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SUBJECT: CSTAG Recommendations on the Tri-State Mining District Watershed. CSTAG Milestone Meeting 1 – Site Characterization

FROM: Contaminated Sediments Technical Advisory Group

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BACKGROUND

In 2002, OSWER Directive 9285.6-08, Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (the 2002 Principles Memo)[1], established the Contaminated Sediments Technical Advisory Group (CSTAG) to "monitor the progress of and provide advice regarding a small number of large, complex, or controversial contaminated sediment Superfund sites". CSTAG members are site managers, scientists, and engineers from the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) with expertise in Superfund sediment site characterization, remediation, and decision-making. One purpose of CSTAG is to guide site project managers to appropriately manage their sites throughout the Superfund process in accordance with EPA's contaminated sediment guidance, including the 2002 Principles Memo, the 2005 Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (EPA-540-R-05-012)[2], and the 2017 Directive on Remediating Contaminated Sediments (OLEM Directive 9200.1-130).[3]

The Tri-State Mining District (TSMD) Watershed site Operable Units contain the surface water and sediments in perennial (always flowing) water bodies of four Superfund sites: Cherokee County Site (Cherokee County, Kansas), the Oronogo-Duenweg Site (Jasper and Newton Counties, Missouri), the Newton County Mine Tailings Site, (Newton and Lawrence Counties, Missouri), and the Tar Creek Superfund Site (Ottawa County, Oklahoma). This area is a "Tier 2" (CSTAG) site, subject to review per CSTAG's policies and procedures.[4]

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[1] Available at: https://semspub.epa.gov/src/document/HQ/174512
[2] Available at: https://semspub.epa.gov/src/document/HQ/174471
[3] Available at: https://semspub.epa.gov/src/document/11/196834
[4] Available at: https://semspub.e`pa.gov/work/HQ/100002365.pdf

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BRIEF DESCRIPTION OF THE SITE

The Tri-State Mining District (TSMD) consists of an area over 2,500 square miles where widespread historical lead and zinc mining operations were conducted throughout the Tri-State region of southeast Kansas and southwest Missouri (EPA Region 7), and northeast Oklahoma (EPA Region 6). The wastes associated with the historical mining and smelting operations are contaminated with residual heavy metals and have impacted surface and subsurface soils, groundwater, surface water, and stream sediments. The primary contaminants of concern (CoCs) are lead, cadmium, and zinc.

After the excavated rock was processed and the metal ore extracted in mining operations, the tailings that remained were deposited into "chat piles", many of which remain on the site along with fine tailings ponds containing wastes from the floatation milling process, numerous abandoned horizontal mine shafts, open pits, open vertical shafts, and smelter sites. The significant continuing sources of sediment contamination are chat piles, fine tailings ponds, chat pile seepage, weathering, runoff, and surface and subsurface discharges from the underground mines. Other media and exposure areas are managed as other OUs at each site (e.g., residential yards, non-residential mine waste, floodplain soils, etc.). For the Remedial Investigation/Feasibility study (RI/FS), the TSMD Watershed was split between the Upper Spring River watershed and the Lower Spring River/Neosho River watersheds. The RI/FS for the Lower Spring River watershed was completed in 2020[5]; the RI for the upper watershed is ongoing.

SITE REVIEW

The CSTAG review of the contaminated sediment portions of the TSMD was held July 12-14, 2022, via webinar. The meeting addressed decision-making milestone 1 of the CSTAG operating policies, corresponding generally to a review of the site's characterization in the RI and initial concepts for the risk reduction strategy. The stakeholder listening session was held on July 12, 2022 and included presentations and/or submitted material from a wide variety of stakeholders including the Quapaw Nation, two State of Missouri agencies, the LEAD Agency (a community group), and the Department of Interior, including the U.S. Fish and Wildlife Service.

RECOMMENDATIONS

1. Source Control

The regions described the mining source control measures implemented to date within the TSMD watershed sites, including remediation of chat piles, tailings ponds, seeps, and mine discharges. The source control challenge of the TSMD sites stems from the vast number and size of source areas. EPA and its partners have managed millions of tons of mine waste on thousands of acres of land, yet the region estimates there are still approximately 50 years of remaining source control actions.

