Potential Danger for Northeast Oklahoma?

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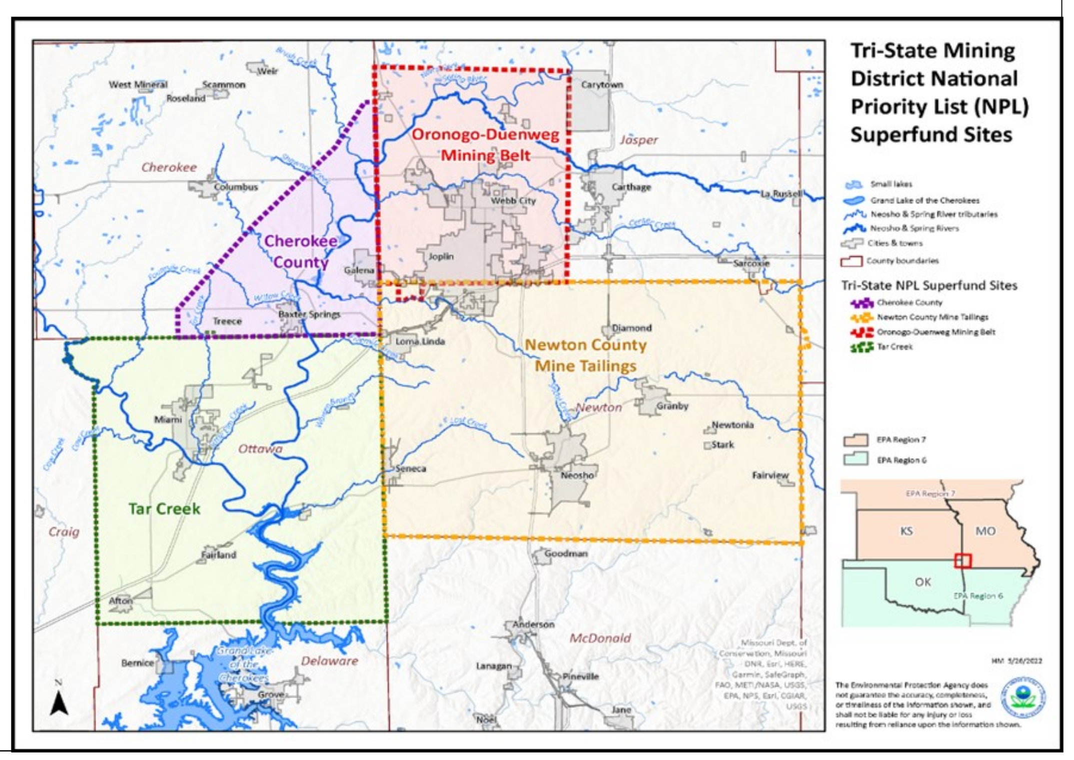
Abstract

Across the U.S. there are 1335 superfund sites that range from abandoned mines to old military bases that pose serious risk to the public if not remediated properly. The Tar Creek Superfund site, located in Picher, OK, is one example which could potentially contaminate downstream water supplies due to the heavy metals, such as Cd and Pb, left behind from the mining activities. This study seeks to determine whether ongoing remediation are proving effective at Tar Creek, and whether contaminated sediment is migrating downstream through the watershed to lower reaches.

Background

Abandoned mines have been widely documented to be hazardous to the environment, both physically and chemically. Specifically, lead (Pb) and zinc (Zn) mining has occurred for centuries, leading to mine waste being left behind after abandonment contributing to land and water degradation (Gutierrez et al., 2016). Legacy sediment has also been widely documented in the United States from mining activities (James, 1997). One of the most well-known examples of legacy sediment contamination is the Tri-State Mining District (TSMD) located in Kansas, Missouri, and Oklahoma, where Pb and Zn occurred (James et al., 2020). Environmental damages from mining caused TSMD to be sub-divided into four superfund sites; this study focused on the Tar Creek Superfund site (TCSS) located in Oklahoma. Two aquifers, the Boone and Roubidoux, underlay parts of TCSS, which seeped groundwater into mining shafts causing flooding. Once mining operations ceased, leftover minerals, such as ferrous hydroxide, mixed with groundwater and contaminated the countryside. The only previous research in this area was that of Barrett (2022) who focused on whether one specific chat pile was contaminating local fluvial systems downstream of the active remediation occurring by the Quapaw Tribe in connection with the EPA. This research continued Barrett's (2022) work through incorporating her Bird Dog North data for both water and sediment to best determine if legacy sediment is reaching downstream systems and to what extent.

