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Stability Problems Associated with Abandoned Underground Mines in the Picher Field Northeastern Oklahoma

KENNETH V. LUZA

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Title Page Illustration

A 20-ft-diameter circular collapse, Howe Mine, 29N-23E-17.

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STABILITY PROBLEMS ASSOCIATED WITH ABANDONED UNDERGROUND MINES IN THE PICHER FIELD NORTHEASTERN OKLAHOMA

Kenneth V. Luza[1]

Abstract—Approximately 2,540 acres are underlain by underground lead–zinc mines in northeastern Oklahoma. Mine-workings maps and field surveys indicate that at least 1,064 shafts existed in the Oklahoma portion of the Picher Field. At the time of this study, more than 50% of these shafts were concealed or filled. There are 481 shafts either open or in some stage of collapse. About 65% (316 sites) could be filled. This category includes open shafts with minor collapse, minor collapses, and moderate collapses. A total of 18 sites are recommended to be fenced, and 40 sites are recommended to be either fenced or filled. Collapses at these locations generally exceed 100 ft in diameter. Filling of large surface-collapse features might not be economically feasible; therefore, the suggested remedy would be to fence. There were 55 non-shaft-related collapses. Most of these are west of Commerce and west of Cardin. Apparently most of the non-shaft-related collapses are related to multiple mine levels and/or large stopes and/or incompetent roof rock.

A tabulation indicates that approximately 2,900 acres were overlain by mine- and/or mill-waste materials. The inventory indicated 146 former-chat-pile locations and 119 existing chat piles. Forty-six (32%) of the former-chat-pile sites were reclaimed. Most of the reclaimed land supports some form of agricultural activity. However, some sites are being used for residential housing and light industry. Also, 14 major tailings ponds were inventoried.

Numerous examples of ongoing ground failure adjacent to existing collapse features are evident. Therefore, a shaft-filling program is probably the best method to stabilize and/or possibly control future collapse.

INTRODUCTION

Zinc and lead ores (principally sphalerite and galena) were mined in the Picher Field in northeastern Oklahoma and southeastern Kansas for more than 60 years. Oklahoma led the nation in zinc production almost every year from 1918 through 1945 (Southard and others, 1972). Lead and zinc production from the Picher Field ceased late in 1970. More than 1.3 million tons of lead and 5.2 million tons of zinc were produced since mining started in 1891 (Southard and others, 1972). Minor quantities of zinc and/or lead concentrates were produced in 1974, 1976, and 1977 (Arndt and others, 1977,1979,1981). The concentrates were derived from ore mined by independent underground-mine operators as well as from reprocessed mill-waste materials.

Subsidence problems associated with abandoned underground zinc–lead mines either existed during mining or have developed since cessation of mining in the Picher Field. Some subsidence problems associated with abandoned underground mine workings were studied by the U.S. Bureau of Indian Affairs in the middle to late 1960s. Numerous unpublished reports resulted from these studies (e.g., Westfield and Blessing, 1967; Stroup and Stroud, 1967). Unfortunately, little effort or expenditure of funds was made to correct the problems.

In 1979, three U.S. Congressmen representing the citizens of their respective states in the Tri-State area (Kansas, Oklahoma, and Missouri) expressed concern for the safety of their constituents. As a result of the interest and concerns of Congressmen Whittaker, Synar, and Taylor, the U.S. Bureau of Mines initiated a study to document existing mine-related problems and to determine what corrective actions might be needed. Cooperative agreements were made between the U.S. Bureau of Mines and the state geological

[1]Engineering geologist, Oklahoma Geological Survey.

surveys of Oklahoma, Kansas, and Missouri to investigate the mine-related problems of the Tri-State area. The principal objectives of the investigation were (1) to compile on a series of maps the location and extent of past mining activities and the resulting surface effects (underground and open-pit mine workings, shafts, ground subsidence, accumulations of mine waste, and tailings ponds); (2) to identify hazardous areas with potential for future damage to persons or property; and (3) to consider methods to protect the public from hazardous and potentially hazardous conditions. The results of these investigations were released as a series of open-file reports by the U.S. Bureau of Mines (Luza, 1983; McCauley and others, 1983; McFarland and Brown, 1983). This report presents the results of the Oklahoma portion of this study.

Numerous individuals assisted in various phases of this project. Donald A. Preston and William E. Harrison assisted in the field-inspection program. Donald A. Preston determined the volumes of the major chat piles. George A. Lagurος, Leda Fazlalizadeh, Brent L. Seaton, Stuart Merriken, Carrie L. Potter, and Rosann E. Rayome compiled information on the underground mines and surface-collapse features. Ernest R. Achterberg of the U.S. Bureau of Land Management, Tulsa, Oklahoma (formerly of the U.S. Minerals Management Service and U.S. Geological Survey Conservation Division), and John Mott of Picher, Oklahoma, provided detailed mine-map information from their files. Johnny Pate of the U.S. Bureau of Indian Affairs, Muskogee, Oklahoma, compiled information on land ownership. Special appreciation is extended to Alice Allen and Waldemar (Wally) M. Dressel of the U.S. Bureau of Mines, who provided a number of unpublished reports that gave valuable insight into the problems. The Oklahoma Geological Survey appreciates the cooperation and the information given by many local citizens and officials of city and county organizations. Frank J. Cuddeback, mine consultant, of Miami, Oklahoma, was particularly helpful in sharing his Tri-State mining experiences with us. The Oklahoma Water Resources Board permitted unlimited access to its aerial-photograph collection. These photographs were most helpful in the surface-collapse inventory.

The manuscript was reviewed by R. H. Arndt, D. C. Brockie, K. S. Johnson, Alice Allen, W. M. Dressel, F. J. Cuddeback, and staff members of the Oklahoma Conservation Commission and the Oklahoma Water Resources Board. I am grateful for their assistance. Recommendations made by each have been incorporated in the report.

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MINING HISTORY

The Oklahoma portion of the Picher Field is situated in Ottawa County, near the Kansas and Missouri state lines (Fig. 1). The principal towns in the area include Quapaw on the southeast, Commerce on the southwest, and Cardin and Picher near the center of the field. Approximately 45 sections in T28–29N, R22–24E, contain mine workings in the Oklahoma portion of the Picher Field (Pl. 1). Additional mine workings occur in sec. 12, T28N, R24E, near Peoria, Oklahoma (6 mi east and 1 mi south of Lincolnville, out of the area covered by Fig. 1), and in sec. 13, T29N, R21E (8 mi west of Picher).

The first discovery and earliest mining operations carried on in Ottawa County were in the vicinity of Peoria, Oklahoma (Weidman and others, 1932; Snider, 1912). The Peoria Mining Co. was one of the first companies to develop properties near Peoria in 1891. The most productive area adjoined the village of Peoria on the northwest and underlay the bottom and north bluff of Warren Branch. The principal ores were galena, sphalerite, and zinc silicate. Most of the workings were shallow (<50 ft), and drifts were developed 6–8 ft in height and 10–12 ft in width. Much of the ore from the Peoria Camp was hauled by wagon and later by truck to Joplin, Missouri, and/or Galena, Kansas. The absence of rail transportation made marketing of the ore very expensive (Snider, 1912). Apparently, the greatest amount of ore from the Peoria Camp was produced in the 1920s (John Robinson, Peoria, Oklahoma, personal communication, 1982).

The Log Cabin Mine, near the C sec. 12, T28N, R24E, was the last major productive mine in the Peoria Camp. The mine was developed in the 1920s and was periodically worked until 1949. The principal ore was galena, which occurred at the 96-ft level. The average working height was 6 ft, and the workings extended southward for about 1,000 ft (John Robinson, Peoria, Oklahoma, personal communication, 1982).

Almost all prospect and development shafts have been filled. Except for some mill-waste piles composed chiefly of chert fragments, little evidence of past mining activity in the Peoria Camp exists.

McKnight and Fischer (1970) presented an excellent account of the mining history for the main part of the Picher Field. The following is a brief summary of their account.

In 1902, about 1.5 mi northeast of Lincolnville, ore was discovered on Abrams land (SE¼ sec. 30, T29N, R24E) and on Julia Whitebird land (SW¼SW¼ sec. 29, T29N, R24E). The first re-

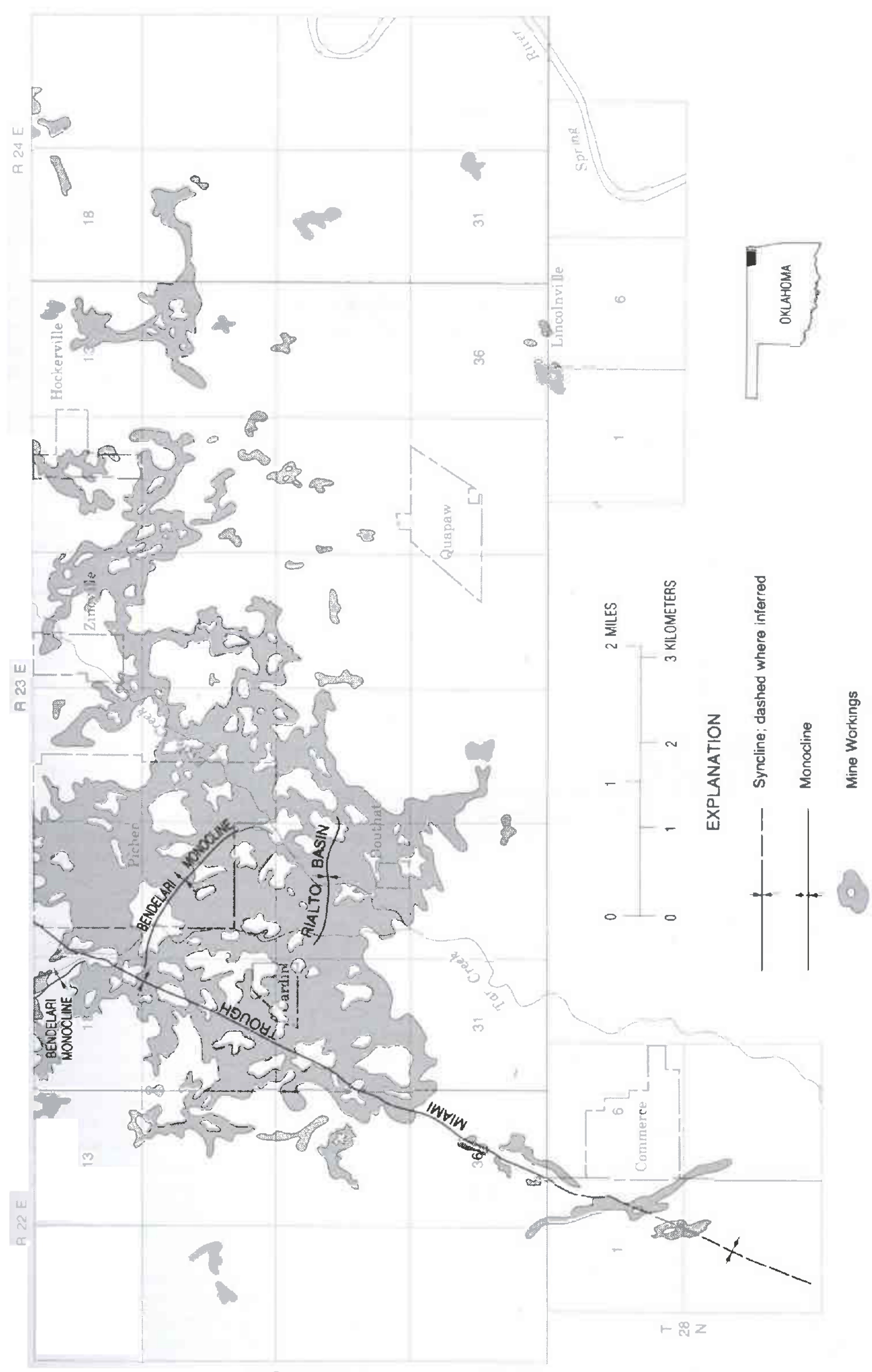


Figure 1. Generalized distribution of underground-mine workings, Picher Field, Oklahoma (modified from McKnight and Fischer, 1970).

corded output of concentrates from the Lincolnville area was in 1904. Peak production of the Lincolnville deposits occurred in 1909.

The next major discovery was made in 1905 at the southwest side of the field near Commerce (formerly Hattenville). The early mines in this area were comparatively shallow, at depths of 90–130 ft; but as the ore was followed northwestward in succeeding years, the depth increased to as much as 250 ft by 1911, and eventually to more than 320 ft.

Exploration, stimulated by the richness of the Commerce ores and by the recognition of a northeasterly trend in some of these ore runs, led to the discovery of the main part of the field in 1912. In 1914, Picher Lead Co. (now Eagle Picher Industries, Inc.) discovered ore on the Crawfish land and on several adjacent Indian-land allotments (northwest Picher, Oklahoma). Near the close of 1917, the Oklahoma part of the field was fairly well defined by producing mines. It was estimated in 1918 that there were 230 mills built or under construction in the Oklahoma part of the field.

The 1920s marked the maturity of the field. In the latter half of the 1920s, zinc recovered from reworked tailings became an important factor in total zinc production. Zinc concentrates were derived from rerun tailings as early as 1909 in the Commerce area, and the practice was carried out to some extent elsewhere in the field. A flotation process was adopted at several of the mills during World War I, and by the mid-1920s the process was in wide use. The use of the flotation process as an adjunct to jigging and tabling in the last half of the 1920s and in later years ensured the recovery of 80–85% of the metal contained in the crude ore, compared to the 58–70% recovery estimated for the older milling. By 1940 most of the tailings were retreated for the first time; the annual average grade was never lower than 0.71%. Peak production from tailings came in 1936. During World War II, tailings were reprocessed for a second time, and even for a third time. In 1946, average annual recovery of zinc from tailings dropped to a low of 0.19%.

The 1930s witnessed the growth of central milling in the field. The first mill built to treat ore from several tracts was the Bird Dog Mill of the Commerce Mining & Royalty Co., completed in 1930. This plant was designed to process 2,750 tons/day on a 24-hr basis. The sampling and milling of ores from several different tracts proved economically feasible. The milling practice up to that time (largely at the landowner's and royalty owner's insistence) was to have separate mills on each 40- or 80-acre lease to ensure proper royalty distribution. In 1932, Eagle Picher completed a central mill near the southwest corner of the field. The initial capacity, rated at 3,600 tons, was shortly increased to 5,500 tons and later to 10,000 tons/day, with an ultimate capacity of 18,000 tons/day.

By 1940, Eagle Picher dominated production in the field. The 1940s were characterized by increased mechanization of mining equipment. Introduction of slushers in sheet-ground mines in the late 1930s and of track-mounted shovels in the early 1940s did away with the traditional method of hand shoveling ore into steel cans at the working face. Rubber-tired diesel trucks of 10-ton capacity were perfected for underground haulage in 1946. These technological developments contributed greatly to the recovery of lower-grade ores.

Because of depressed metal markets, many operations were cut back or suspended in 1957. By midyear of 1958, all major mining operations were closed. Mining was resumed at a reduced rate in 1960, and the last record of significant production occurred in 1970.

PHYSIOGRAPHY, TOPOGRAPHY, AND LAND OWNERSHIP

The eastern part of the Oklahoma portion of the Picher Field (Peoria Camp) is situated on the west edge of the Ozark Plateau province. The Ozark Plateau is a broad, low structural dome lying mainly in southern Missouri and northern Arkansas. However, the main part of the Picher Field is within the Central Lowland province. This province is characterized by a nearly flat, treeless prairie underlain by Pennsylvanian shales.

The streams that traverse the mining field, which are only slightly incised below prairie level, flow southward to the Neosho River. Elm Creek, on the western edge of the field, and Tar Creek and its main tributary, Lytle Creek, are the principal streams in the main productive part of the field. Elm, Tar, and Lytle Creeks furnished some water for the mill operations, although most mill water was pumped from the mines and/or from deep wells. A short distance east of the mining field is Spring River, which is the major south-flowing tributary of the Neosho. The physiographic boundary closely parallels Spring River: the region east of the river is hilly and moderately dissected by through-going streams, whereas to the west the terrain is a nearly level prairie.

Topographic relief in the mining field is relatively small. The lowest point, south of Commerce, is about 780 ft above mean sea level. From Commerce, the land rises gradually to an average altitude of about 830 ft above mean sea level. In the eastern part of the field (sec. 30, T29N, R24E) one summit is as high as 900 ft above mean sea level.

The Quapaw Indians, who were originally from Ohio, were given 150 sections of land in southeastern Kansas and northeastern Oklahoma (Indian Territory) in 1833. In 1867, the Quapaws were forced to give up their lands in Kansas. Although land ownership in Oklahoma originally was vested with the Quapaw Indian tribe, an allotment plan approved in 1893–94 divided the reservation into 236 200-acre allotments and 231 40-acre allotments (Stroup and Stroud, 1967).

Today, land ownership can be classified as (1) private, (2) government, or (3) Indian-restricted. Most of the land, approximately 9,120 acres, is classified as Indian-restricted. This land is still owned by Indian allottees and/or their heirs in the vicinity of the Picher Field (Fig. 2). The remaining lands are owned either by individuals, local municipalities, or the Ottawa County Reclamation Authority. No attempt was made to separate surface-ownership from subsurface-ownership rights.

GEOLOGIC SETTING

The geologic framework and origin of the lead–zinc deposits have been discussed in numerous publications; these include Siebenthal (1908, 1915), Snider (1912), Weidman and others (1932), Reed and others (1955), Brockie and others (1968), and McKnight and Fischer (1970).

The major geologic and tectonic features of the region are shown in Figure 3. The Picher Field straddles the Cherokee Platform–Ozark Plateau boundary in northeastern Oklahoma. Other major geologic features include the Bourbon Arch, Nemaha Ridge, and Arkoma Basin.

The rock formations exposed at the surface in the mining field include Mississippian and Pennsylvanian units that are nearly flat, with a low regional northwestward dip of about 20–25 ft/mi (Fig. 4). Cambrian and Ordovician formations, primarily dolomite and chert with some sandstone and minor shale, are encountered only in deep drill holes and water wells in this area (Fig. 5).

Mississippian rock units, principally the Boone Formation, are the host for most of the ore deposits. The Boone Formation is composed of fossiliferous limestone and thick beds of nodular chert. The term *Boone* is commonly used to describe the sequence of Mississippian interbedded limestone and chert units that crop out in northeastern Oklahoma. The Boone Formation, which is 350–400 ft thick in the Picher area, is subdivided into seven members (in ascending order): St. Joe Limestone, Reeds Spring, Grand Falls Chert, Joplin, Short Creek Oolite, Baxter Springs, and Moccasin Bend (McKnight and Fischer, 1970). Fowler and Lyden (1932) and Fowler (1942) further subdivided these members into 16 beds (Fig. 5). Letters of the alphabet were used to distinguish individual beds, beginning with *B* near the top of the Moccasin Bend Member and ending with *R* in the Reeds Spring Member. In the Picher Field, most of the mine workings are within the *M* bed. Other important ore zones occurred within the *K*, *G*, *H*, and *E* beds, and sheet ground, or low-grade blanket deposits, within the Grand Falls Chert Member.

The Boone Formation is overlain by the Quapaw Limestone near Lincolnville and in part of the main Picher Field. The Chesterian Series, represented by the Hindsville Limestone, Batesville Sandstone, and Fayetteville Shale, generally forms a disconformable contact with the Boone Formation and/or Quapaw Limestone. Chesterian rocks are exposed on the east side of the Picher Field. However, the Batesville and Hindsville also crop out near Douthat. Both the Hindsville and Batesville are locally mineralized, especially in the eastern part of the mining field near Lincolnville.

Pennsylvanian formations of the Krebs Subgroup (lower division of the Cherokee Group) overlie the Boone Formation. The Krebs Subgroup was deposited on a post-Mississippian erosion surface. The formations, as mapped by Branson (Reed and others, 1955), include the McAlester Formation, the Savanna Formation, and the basal Bluejacket Sandstone Member of the Boggy Formation (Fig. 4). These formations consist of alternating terrestrial fine-grained sandstone, shale, and thin coal beds. The sandstone units are discontinuous and vary significantly in thickness where they are laterally continuous.

At a few places, sharply defined structural features are accompanied by appreciable dips. The Miami Trough, Bendelari Monocline, and Rialto Basin are three prominent structures that dominate the main part of the Picher Field (Fig. 4). The Miami Trough is a linear feature (syncline and/or graben) that crosses the western part of the Picher Field with an average trend of N. 26° E. The width of this structure is 300–2,000 ft, averaging about 1,000 ft. The maximum vertical displacement is about 300 ft. The Bendelari Monocline crosses the mining field with a northwest trend and drops the mineral-bearing ground a maximum of 140 ft on the northeast side. The maximum dip is about 20°. Chesterian strata are preserved in greater thicknesses on the down-dropped side, and the structure is hardly noticeable in Pennsylvanian strata. The Rialto Basin is an irregular, east-trending, faulted syncline nearly a mile long and as much as a quarter of a mile wide. It has a maximum displacement of 80 ft and contains a thicker sequence of Chesterian strata than normal (McKnight and Fischer, 1970).

The linear structural features, such as the Miami Trough, are of tectonic origin and probably have been modified by some dissolution of carbonate rocks at depth, resulting in additional subsidence. The Rialto Basin and smaller basins may have developed where dissolution along deep-seated fractures was accompanied by subsidence (McKnight and Fischer, 1970).

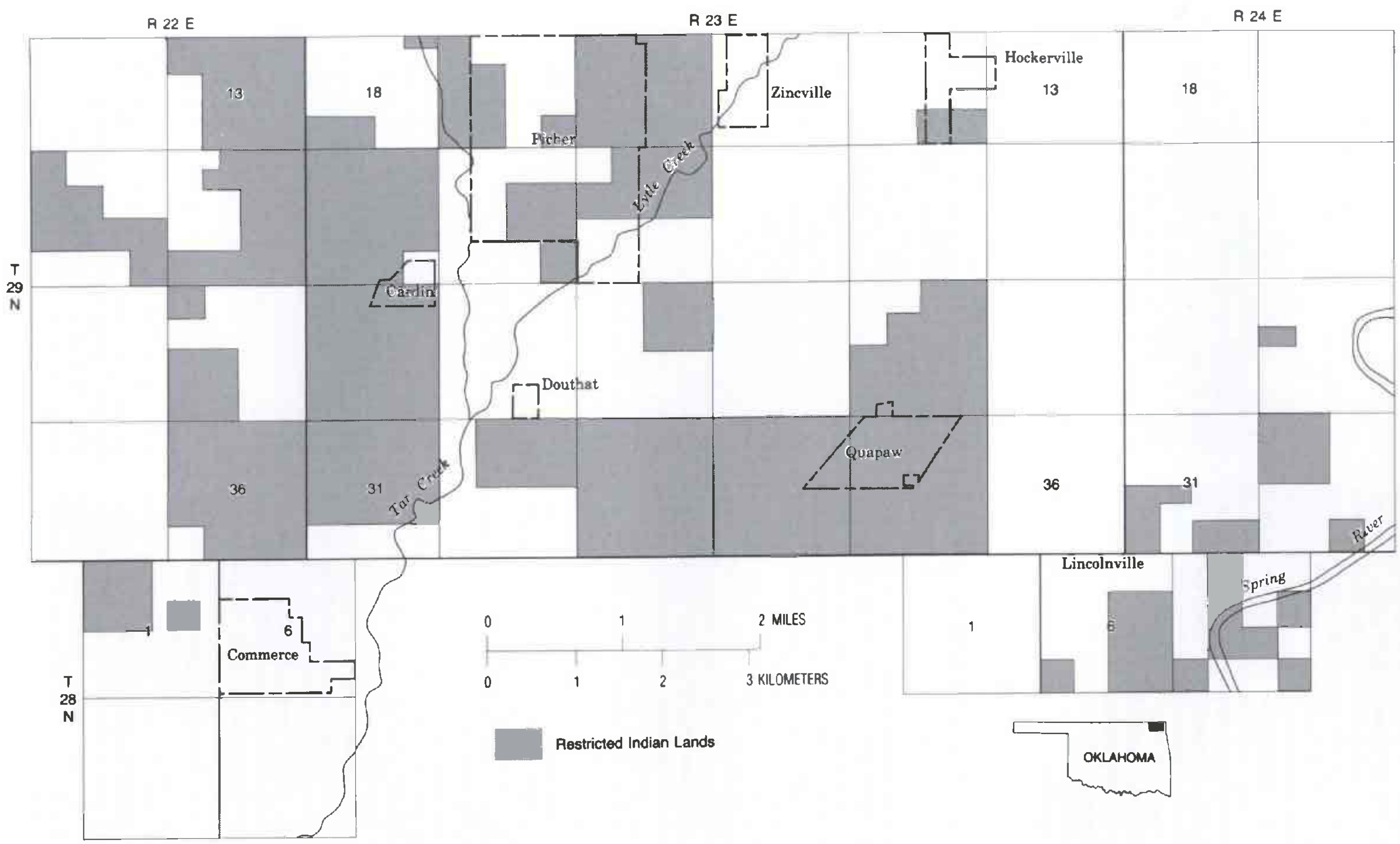


Figure 2. Distribution of Indian-restricted lands, Picher Field, Oklahoma.