Mine waste features are widely dispersed in the Tri-state areas with varying degrees of connectedness to surface waters and some of the highest priorities for remediation (e.g., residential yards) may not directly influence surface waters. As a first tier of remediation within the aquatic system, the regions have acted to stabilize, remove, or treat some of the direct sources of metals. The focus on source control is consistent with EPA's contaminated sediment management principles, however, due to the widespread nature and severity of the contamination, substantial metals releases and transport remain in the aquatic system. In the upper TMSD watershed, there are ongoing site characterization activities including

[5] Available at: https://semspub.epa.gov/work/06/9929889.pdf

sampling and analysis efforts to refine the nature and extent of contamination, refine the understanding of contaminant fate and transport, and supplement the risk assessments. The extent to which these characterization efforts will be sufficient to identify additional source control or specific areas for action is unclear.

Recommendation

CSTAG supports the regions' continued identification and prioritization of upland source areas and media that are directly connected to the aquatic system, while continuing to protect human health. CSTAG recommends that site planning emphasize an ongoing and iterative process for obtaining a more highly resolved delineation of source areas. Sampling objectives and designs should be explicitly intended to identify targets for upland or in-water source control. Such action should include chemical or physical monitoring to discern high concentration, low stability banks; sediment beds prone to transport; or COC seep areas. Key study questions could include the identification of the specific river or tributary reaches that are contributing to metals loading and the media and process responsible for the loading.

2. Site Characterization and Conceptual Site Model (CSM) Development

The National Contingency Plan (NCP) states: "The purpose of the remedial investigation (RI) is to collect data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives (NCP 300.430(d)(1))" and data collection "should reflect the scope and complexity of the site problems being addressed (NCP 300.430(a)(ii)(C)". Clearly, the site's chemical and physical features are large and complex, with hundreds of miles of stream bed, multiple known and unknown primary and secondary CoC sources in several media, and an array of sediment and chemical transport mechanisms. As such, it's anticipated that the data collection necessary to develop effective alternatives will be similarly large and complex.

The regions presented existing data on CoC concentrations in the creeks and waterways of the TSMD as well as the risks that have been characterized to date. CSM diagrams were provided to present the COC exposure and transport pathways. Additional data gap sampling is occurring and modeling work to evaluate site information is anticipated during the FS.

CSTAG recognizes the challenges associated with combining the surface water operable units from four sites and two regions and that those efforts are ongoing. However, materials provided by the region did not convey sufficient information to understand relative contributions of the different types of sources, the priority areas or exposure pathways that present the highest risks, or which areas should be addressed first in future management decisions (or, conversely, areas where sediments and surface waters do not pose unacceptable risk). It is understood that the proposed modeling work will supplement portions of the CSMs and support alternative development, however, modeling is not a replacement for data collection to support the CSM, to identify priority areas, or explain important information with respect to the site.

At present, even with data gap sampling and modeling, there will likely not be sufficient data to fully describe the nature and extent of contamination and to develop and evaluate effective, final remedial alternatives for the site. For example, there are miles of river within the site without characterization, almost no sampling of the depth of sediment contamination, and an incomplete understanding of the surface water-ground water exchange areas, mechanisms, and significance, and a limited understanding of specific riverbed, bank, or overland sources prone to transport. However, it also is not prudent to seek to fully characterize a site of this size and complexity prior to taking any action. As a result, it is anticipated that "[s]ite characterization may be conducted in one or more phases to focus sampling efforts and increase the efficiency of the investigation (NCP 300.430 (d)).” These phases could then support the development of effective alternatives in localized areas, tributaries, or sub-watersheds as early actions to expedite the completion of total site cleanup (See 2017 sediments directive, recommendation #1). Information collected during site characterization and early actions could also be used to measure system response to manipulation during interim cleanups, support CSM development, assist in the identification of additional areas for remediation, or provide the basis to exclude areas from further consideration.

This phased approach appears to be consistent with the region’s desire to develop a framework for identifying and implementing early or interim actions. Thus, while the site characterization data do not appear able to develop a final, preferred alternative, they may be able to support a framework for identifying priority areas for iterative actions. Additional sampling to support interim action evaluations will be necessary as part of FS development, consistent with the NCP that states “…as new information is obtained, site characterization activities should be fully integrated with the development and evaluation of alternatives in the feasibility study” (NCP 300.430(d)(1)).

Recommendations

a. CSTAG recommends that the regions synthesize the collected data to update the site CSMs to:

1. Explain which risk pathways are the most significant and evaluate whether the available data are sufficient to quantify the exposures.