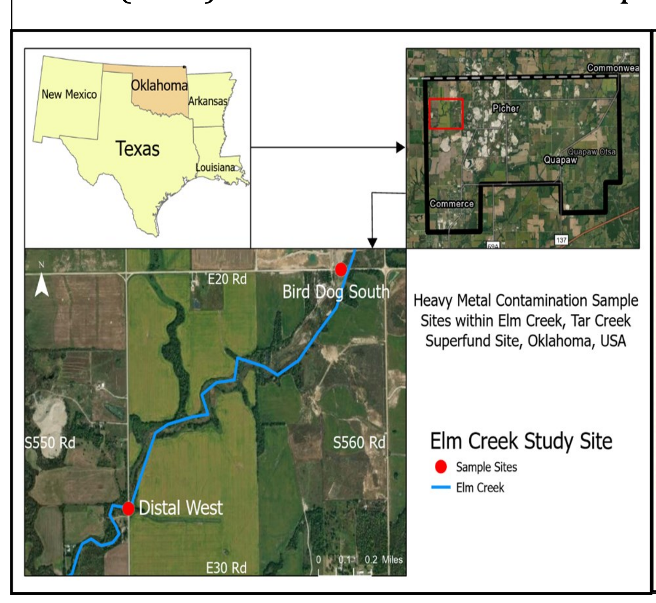


Objectives

The overall objectives of this research are :(1) to assess the current magnitude and extent of mining-related sediment contamination in Tar Creek, and (2) to quantify the transport and environmental fate of legacy sediment from the TCSS to downstream watersheds.

Field Site & Methods

The study site, shown below, is situated within the TCSS. Two sampling locations were selected: Bird Dog South (BDS) and Distal West (DW) located downstream of Barrett's field site Bird Dog North (BDN) and the remediated chat pile, which are all upstream of the Neosho River.