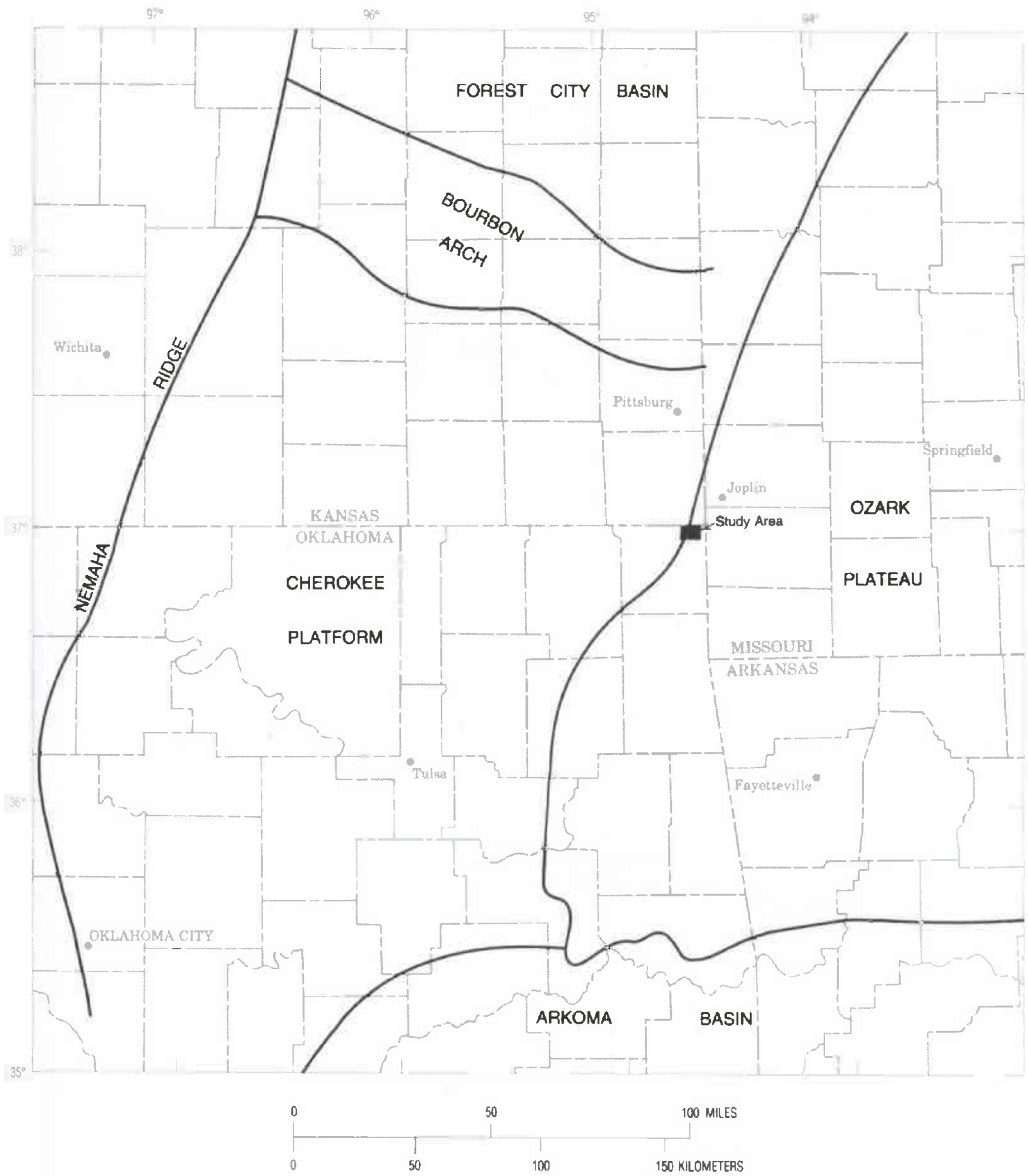
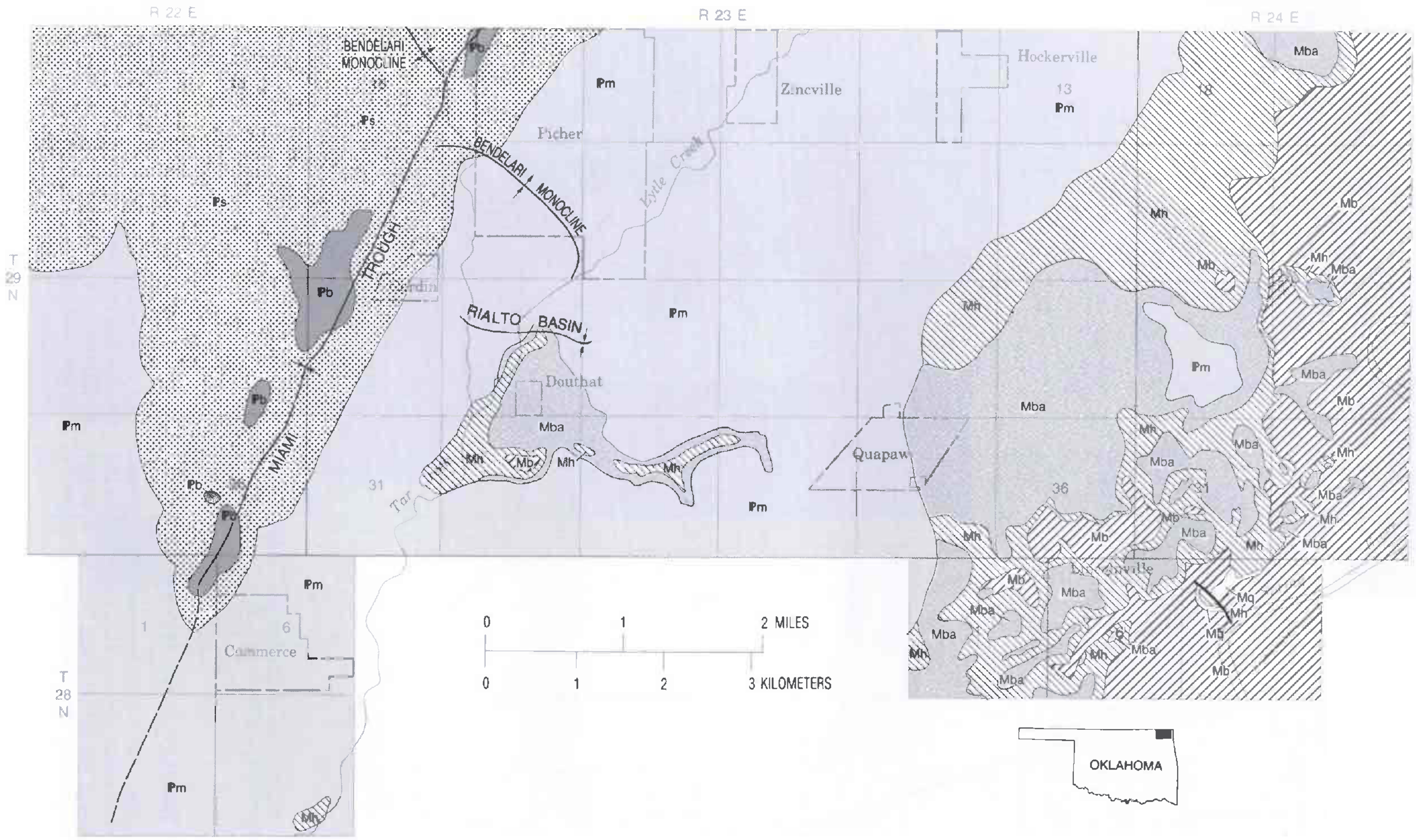


Figure 3. Major geologic and tectonic provinces in northeastern Oklahoma, southeastern Kansas, southwestern Missouri, and northwestern Arkansas.

HYDROLOGY OF MINED AREA

Tar Creek and its main tributary, Lytle Creek, are the two major streams that flow through the main part of the Picher Field. The movement of water down these streams has been modified by mill-tailings piles adjacent to and sometimes within the main channels. In some areas, diversion dikes were constructed to keep water from overflowing into shafts. At the time of mining, surface water was generally of poor quality and was not used for domestic consumption. As men-



R 22 E
R 23 E
R 24 E
T 29 N
T 28 N
BENDELARI MONOCLINE
MIAMI TROUGH
RIALTO BASIN
Picher
Zincville
Hockerville
Douthat
Quapaw
Commerce
Pm
Ps
Pb
Mba
Mh
Mb
Mq
0 1 2 MILES
0 1 2 3 KILOMETERS
OKLAHOMA

EXPLANATION

MIDDLE PENNSYLVANIAN

Desmoinesian

IPb
IPs
IPm

KREBS SUBGROUP OF CHEROKEE GROUP

Predominantly gray, dark-gray, and black shale interbedded with buff, fine- to medium-grained sandstone. Boggy Formation, IPb (Bluejacket Sandstone Member only); Savanna Formation, IPs; McAlester Formation, IPm (Warner Sandstone and McCurtain Shale Members)

UNCONFORMITY

MISSISSIPPIAN

Chesterian

Mba

BATESVILLE SANDSTONE

Mh

HINDSVILLE LIMESTONE

UNCONFORMITY

Meramecian

Mq

QUAPAW LIMESTONE

Osagean

Mb

BOONE FORMATION

Gray crinoidal limestone interbedded with nodular chert

Contact

Fault

Syncline; dashed where inferred

Monocline

Figure 4. Generalized geologic map, Picher Field, Oklahoma (modified from McKnight and Fischer, 1970; Reed and others, 1955; Wilson, 1979).

System	Series		Group, Formation or member	Bed (Informal Letter Classification)
PENNSYLVANIAN	Desmoinesian	Krebs Subgroup (Cherokee Group)	Bluejacket Sandstone Member (of Boggy Formation)	
			Savanna Formation	
			Doneley Limestone Member (Reed and others, 1955)	
			McAlester Formation Warner Sandstone Member	
			McCurtain Shale Member	
			UNCONFORMITY	
MISSISSIPPIAN	Chesterian		Fayetteville Shale	
			Batesville Sandstone	
			Hindsville Limestone	
			UNCONFORMITY	
	Meramecian		Quapaw Limestone	
		Boone Formation	Moccasin Bend Member	B C D E F G H
			Baxter Springs Member	J K L
			Short Creek Oolite Member	
			DISCONFORMITY	M
	Osagean		Joplin Member	
			Grand Falls Chert Member	N O P Q
			Reeds Spring Member	R
			St. Joe Limestone Member	
MISSISSIPPIAN AND DEVONIAN	Kinderhookian and Upper Devonian		Chattanooga Group	
			UNCONFORMITY	
ORDOVICIAN	Lower Ordovician		Cotter Dolomite Jefferson City Dolomite Roubidoux Formation Gasconade Dolomite Gunter Sandstone	
CAMBRIAN	Upper Cambrian		Eminence Dolomite Potosi Dolomite Derby–Doe Run Dolomite Davis Formation Reagan Sandstone	
PRECAMBRIAN			Granite and volcanics	

Figure 5. Correlation chart for Tri-State District, Oklahoma (modified from Reed and others, 1955; McKnight and Fischer, 1970; Kurtz and others, 1975; Wilson, 1979; Reis, 1984).

tioned earlier, until the early 1930s a mill was operated on nearly every mineral lease. Weidman and others (1932) indicated that about 40 gal/min was needed for every ton of ore milled. Water from creeks and/or from mines was pumped into storage ponds and subsequently used in the milling process.

Ground water is the principal source of water for domestic and industrial users adjacent to and within the Picher Field. An investigation of the ground-water resources of Ottawa County was published by Reed and others (1955) and Hittman Associates (1981) described the chemical quality and conditions of ground water within the flooded mine workings.

The Roubidoux and Boone Formations are the principal ground-water aquifers in this region. All public water supplies and most industrial water supplies in Ottawa County come from wells drilled into the Roubidoux. The Roubidoux Formation is a 160-ft-thick sequence of Ordovician cherty dolomite interbedded with thin sandstones. This aquifer is generally 900–1,000 ft deep in the mining area. The principal outcrop area is the central part of the Ozark Mountains, in south-central Missouri and north-central Arkansas, 50–150 mi east of Ottawa County. Reed and others (1955) reported that wells completed in the Roubidoux flowed at the surface prior to 1918. By the 1920s, a number of mill operators drilled wells into the Roubidoux to augment their water supplies. By 1947, the potentiometric surface of the Roubidoux was substantially lower, and pump lifts were as much as 500 ft. Water-level data obtained from the city of Miami suggest that the decline has stabilized since 1975 (Hittman Associates, 1981). The potentiometric surface of the Roubidoux near Miami appears to have remained about 320 ft above mean sea level since 1975 (Hittman Associates, 1981).

Away from the major pumping areas, the potentiometric surface of the Roubidoux is higher. A well completed in the Roubidoux at Eagle Picher's boron plant (northwest of Quapaw) had a water altitude of approximately 490 ft above mean sea level.

After the Roubidoux Formation, the Boone Formation is the most important source of ground water in Ottawa County. However, the water in the Boone has been utilized little, because of the variability in water yields. Contaminated surface waters may enter the Boone readily through fractures and/or sinkholes; this possibility is a serious drawback to the utilization of Boone ground water as a reliable public supply.

Large volumes of water were encountered during mining operations in the Picher Field. Reed and others (1955) pointed out that large ground-water yields from the Boone occur in the mining district where geologic processes may have been especially effective in creating openings in the rock. However, much smaller yields may be the rule in other localities. As the mining district matured, a large network of interconnected underground mines was created. Abandoned mine shafts, surface collapses over abandoned mine workings, and test holes facilitate entrance of surface water into the Boone. Surface-water infiltration undoubtedly contributed to some water problems in the undergound mine workings.

To maintain unsaturated conditions in the mine workings, large-capacity sump pumps were used. Pumpage from the Boone varied with time and depth of mining. Williams (Weidman and others, 1932) reported that 43 stations in Oklahoma and Kansas were pumping more than 13 million gal/day in the early 1930s. Reed and others (1955) reported that total pumpage from the mines exceeded 13 million gal/day during World War II. Pumpage from the Boone continued until the middle to late 1960s, when major mining ceased.

At present, recharge to the mines comes from natural infiltration through fractures and solution cavities, as well as from inflow to abandoned shafts, boreholes, and collapse features. Water samples taken from mine shafts during 1975–77 contained metals such as cadmium, lead, zinc, iron, manganese, and nickel (Playton and others, 1980). Water levels continued to rise in the mine workings until the workings were filled. Acid water charged with above-normal concentrations of iron, lead, and zinc began to discharge to the surface through abandoned boreholes late in 1979. The two main discharge points are (1) south of the brick plant in south Commerce and (2) near the confluence of Lytle and Tar Creeks (a few tens of yards northeast of the bridge).

Considerable interest and concern exist about potential contamination of surface- and ground-water supplies from mine water. Mine water may migrate laterally away from the underground mines through the Boone Formation and possibly contaminate nearby domestic and stock wells. Furthermore, mine water may move vertically downward through abandoned deep water wells that intersect the underlying Roubidoux Formation. A number of investigations to study mine-water contamination problems are being coordinated by the Oklahoma Water Resources Board.

EVALUATION OF HAZARDS AND HAZARD POTENTIAL

In the Picher Field, beds were mineralized over such a large vertical extent that some mining chambers with ceiling heights greater than 90 ft were created during active mining. The overlying rock strata, principally Pennsylvanian shale and sandstone, are not very competent. In some places, stripping of pillars prior to abandonment led to roof instability and subsidence. Unsafe conditions and potential environmental problems have been recognized for many years. Renewed interest in and concern with mine-subsidence problems led to a systematic study to fully evaluate the mine-related cave-ins. The study is intended to serve as a guide to remedy existing and/or potential unsafe conditions.

Information on the location and extent of past mining activities in the Oklahoma portion of the Picher Field is displayed on a 1:15,840-scale map (Pl. 1; Table 1 in Appendix). Hazards such as open shafts and surface-collapse features were mapped, tabulated, and displayed on 1:24,000-scale base maps (Pl. 2; Tables 2 and 3 in Appendix). The program also includes the tabulation and map display of mine- and mill-waste accumulations associated with the underground mines (Pl. 3; Table 4 in Appendix).

UNDERGROUND MINE WORKINGS

Approximately 2,540 acres are underlain by underground lead–zinc mines in northeastern Oklahoma. Underground mines are found in 47 sections north of Miami, Oklahoma. However, the greatest concentration of mining was in the vicinity of Picher, Oklahoma, in T29N, R23E.

The principal ore zones occurred in the Mississippian Boone Formation. The *M* bed was the main ore zone, followed by the *K*, *G*, and *H* beds (Fig. 5). Low-grade, blanket-like ore deposits, referred to as *sheet ground*, occurred in the Grand Falls Chert Member and were of significant commercial value because of their wide areal extent. Some ore was mined from Chesterian beds in the eastern part of the district near Lincolnville. In the eastern part of the district the Pennsylvanian units are absent or very thin; therefore, mining depths were shallow compared to those in the main part of the field 5 mi west and northwest of Lincolnville. Mining depths in the Lincolnville area were generally 80–100 ft, whereas mining depths at the Scammon Hill mines (north of Commerce) exceeded 300 ft. Typical mining depths in the main part of the field were 180–250 ft. A summary of mine depths, ore zones, and working heights for each major mine is given in Table 1 (Appendix).

The size of most mining tracts was 40 acres or some multiple of 40 acres, such as 80 or 160 acres. Some tracts, particularly in the earliest-worked fringe area, were subdivided into areas of 10 acres or less. The orebodies were nearly flat, and the operators mined to the vertical planes that marked the extension of the land boundaries at depth. Mining rights were leased from the landowners, who were paid a percentage royalty of the gross mineral sales from the tract. In Oklahoma, most land ownership was originally vested in individuals of the Quapaw Indian tribe. A common practice in the history of the field was for the holder of the first lease—whether an individual, royalty company, or mining company—to sublease at an increased royalty rate to the actual operator or middleman.

Because of the shallowness of the deposits, the relative ease with which they could be mined and milled, and the wide technical experience gained from earlier operations in adjacent subdistricts of the Tri-State region, numerous small but efficient mining companies were organized for operation on individual 40-acre tracts. A large turnover in operating companies occurred from year to year. Leases changed hands or were subdivided or regrouped into different operations, and the mine names were constantly changing. Orebodies commonly extended from one tract to the next.

In the main part of the field, an almost continuous underground network of mine workings extended from near Eagle Picher's central mill northward into Kansas. Detailed mine maps were made for each tract to ensure proper royalty payments and to provide a guide for future development. Map scales varied from 1 in. = 40 ft to 1 in. = 100 ft. In the late 1950s or early 1960s, the U.S. Bureau of Mines began to compile underground-mine-workings data and drill-hole information for each section of land on maps at a scale of 1 in. = 200 ft. Two maps, a north half and a south half, were drafted for each section. These maps provide almost complete coverage for the Oklahoma portion of the Picher Field. The original tracings are stored at the Missouri Southern State College (MSSC) library, at Joplin, Missouri, in the archives department.

The half-section maps, detailed mine maps found at MSSC, detailed mine maps rescued by John Mott from a former miner's garage, detailed mine maps from the U.S. Bureau of Land Management (Tulsa) files, and Eagle Picher's maps at a scale of 1 in. = 300 ft were the principal sources of information used to compile a map showing mine workings and shafts for Oklahoma (Pl. 1). The map is intended to serve as a general guide for location and extent of underground mine workings. Only major pillars are shown, because of map-scale limitations. Furthermore, lower and/or upper mine levels that extended beyond the main level are shown as part of the main level in order to portray areal extent. Therefore, some of the mine workings displayed on the map may not be connected on the same level.

Shaft and Surface-Collapse Inventory

Open shafts and surface-collapse features associated with the abandoned underground mine workings probably present the greatest visible hazard potential in the Picher Field. A field-inspection program was initiated in May 1981 to describe the present shaft-site conditions and to locate ground-subsidence areas. The field work was completed in May 1982.

Mine-workings maps and large-scale aerial photographs in color taken in 1980 were used to guide the field inspection. A description of the present condition at each shaft was made. The presence or absence of water was noted, as well as water depth. Surface-collapse dimensions were either measured or estimated. The site conditions at each shaft were recorded on note cards, which were numbered serially as a reference file.

Orebodies had been intersected by vertical shafts usually having but one compartment. Shaft dimensions were commonly 5 × 7 ft or 6 × 6 ft in cross section. Most shafts were sunk 5–12 ft below the level of the orebodies to provide a drainage sump. A platform was constructed over the sump to permit handling of the ore buckets. From the collar down to a point below the shale, the shaft was close-cribbed with 2- × 6-in. pine timbers. Lagging, which was placed behind the cribbing, secured the cribbing and prevented misalignment. A common practice was to crib the shaft through the first shaly zone unless deeper shale or broken strata were encountered. However, a number of shafts were continuously cribbed to guard against the possibility of hanging the bucket on the wall or overturning in the shaft. Men were raised or lowered in buckets, and machinery and supplies were handled either in buckets or with cables (Weidman and others, 1932).

Generally in the initial stages of mine development, an auxiliary shaft or field shaft was sunk about 300 ft from the first shaft. The first shaft usually was used to lift ore up to the surface to be processed by a nearby mill. The two shafts were connected by a drift to improve ventilation and/or to provide an alternate route for egress.

Mining was done by the room-and-pillar method. Rooms or open stopes were created with irregularly spaced pillars. The structure and lithology in the roof or *back* of the stope and the width and height of the orebody controlled the size and spacing of the pillars. If the shaft was completed in the orebody, stopes were opened radially from the shaft to the full height of the ore. Pillars, 20–50 ft in diameter and commonly spaced 30–100 ft apart, supported the back. The minimum height of the working face was about 6 ft, the average about 25 ft, and the maximum more than 100 ft. About 15% of the orebody was left for the pillars. Later, when the reserves were depleted, as much as 50% of the tonnage left in the pillars was recovered by slabbing operations or by complete removal of certain pillars (Weidman and others, 1932).

Mine-workings maps and field surveys indicated that at least 1,064 shafts were sunk in the Oklahoma portion of the Picher Field. These shaft locations are shown on Plate 1. Also, numerous prospect and development shafts, 10–20 ft deep, were sunk in the Peoria district (S½ sec. 12, T28N, R24E) in the late 1800s and early 1900s. A shaft-location map for the Peoria district was not made, because of the absence of mine-map information. Almost all of these shafts were filled and covered with mill-waste debris, thus concealing the shaft locations. The Walton Mine, 8 mi west of Picher in sec. 13, T29N, R21E, is not shown on Plate 1. However, the shaft has been filled.

A classification scheme was developed so that shafts with similar site conditions could be grouped. Surface dimensions (length, width, or diameter) were measured or estimated for each collapse feature. The largest dimension—usually diameter, because most of the collapse features are nearly circular—was used to classify the collapse conditions. They are categorized as (1) minor collapse (2–30 ft), (2) moderate collapse (31–94 ft), and (3) major collapse (≥95 ft).