2. Characterize the relative contribution of source areas to both exposure and long-term transport and fate, including

    i. in river sediments (surface and at depth);
    ii. beaches, banks and floodplains;
    iii. chat and tailings piles (runoff, groundwater discharge, windblown);
    iv. mines (subsidence area overflow, direct discharge, groundwater contamination); and
    v. groundwater discharge into waterways.

3. Establish the areas of highest risk and COC source contribution and those areas that do not pose unacceptable risk.

4. Explain this information to the stakeholders in a simple, sound, and consistent context.

b. To support a framework for identifying and implementing early or interim actions, CSTAG recommends that the region:

1. Evaluate whether characterization data is sufficient to prioritize management areas to prevent current exposure, control sources and reduce the potential for transport, and to define the expected benefit of those actions.

2. Plan for additional sampling in priority areas to support a refined understanding of contaminant source, transport, and exposure so that appropriate remediation alternatives can be developed.

3. Design the sampling efforts, or portions of those efforts, to also serve as a baseline to determine the effectiveness of future site actions in reducing COC exposure and transport (see recommendation 9).

4. Ensure that development of the mass balance budget is based on the CSM, and the output from the mass balance does not conflict with the CSM.

3. Modeling

A multi-component (hydrodynamic, sediment transport, and contaminant transport) model is being considered for use in the TSMD watershed. Descriptions of the effort are contained in the site information package, a Draft Fate and Transport Model Analysis and Proposal (FTMAP, May 2022), and the Modeling Data Gaps Analysis Report (July 2021) provided to CSTAG. The modeling approach applies the HEC-HMS model for hydrology and the 1D HEC-RAS model for hydraulics and sediment dynamics covering Upper and Lower Spring River basins (including associated tributaries), Empire Lake, and the Neosho River.[6] HEC-HMS will cover the entire TSMD watershed and simulate point and non-point runoff as well as sediment erosion and transport in the watershed prior to entering the river system. This would provide lateral inflow boundary conditions for the HEC-RAS model for routing the sediment and runoff. A sediment and contaminant mass budget will be developed and applied "to convert the sediment transport model into a contaminant transport model", performed post-processing.

Model objectives stated in the FTMAP are "refining the CSM; characterizing channel segments regarding supply, transport, and deposition/accumulation of sediments and related metals; screening remedial technologies; making preliminary remedial technology assignments; and developing and evaluating remedial alternatives."

CSTAG members have experience in model development, application, and use at sites, and CSTAG has reviewed multiple such models at large, complex contaminated sites. Here, CSTAG has reviewed technical aspects of the proposed model development and considered its use for site decision making. Several issues are summarized below.

Assumptions: CSTAG questions the assumption underlying model development: "[c]ontamination in the form of heavy metals is expected to migrate predominantly via the mobilization of fine sediments to which it preferentially sorbs." Zinc and cadmium are two of three primary CoCs and they do not appear to transport predominantly via mobilization of fine the sediments. For example, in a study of Tar Creek, USGS concludes "Cadmium and zinc at Tar Creek Study Segment generally were predominate in the dissolved phase, while total iron and lead generally were predominate."[7] This relationship can change in the watershed, depending on proximity to source areas.[8] Groundwater and mine discharges of dissolved cadmium and zinc are primary sources of site CoCs not included in the model structure.

Model Setup: The combined watersheds of the TSMD represent an expansive area and tributary network to model the hydrology, sediment transport, and contaminants. The Draft FTMAP indicates a significant sampling investment to begin constructing the model: "[t]here will be a total of 321 miles of needed channel survey" and "geometry information for all bridges and in-channel structures within the hydraulic model domain will be needed". That effort will be relatively coarse, conducted at 1000 or 500 ft transects (or by LiDAR; the text is ambiguous). This characterization encompasses large areas with low importance from a CoC or remediation perspective. The proposal states that geotechnical properties are needed for soils throughout the watershed (grain size and clay content to inform runoff and infiltration rates), but that these may be obtained through regional or soil maps. There is limited data collection on the geotechnical properties of the riverbed (used to simulate whether they would erode under various conditions) with sediment and bank soil samples proposed from 42 locations across the three States (p. 5-

[6] Another model (WARMF) is also being used by EPA to evaluate the different remediation techniques in the Spring River Watershed.
[7] https://pubs.usgs.gov/sir/2007/5115/pdf/sir2007-5115.pdf
[8] https://pubs.usgs.gov/sir/2009/5032/pdf/SIR2009-5032-web.pdf

5, modeling data gap report). Overall, it is not clear that data collection will be sufficiently robust to characterize these model inputs.