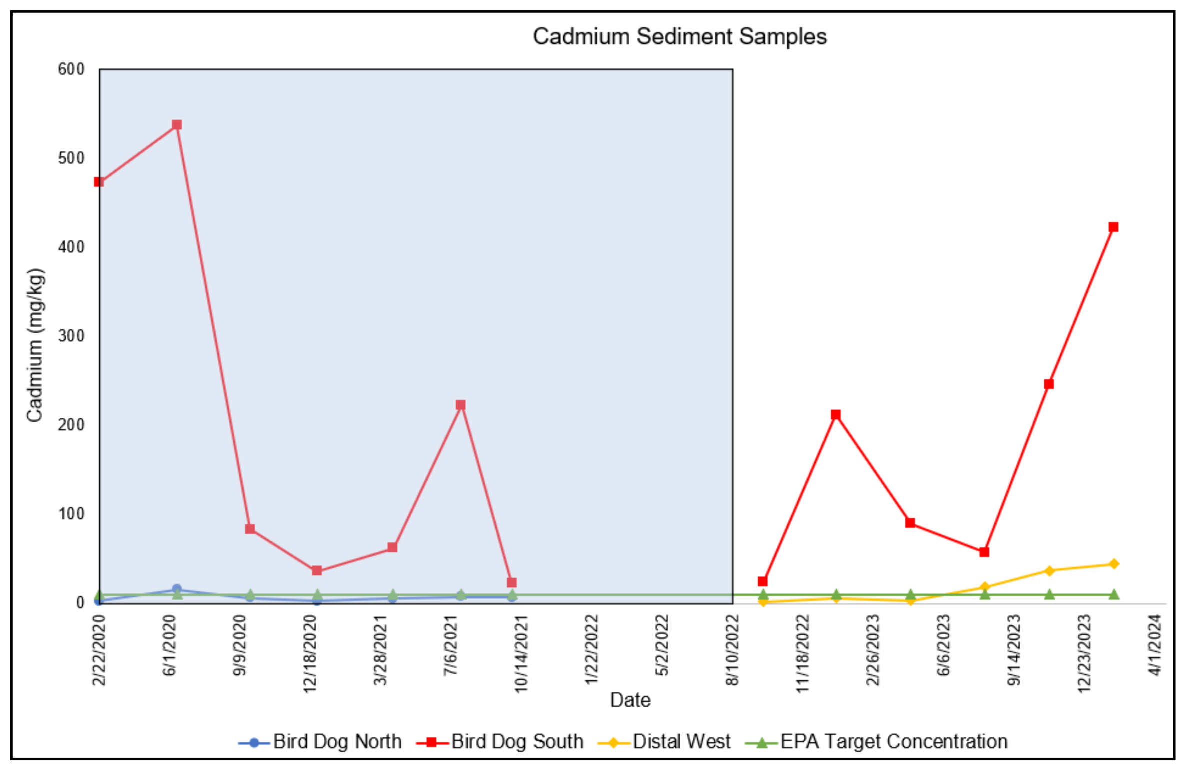


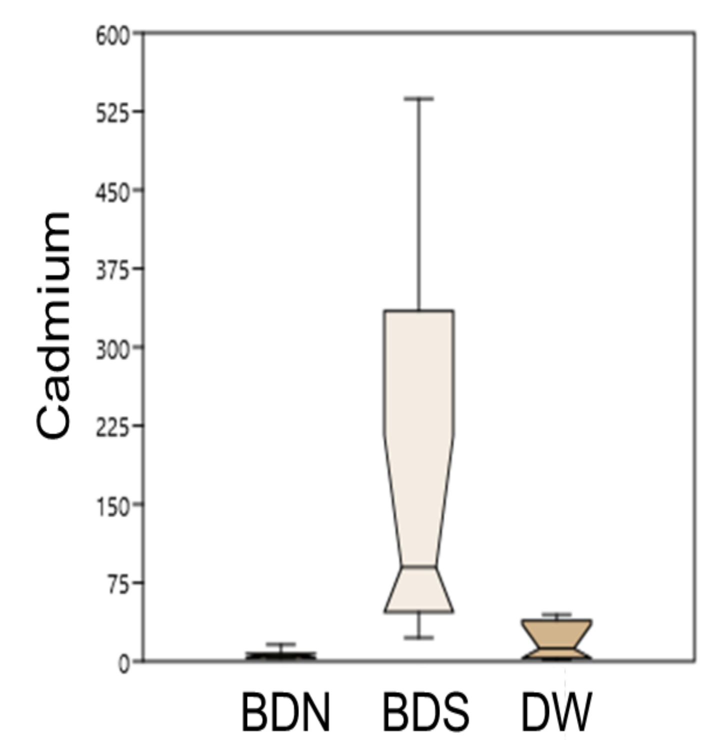
Quarterly water and sediment samples were taken for the following heavy metals: Arsenic (As), Cadmium (Cd), Iron (Fe), Pb, Manganese (Mn), and Zn at field sites BDS and DW. Turbidity, depth, and daily rainfall were also collected for the hydrology portion of this study using a YSI Sonde (left), a water level logger, and a tipping bucket rain gauge.