The shafts were grouped into seven shaft-status categories. A summary of the inventory is listed in Table 5. At the time of the study more than 50% of the shafts were concealed or filled. A number of the shafts are now covered by mill-waste piles. Shafts that were indicated on mine maps but could not be found were classified as concealed. Several shafts have been filled either by the mine operator, the landowner, or the U.S. Bureau of Indian Affairs. With several shafts, it was not possible to distinguish between the filled and/or concealed condition. Therefore, these shafts were grouped into one category. A shaft was considered open if

TABLE 5.—SHAFT-STATUS INVENTORY

Shaft status	Diameter (ft)	Number	Percent of total
Open		59	6
Open with minor collapse	≤10	36	3
Minor collapse	2–30	241	23
Moderate collapse	31–94	115	11
Major collapse	≥95	30[a]	3
Concealed/filled		558	52
Covered		25	2
Total		1,064	100

[a]At three sites, two shafts were involved in the same collapse; collapse is listed twice for each site. At one site, three shafts were involved in the same collapse; collapse is listed three times. Therefore, 30 shafts are involved in 25 separate collapses.

the original cribbing was still intact and no apparent obstruction could be observed. However, most shafts were nearly full of water, which obscured the condition of the shaft below the water line. Some shafts in this condition may be partially filled and/or partially collapsed at depth. Where shaft collars are undergoing minor collapse (<10 ft) and the cribbing is nearly intact, the shaft was classified as open with minor collapse.

About 25 covered shafts were recognized. Generally, a thin concrete slab was used to cover the shaft. Large wooden timbers and/or corrugated metal were also used to cover other shafts. Undoubtedly many more shafts were covered than were recognized. Some of these shafts are probably reported as concealed, especially if the cover was at or slightly below ground level. Some covers probably failed when a shaft began to collapse. Concrete debris from former shaft covers was observed in the bottoms of a few shaft collapses. Thus, it appears that shaft covers are ineffective in securing shafts. There is a high probability that most of the 25 recognized covered shafts will fail in the future.

There are 481 shafts either open or in some stage of collapse. Information about present site conditions for each of these shafts is listed in Table 2 (Appendix). Except for a shaft near Peoria, Oklahoma, shaft locations are shown on Plate 2.

Five shafts that were filled are also listed in Table 2 and are shown on Plate 2. One shaft is within the Quapaw city limits. This shaft has a history of recurring collapse, particularly after lengthy periods of precipitation. The remaining filled shafts are in the Commerce area. One collapsed shaft site, 28N-23E-7(1), was formerly used as a garbage dump. A 1964 aerial photograph shows that a 330- × 200-ft elliptical collapse occupied this site; by 1972 the site was filled. The filled area appears to be slightly depressed, and the ground over the former collapse is unstable. The other three shafts are in sec. 1, T28N, R22E. Major collapses are also associated with these shafts. At site 30 (Pl. 2), a 160- × 130-ft elliptical collapse existed in 1972. By 1979 the collapse was filled. A shaft site at the Turkey-Fat Mine, (site 32, Pl. 2), was associated with a 275- × 210-ft elliptical collapse and a 65-ft circular collapse in 1964. By 1972 the collapses were filled. A slight depression over the filled collapses existed by 1980. By 1972, a 200- × 160-ft elliptical collapse existed at the Midas Mine (site 39, Pl. 2). However, by 1979 the collapse was filled.

The four filled shaft sites near Commerce were included in the table because major collapses were associated with these shafts. The three collapses in sec. 1 are the largest collapse features that have been filled in the Picher Field. These sites should be monitored to evaluate the effectiveness of the filling programs. Construction over these sites probably should be discouraged. The fourth site, a former garbage dump, probably will have instability problems for a long time, because most of the fill material placed into the collapse was highly compressible.

Almost 70% of the open mine shafts and/or shaft collapses occur in T29N, R23E. Secs. 19, 23, 28, and 29 contain 25–38 open mine shafts and/or shaft collapses per section. Secs. 14, 15, 17, 22, 27, 30, 33, and 36 contain 15–22 open mine shafts and/or shaft collapses per section. The remaining sections, 13, 16, 18, 20, 21, 24, 26, 31, 32, 34, and 35, contain 12 or fewer collapse features per section. No open mine shafts or collapse features occur in sec. 25.

The area with the second-largest concentration of open shafts lies northeast of Lincolnville, in secs. 30, 31, and 32, T29N, R24E. This area contains about 11% of the open mine shafts and/or shaft collapses. Mississippian rock units exposed at the surface in the Lincolnville area (Fig. 4) are more competent than the Pennsylvanian units that crop out west of Lincolnville. Therefore, most of the unfilled shafts northeast of Lincolnville are either relatively intact or are associated with minor collapse. A number of shafts in this area have been filled by landowners and/or by Quapaw Indian tribal members. Many of the remaining open shafts in this region could be relatively inexpensively and safely filled.

Table 2 contains information about present site conditions for 486 shafts in the region.[2] Suggested remedial actions to improve safety conditions for each shaft entry are also included in Table 2. The remedial-action column in Table 2 contains at least one of the following suggested actions: (1) none, (2) fill, (3) fence, and (4) fence or fill. No action was recommended for 107 (21%) of the sites. Generally, the no-action category includes collapse features that were nearly full of water and had exhibited no recurring collapse for a number of years. The water is frequently perched on surface debris that has been down-dropped into the mine workings. Usually the water quality is good enough for livestock use. Therefore, many of these sites now serve as stock ponds.

About 65% (316) of the sites were recommended for filling. This category includes open shafts, open shafts with minor collapse, minor collapses, and moderate collapses. Two shaft collapses pose a highly dangerous situation for human safety. One shaft is south of Picher High School, in sec. 20, T29N, R23E, (site 13, Pl. 2). A 25-ft circular collapse occurs in a spoil pile used by motorcycle enthusiasts. The water level is about 25 ft from the top of the spoil material that surrounds the shaft. This collapse should be filled immediately. The second dangerous shaft collapse is a 40-ft circular pit at least 50 ft deep in the middle of a former

[2]There are 481 sites that involve 486 shafts. At three sites, two shafts are involved in the same collapse; at one site, three shafts are involved in the same collapse.

tailings pond, in sec. 17, T29N, R23E, (site 7, Pl. 2). Recreational vehicles and motorcycles frequently pass this location. The collapse cannot be seen until one is very close to the feature. The ground adjacent to the collapse appears to be very unstable. Therefore, the best remedial action probably would be to construct a fence around the collapse.

Eighteen sites are recommended to be fenced, and 40 sites are recommended to be either fenced or filled. Generally, these sites contain collapse features that exceed 95 ft in diameter. Since filling of large surface-collapse features may not be economically feasible, an alternative suggested remedy is to fence. Some moderate- and small-sized collapse features, less than 95 ft across, have near-vertical, actively caving sidewalls, creating unstable ground conditions near the collapse. This situation is unsafe for personnel and heavy equipment that may be needed to fill the collapse. In such cases, the suggested remedy was to fence. However, fencing should be thought of as a practical temporary action, because periodic surveillance and maintenance of fences will be required. Also, fences can be easily breached by vandals, as well as undercut by recurring collapse.

Two open pits are listed in Table 2 (Appendix). One open pit near Lincolnville, 28N-24E-6(1700), is about 200 ft long and 70 ft wide. The depth varies from a few feet to about 30 ft. The second open-pit area, 29N-23E-9(1701), is near Douthat. Two elliptical pits, 330 × 100 ft and 130 × 65 ft, occur at this site. Water is present in the bottom of the Lincolnville pit and fills the Douthat pits nearly to the surface. These pits are thought to have been dug between 1939 and 1952. No remedial action is suggested for these open pits.

All major collapses, which include those associated with shafts and those unrelated to shafts, were studied in detail. There were 29 major collapses associated with 34 shafts and 55 non-shaft-related collapses. Aerial photographs taken in 1939, 1952, 1964, 1972, 1979, 1980, and 1982 were used (1) to date the collapse features and (2) to chart the growth of the collapse features over a period of time. The date of subsidence, location, damages involved, and suggested remedial action are listed for each collapse in Table 3 (Appendix).

Most (66%) of the collapses, listed in Table 3 (Appendix) occurred prior to 1952. A summary of collapses for each time interval is listed in Table 6. Only one new collapse site was found after 1979: late in January 1984, a 20-ft-diameter collapse occurred near Commerce, in the southeast corner of sec. 1, T28N, R22E; this collapse was filled in February 1984. Also, several existing collapses have enlarged since 1979.

Approximately 27 surface acres have been disturbed as a result of shaft-related collapses. Major shaft-related collapses account for more than 80% (22 surface acres) of the total disturbed land. Four shaft-related collapses involving 3.3 acres near Commerce were filled between 1964 and 1979.

TABLE 6.—SUMMARY OF COLLAPSES FOR EACH TIME INTERVAL BETWEEN AERIAL-PHOTOGRAPHIC SURVEYS

Time interval	Number of collapses[a]
Pre-1939	27
1939–52	25
1952–64	9
1964–72	9
1972–79	14

[a]Collapse features described in Table 3 (Appendix).

Most major collapses have occurred in rural areas. The largest concentration of shaft-related major collapses is found in a zone 0.5 mi wide by 1 mi long, extending southward from Hockerville (E½ secs. 14 and 23, T29N, R23E); 10 shafts are involved in eight separate collapses. Other areas that include several major shaft-related collapses are in sec. 19, T29N, R23E, west of Cardin, and near Commerce. The largest collapse feature in the district is associated with three shafts at the Domado Mine, sec. 29, T29N, R23E (Fig. 6). This collapse is 560 ft long and 400 ft wide, covering 4.04 acres, and is filled with water.

Very little destruction of buildings and roads has resulted from surface collapse. However, on 21 July 1967, 18 persons occupied houses that were affected by a 1.5-acre collapse north of Picher High School. Five minor injuries resulted from the collapse. Two houses were in the center of the collapse, and one house on the lip was tilted 25° from the horizontal. An attached garage of a fourth house on the rim of the collapse was broken away from the house and severely crumpled. The surface near the center of the collapse was dropped about 25 ft.

Fifty-five non-shaft-related collapses were inventoried. At least one fatality associated with an automobile accident can be attributed to a non-shaft collapse on east A Street, 2.5 mi east of Picher. On 31 May 1978, a cave-in was observed about 8 a.m. on the south side of east A Street, sec. 23, T29N, R23E (site 1553, Pl. 2). By noon the cave-in had reached the center of the road. The caved-in area was about 90 ft long, 40 ft wide, and 50 ft deep.

Of the 55 non-shaft-related collapses which were located, 30 fall within the major-collapse category. Approximately 20 surface acres have been disturbed as a result of non-shaft-related collapses. Sec. 1, T28N, R22E, west of Commerce, and sec. 19, T29N, R23E, west of Cardin, contain the largest concentration of non-shaft-related collapses. The largest non-shaft collapse is a 450- × 200-ft elliptical collapse that covers about 2.60 acres. This collapse occurs as a 20-ft-deep depres-

Figure 6. Aerial view of 4.04-acre collapse associated with three shafts at Domado Mine, 29N-23E-29 (1-3).

sion in a former tailings pile in sec. 30, T29N, R23E (Fig. 7).

Most of the non-shaft-related collapses appear to be related to mining of multiple ore zones. A high concentration of non-shaft-related collapses west of Cardin is associated with the Crystal and Central Mines. Detailed mine maps of this area indicate that at least two and possibly three ore zones were mined at some places. Large stopes were created during mining at some places. Apparently, the pillars left for support were not sufficiently strong to support the overburden material, or they were subsequently removed, which ultimately led to ground failure above these mine workings.

Mine and Mill Waste

Significant quantities of mill-waste material were generated by milling of the lead–zinc ores (Figs. 8,9). Stroup and Stroud (1967) reported that approximately 5,000 surface acres were affected by mine- and mill-waste materials. However, a recent tabulation of mine- and mill-waste materials suggests that approximately 2,900 acres in Oklahoma were overlain by mine and/or mill byproducts. The discarded mill-waste material, chiefly composed of chert fragments 0.75 in. or less in diameter, was referred to as *chat*. The chat was transferred away from a mill by a series of conveyors and elevators and heaped into piles. Some piles attained heights greater than 200 ft. Prior to 1930, almost every mine had its own mill. Therefore, large areas of land previously used for agriculture were used to store mill waste. Ore recovery prior to 1920 was 58–70%. New advances in extraction metallurgy encouraged mine owners to reprocess the tailings. In some instances tailings were reprocessed for a second and even a third time for their lead and zinc content.

Some of the larger chat piles are being reworked for a final time. The material is now utilized for railroad ballast, road building, and concrete and asphalt aggregate.

An inventory of tailings piles, former tailings piles, and former tailings ponds was conducted by using aerial photographs taken from 1927 to 1980. This information is displayed on Plate 3 and contained in Table 4 (Appendix). There are 146 former chat-pile sites and 119 existing chat piles that occupy about 1,200 acres. Also, 14 major tailings ponds were inventoried.

Approximately 900 acres are overlain by chat piles. There are 33 chat piles that contain 95% of the chat available for commercial use. The major chat piles were mapped on large-scale (1:8,000)

Figure 7. Aerial view of largest non-shaft collapse (2.60 acres), Blue Goose No. 1 Mine, 29N-23E-30(1511).

1980 color aerial photographs. Elevation information was obtained for 15 representative chat piles, using a surveying altimeter. This information was used to calibrate chat-pile elevations on the aerial photographs. The chat piles were contoured, using a 50-ft interval, with a radial planimetric plotter. Then the information was transferred to 1:12,000-scale base maps. A planimeter was used to determine the areal extent of the piles. The areal data and geometric configuration were used to determine the volume (Table 7).

Approximately 45.6 million yd^3 of material are contained in the 33 major chat piles. Volumes ranged from 80,000 to 6.9 million yd^3 as of May 1980. If 100 lb/ft^3 is used for bulk density, then the major chat piles would contain about 61.5 million short tons. There are 87 minor mill-waste piles that contain 30,000 yd^3 or less of chat per pile. The minor chat piles were excluded from the survey. However, their location and areal extent are identified on Plate 3.

Several of the large chat piles are being actively mined. For example, the chat pile near the South Side Mine, 29N-23E-31(1), contained an estimated 1.25 million yd^3 as of May 1980. By March 1982, the chat pile was almost completely removed. Therefore, the survey is valid only for May 1980.

Almost 800 acres were used for tailings ponds in Oklahoma. Almost every mill site had a tailings pond. However, only the major tailings ponds were inventoried. Two of the largest tailings ponds, one covering 79 acres and the other 148 acres, were associated with Eagle Picher's central mill in sec. 31, T29N, R23E. Most tailings ponds are dry and contain a few inches to a few feet of fine-sand- to silt-sized material. This material will support some vegetation. The embankments surrounding such ponds probably should be maintained for erosion control. The establishment of vegetative growth in the bottoms of the former ponds would substantially reduce blowing dust that originates from some of the larger pond sites.

In some areas, particularly on the fringe areas adjacent to the main area of mining, the land beneath former chat piles has been successfully reclaimed. The totally reclaimed areas are being used principally to grow soybeans and/or wheat. The chat material is essentially devoid of organic content and will not support vegetation. In order to ensure a successful reclamation program, the chat must be almost completely removed. If the residual chat veneer is generally less than 3 in. thick, this material can be mixed with original topsoil that existed before emplacement of the chat pile. This is usually accomplished by deep

Figure 8. Foundation for former mill at St. Louis No. 4 Mine (29N-23E-24). Boulder pile is adjacent to mill, and chat pile is in foreground.

Figure 9. Large chat pile (*left*) and boulder (*right*) at Howe Mine (29N-23E-17).

TABLE 7.—MAJOR-CHAT-PILE INVENTORY

Mine name	Location and map number	Field number	Maximum height (ft)	Volume ($\times 10^6$ yd^3)	Mining status
Mehunka Zeka Beaver	29N-22E-13(1)	3	25 (avg.)	0.78	Inactive
Adams-Mudd	29N-22E-23(1)	33	75	.18	Inactive
Wilson	29N-22E-25(5)	2	95	.21	Inactive
Pioneer	29N-22E-25(9)	1	200	6.90	Active
Scott	29N-23E-13(1)	29	80	.21	Inactive
C. Y. Semple	29N-23E-13(2)	28	168	1.38	Intermittent
WMW-Brewster	29N-23E-15(6)	27	114	1.70	Active
Beck	29N-23E-15(11)	25	45	.28	Inactive
Swift-Commonwealth	29N-23E-16(1)	22	122; 107	5.53	Inactive
La Salle	29N-23E-17(9)	8	87	1.98	Inactive
Anna Beaver	29N-23E-19(7)	4	162	2.80	Inactive
John Beaver	29N-23E-19(8)	5	50	.09	Inactive
St. Joe-Premier-Golden Hawk	29N-23E-20(8)	11	150	1.80	Inactive
Premier	29N-23E-20(10)	12	71	.18	Inactive
OKO	29N-23E-20(11)	15	56	.38	Inactive
Rialto	29N-23E-20(12)	14	129	1.27	Active
Rialto	29N-23E-20(13)	13	28	.27	Inactive
Kenoyer	29N-23E-20(16)	10	120	.98	Inactive
Kenoyer	29N-23E-20(21)	9	45	.08	Inactive
Mahutska	29N-23E-21(1)	23	110; 100	2.11	Inactive
Tulsa	29N-23E-22(7)	26	75	2.21	Inactive
St. Louis 4	29N-23E-24(1)	30	80	.55	Inactive
St. Louis 4	29N-23E-24(2)	31	75	.30	Inactive
New Chicago No. 2	29N-23E-28(12)	24	116	2.41	Inactive
Rialto	29N-23E-29(2)	16	52	.46	Active
Rialto	29N-23E-29(2)	17	80	.22	Active
Skelton	29N-23E-29(8)	21	140	1.52	Inactive
Admiralty No. 4	29N-23E-29(14)	20	132	.36	Inactive
Domado	29N-23E-29(17)	18	89	.62	Inactive
Douthat-See Sah-Admiralty No. 4	29N-23E-30(7)	19	100	2.55	Inactive
Blue Goose No. 1-Short Horn	29N-23E-30(13)	6	155	3.92	Active
South Side	29N-23E-31(1)	7	205	1.25	Active (Almost completely removed, 3/1/82)
Montreal	29N-23E-32(2)	32	72	.13	Inactive
			Total	45.61	

disking with a tractor. Approximately 260 acres (22%) of the total acreage once occupied by chat piles has been reclaimed. Most of the reclaimed land supports some form of agricultural activity. However, some sites are being used for residential housing and light industrial activity, such as a salvage yard.

REGULATIONS AND LAWS THAT GOVERN MINING IN OKLAHOMA

All lead–zinc underground mines operated under the Oklahoma State Mining Code. The Oklahoma Legislature passed a bill in 1955 to require that all open vertical mine shafts either be protected by fencing or be plugged and filled. Incorporated into the State Statutes under Title 45, Sections 436 and 437, the law further requires that any person, firm, or corporation that allows a vertical mine shaft to remain open shall be deemed negligent as a matter of law and shall further be guilty of a misdemeanor. However, the law provides no mechanism and no funds for the State to close and/or seal those open shafts that were abandoned by companies that quit business before the law was enacted. Inasmuch as the State Attorney General ruled that mere ownership of the land upon which there is an open mine shaft does not constitute maintenance, use, or abandonment of an open mine shaft, present landowners cannot be compelled to fill, seal, fence, or otherwise take safety measures for the protection of the public.

Mines on restricted Indian lands also were subject to inspection by a supervising mining engineer representing the Indian agency. Apparently, certain rules and regulations (primarily for safety) were set forth by the State and by the Indian agency, and interpretations of compliance were based on the judgment of the inspector (Stroup and Stroud, 1967). Federal inspection by the U.S. Bureau of Mines Health and Safety Division began in 1965.

In 1977, the Surface Mining Control and Reclamation Act (PL 95-87) was passed by the U.S. Congress. The law authorized establishment of a trust fund, the Abandoned Mine Reclamation Fund. Fees paid by coal-mine operators support the fund. The fund is intended for reclamation and restoration of land and water resources adversely affected by past coal mining, and for the protection of public health, safety, general welfare, and property from extreme danger owing to the adverse effects of coal mining. However, fund money may be used to fill open and abandoned tunnels, voids, shafts, and entryways that have resulted from any previous mining if they constitute a hazard to public health or safety. A state governor can request approval of funds to solve this problem.

Section 409 of Public Law 95-87 pertains to filling voids and sealing tunnels. A summary of significant parts of section 409 is listed as follows:

Public Law 95-87—August 3, 1977, Surface Mining Control and Reclamation Act of 1977.
Title IV—Abandoned Mine Reclamation

Sec. 409—Filling voids and sealing tunnels.

a) The Congress declares that voids, open and abandoned tunnels, shafts, and entryways resulting from any previous mining operation constitute a hazard to the public health or safety and that surface impacts of any underground or surface mining operation may degrade the environment. The Secretary of the Interior, at the request of the Governor of any state, is authorized to fill such voids, seal such abandoned tunnels, shafts, and entryways and reclaim surface impacts of underground or surface mines which the Secretary determines could endanger life and property, constitute a hazard to the public health and safety, or degrade the environment. State regulatory authorities are authorized to carry out such work pursuant to an approved abandoned mine reclamation program.

b) Funds available for use in carrying out the purpose of this section shall be limited to those funds which must be allocated to the respective States or Indian reservations under the provisions of subsection 402(g).

c) The Secretary may make expenditures and carry out the purposes of this section without regard to provisions of section 404 in such States or Indian reservations where requests are made by the Governor or tribal chairman and only after all reclamation with respect to abandoned coal lands or coal development impacts have been met, except for those reclamation projects relating to the protection of the public health or safety.

d) In those instances where mine waste piles are being reworked for conservation purposes, the incremental costs of disposing of the wastes from such operations by filling voids and sealing tunnels may be eligible for funding providing that the disposal of these wastes meets the purposes of this section.

e) The Secretary of the Interior may acquire by purchase, donation, easement, or otherwise, such interest in land as he determines necessary to carry out the provisions of this section.

The U.S. Office of Surface Mining (OSM) revised the rules of the abandoned-mine-land-reclamation program. The revision appeared in the Federal Register, volume 44, number 126, on Wednesday, June 30, 1982. The revised rules concern the establishment and administration of the abandoned-mine-land-reclamation program by the states, Indian tribes, and federal government as required by the Surface Mining Control and Reclamation Act of 1977, PL 95-87. A summary of Part 875, non-coal reclamation, sections 11, 12, and 13, is listed as follows:

Federal Register: Vol. 47, No. 126
Wednesday 6-30-82
Rules and Regulations
Part 875—Non-Coal Reclamation
Authority: Secs. 409 and 412, Public Law 95-87

Sec. 875.11—Applicability

The provisions of this part apply to all reclamation projects on lands or water mined or affected by mining of minerals and materials other than coal and are to be carried out with money from the Fund and administered by a State or Indian Tribe under an approved reclamation program according to Part 884 of this chapter.

Sec. 875.12—Eligible lands and waters

Non-coal lands and waters are eligible for reclamation if—

a) They were mined or affected by mining processes;
b) They were mined prior to August 3, 1977, and left, or abandoned, in either an unreclaimed, or inadequately reclaimed, condition;
c) There is no continuing responsibility for reclamation by the operator, permittee, or agent of the permittee under statutes of the State or Federal Government;
d) The reclamation has been requested by the Governor of the State or head of the tribal body;
e) he reclamation is necessary for the protection of the public health and safety, or all coal-related reclamation has been accomplished; and
f) Moneys allocated to the State or Indian tribe under 872.11 (b) (2) & (3) of this chapter are available for the work.

Sec. 875.13—Requirements for non-coal reclamation

Reclamation of eligible non-coal mined lands and waters shall comply with the provisions of Section 409 of Public Law 95-87.

No federal, State, or local laws, regulations, or ordinances directly govern rehabilitation of land disturbed by mining activity in Ottawa County. Negotiations between a chat-haulage operator and the landowner may provide for land reclamation as a private agreement between the two parties.