The flow exchange and primary flow paths between the river and floodplains will be complex and challenging to define in a model framework. Flow will be introduced into a reach either upstream or from lateral inflow via overland flow. The simulated transport of eroded sediments (and from contaminated floodplain features) during a flood event and subsequent deposition onto inundated floodplains would not be simulated adequately with a 1D hydraulics model (e.g., contaminated chat piles are a dominant feature of the floodplain topography). This model produces only cross-section average estimates of sediment transport and does not simulate bank erosion. Further, subsurface loadings of metals from groundwater and mine inputs are not addressed. This would likely require the use of a statically linked groundwater model.

Despite the importance of CoC reduction in Superfund (and CoCs being the focus of some modeling objectives), there is little information on how the model will be parameterized for metals, except to indicate that "there should be sufficient data to characterize the current distribution of contaminants" and that metals will be assigned to the sediment model's output after a "post-processing step". It is not clear that sediment sampling data are sufficient to characterize the contaminant concentrations and loading of both contaminated and clean sediment throughout the drainage network. Overall, the level of characterization needed to adequately simulate watershed, water, sediment, and metals is quite large. The proposed effort seeks efficiency in model parameterization, but the magnitude of the site, complexity of the processes, and the need for precision in targeting areas and media, suggest that such modeling will be extremely challenging and have a high degree of uncertainty.

<u>Calibration and Validation</u>: Data collection to support the calibration and validation of the models is relatively sparse considering the spatial variability of the drainage network. Sampling efforts for calibration and validation include "up to 4" river flow gauges and "up to 5" suspended sediment samplers to be deployed in unstated locations and relationship to the existing 12 USGS stream gauges and 25 USGS/ORD sediment and metals loading stations. This may relate to the limited calibration that appears to be envisioned in the Draft FTMAP: "The proposed approach to use data to calibrate and validate up to three of the sub-basins is based on the primary application of the modeling effort as an analytical tool for delineating channel segments according to whether they are erosional, depositional, or transport reaches." Despite being the focus of modeling objectives and remedial alternatives, metals will not be calibrated or validated.

<u>Uncertainties</u>: In consideration of CSTAG's risk management Principle 6 to "carefully evaluate the assumptions and uncertainties associated with site characterization data and site models", CSTAG had concerns regarding modeling uncertainty. A sensitivity analysis is proposed in lieu of evaluating the model's uncertainty related to predictive accuracy. This sensitivity analysis will vary the Manning's roughness coefficient (also the variable used to calibrate the model) and evaluate the impact on model output. This attempt to quantify the uncertainty in the collected data, the remaining data gaps, and in the proposed modeling approach would result in only a crude estimate of the uncertainty. The total uncertainty would be a minimum of two orders of magnitude and would completely engulf the relative differences between simulated remedial alternatives, which is a stated model objective. EPA's 2017 sediments directive describes how multiple sources of unknown and uncharacterized uncertainty limit a model's ability to provide an accurate (i.e., quantitatively correct) depiction of future conditions and cautions users to consider the limitations of models in predicting future condition for purposes of decision making.

Use in Decision Making: Several of the stated objectives seem to go beyond reasonable expectations for the proposed model. At its most detailed, it appears that the model identifies 1000-5000 ft sections as erosional or depositional. This is coarse output that does not directly inform remediation approaches. Further, this output will be most valuable in contaminated reaches that can be directly measured for sediment erosion and deposition dynamics (e.g., see measurement approaches in USACE Technical Guidelines on Performing a Sediment Erosion and Deposition Assessment [SEDA] at Superfund Sites).[9]

Summary: CSTAG recognizes that some of these issues could well be clarified with additional input or discussion. However, at this juncture it is unclear whether this type of comprehensive modeling approach is even necessary or cost-effective. The time and funding necessary for model development, data collection, parameterization, calibration, validation, and a host of possible iterations is high and will likely delay or preclude using the model to support an FS and/or interim actions. As discussed in these recommendations, the region's focus should be on defining locations or media (bed/bank/groundwater) responsible for driving exposure and transport. New, existing, and ongoing sampling (e.g., the data gaps sampling and ORD/USGS monitoring) supplemented by additional focused characterization and loading studies could provide a faster, more versatile, and cost-effective approach to developing site decisions. Some degree of modeling may have utility, particularly if applied at a smaller scale on priority areas or deposits, but at this juncture, there does not seem to be significant alignment between site needs and model capabilities.

