Attachment No. 1). There are several ways to calculate this. A simple way is to multiply body weight (pounds) by 15-16 kcal/pound to maintain body weight.[4] The Harris-Benedict formula is based on total body weight, height, age, and sex and is a more accurate way to calculate basal metabolic rate. Men: BMR = 66 + (13.7 x wt in kg) + (5 x ht in cm) - (6.8 x age in years), Women: BMR = 655 + (9.6 x wt in kg) + (1.8 x ht in cm) - (4.7 x age in years). The BMR is then multiplied by a factor that considers the activity level of the person:·Sedentary = BMR x 1.2 (little or no exercise, desk job), Lightly active = BMR x 1.375 (light exercise/ sports 1-3 days/week). Moderately active = BMR x 1.55 (moderate exercise/ sports 6-7 days/week). Very active = BMR x 1.725 (hard exercise every day, or exercising 2 xs/day). Extra active = BMR x 1.9 (hard exercise 2 or more times per day, or training for marathon, or triathlon, etc. A similar approach is taken by the University of Maryland.[5] Men who are moderately active should multiply their weight in pounds by 15; women multiply by 12. The resulting number is the total calories per day needed to maintain weight. Relatively inactive men should multiply their weight by 13 and women, by 10. A moderately active woman who weighs 150 lbs. would need 1,800 calories per day to maintain her weight. The US Department of Health and Human Services provides age-specific guidelines in their publication, "Dietary Guidelines for Americans, 2015-2020, 8th edition. [6] For use in this RME, a single simplified value of 2200 kcal/day will be used, for a lightly active to moderately active lifestyle. Note again that, based on the original QTO scenario, the aquatic ecosystem provides only 22% of total food. If OU5 is allowed to contribute 100% of allowable exposure and risk, then none of the other food can come from any other OU, and the person or family cannot live in those OUs and come into contact with them.	A body weight of 70 kg for Tribal Lifeway adults is used in the HHRA, consistent with the *Quapaw Traditional Lifeways Scenario* (Harper, 2008).

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

<table>
<tr><th>Item</th><th>Section</th><th>Page</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th></th><th>Proposed IR based on 70 kg BW & 2000 kcal/day</th><th>Adjusted IR based on 80 kg BW & 2200 kcal/day*</th><th>kcal/100g</th><th>Total daily kcal</th></tr>
<tr><td>Fish (catfish)</td><td>120 gpd</td><td>137 gpd</td><td>100</td><td>137</td></tr>
<tr><td>Shellfish (mussels)</td><td>30 gpd</td><td>34 gpd</td><td>182</td><td>63</td></tr>
<tr><td>Arrowroot root</td><td>133 gpd</td><td>152 gpd</td><td>66</td><td>100</td></tr>
<tr><td>Turtles, frogs</td><td>24 gpd</td><td>27 gpd</td><td>89</td><td>24</td></tr>
<tr><td>Semi-aquatic mammals (beaver)</td><td>69 gpd</td><td>79 gpd</td><td>212</td><td>166</td></tr>
<tr><td>Totals</td><td>376 g (13 oz)</td><td>429 g (15 oz)</td><td></td><td>490 kcal
22% of 2200 kcal/d</td></tr>
<tr><td>EF</td><td>365</td><td></td><td></td><td></td></tr>
<tr><td>FC</td><td>1</td><td></td><td></td><td></td></tr>
<tr><td>ED</td><td>64</td><td></td><td></td><td></td></tr>
<tr><td>BW</td><td>80</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">* A BW of 80 kg requires 2200 kcal/day, as opposed to 2000 for a 70kg body. IR is adjusted m \by the ratio of 70 kg to 80 kg, or multiplying the original IR by 1.14.
NOTE: the original scenario did not evaluate upland versus in-water food or exposures.</td></tr>
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</td><td></td></tr>
<tr><td>13</td><td>Specific Comment</td><td>7,
Bullet 7</td><td>The rationale for the values in the separate document TCTC_RAGS_Table 4 from 2016 are not clear from the footnotes. For example, the Tribes proposed a shellfish IR of 30 gpd, while the proposed value was 12 gpd (not converted to g/kg-d), and the Tribes' IR for plants is 133 gpd while the proposed value was 40 gpd. The rates in the TCOU5RI (the current document under review) no longer have the lower proposed values, so please verify that the older RAGS_Table 4 table is no longer the operative table. Again, the QTO is the RME in which PRGs/RAOs must be based. Comments provided by the TCTC demonstrate that that Tribes belonging to this entity are less likely to be exposed, even in the downstream areas than the QTO7 (Also See Comment No. 5 Attachment No. 1).</td><td>The final values for biota ingestion rates are presented in RAGS Table 4.6; as shown, the shellfish ingestion rate is 30 g/day for adults. The final values for plant ingestion rates are presented in RAGS Table 4.7; as shown, the ingestion rate is 133 g/day for adults.</td></tr>
<tr><td>14</td><td>Specific Comment</td><td>8,
Bullet 8</td><td>The tribal worker scenario is not a useful scenario for two reasons. First, the tribal worker is assumed to spend fewer days per year (250 days) than the resident (312 days), and a shorter exposure duration (25 versus 70 years). It is not clear why the tribal worker's exposure is less than the ordinary resident. The only difference is that the skin surface might be reduced if the worker wears waders, but this difference alone seems unnecessary. Second, if the tribal worker's allowable risk is set at 1e-6 and HI=1, then this worker must live somewhere else, retire somewhere else, he cannot eat fish from the lake with his family members, and he cannot use the sweatlodge. It is more realistic that a regular tribal resident also works on the remedy, which does not change the total exposure in the scenario as described now.</td><td>Aquatic workers are presented separately to address people who work in surface water and sediment (250 days/year) but do not participate in other Tribal Lifeway scenarios (i.e., they may not practice in sweat lodge ceremonies or other Tribal Lifeway scenarios, thus their RME comes from being an aquatic worker exposed to surface water and sediment while working).</td></tr>
<tr><td>15</td><td>Specific Comment</td><td>8,
Bullet 9</td><td>Please remove the term "conservative" throughout the document and substitute the work "reasonable". The RME is reasonable, not a conservative worst case. For example, Section 3.1.4 says both that the RME does not include special high-contact water events but implies that it still over-estimates total reasonable exposures. It would be more appropriate to say that the reasonable maximum may not include certain high-contact events; those events might not need to be addressed in a risk assessment, but special advice to members depending on exposure point concentrations might be warranted.</td><td>The wording in the HHRA indicates that the RME scenario may not include certain high-contact events.</td></tr>
</table>

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
16	Specific Comment	8, Bullet 10	Section 3.1.1 The consideration of salve is good. It is not clear if any other aquatic plants will be sampled, or whether arrowroot represents all edible aquatic vegetation.	Duckweed and arrowhead plants were sampled based on input from QTO and TCTCIT. Both plants are included in the HHRA dataset and are used to represent edible aquatic vegetation. All parts of the arrowhead plant were used to evaluate the salve and ingestion exposure scenarios.
17	Specific Comment	8, Bullet 11	Section 3.3.2, Fish and shellfish ingestion. See comment on adjusting the intake rate. When the actual risk assessment is done, more attention to the method of preparation of various species may be needed, such as a crayfish boil, fish served skin on or off, and so on. A similar comment pertains to aquatic plants and how much sediment might remain on them (relevant to collection and sampling methods as well as to risk estimation).	A body weight of 70 kg was used for Tribal Lifeway adults in the HHRA, so no adjustment was needed for the intake rate. Based on input from QTO and TCTCIT, three types of fish samples were analyzed: head only, fillet only, and eviscerated carcass (the eviscerated whole body was calculated based on these separate parts). The HHRA estimates risk based on calculated whole body concentrations. Differences in concentrations between the estimated whole body concentrations and specific body parts (e.g., head only, fillet only) are discussed in the uncertainty analysis. The sediment ingestion rate (400 mg/day) used in the HHRA incorporates incidental ingestion of residual sediments potentially adhered to unwashed aquatic plants (Harper, 2008). A discussion of potential impacts on the risk estimates related to use of different parts of biota during food preparation (for fish and aquatic plant) is provided in the uncertainty analysis.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
18	Specific Comment	8, Bullet 12	From a public health perspective, past exposures (e.g., in the town of Picher) are relevant to providing appropriate biomedical intervention and specific health advice to individuals. While this is not part of a risk assessment document, it will be relevant when preparing advice based on sampling results, especially if institutional controls are part of the remedy. In point of fact, people who have had past exposures in Picher may already be carrying a high lead burden even if their blood lead levels are now below 5 ug/dl, and some consideration should be made of those past exposures. Remedies are developed for future people who start with no pre-existing body burden and no past exposures, so protecting the health of current tribal members who already have an exposure history should be considered.	Comment noted.
19	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Introduction Memo to Tim Kent, QTO Environmental Program Director and RPM General Comments	1 and 2	This memo constitutes a review of the aforementioned document. Tim Kent has directed us to send this directly to you. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan. The OU4-specific cleanup standards/goals have been developed without considering risk associated with the use of the other OUs. Remediation/removal in OU4 has proceeded relying on these values. Having this concern in 2015, made the Tribe realize that in order to save time and resources, we needed to develop a Reasonable Maximal Exposure Scenario (RME) for each OU as soon as possible.[1] Because the RMEs were not developed, a piecemeal approach is resulting in a requirement for perpetual institutional controls and 5-year reviews, as well as an inability to reuse the lands and resources for their intended uses.[2] Like the proposed plan and ROD, development of the OU5 RME should be a cooperative effort including EPA and the State, and needs to proceed without further delay. Ideally this will result in a cleanup where institutional controls and land use controls are not needed, and UU/UE can be achieved.[3]	The HHRA addresses potential exposures to media within OU5 only. The RME exposure scenarios and assumptions were identified with input from QTO and TCTCIT. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
20	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 1	2	The QTO Traditional Scenario was developed to represent the general or average Traditional QTO citizen who relies on both aquatic AND terrestrial resources—it is not a Reasonable Maximal Exposure (RME) for a given OU.[4] The RME should be a comprehensive site-wide exposure scenario, not an OU-specific exposure. As long as terrestrial and aquatic OUs are separated, the true OU-specific RME is one that describes individuals using either terrestrial OR aquatic OUs. The latter would be an RME for 100% time and 100% sustenance from each OU. For example, the RME for a person who is more reliant on aquatic resources would require a greater aquatic diet, water from surface water or mine discharge (whichever is higher) and more aquatic area exposure time. As presented by EPA, the OU5 user is recreational, which is by definition not comprehensive. Further, limiting OU5 use to recreational use is inconsistent with the Tribes' plans for land use, and is in effect an institutional control. It also prevents a multi-OU cumulative exposure assessment. The options are to either (1) develop an RME for 100% of time and diet in OU5 and another for 100% OU4, or (2) develop a combined OU4/OU5 RME that uses resources from both areas simultaneously (in effect assuming a relative source contribution from each OU). As currently devised, the OU4 user cannot use resources from OU5 because his/her risk allocation has already been filled, and vice versa.	The HHRA addresses potential exposures to aquatic resources within OU5 only. The RME exposure scenarios and assumptions for the Tribal Lifeway scenario – which includes surface water and sediment exposures from fishing, hunting, gathering, recreational activities, and sweat lodge use; potable use of surface water; consumption of aquatic biota and plants; and medicinal use of plants as salve – were identified with input from QTO and TCTCIT. Potential exposures to terrestrial resources (including soil contact, terrestrial small game and large game ingestion scenarios, and plant consumption) were addressed in the OU4 HHRA. The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.
21	Attachment No 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 2	2	Based solely on the approach used to build the RAGS Table 4, the Tribe still foresees major problems associated with the HHRA for the future traditional resident. These problems are overarching and associated with balkanizing the site into OUs without reintegrating risk across the OUs to enable a comprehensive assessment of site risk as required by CERCLA. This concern has been raised by the Tribe previously and is clearly nothing new. The Tribe warned EPA on these issues as far back as 2004 and reiterated these concerns in no less than five memoranda. An early example first is General Comment 3, November 22, 2005	The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

<table>
<tr><th>Item</th><th>Section</th><th>Page</th><th>Comment</th><th>Response</th></tr>
<tr>
<td>22</td>
<td>Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 3</td>
<td>3</td>
<td>
The PRGs/RAOs do not consider the exposure that ecological or human receptors receive from the Surface water pathway as well as riparian resources. This is a major error and omission on the part of both the ecological and the Human Health Risk Assessments (this will be discussed in greater detail in comments on those reports). The residual exposure to humans from drinking surface water and using surface water in sweatlodge ceremonies alone exceed allowable risk. This risk is real and cannot be assumed away or managed via institutional controls such as signage or education— people are using these resources today. This means that that the allowable risk to Tribal members who use resources for traditional cultural practices will be exceeded even if the uplands are returned to background conditions.
The concept of an Operable Unit was developed to partition remedial actions into workable or manageable units—not to balkanize risk assessments. The NCP requires protection of human health and the environment for the reasonably foreseeable land use of the site—not of an OU. In summary, as long as the residual risk from OU1 is measurable, the allowable risk from other OUs must be reduced by an amount so that the cumulative site-wide risk does not exceed the threshold criteria. In this instance, the risk allocated for all other OUs has been usurped by OU1. Therefore, the PRG for all media (e.g. surface water, ground water, soils, floodplain sediments, and air) must be pre-release baseline (background). The following table is included as another early example (excerpted from Attachment No. 2). Pay particular attention to footnote No. 2 to the table.
Tribal Exposure Areas on Tribal lands
<table>
<tr><th>General Activity</th><th>Source Areas: Chat Piles/Bases/Flotation Tailings Ponds</th><th>Transition Zones</th><th>Wetlands/Streams [2]</th></tr>
<tr><td>Relative Potential for Tribal Residential Use</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td>Relative Potential for Tribal Subsistence Fishing Use</td><td>NA</td><td>NA</td><td>High</td></tr>
<tr><td>Relative Potential for Tribal Gathering Use (Aquatic)</td><td>NA</td><td>NA</td><td>High</td></tr>
<tr><td>Relative Potential for Tribal Gathering Use (Terrestrial)</td><td>High</td><td>High</td><td>NA</td></tr>
<tr><td>Relative Potential for Tribal Hunting Use</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td>Relative Potential for Tribal Recreational Use</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td colspan="4">General Population Exposure on Tribal lands [1]</td></tr>
<tr><td>Relative Potential for General Public Sportfishing Use</td><td>NA</td><td>NA</td><td>Moderate-Low</td></tr>
<tr><td>Relative Potential for General Public Bathing Use</td><td>NA</td><td>NA</td><td>Moderate-Low</td></tr>
</table>
NA = Not Applicable
[1] If members of the General Public (GP) reside on Tribal Lands, the residential recreational doses for the GP must also be determined.
[2] although this EA is not officially part of OU4, the dose from these areas must be considered in the Risk Assessment. If the Dose allocation from this EA equals or exceeds Risk Criteria defined by the NCP, then all other EAs must be cleaned-up to pre-release background conditions.
</td>
<td>The approach for development of PRGs and target levels for various health endpoints (e.g., cancer risk, hazard index, blood lead level) have not yet been established.</td>
</tr>
</table>

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
23	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 3	4	Conversion to g/kg-d. This seems to be a systemic problem. An example for fish from Table 3-1 is that the fish daily ingestion rate = 120 g/d; (mistakenly converted to 15 g/kg-d by EPA). This is simply a dilution of the 120 g/d estimate by a 70 kg person into an 80 kg person because EPA assumes that the same amount is eaten by both a 70 kg person and an 80 kg person. (120 g/d)/70 kg = 1.714 g/kg/d, not 1.5 g/kd-d. EPA's value of 1.5 g/kg-d comes from dividing the 120 g/d by 80 kg, which means that the larger person is eating less per body weight than the original 70 kg person. 2000 kcal (1526 g/d) is not enough to sustain an 80 kg person, as shown below (See Attachment). We do not dispute that the average American is now 80 kg. But this means that everyone is eating more. If EPA wants to assume that people are heavier today, then they also have to recognize that they eat more, i.e., every intake factor needs to be multiplied by 1.145. The goal for Tribes is to recapture its old lifestyle that leads to non-supersized people. The Traditional Scenario was developed for when people were a traditional size. If EPA wants to adjust to new super-sized people to assess risk for current conditions, they must scale all of the aforementioned exposure factors. However, the goal of the Tribe goal is for our future citizens to reach 70 kg once again. This means that the future traditional Tribal resident needs to be assessed assuming a traditional body weight of 70 kg, or alternately that the 80 kg person eats proportionally more. *We recommend that EPA also examines the total caloric intake for the whole diet and compare it to the caloric needs per kg of body weight, rather than simply diluting a 70-kg diet into an 80-kg body.*	A body weight of 70 kg was used for Tribal Lifeway adults in the HHRA, so no adjustment was needed for food intake rates.
24	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 4	5	Use of two Canadian studies for reducing the soil ingestion rate. These two fecal tracer studies were conducted with the Nemiah Band, a traditional community; all food was provided to the participants by the investigators in the Davis et al. (2012) study, and participants were engaged in fisheries activities. A similar study of the same community was conducted by the same investigators (Irvine et al., 2014), with participants engaged in traditional activities; all food was provided to the participants by the investigators. As explained in Attachment No. 4: Soil Ingestion for Oklahoma," these two studies are not considered to be applicable to the Quapaw exposure scenario. QTO believes that decades of previous work with multiple lines of evidence is not invalidated by these two studies. The approved Quapaw scenario uses a soil/sediment ingestion of 400 mg/d; the attachment presents the rationale for reducing the soil ingestion rate for another Tribe that behaves differently to 330 mg/d if the other Tribe(s) so desire.	A sediment ingestion rate of 400 mg/day was used in the HHRA for Tribal Lifeway adults and children.

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Item	Section	Page	Comment	Response
25	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 5	5	Geographic scope of OU5 needs to be revised. We see several problems: a. We cannot ascertain the geographic scope from the provided information. Does OU5 extend all the way to Grand Lake. Or is it solely within the OU4 boundary? b. It is not clear whether riparian and flood-plain soils are included and whether the nature and extent of contamination has been characterized downstream of the source area on the QTO reservation. c. Downstream Tribes who are not using the source area uplands should perhaps have a separate OU and subsequent RME based on that OU. That RME would include the floodplains where residences occur.	a. The geographic scope of OU5 is shown on Figure 1-1 of the HHRA. b. Riparian and floodplain soils were included in the HHRA for OU4. c. The RME for the Tribal Lifeway scenario in OU5 was based on input from both QTO and TCTCIT, with the more conservative input used where input differed. Floodplains are addressed in OU4.
26	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - General Comment 6	6	Frequency of sweat lodge use. The Quapaw scenario includes daily use of a sweatlodge. We note that asking one tribal member about a lower rate does not invalidate the value used in the officially approved scenario. However, if the downriver tribes wish to use a lower frequency, they may do so.	A sweat lodge exposure frequency of 365 days/year, exposure time of 1 hour/event, and exposure duration of 64 years is used for adults in the HHRA. These exposure assumptions are more conservative than input provided by Quapaw and TCTCIT. A sweat lodge exposure frequency of 365 days/year, exposure time of 1 hour/event, and exposure duration of 4 years (children ages 2 to 6) is used for children in the HHRA based on input from QTO since TCTCIT indicated that children do not use the sweat lodge.

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
27	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 3-1	• Does waterfowl data already exist (so it is not a data gap)? • Cell 8j: “Two plant types (duckweed and arrowhead root); duckweed = washed whole plant; arrowhead = washed tuber only, washed fine roots only, and washed leaves/stalk only.” (OK, but duckweed is not listed in Table 4-1.) • Cell 11j: What grain size will be used in sieving? As EPA knows, more contaminants are adsorbed as the surface area increases with smaller grain sizes, and stream silt would have smaller grain sizes. Additionally, the sand- silt cutoff (63 um) is the point at which grittiness is detected and spit out. See the Soil Ingestion attachment for a longer discussion	As indicated in the Data Gap Summary Report (2017), site-specific waterfowl (duck) breast meat/tissue data were not identified during the compilation of existing data. However, based on information provided in the Bunker Hill Superfund Site HHRA (TerraGraphics, 2001) and additional literature (van der Merwe et al., 2011), waterfowl tissue are qualitatively assessed in the uncertainty analysis, so there is not a data gap. Duckweed and arrowhead plant are included in the HHRA dataset for aquatic plant consumption. The available dataset for sediment includes both sieved and unsieved samples; the sieved samples were sieved using various sieve sizes ranging from 2 mm to 63 µm.

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Item	Section	Page	Comment	Response
28	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-1 Food	Footnote 3 – 10% of aquatic food is shellfish, which is reasonable, but what % of the total diet is aquatic?	The percentage of the total diet that is aquatic is not identified in the HHRA but is presented in Figure 9 of the *Quapaw Traditional Lifeways Scenario* (Harper, 2008). In this figure, the following food categories are shown as percentages of daily grams and are incorporated into the OU5 HHRA: • Aquatic and Fish 8% – 100% of the category is assumed to be OU5 fish and shellfish. • Small game 4% – 100% of the category is assumed to be OU5 semi-aquatic mammals (represented by raccoon samples). An additional 35% of the category is assumed to be OU5 amphibians and reptiles (represented by frog leg samples). • Roots and Bulbs 9% – 100% of the category is assumed to be OU5 aquatic plants (represented by duckweed and arrowhead samples). Based on the addition of these categories (8 + 4 + 9), approximately 21% of the diet is aquatic. An alternative (higher) Tribal Lifeway plant ingestion rate is presented in Appendix F4.
29	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-1 Food	Footnote 4 – 20% of aquatic food is amphibian and reptile; 20% is plants. This leaves 50% for fish if small mammals are kept separate; again, what % of the total diet is comprised of aquatic-sourced foods, and what assumption are made about where the rest of the food comes from? It cannot come from OU4, because OU4 has already filled the entire risk allocation.	Approximately 21% of the total diet is aquatic. The rest of the food comes from terrestrial sources, consistent with Figure 9 of the *Quapaw Traditional Lifeways Scenario* (Harper, 2008). Terrestrial food items were addressed in the HHRA for OU4.

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Item	Section	Page	Comment	Response
30	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-1 Food	It is not clear whether EPA intends to use a fish ingestion rate of 120 g/d plus shellfish (12 g/d), aquatic tubers (40 g/d), plus herps (24 g/d). or whether EPA intends to divide 120 g/d into different fractions.	As indicated in RAGS Tables 4.6 and 4.7 (RAGS tables are presented in Appendix B of the HHRA), the following ingestion rates are used for adults: fish = 90 g/day, shellfish = 30 g/day, frog = 24 g/day, raccoon = 69 g/day, and aquatic plants = 133 g/day.
31	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-1 Food	Aquatic tubers = 40 g/d (no duckweed?)	As indicated in RAGS Table 4.7 of the HHRA, an aquatic plant ingestion rate of 133 g/day was used for adults; this ingestion rate is applied to the aquatic plant dataset consisting of duckweed and all arrowhead plant data.
32	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-1 Food	Again, EPA should not convert a 70kg person diet into an 80kg person unless the values are raised to account for a larger person eating more.	A body weight of 70 kg was used for Tribal Lifeway adults in the HHRA, so no adjustment was needed for the intake rate.
33	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comments	6, Table 4-2 Sediment	The exposure frequency of 126 days per year is reasonable for recreational use, but the QTO has not agreed that OU4 is solely recreational or that it is off-limits to users of other OUs (due to unacceptable cumulative risk).	A sediment exposure frequency of 312 days/year is used for the Tribal Lifeway scenario in the HHRA, as indicated in RAGS Table 4.1.

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Item	Section	Page	Comment	Response
34	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4.3 SW Potable (surface water in creeks) and Table 4-4 SW (also in surface water creeks	It is not clear how these two tables are different. If the difference is expected to be related to exposure point concentration, then it would seem that a single set of exposure assumption should be used with several different exposure point concentrations (the creek, the mine drainage, the river, and groundwater).	The differences in the tables are based on exposure assumptions. Four RAGS tables present the exposure assumptions used in the HHRA for various Tribal Lifeway scenarios in surface water: • Table 4.2 – Water contacted during swimming and wading activities for 6 hrs/day (312 days/year for adults and 234 days/year for children) • Table 4.3 – Water used as a daily drinking water source (2.5 L/day for adults and 0.78 L/day for children) • Table 4.4 – Water as a drinking water source when using a sweat lodge (an additional 1 L/day for adults and children) • Table 4.5 – Water inhaled while in a sweat lodge Mine discharge is evaluated using the same exposure scenarios and assumptions as surface water in Appendix F3. Separate exposure point concentrations (EPCs) are used for each watershed.

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Item	Section	Page	Comment	Response
35	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4.3 SW Potable (surface water in creeks) and Table 4-4 SW (also in surface water creeks	The drinking/swimming/sweatlodge RME should use maximum concentration of whatever resource is more contaminated. This will provide the upper bound of risk. Then, several mixes of the various sources would provide a more central tendency of risks (e.g., 50:50 GW and SW for 365 days/year, plus swimming during 126 days/year).	The exposure scenarios evaluated in the risk assessment are for chronic exposure durations (64 years for adults and 6 years for children for the Tribal Lifeway scenarios). Consistent with EPA guidance presented in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA, 2002), EPCs are based on 95% upper confidence limit (UCL) of the arithmetic mean concentrations (or mean concentrations for lead) rather than maximum detected concentrations. This approach is appropriate since chronic exposures would not occur to maximum detected concentrations. Groundwater was addressed in OU1 and is not addressed in the OU5 HHRA.
36	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4-5 SW sweat lodge	Infants (0-24 months) have no sweat lodge use (OK). See note above about frequency	Children below the age of 2 were not included as sweat lodge receptors in the HHRA.
37	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4-6 Arrowhead -medical salve (in addition to ingestion in Table 4-1	Includes dermal while digging, 12 d/yr x 64 yrs (adult) or 6 yrs (child). This is OK, but the same exposure is received when gathering for food use	The sediment ingestion rate (400 mg/day) used in the HHRA incorporates a variety of soil exposure pathways and activities such as wild foods harvesting and/or gathering, as indicated in Harper (2008).

Table 2b. Response to Comments Provided by AESE, Inc., on Behalf of Quapaw Nation on Document No. 2 and No. 3

Item	Section	Page	Comment	Response
38	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4-7 Discharge	Dermal exposure 1 hr/event (washing) x 10 events/yr. – adult and child. The exposure frequency should be the same as for the other water bodies, even if the drainage is intermittent.	The mine discharges occur intermittently, have a typically low flow rate, and are not easily accessible. Although the mine discharges are only intermittent and the discharges are not easily accessible, mine discharge was conservatively evaluated for the same exposure scenarios and assumptions as surface water in Appendix F3.
39	Attachment No. 1, December 13, 2017 on the Review of HHRA RAGS Part D Table 4 Review - Specific Comment	7, Table 4-7 Discharge	The RME should use the maximum concentration from whatever resource is more contaminated. Thus, this is a question of exposure point concentration, not exposure frequency	If at least eight sample results and four detections of a chemical are available in the dataset, EPCs are based on 95% UCL of the arithmetic mean concentrations (or mean concentrations for lead) rather than maximum detected concentrations. The use of 95% UCL of the arithmetic mean concentrations is consistent with EPA guidance presented in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA, 2002), This approach is appropriate since chronic exposures would not occur to maximum detected concentrations. Mine discharge was evaluated in Appendix F3.

Attachment No 5. Expedited Review of August 17, 2017

Technical Memo prepared by CH2MHill for EPA entitled"
"Tar Creek Source Material Operable Unit Remedial
Action Development of Potential Lead Preliminary
Remediation Goal for Transition Zone Soil"

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, Environmental Division Director,
Quapaw Tribe of Oklahoma (O-Gah-Pah)

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: November 2, 2017

SUBJECT: Expedited Review of August 17, 2017 Technical Memo prepared by CH2MHill for EPA entitled" ***"Tar Creek Source Material Operable Unit 4 Remedial Action Development of Potential Lead Preliminary Remediation Goal for Transition Zone Soil"***

CC: Dr. Harper
File

This memo is a review of the aforementioned document under the "deviated approach" to the RI/FS described by EPA. A few General comments follow.

General comments

1. QTO's long term planning goal, described in various resolutions is to repatriate all lands within the reservation boundaries for the unrestricted use by future QTO generations. This is the land use promised to the Tribe by the United States, when these lands were reserved for the QTO. Therefore, regardless of current ownership or current land designation the Tribe cannot support any land uses that do not support at a minimum the Tribe's ability to hunt fish and gather at traditional rates (HF&G) [1] on any land, unless QTO resolves to change these goals.[2] This requirement is by no means new to EPA and its contractors,[3] yet the EPA TM fully omits the Tribe's reasonably foreseeable future land use (RFFLU) and incorrectly concludes that an adolescent of the general population who recreates in the area is the most sensitive subpopulation.[4]

2. The only way to break the various pathways from contaminated soils/sediments to humans and other terrestrial receptors is to burry contaminated soils or sediments with clean soils[5] or with water via flooding and turning the area into a wetland/reservoir.

   EPA's proposal to evaluate changing land use to reduce the cost of cleanup is rooted in the unavailability of local soils to cover contaminated material or bedrock that remains after a removal (or projected removal)[6]. Reduction in cleanup cost is attractive to EPA; however, it comes at the expense of QTO current and future uses of reservation lands (See General comment No. 1).

   In order to facilitate the change in PRG evaluation, EPA assumes that the RFFLU is Pasture since it is the dominant current land use type. However, pasture lands also support traditional uses (HF&G). [7] Along with omitting the Tribe's federally

[1] Lands within the Site that do have attached deed restrictions, also must include residential use along with traditional HF&G

[2] For example, the Tribe could resolve to commit specific lands to wetlands development.

[3] A search of the Tribe's comments reveals that this discussion occurs in some the Tribe earliest comments on Data gaps in 2004

[4] A QTO adolescent who resides and follows traditional uses (HF&G) is more sensitive receptor.

[5] This includes excavation and hauling contaminated media to a repository.

[6] As I pointed out in comments on an early Draft of the FS where EPA's preferred Alternative was to cover a majority of the material with imported soils, EPA's preferred alt would require scalping the soils off of the next county, leaving two counties in bad shape.

[7] The logic employed to derive this conclusion is circular. The Current land use is affecte3d by presents of contamination and advisories. The logic is analogous to a asking a fisherman how many fish he consumes per month on average and he replies 0.5 fish, but further responds "I only earth that small amount because that is what YOU advise".

reserved RFFLU, it is clear that that EPA does not understand that land uses are multiple and change over time. For example, lands designated as predominantly pasture, grazing, etc. also support HF&G[8], wildlife. Uses of these lands shift quickly to the higher and better use as these lands are remediated. Another example is that the frequency of uses shift over time when lands slowly reverts without active RA to near natural conditions. For example the subsidence buyout areas will be restricted from residential development, but these areas will be attractive for HF&G, since resident s are not present and the areas support wildlife.

The bottom line is since all dominant land use types support multiple uses and land uses change over time, in order to address permanence under NCP, cleanup needs to be governed by highest and best RFFLU— traditional QTO HF&G.

3. The surface of the majority of the site is located within the floodplains of Tar and Lytle creeks and therefore is geologically active from an overland surface water flow standpoint. This means that soils and sediments are resuspended, transported, and redistributed on nearly an annual basis. This also means that multiple uses with multiple soil/sediment PRGs are not appropriate for this site, since lower quality cleanup areas restricted for pasture or a lower use only, would be sources for areas for unrestricted use lands such as those required by the QTO. This concern was identified early on during development of the proposed plan.[9]

   This means that PRGs for surficial materials for the highest and best use lands located downstream, dictate the level of cleanup necessary in upstream lands. This is the reason sequencing of cleanup is designed to begin upstream in the Treece or the Distal areas and progress downstream toward the Spring River. In summary the highest and best RFFLU, which is "unrestricted' for Traditional hunting fishing and gathering, dictates the cleanup for all surfaces of the entire site. This concern is further driven home by the fact that tornados have been observed to dance through the area, redistributing materials unpredictably in nearly all directions. Since EPA cannot control flooding nor Oklahoma's weather in general, clean up to the highest and best uses suffices for all uses for all instances. Anything short of this will result in

[8] On reservations out west, a Tribal member can take a deer or gather on fee land owned by a member of the general public

[9] The author was one of the main architects of the proposed plan. During this work I reminded all of designers what farmer Frank Frucci stated at the public meeting for the Coeur d'Alene superfund site when face with recontamination issues: "momma always taught us to wash a car from top to bottom". This simple logic is more applicable to this site due to its location in the floodplain.

recontamination and will require re-remediation, which is clearly antithetic to the permanency requirement of the NCP 9 Criteria. [10]

From the previous comments, criteria required for changing the PRG to a lower use such as pasture land include:

1. Lands cannot be located within the reservation boundary, unless QTO resolves to enable this change to occur;
2. Lands are not likely to ever be used for higher purposes including HF&G; and
3. Lands are not likely to be a source to other nearby lands

These instances seem very limited and if allowed to occur, these Ag lands will be new sources for recontamination during next flood event. Further pursuit of this type of thinking where many of the answers are known, and have been known for some time in advance, has resulted in a major waste of time and resources.

[10] 40CFR300.430(e)(9)

Attachment No 6. Review of: Remedial Investigation Report Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma, June 2019.

AESE, Inc.

P.O. Box 50392,
Henderson, NV 89016
509-590-3758
http://www.aeseinc.com

MEMORANDUM

TO: Tim Kent, PG, QTO Environmental Program Director and RPM

FROM: Dr. F. E. Kirschner, Senior Scientist

DATE: October 17, 2019

SUBJECT: Review of: ***Remedial Investigation Report Version 1.1 Tar Creek Superfund Site Operable Unit 5 Ottawa County, Oklahoma, June 2019.***

CC: File

This memo constitutes a review of the aforementioned document. A few general comments follow. In preparing these comments, the Tribe has attempted to focus on issues that could make a difference in the RI/FS and ultimately selection of the remedy in the Proposed Plan.

General Comments

1. **The Draft RI is Premature: issues surrounding the HHRA, BERA, ARARs and PRGs/RAO have not been resolved prior to publication of this document (40CFR300.430(c).**[1] Feasibility Study and remedy designers require delineation of the three-dimensional material that needs to be addressed under the remedial action. Delineation of the nature and extent of contamination (N&E) of all media is required in order to estimate volumes of materials requiring removal or treatment. The N&E is determined by comparing pre-contamination and post contamination levels of contaminants sampled in all media. Sometimes the extent of unallowable risk is determined by comparing risk-based numeric values of PRGs/RAOs to post release conditions. Remedies based on this approach are less protective and uncertain, since redistribution and re-concentration of residual contamination over time cannot be addressed[2]. As pointed out in numerous reviews dating back nearly 20 years, PRGs/RAOs for this site in which Tribal subsistence is the reasonably foreseeable land use, the PRGs must be based on background threshold values (BTVs). If cleanup achieves BTVs, the site is truly cleaned up for all foreseeable and unrestricted land uses. Below is a General Comment No. from 2005 regarding this issue (Attachment No. 1):

   > 6. *For this site, which involves several Native American Tribes, typical PRG's/RAOs/ARARs will not be protective. Therefore, any sample designs based on the attainability of PRG's/RAOs/ARARs that are designed to protect the general population will not be applicable here (i.e. any study that uses these "standards", designed for the general population, to falsely and incorrectly screen-out COCs, media, pathways, or exposure areas) and will only complicate matters later on in the process when the BHHRA has been completed and it is "discovered" that ARARs, PRGs, and PRAOs are not protective of the Tribes.*

   This issue is explored in much more detail in Berrey, et. al (2019; Attachment No. 1):

   The RI is of little use until issues surrounding the HHRA[3], BERA, ARARs and PRGs/RAO have been resolved. Regardless of the millions spent on studies, EPA has not gained any further knowledge of importance to the Feasibility Study

[1] The site characterization report, the BERA, the HHRA, and the PRGs/RAOs determination are finalized prior to publication of the RI. This is another example of "ready, fire, aim."