DISCUSSION

Most surface-collapse sites in the Oklahoma portion of the Picher Field are associated with abandoned mine shafts. Many shaft collapses begin with the deterioration of the wooden cribbing near the shaft collar (Fig. 10). Generally, a 40- to 60-ft-thick sequence of interbedded shale and sandstone occurs near the surface. This material is highly susceptible to erosion and will cave in toward the shaft. Many of the cave-ins are 20–60 ft in diameter (Fig. 11). Cave-ins that extend into the underground workings are generally accompanied by spectacular surface collapses 200–400 ft in diameter (Figs. 12,13). There are 481 shafts either open or in some stage of collapse. Probably 316 of these shafts could be closed or sealed.

According to Frank J. Cuddeback, former manager of Eagle Picher's Tri-State mines and currently a mine consultant in Miami, Oklahoma, several shaft-sealing methods were used in the Tri-State district. A few shafts were sealed with concrete covers before 1937. A platform composed of 2- × 12-in. oak planks was placed at the original ground level on top of the shaft cribbing. Then, 10 to 12 in. of concrete was poured on top of the oak planks. Unfortunately, this type of seal lasted only as long as the old cribbing. Between 1937 and about 1947, several shafts were sealed with a large reinforced-concrete slab. A concrete slab 18–20 in. thick and 20 × 20 ft in area was constructed across the shaft opening 15–20 ft below the collar. After the concrete had hardened, the sealed shaft was filled to the surface with rock (usually chat). The subsurface seal was an improvement over the surface seal; however, the supporting material—commonly poorly consolidated shale—was susceptible to rapid sloughing when wet. During wet weather, caving under the slab often occurred, which eventually resulted in slab failure.

After 1947, Eagle Picher's shaft-sealing crew employed two shaft-sealing methods that were followed until final mine closure. One method consisted in the placement of a shaft seal or plug in solid rock, and the other method used a 6.5-ft concrete cube. Site conditions determined which method was used, the shaft seal in solid rock being the preferred method. The decision to use this method was based on the condition of the old cribbing. If the old cribbing was sufficiently strong to permit the work to be done safely, a location for the seal was chosen, preferably in limestone at a point below the cribbing. Generally the shaft walls were sufficiently irregular to hold the seal or plug. Usually four 6- × 8-in. supporting timbers were wedged in place across the narrow dimension of the shaft. Two- × 12-in. oak planks were laid over the support timbers to form a platform. The cracks and openings around the platform were sealed before the platform was covered by two layers of roofing tarpaper. Concrete was poured over the platform to a depth of about 12 in. A rectangular grid of reinforcing bars or scrap mine rails spaced 12 in. apart was laid on the concrete and covered with an additional 2.5 ft of concrete. After the concrete had hardened, the sealed shaft was filled to the surface with mill tailings. There have been no reports of failures for these seals since they became widely used in the late 1940s (F. J. Cuddeback, personal communication). This method of sealing is no longer applicable to abandoned open shafts in the Oklahoma portion of the Picher Field, because most shafts are completely filled with water. Where shafts are not filled with water, deterioration of the cribbing makes entry for installation unsafe.

Many abandoned shafts could not be sealed in solid rock. Eagle Picher's shaft-sealing crew successfully employed the concrete-cube technique

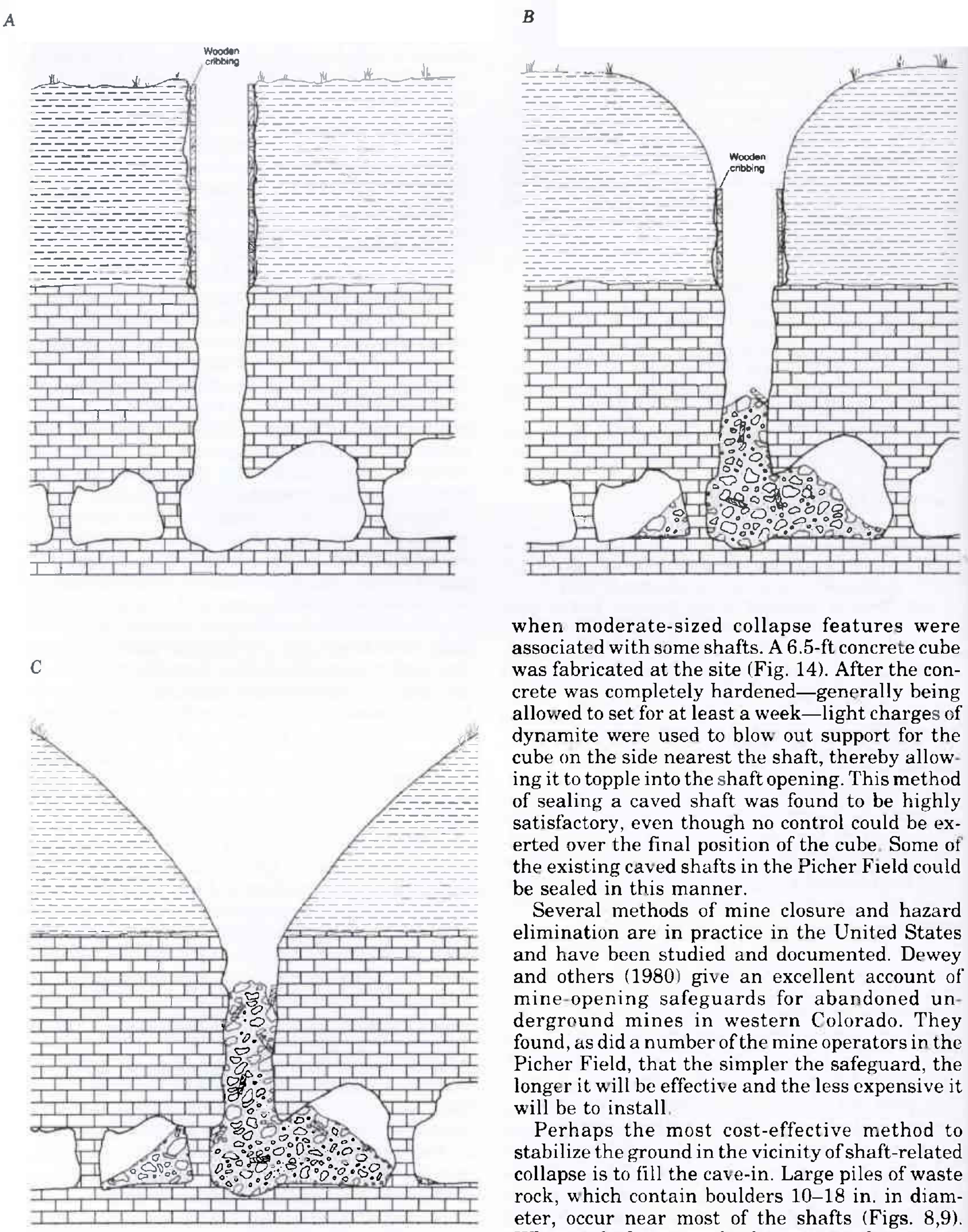


Figure 10. Sequence of schematic cross sections illustrating various stages of surface collapse associated with shaft failure. *A*, typical open shaft and underground mine workings. *B*, early stage of shaft failure. *C*, advanced stage of shaft failure.

when moderate-sized collapse features were associated with some shafts. A 6.5-ft concrete cube was fabricated at the site (Fig. 14). After the concrete was completely hardened—generally being allowed to set for at least a week—light charges of dynamite were used to blow out support for the cube on the side nearest the shaft, thereby allowing it to topple into the shaft opening. This method of sealing a caved shaft was found to be highly satisfactory, even though no control could be exerted over the final position of the cube. Some of the existing caved shafts in the Picher Field could be sealed in this manner.

Several methods of mine closure and hazard elimination are in practice in the United States and have been studied and documented. Dewey and others (1980) give an excellent account of mine-opening safeguards for abandoned underground mines in western Colorado. They found, as did a number of the mine operators in the Picher Field, that the simpler the safeguard, the longer it will be effective and the less expensive it will be to install.

Perhaps the most cost-effective method to stabilize the ground in the vicinity of shaft-related collapse is to fill the cave-in. Large piles of waste rock, which contain boulders 10–18 in. in diameter, occur near most of the shafts (Figs. 8,9). When a shaft was sunk, the waste rock was cast into piles adjacent to the shaft. Unlike the chat piles, this material has no known economic value and could be bulldozed into the collapse, not only filling the collapse but also helping to eliminate some of the mine-waste material.

Figure 11. A 20-ft-diameter circular collapse, Howe Mine, 29N-23E-17(41).

Figure 12. A 180- × 100-ft elliptical collapse, Gordon No. 2 Mine, 29-23E-18(8). Water level is approximately 35 ft below surface.

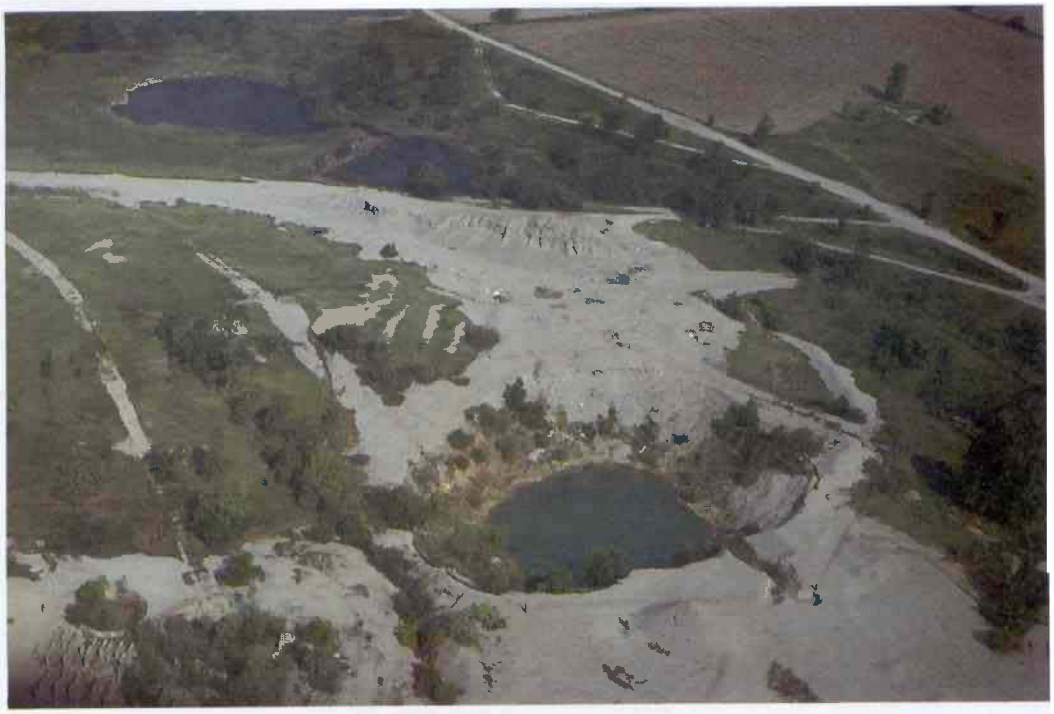


Figure 13. Two major shaft-related collapses, Anna Beaver lease, 29N-23E-19 (6, upper; 7, lower).

Figure 14. A 6.5-ft concrete cube used to seal a shaft on Grace Walker lease, 29N-23E-21(41).

An open mine shaft like the one depicted in Figure 10A may be filled in the manner shown in Figure 15. Material dumped into a mine shaft will generally form a conical pile on the floor of the underground mine working below the shaft. The size of the pile will depend on the type of material used, the height of the pile (vertical distance between the floor and ceiling), and the proximity to nearby support pillars. The angle of repose, or angle at which loose material will come to rest on a pile, varies with the frictional properties of the material and increases slightly as the size and angularity of the fragments increase.

The relative applicability of locally available materials for filling the voids is affected by water that fills all the mines in the Picher Field. If chat (coarse- to fine-sand-sized material) were dumped into a mine shaft, it would have a tendency to move laterally along the floor of the mine workings, assuring low angles of repose. This condition would probably require that large quantities of chat be used to fill some of the underground mine openings. Furthermore, saturated chat in an unconfined state, such as in an underground mine working, may move laterally under the weight of the fill within the shaft, causing recurring settlement problems. For these reasons, chat is not recommended as an initial fill material in the unconfined portion of the mine. Waste rock from the large boulder piles found adjacent to most mine shafts would be better suited for the initial fill.

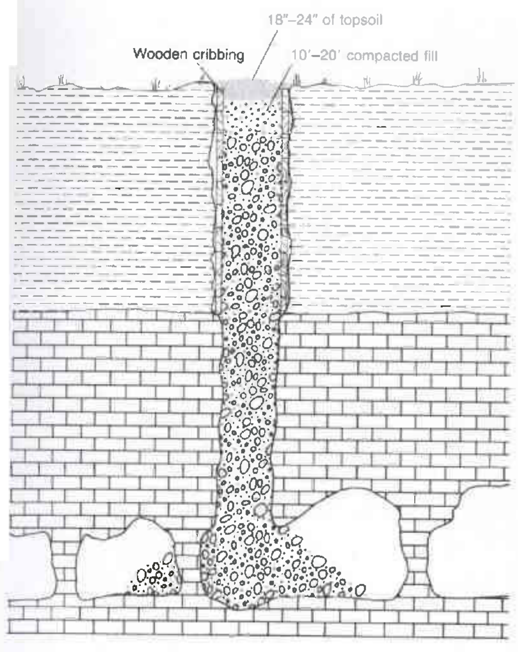


Figure 15. Schematic cross section of open mine shaft, illustrating one way to seal or close the opening in early stage of shaft failure.

To help determine the approximate volume of material needed to fill and seal abandoned mine-shaft sites, volume estimates were made for different sizes of collapse features, room heights, and shaft lengths (Table 8). For example, if a shaft opens into a 25-ft-high room, and boulder material, which has an angle of repose of 37°, were dumped into a shaft, a conical pile 25 ft high and 66 ft across at its base would be created. The pile would contain approximately 1,070 yd^3 of material (Table 8). If the shaft extended 250 ft vertically above the top of the underlying room, an additional 335 yd^3 of material would be needed to fill the void space. Near the top of the shaft, 10–20 ft of compacted fill could be placed into the shaft to reduce settling, as schematically shown in Figure 15. A 3- to 5-ft clay plug could be placed within the fill near the top of the shaft to retard surface-water infiltration.

An example of one way to fill a site that is in an early stage of shaft failure is illustrated in Figure 16. The shaft-filling technique is almost the same as that for an open shaft. Debris derived from material that caved into the shaft is shown occupying the lower part of the mine shaft. Most commonly, the underground opening is sufficiently large that the debris pile resulting from surface collapse is not high enough to extend upward into the shaft. The debris is usually composed of poorly consolidated, saturated shale and sandstone fragments and will offer little support to any fill material dumped on top of it. Therefore, initial volume estimates could assume that the debris plays no role in a shaft-filling program. After several shaft-collapse sites are filled, volume estimates could be modified to reflect actual site conditions.

Void-space estimates for different-sized surface-collapse features are shown in Table 8. A typical collapse is shaped like an inverted cone with a 45° slope angle. However, some collapses have a higher slope angle and a geometric shape that approaches a cylinder. The cylinder-shaped collapse features would require considerably more material to fill the surface void beyond that listed in Table 8.

Very large quantities of material would be needed to fill underground mine workings that have ceiling heights greater than 50 ft (Table 8), which could result in considerable expense. Perhaps the most cost-effective method of dealing with these problems would be to fence and monitor the collapses (Fig. 17). Some smaller-diameter surface collapses appear to have unstable ground adjacent to the collapse (Fig. 17). This condition presents a hazard to equipment operators and the heavy equipment needed to fill the collapse. Although conveyors could be used to reduce the hazard to equipment and personnel, it would be

TABLE 8.—VOLUME AND VOID-SPACE ESTIMATES FOR VARIOUS COLLAPSE FEATURES, SHAFT LENGTHS, AND ROOM HEIGHTS

Surface collapse			Shaft[c]		Conical boulder pile		
Diameter[a] (ft)	Depth (ft)	Volume[b] (yd^3)	Shaft depth (ft)	Volume (yd^3)	height[d] (ft)	Diameter[e] (ft)	Volume[b] (yd^3)
25	12.5	75	100	135	12	31.9	120
50	25	605	200	270	25	66.4	1,070
60	30	1,050	250	335	50	132.7	8,540
75	37.5	2,045	300	400	75	199.1	28,830
100	50	4,850	350	470	100	265.4	68,300

[a]Based on 45° slope angle.

[b]Volume of a cone formula used to calculate volume: volume (in cu yds) = $\frac{0.2618 \times d^2 \times h}{27}$ where d = diameter and h = height or depth.

[c]6- × 6-foot cross section.

[d]Height is the difference between the floor and ceiling elevations in the vicinity of a shaft.

[e]Based on 37° angle of repose.

Note: Above table is approximate for use as a guide to estimate void space for different-sized collapse features and shaft lengths, and the volume of conical boulder piles that would occupy various sizes of underground-mine chambers.

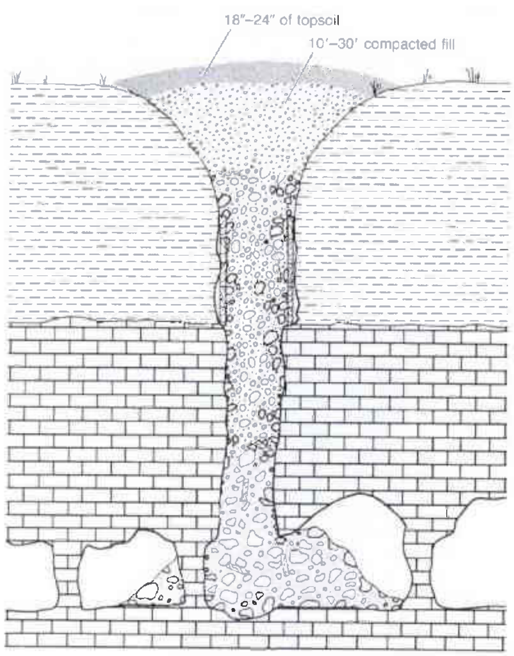


Figure 16. Schematic cross section of shaft site illustrating one way to seal or close the site in early stage of shaft failure.

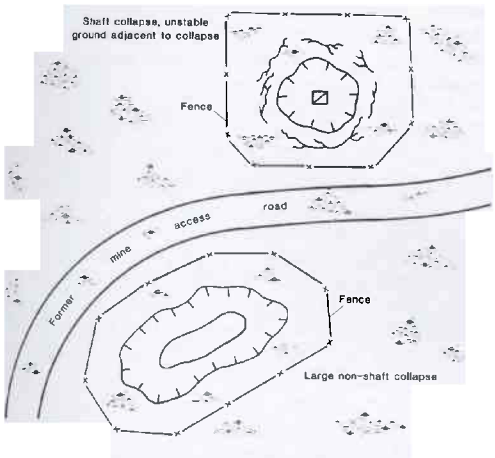


Figure 17. Fencing is a suggested safeguard for shaft collapses with adjacent unstable ground, as well as for very large collapse features. Periodic surveillance and maintenance of fences would be required.

Figure 18. A 240- × 160-ft elliptical non-shaft collapse, Crystal Mine, 29N-23E-19(1504); water level is 45 ft from surface.

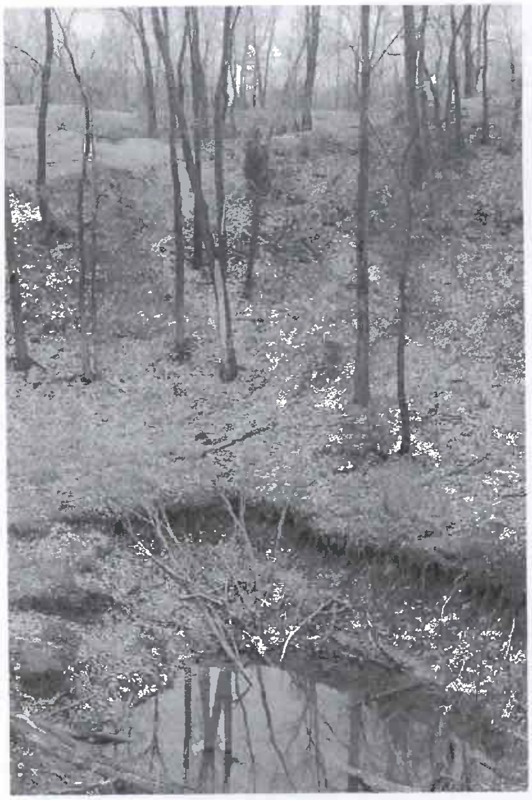


Figure 19. Trees growing in the bottom and sides of a 160-ft circular non-shaft collapse, Crystal Mine, 29N-23E-19(1507).

simpler to construct a fence around the unstable sites.

At 55 sites, surface collapse appears to be unrelated to shafts. An area west of Commerce and one west of Cardin have the highest concentrations of non-shaft collapses (Figs. 18,19). Because detailed mine maps were not available for most of the Commerce area, some of these collapses conceivably may be related to former shafts. Detailed mine maps of the Crystal and Central Mines west of Cardin suggest a strong correlation between collapse and multiple mine levels and/or large stopes.

It is almost impossible to predict where the next non-shaft-related collapse will occur. Most of the non-shaft-related collapses are related to multiple mine levels. However, large areas contain multiple mine levels that do not contain collapse features. For example, sec. 17, T29N, R23E, northwest of Picher, contains the greatest concentration of multiple mine levels but has very few collapse sites. Perhaps Chesterian beds in this area are sufficiently thick to provide good roof support.

Historically, most major collapses took place prior to 1952, but they have continued to enlarge. Few major collapses have occurred since mining ceased in 1970. Apparently, cave-ins associated with multiple mine levels and/or large stopes took place very soon after the workings were abandoned. Generally, stripping of the pillars prior to abandonment led to roof instability and subsequent collapse.

Ample evidence shows that the ground around some of the smaller collapses is continuing to cave into them. Few new collapses have occurred since 1980, and most new ground failure is associated with former collapses. For example, a collapse at the Goodeagle Mine, 29N-22E-25(5), increased four times in size during a period of about six months (Fig. 20). Non-shaft-related collapses can be filled and/or fenced in the same manner as the collapses associated with shafts. A collapse-filling program is probably the best method of controlling existing smaller collapse sites before they become too large to fill economically.

All the underground workings in the Picher Field of Oklahoma were completely filled with water by the late 1970s. This probably has contributed to ground stability over the mine workings, as most of these workings in the main part of the Picher Field are interconnected. However, cave-ins and roof failures have a tendency to reduce connections by creating compartments within the underground workings. Thus, water within these compartments will aid in the support of the overlying rock strata.

Figure 20. A 220-ft circular collapse, Goodeagle Mine, 29N-22E-25(5). The collapse increased four times in size in about six months.

REFERENCES CITED

Arndt, R. H.; Johnson, K. S.; and Harrison, W. E., 1981, The mineral industry of Oklahoma, *in* Area reports: domestic, *v. 2 of* Minerals yearbook 1977: U.S. Bureau of Mines, p. 473–487.

Arndt, R. H.; Johnson, K. S.; and Roberts, J. F., 1977, The mineral industry of Oklahoma, *in* Area reports: domestic, *v. 2 of* Minerals yearbook 1974: U.S. Bureau of Mines, p. 551–569.

——— 1979, The mineral industry of Oklahoma, *in* Area reports: domestic, *v. 2 of* Minerals yearbook 1976: U.S. Bureau of Mines, p. 589–612.

Brockie, D. C.; Hare, E. H., Jr.; and Dingess, P. R., 1968, The geology and ore deposits of the Tri-State District of Missouri, Kansas, and Oklahoma, *in* Ridge, J. D., editor, Ore deposits of the United States, 1933–1967: American Institute of Mining, Metallurgical, and Petroleum Engineers, v. 1, p. 400–430.

Dewey, R. S.; Robbins, L. A.; Oehler, L. D.; Reed, T. L.; and Bilzi, P. A., 1980, A study of hazardous openings to abandoned underground mines in western Colorado: U.S. Bureau of Mines Open-File Report OFR 21(1)–81, 214 p.

Fowler, G. M., 1942, Ore deposits in the Tri-State zinc and lead district, *in* Newhouse, W. H., editor, Ore deposits as related to structural features: Princeton University Press, p. 206–211.