Recommendation

Overall, CSTAG has several concerns regarding the development, application, use, and need for the proposed model. CSTAG recommends that the region reconsider the need for a watershed-wide modeling effort to achieve the primary objectives of an interim approach (targeting primary metals loading or exposure areas). Alternate empirical approaches to identify and resolve contaminant loading media and areas (e.g., mass-balance approaches, higher-resolution characterization in priority reaches, loading analyses, repeat bathymetry, and geomorphic analysis) can achieve similar interim objectives more accurately and cost-effectively.

4. Site Characterization to Support the Ecological Risk Assessment (ERA)

A screening-level ecological risk assessment (SLERA) was conducted to evaluate potential risks to aquatic organisms utilizing aquatic habitats in the study area and a detailed ecological risk assessment (DERA) was conducted to assess risks to benthic invertebrates utilizing habitats within the study area. Together, these two ERAs are referred to as the Advanced SLERA for the TSMD.[10]

The SLERA identified ten main receptor groups with potentially complete exposure pathways within OU5 of the TSMD, including microbiota, aquatic plants, aquatic invertebrates, fish, amphibians, terrestrial plants, terrestrial invertebrates, reptiles, birds, and mammals. Conservative toxicity reference values for contaminants in surface water, sediment and sediment pore water were identified and compared to concentrations of contaminants detected across the site to develop hazard quotients for each contaminant and medium. The results indicated that exposure to contaminants in surface water, sediment and sediment pore water posed potential risk to aquatic receptors. The subsequent DERA focused on the benthic invertebrate community and concluded that exposure to contaminants in sediment posed moderate to high risk to benthic invertebrates in about 78 percent of the locations sampled. The DERA was more

[9] Available at: https://semspub.epa.gov/work/HQ/174625.pdf
[10] Available at: https://semspub.epa.gov/src/document/06/9226600

empirical in nature and based primarily on laboratory toxicity testing of site sediment using amphipod (*Hyalella azteca*), midge (*Chironomus dilutus*), and mussels (*Lampsilis siliquoidea*) as the test species and several lethal and sublethal measurement endpoints. These data were used to derive a site-specific relationship between metals and benthic toxicity to support the development of preliminary remedial goals (PRGs).

In 2020, a technical memorandum (appendix H of the OU5 RI) was produced by EPA contractors to evaluate whether the advanced SLERA "meets the requirements of a baseline ecological risk assessment (BERA) sufficient to support the characterization of ecological risk and the selection of PRGs for OU5." Central to this evaluation is determining whether the PRGs derived in the DERA for benthic invertebrates are also protective of other receptors. The 2020 technical memorandum states:

> "EPA and its partners decided to focus the follow-up assessment, or DERA, on evaluating risks to the benthic invertebrate community posed by exposure to contaminated environmental media in the study area. Data and information from other sites indicate that benthic invertebrates are expected to be more sensitive to sediment-associated COPCs than are other aquatic receptors (MacDonald et al., 2002, 2003).[11] This decision was made because contaminated sediments represent long-term sources of COPCs to downstream areas, and controlling these and other sources (such as mine water and tailings disposal areas) will be critical for overall risk reduction. Accordingly, conditions that are protective of benthic invertebrate communities are presumed to be protective of other aquatic receptor groups." (Section 2.2)

The technical memorandum primarily reviewed whether the benthic invertebrate assessment adhered to framework and the eight-step process in the ERA guidance.[12] It minimally considered impacts to the rest of the aquatic community (see quoted text, above). However, the ERA guidance recommends that if the data indicate that there is (or might be) a risk of adverse ecological effects, the ecological risk assessment process will continue beyond the screening level. As such, CSTAG questions why a more detailed evaluation was not conducted as part of a BERA after the SLERA identified unacceptable risk to the 10 receptor groups. At a minimum, the effect of the proposed PRGs to other receptor groups should be evaluated to support the presumption that PRGs are protective of those groups.

Recommendation

CSTAG recommends that the region provide further rationale and evaluation to demonstrate that the proposed PRGs are protective of the ecological receptors with identified risks in the SLERA. In this evaluation, CSTAG recommends that the region assess the protectiveness of the PRGs by comparing the CoC sensitivity of benthic invertebrates to the other receptor groups.