[2] This problem is amplified at sites like this where buried historic solids that have not been characterized, become available for erosion during annual runoff events.

[3] The Tribe provided over 100 pages of comments on the HHRA alone in its September 26, 2018 memo entitled: Review of: Tar Creek Source Material Operable Unit 4 Remedial Action Exposure Scenario for Human Receptors in Riparian Areas.

regarding the nature and extent of contamination since 2005, and perhaps much earlier, when investigators concluded that the contaminants are numerous and pervasive and the extent of contamination is not contained within the boundaries of OUs 4 or 5. Again, FS designers require three-dimensional delineation of the nature and extent of contamination in order to estimate volumes of materials requiring removal or treatment. The OU5 RI does not meet these FS requirements and will not meet these requirements until consensus has been attained on the aforementioned documents.

2. **Characterization of the main source of Acid rock drainage (ARD), the main cause of release and transport of COCs in both surface waters and sediments, has been omitted.** Kirschner (2008) demonstrates that the Mine discharges are responsible for major dissolved load during baseflow and increases dramatically during recharge and resaturation of mine workings which coincides with major runoff events.[4] Rationale for sampling the different portions of the hydrograph is described in Kirschner (2008)":

> *3.2.1 Field Considerations*
>
> *One goal of surface water sampling (described in greater detail below) was to sample during baseflow conditions and during the peak of the hydrograph in the Douthat Bridge area. This area is of interest because Tar Creek gains flow and COCs from the mine pool via discharging shafts/air vents in that area. This relationship has been described during several historical investigations, including work performed by EPA while working toward a remedy on operable unit 1 (OU1, medium based OU, defined as ground water for the site).*
>
> *In general, early investigators noted that Tar Creek turns red in color as ferri-oxyhydroxides and other metals precipitate out of solution in the mixing zone formed by the confluence of mine-pool and Tar Creek flows (Figure 3). In order to understand loading or COCs, it is necessary to understand contribution of COCs in this area during peak and baseflow.*
>
> *Sampling during baseflow is required to understand transport under typical conditions. Depending on meteorologic conditions, baseflow*

[4] Schaider, (2014), CH2M (2010), and CH2M (2017), the main reports relied upon to describe mine discharge, do not sample on the rising and falling limbs of the hydrograph and therefore, miss major release events.

> *for the site generally occurs in the spring, prior to the rainy season, and in late fall after the rainy season. Sampling during the spring baseflow period is preferred, because it generally follows a long period of minimal precipitation. Under such conditions, salts and other acid rock drainage byproducts are believed to build-up in pore waters of the unsaturated zones of both the bedrock aquifer and the chat pile aquifers. Such COC containing salts and ARD byproducts are typically released upon the first large meteorologic event or freshet.*
>
> *Another goal of the surface-water sampling program was to obtain a near instantaneously sampled dataset or snapshot of the site. However, it was realized that it could be difficult to acquire a snapshot of baseflow conditions, as the rainy season approached. A two-scale monitoring network was developed to obtain snapshots on a coarse network grid (Figure 7). Three snapshots were made: (1) during baseflow, (2) near the peak of the hydrograph, and (3) on the trailing limb of the hydrograph*.

Results depicted in Kirschner (2008) demonstrate that COCs sampled from the rising and trailing limbs of the hydrograph at the Douthat area are roughly the same, or slightly less, than during baseflow, even though flow was more than 1,000 times higher than baseflow.[5] This means that areas like Douthat are transmitting and introducing, for the first time to OU5[6], enormous volumes of COCs into the surface water/sediment system. To make matters worse, all of this occurs during annual high-flow events that result in flooding and contamination of riparian (OU5) and terrestrial soils (OU4).

Kirschner (2008) concludes:

> *Tables 5 and 6 summarize both the total and dissolved COCs that exceed the statistically or functionally supportable values of background as well as the maximum observed background values. From this, it is evident that at least one COC is exceeded at almost all locations. It is apparent that the mine-pool discharge in the vicinity of the Douthat Bridge area is contributing a disproportionate amount of COCs to the system. Equally important, is that there are no other loading sources to Tar Creek that are as significant as the mine pool at Douthat Bridge.* [Emphasis added]

[5] Dilution of COCs is observed upstream of Douthat on the rising and trailing limbs of the hydrograph, demonstrating that the release from chat piles is less important than the release associated with discharge from the mine pool.

[6] Unlike stream sediments which are resuspended or eroded from OU4.

This omission in the RI is considered a fatal flaw since the FS design team will need to design for these conditions which occur annually—not conditions associated with baseflow.[7] For example, if not appropriately addressed via FS design, remediated riparian/terrestrial soils will be recontaminated during large storm events that cause the river/creeks to back-up, flood, and deposit sediments over large areas.

These issues are not new to EPA. Attached is the Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site (2007; Attachment 2). Section **3.1.3** ***"Hydrogeologic studies to determine strategic locations within mine pool for injection."*** should be re-consulted.[8]

3. **Potentially impacted ephemeral streams/creeks and all riparian soils have been omitted from all OUs.** Transition zone (TZ) soils are partially addressed in OU4[9]. OU5 covers perennially saturated sediments and surface waters. The 100 yr. floodplain is large and has been inundated several times during my 20+ years on the project. In some instances, the heart of the site becomes completely inundated, with solids being resuspended and redistributed. Along these lines is the fact that tornadoes clearly have redistributed solid materials in both volumes and directions that are not readily predictable using standard air-phase transport theories.

   Instead of spending 15-20 more years conducting piecemeal sampling campaigns of these areas, the Tribe recommends assuming that the 100yr floodplain is equally as contaminated as stream sediments. This makes practical sense, since riparian soils become sediments during annual runoff events. This means that the numeric PRGs/RAOs for upland or riparian soils cannot exceed those for sediments. Otherwise they are a source to OU4[10]. Again BTV's for sediments and soils are similar and should be used as the numeric PRG/RAO required by the FS designers to proceed.[11] Obviously, recontamination concerns would

[7] A rule of thumb particularly pertinent to soil/sediment transport is that "the majority of soils or sediments are transported and redistributed during one or two days in a given year, during major storm events." Based on Kirschner (2008), this rule of thumb also applies to surface water COC flux, due to the nature of interconnection between the mine pool and surface water at Tar Creek.

[8] This document was central to the proposed plan for OU4, which was cooperatively developed by the QTO, EPA, and the State of OK.

[9] The definition describing OU4 is incorrect: "addresses the undeveloped rural and urban areas of the site where mine and mill residues and smelter wastes have been placed, deposited, stored, or disposed of, or otherwise have come to be located as a result of mining, milling, smelting, or related operations." This "comes to be located" language covers sediments etc. and is much more expansive than OU4 which ends with TZ soils and chat in streams.

[10] This issue was raised with EPA during the Tribe's review of OU4.

[11] By definition these media are not affected by anomalous concentrations (i.e. contamination).

necessitate cleanup of upgradient riparian and upgradient upland soils prior to the downstream streambeds and banks.

4. **EPA demonstrates it lacks understanding of the geo-physical system while attempting to delineate the nature and extent of contamination.** EPA employed PIA to BTV point comparisons as well as PIA to background population distributions using a central tendency test. The latter approach is patently incorrect and provides no additional useful information. This approach should be removed from the following draft.[12]

5. **All results indicate that EPA has not delineated the N&E of sediments.** All PIA samples exceed at least one BTV by a large amount (generally 10x the BTV). The goal to delineating the N&E is to employ step-out sampling until two non exceedances are observed in all directions. From the FS standpoint, at least one of the measured COCs exceeds BTV throughout each area of interest. Therefore, ALL AOIs need to be addressed, by yet to be specified general response actions (GRAs). Exceedance maps tell the story. Exceedances are large and pervasive. All of the verbiage related to the N&E is a regurgitation of what the maps and tables already tell us, and is not very useful. It is clearly unnecessary filler.

6. **Criteria used to delineate the N&E of surface water is incorrect and not protective.** Unlike the sediments which employed BTV to evaluate the N&E, the RI employs KS, MO, and OK state surface water quality standards (SWQS) to evaluate water quality. These state SWQS are risk-based not pre-release conditions based, meaning that areas that do not exceed state SWQS are not necessarily clean. This means that the N&E of surface water has not been appropriately evaluated. BTV concentrations calculated in Kirschner (2008) are clearly lower than all state SWQS and should be used as the metric to compare to sampling points in the potentially impacted area (PIA) to delineate the N&E. This analysis will also conclude that COCs measured in surface water are numerous, pervasive, and the extent of contamination is not contained within the boundaries of OUs 4 or 5.

7. **Although SWQS are likely ARARs, they are not the only ARARs.** The Quapaw Nation has surface water quality standards that apply to their lands (Attachment No. 3). None of the "state standards" employ Harper (2018)[13] and therefore are not protective of Tribal uses. Therefore, this ARAR is not protective of Human health (FS design Threshold criteria under 40CFR300.430). EPA

[12] Some of the greatest gold discoveries would have been overlooked employing this approach.
[13] Tar Creek Superfund Site RME, Prepared by Dr. Barbara Harper, DABT, AESE Inc. August, 2018.

would save a lot of time and resources by calculating SWQS now, based on Harper (2018).

8. **Both COCs measured in sediments and soils are temporally variable,** and as demonstrated in Kirschner (2008), have a wide range of variability, especially during storm events. This means that all depictions of the nature and extent of contamination in the RI are not static—the maps change over time, depending on when and where sampling has occurred.

   As described above, the FS team requires knowledge related to worst case probable conditions. This draft does not reflect such conditions—only the conditions during sampling on a given date.

9. **In many instances, EPA only sampled 3 COCs which does not enable evaluation of risk or direct consequences to man or flora or fauna.** For example, Kirschner (2008) employed the full EPA Target Analyte List, plus molybdenum. Molybdenum was included specifically to evaluate copper deficiency in ruminants (cattle). The ability to use some of these lands for grazing will continue to be questionable. The Tribe has commented numerous times obviating the problems with EPA's approach. These problems continue to propagate through the RI/FS process.

10. **The BTVs for sediments have numerous concerns.** The Tribe concurs with using four-mile creek as an appropriate reference stream for sediments of Tar, Lytle, and Beaver Creeks, but we cannot support application of Four-mile derived BTVs to other areas, such as Neosho River whose watershed is much larger and drains much different geologic units.

    Kirschner's rationale for employing Fourmile Creek as a reference stream for Tar, Lytle, and Beaver Creeks is as follows (Kirschner, 2008):

    > "*Fourmile Creek and the upper reaches of Tar Creek (Upper Tar Creek) serve as provisional reference streams (Figures 2 and 3). These reference areas were selected based on bedrock geology, soil-types, stream gradient, stream size, and field reconnaissance of vegetation. Due to agricultural uses, housing development, and all other uses or anthropogenic actions occurring within the watersheds of these reference areas, these reference streams are not "perfect analogs of premining conditions", but they are analogous to conditions that would likely be present if past mining had not*

occurred. The reference areas that are upstream on Tar Creek may also be affected by upstream deposition of contaminants from the site via periodic backing-up of the stream behind Grand Lake and from wind-blown deposition. Both reference areas may also be affected by the use of chat in a variety of construction projects.

Comparison of values of COCs measured in media representing the reference areas to those obtained in the potentially impacted areas yield insight on the nature and extent of contamination within the Quapaw Indian Reservation. "

Table ES-1 has several issues:

a. The Tar Creek mining deposit is at depth with no observable geochemical anomalies (COCs) observable on the surface (i.e. blind deposit discovered by drilling). Appropriate reference streams/areas also should exhibit this blind behavior, meaning that there are no real surficial sources to contribute COCs to sediment/soils. Subsequently, both sieved and unsieved sediments, regardless of the sieve size should exhibit similar concentrations of COCs and should be relatively temporally static.[14] In fact concentrations are similar except MacDonald's max value of unsieved zinc is 100% higher than Kirschner's sieved max value.[15] All other specimens appear to be fairly close in concentration.[16] Since the highest values drive the BTV, we recommend censoring or culling MacDonald's high value of Zn. Doing so renders a more protective value and makes the dataset more internally logical.

b. The denominator of the Frequency of detection (FOD) reveals that the list of COCs are quite variable, meaning they were likely sampled by different investigators using different protocols designed to answer different DQO's. Regardless, exceedances of BTVs are pervasive.

c. All samples acquired from the potentially impacted area (PIA) contain COC's that exceed the BTVs. This only demonstrates that the EPA's reliance on the

[14] This relationship does not hold for the PIA, where ores have been brought to the surface and releases occur due to past mine waste management practice. In the PIA, sieve size can make a huge difference since transport and size reduction is occurring. PIA samples should be obtained just prior to the annual runoff event and samples should be sieved to a similar size to determine N&E. Also -63um should be used since its transport distance is much greater. Finally, Kirschner (2008) sieved samples to -63um—not -250 um as reported in Table 5-2 and elsewhere.

[15] Analysis of the dataset indicates that sample FCSD09 may be near a shaft our downstream from a chat-covered road crossing.

[16] Temporal variability cannot be evaluated. A q-q plot of Zn visually identifies this outlier.

administrative order on consent (AOC), to limit the future sampling suite, was erroneous and ultimately not protective of humans, flora, or fauna.

11. **Figure E-6 (CSM) has several problems:**
    a. The CSM attempt to compartmentalize by OU
    b. Many of the media cross OU boundaries
    c. Groundwater is not considered an exposure media
    d. Omits groundwater, soils, and the air pathways

12. **A retrospective datagap analysis has not been performed to evaluate the new data gathered post 2017.** Revelations on sampling associated with biota demonstrates that DQOs were not met. However, such revelations for other media are not as obvious. Also note that DQOs are not even described in the RI.

13. **Tables 5-3& 5-4.** Recommend reporting "n" as well as max value detected. Kirschner (2008) samples were sieved to -63 um—not 250 um

14. **Table 5-6.** Cd UTL95-95 appears to be over an order of magnitude higher than Kirschner (2008). Appears to be a problem with decimal placement. All maps/interpretation relying on this table needs to be checked.

15. **Figure 5-1 through 5-4**. The watershed polygons are not useful for interpretation. Reference areas must contain similar geology and soils. This requirement is basic to experimental design and selection of the reference areas. Recommend that geology or soil-type polygons be displayed instead of watershed polygons.

16. **Figures 6x (exceedance maps).** The lowest criterion of 10x background is not helpful. Recommend 2x or 3x—not 10x. Sieved and unsieved sediments of the PIA should not be pooled and compared to BTVs to determine the N&E. The -63um sieve size should be used to delineate the N&E. See footnote 10 above. If larger fractions are employed to map the N&E, a qualifying statement, such as "these comparisons are made using non-comparable values—the result depicted on the map is smaller than the actual size".

17. **Figure 7-1.** Omits ARD in unsaturated bedrock which is a major exogenous source today.

18. **Figure 7-2.** Fully omits underground workings and connection to upstream surface water that recharges the mine pool and controls the GW to SW pathway (flow and chemistry).

19. **Figure 7-3.** ARD source omitted. Ingestion, dermal, inhalation needs to be evaluated. Also need irrigation of plants with groundwater/surface water that is mine affected. Plant to cattle to human is omitted. Water to cattle to human is omitted. This CSM needs a major revision.

20. **Appendix F Statistics.** The exploratory data analysis (EDA) for the reference area samples is weak and poorly performed. Need q-q plots for sieved and unsieved sediments from the reference area. Once it has been determined that the area is relatively homogeneous for both sample types, these data can then be pooled. We know multiple populations creating gradients are present in the PIA; therefore, q-q plots are not useful for the PIA. Also, sieved and unsieved sediments of the PIA should not be pooled and compared to BTVs to determine the N&E. The -63um sieve size should be used to delineate the N&E. See footnote 10 above. If larger fractions are employed to map the N&E, a qualifying statement, such as "these comparisons are made using non-comparable values—like a re-view mirror, the result depicted on a given map is smaller than the actual size".

    The Tribe recommends the following process to determine PMB of sediments and surface water[17]:

    a. EDA (predominantly q-q plots) to ID any outliers (note MESL's high value of Zn is clearly an outlier). Since the deposit is blind, the distribution of each COC should be roughly normal (they are).
    b. Since the number of samples ("n") is low, the max observed for each COC (with outliers culled) should be used at the BTV.
    c. Delete all other UTL assumptions/attempts to qualify distribution as something other than normal, or retain them to show that it really does not matter[18]

    Comparison of concentrations of COCs in the PIA to BTVs should be point to point (or point to cutoff). EPA needs to delete all population-to-population or population-to-cutoff comparisons. Although these items provide good filler, the

[17] Since surface water is highly temporally variable and tied to mine discharges, surface water needs to be from same time period (if multiple time periods are to be characterized) or from the period likely to be highest (baseflow). This approach was followed by Kirschner (2008).

[18] The fact that other methods are close to the max value for each COC suggests that distribution is homogeneous.

approach is not correct and is not helpful. This and “c.” above only demonstrate the statisticians lack of understanding of the physical situation.

21. Appendix H: BERA General comment No. 3 applies to the entire BERA as well as the entire RI.

a. The RAOs/PRGs are qualitative at best and are not implementable and therefore not effective:

> ***“ • RAO for aquatic receptors: Minimize or prevent exposure to sediments and/or pore water that are sufficiently contaminated to pose moderate or high risks, respectively, to microbial, aquatic plant, benthic invertebrate, or fish communities (particularly for fish species that use sediment substrates for spawning).***
>
> ***• RAO for aquatic-dependent wildlife: Minimize risks to sediment-probing birds or omnivorous mammals associated with incidental ingestion of sediments during feeding activities.”***

It is clear that these broad aspirational statements are the goals of any CERCLA cleanup and therefore apply to any Superfund site. Therefore, they could have been developed without any prior knowledge of the site, saving millions of dollars. These aspirational statements are of no use to the FS team. As stated over the years on previous drafts produced by MacDonald, the Tribe does not agree with the method in which non-cumulative hazard indexes are employed and interpreted, when clearly there are numerous COCs adding to the risk to receptor groups. Again, the Tribe believes that the PRGs/RAOs will ultimately be determined based on Tribal uses, and will default to BTVs as described in Attachment No. 1. Therefore, we do not see the role of the BERA/ASLER/DERA in making FS and subsequently remedial decisions.

b. This is the first we have seen this document, even though it was published on April 10, 2019 (see General Comment No. 1)

c. The ASLERA and DERA are dated and have not been updated with the 2017 data and its interpretation. However, we are not sure that an update would matter—the ASLERA sampling is but just a snapshot in time that was not designed to characterize worst case conditions. Regardless, analysis of the snapshot concludes that nearly all of the perennial waterways and there sediments are clearly contaminated and require remediation.

d. The CSM (Figure 3) includes terrestrial and floodplain soils as exposure media; however, these media were never sampled and up-chain risk was never evaluated (See General Comment No. 3). The CSM also omits ARD and transport to SW via GW from the mine discharges as a primary release mechanism.

Attachment No 1. Berrey, J.[18], Kent, T.[19], Kirschner, F.E. [20] and, Harper, B. 2019[21], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[18] Chairman of the Quapaw Nation
[19] Environmental Director, Quapaw Nation
[20] Senior Scientist, AESE, Inc.
[21] Senior Scientist, AESE, Inc.

Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources

By

Chairman Berrey, Quapaw Nation

Tim Kent, Environmental Director, Quapaw Nation

Dr. Frederick Kirschner, Quapaw Nation

Dr. Barbara Harper, Quapaw Nation

Prior to delving into RI/FS studies, EPA needs to realize that the goal of any tribe is to restore its traditional cultural practices and lifeways, including returning to a subsistence level of hunting, gathering, and fishing. It is our experience that this reasonably anticipated future land use (RAFLU) is not contemplated by EPA, DOI, USDA, the State, and their consultants early in the Superfund Process.

By definition, a reservation is reserved by the Federal Government, the land owner, to be the permanent homeland to the Tribe, providing all the natural resources required to sustain the Tribe's health, welfare, and culture. In nearly all superfund cases, the current demography is highly influenced by contamination and subsequent advisories or other institutional controls that reflect reduced land uses that have resulted from current contaminated conditions. Therefore, current demographic conditions and land uses should not be considered as RAFLU in any of the risk assessments. Again, the lands were reserved by congress or executive order for traditional Tribal uses—not current uses that have evolved as a consequence of widespread contamination.

The requirement of the reservation to provide for a permanent homeland capable of supporting traditional uses, necessarily means that the land <u>must be cleaned up for Unrestricted Land Use</u>. This concept of identifying the RAFLU early within the process is not new to EPA—it is consistent with "Land Use in the CERCLA Remedy Selection Process, (OSWER Directive No. 9355.7-04). The concept of an unrestricted land use also is not new to EPA—it is consistent with "Comprehensive Five-Year Review Guidance (EPA 540-R-01-007; OSWER Directive No. 9355.7-03B-P).

Knowing EPA's propensity to attempt to compartmentalize a given problem, it is very important that EPA and the designer of the Remedial Action Alternatives realize that maximizing lands for RAFLU is an overarching goal—capping a lake bottom or capping ponds/piles or relying on long-term institutional controls, by definition, cannot result in an "Unrestricted Land Use" status.[1] Similarly, a brownfield remediation is, by definition, a land use restriction that should not be a final remedy unless the land owner is fully cognizant of the residual contamination and

[1] This discussion applies to Brownfield designation as well.

is in agreement that a brownfield land use is a permanent deed restriction with associated responsibilities of monitoring and informing its members/constituents.

This RAFLU goal does not only apply to lands held in trust by the federal government. Tribes are repatriating lands with the ultimate goal of re-acquiring all nearby non-Indian owned lands. If lands currently held by non-Indians are not also cleaned-up to protect the Tribe's members for unrestricted uses (including but not limited to historical traditional cultural practices), these areas will effectively zone-out Indian interests within the reservation, implicating civil rights concerns.

It is extremely important that EPA view the remediation of sites containing widespread contamination[2] in the broader context of the environmental justice initiatives that have been developing in the recent years. In the past, the implementation of CERCLA has predominantly focused on cleaning-up organic chemical-related sites that affected large populations of U.S. citizens. Remediation of these sites has been viewed from the narrow lens of protecting the "general public", without taking into account the needs of more sensitive populations. For the citizens of the Tribe, who have the right to "live close to the land" and are forced to live on a parcel of land termed a reservation, creating a remedy that is sufficiently protective of human health poses a new challenge—the resources affected by the site must be much more clean than lands used by members of the General Public, since the General Public is much less exposed than those who rely on the land for sustenance. This is particularly true of mine sites, because, unlike organic chemicals that can be expected to eventually degrade, metals and minerals do not degrade.

As discussed, above, If RAFLU is not contemplated by the parties, the initial preliminary remedial objectives/remedial action objectives (PRGs/RAOs) employed to evaluate the Remedial Action Alternatives (and all of their supporting documents) will not be protective of a Tribe for Unrestricted Land Use ["unlimited use and unrestricted exposure (UU/UE; OSWER Directive No. 9355.7-03B-P)"]. Again, in general, Congress or the President set aside reservations with the intent that these tracts of land be the permanent homelands for Tribes, providing all the natural resources required to sustain the Tribe's health, welfare, and culture.

It is our experience working with tribes on superfund issues throughout the U.S., that because tribes rely heavily on natural resources, in many instances, their sole source of sustenance, these resources have to be free of site contamination[3]. In essence, the Tribal members are the largest omnivores in the valley that are constrained to the reservation *(site)* over their entire life-span. Our experience at more than 10 Tribal-related sites indicates that cleanups are being driven by levels that are safe for humans—not levels that are safe for ecological receptors or not levels that are determined to be an applicable relevant or appropriate requirement (ARAR)[4]. In many cases, a true non-risk based cleanup is required (i.e. pre-mining baseline/background becomes the PRG/RAO/ARAR). This is clearly the case for mine sites in which a fingerprint of naturally

[2] For example mining-related Superfund sites such as Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, or Yerington.
[3] Contaminants released from the site that are in excess of natural pre-mining background (PMB).
[4] Non-Tribal ARARs are designed to protect the General Public, not Citizens of the Tribe.

occurring contaminants was present prior to mining[5]. In such instances, PMB is clearly the PRG/RAO, since PRPs cannot be forced to cleanup to conditions better than PMB. Finally, in practice, since excavators cannot "see the PRG/RAO contour line on the ground", and since excavators benefit more financially when more dirt is moved, all near-mine areas that do not rely on institutional controls are generally more protective than estimated.[6]

This concept of cleaning-up a site based on "what the site looked like prior to contamination" also is not new to the U.S. For example for uranium mill sites, the US Nuclear Regulatory Commission (NRC) employs the concept of cleaning-up to As Low as Reasonably Achievable (ALARA, 10 CFR 20) and at a minimum 25 mrem incremental risk above background. Since the difference between 25 mrem and background for a mill tailings pond is on the order of 1 foot of cover soil, the majority of sites are cleaned up to PMB. The DOI NRDAR regulations 43 CFR 11 revised in 2008 also acknowledge the restoration goal[7] for any site, regardless of Tribal involvement is pre-release baseline (PRB)[8]. Finally, when a reasonable U.S. citizen is asked what he or she believes to represent cleanup, the result is invariably "what the area looked like before it was contaminated"—not to a level that results in no more than risk 10^{-6} chance of premature cancer from residual contamination or exceeding hazard indices (HI) as specified under Superfund (40 CFR 300).

In Summary, for mine sites affecting Tribal resources, drawing the conclusion that PMB is the PRG/RAO early in the process enables the focus of work to shift from estimating risk and back-calculating PRG/RAOs, to determining PMB and mapping the nature and extent of contamination. This early realization will result in saving large sums of time and money, makes EPA to appear more credible to the public, speeds the cleanup process while not costing the responsible parties additional sums, and more rapidly brings closure to the RI/FS and NRDA processes. Aspects of the Baseline Human Health Risk Assessment may still be necessary to assess residual risk associated with each general action evaluated in the FS and to ensure that the proposed alternative is protective of human health and the environment. However, this work can come later.

[5] This is the case for most mining-related superfund sites, including the Midnite Uranium Mine, Leviathan Mine, Sulphur Bank Mercury Mine, etc.
[6] Large sites Tar Creek, Bunker Hill, Sulphur Bank Mercury Mine, Upper Columbia River, etc., where residual mine contamination and concomitant residual risk will occur in distal waterways for geologic time, require the pathway from source areas to be fully broken via removal action.
[7] From 43 CFR Part 11, Subpart A § 11.14 Definitions. (e) Baseline means the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred. (ll) Restoration or rehabilitation means actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties or the services it previously provided, when such actions are in addition to response actions completed or anticipated, and when such actions exceed the level of response actions determined appropriate to the site pursuant to the NCP.
[8] PRB and PMB are synonymous.

Attachment No 2. The Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site Prepared by AESE Inc. For The Quapaw Tribe of Oklahoma March 9, 2007

The Quapaw Tribe of Oklahoma's Proposed Remedial Action Alternative for the Tar Creek Superfund Site

Prepared by AESE Inc.

For

The Quapaw Tribe of Oklahoma

March 9, 2007

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1.0 Introduction

EPA developed and evaluated approximately 10 alternatives in the RI/FS process. A Draft Proposed Plan identified Alternative No. 4 as EPA's Preferred Alternative. The Preferred Alternative, as well as all other alternatives had major shortfalls with respect to protection of human health of Tribal members for the reasonably foreseeable land use as well as with other criteria used to evaluate alternatives under the NCP (40 CFR 300.430(e)(9), (f))

A Remedial Action Alternative, which includes three options is described below. This alternative is similar to the alternative proposed to EPA and the PRP on November 29, 2005. This alternative differs greatly from EPA's Proposed Remedial Action Alternatives in five important aspects:

1. This Alternative is designed to address site-wide wastes including those in the Treece Area of Kansas. EPA's alternatives focus only on surficial wastes in Oklahoma.

2. This Alternative is designed to consolidate wastes by addressing distal areas first, working toward the center of the site. EPA's alternatives rely predominantly on covering wastes in place.

3. This Alternative is designed to be protective of the Tribe's current and future residents for Tribe's designated Future Land Use. EPA's alternatives do not consider the Tribe's Future Land Use.

4. This Alternative is designed to address the ground water and surface water problems, positively affecting downstream interests. EPA's alternatives focus only on surficial wastes in Oklahoma.

5. This Alternative is much more prescriptive and more completely staged than EPA's alternatives. EPA's alternatives are poorly specified which increases the probability of realizing unintended consequences associated with not paying close attention to cumulative effects.

An outline of the proposed alternative is described followed by a detailed discussion of tasks. Although we do not believe that EPA choice of excavation and hauling equipment has been optimized, EPA's unit costs from: *"**Feasibility Study Tar Creek Superfund Site Operable Unit No. 4 Ottawa County, Oklahoma**"* are employed herein to enable comparisons.

Finally, the alternative as well as EPA's alternatives are evaluated or screened against the nine criteria of the NCP as well as other criteria EPA has used to compare its alternatives and develop its Draft Proposed Plan.

2.0 Outline for Tribal Alternative 1 (TA1)

To be consistent with EPA's Draft Proposed Plan, TA1 also consists of two main phases separated by approximately 10 years. The basic elements of each phase are:

Phase I

1. Chat Processing via Continued Sales (same as EPA's Proposed Plan); however, this Task is officially a portion of the CERCLA remedy. This assumes that 75% of all of the remaining chat is removed in 20 years via sales. This assumption is employed to be consistent with EPA's alternatives[1]. No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern (COC).

2. Removal of Chat and Chat base material from Distal Areas where chat is not currently marketable. This task consists of excavating, hauling, and delivering chat and chat base materials from distal areas to Chat Washers. This is cheaper than disposal in a repository and should help to bolster longevity of chat market.

   No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

[1] Unlike the EPA proposed Alternative, consolidation of chat bases and chat piles will result in "controlled management" of the hazardous substances via temporary institutional controls. This approach differs greatly from EPA's approach that employs "uncontrolled management" (actions are at the mercy of the market forces), reportedly necessitates the 20-year timeframe based on human health concerns. Controlled management as described herein should allow for sales to continue much longer. With time, non-marketable chat and chat bases could be wet-sieved by the governments, making the chat free for pickup to entities located beyond the market's "break-even" radius (reported to currently be approximately 200 miles).

3. Hydrogeologic studies to determine and identify strategic subsurface locations for injection. The study would also investigate interconnection with Commerce workings (if any).

4. Injection of Fine Wastes into strategic subsurface locations in order to change the hydrogeology. The goal is to minimize periodic oscillations of the water table thereby minimizing Acid Rock Drainage (ARD) Production in the Mine Pool (i.e. solve the problem). No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

5. Divert Tar Creek and install a headgate at the Treece Swimming Hole Dike to re-direct flow of Tar Creek into Treece Swimming Hole. This is designed to recharge the Mine Pool in KS. Install another headgate at the Cardin recharge area to re-direct flow of Tar Creek into Mine Pool. These actions are designed to flood pyrite bearing zones in the Pennsylvanian crown-pillar and to reduce the production of acid rock drainage (fix the main problem).

6. If necessary, Temporary Active Water Treatment of Mine Pool at Douthat using a Portable Plant; Discharge of Water Treatment Plant effluent at north end of channel liners (in KS) via pipe to restore river to clean flowing system that will support all future uses.

7. Excavation of Chat/Wastes in Tar, Lytle, and Beaver Creeks. Deliver the excavated chat to local chat washers or dispose of the wastes in one (or two) large lined and capped repository. The large repository will have a designated low-exposure beneficial use (e.g. golf course). No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

8. Install Flexible Membrane Liners (FML) in Tar and Lytle Creeks, from the Douthat Bridge area north past the Mine Workings in KS and over the mined-out areas in Beaver Creek . This is designed to immediately break the ground-water to Surface Water Pathway. Fines, chat, or relatively cleaner soils are used as Sub-Base for the FML. River substrate is purchased from mine Limestone quarry onsite or on the reservation (near Tribal HQ) and is placed on top of the FML and filter layer. This will remediate surface water, sediments, ground water, and riparian areas within the site as well as down gradient. This work and subsequent design is contingent on the findings of the aforementioned Hydrogeologic Studies.

9. Conduct education and community awareness throughout the site for the duration of the remedy. This has proved to be very effective at Tar Creek and other lead sites across the nation.

10. Remove or amend the transition zone soils to background conditions.

Phase II (after ~10 years)

1. Wet sieve remaining chat/chat bases, making the chat free for pickup to entities located beyond the “break-even” radius (reported to be approximately 200 miles). Compared to capping in place or disposal in designed repositories, this not for profit approach will enable subsurface disposal of all fines at a nominal unit cost.

3.0 Detailed Description of Tasks

A Remedial Action Alternative, in addition to those developed by EPA is provided below. This alternative is similar to that proposed to EPA and the PRP on November 29, 2005. This alternative differs greatly from EPA’s Proposed Remedial Action Alternatives in several important aspects:

1. This Alternative is designed to address site-wide wastes including those in the Treece Area of Kansas.

2. This Alternative is designed to consolidate wastes by addressing distal areas first, working toward the center of the site.

3. This Alternative is designed to be protective of the Tribe’s current and future residents for Tribe’s designated Future Land Use.

4. This Alternative is designed to address the ground water and surface water problems, positively affecting downstream interests.

5. This Alternative is much more prescriptive and more completely staged than EPA’s alternatives.

This broader, watershed-wide, approach is required because the ground water and surface waters of Kansas and Oklahoma in the Tar Creek area are inextricably linked. This means that Remedial Actions taken in the Treece, Kansas area will affect down gradient abiotic media, including, but not limited to ground water, surface water, sediments and riparian soils.

If not correctly implemented, actions taken by EPA in KS are likely to recontaminate downstream areas wasting time and monetary resources.

Besides the obvious benefit of reducing the footprint of the site early, consolidation of wastes via removals in distal areas first, has the added benefit of cleaning up the outlying watersheds early. Removals in these areas will cleanup these lands to be consistent with Tribal Land Uses. This means more lands will be available to the Tribe for subsistence hunting and gathering, taking pressure off of other reservation lands and resources.

Although not strictly a portion of OU4, this Alternative utilizes waste material to positively affect the ground water flow system by reestablishing the natural potentiometric surface of the Boone aquifer system. Doing so, in concert with other provisions, will break the ground water to surface water pathway currently responsible for the majority of release of soluble contaminants to downstream areas. A much more thorough discussion is provided below.

Finally, this Alternative is much more prescriptive and much more completely staged than any of EPA's alternatives. A prescriptive remedy is much more attractive to the governments, since uncertainties associated with funding or changes in the personalities of project personnel are minimized. A prescriptive remedy will also enable more accurate cost estimating, once construction methods and equipment are finally determined. Again, although we do not necessarily agree with EPA's selection of dir-moving equipment, EPA's unit costs are used herein, in order to be consistent with EPA's estimates.

3.1 Detailed Description and Staging of Phase I Tasks

Figure 1 represents the basic land features involved in the proposed remedial action Alternative. The basic elements of Phase I are:

1. Chat Processing via Continued Sales.

2. Removal of Chat and Chat Bases from Distal Areas.

3. Perform hydrogeologic studies to determine strategic locations within mine pool for injection. Study would also investigate interconnection with Commerce workings (if any).

4. Injection of Fine Wastes in Strategic Mined-out areas to change hydrogeology

5. Install hydraulic control systems to flood the pyrite-bearing zones in the Pennsylvanian crown-pillar and to reduce the production of mine drainage without creating any new discharges. These systems would be designed to recharge the mine pool in Kansas and to maintain and direct recharge at strategic locations in the Tar Creek site.

6. If necessary, Temporary Active Water Treatment of Mine Pool at Douthat.

7. Excavation of Chat/Wastes in Tar, Lytle, and Beaver Creeks.

8. Install Flexible Membrane Liners (FML) in Tar, Lytle, and Beaver Creeks from Southern Reservation Boundary North past Mine Workings in KS.

9. Implement public education plan.

Tasks 1-5 can be implemented concurrently and immediately. Initiation of Tasks 6-8 is contingent on the results of the Hydrogeologic Study (Task 3).