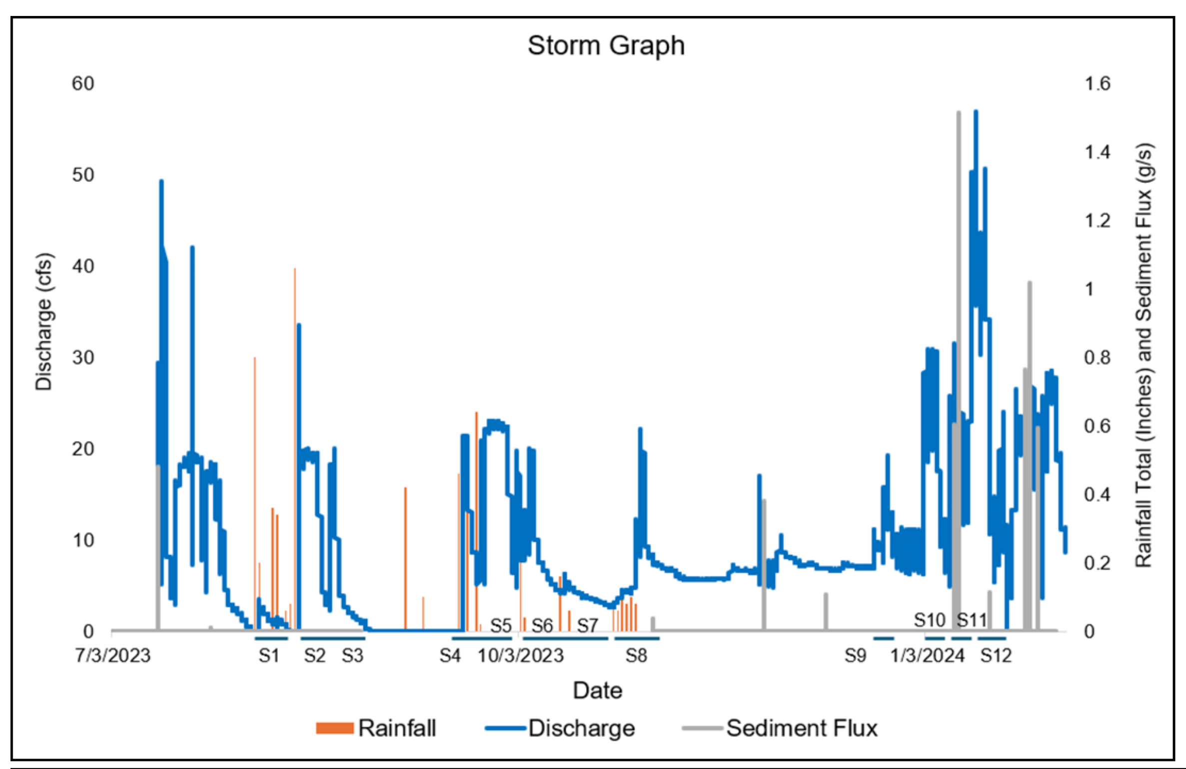
Results

Sediment Results							
Sample ID	Date	As (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
EPA Target Concentration		5	10	N/A	500	N/A	5500
Bird Dog South	9/23/2022	**5.2**	**24.4**	9480	135	2070	5310
Distal West	9/23/2022	ND	1.6	9000	259	47.6	263
Bird Dog South	1/4/2023	**17.9**	**212**	18100	151	18800	**34000**
Distal West	1/4/2023	**5**	6.3	8770	**683**	235	1180
Bird Dog South	4/21/2023	**11.3**	**89.7**	21700	429	8500	**20400**
Distal West	4/21/2023	4.47	3.47	10400	**559**	75.7	597
Bird Dog South	8/3/2023	**8.81**	**57.7**	14700	218	5870	**17400**
Distal West	8/3/2023	**5.89**	**18.1**	13500	**653**	352	2130
Bird Dog South	11/3/2023	**13.7**	**246**	19900	280	30900	**52400**
Distal West	11/3/2023	**5.17**	**37.1**	11800	444	412	4490
Bird Dog South	2/3/2024	**23.3**	**423**	22400	**57000**	230	**95900**
Distal West	2/3/2024	**5.36**	**44.5**	13200	420	1590	5410
Bolded Values exceed EPA Target Concentration. ND = Non Detectible							

The table shown at left provides the average concentrations for BDS and DW for the six metals listed. The bolded values are those that exceed the EPA target limits. One non-detectible sample occurred which is labeled as ND. We also show the temporal trend of Cd concentrations over time for the three field sites and the EPA target limit. The blue box captures Barrett's (2022) data. The figure below is a notched box plot comparing the three sites and indicates a significant difference (~95%) between samples as the notches for BDS and DW do not overlap.