Fowler, G. M.; and Lyden, J. P., 1932, The ore deposits of the Tri-State district (Missouri–Kansas–Oklahoma) (with discussion): American Institute of Mining and Metallurgical Engineers Transactions, v. 102, p. 206–251.

Hittman Associates, Inc., 1981, Surface and ground water contamination from abandoned lead–zinc mines, Picher Mining District, Ottawa County, Oklahoma: Oklahoma Water Resources Board open-file report, 80 p.

Kurtz, V. E.; Thacker, J. L.; Anderson, K. H.; and Gerdemann, P. E., 1975, Traverse in Late Cambrian strata from St. Francois Mountains, Missouri, to Delaware County, Oklahoma: Missouri Geological Survey and Water Resources Report of Investigations 55, 112 p.

Luza, K. V., 1983, A study of stability problems and hazard evaluation of the Oklahoma portion of the Tri-State mining area: U.S. Bureau of Mines Open-File Report OFR 76–83, 147 p.

McCauley, J. R.; Brady, L. L.; and Wilson, F. W., 1983, A study of stability problems and hazard evaluation of the Kansas portion of the Tri-State mining area: U.S. Bureau of Mines Open-File Report OFR 75–83, 193 p.

McFarland, M. C.; and Brown, J. C., Jr., 1983, Study of stability problems and hazard evaluation in the Missouri portion of the Tri-State mining area: U.S. Bureau of Mines Open-File Report OFR 97–83, 141 p.

McKnight, E. T.; and Fischer, R. P., 1970, Geology and ore deposits of the Picher field, Oklahoma and Kansas: U.S. Geological Survey Professional Paper 588, 165 p.

Playton, S. J.; Davis, R. E.; and McClaflin, R. G., 1980 [1981], Chemical quality of water in abandoned zinc mines in northeastern Oklahoma and southeastern Kansas: Oklahoma Geological Survey Circular 82, 49 p.

Reed, E. W.; Schoff, S. L.; and Branson, C. C., 1955, Ground-water resources of Ottawa County, Oklahoma: Oklahoma Geological Survey Bulletin 72, 203 p.

Reis, J. M., 1984, Lithostratigraphy of Cambro-Ordovician rocks and radionuclide analysis of associated waters, northeastern Oklahoma: University of Oklahoma unpublished M.S. thesis, 83 p.

Siebenthal, C. E., 1908, Lead and zinc. Mineral resources of northeastern Oklahoma, *in* Metals and nonmetals, except fuels, *pt. 1 of* Contributions to economic geology, 1907: U.S. Geological Survey Bulletin 340, p. 187–228.

——— 1915, Origin of the zinc and lead deposits of the Joplin region, Missouri, Kansas, and Oklahoma: U.S. Geological Survey Bulletin 606, 283 p.

Snider, L. C., 1912, Preliminary report on the lead and zinc of Oklahoma: Oklahoma Geological Survey Bulletin 9, 97 p.

Southard, L. G.; Johnson, K. S.; and Roberts, J. F., 1972, The mineral industry of Oklahoma, *in* Area reports: domestic, *v. 2 of* Minerals yearbook 1970: U.S. Bureau of Mines, p. 569–584.

Stroup, R. K.; and Stroud, R. B., 1967, Zinc–lead mining and processing activities and relationship to land-use patterns, Ottawa County, Oklahoma: U.S. Bureau of Mines unpublished report, 22 p.

Weidman, Samuel; Williams, C. F.; and Anderson, C. O., 1932, The Miami–Picher zinc–lead district, Oklahoma: Oklahoma Geological Survey Bulletin 56, 177 p.

Westfield, J.; and Blessing, E., 1967, Report of investigation of surface subsidence and safety of underground employees in the Picher, Oklahoma, field of the Tri-State mining district: U.S. Bureau of Mines unpublished report, 25 p.

Wilson, L. R., 1979, Palynological evidence for age assignment of basal Cherokee (Pennsylvanian) strata in southeastern Kansas [abstract]: Oklahoma Geology Notes, v. 39, p. 76–79.

APPENDIX

Tables 1–4

TABLE 1. - Summary of mine depths, ore zones, and working heights for each major mine

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	28N-22E-1						
Thirty Acre	NW NE	.86	No Data		210-240	No Data	
Carson Min. Co.	NW NE	2.08	No Data		210-240	No Data	
Lennan & Co.	NE NE	1.69	No Data		No Data	No Data	
Lennan & Co.	SE NE	2.55	No Data		No Data	No Data	
Prairie Min. Co.	SE NE	2.34	No Data		No Data	No Data	
Oklahoma Lead-Zinc Co.	SW NE	3.61	No Data		No Data	No Data	
Never Sweat	NW SE	1.49	No Data		No Data	No Data	
Okmulgee	NW SE	.06	No Data		No Data	No Data	
Lolita	NW SE	.17	15-23	20	150-165	No Data	
Emma Gordon	NE SE	5.90	No Data		No Data	No Data	
Ash Mining Co.	NE SE	.19	No Data		No Data	No Data	
Queen City	SE SE	1.12	No Data		No Data	No Data	
Old Chief	SE SE	1.00	No Data		No Data	No Data	
Miami Amalgamated	SE SE	.54	No Data		No Data	No Data	
Turkey-Fat	SE SE	1.40	No Data		No Data	No Data	
Wahtahnahzhe	SW SE	.57	9-41	25	170-195	No Data	
Consolidated	SW SE	1.67	12-45	25	115-206	No Data	
Jeanette	SW SE	1.20	--	15	60-180	No Data	
Midas	SW SE	2.58	10-25	15	70-160	No Data	
Southern Queen	SW SE	2.30	7-35	15	100-170	No Data	
Blue Bell	SW SE	.11	14-25	20	105-200	No Data	
	28N-22E-12						
Lost Trail-Frosty Morning	NW NE	6.91	7-44	15	120-210	No Data	
Edna Ray	NE NE	.24	No Data		100	No Data	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	28N-23E-1						
Old Mission	NE NE	6.43	No Data		No Data	K	
	28N-23E-6						
Warner Fee	NW NW	2.25	No Data		No Data		No Data
Tom Lawson	SW SW	.20	No Data		100		No Data
	28N-23E-7						
New State	NW NW	1.32	No Data		100-110		No Data
King Jack	NW NW	1.04	No Data		100-110		No Data
Kenwood	NW NW	1.63	No Data		No Data		No Data
Commonwealth	NW NW	.76	No Data		No Data		No Data
Swastika	SW NW	.38	No Data		No Data		No Data
	28N-24E-6						
Romo	NW NW	2.14	No Data		No Data	K	
	29N-22E-13						
Laura Jenny Zheka	SE NW	.35	No Data		No Data	G-H	
Stanley	NE NE	2.58	No Data		No Data	M	
Bird Dog	SE NE	4.60	No Data		No Data	M	
Mehunka Zheka	S½ SE	2.25	15-52	25	190-235	M	G-H
Beaver							E & Chester
	29N-22E-14						
Wild Bull	SW SW	.33	No Data		No Data		No Data

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-22E-23						
James Xavier	W ½	1.49	No Data		No Data	No Data	
Adams	S½ NE	2.41	No Data		No Data	No Data	
Mudd	NE SE	4.08	--	12	215-260	No Data	
Xavier-Mudd	NE SW & NW SE	4.68	14-20	15	160-190	No Data	
	29N-22E-24						
Garrett	SE NW	.95	13-15	15	230-245	No Data	
Little Greenback	N½ NE	6.24	14-72	25	160-230	M	G-H
Little Greenback	SW NE	7.18	12-54	25	185-245	M	
Kitty	SE NE	9.48	11-40	25	180-240	M	G-H
Wesa Greenback	NW SE	6.01	10-39	20	180-260	M	G-H
Kitty	NE SE	5.57	14-60	25	180-260	M	G-H
Wesa Greenback	SW SE	2.42	14-20	20	210-250	M	G-H
Wesa Greenback	SE SW	.12	No Data		No Data	G-H	
	29N-22E-25						
Pioneer	SE NW	4.00	No Data		No Data	M	
Good Eagle	NW NE	5.06	6-20	10	250-270	M	
Good Eagle	NE NE	4.68	7-47	25	200-230	M	
Good Eagle	SE NE	3.55	7-30	20	210-260	M	
Good Eagle	SW NE	4.21	8-38	20	220-260	M	G-H
Childress-Heggem	NW SE	3.00	14-29	25	155-270	M	E & Chester, G-H
Wilson	NE SE	10.56	9-49	30	225-270	M	G-H
Blue Bird	SE SE	13.25	10-62	40	240-305	M	G-H
Pioneer	NE SW	3.43	No Data		245-260	M	G-H

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-22E-36						
S. S. & G.	NE NE	3.56	8-80	25	175-310	M	G-H
Roanoke	SW NE	2.13	17-44	30	165-195	G-H	
Scammon Hill	NW SE	2.02	11-41	25	195-260	G-H	E & Chester
Scammon Hill	SW SE	4.04	8-65	25	155-300	G-H	E & Chester, M
Scammon Hill	NE SW	2.14	17-47	35	190-260	G-H	
Scammon Hill	SE SW	2.16	10-61	20	255-320	G-H, E & Chester	M
Haymaker	SW SW	1.20	No Data		200	G-H	
	29N-23E-13						
Scott	SE NE	7.85	No Data		No Data	sheet ground	
Scott	SE	15.42	No Data		No Data	M	G-H
Niday No. 1	SW SE	5.89	No Data		No Data	M	G-H
	29N-23E-14						
W. M. & W.	SE NW	2.49	13-55	30	125-180	M	K
Farmington	W½ NE	15.64	No Data		No Data	M, K	G-H
Farmington	E½ NE	1.23	No Data		No Data	M	
Lucky Jenny	NW SE	6.66	No Data		No Data	M, K	
Lucky Jenny	NE SE	1.21	No Data		No Data	K	M
Blue Ribbon	S½ SE	3.85	No Data		No Data	M, G-H	E & Chester
Dobson	NW SW	.14	10-16	15	130-150	No Data	
Dobson	NW SW	3.45	No Data		No Data	M	
Dobson	NE SW	7.92	No Data		No Data	M, G-H	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-14						
Dobson	SE SW	4.93	No Data		No Data	M	G-H
Dobson	SW SW	5.04	No Data		No Data	M	G-H
	29N-23E-15						
Mary Ann	SE NW & SW NE	14.18	--	15	170-180	K, M	
Shaffer	SW NW	.10	No Data		No Data	K	
W. M. & W.	SE NE	9.79	9-45	20	120-240	M, K	G-H, E & Chester
W. M. & W.	NW SE	5.03	No Data		No Data	M	G-H
W. M. & W.	NE SE	18.28	No Data		No Data	M	G-H
Brewster	SE SE	15.94	No Data		No Data	M	
Brewster	SW SE	13.72	No Data		No Data	M	G-H
Wade	NW SW	1.94	No Data		No Data	M, K	G-H
Golden Eagle	NE SW	.42	No Data		No Data	M, K	
Beck	SE SW	14.34	No Data		No Data	M	G-H
Beck	SW SW	6.81	No Data		No Data	M, K	
	29N-23E-16						
Swift	NW NW	.87	45	--	265	M	
Swift	SE NW	1.39	No Data		No Data	K	
Swift	SW NW	12.92	7-28	15	200-280	M, K	
Swift	NE NE	1.64	No Data		No Data	K	
Hunt	SE NE	2.14	No Data		No Data	M	G-H
Hunt	SW NE	5.27	No Data		No Data	M	
Cortez	NW SE	8.20	No Data		No Data	M	G-H
Consolidated No. 3	NE SE	11.40	10-31	20	220-245	M	G-H
Consolidated No. 2	SE SE	16.14	No Data		No Data	M, G-H	
Endora Whitebird	SW SE	3.91	No Data		No Data	M	
Swift	NW SW	9.25	7-27	15	190-255	M, G-H	K

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-16						
Commonwealth	NW SW	8.34	10-35	15	160-220	K	
Commonwealth	NE SW	7.62	9-26	15	170-200	K	
Endora Whitebird	SE SW	4.63	12-15	15	200-270	M, K, G-H	
Whitebird	SW SW	16.22	8-34	15	230-285	M	G-H, K
	29N-23E-17						
La Salle	NE NW	2.36	No Data		No Data	M, G-H, K	E & Chester
Ohimo	SE NW	7.67	No Data		No Data	M, G-H, K	E & Chester
Slim Jim	SW NW	6.49	9-38	20	145-295	G-H, K, sheet ground, E & Chester	
La Salle	NW NE	1.77	8-21	15	160-260	K	M, G-H
Goodwin	NE NE	4.12	24-35	30	200-260	M	K
Goodwin	SE NE	27.47	8-27	15	120-255	K, M, G-H	
La Salle	SW NE	16.7	8-21	15	150-270	G-H, M, K	
Otis White	NW SE	24.67	8-40	15	130-230	G-H, K, E & Chester	
Big Chief	NE SE	26.55	7-14	10	120-190	G-H, K, E & Chester	
Crawfish	SE SE	22.79	8-44	20	140-260	M, G-H	K, E & Chester
Netta White	SW SE	23.63	7-49	20	160-245	G-H, K, E & Chester	M
Lucky Syndicate	NW SW	13.85	8-49	20	175-255	G-H, E & Chester	K
Lucky Syndicate	NE SW	23.57	8-38	15	155-210	G-H, E & Chester	K

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-17						
Piokee	SE SW	19.01	6-63	20	140-205	G-H, E & Chester	
Howe	SW SW	18.82	6-45	25	160-270	G-H, E & Chester;	M, K
	29N-23E-18						
Pelican	NW	13.12	No Data		No Data	M	
Gordon No. 2	NW NE	4.06	12-35	25	185-215	M	
Whisk Broom	NE NE	3.16	No Data		No Data	M	G-H
Gordon No. 3	SE NE	5.10	10-31	20	200-260	M	
Gordon No. 2	SW NE	7.70	10-36	20	185-230	M	
Gordon No. 3	NW SE	10.74	12-50	25	135-230	M	G-H
Gordon No. 3	NE SE	14.68	7-53	20	135-255	M	G-H
Gordon No. 3	SE SE	11.26	7-60	20	125-235	M	G-H
Gordon No. 3	SW SE	5.81	No Data		No Data	M	G-H
Pelican	NW SW	.98	No Data		No Data	M, G-H	K, G-H
Tongaha	SW SW	.04	No Data		No Data	M	
	29N-23E-19						
Tongaha	NW NW	4.06	No Data		No Data	M	
Tongaha	NE NW	6.65	No Data		No Data	M	G-H, E & Chester
Anna Beaver	SE NW	7.15	10-76	30	150-240	M	G-H
Tongaha	SW NW	5.92	14-25	15	170-265	M	G-H
Anna Beaver	NW NE	12.43	7-37	20	160-190	M	G-H
Anna Beaver	NE NE	13.25	6-44	15	160-205	M	G-H
Anna Beaver	SE NE	12.23	10-47	20	130-200	M	G-H, sheet ground

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-19						
Anna Beaver	SW NE	11.46	11-53	30	150-240	M	G-H
John Beaver	NW SE	12.05	7-56	20	180-285	M	G-H
John Beaver	NE SE	15.94	7-28	15	160-215	M	sheet ground
Townsite	SE SE	9.57	6-22	15	200-240	M, sheet ground	
John Beaver	SW SE	22.64	6-39	25	185-265	M	G-H, sheet ground
Velie Lion	NW SW	15.03	No Data		220-240	M	G-H
Velie Lion	NE SW	15.73	14-24	20	190-310	M	G-H, E & Chester
Crystal-Central	SE SW	23.22	7-54	20	130-340	M, E & Chester;	G-H
Harrisburg	SW SW	9.70	7-53	25	190-260	M	G-H, E & Chester
	29N-23E-20						
Dorothy Bill No. 2	NW NW	9.00	10-35	20	140-200	M	G-H
Dorothy Bill No. 2	NE NW	3.15	8-58	35	195-215	M	E & Chester
Kenoyer	SE NW	22.23	14-39	25	165-190	M	G-H
Kenoyer	SW NW	15.88	8-13	10	180-195	M	G-H
West Netta	NW NE	24.51	10-39	20	165-270	M, K, G-H	E & Chester
East Netta	NE NE	21.92	8-40	20	180-250	M, G-H	K, E & Chester
St. Joe	SE NE	10.89	12-28	15	130-240	M	G-H, E & Chester

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-20						
Vantage	SW NE	18.88	12-37	25	220-235	M	G-H, E & Chester
Golden Hawk	NW SE	19.34	12-32	20	130-210	M	K, G-H
Premier	NE SE	20.06	11-30	20	200-225	M	K
Oko	SE SE	18.78	18-50	25	185-230	M	G-H
Barbara J.	SW SE	13.96	6-25	15	120-235	M	G-H
Kenoyer	NW SW	15.72	6-30	15	165-193	M	
Kenoyer	NE SW	22.55	11-18	15	190-205	M	G-H, E & Chester
Rialto	SE SW	16.80	12-51	25	165-200	M	G-H
Kenoyer	SW SW	11.33	16-23	20	190-200	M	
	29N-23E-21						
North Bingham	NW NW	9.90	9-14	10	235-265	M	
Endora Whitebird	NE NW	18.79	7-19	15	205-270	M, K	G-H
Mahutska	SE NW	14.76	16-37	20	160-245	M, K	E & Chester
South Bingham	SW NW	17.98	8-18	10	190-235	M	G-H
Endora Whitebird	NW NE	8.93	12-15	15	175-255	M	K
Black Eagle	NE NE	7.95	15-35	25	210-230	M	G-H, E & Chester
Jeff City	SE NE	5.86	10-22	15	215-230	M	K, E & Chester
Jeff City	SW NE	18.34	No Data		175-245	M, K	E & Chester
Grace Walker	NW SE	15.68	8-27	15	150-235	M	K, G-H
Jefferson	NE SE	10.43	8-30	20	160-230	M	K, G-H
Royal	SE SE	10.25	No Data		No Data	M	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-21						
Royal	SW SE	3.87	7-23	15	180-200	M	
Grace Walker	SW SE	7.52	8-20	15	150-185	M, K	
Black Hawk	NW SW	15.64	8-21	15	175-235	M, G-H	
Acme	NE SW	17.95	No Data		No Data	M, K	
Grace Walker	SE SW	18.93	8-25	15	160-280	M, K	sheet ground, G-H
New York	SW SW	19.74	6-27	15	200-280	M, sheet ground	K
	29N-23E-22						
Dardene	NW NW	8.03	No Data		No Data	M	
Hudson	NE NW	7.57	No Data		No Data	M	
Tulsa	SE NW	7.44	No Data		No Data	M	
Crutchfield	NW NE	.05	No Data		160	No Data	
Crutchfield	NW NE	1.57	No Data		210	M	G-H
Indiana	NE NE, SE NE, NE SE	7.02	No Data		No Data	M, K	
Van Buren-Tulsa	SW NE, NW SE	6.96	No Data		No Data	M	G-H
Ottawa	SE SE	.70	No Data		No Data	K	
Jo Buffalo	SW SE	3.61	No Data		No Data	G-H	M
Huttig-Beck	NW SW	1.79	No Data		No Data	M	
Tulsa	NE SW	9.46	No Data		No Data	M, G-H	
Walker	SE SW	14.44	No Data		No Data	M, G-H	
Maxine	SW SW	7.95	No Data		No Data	M	G-H

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-23						
Texas	NW NW	8.72	No Data		No Data	M	
Santa Fe	NE NW	9.25	No Data		No Data	M	G-H
Kropp	S½ NW	9.05	No Data		No Data	M	K
Aztec	NW NE	6.21	10-76	15	135-230	M	G-H
Blue Bonnet	NE NE	6.86	No Data		No Data	M, G-H	E & Chester
Massel	SE NE	2.96	No Data		No Data	M, G-H	
Meteor	SW NE	3.47	No Data		No Data	M	G-H
Mission	N½ SE, SE SE	4.87	No Data		No Data	M, K	
Mission	SW SE, SE SW	7.19	No Data		No Data	M	K, E & Chester
Kropp	N½ SW	6.89	No Data		No Data	M	
	29N-23E-24						
St. Louis No. 4	NE NW	.70	No Data		No Data	M	
Imbeau	S½ NW	4.66	No Data		No Data	M	G-H
St. Louis No. 4	NW NE	6.67	No Data		No Data	M	G-H
St. Louis No. 4	NE NE	7.45	No Data		No Data	M	G-H
St. Louis No. 4	SE NE	9.71	No Data		No Data	M	G-H
St. Louis No. 4	SW NE	5.88	No Data		No Data	M	G-H
Crane	N½ SE	2.38	No Data		No Data	M	
Crane	SW SE	.31	No Data		No Data	M	
Imbeau	SW SW	.50	No Data		No Data	M	
	29N-23E-25						
Mary Jane	NW NE	2.60	No Data		No Data	M	
W. W. Dobson	SW SW	.04	No Data		No Data	K	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-26						
Davenport	W½ NW	1.16		No Data	No Data	M, G-H	
Hope	NW NE	4.19		No Data	No Data	M	
Longhunt	NE NE	.19		No Data	No Data	M	
Quajack	SE NE	.04		No Data	No Data	M	
Hobart	SW NE	2.52		No Data	No Data	M, G-H	
Alice Greenback	NE SE	1.30		No Data	No Data	M	
Betsy Greenback	NW SW	2.19		No Data	No Data	M	E & Chester
	29N-23E-27						
Pat	N½ NW	6.49		No Data	No Data	M	
Pat	SW NW, NW SW	3.97		No Data	No Data	M	G-H
Rainbow	NW NE	.87		No Data	No Data	M, G-H, K	
Arthur Buffalo	NE NE	3.37		No Data	No Data	M, G-H	
Prairie Dog	SW NE	2.06		No Data	No Data	G-H	
Doris	NW SE	.07		No Data	No Data	M	
J. R. Randall	SW SE	.04		No Data	No Data	G-H	
First National	NE SW	.21		No Data	No Data	M, G-H	
Beck	S½ SW	.46		No Data	No Data	M, G-H	
	29N-23E-28						
Birthday-Mo. Mule	NW NW	13.60	9-35	25	120-230	M, K	G-H
Midas	NE NW	7.71	10-19	15	165-210	M	G-H, K
New Chicago No. 2	SE NW	15.37	14-66	30	130-200	M, K	
Federal-Fort Worth	SW NW	8.41	8-35	20	160-220	M	K
New Chicago No. 1	NW NE	10.91		No Data	No Data	M, G-H, K	
New Chicago No. 1	NE NE	3.94		No Data	No Data	M	
New Chicago No. 1	SE NE	7.29		No Data	No Data	K	M
New Chicago No. 1	SW NE	9.39		No Data	No Data	K	G-H, M