3.1.1. Chat Processing via Continued Sales

Chat Processing via Continued Sales is assumed to continue (Same as EPA's Proposed Plan). It is also assumed that introduction of distal chat and chat-base materials, described below, will not negatively affect the chat market.

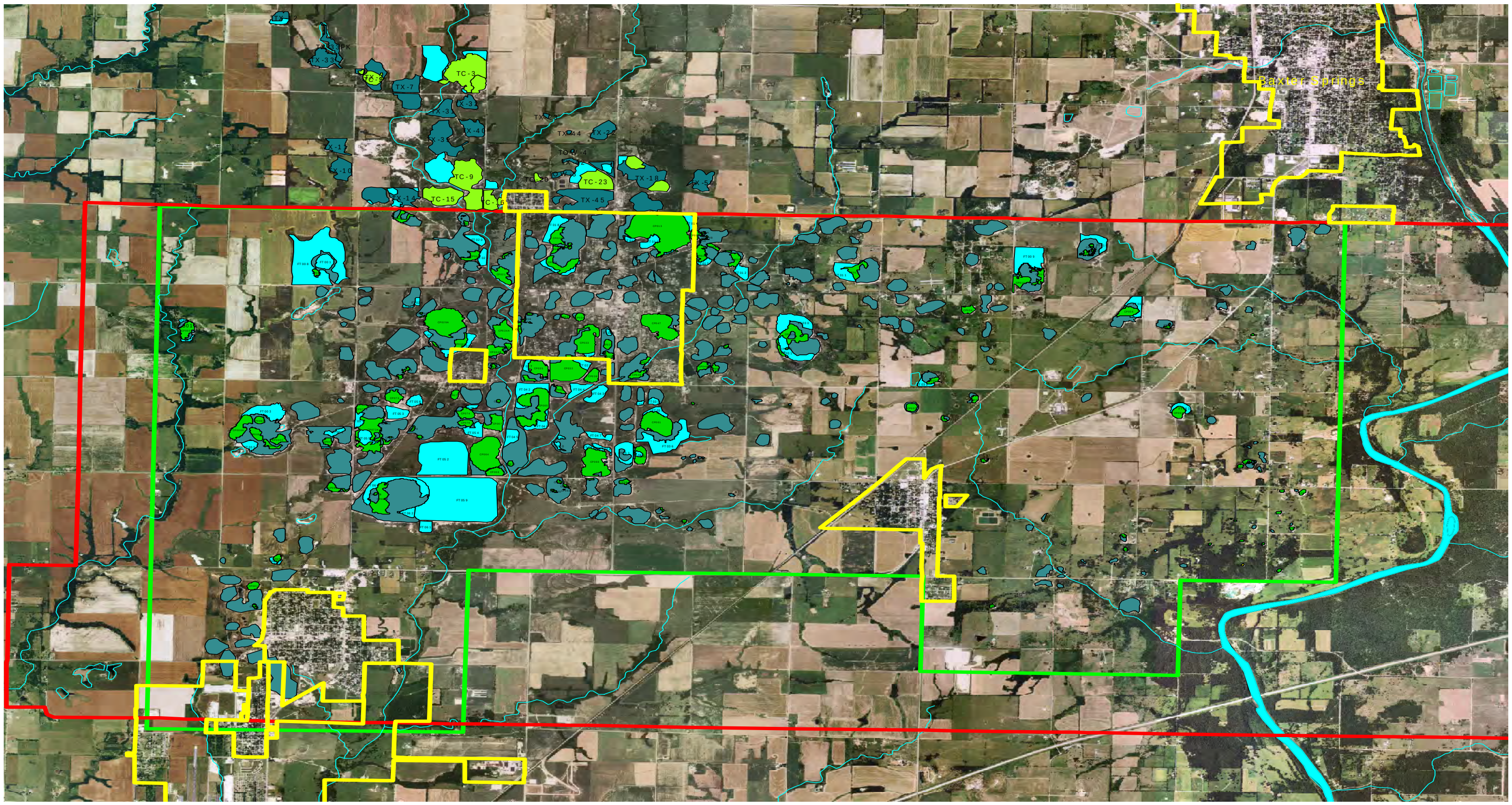


Figure 1. Map of the Superfund site showing chat piles (green polygons), chat bases (dark blue polygons), fine tailings ponds (light blue polygons), the QTO reservation boundary (red line), the NPL boundary (light green line), and town boundaries (yellow lines).

3.1.2. Removals of Chat and Chat Bases from Distal Areas

The disposition of chat and chat bases is determined using Decisional Flow Chart 1 (Figure 2). For the purposes of conservatively estimating costs, it is assumed that all of the chat and chat-base materials are excavated, hauled, and delivered to Chat Washers. Therefore the actual costs may be slightly less upon implementation.

For staging and cost estimating purposes, the NE and SE zones have been delineated (Figure 3). Each zone is terminated by a node or haul-point. These nodes are used only to allow flexibility and should not be construed as a drop-off or pick-up point.

Currently, all of the wastes in the NE zone are assumed to be delivered to the haul-point in Treece and all wastes in the SE zone are assumed to be delivered to the haul-point in east of Cardin (Figure 3). The total volumes of each zone based on EPA RI/FS data are:

NE = 2,263,163 combined cubic yards
SE = 725,379 combined cubic yards

These volumes do not include transition zone soils. The cost and duration of this portion of the project is directly affected by the types and numbers of excavation and hauling equipment. In order to facilitate comparison of this alternative to EPA's alternatives, EPA's unit costs are used herein. However, we would propose using low-ground pressure dozers (e.g. CAT D6) to rip, excavate, and push materials to a pile to feed a loading unit (e.g. CAT 988). The loader would then load off-road haul trucks (e.g. CAT 769). The number of trucks in the hauling unit will depend on the optimum production rate determined for a given pile or work area.

Delivery of wastes to Chat Washers is cheaper than disposal in a repository and should help to bolster longevity of chat market. Delivery of chat directly to the chat washers should enable the washers to remain in a given location for a longer period. Chat Washers will maintain the ability to set up an operation at a large pile. It is also assumed that introduction of distal chat and chat-base materials, described below, will not negatively affect the chat market.

No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

3.1.3 Hydrogeologic studies to determine strategic locations within mine pool for injection.

Work conducted by the Tribe indicates that during baseflow conditions, the discharge from the mine pool at the Douthat Bridge springs is responsible for the majority of loading of contaminants of concern in the entire Tar Creek watershed. USGS (2006) has demonstrated that the chat piles contribute COCs during other portions of the year. A generalized conceptual site model is provided in Figure 4. A more detailed analysis of the hydrogeology based on current information is provided in Appendix A

Modes of release and transport of COCs observed at Tar Creek are similar to those observed at other lead-zinc mining sites:

1. During baseflow and typical flow conditions, the majority of COCs are transported via the liquid phase, as dissolved COCs.

2. Compounds of COCs exhibiting lower solubility, such as $PbSO_4$ are transported predominantly during runoff events.

A rule of thumb is that 95% percent of the annual total load of a given for a relatively insoluble COC (e.g. anglesite or $PbSO_4$) from a given basin can occur during a single annual event. Since these events are so infrequent and very high energy, they are rarely adequately characterized via monitoring.

Another important aspect of these types of events is that they are characterized by concomitant large discharges and flows in surface water. This means that although large loads may be released and transported from piles or the mine pool during runoff, the impact to surface water is generally mitigated by natural dilution from the high flows in the streams. In fact waste treatment ponds at many mine sites and many water treatment plants are designed to overspill during high runoff events, taking advantage of dilution by high flowing streams.

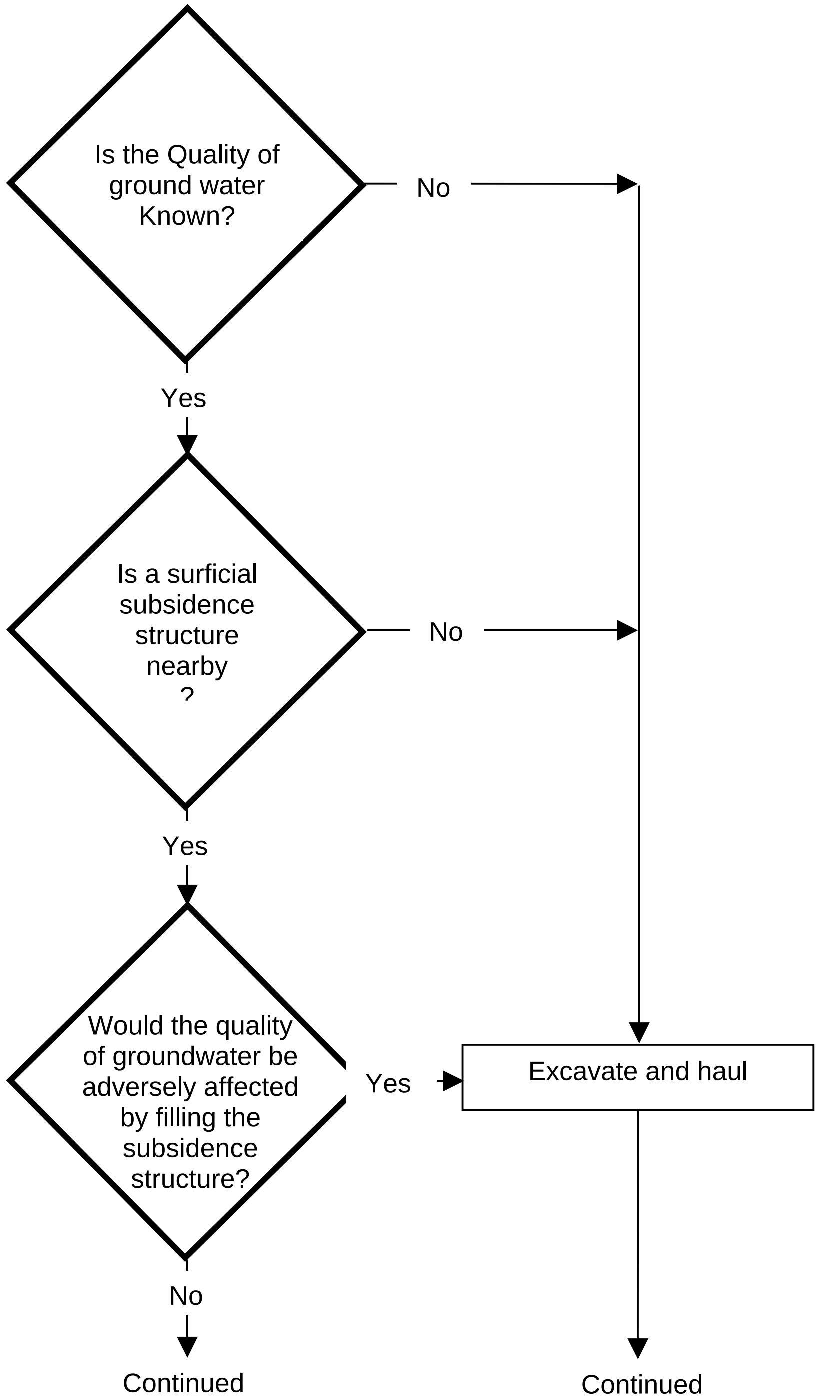
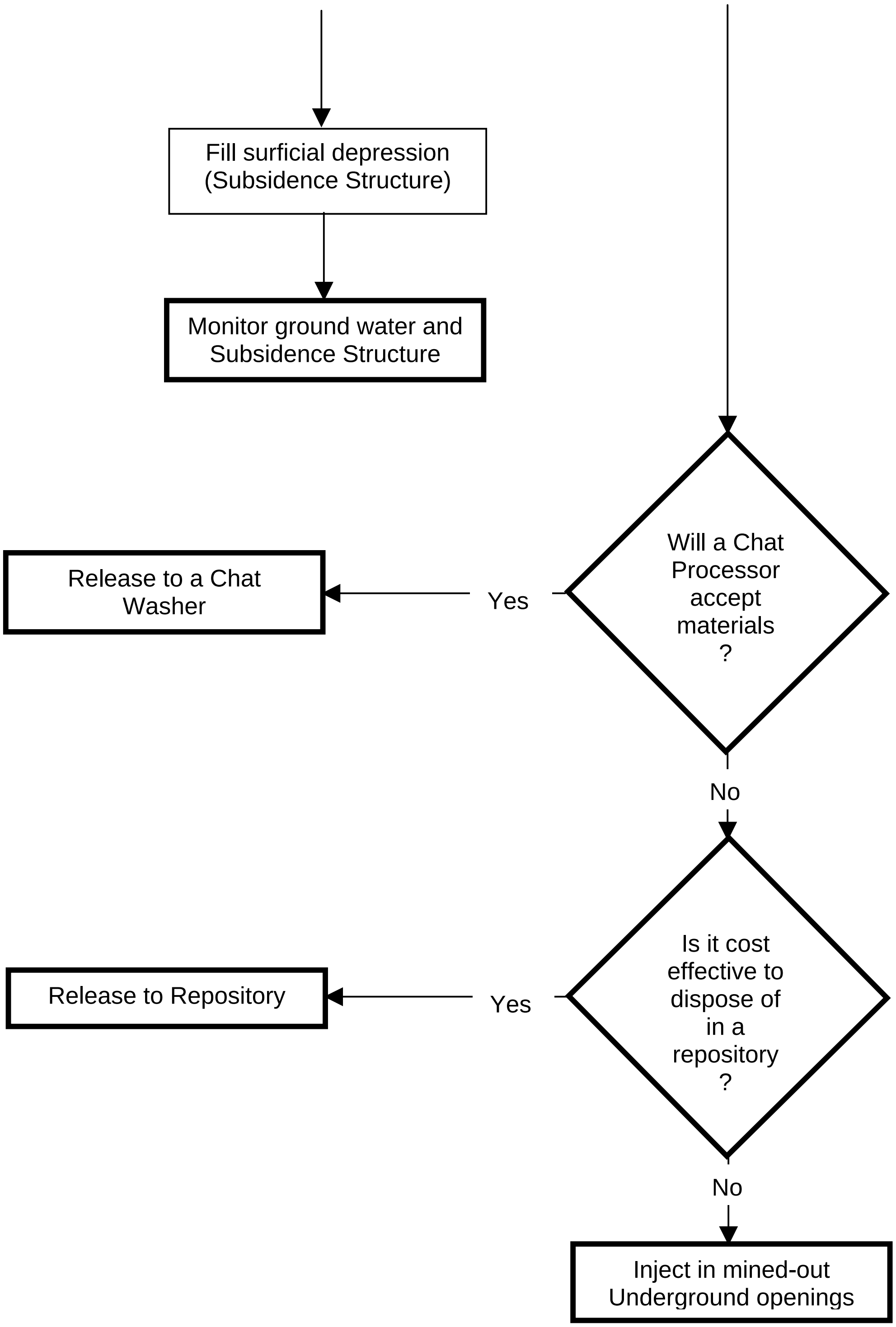


Figure 2. Decision flowchart for disposal of Chat/Chat Bases (continued on next page)


Fill surficial depression (Subsidence Structure)
Monitor ground water and Subsidence Structure
Release to a Chat Washer
Yes
Will a Chat Processor accept materials ?
No
Release to Repository
Yes
Is it cost effective to dispose of in a repository ?
No
Inject in mined-out Underground openings

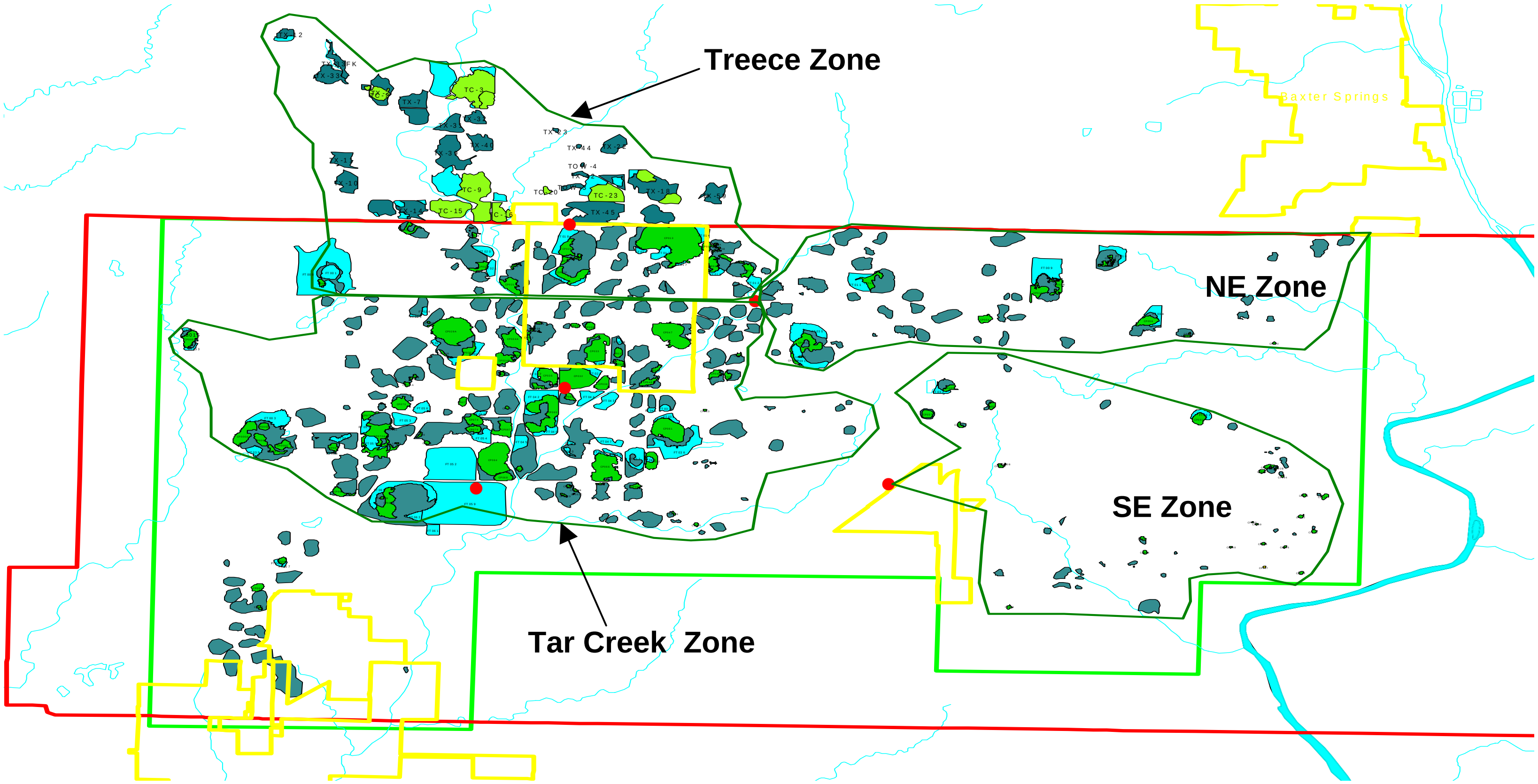


Figure 3. Map of the Tar Creek Superfund Site showing the NE, SE, Treece, Tar Creek staging zones and haul points (red dots), as well as chat piles (green polygons), chat bases (dark blue polygons), fine tailings ponds (light blue polygons), the QTO reservation boundary (red line), the NPL boundary (light green line), and town boundaries (yellow lines).

On the other hand, during baseflow conditions, when the creeks are flowing minimally, and the discharge from the minepool is relatively constant, the concentration of COCs in the mine pool water contribute the majority of COCs to the surface water system. Pb in the mine pool discharge at Douthat Bridge Springs is very low since the mine pool waters contain large amounts of SO4 released from ARD. However, all of the other COCs are indeed elevated above all other surface water qualities determined at other locations. Figures 3 and 4 are just two examples depicting concentrations of COCs measured in surface water vs. river mile obtained during a synoptic survey. Note that the elevated concentrations of these two COCs coincide with the discharge at the Douthat Bridge Springs. Figures 5 and 6 are just two examples depicting concentrations of COCs measured in sediments vs. river mile obtained during a synoptic survey. Note that the elevated concentrations of these two COCs also coincide with the discharge at the Douthat Bridge Springs.

Figure 7 is a conceptual site model of the site along the axis of Tar Creek. This CSM was developed through observations of water levels on several occasions. The water level in the well or vent pipe shown in Figure 7 is roughly 10 feet higher than the stream elevation during baseflow conditions in May-June of 2005. The water level observed in the well coincided with the level of water in the nearby ponds, south of the Douthat Road as well as the pond formed by the ring-dike constructed as part of EPA's remedy (Figure 8).

Note that the Boone Aquifer (mine pool) is relatively flat lying and is artesian at Douthat Bridge area.

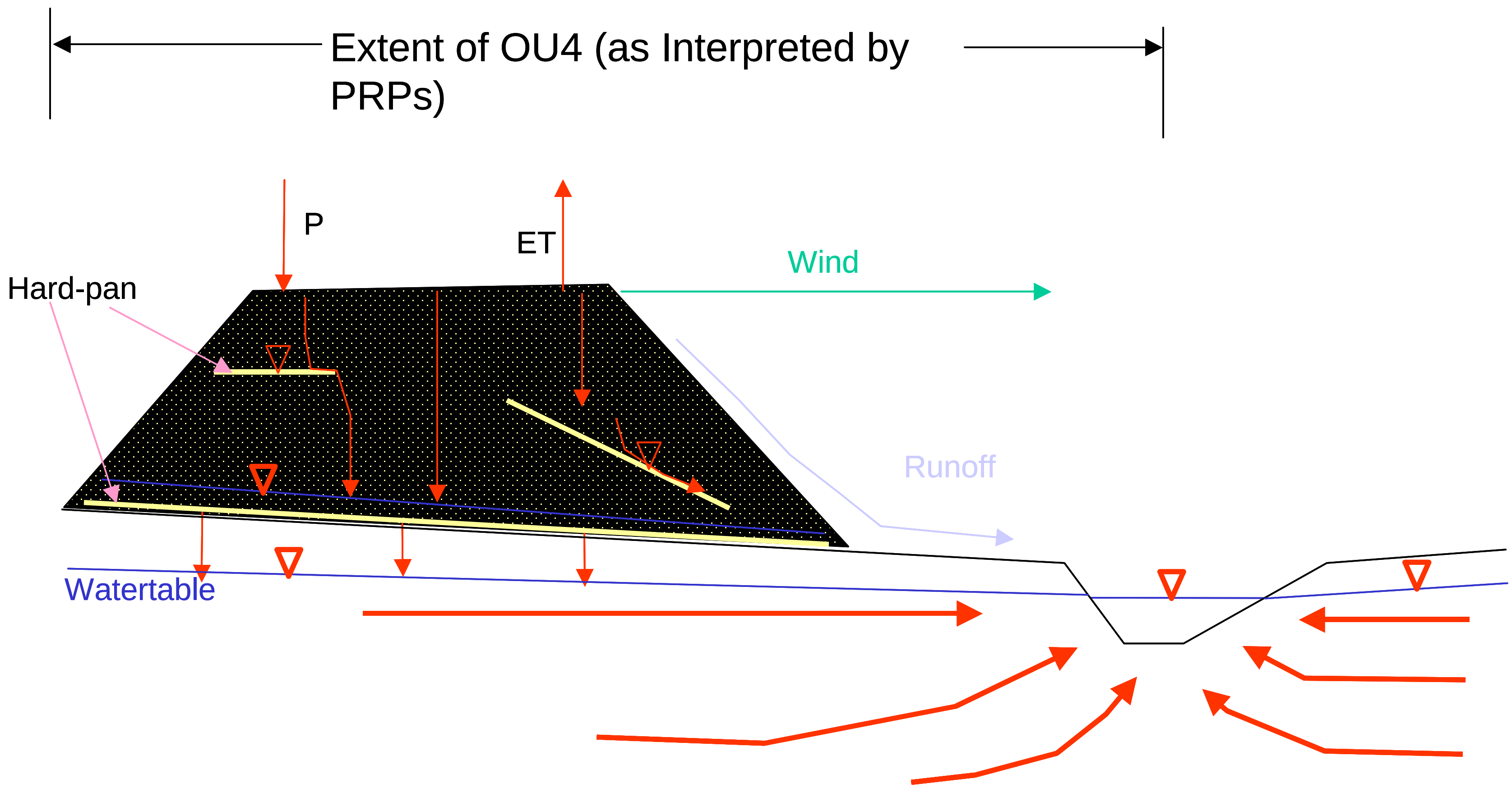


Figure 4. Generalized conceptual model of flow and transport of contaminants of concern from a given waste pile.

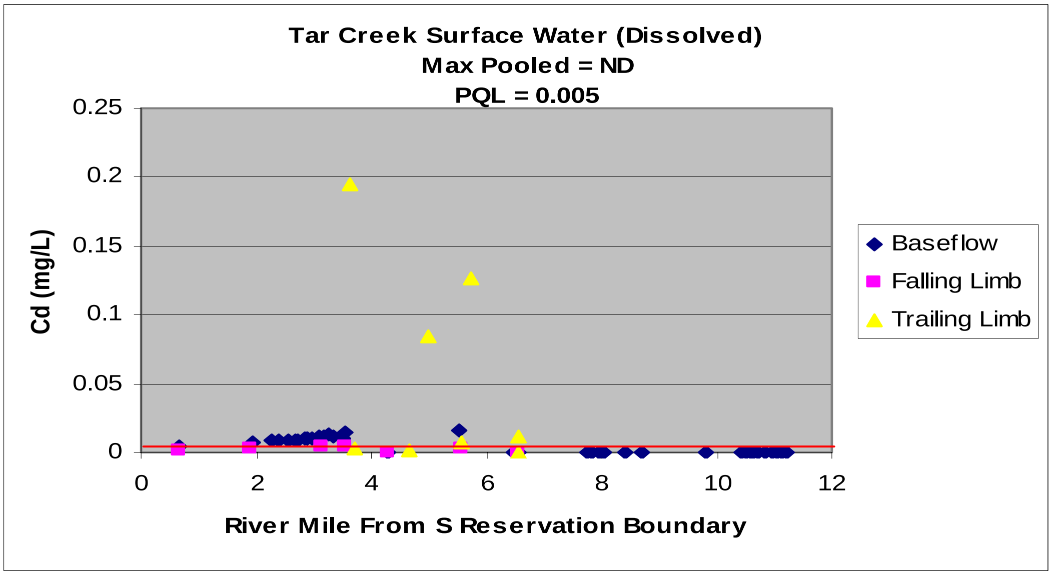


Figure 5. Concentration of Cd in surface water. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

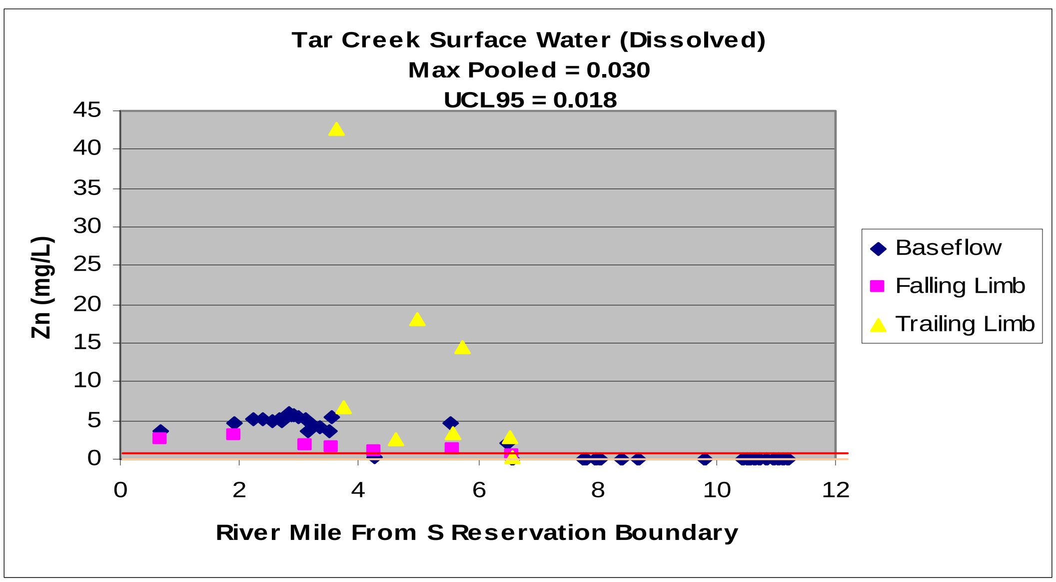


Figure 6. Concentration of Zn in surface water. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

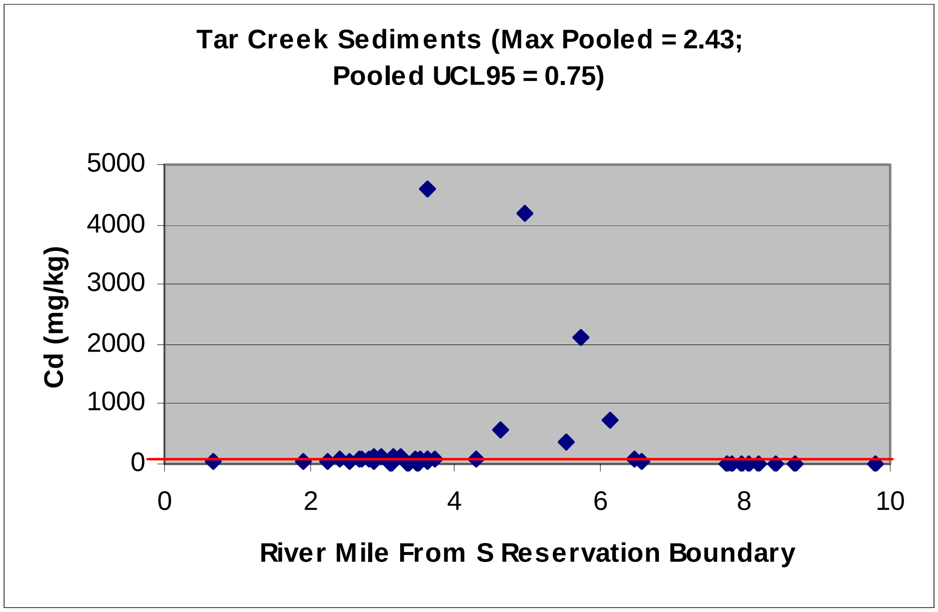


Figure 7. Concentration of Cd in sediments. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

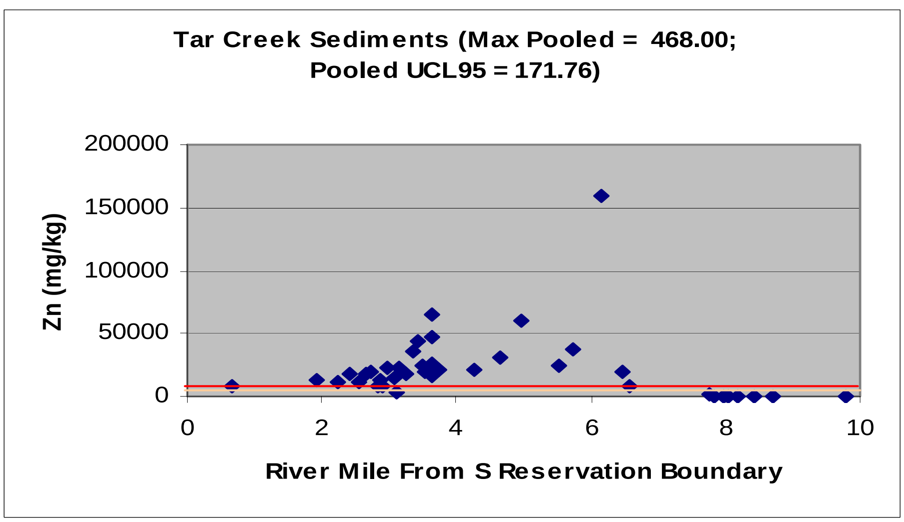


Figure 8. Concentration of Cd in sediments. Red Line represents the maximum value sampled in the Reference Areas. Orange line represents the UCL95 for the pooled Reference Areas. Douthat Bridge ~ 3.2 Miles from the Southern Reservation Boundary; Confluence with Lytle Creek ~ 3.5 Miles; Northern Reservation Boundary (Kansas State Line) ~6.6 miles.

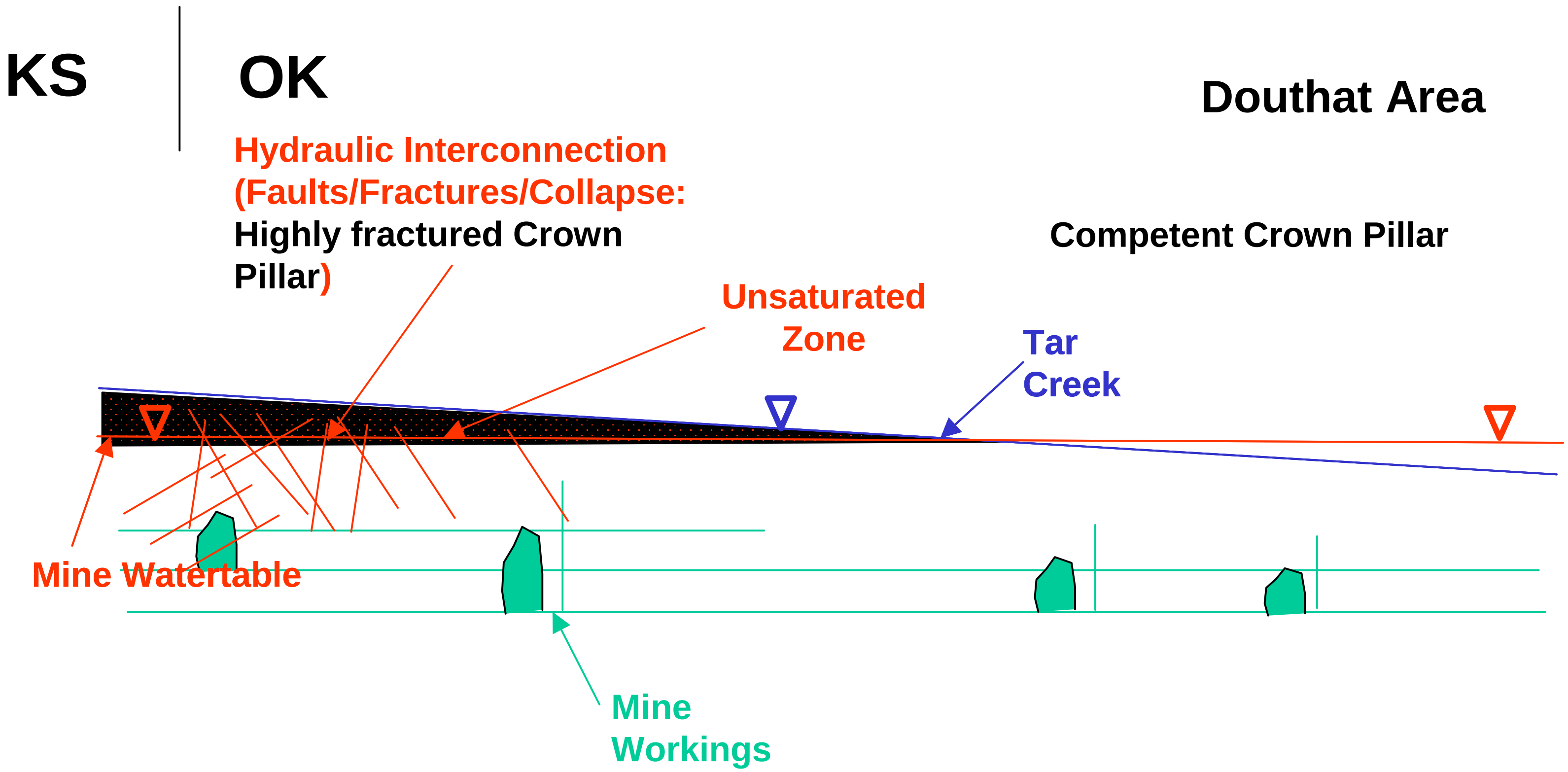


Figure 9. Conceptual N-S Cross-section along Tar Creek from Kansas (left) to the Douthat Area. Note that artesian conditions are observed near Douthat Bridge.

