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Prepared in cooperation with the Bureau of Indian Affairs

GIS Analysis of Changes in Volume and Mass of Chat Piles in the Picher Mining District, Ottawa County, Okla., 2005–10

Introduction

From the 1890s through the 1970s the Picher mining district (PMD) in northeastern Ottawa County, Oklahoma, was the site of mining and processing of lead and zinc ore. When mining ceased in about 1979, as much as 165–300 million tons of mine tailings, locally referred to as "chat," remained in the PMD. Since 1979, some chat piles have been mined for aggregate materials and have decreased in volume and mass. Currently (2013), the land surface in the PMD is still covered by thousands of acres of chat (fig. 1), much of which remains on Indian trust land owned by allottees. To help the BIA better manage the sale and removal of chat, the U.S. Geological Survey (USGS), estimated the 2005 and 2010 volume and mass and the 2005–10 changes in volume and mass of 34 selected chat piles on 16 properties in the PMD (table 1).

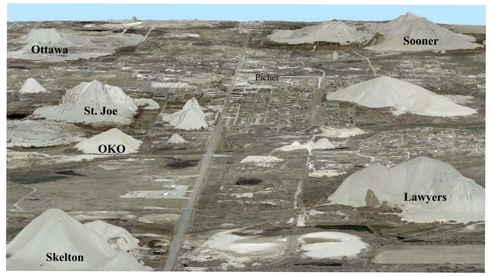


Figure 1. Aerial-photo draped bare-earth lidar survey scene, 2010, showing the town of Picher and chat piles on properties in the Picher mining district.

Land-Surface Changes from Lidar, 2005–10

Land-surface altitudes were determined by using bare-earth digital elevation modes (DEMs) developed from aerial-based light detection and ranging (lidar) surveys. The 2005 lidar survey was flown in March 2005 (Aero-Metric, Inc., 2005). The resulting 2005 bare-earth DEM had a horizontal resolution of 10 ft (3.05 meters [m]) and a vertical precision of 0.01 ft (0.003 m). The 2010 lidar survey was flown on April 11, 2010 (Photo Science, Inc., 2010). The resulting 2010 bare-earth DEM had a horizontal resolution of 3.28 ft (1 m) and a vertical precision of 0.0328 ft (0.01 m). The lidar data were reprojected to Lambert Conformal Conic, Oklahoma State Plane North projection, and the 2005 DEM was resampled by using bilinear interpolation to match the extent and resolution of the 2010 DEM prior to analysis.

A preliminary, map-based assessment of land-surface altitude changes was necessary to ensure that the chat-pile footprints covered all areas where chat was removed or redistributed. A map (fig. 2) showing changes in land-surface altitude for the period 2005 through 2010 was created by subtracting the 2005 DEM from the 2010 DEM by using the ArcGIS Raster Calculator tool (ESRI, Inc., 2012) and rounding to the nearest foot. Yellow and red hues (negative changes in altitude) on the map indicate removal of material (as much as -99 ft), and blue hues (positive changes in altitude) indicate accumulation of material (as much as 59 ft) during the period 2005 through 2010 (fig. 2). The Sooner and Ottawa properties, for which both red and blue areas are indicated (fig. 2), show redistribution of chat as it was removed from one area, sorted or screened, and placed in another area.

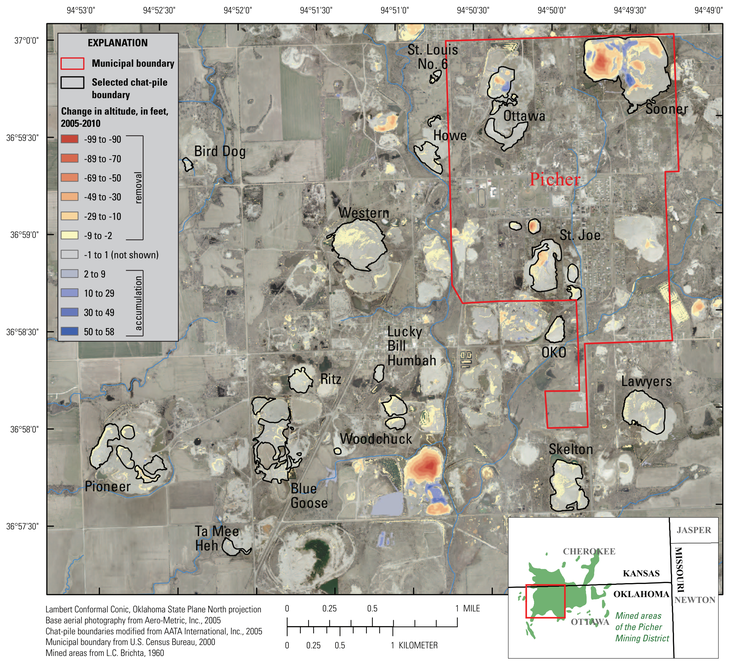


Figure 2. Changes in land-surface altitude in the Picher mining district, Ottawa County, Oklahoma, 2005–10.