5. Surface Water Data Review of Mercury

CSTAG conducted a cursory review of the surface water data presented in the Tar Creek Superfund Site OU5 Remedial Investigation. In this area, mercury is considered a CoC for ecological health, but not for human health.[13] Data presented in the RI indicates that 54% of sieved sediments in OU5 exceeded

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[11] References are associated with a BERA and PRG evaluation of the Calcasieu Estuary cooperative site, Lake Charles, LA.

[12] Available at: https://semspub.epa.gov/work/HQ/157941.pdf

[13] In the refinement of COCs, mercury was excluded as a COC, stating "Literature review was performed to evaluate the likelihood of the preliminary COC being associated with TSMD ore bodies (Table 7-1 of the RI report)." That table states that Hg is "[l]isted in 2 literature references as associated with some MVT [Mississippi Valley Type] deposits" but then concludes that mercury is "[n]ot likely to be associated with TSMD ore bodies".

background concentrations for Hg (RI, Table 6-5); only 1% of unfiltered water samples ("total Hg") exceeded background. Compared to other CoCs, water sampling for mercury was conducted infrequently.[14] Water sampling data were compared to water quality standards and background threshold values (BTVs) for the nature and extent evaluation.[15]

For mercury at least, these comparisons appear problematic. For example, in Tar Creek (the most heavily sampled sub-watershed in the lower watershed) mercury is often not analyzed (Table 6-19). When Hg is analyzed, the detection limits frequently exceed both the BTV and the WQS.[16] The most common total Hg detection limit in water is 0.001 mg/L, which is 20-fold greater than the WQS and >3-fold higher than the BTV (which itself was based on a maximum detection limit, not a measured value). The analysis concludes that 2 samples exceed the WQS; one sample exceeds the WQS and BTV. The overall conclusion is that the Tar Creek Watershed water samples do not exceed the background population for total mercury (RI Table 6-21 and 6-54).

Recommendation

CSTAG is not able to fully evaluate chemistry for all media and analytes. However, based on its cursory review of the water quality data set, CSTAG recommends that future analyses of Hg (and other CoCs as necessary) produce data sets using analytical approaches that can support conclusions (e.g., that analytical detection limits are below concentration criteria for decisions). In the case of Hg, future analyses could utilize EPA methods 1631 and 1630 for total Hg and methylmercury in water, respectively.

6. Appropriate Background CoC Derivation

Background data is used at Superfund sites to delineate the extent of contamination, understand CoC transport into the site, and to define recontamination levels, as well as to determine the cleanup level when risk-based PRGs s are below background. Background concentrations of sediment were derived from the Fourmile Creek sub-watershed in the lower portion of the TSMD watershed site. CSTAG noted the lack of information on sediment COC concentrations entering the TSMD watershed site boundaries from other riverine sources, particularly in the upper watershed. The lack of information on those inputs creates uncertainty regarding whether upstream COC sources exist and lessens the agency's ability to determine the potential for recontamination of remedial actions in the upper watershed (or dilution from incoming less-contaminated sediment). It was not clear if background data on the rivers and tributaries entering the TSMD watershed site has been collected and were not provided, or if data still need to be collected to support this determination.

It is likely that background COC concentrations will be important for considerations of remediation goals, recontamination potential, and post-remedy expectations. The 2017 sediments directive emphasizes the importance of ensuring adequate data collection during the RI/FS to support the evaluation of alternatives: "[It is] important to evaluate background concentrations and the potential for recontamination to determine the level of risk reduction and contaminant levels that can be achieved."

[14] For example, the Tar Creek sub-watershed has 1384 total Zn water samples; total Hg has 158 water samples (RI Table 6-21).
[15] WQS for total Hg (0.00005 mg/L) and dissolved Hg (0.00077 mg/L) (RI Table 5-22) were apparently based on State of Oklahoma WQS for the protection of human health and State and Federal WQS chronic aquatic life criteria, respectively (RI, Appendix G, Table G-1). BTVs were based on water samples (n=30) from the Fourmile sub-watershed. Hg was not detected at the detection limits used, so the BTVs were based on the maximum detection limit of 0.0003 mg/L for both total and dissolved Hg (RI Table 5-6, 5-8).
[16] It appears that only 3 of 158 samples have detection limits lower than the BTV and WQS.