The goal of this task is to reduce the overall hydraulic conductivity of the Boone aquifer in the vicinity of the mine workings. Reducing the effective K of the Boone Aquifer, will:

1. Return the water table to its near natural surface which roughly paralleled, but was few feet lower than, the base of the stream channel. This will relieve artesian conditions, breaking the continued release from the site via ground-water to surface water pathway

2. Dampen and minimize periodic oscillations of the water table thereby minimizing Acid Rock Drainage (ARD) production in the crown pillar (i.e. solve the ARD problem).

3. Reduce flow and stream loss to the Boone Mine Pool, reducing flow of oxygenated waters into the system,

4. Promote stream flow, due to a reduction in storage in the Boone/mine pool aquifer system, and

5. Reduce ground water flow volumes and velocities controlling the geochemistry and facilitating injection of the fines.

Approximately 10 locations are tentatively identified as strategic candidate injection locations (Figure 9). The preliminary criteria for identifying these locations are:

1. Upstream of the relatively competent portion of the crown pillar;

2. Drifts that appear to be interconnectors to underground mine workings

Drifts are more attractive because they require less volume to fill and plug, and the crown pillar over the drifts are generally more competent and therefore less permeable.
Again, these locations will be better defined during the hydrogeologic characterization. These tentative locations are used in to estimate cost of this task.

3.1.4 Injection of Fines

This tasks has two goals: 1) removal of mine waste from the surface and 2) returning the water table to its near natural surface by reducing the overall hydraulic conductivity of the Boone aquifer in the vicinity of the mine workings This will be accomplished by injecting fine materials into strategic locations identified during the previous task. Approximately 10 locations are identified as strategic candidate injection locations (Figure 6).

Fines excavated and transported to the injection sites from the distal areas will be used for a portion of the task. Like the chat piles for distal areas, zones and haul-points or injection points have been developed for the fine materials (Figure 10). Again the haul points are used only to facilitate cost estimations and should not be construed as areas in which double handling occurs.

The disposition of the fine materials is determined using Decisional Flow Chart 2 (Figure 11). For the purposes of conservatively estimating costs, it is assumed that:

1. all fine materials located outside of the Tar Creek and Lytle Creek watersheds are excavated, hauled-in, and injected in strategic locations.

2. the remaining fines, located in the Tar Creek and Lytle Creek Watersheds are injected al the location of the accumulation.

In order to inject the fines, it will be necessary to resuspend the fines as a mixture. This will require excavation, and depending on the distance, could result in short-distance hauling. Several mobile large-scale wet-sieves or similar devices will be required. It is anticipated that the resuspension process will be the rate-limiting step in the injection process.

In order to facilitate comparison of this alternative to EPA's alternatives, EPA's unit costs are used herein. However, we would propose using low-ground pressure dozers (e.g. CAT D6) to rip, excavate, and push materials to a pile to feed a loading unit (e.g. CAT 988). The loader would then load off-road haul trucks (e.g. CAT 769). The number of trucks in the hauling unit will depend on the optimum production rate determined for a given pile or work area. The rate limiting step in the entire process is wet sieving and injecting. The rate-limiting step in the loading and hauling process is hauling; therefore, it would be necessary to have a sufficient number of trucks. The number of trucks depends on the haul distance for a given pile or work area.

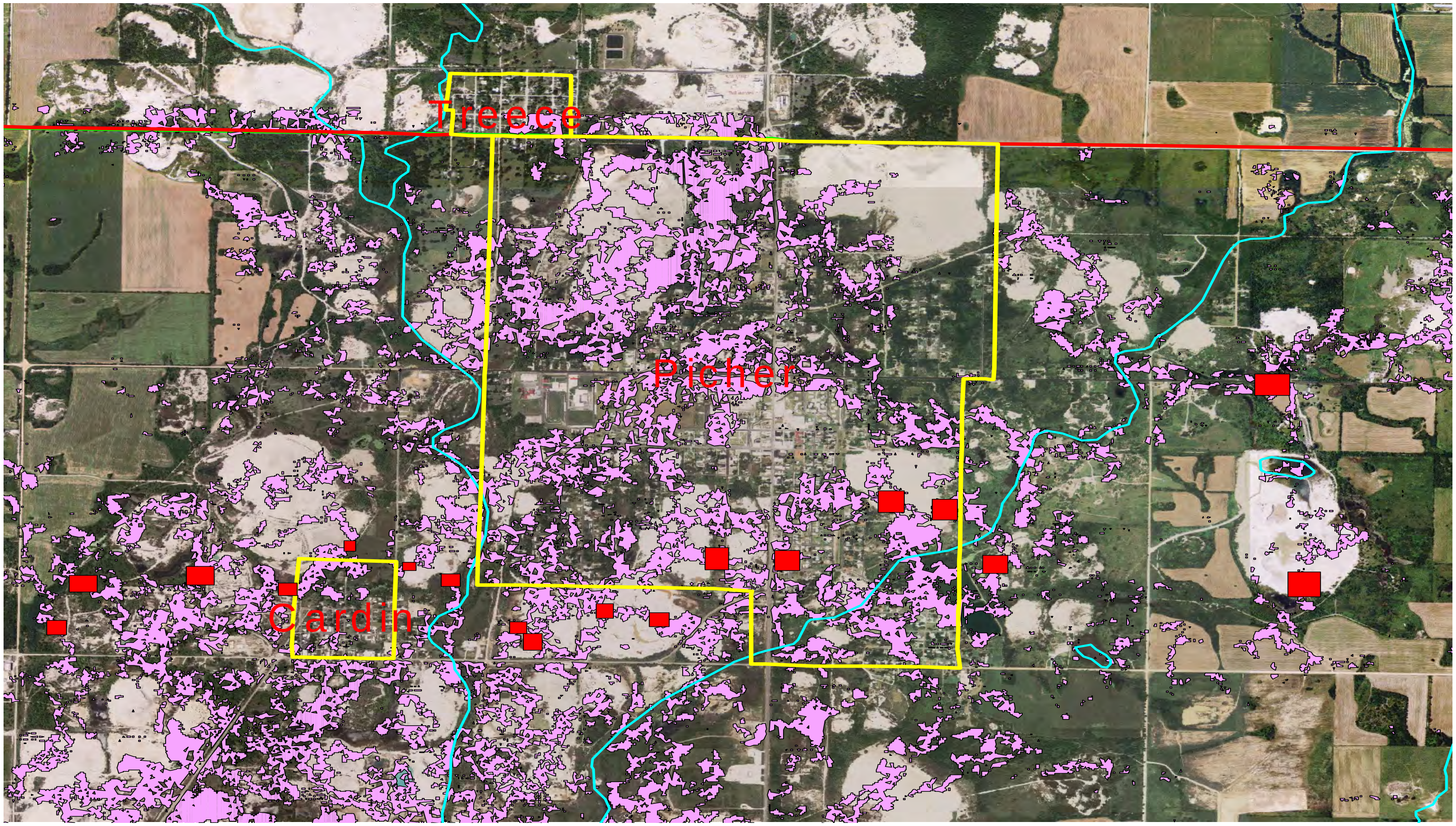


Figure 10. Map depicting the tentative strategic locations for injection of fines (red squares), the QTO reservation boundary (red line), and town boundaries (yellow lines).

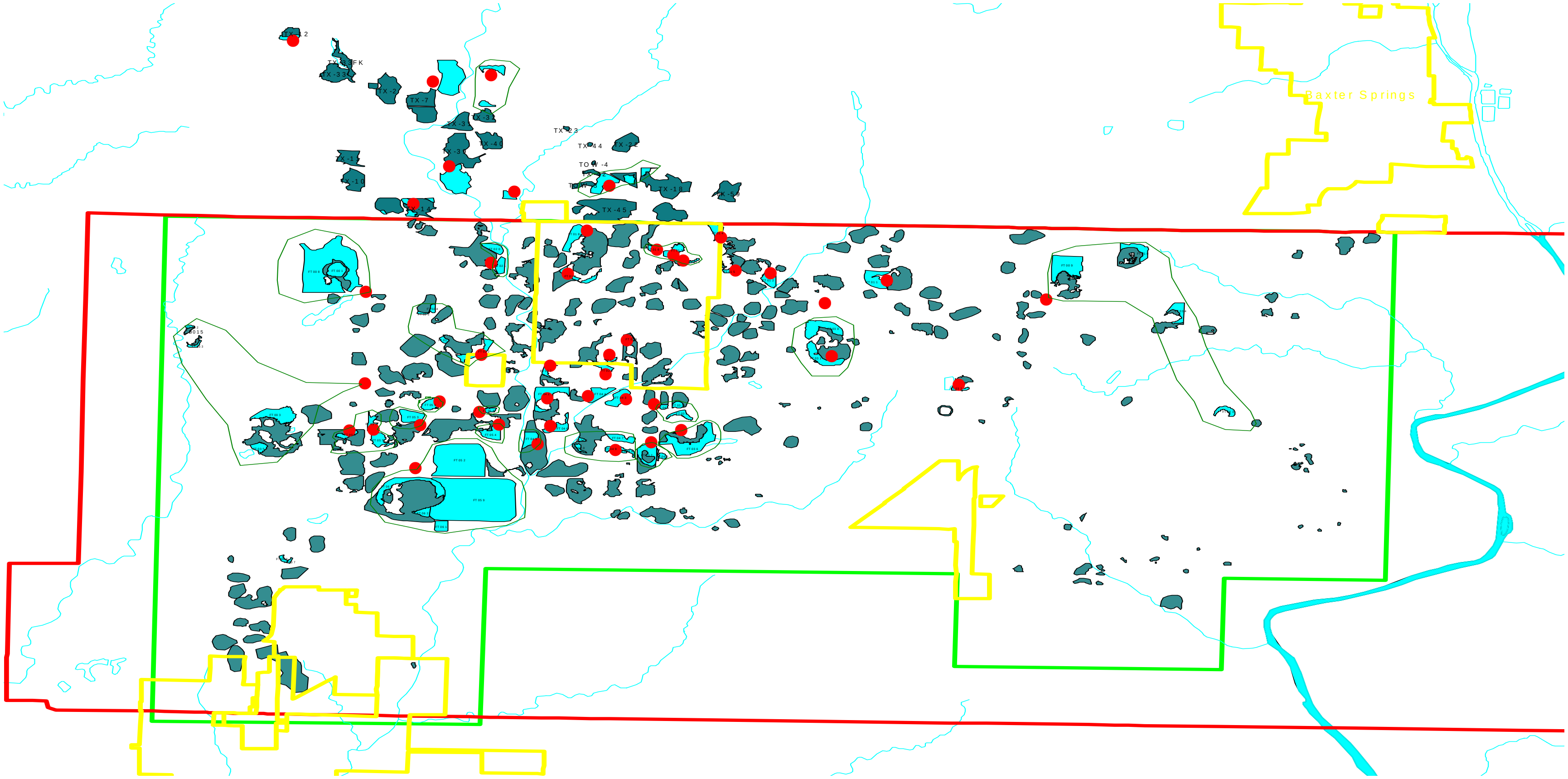


Figure 11. Injection points and zones used to estimate injection costs for the remaining fine materials and/or chat bases.

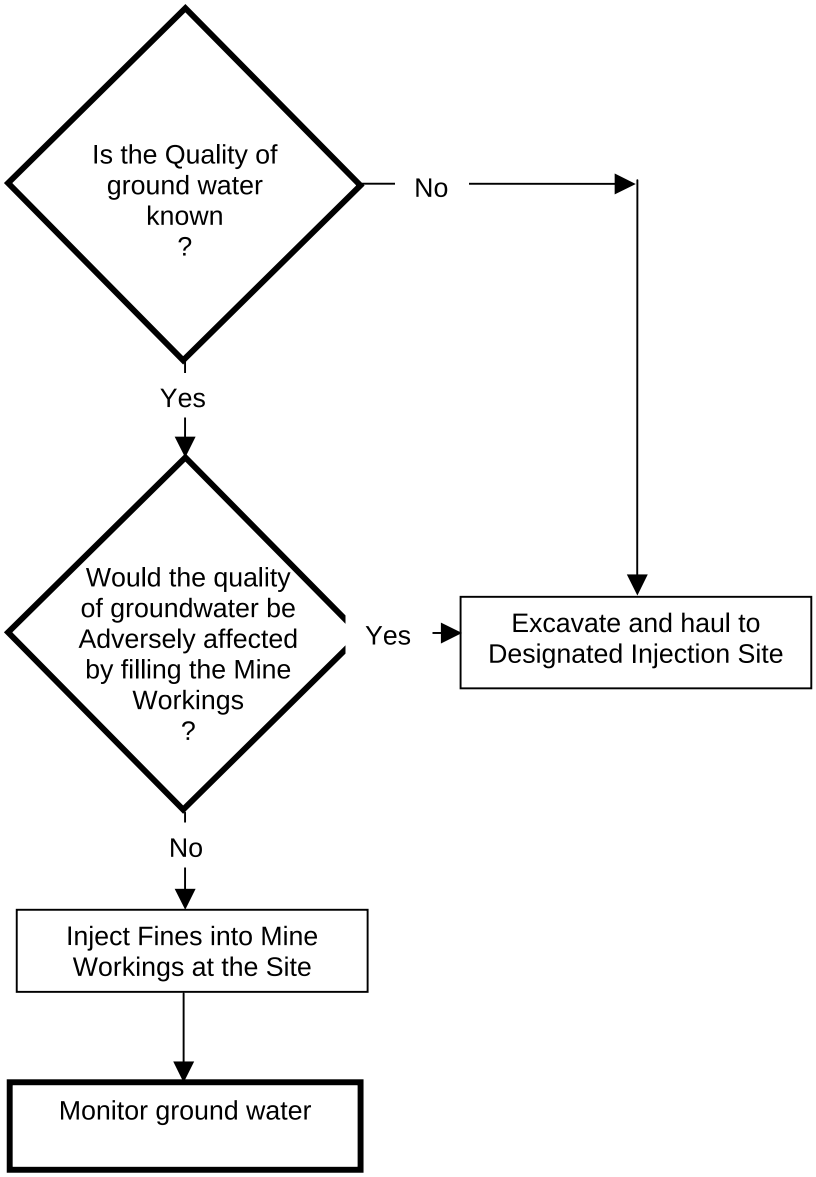


Figure 12. Decision flowchart for injecting fine materials.

Instances in which large volumes of fines are injected, such as the Central Mill Pond injected into the Blue-Goose mine workings, may employ cheaper traditional large volume sand-filling technologies typically employed in underground mines. However, In order to facilitate comparison of this alternative to EPA's alternatives, this approach has not been assumed in the following estimates of cost.

No soil cover is hauled-in and installed in the excavated areas. Soils are allowed to rebuild naturally via standard land preparation practices such as ripping, contouring, disking, and fertilizing as necessary. The Remedial Action Objective RAO is background for all of the contaminants of concern.

3.1.5. Install Flexible Membrane Liners (FML) in Tar, Lytle, and Beaver Creeks (Contingency)

Installation of a system to immediately break the ground-water to surface water pathway. Previous work has determined that surface water in these creeks are contaminated by a combination of runoff, ground water discharge from chat aquifers, and discharge from the Boone Aquifer which has been impacted by mining. A conceptual site model of flow and transport is provided in Appendix A. The installation of Flexible Membrane Liners as a control system is used for cost estimating purposes.

FMLs have been used successfully at other mine site throughout the nation to contain wastes. A simplified conceptual model of a channel x-section of pre and post remediation conditions is provided in Figures 12 and 13.

For cost estimation purposes, it is assumed that the FMLs extend from the Douthat Bridge areanorth past Mine Workings in KS. In-place chat, fines, or relatively cleaner transition zone soils will be used as sub-base and filter material for the FMLs. Material to be used for river substrate would be purchased from a nearby limestone quarry or elsewhere on the reservation (near Tribal HQ) and is placed on top of the FML and filter layer. This will remediate surface water, sediments, ground water, and riparian areas within the site as well as down gradient. The engineering design related to this work should rely on the findings of the aforementioned Hydrogeologic Studies.

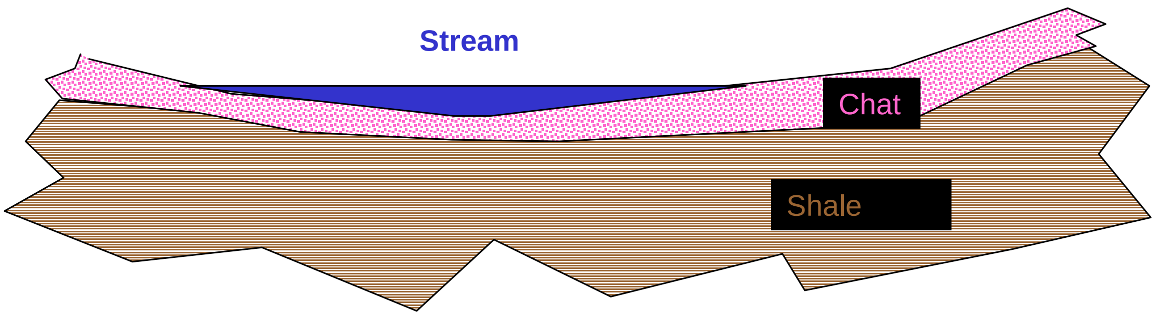


Figure 13. Conceptual pre-construction channel x-section.

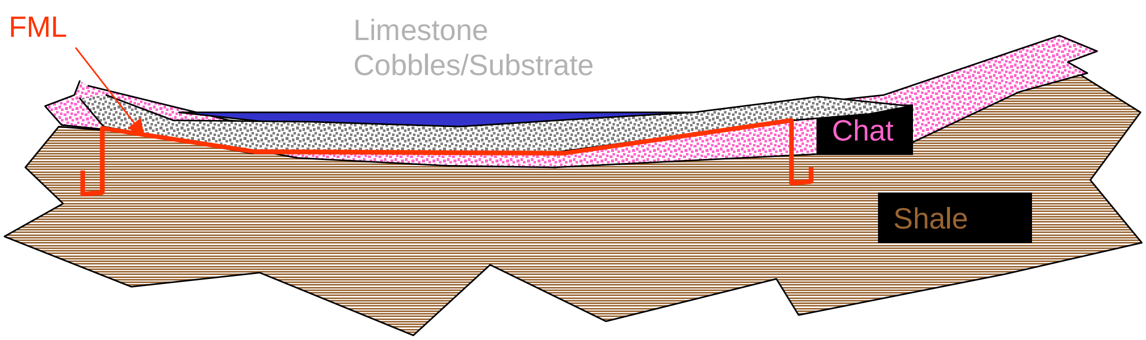


Figure 14. Conceptual post-construction x-section.

3.1.6. Control water level within the crown pillar via flow diversions and monitoring devices.

Again, the crown pillar is the current source of ARD production when periodically allowed to desaturate. Hydraulic alteration of the Boone aquifer via injection of fines will help to restore the water table to near natural conditions: however, the crown pillar will still be relatively higher permeability than similar Pennsylvanian rock outside of the mined are. In order to maintain and control saturation of the crown pillar to near natural conditions, it may be necessary to install headgates at the Treece Swimming Hole and Cardin Recharge areas to re-direct flow of Tar Creek into the crown pillar. These actions are designed to flood pyrite bearing zones in the Pennsylvanian crown-pillar and reduce production of acid rock drainage (fix the main problem).

Head in the crown pillar will be monitored in a near-real time manner. Results of monitoring will be used to tune the system, via the headgates, to minimize oscillating conditions in the crown pillar under a variety of hydrologic conditions.

3.1.7. Temporary Active Water Treatment of Mine Pool at Douthat (contingency)

Temporary active water treatment of the mine pool at the Douthat discharge is included in the proposal as a contingency in the event that ground water quality is temporarily impacted by chat washers or via remedial actions. A portable conventional lime precipitation plant is proposed. The water treatment plant effluent would be discharged at north end of channel liners (in KS) to remediate the river to a clean flowing system that will support all future uses.

3.2 Detailed Description of Phase II Tasks

3.2.1 Unmarketable chat/chat bases remaining after 10 years

Currently three options exist that are consistent with future land uses for disposal of these materials. These options are listed in the order of increasing expense, based on EPA's unit cost information:

Option 1: Excavation and onsite washing by the governments with small mobile wet sieves followed by direct injection of fines (Current best Management Practices for Chat Washers)

Option 2: Excavation, loading, and delivery to chat washers for processing;

Option 3: Excavation, loading, hauling and disposal in an engineered facility

The cost difference between the three options is quite large. All three options involve excavating approximately 15 million cubic yards of materials (EPA unit cost of $3.50 cubic yard[2]). Beyond that, Option 1 involves only wet sieving costs (estimated to be approximately $2.00 per cubic yard[3]). Additional costs for Options 2 and 3 involve hauling costs (EPA unit cost of $5.00 per cubic yard). Additional costs for Option 3 involves land purchase, construction, and long term operation and maintenance of one or two large-scale repositories. Options 1 and 2 currently comply with the Tribe's Future Land use plans. Option 3 would require other measures.

Unlike the EPA proposed Alternative, consolidation of chat bases and chat piles will result in "controlled management" of the hazardous substances via temporary institutional controls. This approach differs greatly from EPA's approach that employs "uncontrolled management" (actions are at the mercy of the market forces), and reportedly necessitates the 20-year timeframe based on human health concerns. Controlled management as described herein should allow for sales to continue much longer. With time, non-marketable chat and chat bases could be wet-sieved by the governments, making the chat free for pickup to entities located beyond the market's "break-even" point (reported currently to be approximately 200 miles away).

4.0 Estimated Costs

As discussed elsewhere herein, in order to facilitate comparison of this alternative and its three options to EPA's alternatives, EPA's unit costs are used herein. The detailed analysis of costs included the following assumptions:

1. EPA unit Costs
2. EPA Time frame
3. EPA construction concerns described above

[2] This unit cost is believed to be overestimated. The current cost of wet sieved chat picked-up at the pile is approximately $4.10 per cubic yard. Using EPA's value of $3.50 per yard would result in a negligible profit margin.

[3] The current cost of wet sieved chat picked-up at the pile is approximately $4.10 per cubic yard. The estimate of $2.00 per cubic yard processing fee assumes that the chat washers make slightly more than 100% profit)

Summary of costs for the three alternatives is provided in Table 1. Based on a percentage basis of the overall project, a major portion of the project requires a lot of dirt-work. Therefore, the overall cost is fairly sensitive to unit cost values. Detailed Costs are provided in Appendix B.

Table 1. Summary of Estimated Costs.

Awaiting new EPA unit costs

5.0 Conclusion

Remedy TA1 has a highest probability of all alternatives of meeting all nine criteria of NCP for OU1, OU4, and OU5. Onsite Surface water and sediments will be remediated. Downstream uses will return over short time. Monetary, ecological, and political costs associated with importing soils are mitigated.

Attachment No 3. RESOLUTION NO. 052105-APPROVING REGULATIONS CONTAINING WATER QUALITY STANDARDS FOR THE QUAPAW TRIBE OF OKLAHOMA

QUAPAW TRIBE OF OKLAHOMA

P.O. Box 765
Quapaw, OK 74363-0765

(918) 542-1853
FAX (918) 542-4694

RESOLUTION NO. 052105-A

A RESOLUTION APPROVING REGULATIONS CONTAINING WATER QUALITY STANDARDS FOR THE QUAPAW TRIBE OF OKLAHOMA

WHEREAS, the Quapaw Tribe of Oklahoma is a federally recognized Indian Tribe and is governed by a Governing Resolution adopted by the Quapaw Indian Council on August 19, 1956, and approved by the Commissioner of Indian Affairs on September 20, 1957; and

WHEREAS, the Governing Resolution delegates authority to the Quapaw Tribal Business Committee to speak and act on the behalf of the Quapaw Tribe; and

WHEREAS, the Quapaw Tribal Business Committee is thus empowered and obligated to transact Tribal business, including adopting and implementing ordinances and regulations for the Tribe concerning the protection and regulation of the environment and waters on Tribal lands; and

WHEREAS, after public notice and comment and public release of preliminary water quality standards, the Environmental Department of the Tribe has prepared and finalized proposed Water Quality Standards for the Tribe to be applicable to lands within the jurisdiction of the Quapaw Tribe; and

WHEREAS, the Quapaw Tribal Business Committee desires to adopt and approve such Water Quality Standards, and to have them duly codified with other Tribal laws and regulations, and to authorize the Director of the Environmental Department to submit them to the Administrator of the United States Environmental Protection Agency, Region 6 (the "EPA"), for approval and to obtain treatment-as-a-state status for the Tribe pursuant to the federal Clean Water Act, 33 U.S.C. § 1377(e).

NOW THEREFORE BE IT RESOLVED by the Quapaw Tribal Business Committee that the proposed Water Quality Standards for the Tribe, a copy of the final version of which is attached hereto, are hereby approved and adopted to take effect immediately, and to be codified with other Tribal laws and regulations; and

BE IT FURTHER RESOLVED, that the Director of the Tribal Environmental Department is hereby authorized to apply to the EPA forthwith for approval of such Water Quality Standards and to make all applications to the EPA as are necessary to obtain treatment-as-a state status for the Tribe pursuant to the federal Clean Water Act.

CERTIFICATION

The foregoing resolution of the Quapaw Tribe of Oklahoma was presented and duly adopted at a regular meeting of the Quapaw Tribal Business Committee on May 21, 2005, with a vote reflecting 7 yes, ___ no, ___ abstaining, and ___ absent.

John L. Berrey, Chairman
Quapaw Tribal Business Committee

J.R Mathews, Vice-Chairman
Quapaw Tribal Business Committee

TITLE ____. Environmental Department, Quapaw Tribe of Oklahoma (O-Gah-Pah)

CHAPTER ____. SURFACE WATER QUALITY STANDARDS

Introduction:

These regulations were adopted by the Business Committee of the Quapaw Tribe of Oklahoma (O-Gah-Pah) effective May 21, 2005.

Subchapter **Section**

SUBCHAPTER 1. GENERAL PROVISIONS

Section

xxx:yy-1-1. Purpose

(a) By the Treaty of May 13, 1833, (Kappler, 1904, vol. 2, p. 395), the United States set aside the Quapaw Reservation for the purpose of providing a permanent homeland for the Quapaw People. Pursuant to that purpose, as well as the laws of the Quapaw Tribe, the Tribe's reserved water rights, and its sovereign rights to regulate its natural resources, and in recognition that water is a valuable resource of the Quapaw People, the Business Committee of the Tribe hereby establishes and adopts these water quality standards to apply to all surface waters on lands within the jurisdiction of the Tribe. These standards shall provide a mechanism for the Tribe to manage and regulate the quality and use of said waters by establishing standards for specific water bodies.

(b) These water quality standards shall serve to protect the public health, safety and welfare, to enhance and improve the quality of water, and to ensure that degradation of existing quality of surface waters of the Tribe does not occur. These standards are intended: to restore, maintain and protect the chemical, physical, biological, and cultural integrity of the surface waters; to promote the health, safety, welfare, and economic well-being of the Tribe and its people; to achieve a level of water quality that provides for the protection and propagation of fish and wildlife and for all existing and designated uses of the water; to promote the holistic watershed approach to management of the Tribe's water; and to provide for protection of threatened and endangered species.

(c) These standards are designed to establish the uses for which the surface waters of the Quapaw Tribe shall be protected. The water use and quality criteria set forth herein are established in general conformance with water uses of the surface waters of the Quapaw Tribe and in consideration of the natural water quality potential and limitations of the same.

(d) These standards specify numeric and narrative criteria to protect beneficial uses designated for certain surface waters of the Quapaw Tribe. Beneficial use designations can be found in Appendix A of this Chapter for listed surface waters and in xxx:yy-5-3 for unlisted surface waters. The numeric and narrative criteria assigned to protect surface water beneficial uses are shown in Subchapter 5 of this Chapter. The criteria that are the standards for a specific water of the Tribe do not consider cumulative affects associated with multiple contaminants, multiple pathways, nor multiple media. In the event that multiple contaminants, multiple pathways, or multiple media are involved, site-specific numerical standards must be calculated by a qualified toxicologist.

(e) These standards were prepared in preliminary form by the Environmental Department of the Quapaw Tribe. A public notice was issued in December 2003 concerning the proposed standards, and subsequently the preliminary proposal was released for public comment. A public hearing was conducted on the standards on January 29, 2004, and comments were received from various commenters, including the Oklahoma Department of Environmental Quality. After the comments were received, the standards were revised and placed into a final form by the Environmental Department. These standards shall become effective on the date of adoption, and shall be applicable and in force, to the full extent of the law, until repealed or replaced by the Business Committee of the Tribe.

xxx:yy-1-2. Definitions

The following words and terms, when used in this Chapter, shall have the following meaning unless the context clearly indicates otherwise:

"Abatement" means reduction of the degree or intensity of pollution.

"Acute test failure" means greater than or equal to 50% lethality to appropriate test organisms in 100% effluent in 48 hours.

"Acute toxicity" means greater than or equal to 50% lethality to appropriate test organisms in a test sample.

"Alpha particle" means a positively charged particle emitted by certain radioactive materials. It is the least penetrating of the three common types of radiation (alpha, beta and gamma).

"Ambient" means surrounding, especially of or pertaining to the environment about an entity, but undisturbed and unaffected by it.

"Appropriate reference site or region" means a site on the same water body or within the same basin or eco-region that has similar fish and wildlife habitat conditions and which is expected to represent the best attainable water quality and biological community within the area(s) of concern.

"Assimilative capacity" means the amount of pollution a water body can receive and still maintain the water quality standards designated for that water body.

"Attainable uses" means the best uses achievable for a particular water body given water of adequate quality. The process of use attainability analysis can, and in certain cases must, be used to determine attainable uses for a water body.

"BCF" means bioconcentration factor.

"Beneficial uses" means a classification of the surface waters of the Tribe, according to their best uses in the interest of Tribal members.

"Benthic macroinvertebrates" means invertebrate animals that are large enough to be seen by the unaided eye, can be retained by a U. S. Standard No. 30 sieve, and live at least part of their life cycles within (e.g. hyporheic zone) or upon available substrate in a body of water or water transport system.

"Best Available Technology" means the best proven technology, treatment techniques or other viable means which are commercially available.

"Best management practices" means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of surface waters of the Tribe or United Tribes. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

"Beta particle" means a negatively charged elementary particle emitted by radioactive decay that may cause skin burns. It is easily stopped by a thin sheet of metal.

"Bioconcentration factor" means the relative measure of the ability of a contaminant to be stored in tissues (usually fish) and thus to accumulate through the food chain and is shown as the following formula: BCF = Tissue Concentration divided by Water Concentration.

"BMPs" means best management practices.

"BOD" means biochemical oxygen demand.

"Carcinogenic" means cancer causing..

"Chronic test failure" is the statistically significant difference (at the 95% confidence level) between survival of the appropriate test organism in the chronic low flow dilution (LFD) after 7 or 21 days and a control. Statistical analyses shall be consistent with methods described in EPA's publication no. 600/14-89/001, "Short-Term Methods For Estimating The Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", or most recent revision.

"Chronic toxicity" means a statistically significant difference (at the 95% confidence level) between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity.

"Coliform group organisms" means all of the aerobic and facultative anaerobic gram-negative, non-spore-forming rod shaped bacteria that ferment lactose broth with gas formation within 48 hours at 35 C.

"Color" means true color as well as apparent color. True color is the color of the water from which turbidity has been removed. Apparent color includes not only the color due to substances in solution (true color), but also that color due to suspended matter.

"Conservation plan" means, but is not limited to, a written plan which lists activities, management practices and maintenance or operating procedures designed to promote natural resource conservation and is intended for the prevention and reduction of pollution of surface waters of the Tribe.

"Critical temperature" means the higher of the seven-day maximum temperature likely to occur with a 50% probability each year, or 29.4°C (85°F).

"Criterion" means a number or narrative statement assigned to protect a designated beneficial use.

"Degradation" means any condition caused by the activities of humans which result in the prolonged impairment of any constituent of the aquatic or riparian environment.

"Department" means the Environmental Department of the Tribe.

"Designated beneficial uses" means those uses specified for each water body or segment whether or not they are being attained.

"Dissolved oxygen (DO)" means the amount of oxygen dissolved in water at any given time, depending upon the water temperature, the partial pressure of oxygen in the atmosphere in contact with the water, the concentration of dissolved organic substances in the water, and the physical aeration of the water.

"DO" means dissolved oxygen.

"EPA" means the United States Environmental Protection Agency.

"Ephemeral stream" means an entire stream which flows only during or immediately after a rainfall event, and contains no refuge pools capable of sustaining a viable community of aquatic organisms.

"Epilimnion" means the uppermost homothermal region of a stratified lake.

"Eutrophication" means the process whereby the condition of a water body changes from one of low biologic productivity and clear water to one of high productivity and water made turbid by the accelerated growth of algae.

"Existing beneficial uses" means those uses listed in Title 40 CFR §131.3 actually attained by a water body on or after November 28, 1975. These uses may include public water supplies, fish and wildlife propagation, recreational uses, agriculture, industrial water supplies, navigation, and aesthetics.

"Fecal coliform" means a group of organisms common to the intestinal tracts of humans and of animals. The presence of fecal coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

"Geometric mean" means the nth root of the product of the samples.

"Ground water" means water in a saturated or unsaturated zone in stratum beneath the surface of land or water. Ground water is further defined herein to contain both dissolved solids and suspended solids. Dissolved solids are that fraction of the sample that passes 0.42 μm filter. Suspended solids are that fraction of the sample that is retained on the 0.42μm filter.

"HQW" means High Quality Water.

"Intolerant climax fish community" means habitat and water quality adequate to support game fishes or other sensitive species introduced or native to the biotic province or ecological region, which require specific or narrow ranges of high quality environmental conditions.

"Lake" means:

(A) An impoundment of surface waters of the Tribe over 50 acre-feet in volume.

(B) Licensed surface impoundments which are used as a treatment works for the purpose of treating stabilizing or holding wastes are excluded from this definition.

"LC_{50}" means lethal concentration and is the concentration of a toxicant in an external medium that is lethal to fifty percent of the test animals for a specified period of exposure.

"Long-term average flow" means an arithmetic average stream flow over a representative period of record.

"MDL" means the Method Detection Limit and is defined as the minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero (0). MDL is dependent upon the analyte of concern.

"Narrative criteria" means statements or other qualitative expressions of chemical, physical or biological parameters that are assigned to protect a beneficial use.

"Natural conditions" means the physico-chemical conditions that were present or would be present in the absence of man-made influences.

"Natural source" means source of contamination that is not human induced.

"NIW Impairment Study" means a scientific process of surveying the chemical, physical and biological characteristics of a nutrient threatened reservoir to determine whether the reservoir's beneficial uses are being impaired by human-induced eutrophication.

"Nonpoint source" means a source of pollution without a well defined point of origin.

"NTU" means Nephelometric Turbidity Unit, which is the unit of measure using the method based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension (formazin). The higher the intensity of scattered light, the higher the turbidity.

"Numerical criteria" means concentrations or other quantitative measures of chemical, physical or biological parameters that are assigned to protect a beneficial use.

"Numerical standard" means the most stringent of the numerical criteria assigned to the beneficial uses for a given stream.

"Nutrient impaired reservoir" means a reservoir with a beneficial use or uses determined by an NIW Impairment Study to be impaired by human-induced eutrophication.

"Nutrient-impacted watershed (NIW)" means a watershed of a water body with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's Trophic Tribe Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NIW" in Appendix A of this Chapter.

"Nutrients" means elements or compounds essential as raw materials for an organism's growth and development; these include carbon, oxygen, nitrogen and phosphorus.

"ORW" means Outstanding Resource Water.

"PCBs" means polychlorinated biphenyls.

"Picocurie (pCi) " means that quantity of radioactive material producing 2.22 nuclear transformations per minute.