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-28						
Bull Frog	SE SE	1.31	No Data	No Data	No Data	G-H	
Bull Frog	SW SE	1.27	No Data	No Data	No Data	M	G-H, E & Chester
Skelton	NW SW	15.13	8-30	20	120-180	M	K, G-H, E & Chester
New Chicago No. 1 (Thomas Buffalo)	NE SW	2.62	8-27	15	160-190	M	K
Skelton	SW SW	14.03	9-28	20	115-165	M	G-H, K, E & Chester
	29N-23E-29						
Baby Jim	NW NW	20.48	18-41	30	175-205	M	
Rialto	NE NW	21.63	11-59	25	170-210	M	G-H
Domado	SW NW	22.08	14-103	40	140-215	M	G-H, E & Chester
Rialto	SE NW	21.71	13-72	30	160-255	M	G-H, sheet ground
Barbara J.	NW NE	16.47	12-33	25	150-255	M	G-H
Barbara J.	NE NE	13.98	10-37	20	160-220	M	G-H, K
Barbara J.	SE NE	12.89	8-37	20	165-240	M	K
Barbara J.	SW NE	17.66	7-36	20	170-250	M	K, sheet ground
Skelton	NW SE	22.93	10-25	15	170-240	M, K	
Skelton	NE SE	20.48	8-35	20	165-210	M	K, E & Chester
Skelton	SE SE	22.55	6-33	20	60-210	M, K, sheet ground	E & Chester
Admiralty No. 3	SW SE	21.43	15-25	20	55-210	M	K, E & Chester
Douthat	W½ NW SW	6.71	10-45	20	180-220	M	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-29						
Admiralty No. 4	E½ NW SW	7.85	10-15	15	200-250	M	G-H
Admiralty No. 2	NE SW	22.63	7-30	15	200-245	M	G-H, K, E & Chester
Admiralty No. 1	N½ SE SW	10.14	9-22	15	150-195	M	G-H, E & Chester
Lavrion	S½ SE SW	10.54	30-36	30	90-170	M	G-H
Admiralty No. 4	SW SW	2.11	15-35	25	195-230	M	
	29N-23E-30						
Lottson	NW NW	11.37	9-46	20	200-270	M	G-H
Ritz	NE NW; NW NE	26.24	No Data		No Data	M	G-H, E & Chester
Hum-Bah-Wat-Tah	SE NW	24.20	7-50	15	230-325	M, sheet ground	
Blue Goose No. 1	SW NW	15.44	9-74	35	155-330	M	G-H, sheet ground
Bennie	E½ NW NE	8.43	10-50	30	225-300	M	
Lucky Bill	NE NE	21.31	12-40	25	115-295	M	G-H
Woodchuck	SE NE	19.80	15-77	40	160-260	M	G-H
Jay Bird	SW NE	26.56	7-66	25	220-300	M	sheet ground
See-Sah	NW SE	28.06	8-25	15	280-300	sheet ground	M
See-Sah	NE SE	19.27	8-24	10	200-280	sheet ground, M	
See-Sah	SE SE	6.63	7-13	10	265-270	sheet ground	
See-Sah	SW SE	20.88	6-13	10	280-295	sheet ground	
Shorthorn	NW SW	12.90	11-60	35	245-310	M	G-H
Blue Goose No. 2	NE SW	17.49	6-71	15	270-315	sheet ground, M	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-30						
Blue Goose No. 2	SE SW	18.27	8-14	10	295-310	sheet ground	
Tom L.	SW SW	5.93	--	20	270-325	M	G-H
	29N-23E-31						
Southside	NW NW	11.08	21-50	35	240-300	M	G-H, E & Chester
Southside	NE NW	12.02	10-45	20	240-300	sheet ground, M	
Southside	NW NE	3.24	--	10	290-295	sheet ground	
	29N-23E-32						
Eagle Picher	NW NW	.14		No Data	No Data	M	
Quebec	NE NW	3.19		No Data	150	M	
Montreal	NW NE	9.62		No Data	No Data	M	
Beck	NE NE	6.30		No Data	No Data	M	
Wesley Smith	SE NE	4.10		No Data	No Data	M	E & Chester
George Van Pool	NE SE	3.13		No Data	No Data	K	
	29N-23E-33						
Craig	NW NW	17.00		No Data	No Data	M	K
Craig	SE NW	.95		No Data	No Data	M	
Craig	SW NW	10.33		No Data	No Data	M	
Wolverine	NE NE	.78		No Data	No Data	M	
Craig	SE NE	.04		No Data	No Data	M	
Craig	SW SE	3.30		No Data	No Data	M	G-H
John Hunt	NW SE	4.19		No Data	No Data	M	
John Hunt	NW SW	2.19		No Data	No Data	M, K	
John Hunt	NW SW	2.80	10-61	25	145-215	M	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c] Range (ft)	Working height(s)[c] Average (ft)	Depth[d] Range (ft)	Ore Zone(s)[e] Major	Ore Zone(s)[e] Minor
	29N-23E-34						
Imperial	NE NW	.46	No Data		No Data	G-H, M	
Big Three	SE NW	.56	No Data		No Data	M	G-H
Ruth Goodeagle	SW NW	.85	No Data		No Data	M, G-H	
Muskogee	NW NE	.09	No Data		No Data	G-H	
Springfield	NE NE	.06	No Data		No Data	G-H	
	29N-23E-35						
Harry Whitebird	E½ NE	.22	No Data		No Data	G-H	
Buckeye	SE SE	1.64	No Data		No Data	M, G-H	
	29N-23E-36						
Crawford	SE NW	.23	No Data		No Data	K	
Silver Streak	SE SE	4.53	No Data		No Data	K, E & Chester	
Petersburg	SW SE	4.02	No Data		No Data	K	
	29N-24E-17						
Martha B	SE NW	3.24	No Data		No Data	No Data	
C. R. Meyers	SE NW	.22	No Data		No Data	No Data	
Discard	SW NW	8.17	No Data		No Data	No Data	
Weepah	SW NE	.37	No Data		No Data	No Data	
M. W. Clark	NW SW	.04	No Data		No Data	No Data	
	29N-24E-18						
Bingham	NE	3.17	No Data		No Data	M	
Diamond Joe	SW SE	.71	No Data		No Data	M	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c]		Depth[d]	Ore Zone(s)[e]	
			Range (ft)	Average (ft)	Range (ft)	Major	Minor
	29N-24E-19						
Campbell	NE NW	1.59	No Data		No Data	M	
Campbell	S½ NW	6.68	No Data		No Data	M	
Malsburg	NW NE	9.10	No Data		No Data	M	
Bendene	NE NE	.49	No Data		No Data	M	
V-1	SE NE	1.03	No Data		No Data	M	
Campbell	SW NE	1.36	No Data		No Data	M	
Sunnyside	SW SE	.19	No Data		No Data	G-H	
	29N-24E-30						
John L.	E½ NW	5.52	No Data		No Data	K	
Pearl	SE NW	.07	No Data		No Data	K	
11th Hour	NW NE	.22	No Data		No Data	K	
Donna Jane	SW NE	2.62	No Data		No Data	K	
Sam Abrams	NE SE	.03	No Data		No Data	M	
Sunnyside	SE SE	.07	No Data		No Data	M	
Ten o'clock-40 Acres	NE SW	.66	No Data		No Data	M	
	29N-24E-31						
West Virginia	NE NE	.37	No Data		No Data	M	
Waxahachie	SE NE	3.29	No Data		No Data	K	
Quivera	SW NE	.10	No Data		No Data	M	
Red Eagle	NE SE	.24	No Data		No Data	K	
Preston	SE SW	.50	No Data		No Data	K	
Old Abe	SW SW	.78	No Data		70-90	K	

TABLE 1. - (Continued)

Mine name	Location[a]	Area[b] (acres)	Working height(s)[c]		Depth[d]	Ore Zone(s)[e]	
			Range (ft)	Average (ft)	Range (ft)	Major	Minor
	29N-24E-32						
Lead Boy	NW NW	.17	No Data		No Data	No Data	
50-50	NW NW	.22	No Data		No Data	No Data	
Lancaster Min. Co.	SW NW	1.28	No Data		No Data	No Data	
Blacksnake	SW NW	.22	No Data		No Data	No Data	

[a]Location given in township, range, and section, generally to the nearest quarter-quarter.
[b]Area represents areal extent of underground-mine workings minus principal support pillars.
[c]Working-height information determined from representative floor-ceiling data found on detailed mine maps. Working height averages rounded to nearest 5 feet.
[d]Mine-depth information, rounded to nearest 5 feet, given to top of mine workings.
[e]Principal ore zones determined from Eagle Picher's 1:3,600-scale maps.

TABLE 2. - Open mine shafts and pits

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	28N-22E - 1		
Thirty Acre Mining Company	1	60- x 40-foot, elliptical collapse; water level 12 feet from surface	Fence and/or fill[b]
Thirty Acre Mining Company	2	40-foot (1,257 ft^2), .03 acre, circular collapse; water level 1 foot from surface	None
Carson Mining Company	3	25-foot, circular collapse; water level 1 foot from surface	None
Carson Mining Company	4	30-foot, circular collapse; water present	Fill
Oklahoma Lead & Zinc Mining Company	6	45- x 30-foot, elliptical collapse; water level near surface	None; could be filled
Lennan & Co.	7	Open shaft, minor collapse; water level 20 feet from surface	Fill
Oklahoma Lead & Zinc Mining Company	*9	45-foot, circular collapse; water level 18 inches from surface	None
Prairie Mining Company	10	50-foot, circular collapse; water level 5 feet from surface	Fill
Prairie Mining Company	11	25-foot, circular collapse; water level near surface	None
Oklahoma Lead & Zinc Mining Company	*12	45-foot, circular collapse; water level near surface	None
Okmulgee	20	50- x 30-foot, elliptical collapse; water level 1 foot from surface	None
Emma Gordon	22	Open shaft; water level 30 feet from surface; railroad ties over shaft	Fill
Miami Amalgamated	30	By 1972, 160- x 130-foot, elliptical collapse; filled by 1979	None; monitor
Turkey-fat	32	By 1964, 275- x 210-foot, elliptical 65-foot, circular collapse; filled by 1972; slight depression over filled collapse by 1980	None; monitor
Miami Amalgamated	34	Open shaft; water level 18 feet from surface; steel-rail grate over shaft	Fill
Midas	38	25-foot, circular collapse; 5 feet deep; filled with concrete debris	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	28N-22E - 1		
Midas	39	By 1972, 200- x 160-foot, elliptical collapse; filled by 1979	None; monitor
Lolita	43	50- x 30-foot, elliptical collapse; water level 1 foot from surface	None
Last Chance	50	25-foot, circular collapse; water level 4 feet from surface	None; could be filled
	28N-22E - 12		
Jennie May	1	35-foot, circular collapse; water level near surface	None
Jennie May	2	25-foot, circular collapse; water level 3 feet from surface	None could be filled
Frosty Morning	5	120-foot, circular collapse; water level 18 feet from surface	Fence and/or fill
Neill	6	40-foot, circular collapse; water level 6 inches from surface	None
Neill	7	50-foot, circular collapse; 10 feet deep, filled with garbage	Fence and/or fill
Edna Ray	10	18-foot, circular collapse; water level 4 feet from surface	Fill
	28N-23E - 1		
Old Mission	1	15-foot, circular collapse; water level 12 feet from surface	Fill
Old Mission	2	8- x 5-foot, elliptical collapse; 5 feet deep	Fill
Old Mission	3	18-foot, circular collapse; filled with tires	None
Old Mission	4	15-foot, circular collapse; 10 feet deep	Fill
	28N-23E - 6		
Warner Fee (Eagle Picher)	4	115-foot, circular collapse; water level near surface; area around shaft has been reclaimed	None
	28N-23E - 7		
New State	1	By 1964, 330- x 200-foot, elliptical collapse; filled by 1972; filled area appears to be slightly depressed (formerly a garbage dump)	None; monitor; ground over collapse unstable
King Jack	2	280- x 20-foot, elliptical and 45-foot, circular collapse; water level near surface	None; monitor

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	28N-23E - 7		
Commonwealth	4	40-foot, circular collapse; water level 3 feet from surface	Fill
Commonwealth	5	45-foot, circular collapse; water level 3 feet from surface	Fill
	28N-24E - 5		
Lead Queen	2	Open shaft with 10-foot, circular collapse at surface; collapse is 30 feet deep	Fill
Spring (River) Riser	6	Open shaft with 10-foot, circular collapse at surface; water level 60 feet from surface	Fill
	28N-24E - 6		
Romo	3	12-foot, circular collapse; water level 20 feet from surface	Fill
Big Squaw	*10	Open shaft with 10-foot, circular collapse at surface; water level 60 feet from surface	Fill
Unknown	1700	260- x 130-foot, elliptical open pit; 30 feet deep; filled with water and tires	None
	28N-24E-12		
Log Cabin	1	8-foot, circular collapse; 4 feet deep; filled with chat (not shown on map)	None
	29N-22E - 13		
Laura Jenny Zheka	*1	60-foot, circular collapse; 40 feet deep; mature trees growing on sides	Fence and/or fill
Bird Dog	*2	Open shaft with minor collapse at surface; water level 25 feet from surface	Fill
	29N-22E - 23		
James Xavier	*1	40-foot, circular collapse; 35 feet to wooden cribbing; water level 70-80 feet from surface	Fence and/or fill
James Xavier	*2	Open shaft; partially filled with debris 40 feet from surface	Fence and/or fill
James Xavier	*3	60-foot, circular collapse; water level 3 feet from surface	None
Adams	6	45-foot, circular collapse; water level 15 feet from surface; fenced	Maintain fence and/or fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-22E - 23		
Mudd	*8	Open shaft with minor collapse at surface; water level 15 feet from surface	Fill
Xavier-Mudd	*9	15-foot, circular collapse; water level 15 feet from surface	Fill
Xavier-Mudd	*10	40-foot, circular collapse; water level 18 inches from surface	None
	29N-22E - 24		
Garrett	1	25-foot, circular collapse; water level 3 feet from surface; fenced; surrounded by wheat	Maintain fence
Little Greenback	*3	6- x 8-foot, elliptical collapse; 5 feet deep	Fill
Kitty	*10	Open shaft with 6- x 8-foot, rectangular collapse at surface; 5 feet deep; filled with debris	Fill
	29N-22E - 25		
Goodeagle	3	20-foot, circular collapse; 10 feet deep	Fill
Goodeagle	4	50- x 20-foot, elliptical collapse; 20 feet deep	Fill
Goodeagle	5	220-foot, circular collapse; water level 20 feet from surface	Fence; monitor; area adjacent to collapse unstable
Goodeagle	6	50-foot, circular collapse; water level 1 foot from surface	None
Goodeagle	7	70- x 50-foot, elliptical collapse; water level 1 foot from surface	None
Goodeagle	8	Minor collapse; water level near surface	None
Wilson	12	15-foot, circular collapse; water level 60 feet from surface	Fence and/or fill
Wilson	15	25-foot, circular collapse; 16 feet deep	Fill
Blue Bird	16	Minor collapse; probably a multi-compartment shaft	Fill
Blue Bird	18	35-foot, circular collapse; water level 18 inches from surface	None

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-22E - 25		
Wilson	22	60-foot, circular collapse; water level 1 foot from surface	None
Childress-Heggem	23	20-foot, circular collapse; partially filled with debris	Fence and/or fill
Childress-Heggem	24	50-foot, circular collapse; water level 20 feet from surface	Fence and/or fill
	29N-22E - 35		
Grey Top	1	40- x 20-foot, elliptical collapse; water level 18 inches from surface; reclamation in progress (6/3/81)	None
	29N-22E - 36		
S S & G	*1	60- x 35-foot, elliptical collapse; water level 1 foot from surface	None
S S & G	*3	35-foot, circular collapse; water level 1 foot from surface	None
Roanoke	*4	15-foot, circular collapse; 15 feet deep	Fence and/or fill
Scammon Hill	*6	80- x 60-foot, elliptical collapse; water level 18 inches from surface	None
Scammon Hill	*8	Open shaft; debris 25 feet from surface	Fill
Scammon Hill	*9	45-foot, circular collapse; water level 18 inches from surface	None
Scammon Hill	*12	Open shaft with minor collapse at surface; water level 40 feet from surface	Fill
Scammon Hill	*15	45-foot, circular collapse; water level 1 foot from surface	None
Scammon Hill	*16	40-foot, circular collapse; water level 18 inches from surface	None
	29N-23E - 13		
Scott	2	Open shaft with minor collapse at surface; water level 16 feet from surface	Fill
Scott	3	100-foot, circular collapse; water level 10 feet from surface	Fence and/or fill
Scott	4	28-foot, circular collapse; water level 20 feet from surface	Fill
Scott	6	Open shaft; debris 10 feet from surface	Fill
Scott	8	Open shaft; debris 15 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 14		
Farmington	2	30-foot, circular collapse; 10 feet deep	Fence and/or fill
Farmington	3	40-foot, circular collapse; 20 feet deep	Fence and/or fill
Farmington	5	50-foot, circular collapse; 25 feet deep; partially filled with trash	Fence and/or fill
Farmington	6	30- x 20-foot, elliptical collapse; 5 feet deep; partially filled with trash	Fill
Farmington	7	50-foot, circular collapse; 30 feet deep	Fence and/or fill
Farmington	8	200-foot, circular collapse; water level 40-50 feet from surface; trees growing on sides of collapse	Fence
Lucky Jenny	11	15-foot, circular collapse; 8 feet deep	Fill
Blue Ribbon	*12	100- x 90-foot, elliptical collapse; water level 15 feet from surface	Fence
Blue Ribbon	*13	50-foot, circular collapse; water level 6 feet from surface	Fill
Blue Ribbon	*14	20-foot, circular collapse; water level 1 foot from surface	None
Blue Ribbon	*15	50- x 20-foot, elliptical collapse; water level 20 feet from surface	Fill
Blue Ribbon	*16	100-foot, circular collapse; 80 feet deep	Fence and/or fill
Blue Ribbon	*17	40-foot, circular collapse; water level 10 feet from surface	Fill
Lucky Jenny	18	Open shaft with minor collapse at surface; water level 80-100 feet from surface	Fill
Dobson	25	30-foot, circular collapse; partially filled with trash	Fill
Dobson	28	6-foot, circular collapse; 25 feet deep; originally filled, but recollapsed	Fill
	29N-23E - 15		
Mary Ann	2	30-foot, circular collapse; water level 12 feet from surface; partially filled with brush and debris	Fill
Mary Ann	3	Open shaft with minor collapse at surface; water level 30-40 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 15		
Mary Ann	4	Open shaft; water level 30-foot from surface	Fill
Mary Ann	8	Open shaft with 10-foot, circular collapse	Fill
Mary Ann	11	Open shaft with minor collapse at surface; water level 10 feet from surface	Fill
W M & W	13	25-foot, circular collapse; water level 5 feet from surface	Fill
W M & W	16	30-foot, circular collapse; water level 250 feet from surface	Fill
W M & W	24	Open shaft; water level 50 feet from surface; auto body over shaft	Fill
Brewster	26	90- x 100-foot nearly circular collapse; water level near surface; berm around collapse	None
Brewster	27	25-foot, circular collapse; 25 feet deep	Fill
Brewster	28	Open shaft with minor collapse at surface; water level 25 feet from surface	Fill
W M & W	29	30-foot, circular collapse; water level at surface	None
Golden Eagle	30	Open shaft; water level 15 feet from surface	Fill
Golden Eagle	31	Open shaft; water level 140 feet from surface	Fill
Beck	32	Open shaft; water level 30 feet from surface	Fill
Wade	36	30- x 15-foot, rectangular collapse; water level 2 feet from surface	None
Wade	37	18- x 9-foot, rectangular collapse; water level 1 foot from surface	None
	29N-23E - 16		
Swift	*2	10- x 8-foot, rectangular collapse; 5 feet deep; probably partially filled; large diameter (12") tree in bottom	None
Hunt	*9	Open shaft; water level 30 feet from surface; sides beginning to cave inward	Fill
Cortez	*11	Open shaft; partially filled to 20 feet from surface	Fill
Cortez	*12	Open shaft; water level 25 feet from surface; partially filled	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 16		
Consolidated No. 3	*13	55-foot, circular collapse; water level 10 feet from surface	Fence and/or fill
Consolidated No. 3	*15	Open shaft; water level 35 feet from surface	Fill
Consolidated No. 2	*16	Open shaft; water level 25 feet from surface; cribbing beginning to cave	Fill
Eudora Whitebird	*20	20- x 12-foot, elliptical collapse; 6 feet deep; partially filled with debris	Fill
	29N-23E - 17		
Slim Jim	*4	20- x 15-foot, elliptical collapse; water level 18 inches from surface	None
Ohimo	*6	10-foot, square collapse; 6 feet deep; filled with debris	Fill
Ohimo	*7	40-foot, circular collapse; water level 50 feet from surface; water seeping into opening; very dangerous, in middle of tailings pond	Fill and/or fence
Ohimo	8	6- x 4-foot, elliptical collapse; 1 foot deep; partially filled with debris	Fill
Goodwin	11	40- x 30-foot, elliptical collapse; 8 feet deep; partially filled with debris	Fill
Goodwin	12	6-foot, circular collapse; 4 feet deep	Fill
Goodwin	15	Minor collapse; mostly concealed by honeysuckle; fenced	None
Netta White	27 and 28	240-foot circular, and 280- x 140-foot elliptical collapse; 25 feet deep; few small trees growing on sides of collapse	Fence
Netta White	29	10-foot, square collapse; water level 21 feet from surface; may be filled with debris	Fill
Lucky Syndicate	*33	40-foot, circular collapse; 12 feet deep	Fill
Lucky Syndicate	*34	60-foot, circular collapse; water level 8 inches from surface	None
Lucky Syndicate	*35	6- x 4-foot, elliptical collapse; 3 feet deep; filled with boulders	Fill
Piokee	*37	Open shaft; partially filled with debris	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E- 17		
Piokee	*39	3-foot circular collapse; 2 feet deep; filled with concrete debris	None
Howe	*41	20-foot, circular collapse; water level 6 inches from surface	None
Lucky Syndicate	*43	10-foot, square collapse; 4 feet deep; filled with chat	Fill
Lucky Syndicate	*44	10-foot, square collapse; 3 feet deep; concrete cube has settled	None
	29N-23E - 18		
Pelican	1	15-foot, circular collapse; 8 feet deep	Fill
Pelican	2	10-foot, circular collapse; 5 feet deep	None
Pelican	7	25-foot, circular collapse; water level 30-40 feet from surface	Fill
Gordon No. 2	8	180- x 100-foot, elliptical collapse; water level 35-40 feet deep	Fence
Gordon No. 3	12	50-foot, circular collapse; water level 1 foot from surface	None
Gordon No. 3	21	Minor collapse; partially filled with debris	Fill
Gordon No. 3	23	75- x 50-foot, elliptical collapse; water level 1 foot from surface	None
Gordon No. 3	24	45-foot, circular collapse; water level 2 feet from surface	None
Tongaha	*26	20-foot, circular collapse; 10 feet deep; partially filled with debris	Fill
	29N-23E - 19		
Tongaha	*2	40- x 25-foot, elliptical collapse; water level 4 feet from surface	None
Tongaha	*3	60-foot, circular collapse; water level 2 feet from surface	None
Tongaha	*4	25-foot, circular collapse; water level 3 feet from surface	None
Anna Beaver	*5	15-foot, circular collapse; 10 feet deep	Fill
Anna Beaver	*6	240- x 220-foot, elliptical collapse; water level 15 feet from surface	Fence