Recommendation

CSTAG recommends that the region characterize background concentrations of COCs entering the site at key locations upstream and through tributaries. Data from the primary sediment inputs to TSMD should be evaluated to ascertain whether the current background values are appropriate or should be modified. When assembling background data, sampling protocols (e.g., collection and sieving) should be as similar as possible to on-site data to make relevant comparisons. The use of this background data would be determined by the stage of the Superfund process, the decision to be made, the Data Quality Objectives, and the characteristics of the data. When the data sets are assembled the region should evaluate whether different source areas require different background values or consideration.

7. Pilot Studies to Support Technology Selection and Source Control

The region has conducted multiple sediment, bank, and mine-discharge remediation pilots. Two passive treatment systems (operated by university and State partners) capture and treat metals-contaminated mine water discharges. In its fifth five-year review for the Tar Creek Superfund site, the region documented the effectiveness of these systems for reducing metal-contaminated mine water discharges to surface waters and improving the biologic conditions of receiving streams.[17] Between 2019 and 2022, pilots on sediment traps, dredging and sediment sorting, bank stabilization, and surface water treatment using biochar have been completed. Documentation of the biochar pilot (construction completed in 2022) indicates that monitoring of metals removal is central to the effort. Based on the final construction reports of the bank stabilization (2019) and dredging, sorting, and grading pilots (2020), it is unclear if and how the impact of the pilots on contaminants was measured. Performance monitoring reports were not available for these efforts.

EPA's contaminated sediment guidances (see Background) encourage the use of an iterative approach that can include pilot testing to determine the effectiveness of various remedial technologies at a site. CSTAG supports the regions' efforts to implement a range of pilot studies capable of field-testing technologies and, in some cases, reducing source contributions and improving ecological conditions. As the scale of pilots (or early actions) increases, the effectiveness of the approaches for achieving site objectives (at least on a localized scale) should be discernible, if actions are appropriately monitored.

Recommendation

CSTAG recommends that additional pilots (or early actions) be structured to explicitly consider or include evaluations of the impact of the action on site-related objectives (e.g., reduction in CoC sources, exposure, transport) at least at the local scale. These evaluations should include monitoring metrics to determine performance directly related to site objectives. This information will be central to demonstrating progress and informing future remedies in conjunction with the site's long-term monitoring program.

8. Interim Approach to Risk Management

The region indicated that a risk management approach using interim remedies prior to a final remedy was being considered. This approach would focus interim actions on the most highly contaminated sediments

[17] Available at: https://semspub.epa.gov/work/06/9679184.pdf

and mine discharges, and the actions would be accompanied by performance monitoring to provide a basis for decisions in a final ROD.

Given the aerial extent, variety of contaminant sources, and the extensive watershed, CSTAG agrees with an interim approach to address sources, exposure, and transport in specific areas. The site characterization to support development of final, protective alternatives is not available or readily attainable, and the scope and duration of proposed "final" remedial alternatives would be highly uncertain. There are hundreds of miles of riverbed and banks over which CoC loading is not uniform or well-defined. For remediation to be cost-effective, remediation needs to accurately target specific primary CoC-loading areas of the system. However, it is not clear to CSTAG if the current characterization is adequate to identify specific areas and media for prioritization and the regions' plans to use existing data or collect additional data to prioritize and sequence interim actions are not yet defined (see also recommendations 1 and 2).

Recommendations

a. CSTAG recommends the region develop a prioritization scheme to select and sequence early or interim action areas. This scheme will be a critical tool for documenting the basis for selecting specific areas based on different considerations such as flux of erodible source material, highest risk, soluble CoC release, or potential to drive recontamination. Targeting the primary CoC loading areas will be necessary if progress at the site is to be achieved in a cost-effective manner. As highlighted in recommendation 2, CSTAG recommends that the region critically evaluate whether RI data are sufficient to support that prioritization and conduct additional sampling, if necessary. Existing (and new) RI data will aid this process as will additional geomorphic analysis and higher resolution sampling. Besides upland source control, high-priority in-stream interim actions could include large areas with high-volume, high-concentration sediment areas associated with low-head dams or bridge crossings.

b. As the region develops its process for identifying priority areas for interim actions, CSTAG recommends it consult EPA's "Adaptive Site Management – A Framework for Implementing Adaptive Management at Contaminated Sediment Superfund Sites".[18] This document describes how adaptive site management can be used to implement early or interim actions to support a final remedy through goal identification and iterations of remediation, monitoring, and evaluation.