"Point source" means any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, well, discrete fissure, container, rolling stock or concentrated animal feeding operation from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture.

"Pollutant" means any material, substance or property which may cause pollution.

"Pollution" means contamination or other alteration of the physical, chemical or biological properties of any natural surface waters of the Tribe, or such discharge of any liquid, gaseous or solid substance into any surface waters of the Tribe as will or is likely to create a nuisance or render such waters harmful, or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life".

" Primary Contact Ceremonial and spiritual" water use means activities involving Native American religious, spiritual and cultural practices which may involve primary and secondary contact with water, and immersion and intentional or incidental ingestion of water or steam. Such use also requires protection of sensitive and valuable aquatic life and riparian habitat.

"Primary contact recreation" means activities in which a person would have direct contact with water to the point of complete submergence, including but not limited to ceremonial, spiritual and cultural uses, and skin diving, swimming and water skiing.

"Polychlorinated biphenyls" means a group of organic compounds (209 possible) which are constructed of two phenyl rings and more than one chlorine atom.

"Put and take fishery" means the introduction of a fish species into a body of water for the express purpose of sport or subsistence fish harvest where existing conditions preclude a naturally reproducing population.

"Regulatory Variance" means a temporary (not to exceed three years) exclusion or waiver of a specific numerical criterion for a specific discharge to a specific water body.

"Salinity" means the concentration of salt in water.

"Seasonal base flow" means the fair-weather stream flow sustained by groundwater and normal surface water inputs such as tributaries.

"Seasonal seven-day, two-year low flow" means the design flow for determining allowable BOD load to a stream.

"Seasonal 7Q2" means the seasonal seven-day, two-year low flow.

"Sensitive representative species" means *Ceriodaphnia dubia, Daphnia magna, Daphnia pulex, Pimphales promelas* (Fathead minnow), *Lepomis macrochirus* (Bluegill sunfish), or other sensitive organisms indigenous to a particular water body.

"Seven-day, two-year low flow" means the design flow for determining allowable discharge load to a stream.

"7Q2" means the seven-day, two-year low flow.

"Standard deviation" means a statistical measure of the dispersion around the arithmetic mean of the data.

"Standard Methods" means the publication "Standard Methods for the Examination of Water and Wastewater", published jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation.

"Standards", when capitalized, means this Chapter, which constitutes the Quapaw Tribal Surface Water Quality Standards described herein. Whenever this term is not capitalized or is singular, it means the most stringent of the criteria assigned to protect the beneficial uses designated for a specified water of the Tribe.

"Storm water" means runoff from sheet flow or conveyance resulting from inclement weather conditions and snow melt .

"Subwatershed" means a smaller component of the larger watershed.

"Surface Waters of the Tribe" means all streams, lakes, ponds, marshes, wetlands, watercourses, waterways, springs, seeps, irrigation systems, drainage systems, and all other bodies or accumulations of surface water contained within, flow through, or border upon Tribal lands or any portion thereof.

"Synergistic effect" means the presence of cooperative pollutant action such that the total effect is greater than the sum of the effects of each pollutant taken individually.

"Thermal pollution" means degradation of water quality by the introduction of heated effluent.

"Thermal stratification" means horizontal layers of different densities produced in a lake caused by temperature differences.

"Tribe" means the Quapaw Tribe of Oklahoma (O-Gah-Pah).

"Warm Water Aquatic Community" means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support intolerant climax fish communities and includes an environment suitable for the full range of warm water benthos.

"Wastes" means industrial waste and all other liquid, gaseous or solid substances which may pollute or tend to pollute any surface waters of the Tribe.

"Water body" means any specified segment or body of surface waters of the Tribe, including but not limited to, an entire stream or lake or a portion thereof.

"Water quality" means physical, chemical, and biological characteristics of water which determine diversity, stability, and productivity of the climax biotic community or affect human health or use.

"Watershed" means the surface water drainage area of a water body including all direct or indirect tributaries.

"WWAC" means Warm Water Aquatic Community.

"Zone of passage" means a three dimensional zone expressed as a volume in the receiving stream through which mobile aquatic organisms may traverse the stream past a discharge without being affected by it.

xxx-yy-1-3. Adoption and enforceability of the standards

(a) Quapaw Tribal Surface Water Quality Standards adopted and promulgated by the Tribe shall be applicable to all activities that may affect the quality of waters of the Tribe and shall be utilized by all appropriate Tribal environmental agencies in implementing their respective duties to abate and prevent pollution to waters of the Tribe.

xxx-yy-1-4. GENERAL CONDITIONS

The following conditions shall apply to the water quality criteria and classifications set forth herein.

(a) All surface waters shall be free from pollutants and other materials in concentrations or combinations that do not protect the most sensitive existing or designated use of the water body.

(b) Whenever the natural conditions of any specific surface waters of the Tribe are of a lower quality than the criteria assigned to waters typical of that class, the Department may determine that the natural conditions shall constitute the water quality criteria.

(c) At the boundary between surface waters of different classifications, the more stringent water quality criteria shall prevail. If existing or designated uses of more than one resource are affected, the most protective criteria shall apply.

(d) The Department may revise the criteria on as to Tribal lands in general or on water body-specific basis as needed to protect aquatic life and human health and other existing and designated uses and to increase the technical accuracy of the criteria being applied. The Tribal Business Committee shall formally adopt any revised criteria following public review and comment, and shall submit revisions to EPA for review and approval.

(e) The analytical testing methods used to measure or otherwise evaluate Water Quality Standards shall to the extent practicable, be in accordance with the most recent editions of "Standard Methods for the Examination of Water and Wastewater," published by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, and "Methods for Chemical Analysis of Water and Wastes," published by the EPA, and other or superseding methods published and/or approved by the Department following consultation with and concurrence of the EPA.

xxx:yy-1-5. Revision procedures

(a) Any member may petition the Department to modify or repeal any criterion or beneficial use designation.

(b) The petitioner, through objective and acceptable scientific studies, data and other information, shall be required to show that the requested modification or repeal will be in accordance with the requirements of applicable Tribal and Federal law regarding water quality and in the best interest of the Tribe.

(c) Procedures required by applicable Tribal and Federal law for revising the designated beneficial uses and criteria or water quality shall be followed in any revision which is the subject of the petition.

xxx:yy-1-6. Errors and reparability

(a) Errors resulting from inadequate and erroneous data or human or clerical oversight will be subject to correction by the Department.

(b) The discovery of such errors does not render the remaining and unaffected Standards invalid.

(c) If any provision of these Standards, or the application of any provision of these Standards to any person or circumstances is held to be invalid, the application of such provisions to other persons and circumstances and the remainder of the Standards shall not be affected thereby.

SUBCHAPTER 2. ANTIDEGRADATION REQUIREMENTS

Section

xxx:yy-2-1. Purpose; antidegradation policy statement

(a) Waters of the Tribe constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the Department to protect all waters of the Tribe from degradation of water quality.

(c) The existing in-stream beneficial uses of each water body and the level of water quality necessary to protect those uses shall be maintained and protected.

(d) Where the quality and total maximum daily loads of the waters are at higher qualities than necessary to support propagation of fish, shellfish and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the Department finds, after full satisfaction of the intergovernmental coordination and public participation required by law, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the Department shall assure water quality adequate to protect existing uses fully. Further, the Department shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.

(e) Where high quality waters constitute an outstanding national or Tribal resource, or waters of exceptional recreational or ecological significance, the water quality and uses of those water bodies shall be maintained and protected.

(f) In those cases where potential water quality impairments associated with thermal discharge are involved, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act, as amended (33 U.S.C. § 1326).

xxx:yy-2-2. Applications of antidegradation policy

(a) **Application to Primary Body Contact Cultural and Spiritual waters (PBCC).** All waters of the Tribe constitute an outstanding resource or have exceptional significance. These waters include streams designated "PBCC" in Appendix A.

SUBCHAPTER 3. SURFACE WATER QUALITY STANDARDS

PART 1. GENERAL PROVISIONS

xxx:yy-3-1. Declaration of policy; authority of Department

(a) **General policy to protect, maintain and improve water quality.**

Whereas the pollution of the waters of this Tribe constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, it is hereby declared to be the public policy of the Tribe to conserve and utilize the waters of the Tribe and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses.

(b) **Department authority to promulgate Standards.**

(1) The Department, with the approval of the Tribal Business Committee, is authorized to develop, propose amendment to and otherwise promulgate rules to be known as the Quapaw Tribal Surface Water Quality Standards which establish classifications of uses of waters of the Tribe, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters. These Standards shall, at a minimum, be designed to maintain and protect the quality of the waters of the Tribe.

(2) Wherever the Department finds it is practical and in the public interest to do so, the rules may be amended to upgrade and improve progressively the quality of waters of the Tribe.

(3) Subject to the approval of the Tribal Business Committee, the Department may also amend the Standards to downgrade a designated use of any waters of this Tribe which is not an existing use, may establish subcategories of a use or may provide for less stringent criteria or other provisions thereof only in those limited circumstances permissible under the Federal Water Pollution Control Act as amended or federal rules which implement said act. As provided herein, and with the approval of the Tribal Business Committee, the Department may amend these Standards to downgrade a designated use, establish subcategories of a use or may provide for less stringent criteria or other provisions thereof only to the extent as will maintain or improve the existing uses and the water quality of the water affected.

xxx:yy-3-2. Beneficial uses: existing and designated

(a) Beneficial uses are designated for all waters of the Tribe. Such uses are protected through the restrictions imposed by the antidegradation policy statement, narrative criteria and numerical standards. Some uses require higher quality water than others. When multiple uses are assigned to the same waters, all such uses shall be protected. Beneficial uses are also protected by permits or other authorizations issued to meet these Standards for point sources and through practical management or regulatory programs for nonpoint sources. The criteria to protect the beneficial uses designated in Appendix A of this Chapter for certain surface waters of the Tribe are described in sections xxx:yy-5-10 through xxx:yy-5-20 of this Chapter.

(b) Beneficial uses designated in Appendix A of this Chapter for certain surface waters of the Tribe may be downgraded to a lower use or removed entirely, or subcategories of such designated uses may be established, if:

(1) the use, despite being designated, is not a use which is or has been actually attained in the water body on or after November 28, 1975; and

(2) for the use of Fish and Wildlife Propagation, Primary Body Contact Recreation or Secondary Body Contact Recreation, or any subcategory of such use or uses, it is demonstrated to the satisfaction of the Department and the EPA that attaining the designated use is not feasible because:

(A) naturally occurring pollutant concentrations prevent the attainment of the use, or

(B) natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating Tribe water conservation requirements to enable uses to be met, or

(C) human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place, or

(D) dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use, or

(E) physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses, or

(F) controls more stringent than those required by sections 301(b) and 306 of the federal Clean Water Act as amended would result in substantial and widespread economic and social impact; and

(3) such downgrade, removal, or establishment of a subcategory will maintain or improve the quality of water affected.

xxx:yy-3-3. Beneficial uses: default designations

(a) **Surface waters excluding lakes.**

(1) For those surface waters of the Tribe not listed in Appendix A of this Chapter, the following beneficial uses are designated:

(A) Primary Contact Ceremonial and spiritual

(2) Beneficial use determinations that follow use attainability analyses are subject to administrative rulemaking proceedings.

(b) **Lakes.**

(1) Lakes are assigned the following designations:

(A) Primary Contact Ceremonial and spiritual;

(B) Primary Body Contact Recreation;

(C) The Warm Water Aquatic Community subcategory of the beneficial use classification Fish and Wildlife Propagation;

(D) Agriculture;

(E) Industrial and Municipal Process and Cooling Water; and

(F) Aesthetics.

xxx:yy-3-4. Applicability of narrative and numerical criteria

(a) For purposes of permitting discharges for attainment of numerical criteria or establishing site specific criteria, streamflows of the greater of 1.0 cfs or 7Q2 shall be used to determine appropriate permit conditions.

(b) Narrative criteria listed in this Chapter shall be maintained at all times and apply to all surface waters of the Tribe.

(c) If more than one narrative or numerical criteria is assigned to a stream, the most stringent shall be maintained.

(d) A temporary regulatory variance may be granted at the sole discretion of the Department in limited circumstances only for specific numerical criteria listed in Table 2 of Appendix B of this Chapter addressing water column numerical criteria to protect human health for the consumption of fish and water, for specific numerical criteria listed in Appendix B Table 2 addressing numerical criteria for toxic substances, and for specific numerical criteria listed in Appendix B Table 2 addressing water column numerical criteria to protect human health for the consumption of fish flesh only.

PART 3. BENEFICIAL USES AND CRITERIA TO PROTECT USES

xxx:yy-3-5. General narrative criteria

All surface waters of the Tribe waters shall be free from pollutants and other materials attributable to point source discharges, nonpoint sources, or in-stream activities in accordance with the following:

(a) **Minerals.** Increased mineralization over natural conditions from elements such as, but not limited to, calcium, magnesium, sodium and their associated anions shall not impair any beneficial use.

(b) **Floating Solids, Oil and Grease.** All waters shall be free from visible oils, scum, foam, grease, and other floating and suspended materials of a persistent nature resulting from other than natural causes.

(c) **Color.** True color-producing materials resulting from other than natural causes shall not create an aesthetically undesirable condition; nor should color inhibit photosynthesis or otherwise impair the existing and designated uses of the water.

(d) **Odor and Taste.** Materials from other than natural causes shall be limited to concentrations that will not impart unpalatable flavor to fish, or result in offensive odor or taste arising from the water, or otherwise interfere with the existing and designated uses of the water.

(e) **Nuisance Conditions.** Nutrients or other materials from anthropogenic causes shall not be present in concentrations which will produce objectionable algal densities or nuisance aquatic vegetation, result in a dominance of nuisance species, or otherwise cause nuisance conditions.

(f) **Turbidity.** Turbidity shall not be at a level to threaten or impair existing and designated uses or aquatic biota.

(g) **Bottom Deposits.** All surface waters of the tribe shall be free from anthropogenic materials that may settle and have a deleterious effect on the aquatic biota or that will significantly alter the physical and chemical properties of the water or the bottom sediments.

(h) **Permits**. In issuing permits, Tribal authorities shall attempt to insure that to the extent practicable, all waters shall be free from soil particles resulting from erosion of land involved in earthwork, such as construction of public works, highways, or commercial or industrial developments, or the cultivation and management of agricultural or forested lands, or resulting from discharges from consumptive or nonconsumptive uses of water following surface water diversions or ground water pumping.

xxx:yy-3-6. TOXIC POLLUTANTS

(a) Toxic pollutants shall not be introduced into surface waters of the Tribe in concentrations which have the potential either singularly or cumulatively to adversely affect existing and designated uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the Department.

(b) The Department may employ or require chemical testing, acute and/or chronic toxicity testing, and biological assessments, as appropriate, to evaluate compliance with subsection (1) of this section. Where necessary, the Department may establish controls to ensure that aquatic communities and the existing and designated beneficial uses of waters are being fully protected.

(c) Criteria for toxic pollutants and other materials not currently listed in Table 2 shall be determined with consideration of *U.S. EPA Quality Criteria for Water, 1986*, as updated, and other relevant information as appropriate.

(d) Risk-based criteria for carcinogenic materials shall be applied such that the upper-bound excess cancer risk is less than or equal to one in one million, which means the probability of one excess cancer per one million people exposed.

(e) The guidelines set forth in 40 CFR Part 136 shall be used as guidance for analytical methodologies

(f) The criteria in Table 2, Appendix B shall be applied to all surface waters of the tribe for the protection of aquatic life and human health. The concentration for each compound listed in Table 2 is a criterion for aquatic life or human health protection. Selecting values for regulatory purposes will depend on the most sensitive beneficial use to be protected and the level of protection necessary for aquatic life and human health as specified within Table 2, Appendix B. Application for a reduction in the list of compounds or elements must be based on proof that one or more of the proposed compounds are not of concern. Authorization of such a reduction is at the discretion of the Department. All concentrations, except asbestos, are micrograms per liter (ug/L).

(A) Primary Contact Ceremonial and spiritual;

(B) Primary Body Contact Recreation;

(C) The Warm Water Aquatic Community subcategory of the beneficial use classification Fish and Wildlife Propagation;

(D) Agriculture;

(E) Industrial and Municipal Process and Cooling Water; and

(F) Aesthetics.

xxx:yy-3-7. Primary Contact Ceremonial and Spiritual

(a) **General.** Primary Contact Ceremonial and Spiritual is the highest and best use of the resource. The surface waters of this designated use shall be maintained so that toxicity does not inhibit ingestion of subsistence foods by humans including, but not limited to fish, shellfish, plants and terrestrial wildlife. The numerical criteria and values for substances listed in Appendix B, Table 2 of this Chapter shall apply to surface water designated as Warm Water Aquatic Community, Cool Water Aquatic Community, or Trout Fishery.

(b) **Water column criteria to protect for the consumption of fish and water.** Primary Contact Ceremonial and Spiritual use involves direct ingestion of water, flora, and fauna associated with daily subsistence practices as well as inhalation of vapors during sweat lodge ceremonies. In these cases the water shall not contain chemical, physical or biological substances in concentrations that:

1. toxic or cause illness or discomfort upon ingestion by human beings,

2. has the potential to bioaccumulate in subsistence foods; or

3. are irritating to skin or sense organs upon contact with water or vapor.

The water column numerical criteria (total recoverable) identified in the " Fish Consumption and Water " column in Appendix B, Table 2 protect human health for the consumption of fish, shellfish and aquatic life.

(c) **Radioactive materials.**

(1) There shall be no discharge of radioactive materials to Tribal waters.

(2) The concentration of gross alpha particles shall not exceed the criteria specified in (A) through (D) of this subparagraph, or the naturally occurring concentration, whichever is higher.

(A) The combined dissolved concentration of Radium-226 and Radium-228, and Strontium-90, shall not exceed 5 picocuries/liter, and 8 picocuries/liter, respectively.

(B) Gross alpha particle concentrations, including Radium-226 but excluding radon and uranium, shall not exceed 15 picocuries/liter.

(C) The gross beta concentration shall not exceed 50 picocuries/liter.

(D) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in waters having the designated use of Public and Private Water supply shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

(3) **Coliform bacteria.**

(A) The bacteria of the total coliform group shall not exceed a monthly geometric mean of 5,000/100 ml at a point of intake for public or private water supply.

(B) The geometric mean will be determined by multiple tube fermentation or membrane filter procedures based on a minimum of not less than five (5) samples taken over a period of not more than thirty (30) days.

(C) Further, in no more than 5% of the total samples during any thirty (30) day period shall the bacteria of the total coliform group exceed 20,000/100 ml.

(D) In cases where both public and private water supply and primary body contact recreation uses are designated, the primary body contact criteria will apply.

(4) **Oil and grease (petroleum and non-petroleum related).** Primary Contact Ceremonial and Spiritually designated surface waters of the Tribe shall be maintained free from oil and grease and taste and odors.

(5) **General criteria.**

(A) The quality of the surface waters of the Tribe which are designated as Primary Contact Ceremonial and Spiritual shall be protected, maintained, and improved when feasible, so that the waters can be used for all beneficial uses.

(B) These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans or flora and fauna.

xxx:yy-3-8. Public and private water supplies (PPWS)

The following criteria apply to surface waters of the Tribe having the designated beneficial use of Public and Private Water Supplies:

(1) **Raw water numerical criteria.** For surface water designated as public and private water supplies, the numerical criteria for substances identified under the "Public and Private Water Supply (Raw Water)" column in Table 2 of Appendix B of this Chapter shall not be exceeded. Raw water numerical criteria are considered long term average standards. For purposes of permitting discharges for attainment of these standards, the permitting authority shall use long term average receiving stream flows and complete mixing of effluent and receiving water to determine appropriate permit limits.

(2) **Radioactive materials.**

(A) There shall be no discharge of radioactive materials to Tribal waters.

(B) The concentration of gross alpha particles shall not exceed the criteria specified in (i) through (iv) of this subparagraph, or the naturally occurring concentration, whichever is higher.

(i) The combined dissolved concentration of Radium-226 and Radium-228, and Strontium-90, shall not exceed 5 picocuries/liter, and 8 picocuries/liter, respectively.

(ii) Gross alpha particle concentrations, including Radium-226 but excluding radon and uranium, shall not exceed 15 picocuries/liter.

(iii) The gross beta concentration shall not exceed 50 picocuries/liter.

(iv) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in waters having the designated use of Public and Private Water supply shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

(3) **Coliform bacteria.**

(A) The bacteria of the total coliform group shall not exceed a monthly geometric mean of 5,000/100 ml at a point of intake for public or private water supply.

(B) The geometric mean will be determined by multiple tube fermentation or membrane filter procedures based on a minimum of not less than five (5) samples taken over a period of not more than thirty (30) days.

(C) Further, in no more than 5% of the total samples during any thirty (30) day period shall the bacteria of the total coliform group exceed 20,000/100 ml.

(D) In cases where both public and private water supply and primary body contact recreation uses are designated, the primary body contact criteria will apply.

(4) **Oil and grease (petroleum and non-petroleum related).** For Public and Private Water Supplies, surface waters of the Tribe shall be maintained free from oil and grease and taste and odors.

(5) **General criteria.**

(A) The quality of the surface waters of the Tribe which are designated as public and private water supplies shall be protected, maintained, and improved when feasible, so that the waters can be used as sources of public and private raw water supplies.

(B) These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans or flora and fauna.

(6) **Water Column criteria to protect for the consumption of fish flesh and water.**

(A) Surface waters of the Tribe with the designated beneficial use of Public and Private Water Supply shall be protected to allow for the consumption of fish, shellfish, and water.

(B) The water column numerical criteria to protect human health for the consumption of fish flesh and water for the substances identified in Table 2 of Appendix B of this Chapter shall be as prescribed under the "Fish Consumption and Water" column in Table 2 of Appendix B in all surface waters designated with the beneficial use of Public and Private Water Supply. Water column numerical criteria to protect human health for the consumption of fish and water are considered long term average standards. For purposes of permitting discharges for attainment of these standards, the permitting authority shall use long term average receiving stream flows and complete mixing of effluent and receiving water to determine appropriate permit limits. Water column criteria to protect human health for the consumption of fish flesh only may be found in the column "Fish Consumption" in Table 2 of Appendix B of this Chapter.

xxx:yy-3-9. Emergency public and private water supplies

(a) During emergencies, those waters designated Emergency Public and Private Water Supplies may be put to use.

(b) Each emergency will be handled on a case-by-case basis, and be thoroughly evaluated by the appropriate Tribe agencies and/or local health authorities.

xxx:yy-3-10. Fish and wildlife propagation

(a) **List of subcategories.** The narrative and numerical criteria in this section are designed to maintain and protect the beneficial use classification of "Fish and Wildlife Propagation". This classification encompasses several subcategories which are capable of sustaining different climax communities of fish and shellfish. These subcategories are Habitat Limited Aquatic Community, Warm Water Aquatic Community, Cool Water Aquatic Community (Excluding Lake Waters), and Trout Fishery (Put and Take).

(b) **Warm Water Aquatic Community subcategory**. Warm Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality and habitat are adequate to support warm water climax fish communities.

(c) **Cool Water Aquatic Community subcategory.** Cool Water Aquatic Community means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support cool water climax fish communities and includes an environment suitable for the full range of cool water benthos. Typical species may include smallmouth bass, certain darters and stoneflies.

(d) **Trout Fishery subcategory**. Trout Fishery (Put and Take) means a subcategory of the beneficial use category "Fish and Wildlife Propagation" where the water quality, water temperature and habitat are adequate to support a seasonal put and take trout fishery. Typical species may include trout.

(e) **Criteria used in protection of fish and wildlife propagation.** The narrative and numerical criteria to maintain and protect the use of "Fish and Wildlife Propagation" and its subcategories shall include:

(1) **Dissolved oxygen.**

(A) Dissolved oxygen (DO) criteria are designed to protect the diverse aquatic communities.

(ii) by comparison with pre-contamination historical data from the water body being evaluated.

(B) Compliance with the biological criteria to protect Fish and Wildlife Propagation set forth in this paragraph shall be based upon measures including, but not limited to, diversity, similarity, community structure, species tolerance, trophic structure, dominant species, indices of biotic integrity (IBI's), indices of well being (IWB's), or other measures.

(6) **Toxic substances (for protection of fish and wildlife).**

(A) Surface waters of the Tribe shall not exhibit acute toxicity and shall not exhibit chronic toxicity. The narrative criterion specified in this subparagraph (A) which prohibits acute toxicity shall be maintained at all times and shall apply to all surface waters of the Tribe. The narrative criterion specified in this subparagraph (A) which prohibits chronic toxicity shall apply at all times.

(B) Toxicants for which there are specific numerical criteria are listed in Table 1 of Appendix b of this Chapter.

(C) For toxicants not specified in Table 1 of Appendix b of this Chapter, concentrations of toxic substances with bio-concentration factors of 5 or less shall not exceed 0.1 of published LC_{50} value(s) for sensitive representative species using standard testing methods, giving consideration to site specific water quality characteristics.

(D) Concentrations of toxic substances with bio-concentration factors greater than 5 shall not exceed 0.01 of published LC_{50} value(s) for sensitive representative species using standard testing methods, giving consideration to site specific water quality characteristics.

(E) The acute and chronic numerical criteria listed in the "Fish and Wildlife Propagation" column in Table 2 of Appendix B of this Chapter apply to all waters of the Tribe designed with any of the beneficial use sub-categories of Fish and Wildlife Propagation. The numerical criteria which prohibit acute toxicity apply to all Tribal waters.

(i) The numerical criteria specified in Table 1 of Appendix b which prohibit chronic toxicity shall apply at all times.

(ii) Equations are presented in Table 1 of Appendix b for those substances whose toxicity varies with water chemistry. Metals listed in Table 1 of Appendix b are measured as total metals in the water column.

(7) **Turbidity.**

(A) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

(i) Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;

(ii) Lakes: 25 NTUs; and

(iii) Other surface waters: 50 NTUs.

(B) In waters where background turbidity exceeds these values, turbidity from point sources shall be restricted to not exceed ambient levels.

(C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

xxx:yy-3-11. Agriculture: livestock and irrigation

(a) The surface waters of the Tribe shall be maintained so that toxicity does not inhibit continued ingestion by livestock or irrigation of crops.

xxx:yy-3-12. Fish consumption

(a) **General.** The surface waters of the Tribe shall be maintained so that toxicity does not inhibit ingestion of subsistence foods by humans including, but not limited to fish, shellfish, plants and terrestrial wildlife. The numerical criteria and values for substances listed in column "Fish Consumption" in Table 2 of Appendix B of this Chapter shall apply to surface water designated as Warm Water Aquatic Community, Cool Water Aquatic Community, or Trout Fishery.

(b) **Water column criteria to protect for the consumption of fish flesh.** The water column numerical criteria (total recoverable) identified in the "Fish Consumption" column in Table 2 of Appendix b protect human health for the consumption of fish, shellfish and aquatic life.

APPENDIX A. DESIGNATED BENEFICIAL USES FOR SURFACE WATERS

(a) **Introduction.** The Tables that follow in this Appendix identify certain waterbodies throughout Tribal lands and designate beneficial uses for those waterbodies. The waterbodies are identified by their name (e.g., "Tar Creek") or other description (e.g., "Tributary of Tar Creek at Sec. 4) and a "WQM Segment" number.

(b) **Beneficial Use designations.** Designations of beneficial uses for a water body are reflected in the Tables by the presence of the following codes or a dot ("•") in the columns to the right of the water body name. An empty space in a column means that column's beneficial use or subcategory thereof is not designated for that water body. All water bodies of the Tribe are designated Primary contact Cultural Ceremonial Use

The criteria to protect the beneficial uses are provided in Appendix B of this Chapter.

TABLE 1. Designated Beneficial Uses of Surface Waters

Waterbody Name and Sequence	ODEQ WQM Segment	Designation [1]
Beaver Creek	121600	PCCS
Elm	121600	PCCS
Lytle	121600	PCCS
Spring River	121600	PCCS
Tar Creek	121600	PCCS

[1] The designated use is the highest and best use of surface water. This means that this use encompasses all lower-level designations. For example, water meeting the numeric criteria that are protective of Primary Contact Cultural and Spiritual uses (PCCS) which involves consumption of fish and water, will be protective of uses that involve only ingestion of fish or water.

TABLE 1.

Dissolved Oxygen Criteria to Protect Fish and Wildlife Propagation and All Subcategories Thereof

SUBCATEGORY OF FISH AND WILDLIFE PROPAGATION (FISHERY CLASS)	DATES APPLICABLE (MINIMUM)	D.O. CRITERIA (mg/L)	SEASONAL TEMP. (°C)
Habitat Limited Aquatic Community			
Early Life Stages	4/1 - 6/15	4.0	25[3]
Other Life Stages			
Summer Conditions	6/16 - 10/15	3.0	32
Winter Conditions	10/16 - 3/31	3.0	18
Warm Water Aquatic Community			
Early Life Stages	4/1 - 6/15	6.0[2]	25[3]
Other Life Stages			
Summer Conditions	6/16 - 10/15	5.0[2]	32
Winter Conditions	10/16 - 3/31	5.0	18
Cool Water Aquatic Community And Trout			
Early Life Stages	3/1 - 5/31	7.0[2]	22
Other Life Stages			
Summer Conditions	6/1 - 10/15	6.0[2]	29
Winter Conditions	10/16 - 2/28	6.0	18

1 For use in calculation of the allowable load.

2 Because of natural diurnal dissolved oxygen fluctuation, a 1.0 mg/l dissolved oxygen concentration deficit shall be allowed for not more than eight (8) hours during any twenty-four (24) hour period.

3 Discharge limits necessary to meet summer conditions will apply from June 1 of each year. However, where discharge limits based on Early Life Stage (spring) conditions are more restrictive, those limits may be extended to July 1.

TABLE 2.

Numerical Criteria to Protect Beneficial Uses and All Subcategories Thereof

PARAMETER	CAS #	Fish & Wildlife Propagation		Public and Private Water Supply (Raw Water)	Fish Consumption and Water	Fish Consumption
		ACUTE	CHRONIC			
		µg/L	µg/L	mg/L	µg/L	µg/L
INORGANICS						
Arsenic	7440382	360.0	190	0.04		205.0
Barium	7440393			1.00		
Cadmium	7440439	e(1.128[ln(hardness)] - 1.6774)	e(0.1002[ln(hardness)]-3.490)	0.020	14.49	84.13
Cadmium for trout streams		e(1.128[ln(hardness)] - 3.828)	e(0.1002[ln(hardness)]-3.490)	0.020	14.49	84.13
Chromium (total)			50	0.050	166.3	3365.0
Copper	7440508	e(0.9422[ln(hardness)]-1.3844)	e(0.8545[ln(hardness)]-1.386)	1.000		
Cyanide	57125	45.93	10.72	0.200		
Flouride @ 90°F				4.0		
Lead	7439921	e(1.273[ln(hardness)] - 1.460)	e(1.273[ln(hardness)] - 4.705)	0.100	5.0	25.0
Mercury	7439976	2.4	1.302	0.002	0.050	0.051
Nickel	7440020	e(0.8460[ln(hardness)]+3.3612)	e(0.846[ln(hardness)]+1.1645)		607.2	4583.0
Nitrates (as N)	14797558			10.000		

Selenium	7782492	20.0	5	0.010		
Silver	7440224	e(1.72[ln(hardness)] - 6.52)		0.050	104.8	64620.0
Thallium	7440280	1400.0			1.7	6.0
Zinc	7440666	e(0.8473[ln(hardness)]+0.8604)	e(0.8473[ln(hardness)]+0.7614	5.000		
ORGANIGS						
1,1,1-TCE	71556				3094.0	173100.0
2,4,5-TP Silvex	93721		10.0	0.010		
2,4,6-TNT		450.0				
2,4-D	94757			0.100		

PARAMETER	CAS #	Fish & Wildlife Propagation		Public and Private Water Supply (Raw Water)	Fish Consumption and Water	Fish Consumption
		ACUTE	CHRONIC			
		µg/L	µg/L	mg/L	µg/L	µg/L
Acrylonitrile	107131	7550.0			.59	6.7
Aldrin	309002	3.0			0.001273	0.001356
Benzene	71432		2200.0		11.87	714.1
Benzidine	92875			0.001		
Butylbenzyl Phthalate	85687			0.150		
Carbon Tetrachloride	56235				2.538	44.18
Chlordane	57749	2.4	0.17		0.00575	0.00587
Chloroform	67663				56.69	4708.0
Chlorpyrifos (Dursban)	2921882	0.083	0.041			
DDT		1.1	0.001		0.005876	0.0059
Demeton	8065483		0.1			
Detergents (total)				0.200		
Dichlorobromomethane	75274				1.9	157.0
Dieldrin	60571	2.5	0.0019		0.001352	0.00144
Dioxin	1746016				0.00000013	0.000000138
Endosulfan		0.22	0.056			
Endrin	72208	0.18	0.0023	0.0002	.7553	0.814
Ethylbenzene	100414				3120.0	28720.0

Table 3.

Conversion Factors for Total to Dissolved Fractions [H=hardness as $CaCO_3$ (mg/L)]

METAL	CAS #	ACUTE	CHRONIC
Arsenic	7440382	1.000	1.000
Cadmium	7440439	lnH 1.136672 - 0.041838	lnH1.101672 - 0.041838
Copper	7440508	0.960	0.960
Lead	7439921	lnH 1.46203 - 0.145712	lnH 1.46203 - 0.145712
Mercury	7439976	0.85	N/A
Nickel	7440020	0.998	0.997
Silver	7440224	0.85	N/A
Zinc	7440666	0.978	0.986

Attachment No 1.
Berrey, J.[19], Kent, T.[20], Kirschner, F.E. [21] and, Harper, B. 2019[22], **Whitepaper: Early Determination of Pre-Mining Background for Mine Sites Affecting Tribal Lands and Resources, Submitted to Steve Cook, Deputy Assistant Administrator, Office of land and Emergency Management, U.S. EPA-HQ on February 12, 2019.**

[19] Chairman of the Quapaw Nation
[20] Environmental Director, Quapaw Nation
[21] Senior Scientist, AESE, Inc.
[22] Senior Scientist, AESE, Inc.

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

SCOTT A. THOMPSON
Executive Director

KEVIN STITT
Governor

July 14, 2021

Katrina Higgins-Coltrain
US EPA Region 6
Remedial Branch (SEDRL)
1201 Elm Street, Suite 500
Dallas, TX 75202-2102

Re: Tar Creek Superfund Site
Operable Unit 5 (OU5)
Technical Memorandum: Development of Human Health Risk-Based Preliminary Remedial Goals for Operable Unit 5

Dear Ms. Higgins-Coltrain,

On behalf of the Oklahoma Department of Environmental Quality (DEQ), please find our comments (attached) regarding the Technical Memorandum (TM) titled, *Development of Human Health Risk-Based Preliminary Remedial Goals for Operable Unit 5*.

Overall, DEQ is concerned that many of the substantive comments previously submitted to EPA throughout the process that has led to the development of the Preliminary Remedial Goals (PRGs) for Operable Unit 5 (OU5) appear largely unresolved. As such, DEQ respectfully requests a consultation with EPA aimed at finding solutions for the concerns raised and to provide input to the parameters driving the risk-based scenarios chosen for OU5. DEQ's goal is to seek resolution so that no additional effort is wasted modeling scenarios the DEQ may ultimately not support.

As a primary stakeholder working in good faith and as a governmental entity that is obligated to pay match for all OU5-related remedial costs, DEQ is requesting to be more actively included in all aspects of this process moving forward. Please contact me at your earliest convenience to schedule a meeting. DEQ looks forward to working with EPA as we continue to collectively make progress towards our common goals.

If you have any questions or would like to discuss the contents of the comments, please feel free to contact me at Kristen.Bliss@deq.ok.gov or (405) 702-5158.