GIS Methods

The average altitude in the chat-pile footprint was extracted from the 2005 and 2010 DEMs using the ArcGIS Zonal Statistics as Table tool (ESRI, Inc., 2012) (table 1). The average altitude in the chat-pile footprint was used to represent the chat-pile average altitude in computations of chat-pile volume (fig. 3). Determination of the base altitudes of the selected chat piles was accomplished in ArcGIS by using the Buffer tool (ESRI, Inc., 2012) to delineate a 20-foot buffer around each chat-pile footprint (fig. 3). The average altitude in the 20-foot chat-pile buffer was extracted from the 2005 and 2010 DEMs using the ArcGIS Zonal Statistics as Table tool (ESRI, Inc., 2012c) (table 1). The base of all chat piles was assumed to be a horizontal plane with an altitude equal to the 2010 average altitude in the chat-pile buffer. For each selected chat-pile, the chat-pile base altitude was subtracted from the 2005 and 2010 chat-pile average altitudes to compute chat-pile average height in 2005 and 2010 (table 1, fig. 3).The volumes of selected chat piles were computed as the chat pile average height (the chat-pile average altitude minus the chat-pile base altitude) times the chat-pile footprint area (fig. 3). The masses of selected chat piles were computed as the chat-pile volume times an average bulk density of 1.1313 ton/yd3 (83.8 lb/ft3) reported by AATA International, Inc. (2005). The 10th and 90th percentiles of bulk densities were used to assign error margins to all computed masses.

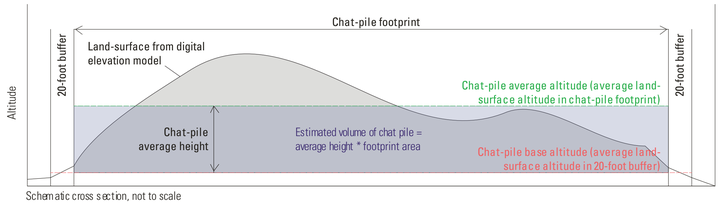


Figure 3. Schematic cross section of a theoretical chat pile showing data used to compute volumes of selected chat piles in the Picher mining district, Ottawa County, Oklahoma.

Any decreases in chat-pile volume and mass were expected to be caused by removal of material by humans. Decreases in chat-pile volume and mass also may occur, however, as a result of natural processes such as settling, erosion by water and wind (an Enhanced Fujita [EF]-4 tornado destroyed many structures and vegetated areas in the vicinity of the St. Joe chat piles on May 10, 2008), or subsurface mine collapse and subsidence. No attempt was made to differentiate between causes of chat-pile volume and mass changes.

Chat-Pile Volume and Mass Changes, 2005–10

The Sooner property had the greatest estimated volume (4.644 million yd3) and mass (5.253 ± 0.473 million tons) of chat in 2010 (fig. 4). Five of the selected properties (Sooner, Western, Lawyers, Skelton, and St. Joe) contained estimated chat volumes exceeding 1 million yd3 and estimated chat masses exceeding 1 million tons in 2010 (fig. 4). The total volume of all selected chat piles was estimated to be 18.073 million yd3 in 2005 and 16.171 million yd3 in 2010 (table 1). The total mass of all selected chat piles was estimated to be 20.445 ± 1.840 million tons in 2005 and 18.294 ± 1.646 million tons in 2010 (table 1).

Figure 4. Estimates of volume and mass for selected properties in the Picher mining district, Ottawa County, Oklahoma, 2005 and 2010.

All of the selected chat piles decreased in volume and mass for the period 2005–10 (fig. 4). The Sooner property and the St. Joe property had the greatest volume (and mass) changes, with 1.266 million yd3 and 0.217 million yd3 (1.432 ± 0.129 million tons and 0.246 ± 0.022 million tons) of chat being removed, respectively (table 1). The chat removed from the Sooner and St. Joe properties accounts for about 78 percent of chat removed from all selected chat piles. The total volume and mass removed from all selected chat piles for the period 2005 through 2010 were estimated to be 1.902 million yd3 and 2.151 ± 0.129 million tons, respectively (table 1).