9. Community Relations and Communication

During the stakeholder listening session, CSTAG was able to hear from the Quapaw Nation, the LEAD agency (a community group), State partners from Missouri, and federal trustees. The EPA regions and stakeholders have been collaborating on aspects of the site cleanup for decades and the stakeholders generally described productive interactions and collaborations with EPA.

As the surface waters of several Superfund sites are combined into the TSMD watershed area, the focus of potential human health impacts will broaden from the high impact mine waste areas to the whole watershed including more populated downstream areas. The focus of community outreach will also likely change. For example, CSTAG heard concerns from community members regarding the potential for contaminant exposures and risks associated with sediments transported from upstream areas and deposited in downstream floodplains. Community concerns focused on recontamination of remediated properties, a lack of information on contamination and exposures in floodplains including signage, and

[18] Available at: https://semspub.epa.gov/work/HQ/100003040.pdf

the potential for contaminant exposure when foraging or recreating in the downstream river and floodplain. Community members had even developed a GIS interface of the site to depicting flood zones and residential yard cleanups to better understand possible contaminated sediment transport. Community members solicited feedback regarding additional data to support the GIS interface. The region is currently expanding community outreach efforts through new communications, media, and provision of technical assistance to communities.

Recommendation

As the scope of areas undergoing characterization and consideration for remediation expands with the TSMD watershed efforts, and the regions seek additional opportunities to engage with the community, CSTAG recommends the region consider providing or developing COC exposure information in areas of community concern. For example, the region could make available a GIS data layer on COC concentrations in the TSMD watershed and consider floodplain sampling and risk communication efforts (including signage, if appropriate) in areas of high concern and likely exposure by the community. Information on low CoC and acceptable risk areas is also valuable from a community perspective.

10. Considerations of Remedy Resiliency

The OU5 Remedial Investigation has characterized the flow patterns and morphology of the Tri-State Mining District's hydrosystem and riparian corridor as flashy and subject to rapid runoff. Much of the site is located within the 100-year floodplain, and periodically experiences flooding associated with severe weather events.

The potential effects of increased winds, temperatures, and the severity/frequency of significant storm events on remedial actions will require specific and long-term planning. In 2021, EPA's Office of Land and Emergency Management (OLEM) issued a directive recommending approaches to consider when evaluating climate resilience throughout the Superfund cleanup process.[19] At this site, example considerations may include modifications to remedy design (e.g., river bed/bank stabilization and mine discharge remediation) and waste and equipment siting.

Recommendation

CSTAG recommends that the region consider the site's vulnerability to the potential effects of higher frequency and intensifying flooding events on upland waste areas and waterways. The region should consider accessing resources and technical capacity to provide climate vulnerability assessments through EPA's Office of Superfund Remediation and Technology Innovation.

11. Baseline and Long-term Monitoring Plans

As indicated by the regions, mine waste remediation throughout the TSMD will likely take several decades. During this time, conditions will continue to change, and it will be important to understand ongoing CoC exposures and the effect and effectiveness of the remedial actions. Developing a robust baseline of CoC exposures and a long-term monitoring (LTM) program for their evaluation over time is emphasized in EPA's 2002 Principles Memo and the 2017 sediments directive (recommendation #9) to demonstrate and communicate progress toward objectives and obtain feedback from the system on the impact of the remedy.

[19] https://semspub.epa.gov/work/HQ/100002993.pdf

The size of the system and large numbers of sub-watersheds and tributaries suggests that an LTM program will include multiple stations to reflect local and systemwide trends and to evaluate attainment of interim and final remedial action objectives related to CoC exposure and transport. The region has already initiated a promising effort in this regard with monthly water sampling of flow, suspended sediment, and total and dissolved metals and sediment sampling at 25 stations that are distributed throughout the site. An effective LTM program in the TSMD would use consistent methodology over time to demonstrate CoC levels and transport at indicator locations. Data from the LTM program would be supplemented by remedy effectiveness evaluations at early action areas. The program would serve as a primary indicator of the status of the system, overall effect of the cleanup program, and a feedback mechanism to determine next steps.

Recommendation

CSTAG recommends the region develop and implement an LTM program capable of evaluating COC exposure and transport in the TSMD and permit ongoing evaluation and feedback of remedy effectiveness. LTM design would capitalize on the RI's sampling programs and interim remedy effectiveness evaluations. Sampling locations should be reviewed to ensure locations indicate contaminated reaches, sub-watersheds, and transport pathways. Planning should begin as soon as possible to ensure that an appropriate baseline is developed.