Kristen E. Bliss, EPS III
Land Protection Division
Oklahoma Department of Environmental Quality

On June 10, 2021, the Environmental Protection Agency (EPA) released the (revised) *Technical Memorandum: Development of Human Health Risk-Based Preliminary Remedial Goals for Operable Unit 5*. DEQ's comments are as follows:

General Comments:

- The *Technical Memorandum: Development of Human Health Risk-Based Preliminary Remedial Goals for Operable Unit 5* contains many of the parameters used within the *Human Health Risk Assessment for the Tar Creek Superfund Site Operable Unit 5* (HHRA) that DEQ found concerning in the letter submitted September 2020 (attached). DEQ states, "DEQ fully supports integrating traditional tribal lifeways into this assessment and understands the value of modeling subsistence lifestyle parameters to best protect human health in Tar Creek. However, in many cases (i.e. sweat lodge scenario; potable water), there is little to no justification provided that would clarify why the model parameters have been used in this this way. Further, these two pathways in particular remain somewhat unjustified yet contribute more to the overall hazard index (HI) than many other pathways combined." While DEQ maintains that the Sweat Lodge Scenario parameters continue to overestimate the risk associated with this important tribal practice, the DEQ will no longer offer comment on the Tribal Lifeway (TLW) parameters. DEQ supports using tribal feedback to ensure achieving the greatest accuracy in quantifying those values and appreciates the effort that has gone into making those contributions. However, DEQ does not support using parameters for any General Public (GP) scenarios that assume residents of the Tar Creek area forgo all residential tap water resources and subsist solely on the untreated surface waters of the surrounding area. What is EPA's reasoning for continuing to use this parameter that is artificially inflating the risk when both DEQ and the Tar Creek Trustee Council Indian Tribes (TCTCIT) have both indicated this assumption is inaccurate? Please provide justification for using this parameter or discontinue use of this parameter in any GP scenarios.

- Also from the September 2020 submittal, DEQ states "What is the justification for over-estimating the "small game" portion of the Tribal Lifeway diet by using 135% dietary intake? As the HHRA states, "This…overestimates intake from these aquatic food sources." While DEQ offers no further comment on the TLW subsistence parameters used, this methodology was used to model GP (Scenario 1) as well. DEQ does not support using additional dietary inputs combined with EPA default dietary intake parameters for any GP scenario. Doing so makes the assumption that individuals consume up to 130% of their dietary intake each day which in turn adds nearly double the potential contaminant consumption. EPA has yet to provide DEQ with any justification for this decision. Please provide justification for using this additive method or discontinue using additional dietary intake parameters in any GP scenarios.

General Comments (continued):

- DEQ requests the addition of a time-weighted average (TWA) approach be included as one of the GP scenarios modeled and discussed within the main body of this TM. Why was GP (Scenario 4) omitted following discussion with TCTCIT then added back into the TM as an addendum? DEQ feels that a hybrid approach, possibly some version of the TWA approach, most closely resembles daily sediment exposure conditions most often encountered by the general public at the Site. DEQ looks forward to discussing this further with EPA so that we can contribute to the accuracy of parameters used to evaluate public use and inform any future decision documents.

Section 4.0

- Site-specific toxicity thresholds (SSTTs) corresponding to the T_{10} values calculated as part of the *TM: Baseline Ecological Risk Assessment for Operable Unit 5 of the Tar Creek Superfund Site, Ottawa County, Oklahoma* (DERA) were included and discussed at some length. What was EPA's reasoning for excluding any mention of the T_{20} values also calculated from this TM? DEQ requests that the T_{20} values remain an option for consideration moving forward during the development of the feasibility study to ensure robust, meaningful discussion surrounding potential remedial goals for this operable unit.

- DEQ previously asked for clarification concerning the derivation of the ∑ PEC-Q value referenced from the DERA. Using Section 2.2.2 from the *Remedial Investigation Report* as well as the citation referenced, DEQ arrives at an index of 7.9 not 6.47. Can EPA provide clarification concerning how the ∑ PEC-Q value was calculated? So far, DEQ cannot reproduce the results of this calculation. Please provide the calculation EPA used to derive the ∑ PEC-Q value 6.47.

Section 6.0

- 6.6.1 "…that is, assumed daily exposure to OU5 sediment and surface water without considering receptors' exposure frequency and time at OU5…" DEQ does not support this approach as it does not accurately represent the realistic time and frequency parameters that reflect how the public may come into contact with OU5 surface water and sediment. PRGs calculated for any GP scenarios should include accurately quantified, site-specific parameters that consider exposure time and frequency.

- 6.6.1 Given the known limitations of using the IEUBK default input values for modeling complex aquatic systems, considerable effort was taken collecting site-specific OU5 data to inform (and replace, if needed) each of the IEUBK defaults in favor of more accurate input parameters. What was the justification for running GP (Scenario 3) with almost all IEUBK default input values? If only four scenarios were included in the main TM for consideration, DEQ suggests eliminating this scenario in favor of using one with more site-specific parameters.

- 6.6.1 "In addition to the IEUBK's default dietary intake, additional lead intake through OU5 fish consumption is calculated…" As mentioned above, DEQ does not support modeling any GP scenarios with IEUBK defaults plus additional dietary input values. The IEUBK software allows a great deal of user flexibility for modeling alternate dietary inputs when they represent more accurate, site-specific parameters. The software even provides an input for the inclusion of game animals (e.g. fish) as well as an additional input parameter that estimates the proportion of fish eaten when compared to other protein sources in a daily diet. Why was it necessary to introduce additional risk parameters instead of simply substituting site-specific parameters in place of IEUBK defaults? Please provide justification for overestimating dietary intake (resulting in additional risk) for GP scenarios or adjust input values so that OU5 fish intake is substituted for other dietary protein sources.

Included Attachments: Letter submitted by DEQ to EPA on September 16, 2020

SCOTT A. THOMPSON
Executive Director

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

KEVIN STITT
Governor

Attachments

September 16, 2020

Katrina Higgins-Coltrain
US EPA Region 6
Remedial Branch (SEDRL)
1201 Elm Street, Suite 500
Dallas, TX 75202-2102

Re: Tar Creek Superfund Site
Operable Unit 5 (OU5)
Draft Human Health Risk Assessment (HHRA)

Dear Ms. Higgins-Coltrain,

On May 14, 2020 the Environmental Protection Agency (EPA) released the Draft Human Health Risk Assessment (version 1.1) for Tar Creek Operable Unit 5 (OU5). DEQ's comments are as follows:

General Comments:

- In general, the Human Health Risk Assessment (HHRA) for the Tar Creek Superfund Site Operable Unit 5 (OU5) contains numerous assumptions which over-estimate the risks associated with the Site. While DEQ acknowledges, and in some cases, supports these conservative assumptions, DEQ feels that the OU5 HHRA does not appropriately highlight the overly conservative nature of many inputs as well as the degree of uncertainty surrounding many of these calculations. DEQ is concerned that the conservative nature of the assessment and the over-estimation of risk will unintentionally misinform the community rather than appropriately informing the community. DEQ is requesting that EPA put more emphasis on the conservative nature of this HHRA. For example, the statement made in Section 6.6.1, "It is improper to consider these estimates as representative of the actual health outcome to potentially exposed individuals because they were estimated by making numerous conservative assumptions…" is extremely vital and it should not take the reader 50 pages to reach that sentence. Please consider making clear statements regarding the conservative nature of the HHRA in the Executive Summary and the Introduction.
- Please consider adding a "Conclusions" or "Results" section to the HHRA that includes narrative stating and explaining the final Excessive Cancer Lifetime Risk (ECLR) and Hazard Index (HI) for each of the proposed risk scenarios. This information is outlined in Tables 6-15 through 6-19. Also consider that Tables 6-17, 6-18, and 6-19 are not cited within the body of the document. DEQ feels the document would be improved with additional narrative explaining the results of the of the risk analysis.
- DEQ could not find Tables that identified the HI or ECLR for Tribal Lifeway Adult Scenarios or for the General Public Fish consumption scenario. DEQ requests that this information be included along similar Tables that outline the results of the risk analysis (i.e 6-15-6-19).

Tribal Lifeway Scenarios:

General

- DEQ has previously expressed concern regarding the overly conservative inputs and scenarios chosen by EPA within this HHRA. DEQ fully supports integrating traditional tribal lifeways into this assessment and understands the value of modeling subsistence lifestyle parameters to best protect human health in Tar Creek. However, in many cases (i.e. sweat lodge scenario; potable water), there is little to no justification provided that would clarify why the model parameters have been used in this this way. Further, these two pathways in particular remain somewhat unjustified yet contribute more to the overall hazard index (HI) than many other pathways combined. For example, as stated in Section 6.6.2.11 of the HHRA , "In the case of Tar Creek, inhalation of water vapor accounts for more than one-third of the combined HI from all exposure media (sediment, surface water, and biota)". DEQ suggests providing more information on what ultimately informed these decisions and assessment inputs beyond what has been provided thus far. Additionally, DEQ requests more prominent placement of this clarification to put the parameters used in this assessment into proper context.

Sweat Lodge

- **Section 6.6.2.11** DEQ requests additional documentation or clarification understanding the principle behind the inhalation risk from the sweat lodge scenario. Basic concepts of distillation and vaporization suggest that due to the non-volatile nature of the contaminants of concern (COCs) only water would vaporize and not any heavy metals present in the water. The critical points for all COCs are well above the maximum temperature that hot stones could generate in a sweat lodge. Further, the memo produced from the EPA Region 6 consultation with the TRW Lead Committee (Appendix E, Attachment A) illustrates a similar concern for this pathway in particular. DEQ is also concerned that this HHRA substantiates an incomplete pathway. DEQ requests that EPA make available a more in-depth explanation of why this is a complete pathway in the Exposure Assessment section or alternatively, explain why this may be an incomplete pathway in the Uncertainty Analysis section.
- The equation provided by the source referenced does not match the one used within this assessment; DEQ is unable to ascertain how this estimation was conducted. Also, the source used to base these assumptions upon does not appear to be peer-reviewed. Were there additional scientific, peer-reviewed sources EPA used to base this methodology upon or was the *Shoshone-Bannock Exposure Scenario* the only source used?
- Why did EPA select a more conservative exposure frequency for the sweat lodge scenario than what was suggested by Quapaw Nation and TCTCIT input? Harper (2008) demonstrates using 365 days/year as a default, but makes note the need to adjust this rate per specific tribal uses.

Drinking Water

- **Section 4.3.2.1** DEQ requests clarification on why this HHRA assumes individuals exclusively consume untreated surface waters as their sole source of potable water at the Site. While DEQ acknowledges that the incidental ingestion of water from surface water bodies is a complete pathway, it is highly unlikely that individuals would forego using residential tap water in favor of subsisting solely on untreated surface waters. What evidence has EPA utilized to justify using surface water exposure point concentrations as a surrogate for residential tap water scenarios? If this is not the case, please provide further explanation and clarify within the body of the document.

Exposure Factors for Food Consumption

- **Section 4.3.2.1** What is the justification for over-estimating the "small game" portion of the Tribal Lifeway diet by using 135% dietary intake? As the HHRA states, "This…overestimates intake from these aquatic food sources." According to the study cited within this section (Harper 2008) there seems to be no justification to overestimate Quapaw dietary proportions or intake. Further, citing this study within this section seems somewhat misleading, given Harper (2008) has no mention of over-estimating intake parameters. DEQ suggests re-wording for clarification.

If you have any questions or comments, please contact me at (405) 702-5158 or e-mail me at Kristen.Bliss@deq.ok.gov.

Sincerely,

Kristen E. Bliss, EPS III
Land Protection Division
Oklahoma Department of Environmental Quality

Attachment 4B
Responses to Review Comments

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
1	General comment		**EPA calculated the lead PRG value (presented in Table 4 of the PRG memo) based on the assumption that Tribal members consume surface water as drinking water**. EPA should use the Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 2010) default drinking water value as the drinking water concentration when calculating the lead PRG for the Tribal Lifeway (TLW) scenario. We note that EPA used this drinking water value to calculate a lead PRG value in the uncertainty analysis (Section 7.2.3), however, this drinking water value should be used to calculate the lead PRG value presented in the Findings section of the PRG memo (Section 8). As stated in Section 7.2.3 of the PRG memo, Abt previously indicated, on behalf of TCTCIT, that the Tribes do not use OU5 surface water as a source of drinking water. Use of this value for drinking water does not accurately reflect Tribal Lifeways for Tribal members, and can exaggerate the risk associated with lead exposure from drinking water. Use of the IEUBK default drinking water value for the drinking water concentration more accurately reflects both Tribal Lifeways and a central tendency exposure value. We also note that the drinking water exposure route is not included in the development of cadmium or zinc. Exposure scenarios should be consistent between the contaminants of concern (COCs).	The TLW scenario presented in the main section of the PRG memo reflects the exposure assumptions used in the HHRA, where OU5 surface water was assessed for both incidental ingestion and a source of drinking water (tap water and sweat lodge use scenarios). It was assumed that OU5 surface water would be used as a source of drinking water because the designated beneficial use for some waterbodies (Neosho River, Spring River, and Lost Creek) within the OU5 watersheds is "Public and Private Water Supply", as indicated in Appendix B of "*Water Quality in Oklahoma 2020 Integrated Report*" (Oklahoma Department of Environmental Quality, 2020). http://www.deq.state.ok.us/wqdnew/305b_303d/. In addition, during the HHRA planning process, Tribal stakeholders indicated that surface water should be considered as a potential future source of drinking water and should be included on the conceptual exposure model. Please note that (as stated in the second paragraph of Section 6.0 of the PRG memo) because the approach used in the exposure analysis of lead is different from that of the cadmium and zinc hazard assessment, PRGs are developed using two different approaches for lead and cadmium/zinc.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
2	Section 6.1.1	6	**To calculate the lead PRG value, EPA treats sediment exposure as soil exposure, assuming daily exposure to OU5 sediment "without considering receptors' exposure frequency and time at OU5 (pg. 6)."** As described in the Human Health Risk Assessment (HHRA), Tribal members are exposed to sediments for 312 days/year and 6 hours per day (CH2M HILL, 2021a). Thus, this exposure is intermittent and EPA's assumption of "daily exposure to OU5 sediment" (pg. 6) is inaccurate. As the Technical Review Workgroup (TRW) Lead Committee describes in Attachment A of the PRG memo (response to question 5), "For an intermittent exposure, the portion of the total exposure frequency (EF) (i.e., days per week, days per year, etc.) that would occur for OU5 media should be determined. For the remaining portion of the total EF, the lead exposure point concentration (EPC) would be based on the receptor's non-site soil lead concentration (e.g., residence, childcare facility, schoolyard), to arrive at a TWA soil (or sediment) lead concentration. The OU5 PRG can then be calculated by knowing what the PRG is for the total receptor exposure and what the lead concentration is in the non-site soil." Thus, a time-weighted average (TWA) soil/sediment concentration should be calculated that considers both time spent at OU5 and time spent at the residence. We note that EPA uses a TWA in the "Addendum to Development of Human Health Risk-Based Preliminary Remediation Goals for Operable Unit 5, Version 1.2, Dated June 9, 2021" for General Public receptors (CH2M HILL, 2021b), and should use a similar approach, with the correct EF, here. EPA's current approach effectively assumes that Tribal members are exposed to sediments continuously, which does not accurately reflect Tribal Lifeways.	The calculated sediment PRGs for the TLW scenario based on the three target blood lead levels (BLLs: 5, 8, and 10 µg/dL) are already less than the lead background threshold value (BTV) of 58 mg/kg. Refining these PRGs using the TWA approach only decreases the PRG further. In fact, no refined PRGs using the TWA approach can be calculated for the TLW scenario because lead exposure from the residential yard soil (EPC of 133 mg/kg in combination with a soil ingestion rate of 400 mg/day) is so significant that even if the sediment lead concentration is zero, it would not achieve all three target BLLs. Therefore, no refined PRGs using the TWA approach were calculated for the TLW scenario. It is understood that TWA discussions may continue based upon discussions with TRW. Please note that in response to ODEQ's comments, PRGs accounting for exposure frequency and exposure time at OU5 (using the TWA approach) were added to the PRG memo for two GP scenarios (GP Scenarios 4 and 5).

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
3	General comment		**Based on the current definition of OU5, EPA is not including all plant dietary exposure media in the PRG analysis. These plant dietary exposure media are not included in any of the other OUs and thus, if not included in the OU5 analysis, they will be excluded from EPA's remedial investigation of the Site.** The estimation of risk due to consumption of gathered plants was limited to the "roots and bulbs" dietary exposure pathway (as identified by Harper, 2008), which EPA has defined as aquatic plants. Therefore, the calculated risk does not account for lead intake due to the consumption of other plants gathered from the Site (i.e., "greens and sweets"; "fruits and berries"). The available data for greens and sweets and fruits and berries demonstrate elevated contaminant concentrations that correlate with contaminated sediments (Abt, 2021). Therefore, there is a complete exposure pathway from sediments to these plants and subsequently the TLW receptors. This pathway indicates that these plants should be included in OU5.	As discussed in the second paragraph of Section 1.0 (Site Background) of the PRG memo, EPA Region 6 generally defines OU5 as sediments and surface water in perennially flowing creeks, streams, and rivers that may be impacted by historical mining activities within the Oklahoma portion of the TSMD and upstream portions in Kansas and Missouri, which does not include floodplain areas where "greens and sweets" and "fruits and berries" are harvested. To encompass dietary lead exposure from a large variety of fruits and vegetables, the PRGs for the TLW Scenario were calculated by incorporating the IEUBK Model's default dietary lead exposure, in addition to the dietary lead exposure calculated for consumption of OU5 aquatic food items. As presented in Table 4 of the PRG memo, the calculated PRGs based on various target BLLs for the TLW Scenario are less than the BTV of 58 mg/kg. Adding lead exposure from additional food items would only decrease the calculated PRGs, which are already less than the BTV. Typically, risk-based concentrations below background levels are not used as remedial goals in cleanup activities; therefore, no change was made based on this comment.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
4	General comment		**If available, EPA should use site-specific contaminant exposure data and Tribal consumption rates to estimate risk due to the consumption of terrestrial dietary items.** During discussions with EPA, Abt recommended that EPA include all exposure media in the development of PRG values, including media sourced from within OU5 and outside of OU5. This includes dietary items, which are one of the main sources of lead exposure in the TLW scenario. From our understanding, EPA has taken this recommendation and included IEUBK's default values for dietary intake to represent terrestrial sources of lead in the diet. We appreciate that this update was made, however, we recommend the use of site-specific data and Tribal consumption rates for inclusion of terrestrial dietary inputs. Although more data is needed to understand tissue concentration for some terrestrial sources (e.g., deer), this approach would allow for inclusion of that data if sampling were conducted. Additionally, this approach could be repeated for development of cadmium and zinc PRG values, which do not have default dietary values, such as those for lead in the IEUBK. At the least, if EPA is including IEUBK's default values for dietary intake to represent terrestrial sources, we recommend that they state that in the PRG memo, and note that this is likely an under-estimate of terrestrial background lead exposure levels.	Please see the last paragraph in the response to Comment #3 regarding adding lead exposure from additional food items to the PRG calculation under the TLW scenario. Additionally, because of the definition of OU5 discussed in the second paragraph of Section 1.0 (Site Background) of the PRG memo, lead exposure through terrestrial food sources (e.g., deer) is not addressed under OU5. However, as suggested in the comment, the text of the PRG memo was revised to state that the PRGs calculated under the TLW Scenario were calculated by incorporating the IEUBK Model's default dietary lead exposure, in addition to the dietary lead exposure calculated for consumption of OU5 aquatic food items, to encompass dietary lead exposure from a large variety of non-OU5 food sources.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
5	Section 6.1.1	6	**In developing lead PRG values, EPA identified a "representative watershed" for each receptor scenario and calculated the PRG using surface water and biota EPCs from that representative watershed.** Rather than using a representative watershed approach, EPA should develop simple regression models to estimate biota input values for PRG calculations. Site-specific data are available to develop regression models between sediment and aquatic foods. In fact, EPA developed a regression model between sediment and arrowhead root (Figure 1, Attachment 2) for all three COCs. These relationships were used to estimate tissue concentrations for cadmium and zinc and subsequently to develop PRG values for these COCs. It follows that the sediment-plant tissue relationship developed for lead could also be used to estimate the lead concentrations in aquatic plants at different sediment concentrations. Additionally, as shown in Abt's PRG Report, site-specific data are available to develop regression models for fish, shellfish, amphibians and plants (Abt, 2021). If the PRG value falls between sediment concentrations in two watersheds, regression models will work better than EPA's representative watershed approach because no watershed would be representative and thus biota values would need to be interpolated between two watersheds. Additionally, EPA accurately notes that the representative watershed approach is further complicated if it is necessary to calculate PRG values at multiple blood lead level (BLL) threshold values since the PRG value changes at each BLL and thus the representative watershed may change as well. Development of regression models would not only be simpler but would also provide versatility. Versatility is especially important if developing multiple PRG values for each COC, as was done in the OU4 HHRA (CH2M HILL, 2006).	Please note that the surface water and biota EPCs from representative watershed are site-specific data collected from Tar Creek OU5. It is acknowledged that COC concentrations in biota can be estimated based on sediment concentrations using various approaches. However, each approach has its own uncertainties and drawbacks (see the response to Comment #9 which lists some drawbacks associated with biota concentration estimates using the linear regression approach). As indicated in the 4th paragraph of Section 7.2.2 of the PRG memo, due to the high variability in COC concentrations in biota samples, the efficacy of sediment remediation for protection of aquatic biota consumption will be assessed via future monitoring and the Five-Year Review process.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
6	Section 7.1	11	**EPA indicates that the Tribal soil ingestion rate of 400 mg/d recommended in the Harper et al, 2007a, and used in the "Quapaw Traditional Lifeways Scenario" (Harper, 2008) is inappropriate to use as an input to the IEUBK. EPA states this is because 1) it "relies in large part" on outdated information in EPA's 1997 Exposure Factors Handbook, and 2) it is a reasonable maximum exposure (RME) value, rather than a central tendency**. We would like to clarify both of these points. First, the ingestion rate proposed by Harper of 400 mg/d (Harper, 2007a; 2007b; 2008) does not in fact "rely in large part" on the 1997 EFH (EPA, 1997). In "Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual", Harper et al. (2007b) presents an entire literature review on soil ingestion rates (see Attachment 1 of this comments memo, Appendix B of Harper et al., 2007b), and synthesized all the reviewed information to develop the 400 mg/d value. Specifically, Harper et al. (2007b) reviewed and synthesized EPA guidance, military guidance, as well as information from the literature on ingestion rates observed in suburban/urban populations (adults and children), and in indigenous populations. Harper et al. (2007b) did report the 400 mg/day value from EPA (1997), but they also summarized information from many other sources. For example, Harper et al. (2007b) reported that the US military assumes ingestion rates of 480 mg per field day, while the UN Balkans Task Force assumes 1 g per field day, and they interpreted a field day to be somewhat analogous to Tribal exposure levels. Notably, they summarized ingestion rates reported in the literature for indigenous populations of several grams per day. According to Harper et al. (2007b), Simon (1998) recommends using a soil ingestion rate for adults of 1g/d (1,000 mg/d) in wet climates, 2 g/d (2,000 mg/d) in dry climates, and 3 g/d (3,000 mg/d) for children. As noted above, Harper et al. (2007b) reviewed all this information and derived a value of 400 mg/d as a reasonable Tribal soil ingestion rate. This value is much lower than the upper end indigenous values from the literature and is meant to reflect a mix of low-contact days and higher contact days (e.g., days spent gathering roots, active at powwows, etc. vs rest days). Hence, it is not intended to be a RME as indicated by EPA, but rather a central tendency value for Tribal populations, based on a synthesis of information from guidance documents and published literature.	The information provided in Attachment 1 (Appendix B from Harper et al., [2007]) was included as an attachment to the PRG memo to provide background on the source of Harper's recommended ingestion rate.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
7	Section 6.2.2	9	**In the development of PRGs for cadmium and zinc, EPA did not include several aquatic exposure pathways that contribute to risk in the TLW scenario. This includes ingestion of fish, shellfish, amphibian and semi-aquatic mammal as well as ingestion of drinking water. This contrasts with the development of the lead PRGs, which included all of these exposure routes.** The PRG values for all COCs should be evaluated using the same exposure scenario, including the same exposure routes and media, unless appropriate toxicological values are unavailable. It is confusing for a receptor (i.e., Tribal member, general public) to understand the risk associated with Site activities if the PRG values are developed using different exposure scenarios. Additionally, all three contaminants are present at all locations. The Remedial Action Objectives will address sediment as a whole and thus, while it is acceptable to present a range of PRG values, it is important that a sediment PRG value for each COC be developed for each exposure scenario. EPA provides multiple explanations for why inclusion of all aquatic dietary items is unnecessary and we address those in the comments below.	See the responses to Comments #8 and #9.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
8	Section 6.2.2	9	**EPA concludes that the only aquatic food item that needs to be included in the PRG calculations for cadmium and zinc is aquatic plants. In Section 6.2.2 of the PRG memo, they state that "the development of PRGs focuses on cadmium and zinc in aquatic plants only, because cadmium and zinc in aquatic plants constitute more than 90% of the total [hazard index] HI associated with COC exposure through consumption of OU5 aquatic food items." This is discussed further in Section 7.2.2 and Table 10 of the PRG memo, which present the hazard quotients (HQs) for sitewide data and Neosho River data.** In the PRG memo, EPA states that "aquatic plants constitute more than 90% of the total HI associated with COC exposure through consumption of OU5 aquatic food items." The HQ data in Table 10 show that aquatic plants account for 95% of total dietary HQ when an average of all the sitewide data (including biota from highly contaminated areas) are used to calculate risk. However, when risk is determined using concentrations for biota from less contaminated areas, risk from aquatic plants account for much less of the total dietary risk. For example, when a total dietary HQ is calculated using concentrations from Neosho River (a less contaminated river), aquatic plants account for only 22% of the total dietary HQ (Table 10). This indicates that the proportion of dietary HQ associated with aquatic plants decreases with decreasing sediment concentration. This is further supported by Figure 7C, which shows the HQ values for aquatic dietary items in Lost Creek, the second least contaminated watershed, and indicates that aquatic plants account for much less than 90% of the aquatic dietary HQ at this sediment concentration. All dietary items should be included in the development of cadmium and zinc PRGs. This includes all aquatic food items (including greens and sweets and fruits and berries, see Comment 3) and all terrestrial food items.	The remediation strategy to minimize or prevent unacceptable health risks focuses on the exposure pathways associated with the most significant risk contributor(s) first. In the PRG memo, the discussion of percent contribution to the overall HQ estimate is provided to identify the specific exposure pathway driving risk so that most HQ reduction can be achieved by addressing that targeted exposure pathway. Therefore, the discussion of the HQ contribution for the least contaminated watersheds such as Lost Creek and Neosho River (whose sediment concentrations are considered comparable to background) is not relevant. In fact, the lower percentage contribution from aquatic plants in these watersheds is expected and the reason why the effort is targeted on aquatic plants. Regarding terrestrial food items, please see the response to Comment #3.

Table 1a. Response to Comments Provided by Abt Associates on behalf of TCTCIT on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
9	Section 7.2.2	13	**EPA further justifies excluding other aquatic dietary items from PRG calculations by stating that "there are no apparent correlations between sediment and some biota" (pg. 13) including fish and raccoon.** Our analysis shows that there are correlations between sediment and most aquatic dietary biota including fish, shellfish, amphibians, and aquatic plants. As stated on pg. 13, Angelo et al., (2007) is a peer-reviewed study that established an empirical relationship between concentrations of COCs in sediment and in co-located freshwater mussels collected from the Spring River Basin. Additionally, Abt's PRG Report presents correlations between sediment and all riparian plant groupings (roots and bulbs, greens and sweets, and fruits and berries), as well as between sediment and fish (Abt, 2021). We note that EPA conducted a regression analysis for sediment and arrowhead root and recommend that EPA use regression models for the additional biota described above. We also recognize that regression analyses may not be appropriate for all dietary exposure media, for example, a correlation between sediment and raccoon is not apparent in the available data.	Abt's efforts in providing additional insight into the data collected from OU5 is appreciated. Regarding the correlations between sediment and fish/amphibians, the outcome of Abt's data analysis does not support strong correlations between sediment and these biota samples. R-squared values for the linear regression analyses are less than 0.1 for most cases with a few exceptions (lead in fish [0.23] and zinc in amphibians [0.59]). Additionally, it appears that most of the regression curves are often significantly influenced by data from the watershed with higher sediment concentrations (e.g., Tar Creek) and do not reflect relationships in the lower range of sediment concentrations around which the calculated PRGs are likely to be established (e.g., the ecological-based T10). Further, it is not always appropriate to assume that the complex biological accumulation phenomena can be explained using a simple linear relationship, especially within a wide range of concentrations in sediment, such as those observed in the OU5 datasets.
10	Section 7.2.2	13	**Re: The risk-based PRG values calculated by EPA for cadmium and zinc were developed including aquatic plants only and no other aquatic dietary items. EPA concludes that this approach is justified because empirical data for aquatic dietary items from the reference watershed (Lost Creek) result in a HQ between 2 and 3 for cadmium and zinc.** As stated on pg. 8, "the target HI is set at 1 for each COC." Thus, while we agree that a HQ value of 2 is not particularly large, the PRG values for cadmium and zinc do not meet the target HI of 1. It should also be noted that these HQ values only include risk from dietary items and do not include the other exposure routes including sediment/soil incidental ingestion and drinking water. Overall, the analysis presented on the HQs for Lost Creek do not seem to justify exclusion of other aquatic biota from the development of cadmium and zinc PRGs.	As indicated in the 4th paragraph of Section 7.2.2 of the PRG memo, because of high variability in COC concentrations in biota samples, the efficacy of sediment remediation for protection of aquatic biota consumption will be assessed via future monitoring and the Five-Year Review process.

Table 1b. Response to Comments Provided by L.E.A.D. Agency, Inc. on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
1	General comment		**Our comment remains:** Why is OU-5 CSM only considering these media stated above and not also including riparian and floodplain areas, groundwater and air deposition? The Region 7 CSM does include these, as well as the others. We do not accept that OU-4 takes care of these media, because this is off-site of OU-4 and these are all different watersheds, except for Tar Creek, Elm and Fourmile Creeks. Springs are located along these watersheds that have not been identified and studied by EPA, for example. Groundwater discharge and re-charge zones need to be identified and make clear to the public for our comment in these documents. Air monitoring data, supposedly taken by the Quapaw Nation should either be made available to the public or new data be collected for the public knowledge. We know that the riparian and floodplains have been contaminated and the plants, foods that are harvested are contaminated. Previous studies presented by the tribes and LEAD bear that out. Why are they not relevant to OU-5?	OU5 is defined as the wet-bank-to-wet-bank boundaries of perennial flowing streams., . Section 11.0 of the OU4 Record of Decision (ROD) states: *"The NCP, 40 CFR Section 300.5, defines an operable unit as a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.* *Due to the complex nature of contamination associated with the Tar Creek Site, remediation has been handled through various removal response actions and remedial actions. The following five operable units (OUs) have been designated at the Site: OU1 - surface water/ground water; OU2 – residential areas; OU3 - Eagle-Picher Office Complex (abandoned mining chemicals); OU4 - Mine and Mill Waste, and Smelter Waste and, OU5 - Sediments. A ROD was signed for OU1 in 1984 that addressed the surface water degradation of Tar Creek and the threat of contamination to the drinking water. This remedy is in an after-action monitoring phase. The ROD for OU2 was signed in 1997 and has addressed lead-contaminated soils at over 2225 properties. OU3 was a removal action that requires no further action, and OU5 is currently in the early site characterization phase.* *(RESPONSE CONTINUED NEXT PAGE)*

Table 1b. Response to Comments Provided by L.E.A.D. Agency, Inc. on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
				RESPONSE CONTINUED FROM PREVIOUS PAGE *The remedial action addressed in this ROD, referred to as OU4, will address the parts of the Site (both urban and rural) that are not presently used for residential purposes or which are sparsely used for residential purposes, where mine and mill wastes and smelter waste have been deposited, stored, disposed of, placed, or otherwise come to be located as a result of mining, milling, smelting or related operations. Areas where such material has come to be located as a result of "related operations" that OU4 will address include without limitation chat covered haul roads and non-operating railroad grades. OU4 will also address areas where mine and mill wastes and smelter wastes have been moved by anthropogenic activities (e.g., where chat has been used as a driveway in a rural area) or by natural actions including erosion (e.g., where chat has washed from a chat pile into a stream). OU4 will generally not address sediment, except where sediment is incidentally addressed when chat is removed from in-stream or near-stream areas. OU4 will not address ground water or surface water, except indirectly by eliminating some of the sources of ground water and surface water contamination. OU4 will also generally not address contamination in streams that is due to mine drainage. OU4 includes residential yards located in Ottawa County outside of city or town limits except for those residential yards that have been addressed under OU2."* Each site is unique, and the focus of the remedial investigation may vary; therefore, other sites (such as those in EPA Region 7) may include different or additional exposure media on their CSMs.

Table 1b. Response to Comments Provided by L.E.A.D. Agency, Inc. on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
2	Table 2		In Table 2 of the Technical Memorandum, no chemicals of concern were identified for the sediment in Neosho River and Lost Creek. Only lead in sediment is identified in Lower Spring River. In discussing this aspect of Table 2, EPA states: [T]he lead exposure estimated ... at the reference watershed (Fourmile Creek, which represents background lead concentrations in sediment and surface water) also exceeds the target lead exposure criterion ... Concentrations of lead in sediment and surface water at two of the watersheds (Neosho River and Lost Creek) are comparable to background concentrations; therefore, lead was identified as a final COC in all watersheds (Elm Creek, Tar Creek, Beaver Creek, and Lower Spring River) except these two watersheds.	Please note that PRGs developed for OU5 are not watershed-specific values and they are applicable to all watersheds within OU5. A further discussion of the application of the final PRGs to OU5 watersheds will be performed in the Feasibility Study.
3	Table 2		Because lead levels in Neosho River and Lost Creek are comparable to background, it is likely these lead levels, like those at Fourmile Creek, exceed the target lead exposure criterion. Nonetheless, EPA declines to establish PRGs for lead in Neosho River and Lost Creek. While we understand the function of a background and that lead levels in this region tend to be higher than in other regions, we nevertheless maintain that in declining to set PRGs for lead in Neosho River and Lost Creek EPA fails to adequately protect the health of the community. We are very concerned with metals in Neosho River and what happens to them between the convergence with Tar Creek and the Twin Bridges State Park. We urge EPA to set PRGs for lead in both waterways - and to reevaluate the appropriateness of using a contaminated waterway as the background reference for sitewide remediation. In this regard, we ask EPA to compare Tar Creek's background with backgrounds from other sites with similar watershed characteristics and exposure concerns and identify off-site alternative backgrounds for LEAD/Community.	See response to Comment #2.

Table 1b. Response to Comments Provided by L.E.A.D. Agency, Inc. on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
4	General comment		It is unclear how site cleanup will be staged and whether runoff from mine wastes on surrounding land is expected to significantly affect the long-term success of a sediment cleanup. This may be evaluated during the feasibility study. We request that during the feasibility study EPA discuss how long-term maintenance of sediment PRG levels will be evaluated. We believe it may be appropriate to set variable PRGs for sediment. Background values could be appropriate for areas where sediment is being washed downstream and deposited as soils due to flood scour. OU5 sediments could be deposited along creek shorelines or even on the Grand Lake shoreline. We ask that EPA identify stream reaches that are susceptible to flood scour and set stream-specific or stream reach-specific PRGs. Additionally, during numerous future flooding events OU5 sediments **will be** repeatedly deposited atop OU2 properties, remediated and unremediated alike. We ask EPA investigate the feasibility of setting OU5 PRGs that consider flood-borne contamination of OU2 properties.	Comment noted. The specific details of future sediment cleanup effort (including those topics mentioned in the comment) will be determined during the Feasibility Study.
5	General comment		There is substantial uncertainty in the protectiveness built into the model-derived PRG values. There are more contaminants present in sediment from Elm Creek, Tar Creek and Beaver Creek that may affect the potential toxicity of the sediments. Acid mine drainage and runoff (including from riparian and floodplains) could make metals in surface water and sediment more bioavailable. How it will EPA determine if sediment PRGs are suitably conservative to account for the multiplicative effects arising from exposure to multiple metals?	Among the various metals evaluated in the HHRA, lead, cadmium, and zinc are the only metals that were identified as the final COCs in sediment. Therefore, sediment cleanup effort will be focused on these three metals. During PRG development, it was assumed that cadmium and zinc are 100% bioavailable, and that lead was 60% bioavailable (EPA's default level). As indicated in Table 6-15 of the OU5 RI Report (CH2M, 2020), the average measured surface water pH concentrations in the six site watersheds ranged from 7.34 to 7.89; therefore, the surface water pH levels have an insignificant impact on bioavailability. Because the three sediment COCs (cadmium, lead, and zinc) have different health endpoints, they are assessed separately when calculating PRGs, consistent with EPA approaches.