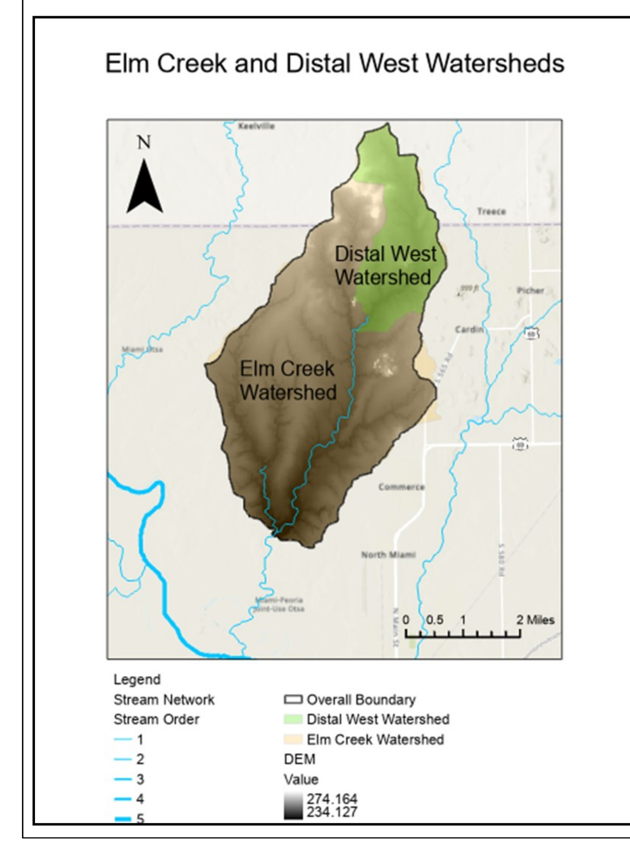
The graph at left shows discharge (cfs) over an eight-month timeframe for DW with an additional axis for total rainfall (In) and sediment flux (g/s). The twelve storms labeled were analyzed during this research to hydrologically characterize the Elm Creek watershed.

The Cadmium data are shown here as they are representative of the overall metals response. The data from Bird Dog South exhibited a high degree of variability, consistent with Barrett's findings (data within the blue box). We note an increase in contamination following removal of the chat pile (Nov. 2021). This increasing trend was also observed at Distal West, although to a lesser extent. At Bird Dog South, all samples exceeded the EPA target limit of 10 mg/kg, while Distal West only exceeded the EPA target limit for the last three quarterly samples from 8/3/2023 to 2/3/2024. The notched box plot suggests a significant difference between BDS and the other two field sites, which coincides with BDS being the primary site of ongoing excavation and remediation.

The response of Elm Creek to the 12 storm events indicated a hydrologically sluggish watershed. Average time-to-peak was 41 hours and average lag time was computed at 17 hours. Sediment flux peaked at 0.12 Mg/day indicating minimal transport of fine-grained material to downstream sections.

Conclusion

Our results confirm that Bird Dog South has been heavily impacted by the ongoing remediation with significantly higher concentrations of metals than either the upstream Bird Dog North or downstream Distal West sites. Very little of the sediment excavated during remediation made its way downstream with storage of sediment observed in both retention ponds and beaver dams. The Distal West watershed contributes ~35% of the discharge to Elm Creek, a creek dominated by subsurface storm processes due to the lag times mentioned previously. Thus, in the short-term health problems should not arise from this fluvial system to downstream systems like the Neosho River. We do acknowledge this storage of sediment does not indicate whether long-term contamination will follow a similar trend.



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