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 19		
Anna Beaver	*7	350- x 225-foot, elliptical collapse; water level 30 feet from surface	Fence
Tongaha	*10	20- x 15-foot, rectangular collapse; 15 feet deep; appears to be ventilation shaft; 3-foot-diameter concrete cylinder sticking up at ground level; has grate cover	Fill
Tongaha	*11	70-foot, circular collapse; water level 10 feet from surface; shows sign of fresh collapse (3/8/82)	Fence and/or fill
Tongaha	*12	30-foot, circular collapse; water level 1 foot from surface	None
Anna Beaver	*13	35-foot, circular collapse; water level 10 feet from surface	Fill
Anna Beaver	*14	45-foot, circular collapse; water level 20 feet from surface	Fill
Anna Beaver	*16	55-foot, circular collapse; water level 8 feet from surface	Fill
Anna Beaver	*18	85-foot, circular collapse; water level 6 feet from surface	Fence and/or fill
Anna Beaver	*19	30-foot, circular collapse; 15 feet deep	Fill
Anna Beaver	*24	45-foot, circular collapse; water level near surface	None
Anna Beaver	*25	2-foot, circular, shallow depression	None
John Beaver	*31	50-foot, circular collapse; water level 18 inches from surface	None
Central	*34	35-foot, circular collapse; water level 1 foot from surface	None
Central	*36	12- x 6-foot, rectangular collapse; 3 feet deep	Fill
Velie Lion	*38	15- x 10-foot, rectangular collapse; 20 feet deep	Fill
Velie Lion	*39	25-foot, circular collapse; 10 feet deep	Fill
Velie Lion	*42	80-foot, circular collapse; water level 2 feet from surface	None
Harrisburg	*43	30-foot, circular collapse; 5 feet deep	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 19		
Harrisburg	*44	50- x 30-foot, elliptical collapse; water level 2 feet from surface	None
Crystal	*45	120- x 100-foot, elliptical collapse; 25 feet deep; trees growing in collapse	None
Crystal	*46	25-foot, circular collapse; water level 15 feet from surface	Fill
Crystal	*47	220-foot, circular collapse; water level 40 feet from surface; trees growing on sides of collapse	Fence
Harrisburg	*51	60- x 30-foot, elliptical collapse; 12 feet deep	Fence
Velie Lion	*52	30-foot, circular collapse; water level 25 feet from surface; everything has slumped about 6 feet	Fence
	29N-23E - 20		
Dorothy Bill No. 2	5	15-foot, circular collapse; 6 feet deep	Fill
Kenoyer	9	Shallow depression filled with debris	Fill
Kenoyer	12	Open shaft; water level 15 feet from surface	Fill
Kenoyer	13	25-foot, circular collapse; in chat pile; water level 25 feet from top of chat; very dangerous	Fill immediately
Kenoyer	14	25-foot, circular collapse; water level 1 foot from surface	None
Dorothy Bill No. 2	15	Minor collapse; partially filled with debris	Fill
Dorothy Bill No. 2	17	25- x 20-foot, elliptical collapse; 15 feet deep	Fill
Oko	*36	6- x 10-foot, rectangular collapse; 2 feet deep; appears to be filled	None
Kenoyer	47	Open shaft with 10-foot, circular collapse at surface; water level 12 feet from surface; partially filled with garbage	Fill
Kenoyer	49	25-foot, circular collapse; water level 15 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 20		
Kenoyer	50	25-foot, circular collapse; water level 15 feet from surface	Fill
Kenoyer	52	Open shaft; water level 15 feet from surface	Fill
	29N-23E - 21		
South Bingham	*9	15- x 10-foot, elliptical collapse; 5-10 feet deep; filled with debris	Fill
Eudora Whitebird	*13	20-foot, circular collapse; 15 feet deep; filled with debris	None
Jeff City	*22	15-foot, circular collapse; 10 feet deep; partially filled	Fill
Jeff City	*23	40-foot, circular collapse; water level 40 feet from surface; fenced	None; maintain fence
Grace Walker	29	12-foot, circular collapse; water level 5 feet from surface; appears shaft is partially filled	Fill
Jefferson	32	12- x 10-foot, elliptical collapse; 6 feet deep; concrete cube sitting in bottom	Fill
Jefferson	33	25-foot, circular collapse; water level 1 foot from surface	None
Royal	35	40-foot, circular collapse; water level 15 feet from surface, fenced	Fill
Royal	39	Open shaft with minor collapse at surface; water level 20 feet from surface; partially covered with sheet metal	Fill
Grace Walker	41	12-foot, circular collapse; 6 feet deep; large cube, 8 feet, rotated in bottom	Fill
	29N-23E - 22		
Dardene	1	40- x 20-foot, elliptical collapse; 20 feet deep; debris in bottom	Fill
Van Buren	9	40- x 20-foot, elliptical collapse; 15 feet deep; mature trees in bottom	None
Crutchfield	10	20-foot, circular collapse; 15 feet to cribbing; water running into shaft	Fill
Crutchfield	11	20-foot, circular collapse; water level 18 inches from surface	None

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 22		
Indiana	12	30-foot, circular collapse; water level 1 foot from surface	None
Indiana	13	20-foot, circular collapse; water level 1 foot from surface	None
Indiana	14	20-foot, circular collapse; water level 18 inches from surface	None
Indiana	15	22-foot, circular collapse; water level 50 feet from surface; walls vertical; fenced	Fill
Indiana	16	Open shaft; water level 30-40 feet from surface	Fill
Indiana	18	25-foot, circular collapse; water level 18 inches from surface	None
Ottawa	19	Open shaft; water level 40 feet from surface	Fill
Ottawa	20	40-foot, circular collapse; water level 60 feet from surface	Fill
Jo Buffalo	22	30- x 15-foot, rectangular collapse; 30 feet deep; appears cover or plug has fallen into bottom	Fill
Tulsa	24	30- x 15-foot, rectangular collapse; water level 1 foot from surface	None
Walker	28	40-foot, circular collapse; 15 feet deep; probably partially filled	Fill
Walker	29	50-foot, circular collapse; water level 40 feet from surface	Fill
Maxine	31	20-foot, circular collapse; water level 50 feet from surface	Fill
Maxine	32	Open shaft; water level 40 feet from surface; 15-foot collar; wood cribbing gone beneath collar to a depth of 15 feet; metal grate over shaft	Fill
Huttig-Beck	33	20-foot, circular collapse; water level 40 feet from surface	Fill
Huttig-Beck	34	40- x 20-foot, elliptical collapse; water level 30 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 23		
Texas	2	Open shaft; water level 100 feet from surface; wooden grate over opening	Fill
Texas	4	30-foot, circular collapse; water present; located in wheat field	Fill
Kropp	6	25-foot, circular collapse, water level 6 feet from surface; partially filled	Fill
Kropp	7	30-foot, circular collapse; 15 feet deep	Fill
Santa Fe	13	20-foot, circular collapse; 15 feet deep; rubble filled	Fill
Santa Fe	14	230- x 200-foot, elliptical collapse; 20 feet deep; used as dump; trash filled	Filled by 1981; recollapsed between 1981-1982; Fill
Blue Bonnet	16	30- x 25-foot, elliptical collapse; filled with rubble and trash	Fill
Blue Bonnet	18	Open shaft; water level 40 feet from surface; fenced	Fill
Blue Bonnet	19	Open shaft; water level 40 feet from surface; fenced	Fill
Blue Bonnet	20	50-foot, circular collapse; water level 25-30 feet from surface	Fill and/or fence
Blue Bonnet	22	50-foot, circular collapse; water level 50 feet from surface	Fill and/or fence
Massel	23	50-foot, circular collapse; water level 50 feet from surface	Fill and/or fence
Massel	24	40- x 15-foot, elliptical collapse; rubble filled	None
Massel	25	200- x 180-foot, elliptical collapse; 70 feet deep; trees growing in collapse	Fence
Massel	26	50-foot, circular collapse; water level 10 feet from surface	Fill and/or fence
Massel	27	20- x 15-foot, elliptical collapse; water level 140 feet from surface	Fill
Meteor	29 and 30	275- x 225-foot, elliptical collapse; water level 50 feet from surface; partially filled with trash and debris; has taken in part of a small road	Fence

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 23		
Meteor	31	95-foot, circular collapse; water level 30 feet from surface; trees growing in collapse	Fence
Massel	32	20-foot, circular collapse; water level 100 feet from surface	Fill
Mission	33 and 34	230- x 225-foot, elliptical collapse; 80 feet deep; 70- to 80-foot-tall trees growing in bottom of collapse	Fence
Mission	35	40-foot, circular collapse; water level 5 feet from surface; slight depression	None
Kropp	39	40-foot, circular collapse; water level 15 feet from surface	Fill
Kropp	42	30-foot, circular collapse; water level 3 feet from surface	None
Kropp	43	50-foot, circular collapse; water level 20 feet from surface	Fill and/or fence
	29N-23E - 24		
St. Louis No. 4	2	25- x 20-foot, elliptical collapse; 15 feet deep; filled with debris	Fill
St. Louis No. 4	8	18-foot, circular collapse; water level 2 feet from surface	None
St. Louis No. 4	9	25- x 13-foot, elliptical collapse; water level 1 foot from surface	None
	29N-23E - 26		
Hobart	*5	Minor collapse; filled with debris	None
Hope	*7	35- x 25-foot, elliptical collapse; water level 1 foot from surface	None
Hope	*8	20- x 15-foot, elliptical collapse; 15 feet deep	Fill
Hope	*10	40- x 30-foot, elliptical collapse; 20 feet deep	Fill
Longhunt	*11	25-foot, circular collapse; 20 feet deep	Fill
Alice Greenback	*15	25- x 20-foot, elliptical collapse; 15 feet deep; partially filled with debris	Fill
Alice Greenback	*16	30-foot, circular collapse; 15 feet deep	Fill
Betsy Greenback	*18	50-foot, circular collapse; water level 15 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 27		
Pat	2	50-foot, circular collapse; 25 feet deep	Fill
Pat	3	20-foot, circular collapse; 15 feet deep	Fill
Pat	4	35- x 25-foot, elliptical collapse; water level 25 feet from surface	Fill
Rainbow	6	40-foot, circular collapse; 15 feet deep; large trees growing in bottom	Fence
Arthur Buffalo	8	25-foot, circular collapse; 15 feet deep; partially filled with debris and junk	Fill
Arthur Buffalo	9	40- x 20-foot, elliptical collapse; water level 10 feet from surface; fenced, with rotated slab	Fill
Prairie Dog	10	40- x 25-foot, elliptical collapse; water level 2 feet from surface	None
Prairie Dog	11	25-foot, circular collapse; water level 50 feet from surface; under collapsed chat pile (20 feet to shaft)	Fill
Doris	13	30- x 25-foot, elliptical collapse; water level 8 feet from surface	Fill
Rose	14	30- x 20-foot, elliptical collapse; 5 feet deep; filled with debris	None
Doris	17	15- x 10-foot, elliptical collapse; water level 30 feet from surface	Fill
Beck	22	25-foot, circular collapse; 20 feet deep; junk filled	Fill
First National	24	15-foot, circular collapse; water level 5 feet from surface	Fill
First National	25	25-foot, circular collapse; 15 feet deep; junk in collapse (concrete pad)	Fill
First National	26	20-foot, circular collapse; water level 5 feet from surface	Fill
Beck	27	25-foot, circular collapse; water level 1 foot from surface; probably perched	None
Beck	28	20-foot, circular collapse; water level 1 foot from surface	None

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 27		
Beck	29	20-foot, circular collapse; water level 25 feet from surface	Fill
Pat	31	50-foot, circular collapse; 25 feet deep	Fill and/or fence
	29N-23E - 28		
Birthday	2	Open shaft with minor collapse at surface; water level 50 feet from surface	Fill
Birthday	3	25-foot, circular collapse; water level 25 feet from surface	Fill
Federal	4	50-foot, circular collapse; water level 30 feet from surface	Fill and/or fence
Federal	5	Open shaft; water level at surface	Fill
Federal	6	Open shaft; 70 feet deep	Fill
Fort Worth	8	30-foot, circular collapse; 20 feet deep	Fill
Fort Worth	9	160-foot, circular collapse; water level 30 feet from surface; mature trees growing on sides of collapse	Fence and/or fill
New Chicago No. 2	11	Open shaft; water level 50 feet from surface	Fill
New Chicago No. 2	14	30-foot, circular collapse; 20 feet deep	Fill
New Chicago No. 2	15	30-foot, circular collapse; water level 15 feet from surface	Fill
New Chicago No. 2	16	25-foot, circular collapse; 10 feet deep	Fill
Mo Mule	17	Open shaft; water level 50 feet from surface	Fill
Midas	19	Open shaft with minor collapse at surface	Fill
Midas	20	10-foot, circular collapse; 6 feet deep	Fill
New Chicago No. 1	*21	20-foot, circular collapse; partially filled with debris and car bodies	Fill
New Chicago No. 1	*22	30-foot, circular collapse; 20 feet deep	Fill
New Chicago No. 1	*24	40-foot, circular collapse; water level 30 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 28		
New Chicago No. 1	*25	Open shaft with minor collapse at surface; water level 3 feet from surface	Fill
Bull Frog	27	30-foot, circular collapse; water level 12 feet from surface	Fill
Bull Frog	28	40-foot, circular collapse; 25 feet deep	Fill
Bull Frog	29	40-foot, circular collapse; 20 feet deep	Fill
Bull Frog	31	60-foot, circular collapse; 20 feet deep	Fill and/or fence
Bull Frog	32	60-foot, circular collapse; water level 15 feet from surface	Fill and/or fence
Skelton	39	30-foot, circular collapse; 15 feet deep	Fill
Skelton	42	30-foot, circular collapse; 12 feet deep	Fill
Skelton	43	Open shaft with minor collapse at surface	Fill
	29N-23E - 29		
Domado	1, 2, and 3	560- x 400-foot (4.04 acres), elliptical collapse; water level near surface	Fence
Baby Jim	9	Open shaft; 20 feet deep	Fill
Domado	14	Open shaft; water level 11 feet from surface	Fill
Rialto	15	Open shaft; water level 25 feet from surface; metal grate over shaft	Fill
Rialto	17	Open shaft; water level 25 feet from surface; metal grate over shaft	Fill
Rialto	18	Open shaft; water level 25 feet from surface	Fill
Barbara J.	25	Open shaft; water level 20 feet from surface	Fill
Barbara J.	26	Open shaft; water level at surface	Fill
Barbara J.	27	70- x 40-foot, elliptical collapse; water level 6 feet from surface	Could be fenced
Barbara J.	29	25-foot, circular collapse; water level 15 feet from surface	Fill
Barbara J.	30	20-foot, circular collapse; 10 feet deep; rubble filled	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 29		
Barbara J.	31	30-foot, circular collapse; 20 feet deep	Fill
Barbara J.	32	40-foot, circular collapse; 25 feet deep	Fill
Barbara J.	33	Open shaft with minor collapse at surface; water level 8 feet from surface	Fill
Barbara J.	34	Open shaft; water level 7 feet from surface	Fill
Barbara J.	35	20-foot, circular collapse; water level 8 feet from surface	Fill
Barbara J.	36	Open shaft with minor collapse at surface; water level 20 feet from surface	Fill
Skelton	38	Open shaft; rubble 20-30 feet from surface	Fill
Skelton	40	Open shaft with minor collapse at surface; water level 30 feet from surface	Fill
Skelton	43	40-foot, circular collapse; 20 feet deep; rubble filled	Fill
Skelton	44	10-foot, circular collapse; 10 feet deep	Fill
Skelton	47	30-foot, circular collapse; 15 feet deep; debris filled	Fill
Skelton	53	40-foot, circular collapse; 35 feet deep	Fill
Skelton	54	20-foot, circular collapse; water level 8 feet from surface	Fill
Skelton	55	Open shaft; chat-filled, 10 feet from surface	Fill
Admiralty No. 3	56	Open shaft with minor collapse at surface; water level 8 feet from surface	Fill
Admiralty No. 3	57	Open shaft with minor collapse at surface; water level 30 feet from surface	Fill
Admiralty No. 3	58	Open shaft; water level 30 feet from surface	Fill
Skelton	59	Open shaft; water level 13 feet from surface	Fill
Admiralty No. 1	60	12- x 6-foot, elliptical collapse; 10 feet deep	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 29		
Lavrion	61	Open shaft with 10-foot, circular collapse at surface; 8 feet deep; partially filled with debris	Fill
Admiralty No. 1	64	10-foot, circular collapse; water level 8.5 feet from surface	Fill
Admiralty No. 4	65	Open shaft with 10-foot, circular collapse at surface; water level 8 feet from surface	Fill
Admiralty No. 2	66	40-foot, circular collapse; water level 8 feet from surface	Fill
Admiralty No. 2	67	Open shaft with minor collapse at surface; water level 8 feet from surface	Fill
Admiralty No. 4	69	Open shaft with minor collapse at surface; water level 10 feet from surface	Fill
Admiralty No. 4	70	Open shaft; water level 7 feet from surface	Fill
Douthat	71	60- x 40-foot, elliptical collapse; water level 7 feet from surface	Fence and/or fill
Douthat	72	Open shaft; water level 9 feet from surface	Fill
Lavrion	1701	Irregularly shaped, 1.17-acre open pit; water level near surface; trees adjacent to pit	None
	29N-23E - 30		
Lottson	*1	60-foot, circular collapse; water level 10 feet from surface	Fence and/or fill
Lottson	*2	12-foot, square collapse; 10 feet deep; filled with debris	Fill
Blue Goose No. 1	*5	Open shaft; 6 feet deep; partially filled with chat	Fill
Ritz	*10	40-foot, circular collapse; water level 1 foot from surface	None
Lottson	*15	Minor collapse, mostly concealed	None; monitor
Jay Bird	*23	Minor collapse; mostly covered by dirt	Fill
Lucky Bill	*28	Minor collapse; filled with debris to surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 30		
Woodchuck	*32	60-foot, circular collapse; water level 27 feet from surface	Fence and/or fill
Woodchuck	*33	Open shaft; water level 2 feet from surface; cattails growing in shaft	Fill
Woodchuck	*34	70-foot, circular collapse; water level 18 feet from surface	Fence and/or fill
Woodchuck	*35	165-foot, circular collapse; water level 15 feet from surface	Fence
See-Sah	*38	Open shaft; water level about 3 feet from surface	Fill
Shorthorn	*43	60- x 50-foot, elliptical collapse; water level 1 foot from surface	None
Shorthorn	*44	25-foot, circular collapse; water level 1 foot from surface	None
Shorthorn	*45	190-foot, circular collapse; coincides with depression in chat pile	Monitor
Shorthorn	*47	20-foot, circular collapse; partially filled with chat to 8 feet from surface	Fill
	29N-23E - 31		
Southside	*1	Minor collapse; water level 2 feet from surface	None
	29N-23E - 32		
Quebec	*2	Minor collapse; filled with debris to 3 feet from surface	Fill
Quebec	*4	Open shaft; water level 10 feet from surface	Fill
Quebec	*5	Open shaft; water level 8 feet from surface	Fill
Montreal	*6	15-foot, circular collapse; 15 feet deep	Fill
Beck	*10	15- x 12-foot, elliptical collapse; water level 30 feet from surface; mature trees in collapse	Fill
Beck	*11	40-foot, circular collapse; water level 30 feet from surface	Fill
Beck	*12	30-foot, circular collapse	Fill
Beck	*14	Minor collapse	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 32		
Beck	*15	30-foot, circular collapse; water level 30 feet from surface	Fill
Beck	*16	12-foot, circular collapse; 6 feet deep	Fill
Wesley Smith	*19	10-foot, circular collapse; 6 feet deep	Fill
Wesley Smith	*20	7-foot, circular collapse; 4 feet deep	Fill
	29N-23E - 33		
Craig	*3	15-foot, circular collapse; water level 8 feet from surface	Fill
Craig	*6	40- x 20-foot, elliptical collapse; water level at surface	None
Craig	*7	20-foot, circular collapse; water level 30 feet from surface	Fill
Craig	*10	20- x 15-foot, elliptical collapse; 15 feet deep; filled with debris	Fill
Craig	*11	25-foot, circular collapse; 15 feet deep	Fill
Craig	*12	Open shaft with minor collapse at surface; water level 30 feet from surface	Fill
Craig	*13	20-foot, circular collapse; water level 12 feet from surface	Fill
Craig	*14	20-foot, circular collapse; 12 feet deep; partially filled with debris	Fill
Craig	*15	15-foot, circular collapse; 12 feet deep	Fill
Wolverine	*18	50- x 20-foot, elliptical collapse; 20 feet deep	Fill and/or fence
Wolverine	*19	50- x 40-foot, elliptical collapse; 25 feet deep	Fence and/or fill
Craig	*20	25-foot, circular collapse; water level 20 feet from surface; fenced	Fill
Craig	*21	13-foot, circular collapse; 12 feet deep	Fill
Craig	*22	20-foot, circular collapse; 12 feet deep	Fill
John Hunt	*24	15-foot, circular collapse; water level 25 feet from surface	Fill
John Hunt	*25	Open shaft with minor collapse at surface; water level 25 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 33		
Craig	*26	30-foot, circular collapse; 15 feet deep	Fill
John Hunt	*27	Open shaft; water level 15 feet from surface	Fill
John Hunt	*28	40-foot, circular collapse; 15 feet deep	Fill
John Hunt	*29	20-foot, circular collapse; water level 40 feet from surface	Fill
John Hunt	*30	50- x 40-foot, elliptical collapse; 15 feet deep; mature trees growing in bottom of collapse	Fence and/or fill
John Hunt	*31	Minor collapse; covered by brush	Fill
	29N-23E - 34		
Ruth Goodeagle	*1	20-foot, circular collapse; 10 feet deep	Fill
Ruth Goodeagle	*3	30-foot, circular collapse; 15 feet deep; partially filled; looks unsafe at bottom	Fill
Imperial	*6	40- x 20-foot, elliptical collapse; partially filled with debris	Fill
Muskogee	*8	20-foot, circular collapse; partially filled to 25 feet from surface	Fill
Muskogee	*9	25-foot, circular collapse; 15 feet deep; filled with debris	Fill
Andrew Greenback	*11	20-foot, circular collapse; water level 8 feet from surface	Fill
	29N-23E - 35		
In Quapaw city limits	*3	Nearby resident said site "caved in after heavy rains of 1981"; has since been backfilled	Monitor
Harry Whitebird	*4	15- x 12-foot, elliptical collapse; 12 feet deep; partially filled with concrete blocks and structural steel	Fill
Julia Shapp	*9	14- x 10-foot, elliptical collapse; water level 25 feet from surface	Fill
	29N-23E - 36		
Crawford	1	30- x 12-foot, elliptical collapse; water level 15 feet from surface	Fill
Crawford	2	12-foot, circular collapse; filled with debris	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 36		
Frank Buck	3	25-foot, circular collapse; 20 feet deep	Fill
Frank Buck	5	15- x 10-foot, elliptical collapse; 25 feet deep; filled with garbage	Fill
Frank Buck	6	Open shaft with minor collapse at surface; water level 15 feet from surface	Fill
Frank Buck	7	15-foot, circular collapse; 25 feet deep	Fill
Frank Buck	9	15-foot, circular collapse; water level 15 feet from surface	Fill
Frank Buck	10	14-foot, circular collapse; water level 10 feet from surface	Fill
Silver Streak	12	20-foot, circular collapse; filled with debris and 1960 Chevy	Fill
Silver Streak	13	12-foot, circular collapse; water level 15 feet from surface	Fill
Silver Streak	14	10-foot, circular collapse; water level 20 feet from surface	Fill
Silver Streak	15	15- x 8-foot, elliptical collapse; filled with timbers	Remove timbers and fill
Silver Streak	16	20- x 15-foot, elliptical collapse; 15 feet deep; filled with debris	Fill
Petersburg	20	12-foot, circular collapse; water level 15 feet from surface; shaft mostly intact at depth of 12 feet	Fill
Petersburg	22	Open shaft; water level 15 feet from surface	Fill
	29N-24E - 17		
M. W. Clark	1	Open shaft with minor collapse at surface	Fill
Discard	2	Open shaft; water level 40 feet from surface	Fill
Discard	3	40-foot, circular collapse; water level 40 feet from surface	Fill
Discard	4	Open shaft; filled with debris to 30 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-24E - 17		
Discard	5	20-foot, circular collapse; 151 feet deep; partially filled with debris	Fill
Martha B.	6	40- x 20-foot, elliptical collapse; 20 feet deep	Fill
Martha B.	8	60- x 40-foot, elliptical collapse; water level 18 inches from surface	None
	29N-24E - 18		
Diamond Joe	3	20- x 10-foot, elliptical collapse; water level 18 feet from surface	None
	29N-24E - 19		
Campbell	1	30-foot, circular collapse; 15 feet deep; partially filled with debris	Fill
Campbell	2	40-foot, circular collapse; water level 8 feet from surface	Fill
Campbell	3	20-foot, circular collapse; debris to 20 feet from surface	Fill
Malsbury	4	25-foot, circular collapse; water level 12 feet from surface	Fill
Malsbury	5	Open shaft with minor collapse at surface; debris to 15 feet from surface	Fill
Campbell	13	12-foot, circular collapse; water level 12 feet from surface	Fill
Sunnyside	15	20-foot, circular collapse; water level 18 inches from surface	None
M. Sullivan	17	15-foot, circular collapse; water level 15 feet from surface	Fill
M. Sullivan	18	10-foot, circular collapse; water level 18 feet from surface	Fill
	29N-24E - 29		
Majeska	1	15-foot, circular collapse; 18 feet deep	Fill
	29N-24E - 30		
John L.	1	60- x 40-foot, elliptical collapse; 25 feet deep	Fence and/or fill
John L.	4	30- x 20-foot, rectangular collapse; water level 18 inches from surface	None
John L.	5	15-foot, circular collapse; water level 18 inches from surface	None