Table 1b. Response to Comments Provided by L.E.A.D. Agency, Inc. on PRG Memo Version 1.2 dated June 9, 2021

Item	Section	Page	Comment	Response
6	Section 8	14	The ecological-based T10 PRGs are lower (more conservative) than most of the Human Health PRGs presented in the Technical Memorandum. It seems appropriate to conduct a literature-based evaluation of other sediment PRGs from comparable sites to assist EPA in selecting PRGs that are suitably conservative (protective). Please compare site-specific PRGs with PRGs from other sites with similar watershed characteristics and exposure concerns and provide to LEAD/Community.	Comment noted. However, the focus of this specific memo is human health risk-based PRGs. Further discussions of the site-specific human health-based and ecological-based PRGs and selection of the final PRGs will occur during the Feasibility Study.
7	Section 4	3	It is not clear if or how ∑PEC-Q could be used as one of the final PRGs. How will this PRG affect cleanup decisions and post-remedial levels of cadmium, lead and zinc in sediment. Please address flood scour in the erosion of a riverbed or riverbank by fast-flowing floodwater.	Please see response to Comment #4.
8	General comment		The presented ecological (T10) PRGs are several times greater than background levels for cadmium (16 times), lead (3 times) and zinc (4 times). The Technical Memorandum indicates that these ecological PRGs would also protect human health for cadmium and zinc. LEAD agrees with the Quapaw Nation that the sediment PRGs should be the same as background levels. Setting PRGs to be the same as background could be more protective. LEAD does not accept that time and funding should dictate cleanup levels where human & ecological health is at stake!	Comment noted. Further discussions of the PRGs will occur during the Feasibility Study.

Table 1c. Response to Comments Provided by Quapaw Nation on PRG Memo Version 1.2 dated June 13, 2021

Item	Section	Page	Comment	Response
1	General comment		After more than 40 years involvement in the TCSFS, more than 20 of which have been on behalf of the QTO, EPA finally concludes that, in order to be protective of the QTO and comply with QTO's ARARs, PRGs need to be set to pre-release baseline conditions (PRB, the condition prior to man-made contamination).[1,2] 1 The line of reasoning supporting this decision for superfund sites on Tribal lands is described in Attachments 1 and 2. 2 The amount of time and resources wasted on these sites is the subject of a current research paper.	Comment noted.
2	General comment		The HHRA supporting the determination that PRGs must be set to PRB, is flawed in several ways, but more importantly, the HHRA is not multi-pathway, is not multi-media, and is not multi-contaminant in nature. This concern was raised in comments on the workplan, way back in 2004, (see Attachment 3 and Attachment 4, for problems with the final HHRA). This realization results in all abiotic media (i.e. soil, sediment, surface water, ground water, and air) requiring PRGs being set to PRB.[3] 3 The document is silent on this issue.	The HHRA risk estimates address potential exposures to media within OU5 only; the RME exposure scenarios and assumptions for OU5 are based on input received from the QTO and TCTCIT. The risk estimates associated with terrestrial-based (rather than aquatic-based) exposures were presented in the HHRAs for OU2 (residential areas) and OU4 (chat piles, fine tailings and smelter waste). Further discussions and selection of the final PRGs will occur during the Feasibility Study.
3	General comment		The implications of the PRGs being set to PRB are immense with major consequences. More importantly, upstream sources of multi-media contaminants feeding the QTO reservation also need to meet PRB. This means that areas within Treece, KS may require a second cleanup. Such work will be costly and was clearly foreseeable (see Attachment No. 5).	Comment noted. Further discussions and selection of the final PRGs will occur during the Feasibility Study.
4	General comment		Since the PRB or BGTV's estimated by EPA are now the PRG, and since superfund risk is clearly associated with COCs in minor excess these levels[4], it is clear that error associated with the estimation of PRBs/BGTVs will result in detrimental human health affects to future users. This means that such errors have large human health implications. The QTO is on record voicing this concern and voicing the concern with EPA's estimation of these BTVs (See Attachment No. 6). 4 Many of the COC's exceed allowable daily intake concentrations.	The final PRGs have not yet been selected. Further discussions and selection of the final PRGs will occur during the Feasibility Study.

Table 1c. Response to Comments Provided by Quapaw Nation on PRG Memo Version 1.2 dated June 13, 2021

Item	Section	Page	Comment	Response
5	General comment		This document memorializes EPA use of the antiquated IEUBK risk model as well as antiquated methods of assessing risk5. 5 Single COC, associated with a single medium, following a single pathway. Clearly not a cumulative multi-pathway human health risk assessment, and clearly does not meet the requirements of CERCLA.	With the exception of GP Scenario 1, all IEUBK model runs for the PRGs were completed using the most recent IEUBK model available at the time (IEUBK Windows, Version 1.1, Build 11), with modifications to input parameter values reflecting the same changes that are incorporated in the new IEUBK model, Version 2.0 (released in May 2021). Due to changes in the dietary information in the IEUBK model, Version 2.0, the PRGs calculated for GP Scenario 1 using the "Alternate Dietary Values" approach were calculated using the IEUBK model, Version 2.0. The TLW PRGs incorporate multi-pathway and multi-media exposures for OU5.
6	General comment		OU5 is nearly entirely on QTO lands. This PRGs memo contains much unnecessary discussion on the general public--a population that does not and never will reside there. This is yet another example of a major waste of time and valuable resources.	Scenarios addressing general public receptors were included to address concerns from other project stakeholders.

Table 1d. Response to Comments Provided by ODEQ on PRG Memo Version 1.2 dated June 14, 2021

Item	Section	Page	Comment	Response
1	General Comment		The Technical Memorandum: Development of Human Health Risk-Based Preliminary Remedial Goals for Operable Unit 5 contains many of the parameters used within the Human Health Risk Assessment for the Tar Creek Superfund Site Operable Unit 5 (HHRA) that DEQ found concerning in the letter submitted September 2020 (attached). DEQ states, "DEQ fully supports integrating traditional tribal lifeways into this assessment and understands the value of modeling subsistence lifestyle parameters to best protect human health in Tar Creek. However, in many cases (i.e. sweat lodge scenario; potable water), there is little to no justification provided that would clarify why the model parameters have been used in this this way. Further, these two pathways in particular remain somewhat unjustified yet contribute more to the overall hazard index (HI) than many other pathways combined." While DEQ maintains that the Sweat Lodge Scenario parameters continue to overestimate the risk associated with this important tribal practice, the DEQ will no longer offer comment on the Tribal Lifeway (TLW) parameters. DEQ supports using tribal feedback to ensure achieving the greatest accuracy in quantifying those values and appreciates the effort that has gone into making those contributions. However, DEQ does not support using parameters for any General Public (GP) scenarios that assume residents of the Tar Creek area forgo all residential tap water resources and subsist solely on the untreated surface waters of the surrounding area. What is EPA's reasoning for continuing to use this parameter that is artificially inflating the risk when both DEQ and the Tar Creek Trustee Council Indian Tribes (TCTCIT) have both indicated this assumption is inaccurate? Please provide justification for using this parameter or discontinue use of this parameter in any GP scenarios.	It was assumed that OU5 surface water would be used as a source of drinking water because the designated beneficial use for some waterbodies (Neosho River, Spring River, and Lost Creek) within the OU5 watersheds is "Public and Private Water Supply", as indicated in Appendix B of "*Water Quality in Oklahoma 2020 Integrated Report*" (Oklahoma Department of Environmental Quality, 2020). http://www.deq.state.ok.us/wqdnew/305b_303d/. Please note that inclusion of a scenario in the PRG Memo does not imply that it will be used as the basis for the final PRGs during the Feasibility Study.
2	General Comment		Also from the September 2020 submittal, DEQ states "What is the justification for over-estimating the "small game" portion of the Tribal Lifeway diet by using 135% dietary intake? As the HHRA states, "This…overestimates intake from these aquatic food sources." While DEQ offers no further comment on the TLW subsistence parameters used, this methodology was used to model GP (Scenario 1) as well. DEQ does not support using additional dietary inputs combined with EPA default dietary intake parameters for any GP scenario. Doing so makes the assumption that individuals consume up to 130% of their dietary intake each day which in turn adds nearly double the potential contaminant consumption. EPA has yet to provide DEQ with any justification for this decision. Please provide justification for using this additive method or discontinue using additional dietary intake parameters in any GP scenarios.	The dietary lead exposure under GP Scenario 1 has been modified and is now assessed using the IEUBK model's "Alternate Dietary Values" option, where the site-specific exposure point concentration in fish fillet (0.100 mg/kg) and % composition of OU5 fish in the total meat intake (25%) were entered as input parameter values.

Table 1d. Response to Comments Provided by ODEQ on PRG Memo Version 1.2 dated June 14, 2021

Item	Section	Page	Comment	Response
3	General Comment		DEQ requests the addition of a time-weighted average (TWA) approach be included as one of the GP scenarios modeled and discussed within the main body of this TM. Why was GP (Scenario 4) omitted following discussion with TCTCIT then added back into the TM as an addendum? DEQ feels that a hybrid approach, possibly some version of the TWA approach, most closely resembles daily sediment exposure conditions most often encountered by the general public at the Site. DEQ looks forward to discussing this further with EPA so that we can contribute to the accuracy of parameters used to evaluate public use and inform any future decision documents.	The GP Scenario 4 has been moved into the main body of the PRG Memo. Also, GP Scenario 5 (GP Scenario 1 modified to use the TWA approach) has been added to the PRG Memo.
4	Section 4	4	Site-specific toxicity thresholds (SSTTs) corresponding to the T10 values calculated as part of the TM: Baseline Ecological Risk Assessment for Operable Unit 5 of the Tar Creek Superfund Site, Ottawa County, Oklahoma (DERA) were included and discussed at some length. What was EPA's reasoning for excluding any mention of the T20 values also calculated from this TM? DEQ requests that the T20 values remain an option for consideration moving forward during the development of the feasibility study to ensure robust, meaningful discussion surrounding potential remedial goals for this operable unit.	As suggested, the T20 values have been included in the PRG Memo.
5	Section 4	4	DEQ previously asked for clarification concerning the derivation of the Σ PEC-Q value referenced from the DERA. Using Section 2.2.2 from the Remedial Investigation Report as well as the citation referenced, DEQ arrives at an index of 7.9 not 6.47. Can EPA provide clarification concerning how the Σ PEC-Q value was calculated? So far, DEQ cannot reproduce the results of this calculation. Please provide the calculation EPA used to derive the Σ PEC-Q value 6.47.	There was a typographic error in Appendix H of the OU5 RI Report (CH2M, 2020). The T10 value of 6.47 was from ecological Scenario 1 and was used in the Advanced SLERA to classify risk. However, the 7.92 (T10) and 11.29 (T20) values in Appendix H were from ecological Scenario 3. The correct values (for ecological Scenario 1) that are now referenced in the PRG Memo are 6.47 (T10) and 10.04 (T20).
6	Section 6	6	6.6.1 "…that is, assumed daily exposure to OU5 sediment and surface water without considering receptors' exposure frequency and time at OU5…" DEQ does not support this approach as it does not accurately represent the realistic time and frequency parameters that reflect how the public may come into contact with OU5 surface water and sediment. PRGs calculated for any GP scenarios should include accurately quantified, site-specific parameters that consider exposure time and frequency.	The GP scenarios in the PRG Memo have been updated; the two GP scenarios using the TWA approach (GP Scenarios 4 and 5) use a more representative exposure frequency (1 day/week) and exposure time (3 hours/day) for GP receptor exposures at OU5.

Table 1d. Response to Comments Provided by ODEQ on PRG Memo Version 1.2 dated June 14, 2021

Item	Section	Page	Comment	Response
7	Section 6	8	6.6.1 Given the known limitations of using the IEUBK default input values for modeling complex aquatic systems, considerable effort was taken collecting site-specific OU5 data to inform (and replace, if needed) each of the IEUBK defaults in favor of more accurate input parameters. What was the justification for running GP (Scenario 3) with almost all IEUBK default input values? If only four scenarios were included in the main TM for consideration, DEQ suggests eliminating this scenario in favor of using one with more site-specific parameters.	The PRGs calculated for GP Scenario 3 are used as the basis for GP Scenario 4, where GP Scenario 4 adds the use of TWA (site-specific exposure frequency and exposure time). Therefore, GP Scenario 3 was retained in the memo. Please note that inclusion of a scenario in the PRG Memo does not imply that it will be used as the basis for the final PRGs during the Feasibility Study.
8	Section 6	8	6.6.1 "In addition to the IEUBK's default dietary intake, additional lead intake through OU5 fish consumption is calculated…" As mentioned above, DEQ does not support modeling any GP scenarios with IEUBK defaults plus additional dietary input values. The IEUBK software allows a great deal of user flexibility for modeling alternate dietary inputs when they represent more accurate, site-specific parameters. The software even provides an input for the inclusion of game animals (e.g. fish) as well as an additional input parameter that estimates the proportion of fish eaten when compared to other protein sources in a daily diet. Why was it necessary to introduce additional risk parameters instead of simply substituting site-specific parameters in place of IEUBK defaults? Please provide justification for overestimating dietary intake (resulting in additional risk) for GP scenarios or adjust input values so that OU5 fish intake is substituted for other dietary protein sources.	Please see responses to Comments 2 and 3.

Attachment 4C
Stakeholder Meeting Presentation

Tar Creek OU-5 Preliminary Remediation Goal Tech Memo (Ver. 1.2) Responses to ODEQ Comments

July 28, 2021

Comments included on cover letter

- Many substantive comments provided previously are unresolved.
- Want to provide input to parameters driving risk-based scenarios.
- Want to be more actively included in all aspects of PRG process.

General comments (bullet 1)

Comments

- Use tribal feedback for TLW parameters.
- Don't assume GP uses OU5 untreated surface water as DW.

EPA Response

- GP Scenario 2 is the only GP scenario with OU5 surface water as DW.
- OK WQS indicate use as DW source.
- Inclusion doesn't indicate selection.

Acronyms:

DW – drinking water, GP – general public, TLW – tribal lifeway

General comment (bullet 2) & Specific comment Section 6.6.1 (bullet 3)

Comment

- Don’t use additional dietary inputs combined with EPA default dietary intake parameters for GP scenarios. Justify or delete.

EPA Response

- GP Scenario 1 will be updated using the alternate dietary intake approach to avoid double counting fish.
- Site-specific concentration and proportion of OU5 fish eaten (in comparison to total meat consumption in a daily diet) will be used as input values.

Acronyms:

GP – general public, IEUBK – Integrated Exposure Uptake Biokinetic

General comment (bullet 3)

Comments

- Add GP scenario TWA approach in main body of the TM.
- A hybrid approach (or a version of TWA approach) better represents sediment exposure by GP.

EPA Responses

- The GP scenario TWA will be added to the TM.

Acronyms:

GP – general public, PRG – preliminary remediation goal, TM – technical memorandum, TWA – time-weighted average

Specific comment – Section 4.0 (bullet 1)

Comment	EPA Response
• Why were SSTT T_{20} values excluded as PRGs? • Retain T_{20} values as an option.	• T_{20} values will be included and discussed as an option.

Acronyms:

PRG – preliminary remediation goal, SSTT – site-specific toxicity threshold, T_{20} – 20% reduction in survival or biomass compared to reference envelope limits

Specific comment – Section 4.0 (bullet 2)

Comments	EPA Responses
• Clarify how ∑PEC-Q value calculated.	• Advanced SLERA prepared by McDonald et al. • ∑PEC-Q scenarios based on various deviations from range of reference stations (e.g., 10% reduction from median response). • Scenario 3 chosen by agency as final ∑PEC-Q. • ∑PEC-Q is like a HHRA hazard index (sum of hazard quotients (HQ); HQ = conc. / toxicity) • ∑PEC-Q mentioned by ODEQ based on Scenario 2 rather than Scenario 3.

Acronyms:

∑PEC-Q - Probable effects concentration quotient, SLERA – screening level ecological risk assessment

Specific comment – Section 6.6.1 (bullet 1)

Comment

- Don’t assume daily exposure to OU5 sediment and surface water without considering receptors’ exposure time and frequency at OU5.

EPA Response

- GP Scenario 5 will be created to address this point.

Specific comment – Section 6.1.1 (bullet 2)

Comment

- Replace GP Scenario 3 (all IEUBK Model default values) with a scenario using more site-specific parameters.

EPA Response

- GP Scenario 3 will be retained.
- Inclusion doesn't indicate selection.

Acronyms:

GP – general public, IEUBK – Integrated Exposure Uptake Biokinetic

Final GP Scenarios for Lead PRGs

- **GP Scenario 1** - All IEUBK default values. OU5 SW not used as DW source. Dietary lead intake using alternate dietary lead intake approach for OU5 fish consumption.
- **GP Scenario 2** - GP exposure factors from the HHRA. All IEUBK default values except SW EPC. OU5 SW used as DW source.
- **GP Scenario 3** - All IEUBK default values. OU5 SW not used as DW source.
- **GP Scenario 4** – All IEUBK default values GP Scenario 3 evaluated using TWA sediment/soil approach (1 day/week and 1 hour/day at OU5, the rest of time at residential yards).
- **GP Scenario 5** - All IEUBK default values GP Scenario 1 evaluated using TWA sediment/soil approach (1 day/week and 1 hour/day at OU5, the rest of time at residential yards) and alternate dietary lead intake approach for OU5 fish consumption.

Scenario	IEUBK Exposure Factors	OU5 SW as DW	OU5 SW direct contact	OU5 Aquatic Biota as Food
GP Scenario 1	Default	no	no	yes - fish only (adjusted)
GP Scenario 2	Same as HHRA	yes	no	no
GP Scenario 3	Default	no	no	no
GP Scenario 4	Default except TWA sed/soil approach	no	no	no
GP Scenario 5	Default except TWA sed/soil approach	no	no	Yes – fish only (adjusted)

DW – drinking water, GP – general public, SW – surface water, TWA – time-weighted average

Tri-State Watershed Preliminary Remediation Goal Memorandum

June 30, 2021

Agenda

- History of PRG development
- Overview of PRG memo content
- PRG scenarios included
- PRGs calculated for each scenario

History of PRG development with stakeholders

20 Nov. 2020
EPA's TRW Lead Committee provided input on lead PRG approaches

29 Jan. 2021
EPA sent Draft PRG Memo v1.1 to stakeholders

23 Feb. 2021
Meeting led by EPA to present Draft PRG Memo v1.1

12 Mar. 2021
TCTCIT/Abt provided initial written feedback

Mar. 2021 and Apr. 2021
Technical meetings to discuss scenarios & assumptions
- March 25 – Meeting led by TCTCIT/Abt
- April 8 – Meeting led by TCTCIT/Abt
- April 16 – Meeting led by EPA & TCTCIT/Abt
- April 28 – Meeting led by EPA & TCTCIT/Abt

Apr. 2021 and May 2021
meetings with EPA's TRW Lead Committee

10 June 2021
EPA sent PRG TM v1.2 to stakeholders

24 June 2021
EPA sent addendum (GP Scenario 4) to stakeholders

Major differences -draft (v.1.1) vs. final (v.1.2) sediment PRGs

Topic	Draft (v1.1)	Final (v1.2)
TLW scenarios for lead	3 scenarios (HHRA; TWA for 5 days/week at OU5; TWA for older child [36-72 months] at OU5 for 5 days/week)	1 scenario (HHRA)
TLW scenarios for lead in food	IEUBK default food ingestion rates	IEUBK default food ingestion rates + additional intake from OU5 aquatic food
GP scenarios for lead	2 scenarios (HHRA; TWA for 1 day/week at OU5)	4 scenarios • HHRA • HHRA plus OU5 fish but no SW as DW • HHRA but no SW as DW • TWA for 1 day/week at OU5*
TLW scenarios for cadmium & zinc in aquatic plants	2 scenarios (25% FI from OU5; 100% FI from OU5)	1 scenario (100% FI from OU5)

***Addendum released on 6/24**

Acronyms:
DW – drinking water
FI – fraction ingested
GP – general public
HHRA – human health risk assessment
IEUBK – Integrated Exposure Uptake Biokinetic
PRG – preliminary remediation goal
SW – surface water
TLW – tribal lifeway
TWA – time-weighted average

Overview of PRG memo content

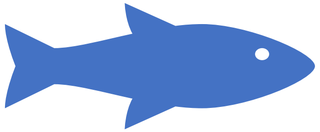
- Site background – history, watersheds
- Preliminary RAOs – human and ecological
- Basis for PRGs – human and ecological target levels
- Summary of ecological PRGs – from the BERA
- Summary of HHRA – receptors, media, final COCs
- Human health risk-based PRG development approach
  - Lead – methodology & receptors
  - Cd & Zn – methodology for direct contact & aquatic food consumption
- Uncertainties
  - Lead – exposure assumptions
  - Protectiveness of sediment PRGs for other exposures (surface water & biota)
- Findings – exposure assumptions driving the PRGs, comparison to ecological PRGs

Preliminary RAOs

Human health - in RI report

Minimize/prevent exposures from contact with metals in sediment/SW posing unacceptable risk

Minimize/prevent exposures to metals in OU5 aquatic biota posing unacceptable risk



Ecological – in SLERA

Aquatic receptors: Minimize/prevent exposure to sediments and/or pore water posing moderate or high risks to microbial, aquatic plant, benthic invertebrate, or fish communities (particularly fish species using sediment for spawning).

Aquatic-dependent wildlife: Minimize risks to sediment-probing birds or omnivorous mammals associated with sediment ingestion during feeding activities.

Basis for Sediment PRGs

- Human health RBCs
  - Lead – target BLLs of 5, 8, and 10 µg/dL
  - Cd and Zn – noncancer hazard index of 1
  - No carcinogenic target risk
- Ecological RBCs
  - Site-specific toxicity threshold; 10% reduction in survival or biomass compared to reference limits (T10)
- Chemical-specific ARARs (not available for sediment)
- Background concentrations

Acronyms:
ARAR – applicable or relevant and appropriate
BLL – blood lead level
Cd – cadmium
RBC – risk-based concentration
Zn – zinc

Summary of ecological PRGs

BERA focused on risks to benthic invertebrate community

Sediment chemistry used as primary line of evidence for risk

Basis = RBCs associated with low and moderate risk

T10 – concentration of each COPC or COPC mixture corresponding to 10% reduction in survival or biomass compared to reference area

- Cadmium – 11.1 mg/kg dw
- Lead – 150 mg/kg dw
- Zinc – 2,083 mg/kg dw
- $\sum PEC\text{-}Q_{Cd,\ Pb,\ Zn}$ – <6.47

Acronyms:
BERA – baseline ecological risk assessment
DW – dry weight
RBC – risk-based concentration
$\sum PEC\text{-}Q_{Cd,\ Pb,\ Zn}$ – probable effect concentration quotient for the mixture of cadmium, lead, and zinc

Summary of HHRA - sediment & surface water scenarios

Exposure Medium	Exposure Scenario/Receptor Population	
	Tribal Lifeway	**General Public**
Sediment	Hunting/fishing/gathering and recreational activities • Incidental ingestion • Dermal contact	Recreational activities • Incidental ingestion • Dermal contact
Surface Water	Hunting/fishing/gathering and recreational activities • Incidental ingestion • Dermal contact Potable source • Ingestion • Dermal contact Sweat lodge use • Ingestion • Dermal contact • Inhalation (water vapor)	Recreational activities • Ingestion • Dermal contact Potable source • Ingestion • Dermal contact
Mine Discharge	Hunting/fishing/gathering and recreational activities • Dermal contact	Recreational activities • Dermal contact

Summary of HHRA – other media scenarios

Exposure Medium	Exposure Scenario/Receptor Population	
	Tribal Lifeway	General Public
Fish Tissue (Estimated whole fish concentrations)	• Aquatic food consumption	
Fish Tissue (Game Fish Fillet)		Recreational Fishing • Fish consumption
Shellfish Tissue (Mussel and Asian Clam)	• Aquatic food consumption	
Aquatic Plant as Food (Arrowhead and Duckweed)	• Aquatic food consumption	
Aquatic Plant as Salve (Arrowhead)	• Dermal contact (medicinal use)	
Amphibian/Aquatic Reptile Tissue (Frog Legs)	• Aquatic food consumption	
Semi-Aquatic Mammal Tissue (Raccoon)	• Aquatic food consumption	

Final COCs from HHRA

Final COCs	Sitewide (Biota Only)	Elm Creek	Tar Creek	Neosho River	Beaver Creek	Lost Creek	Lower Spring River
Sediment							
Cadmium		TL	TL, AW		TL		
Lead		TL, AW, GP	TL, AW, GP		TL, GP		TL, GP
Zinc		TL	TL		TL		
Surface Water							
Antimony		TL					
Arsenic			TL, AW, GP				
Barium				TL			
Cadmium		TL, AW, GP	TL, GP		TL		
Cobalt			TL, AW, GP		TL		
Iron			TL, GP	TL			
Lead[a]		TL, GP	TL, GP		TL, GP		
Manganese			TL, AW, GP				
Nickel		TL	TL, AW		TL		
Zinc		TL	TL				
Biota							
Barium	TL						
Cadmium	TL						
Copper	TL						
Lead	TL, GP						
Nickel	TL						
Silver	TL						
Zinc	TL						

Acronyms:
AW – aquatic worker
GP – general public
TL – tribal lifeway

Scenarios for Lead PRGs

The following exposure scenarios are incorporated into the PRGs for lead:

- **Traditional Tribal Lifeway** - TLW exposure factors from the HHRA + IEUBK default dietary intake.
- **GP Scenario 1** - All IEUBK default values. OU5 SW not used as DW source. IEUBK default dietary lead intake plus additional lead intake through OU5 fish consumption.
- **GP Scenario 2** - GP exposure factors from the HHRA. All IEUBK default values except SW EPC. OU5 SW used as DW source.
- **GP Scenario 3** - All IEUBK default values. OU5 SW not used as DW source.
- **GP Scenario 4** – GP Scenario 3 evaluated using TWA sediment/soil approach (1 day/week at OU5, 6 days/week at residential yards).

Scenario	IEUBK Exposure Factors	OU5 SW as DW	OU5 Aquatic Biota as Food
Traditional Tribal Lifeway	Same as HHRA + IEUBK default dietary lead intake	yes	Yes
GP Scenario 1	Default	no	yes - fish only
GP Scenario 2	Same as HHRA	yes	no
GP Scenario 3	Default	no	no
GP Scenario 4	Default except TWA sediment/soil approach	no	no

Acronyms:
DW – drinking water
EPC – exposure point concentration
GP – general public
SW – surface water
TLW – tribal lifeway
TWA – time-weighted average

TLW Scenario - lead PRGs

Scenario Description	Sediment IR (mg/d)	Surface Water IR (L/d)	Surface Water Lead EPC (µg/L)	Surface Water EPC Basis	Dietary Food Categories	Dietary IR	Dietary EPC Basis
TLW using EFs from HHRA	400	0.78	2.35	Fourmile Creek[1]	IEUBK default + OU5 Aquatic Food	Default + TLW	Default + Fourmile Creek[1]

BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
n/v	n/v	23 mg/kg

Note:
[1] The PRGs are calculated entering background surface water EPCs and dietary lead intake calculated based on background biota EPCs and TLW RME ingestion rates. Sediment concentration (EPC = 27 mg/kg) is close to estimated PRG (23 mg/kg).

Acronyms:
BLL – blood lead level
EF – exposure factor
EPC – exposure point concentration
HHRA – human health risk assessment
IR – ingestion rate
n/v – no sediment PRG value can be calculated using the IEUBK model because of the elevated lead intake through exposure to media other than sediment
RME – reasonable maximum exposure
TLW – tribal lifeway

Units:
L/d – liters per day
mg/d – milligrams per day
µg/dL – micrograms per deciliter
µg/L – micrograms per liter

GP Scenario 1 - lead PRGs

Scenario Description	Sediment	Surface Water			Dietary		
	IR (mg/d)	IR (L/d)	Lead EPC (µg/L)	EPC Basis	Food Categories	IR	EPC Basis
GP using IEUBK default EFs + OU5 fish ingestion	default	default	default	default	IEUBK default + OU5 fish fillet	Default + fish IR	default + avg sitewide fish fillet

BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
137 mg/kg	377 mg/kg	546 mg/kg

Acronyms:
BLL – blood lead level
EF – exposure factor
EPC – exposure point concentration
GP – general public
IR – ingestion rate
OU5 – Operable Unit 5

Units:
L/d – liters per day
mg/d – milligrams per day
µg/dL – micrograms per deciliter
µg/L – micrograms per liter

GP Scenario 2 - lead PRGs

	Sediment	Surface Water			Dietary		
Scenario Description	IR (mg/d)	IR (L/d)	Lead EPC (µg/L)	EPC Basis	Food Categories	IR	EPC Basis
GP using EFs from HHRA (including OU5 SW as DW)	default	default	2.7	Lost Creek[1]	default	default	default

BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
173 mg/kg	413 mg/kg	583 mg/kg

Note:
[1] Representative watershed for SW since sediment EPC (168 mg/kg) is close to estimated PRG (173 mg/kg) based on BLL of 5 µg/dL.

Acronyms:
BLL – blood lead level
DW – drinking water
EF – exposure factor
EPC – exposure point concentration
GP – general public
HHRA – human health risk assessment
IR – ingestion rate
OU5 – Operable Unit 5
SW – surface water

Units:
L/d – liters per day
mg/d – milligrams per day
µg/dL – micrograms per deciliter
µg/L – micrograms per liter

GP Scenario 3 - lead PRGs

Scenario Description	Sediment	Surface Water			Dietary		
	IR (mg/d)	IR (L/d)	Lead EPC (µg/L)	EPC Basis	Food Categories	IR	EPC Basis
GP using IEUBK default EFs (no OU5 SW as DW)	default	default	default	default	default	default	default

BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
199 mg/kg	439 mg/kg	609 mg/kg

Acronyms:
BLL – blood lead level
DW – drinking water
EF – exposure factor
EPC – exposure point concentration
GP – general public
IR – ingestion rate
OU5 – Operable Unit 5
SW – surface water

Units:
L/d – liters per day
mg/d – milligrams per day
µg/L – micrograms per liter

GP Scenario 4 - lead PRGs

	Sediment		Soil			Surface Water			Dietary		
Scenario Description	**IR (mg/d)**	**EF (d/wk)**	**IR (mg/d)**	**EF (d/wk)**	**Lead EPC (mg/kg)**	**IR (L/d)**	**Lead EPC (µg/L)**	**EPC Basis**	**Food Categories**	**IR**	**EPC Basis**
GP Scenario 3 with TWA approach	default	1	default	6	151	default	default	default	default	default	default

BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
487 mg/kg	2,167 mg/kg	3,357 mg/kg

Acronyms:
BLL – blood lead level
DW – drinking water
EF – exposure frequency
EPC – exposure point concentration
GP – general public
IR – ingestion rate
OU5 – Operable Unit 5
SW – surface water
TWA – time-weighted average

Units:
d/wk – days per week
L/d – liters per day
mg/d – milligrams per day
µg/L – micrograms per liter

Scenarios for cadmium/zinc PRGs

Exposure scenarios incorporated into PRGs for cadmium & zinc:

- **Traditional Tribal Lifeway** – (Cd & Zn) Using TLW exposure factors from the HHRA. Contact with sediment and ingestion of aquatic plants as food.
- **Aquatic Worker** – (Cd only) Using exposure factors from the HHRA. Contact with sediment.

Cadmium & Zinc PRGs

Scenario	Exposure Factors	Exposure Media Included	OU5 Aquatic Biota as Food
Traditional Tribal Lifeway	Same as HHRA	Sediment, aquatic plants	Yes – plants only
Aquatic Worker	Same as HHRA	Sediment	No

TLW Scenario – cadmium & zinc PRGs

Scenario Description	Sediment			Dietary		
	IR (mg/d)	EF (d/yr)	ED (yr)	Food Categories	IR	EF (d/yr)
TLW using exposure factors from HHRA	400	312	6	TLW Aquatic Plants	TLW	365

Cadmium	Zinc
13.2 mg/kg	2,095 mg/kg

Acronyms:
ED – exposure duration
EF – exposure frequency
IR – ingestion rate
TLW – tribal lifeway

Units:
d/yr – days per year
mg/d – milligrams per day
yr - year

Aquatic Worker Scenario – cadmium PRG

Scenario Description	Sediment			Dietary		
	IR (mg/d)	EF (d/yr)	ED (yr)	Food Categories	IR	EF (d/yr)
Aquatic worker using exposure factors from HHRA	400	250	25	-	-	-

Cadmium
214 mg/kg

Note: Zinc is not a sediment COC for this receptor.

Acronyms:
ED – exposure duration
EF – exposure frequency
IR – ingestion rate

Units:
d/yr – days per year
mg/d – milligrams per day
yr - year

Lead PRG comparison – all scenarios

Scenario	Description	Sediment PRGs (mg/kg)		
		BLL = 5 µg/dL	BLL = 8 µg/dL	BLL = 10 µg/dL
TLW Scenario	TLW using EFs from HHRA	n/v	n/v	23
GP Scenario 1	GP using IEUBK default EFs + OU5 fish ingestion	137	377	546
GP Scenario 2	GP using EFs from HHRA (including OU5 SW as DW)	173	413	583
GP Scenario 3	GP using IEUBK default EFs (no OU5 SW as DW)	199	439	609
GP Scenario 4	GP using IEUBK default values (no OU5 SW as DW) with TWA approach	487	2,167	3,357
ERA (T10 SSTT)	Site-specific toxicity threshold; 10% reduction in survival or biomass compared to reference limits	150		
Background	Background 95/95 Upper Tolerance Limit	58		

n/v – no sediment PRG value can be calculated using the IEUBK model because of the elevated lead intake through exposure to media other than sediment

Cadmium/zinc PRG comparison – all scenarios

Scenario	Description	Sediment PRGs (mg/kg)	
		Cadmium	Zinc
TLW Scenario	TLW using exposure factors from HHRA	13.2	2,095
Aquatic Worker Scenario	Aquatic worker using exposure factors from HHRA	214	-
ERA (T10 SSTT)	Site-specific toxicity threshold; 10% reduction in survival or biomass compared to reference limits	11.1	2,083
Background	Background 95/95 Upper Tolerance Limit	0.7	534

Note: Cadmium & zinc are not sediment COCs for GP receptors.

Thank you

Questions?

Tar Creek OU-5 Preliminary Remediation Goal Tech Memo Revisions

April 28, 2021

Approach for this meeting

- Used Abt slides from 3/25/2021 and 4/8/2021 & verbal comments from 4/16/2021 call as basis for discussion
- Grouped remaining TCTCIT comments by general topic
- Providing EPA approach to revised PRG Tech Memo

Topic - How Tribal Lifeways are Described

(slide 7 from 3/25/2021 ABT presentation)

Traditional Tribal Lifeway activities have not been accurately captured in the selected PRGs

EPA Response

Refocusing on scenarios consistent with the HHRA.

Eliminating complicated scenarios.

- Time-weighted averaging of sediments/soil.
- Mixing GP ingestion rates with TLW scenarios.
- Other varied assumptions (% consumption rates).

Providing transparency on exposure scenarios included.