References

AATA International, Inc., 2005, DRAFT—Remedial Investigation Report Tar Creek OU4 RI/FS Program: accessed December 4, 2012, at http://www.deq.state.ok.us/lpdnew/Tarcreek/Redesign/Superfund%20Documents/RI%20Reports/Draft_RI_Report_December_2005.pdf., 178 p.

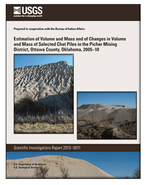
Aero-Metric, Inc., 2005, Aerial lidar and photography survey of the Tar Creek area, Oklahoma, March 2005: Prepared for the U.S. Geological Survey Oklahoma Water Science Center.

ESRI, Inc., 2012, ArcGIS resource center: ArcGIS 10, accessed December 4, 2012, at http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html

Photo Science, Inc., 2010, Aerial lidar survey of the Tar Creek area, Oklahoma, April 2010: Prepared for the U.S. Geological Survey Oklahoma Water Science Center.

Property name	Number of chat piles	Chat-pile footprint total area (acres)	Chat-pile maximum relief 2010 (ft)	Volume and mass: 2005 Volume (thousands of yd3)	2005 Mass (thousands of tons)	2010 Volume (thousands of yd3)	2010 Mass (thousands of tons)	Changes in volume and mass, 2005–10: Volume (thousands of yd3)	Change (percent)	Mass (thousands of tons)
Bird Dog	1	1.8	34.6	25.0	28.3 ± 2.5	22.5	25.4 ± 2.3	-2.5	-10.09	-2.9 ± 0.3
Blue Goose	4	33.8	56.9	465.6	526.7 ± 47.4	416.7	471.5 ± 42.4	-48.8	-10.49	-55.2 ± 5
Howe	2	11.3	60.4	300.9	340.4 ± 30.6	292.6	331.0 ± 29.8	-8.3	-2.75	-9.4 ± 0.8
Lawyers	1	28.7	140.9	2,164.5	2,448.7 ± 220.4	2,118.6	2,396.8 ± 215.7	-45.9	-2.12	-51.9 ± 4.7
Lucky Bill Humbah	1	3.0	28.4	35.7	40.4 ± 3.6	33.2	37.5 ± 3.4	-2.6	-7.22	-2.9 ± 0.3
OKO	1	7.7	71.5	281.5	318.4 ± 28.7	270.9	306.5 ± 27.6	-10.5	-3.75	-11.9 ± 1.1
Ottawa	4	29.6	46.7	595.3	673.5 ± 60.6	549.2	621.3 ± 55.9	-46.1	-7.75	-52.2 ± 4.7
Pioneer	5	31.6	73.7	897.1	1,014.9 ± 91.3	843.0	953.7 ± 85.8	-54.1	-6.03	-61.2 ± 5.5
Ritz	1	8.7	50.3	220.7	249.7 ± 22.5	205.8	232.8 ± 21	-14.9	-6.75	-16.9 ± 1.5
Skelton	1	31.1	142.4	1,702.1	1,925.6 ± 173.3	1,637.5	1,852.5 ± 166.7	-64.5	-3.79	-73.0 ± 6.6
Sooner	1	97.4	139.0	5,909.7	6,685.6 ± 601.7	4,643.5	5,253.2 ± 472.8	-1,266.2	-21.43	-1,432.4 ± 128.9
St. Joe	5	35.9	129.6	1,777.2	2,010.6 ± 181	1,559.9	1,764.7 ± 158.8	-217.3	-12.23	-245.9 ± 22.1
St. Louis No. 6	2	1.5	33.5	11.2	12.6 ± 1.1	9.0	10.2 ± 0.9	-2.1	-19.19	-2.4 ± 0.2
Ta Mee Heh	1	4.7	23.5	30.5	34.5 ± 3.1	27.6	31.2 ± 2.8	-2.9	-9.46	-3.3 ± 0.3
Western	1	43.9	179.2	3,202.7	3,623.2 ± 326.1	3,121.3	3,531.1 ± 317.8	-81.4	-2.54	-92.1 ± 8.3
Woodchuck	3	12.3	84.6	452.9	512.4 ± 46.1	419.4	474.5 ± 42.7	-33.5	-7.40	-37.9 ± 3.4
TOTAL		383.0		18,072.5	20,445.5 ± 1840.1	16,170.8	18,294.0 ± 1646.5	-1,901.8		-2,151.5 ± 193.6

Table 1. Volume, mass, and volume and mass change characteristics of selected chat piles on properties in the Picher mining district, Ottawa County, Oklahoma, 2005–10. Background photo of chat pile on the St. Joe property, looking east, March 20, 2013



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