EPA Response – Scenarios for Lead PRGs

The following exposure scenarios are incorporated into the PRGs for lead:

- **Traditional Tribal Lifeway** - Using TLW exposure factors from the HHRA.
- **General Public (Scenario 1)** - All IEUBK default values. OU5 SW not used as drinking water. In addition to the IEUBK's default dietary lead intake, additional lead intake through GP OU5 fish consumption is added.
- **General Public (Scenario 2)** - Using GP exposure factors from the HHRA. OU5 SW used as drinking water.
- **General Public (Scenario 3)** - All IEUBK default values. OU5 SW not used as drinking water.

Lead PRGs

Scenario	IEUBK Exposure Factors	OU5 SW as DW	OU5 Aquatic Biota as Food
Traditional Tribal Lifeway	Same as HHRA	yes	Yes
GP Scenario 1	Default	no	Yes - fish only
GP Scenario 2	Same as HHRA	yes	no
GP Scenario 3	Default	no	no

EPA Response Cont. - Updated Lead PRG Scenarios

Scenario	Description	Sediment	Surface Water			Dietary		
		IR (mg/d)	IR (L/d)	Lead EPC (µg/L)	EPC Basis	Food Categories	IR	EPC Basis
TLW	**TLW using EFs from HHRA**	400	0.78	2.35	Fourmile Creek[1]	TLW Aquatic Food	TLW	Fourmile Creek[1]
GP (Scenario 1)	**GP using IEUBK default EFs + OU5 fish ingestion**	default	default	default	default	default + OU5 fish fillet	default	default + avg sitewide fish fillet
GP (Scenario 2)	**GP using EFs from HHRA (including OU5 SW as DW)**	default	default	2.7	Lost Creek[2]	default	default	default
GP (Scenario 3)	**GP using IEUBK default EFs (no OU5 SW as DW)**	default	default	default	default	default	default	default

Notes:

[1] The PRGs are calculated entering background surface water EPCs and dietary lead intake calculated based on background biota EPCs and TLW RME ingestion rates.

[2] Representative watershed for SW since sediment EPC (168 mg/kg) is close to estimated PRG (173 mg/kg) based on BLL of 5 µg/dL.

Acronyms:

BLL – blood lead level
EF – exposure factor
EPC – exposure point concentration
GP – general public
IR – ingestion rate
OU5 – Operable Unit 5
RME – reasonable maximum exposure
SW – surface water
TLW – tribal lifeway

Units:

L/d – liters per day
mg/d – milligrams per day
µg/L – micrograms per liter

Cadmium and Zinc PRG Development

(slide 23 from 4/8/2021 ABT presentation & verbal comment from 4/16/2021 EPA presentation)

For cadmium and zinc PRGs, only dietary intake from aquatic plants is considered. All biota should be included to get total risk.

For watersheds with lower sediment concentrations, non-plant biota contributes a higher percentage to cadmium & zinc risk than aquatic plants, so non-plant biota should be included in the PRGs for Cd/Zn.

EPA Response

The TLW scenario includes aquatic plant dietary consumption.

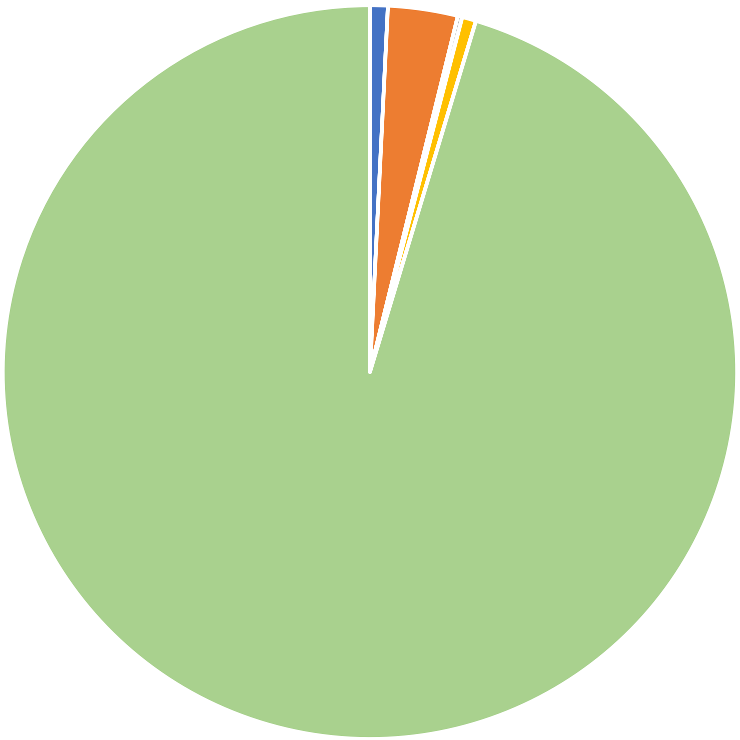
Remediation will address the exposure pathway driving risk.

- Aquatic plants are 95% of risk from diet.
- Sediment remediation addressing aquatic plants addresses risk from other food items.

EPA Response – lower conc. watershed example

- Neosho River – less contaminated watershed with lower EPCs; samples collected for all 5 food categories
- HQs for non-plant food similar between 2 datasets despite large differences in sediment concentrations
- Supports targeting aquatic plants for incorporating into PRGs.

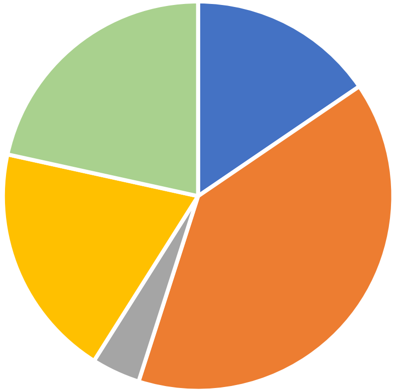
Sitewide Total Aquatic Dietary HQs



Data from HHRA Table 6-15 "Summary of Receptor Hazards for Final COCs - Tribal Lifeway Child".

% contribution of each food category to the total aquatic dietary HQ.

Neosho River Total Aquatic Dietary HQs



Data from HHRA Appendix F5, Table 2 "Summary of Watershed-specific Receptor Hazards for Biota Consumption COCs (Child)".

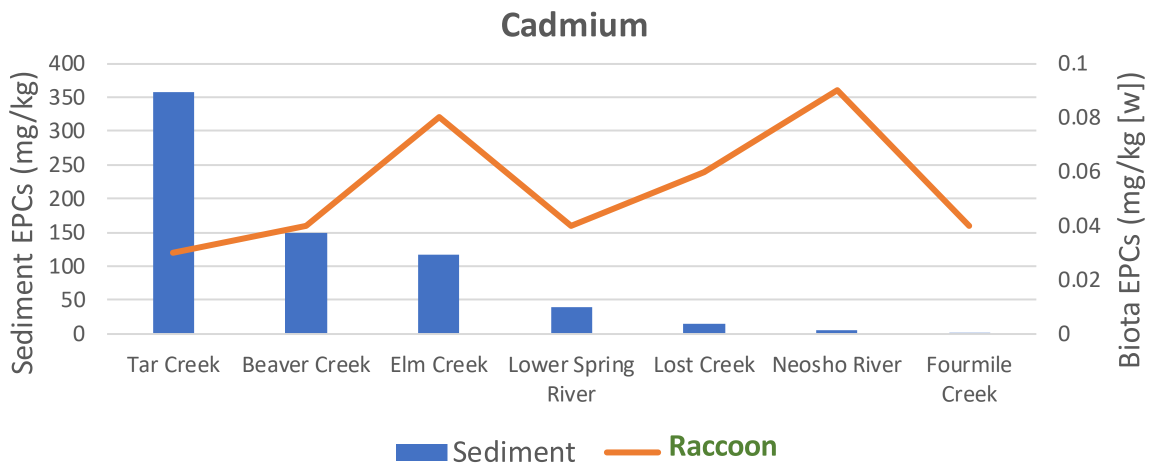
% contribution of each food category to the total aquatic dietary HQ.

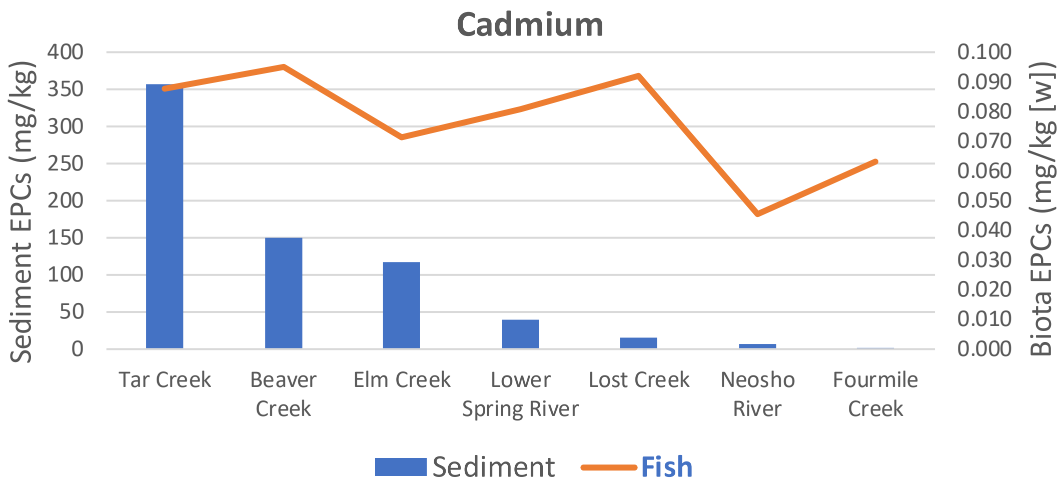
	Sitewide Data		**Neosho River**	
Biota	**HQ**	**%**	**HQ**	**%**
Fish	0.7	0.8%	0.6	15%
Shellfish	3	3.1%	2	39%
Amphibian/Aquatic Reptiles	0.2	0.2%	0.2	4%
Semi-Aquatic Mammals	0.6	0.6%	0.8	19%
Aquatic Plants	91	95%	0.9	22%
Total	**95**	**100%**	**4**	**100%**

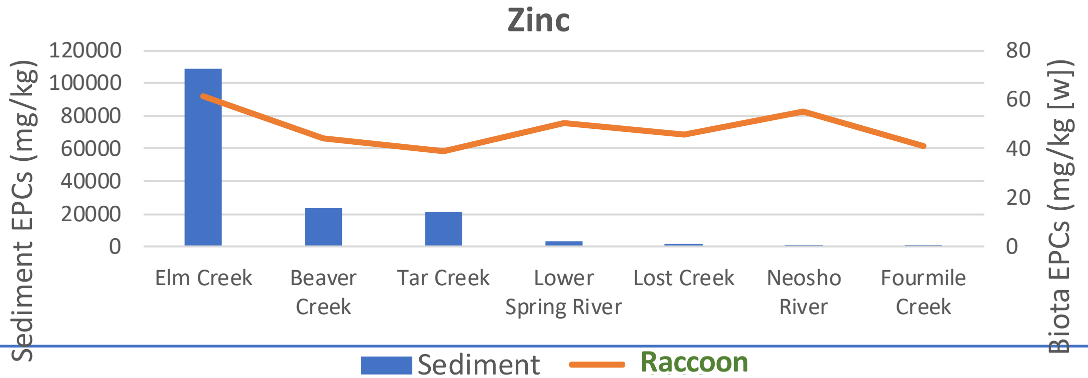
Take-home message: plant contribution to risk is more highly affected by sediment concentration than non-plant biota.

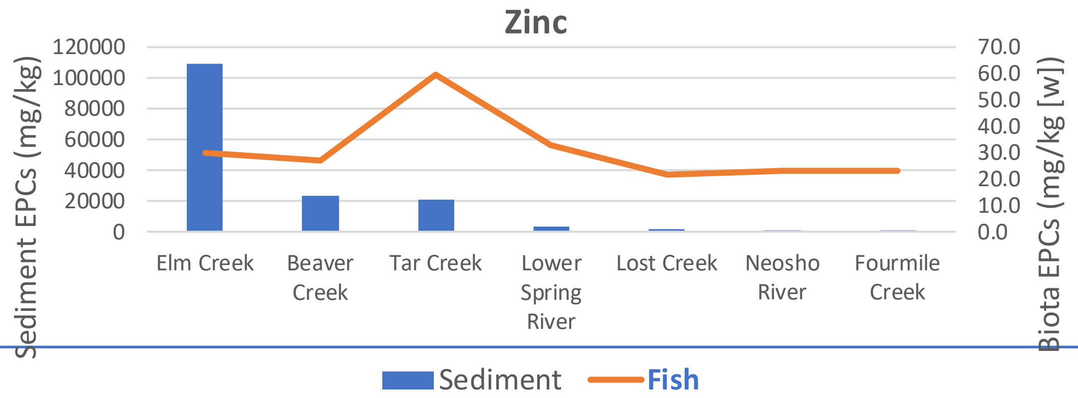
EPA Response – mobile biota example

- Limited data intended for correlation study (e.g., sediment/aquatic plants)
- Lack of apparent correlation between sediment & biota (e.g., fish & raccoon)
- Relationship between sediment and biota is complex (e.g., due to size, home range, species, food source).
- Supports targeting aquatic plants for incorporating into PRGs.



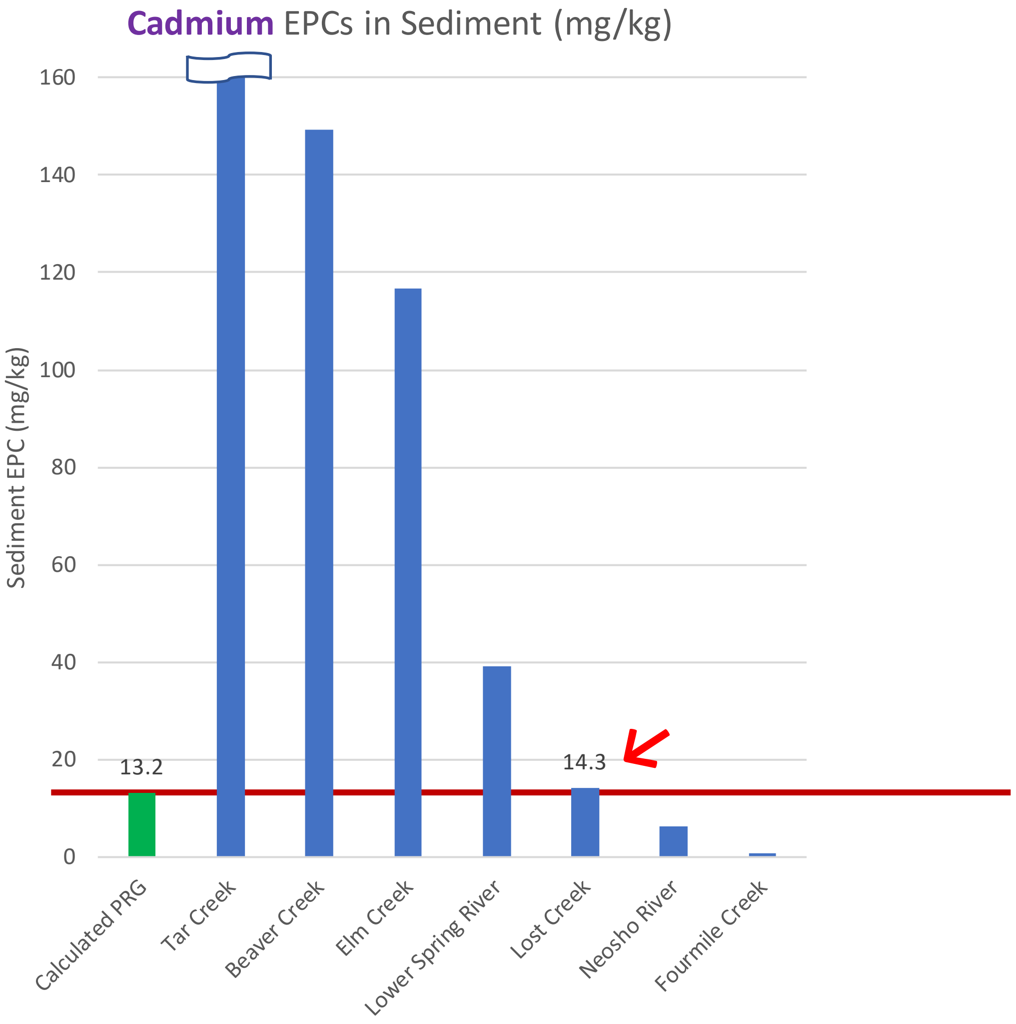


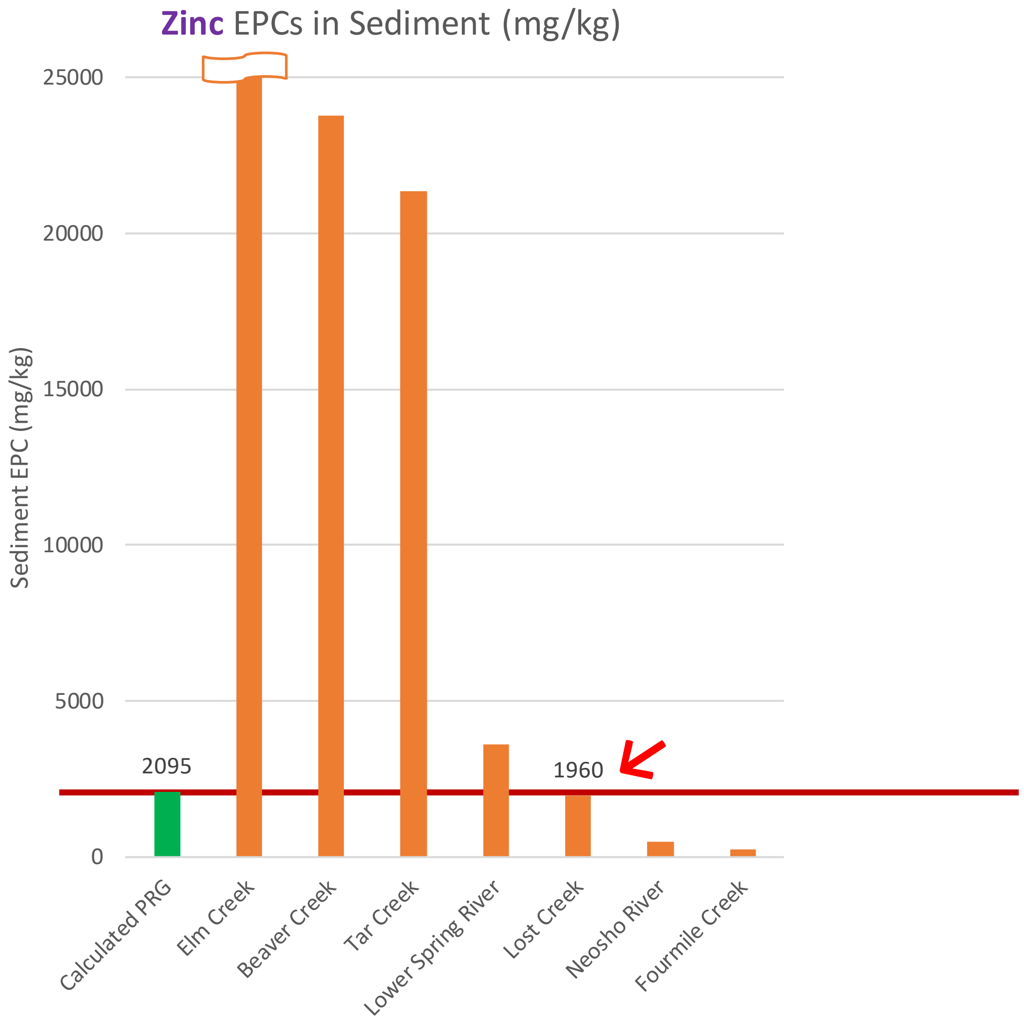




Take-home message: Correlation between non-plant biota & sediment is complex due to mobility, food sources, etc.

EPA Response – watershed EPCs compared to TLW PRGs

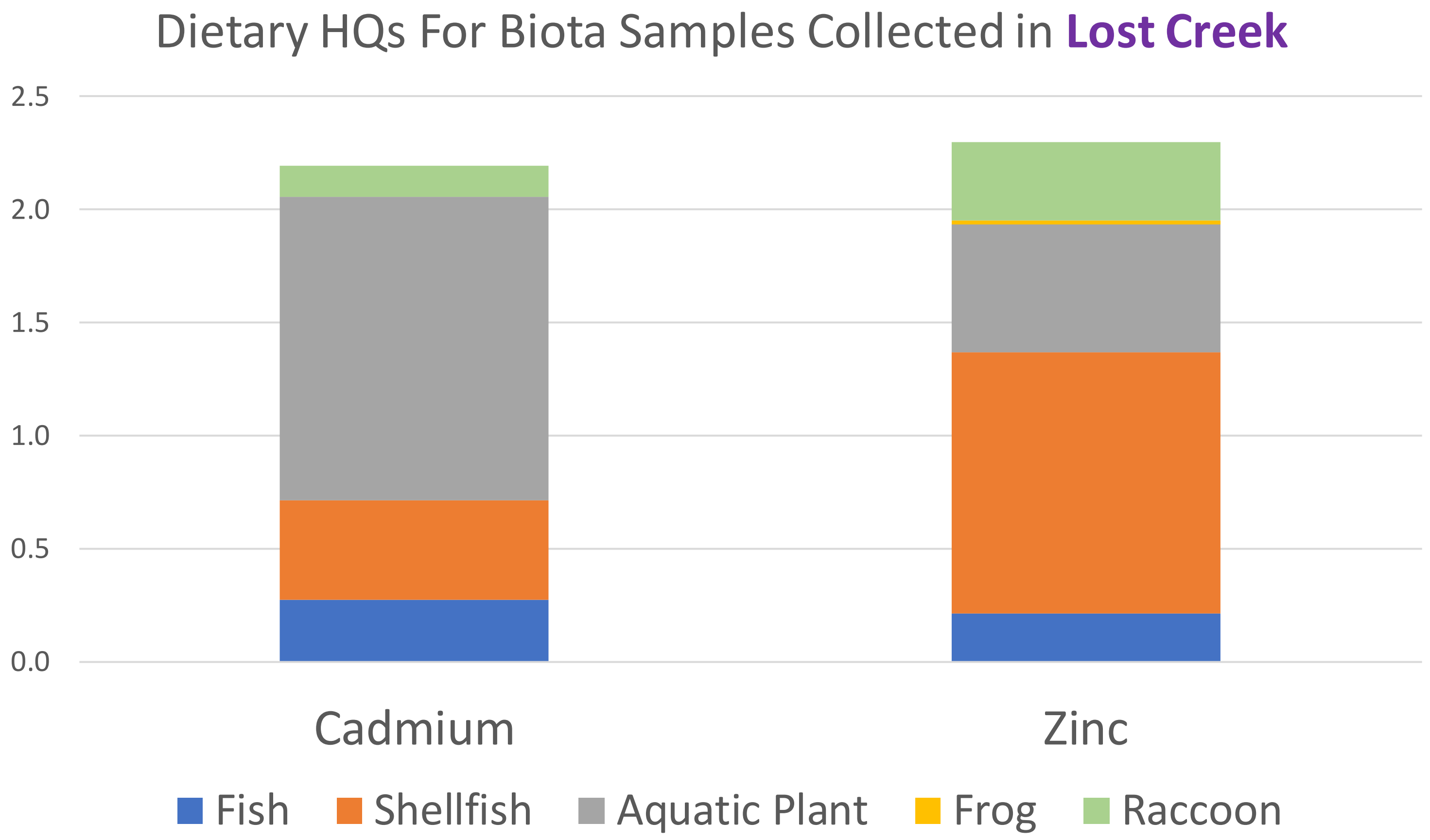




Take-home message: EPCs in Lost Creek are similar to TLW PRGs & provide insight on non-plant biota impact on PRG value.

EPA Response – non-plant biota impact on PRG example

- Lost Creek sediment EPCs similar to TLW PRGs for cadmium & zinc.
- Lost Creek Total HI ~2 for dietary consumption (~1 for non-plant aquatic food).



Lost Creek HQs

Aquatic Food	Cadmium HQ	Zinc HQ
Fish *	0.3	0.2
Shellfish †	0.4	1
Aquatic Plant	1	0.6
Frog	n/d	0.02
Raccoon *	0.1	0.3

† Because no shellfish samples were collected in Lost Creek, HQ was estimated based on the average HQs for Lower Spring River & Neosho River (watersheds with all 5 food categories sampled).

* Similar to HQ from background data.

Take-home message: Addressing aquatic plant risk results in acceptable site-related risk from non-plant biota.

EPA Response – final PRG scenarios for cadmium/zinc

The following exposure scenarios are incorporated into the PRGs for cadmium & zinc:

- **Traditional Tribal Lifeway** – Using TLW exposure factors from the HHRA. Contact with sediment and ingestion of aquatic plants as food.
- **Aquatic Worker** – Using exposure factors from the HHRA. Contact with sediment.

Cadmium & Zinc PRGs

Scenario	Exposure Factors	Exposure Media Included	OU5 Aquatic Biota as Food
Traditional Tribal Lifeway	Same as HHRA	Sediment, aquatic plants	Yes – plants only
Aquatic Worker	Same as HHRA	Sediment	No

EPA Response – final PRG scenarios for cadmium/zinc

Scenario	Description	Sediment			Dietary		
		IR (mg/d)	EF (d/yr)	ED (yr)	Food Categories	IR	EF (d/yr)
TLW	TLW using exposure factors from HHRA	400	312	6	TLW Aquatic Plants	TLW	365
Aquatic Worker	Aquatic worker using exposure factors from HHRA	400	250	25	-	-	-

Acronyms:
ED – exposure duration
EF – exposure frequency
IR – ingestion rate
TLW – tribal lifeway

Units:
d/yr – days per year
mg/d – milligrams per day
µg/L – micrograms per liter
yr - year

Tar Creek OU-5 Preliminary Remediation Goal Tech Memo Revisions

April 16, 2021

Approach for this meeting

Used Abt slides from 3/25/2021 and 4/8/2021 as basis for discussion

Grouped TCTCIT comments by general topic

Providing EPA approach to revised PRG Tech Memo

Topic - Dietary Intake for TLW

(slides 2-8 from 3/25/2021 and slides 4-5 from 4/8/2021 ABT presentations)

In several tables, figures, and text within the PRG memo, dietary intake for TLW receptors is described as "All Food" (100%) or (25%).

- First, it's not "All Food", it's aquatic food groups.
- Second…it's not a percentage of the Tribal diet, it's the percentage of the IEUBK default values that have on-site contaminant concentrations

"Dietary Lead Intake" vs. "Alternate Dietary Value" option

- It is our understanding that except for one scenario within the Sensitivity Analysis, all TLW PRGs were developed with dietary lead intake values that were estimated using the Alternate Dietary Value.

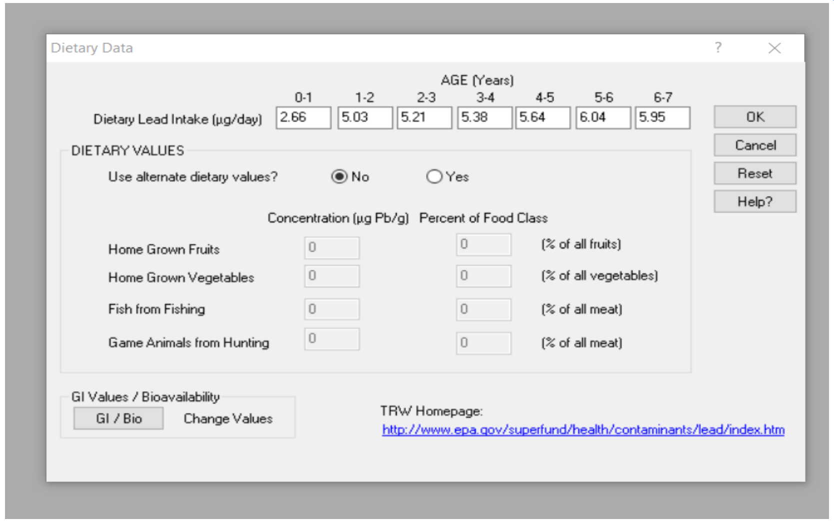
The Tribal ingestion rates should be used to estimate dietary lead intake

Traditional TLW activities have not been accurately captured in the PRGs

EPA Response

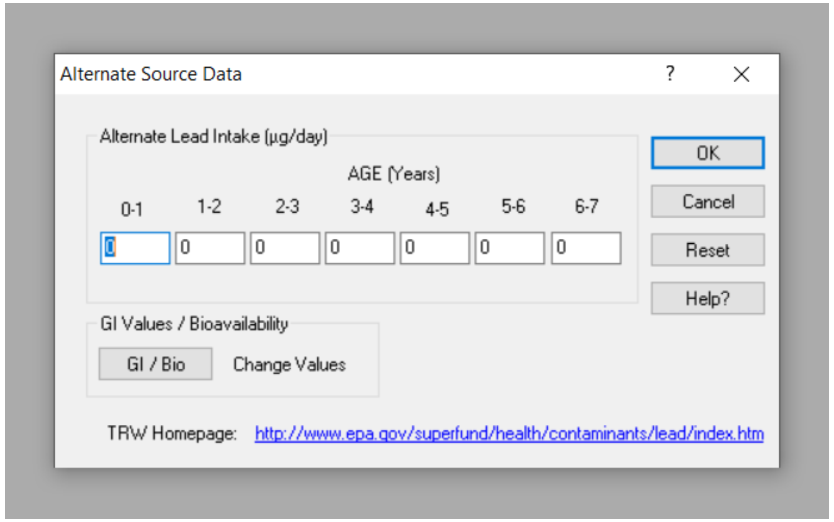
- “All Food” will be replaced with “Aquatic Food”
- TLW aquatic diet from OU-5 will be incorporated into IEUBK model using 1 of 2 ways (pending TRW feedback):

1. **Replacing default** “dietary lead intake” with OU-5 aquatic dietary lead intake



OR

2. **Adding** OU-5 aquatic dietary lead intake **to default** “dietary lead intake” using “alternate source data”



EPA Response Cont. - Updated PRG Scenarios

		Sediment	Surface Water			Dietary		
	Description	**IR (mg/d)**	**IR (L/d)**	**Lead EPC (µg/L)**	**EPC Basis**	**Intake**	**IR**	**EPC Basis**
TLW (Scenario 1)	**TLW using EFs from HHRA**	400	0.78	2.35	Fourmile Creek[1]	OU5 Food	Tribal	Fourmile Creek[1]
GP (Scenario 2)	**GP using EFs from HHRA**	default	default	2.7	Lost Creek	Default	U.S. Diet	Default
Scenario 3	**Additional scenario(s) TBD**	Under development						

Notes:
[1]The PRGs are calculated entering background surface water EPCs and dietary lead intake calculated based on background biota EPCs and TLW RME ingestion rates.

Acronyms:
EF – exposure factor
EPC – exposure point concentration
GP – general public
IR – ingestion rate
OU5 – Operable Unit 5
RME – reasonable maximum exposure
TBD – to be determined
TLW – tribal lifeway

Units:
L/day
mg/d – milligrams per day
µg/L – micrograms per liter

Topic - Non-OU5 Exposure Sources

(slides 6-9 from 4/8/2021 ABT presentation)

The TRW Lead Committee has indicated that all sources of lead need to be included when evaluating risk using the IEUBK model.

For TLW scenarios, this mean including a more complete set of exposure pathways even if sources of lead are not from OU5.

EPCs for non-OU5 sources could be based on:

- Site-specific background concentrations (if applicable)
- Other site data (e.g., TEMS 2012 plant data)
- EPCs calculated using OU4 PRGs

EPA Response

TRW was being asked whether non-OU5 sources (air, dust) could be zeroed out of the IEUBK model (waiting on clarification from TRW).

Calculating PRGs is an iterative process.

EPA recognizes that all OUs are interconnected.

Current focus is OU-5 media (surface water, sediment, and aquatic biota).

OU4 addressed terrestrial, aquatic, and riparian pathways

- Soil, groundwater, ambient air
- Beef, small game, milk, fish, aquatic foods, asparagus, willow, cattail.

Topic - Adjust EPCs Based on PRG Value

(slides 10-13 from 4/8/2021 ABT presentation)

EPCs in biota were set to background mean concentrations regardless of the PRG value.

PRG values of selected scenarios range from 15 to 1,802 mg/kg Pb.

Data are available to adjust EPCs of biota based on PRG value instead of using background.

- Relationship between Pb in sediment and Pb in arrowhead root presented in Appendix B
- TEMS 2012 and Garvin et al. 2017 for other plant food
- Angelo et al. 2007 for shellfish
- Fish and bullfrog tissue data from watersheds (EPA's Equis database)

EPA Response

For scenarios with sediment PRGs > background, may use measured data from a watershed with comparable lead levels in sediment.

e.g.: Scenario 2 (GP) uses Lost Creek SW EPC for sediment PRG* (173 ppm) since similar to Lost Creek sediment conc. (168 ppm)

* Based on target BLL =5

Topic - Soil/Sediment Incidental Ingestion Rate

(slides 14-16 from 4/8/2021 ABT presentation)

- EPA states that Harper's IR of 400 mg/day is based on out-of-date information.
- EPA TRW Lead Committee suggests 200 mg/day to represent a child's mean soil/sediment IR, based on limited adult data.
- In the preferred Hybrid Exposure Scenario, EPA used IEUBK default IR for soil/sediment (52 – 94 mg/day).
- For the High-End TLW Scenarios, IR of 400 mg/day used, but results are dismissed in conclusions.
- For cadmium and zinc, IR of 400 mg/day was used.

EPA Response

RME soil/sediment IR of 400 mg/day will be used for TLW PRG.

IEUBK default IRs will be used for GP PRG.

Other PRGs may be developed based on alternate soil/sediment IRs.

Inherent differences in how risks & PRGs are evaluated for lead vs. non-lead

- Lead - probabilistic model predicting distribution of blood lead levels using central tendency (e.g., average) exposure parameter values.
- Non-lead (including cadmium & zinc) - deterministic model predicting risk associated with RME.

Topic - Additional Comments on Lead PRGs

(slides 17-18 from 4/8/2021 ABT presentation)

- Age group assumptions
    - The assumption that children <36 months would only be exposed to lead in residential soil and not be exposed to contaminated sediment is inconsistent with TLW. EPA should use same assumptions for all age groups.
- Time-weighted average for soil/sediment exposure
    - The assumption that exposure to OU5 sediments occurs 24 hours/day for 5 days a week likely overestimates exposure. Maximum exposure times are estimated to be 6 hours/day every day of the week.

EPA Response

- EPA will use the same sediment exposure assumptions for all age groups
- If TWA PRGs are included, they may account for fraction of hours/day
  - Pending TRW feedback (modifying days vs. hours)

Topic - Cadmium and Zinc PRG Development

(slides 21-23 from 4/8/2021 ABT presentation)

TLW scenarios should always include a dietary component

For cadmium and zinc PRGs, only dietary intake from aquatic plants is considered. All biota should be included to get total risk.

- Scenarios with non-TLW IRs will not be labeled TLW.
- Sediment PRGs focus on exposure pathways driving risk.
- Aquatic plants are >90% of risk associated with dietary intake.
- Sediment remediation will address risks associated with other food consumption.
- EPA will not include other food items in sediment PRG calculations.

EPA Response

Topic - Development of PRGs for Surface Water

(slides 21 and 24-25 from 4/8/2021 ABT presentation)

- Development of PRGs for cadmium and zinc should account for risks from dermal contact and incidental ingestion of metals in surface water.
- The PRG technical memorandum states:
  - "Although ARARs in surface water are present, the additional analysis of surface water ARARs will be conducted in the feasibility study. Therefore, no ARAR-based PRGs were identified in this technical memorandum."
- Are surface water PRGs being developed separately?
- What is EPA's plan for developing surface water PRGs?

EPA Response

Surface water will be addressed in the FS.

Questions?