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-24E - 30		
John L.	6	20-foot, circular collapse; water level 18 inches from surface	None
Sam Abrams	15	20-foot, circular collapse; water level 18 inches from surface	None
Sam Abrams	16	25-foot, circular collapse; brush-covered	Fill
Sam Abrams	20	20- x 12-foot, elliptical collapse; 10 feet deep	Fill
Sam Abrams	23	30-foot, circular collapse; 15 feet deep	Fill
Sam Abrams	27	16-foot, circular collapse; 8 feet deep	Fill
Sunnyside	29	30- x 20-foot, elliptical collapse; water level 18 inches from surface	None
J. E. McGuirk	36	25-foot, circular collapse; 15 feet deep; partially filled with garbage	Fill
J. E. McGuirk	37	Open shaft; water level 16 feet from surface	Fill
J. E. McGuirk	39	5-foot, circular collapse; 3 feet deep	None
J. E. McGuirk	40	25-foot, circular collapse; 15 feet deep; debris-filled	Fill
Ten O'clock	45	Open shaft; water level 30 feet from surface	Fill
Sam Abrams	46	30-foot, circular collapse; 20 feet deep	Fill
	29N-24E - 31		
Quivera	5	25-foot, circular collapse; 15 feet deep; partially filled with debris	Fill
McKibbon	6	40-foot, circular collapse; water level 30 feet from surface	Fill
Waxahachie	7	40-foot, circular collapse; water level 2 feet from surface	None
Waxahachie	8	32- x 20-foot, elliptical collapse; 12 feet deep; partially filled with debris	Fill
Waxahachie	9	10-foot, circular collapse; 15 feet deep; partially filled with garbage	Fill
Red Eagle	10	Open shaft with minor collapse at surface; water level 30 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-24E - 31		
Red Eagle	11	25-foot, circular collapse; 15 feet deep	Fill
Red Eagle	12	30-foot, circular collapse; water level 2 feet from surface	None
Red Eagle	13	15-foot, circular collapse; 15 feet deep; partially filled	Fill
Red Eagle	14	8-foot, circular collapse; 15 feet deep; partially filled with logs and branches	Fill
Red Eagle	15	20- x 15-foot, elliptical collapse; water level 3 feet from surface	None
Red Eagle	16	15-foot, circular collapse; 6 feet deep; partially filled	Fill
Red Eagle	17	15-foot, circular collapse; 10 feet deep; partially filled	Fill
Red Eagle	18	Open shaft; water level 40 feet from surface; concrete surface; cribbing mostly intact	Fill
Red Eagle	19	Open shaft with minor collapse at surface	Fill
Lena Whitebird	*20	15-foot, circular collapse; 6 feet deep	Fill
Lena Whitebird	*21	7-foot, circular collapse; 6 feet deep	Fill
Preston	24	20- x 15-foot, elliptical collapse; water level 25 feet from surface	Fill
Preston	25	Open shaft; water level 25 feet from surface	Fill
Preston	29	8-foot, circular collapse; contains large concrete blocks	Fill
Widow Crawfish	*32	100-foot, circular collapse; water level 20 feet from surface	Fence and/or fill
	29N-24E - 32		
Blacksnake	*1	10-foot, circular collapse; water level 30 feet from surface	Fill
Lancaster Min. Co.	*2	15-foot, circular collapse; water level greater than 30 feet from surface; partially filled with headframe timbers	Fill
Hobo	*3	15-foot, circular collapse; water level 8 feet from surface	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	29N-24E - 32		
Hobo	*4	Open shaft; water level 30 feet from surface; probably covered at one time, now open	Fill
Good Luck	*8	10- x 7-foot, elliptical collapse; water level 25 feet from surface	Fill
50-50	*9	10-foot, circular collapse; water level 25 feet from surface	Fill
Lancaster Min. Co.	*22	10-foot, circular collapse; water level 16 feet from surface	Fill
Lancaster Min. Co.	*23	8-foot, circular collapse; filled with garbage	Monitor
Unknown	*26	Open shaft; water level 25 feet from surface; headframe mostly intact	Fill
Blacksnake	27	12-foot, circular collapse; 6 feet deep	Fill
Scott Thompson	28	15-foot, circular collapse; water level 15 feet from surface	Fill
Scott Thompson	29	25- x 20-foot, elliptical collapse; 10 feet deep	Fill
Scott Thompson	30	Open shaft with 10-foot, circular collapse at surface; 30 feet deep	Fill
Blacksnake	31	20- x 15-foot, elliptical collapse; 8 feet deep	Fill
Blacksnake	32	10-foot, circular collapse; 5 feet deep	Fill
		KANSAS[c]	
	35S-23E - 13		
New Blue Diamond	3	20-foot, circular collapse; 30 feet deep; undercut on south and west sides	Fill
Blue Diamond	5	60-foot, circular collapse; 25 feet deep, dry; overgrown with trees	Fill
Chubb		620-foot, circular collapse in chat pile; 5 feet deep	Monitor
	35S-23E - 14		
Boska	2	15-foot, circular collapse; 10 feet deep, dry	Fill

TABLE 2. - (Continued)

Mine name	Location and site number[a]	Present condition	Suggested remedial action
	35S-23E - 14		
Mid-Continent/ Lawyers	3	20-foot, circular collapse; water level 10 feet from surface	Fill and/or fence
Mid-Continent/ Lawyers	4	20-foot circular collapse; water level near surface	Fill
Wilbur	6	5- x 6-foot open shaft; water level 30 feet from surface	Fill
	35S-24E - 13		
Harrington	3	35- x 25-foot, elliptical collapse; water level near surface; partially filled with debris	Fill and/or fence
Harrington	4	40- to 50-foot, circular collapse; water level near surface	Fence and/or fill
Wade (Commonwealth No. 2)	5	20-foot, circular collapse; water level near surface	Fill and/or fence
Wade (Commonwealth No. 2)	6	250- x 180-foot, elliptical collapse; 60 feet deep, dry; overgrown with trees	Fence
Wade (Commonwealth No. 2)	7	5- x 5-foot open shaft; water level 100 feet from surface	Fill
Wade (Commonwealth No. 2)	8	100-foot, circular collapse; 50 feet to shaft opening	Fence and/or fill
	35S-24E - 16		
Lucky OK.	4	Small 20-foot, deep circular collapse; dry; partially filled	Fill
Lucky OK.	5	25-foot circular collapse; water level 250-300 feet from surface	Fill and/or fence
Bunker Hill	6	30-foot, circular collapse; cribbing 30 feet from surface	Fence and/or fill
	35S-24E - 17		
John Stoskopf	1	20-foot, circular collapse; 20 feet deep; partially filled; contains trees and brush	Fill

[a]Location given in township, range, and section; site numbers correspond to numbers on plate 2; 1,700 numbers used for open pits.
[b]Coarse, 6-12-inch boulder piles are frequently found adjacent to each shaft; this material could be used to fill a shaft and (or) collapse feature.
[c]Shaft-site conditions and suggested remedial action(s) provided by James R. McCauley, Kansas Geological Survey.
*On Indian restricted land.

TABLE 3. - Subsidence events

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
28N-22E - 1			
30	Before 1939	By 1972, 160- x 130-foot, elliptical collapse; covers 16,336 ft^2 (0.38 acre); supports small shrubs	None; back filling began between 1964 and 1972, ended by 1979; several small collapses near site filled by 1972
32	Before 1939	By 1964, 75- x 210-foot elliptical and 65-foot circular collapse; covers 48,675 ft^2 (1.12 acres); site supports small shrubs	None; filled between 1964 and 1972; slight depression over filled collapse appeared between 1979 and 1980
39	Before 1939	By 1972, 165- x 130-foot elliptical and 80-foot circular collapse; covers 25,130 ft^2 (0.58 acre); site supports little vegetation	None; filled between 1972 and 1979
1500	Between 1939 and 1952	By 1982, shape of collapse was a 200- x 150-foot ellipse covering an area of 23,560 ft^2 (0.54 acre)	None; stable since 1952; mature trees growing in collapse feature
1516	Before 1939	By 1982, 150- x 115-foot elliptical collapse; covers an area of 13,550 ft^2 (0.31 acre); unstable; enlarged since 1979; water level near surface; joined with collapses 1528 and 1552 between 1952 and 1964	Monitor; appears to be unstable
1524	Before 1939	By 1964, 130-foot circular collapse; covers an area of 13,270 ft^2 (0.30 acre); stable since 1964	None; back filled between 1979 and 1980; slight depression over collapse feature; some standing water
1525	Before 1939	By 1982, shape of collapse was irregular covering an area of 33,415 ft^2 (0.77 acre); water filled, level near surface	Monitor; appears to be unstable; slight enlargement since 1980
1526	Before 1939	By 1982, 90-foot circular collapse, covers an area of 6,360 ft^2 (0.15 acre); water filled, level near surface	None; stable since 1979
1527	Between 1952 and 1964	By 1982, 90- x 80-foot elliptical collapse; covers an area of 5,655 ft^2 (0.13 acre); water filled, level near surface	None; stable since 1980
*1528	Between 1939 and 1952; joined with 1516 and 1552 between 1952 and 1964	By 1982, 190-foot circular collapse; covers an area of 28,355 ft^2 (0.65 acre); unstable; water filled, level near surface	Monitor, unstable since 1980

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
28N-22-E - 1			
1529	Before 1939	By 1982, 275- x 125-foot elliptical collapse; covers an area of 27,000 ft^2 (0.62 acre); 25 feet deep, dry, partially filled with garbage; area around collapse has been reclaimed	Stable since 1980; fill with rock and (or) non-biodegradable material
1530	Before 1939	By 1972, 165- x 130-foot elliptical collapse; covers an area of 16,845 ft^2 (0.39 acre)	None; filled between 1972 and 1979; junkyard occupies site; monitor
1531	Between 1939 and 1952	By 1979, 200- x 165-foot elliptical collapse; covers an area of 25,920 ft^2 (0.60 acre); site supports little vegetation	None; monitor, filled between 1979 and 1980; slight depression appears over former collapse between 1979 and 1980
1532	Between 1964 and 1972	By 1982, 155-foot circular collapse; covers an area of 18,870 ft^2 (0.43 acre); water filled, level near surface	Monitor, unstable; slight enlargement since 1980
1552	Between 1939 and 1952; joined with 1516 and 1528 between 1952 and 1964	By 1982, 200- x 160-foot elliptical collapse; covers an area of 25,135 ft^2 (0.58 acre); water filled, level near surface	Monitor; unstable; substantial enlargement since 1980
1554	Between 1952 and 1964	By 1982, 45-foot circular collapse; covers an area of 1,590 ft^2 (0.04 acres); water filled, level near surface	None; stable since 1980
28N-22E - 12			
5	Between 1939 and 1952	By 1982, 120-foot, circular collapse; covers 11,310 ft^2 (0.26 acre); water level 18 feet from surface; partially filled with debris and garbage	Could be filled; stable since 1972
28N-23E - 6			
4	Before 1939	By 1982, 115-foot, circular collapse; covers 10,385 ft^2 (0.24 acre); water level near surface; area around site has been reclaimed	None; relatively stable since 1939; little growth since 1979

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
28N-23E - 7			
1	Before 1939	By 1964, 330- x 200- foot, elliptical collapse; covers 51,835 ft^2 (1.19 acre); filled between 1964 and 1972; slight depression appears over former collapse between 1964 and 1972; depression partially filled with garbage and debris	None
2	Before 1939	By 1982, 280- x 200-foot elliptical and 45-foot circular collapse; covers 45,575 ft^2 (1.05 acres); unstable; enlargement since 1980; water level near surface; partially filled with debris	Monitor
1522	Between 1939 and 1952	By 1982, 40-foot, circular collapse; covers 1,260 ft^2 (0.03 acre); stable since 1952; partially filled with garbage and debris	Could be filled
1523	Between 1939 and 1952	By 1982, 245- x 170-foot, elliptical collapse; covers 32,710 ft^2 (0.75 acre); stable since 1979; water level near surface	None
28N-24E - 6			
1521	Between 1939 and 1952	By 1982, 60-foot, circular collapse; covers 2,825 ft^2 (0.06 acre); stable since 1972; 20 feet deep; dry	Could be filled
29N-22E - 25			
5	Between 1952 and 1964	By 1982, 220-foot, circular collapse; covers 38,015 ft^2 (0.87 acre); water level near surface	Monitor; very unstable; enlarged over 4 times since 1980; could be fenced
29N-22E - 36			
*1542	Between 1964 and 1972	By 1982, 140- x 115-foot, elliptical collapse; covers 12,645 ft^2 (0.29 acre); water level at surface	Monitor; unstable; slight enlargement since 1980
*1543	Between 1972 and 1979	By 1982, 45- x 40-foot, elliptical collapse; covers 1,415 ft^2 (0.03 acre); water level near surface	None; stable since 1980
*1544	Between 1964 and 1972	By 1982, 90- x 80-foot, elliptical collapse; covers 5,655 ft^2 (0.13 acre); water level at surface	Monitor; unstable; slight enlargement since 1980

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
29N-23E - 13			
3	Between 1939 and 1952	By 1982, 100-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); water level 10 feet from surface	None; stable since 1972
1519	Before 1939	By 1982, 200- x 175-foot, elliptical collapse; covers 27,490 ft^2 (0.63 acre); water level near surface; fish present in collapse	None; relatively stable since 1972
29N-23E - 14			
8	Before 1939	By 1982, 200-foot, circular collapse; covers 31,415 ft^2 (0.72 acre); water level 60 feet from surface; adjacent to buildings within Hockerville city limits	None; stable since 1964; mature trees growing on sides; could be fenced
*12	Between 1939 and 1952	By 1982, 100- x 90-foot, elliptical collapse; covers 7,070 ft^2 (0.16 acre); water level 15 feet from surface	None; relatively stable since 1979; could be fenced
*16	Before 1939	By 1982, 100-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); water level 60 feet from surface	Monitor; unstable; slight enlargement since 1980; trees growing on sides of collapse; could be fenced
1517	Between 1964 and 1972	By 1982, 200- x 175-foot, elliptical collapse; covers 27,490 ft^2 (0.63 acre); water level 60 feet from surface	None; stable since 1980; could be fenced
1518	Between 1952 and 1964	By 1982, 160- x 140-foot elliptical collapse; covers 17,595 ft^2 (0.40 acre); water level 40 feet from surface; within Hockerville city limits	Monitor; unstable; slight enlargement since 1980; small shrubs growing on sides; could be fenced
29N-23E - 15			
26	Between 1939 and 1952	By 1982, 100- x 90-foot elliptical collapse; covers 7,070 ft^2 (0.16 acre); water level near surface	None; berm around collapse; stable since 1964
29N-23E - 17			
27 and 28	Approximately 12:01 a.m. July 21, 1967	18 persons occupied houses affected; 5 minor injuries; 2 houses, in center; one on lip tilted 25° from horizontal, and attached garage of 4th house in the rim of the collapse was broken away from the house and was severely crumpled; by 1982, 280- x 140-foot elliptical and 240-foot circular collapse; covers 76,025 ft^2 (1.75 acres); 25 feet deep; few small trees grow-	Monitor; could be fenced

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
		ing on sides of collapse; some water present	
29N-23E - 18			
8	Between 1964 and 1972	By 1982, 180- x 100-foot, elliptical collapse; covers 14,135 ft^2 (0.32 acre); water level 40 feet from surface	Monitor; unstable; enlarged since 1980; could be fenced
1513	Before 1939	By 1982, 100- x 80-foot, elliptical collapse; covers 6,285 ft^2 (0.14 acre); water level 30 feet from surface	None; relatively stable since 1939; trees growing in and on sides of collapse; could be fenced (berm built around collapse)
1514	Between 1964 and 1972	By 1982, 80- x 60-foot, elliptical collapse; covers 3,770 ft^2 (0.09 acre); fenced	Monitor; unstable; slight enlargement since 1980; could be filled
29N-23E - 19			
*6	Before 1939	By 1982, 240- x 220-foot, elliptical collapse; covers 41,470 ft^2 (0.95 acre); water level 15 feet from surface	Monitor; unstable; enlarged since 1980
*7	Between 1939 and 1952	By 1982, 350- x 225-foot elliptical collapse; covers 61,850 ft^2 (1.42 acres); water level 30 feet from surface	None; stable since 1979
*45	Between 1939 and 1952	By 1982, 120- x 100-foot, elliptical collapse; covers 9,425 ft^2 (0.22 acre); 25 feet deep	Monitor; unstable; slight enlargement since 1980; trees growing in collapse
*47	Before 1939	By 1982, 220-foot, circular collapse; covers 38,015 ft^2 (0.87 acre); water level 40 feet from surface	None; relatively stable since 1979; could be fenced; trees growing on sides of collapse
*1502	Between 1972 and 1979	By 1982, 100-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); water level near surface	None; stable since 1979
*1503	Between 1972 and 1979	By 1982, 100-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); water level near surface	Monitor; unstable; slight enlargement since 1980
*1504	Between 1964 and 1972	By 1982, 240- x 160-foot, elliptical collapse; covers 30,160 ft^2 (0.69 acre); water level 45 feet from surface	Should be fenced; monitor; unstable; slight enlargement since 1980
*1505	Between 1972 and 1979	By 1982, 90-foot, circular collapse; covers 6,360 ft^2 (0.15 acre); 20 feet deep	Could be filled; stable since 1980

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
29N-23E - 19			
*1506	Between 1972 and 1979	By 1982, 100- x 75-foot, elliptical collapse; covers 5,890 ft^2 (0.14 acre); stable; 25 feet deep	Could be filled; stable since 1979; trees growing on sides of collapse
*1507	Before 1939	By 1982, 160-foot, circular collapse; covers 20,105 ft^2 (0.46 aces); 30 feet deep	Could be filled; unstable; slight enlargement since 1980; trees growing in and on sides of collapse
*1508	Between 1972 and 1979	By 1982, 40-foot, circular collapse; covers 1,255 ft^2 (0.03 acre); water level near surface	Could be filled; stable since 1980
*1509	Between 1964 and 1972	By 1982, 140- x 125-foot, elliptical collapse; covers 13,745 ft^2 (0.32 acre); 30 feet deep	Could be filled; stable since 1980; trees growing on sides of collapse
*1510	Between 1972 and 1979	By 1982, 50- x 40-foot, elliptical collapse; covers 1,570 ft^2 (0.04 acre); water level near surface	None; stable since 1980
*1533	Between 1972 and 1979	By 1982, 40-foot, circular collapse; covers 1,255 ft^2 (0.03 acre); 20 feet deep, some chat in collapse	Could be filled; unstable; slight enlargement since 1980
*1534	Between 1972 and 1979	By 1982, 45-foot, circular collapse; covers 1,590 ft^2 (0.04 acre); collapse in middle of small road; water level 10 feet from surface	Could be filled; unstable; slight enlargement since 1980
*1535	Between 1939 and 1952	By 1982, 80-foot, circular collapse; covers 5,025 ft^2 (0.12 acre); 25 feet deep	Could be filled; stable since 1980; trees growing on sides of collapse
*1536	Between 1972 and 1979	By 1982, 45-foot, circular collapse; covers 1,590 ft^2 (0.04 acre); water level 15 feet from surface	None; stable since 1980
*1537	Before 1939	By 1982, 120- x 100-foot, elliptical collapse; covers 10,365 ft^2 (0.24 acre); water level near surface	Monitor; unstable; slight enlargement since 1980
*1538	Between 1972 and 1979	By 1982, 40-foot, circular collapse; covers 1,255 ft^2 (0.03 acre); water level near surface	None; stable since 1979
*1539	Between 1939 and 1952	By 1982, 110- x 65-foot, elliptical collapse; covers 5,615 ft^2 (0.13 acre); water level 10 feet from surface	None; stable since 1980; trees growing on sides of collapse
*1540	Before 1939	By 1982, 85-foot, circular collapse; covers 5,675 ft^2 (0.13 acre); water level near surface	None; stable since 1952

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
29N-23E - 19			
*1541	Between 1939 and 1952	By 1982, 25-foot, circular collapse; covers 490 ft^2 (0.01 acre); water level near surface	None; stable since 1952
29N-23E - 20			
1520	Betwen 1939 and 1952	By 1982, 90-foot, circular collapse; covers 6,360 ft^2 (0.15 acre); water level 20 feet from surface; fenced	None; fence needs repair; stable since 1972
1550	Between 1939 and 1952	By 1982, 145- x 125-foot, elliptical collapse; covers 14,235 ft^2 (0.33 acre); water level 30 feet from surface; adjacent to chat pile	Monitor; unstable; slight enlargement since 1980; could be filled with nearby chat material
1555	Between 1972 and 1979	By 1984, 75-foot, nearly circular collapse; covers 4,418 ft^2 (0.10 acre); 25 feet deep, some water	Unstable; could be fenced or filled; dangerous, near vertical walls
29N-23E - 23			
14	Before 1939	By 1982, 230- x 200-foot, elliptical collapse; covers 36,130 ft^2 (0.83 acre); former trash dump	Monitor; very unstable; enlarged 1.75 times since 1981, almost filled by 1980 and recollapsed between 1981 and 1982
25	Before 1939	By 1982, 200- x 180-foot, elliptical collapse; covers 28,725 ft^2 (0.65 acre); 70 feet deep	Monitor; could be fenced; unstable; enlarged since 1980; trees growing in collapse
29 and 30	Between 1939 and 1952	By 1982, 275- x 225-foot elliptical collapse; covers 48,595 ft^2 (1.12 acres); water level 50 feet from surface; partially filled with trash and debris; has taken in part of small road	None; stable since 1980; could be fenced
31	Between 1939 and 1952	By 1982, 95-foot, circular collapse; covers 7,090 ft^2 (0.16 acre); water level 30 feet from surface	None; stable since 1979; trees growing in collapse; could be fenced
33 and 34	Before 1939	By 1982, 230- x 225-foot, elliptical collapse; covers 40,645 ft^2 (0.93 acre); 80 feet deep; trees growing in collapse	None; stable since 1980; mature trees growing on sides of collapse; could be fenced
1553	May 31, 1978	A 90- x 40-foot and 50-foot deep cave-in; covers 3,600 $feet^2$ (0.08 acre); began on south side of east A Street about 8 a.m.; by noon the cave-in had reached the center of the road; filled in June, 1978	None; monitor

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
29N-23E - 28			
9	Between 1939 and 1952	By 1982, 160-foot, circular collapse; covers 20,105 ft^2 (0.46 acre); water level 30 feet from surface; mature trees growing on sides of collapse	Monitor; unstable since 1980; mature trees growing on sides of collapse; could be fenced
29N-23E - 29			
1, 2, and 3	Between 1952 and 1964	By 1982, 560- x 400-foot, elliptical collapse; covers 175,930 ft^2 (4.04 acres); unstable; water level near surface; collapse adjacent to large chat pile	Monitor; unstable; enlarged since 1980
1515	Between 1939 and 1952	By 1982, irregularly shaped collapse; covers 91,735 ft^2 (2.11 acres); water level 20 feet from surface; small island supporting trees in center of collapse	Monitor; unstable; enlarged 1.8 times since 1980
1545	Between 1939 and 1952	By 1982, 140- x 100-foot, elliptical collapse; covers 10,995 ft^2 (0.25 acre); 20 feet deep	Monitor; unstable; enlarged since 1980; trees in collapse; could be fenced
1546	Between 1952 and 1964	By 1982, 140-foot, circular collapse; covers 15,395 ft^2 (0.35 acre); 20 feet deep	Monitor; unstable; slight enlargement since 1980; trees growing in collapse; could be fenced
1547	Between 1952 and 1964	By 1982, 75- x 60-foot elliptical collapse; covers 3,535 ft^2 (0.08 acre); water level 15 feet from surface	Monitor; unstable; slight enlargement since 1980; could be fenced
1548	Between 1952 and 1964	By 1982, 90-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); 30 feet deep	Could be filled; stable since 1964
1549	Between 1939 and 1952	By 1982, 65-foot, circular collapse; covers 3,320 ft^2 (0.08 acre); stable since 1964; water level 20 feet from surface	Could be filled; stable since 1964
29N-23E - 30			
*35	Before 1939	By 1982, 165-foot, circular collapse; covers 21,830 ft^2 (0.49 acre); water level 15 feet from surface	None; stable since 1952
*45	Between 1939 and 1952	By 1982, 190-foot, circular collapse; covers 28,355 ft^2 (0.65 acre); 20-foot-deep depression in chat pile	Monitor; unstable; enlarged since 1980
*1511	Between 1952 and 1964	By 1982, 450- x 320-foot, elliptical collapse; covers 113,095 ft^2 (2.60 acres); 20-foot-deep depression in chat pile; trees growing in depression	Monitor; unstable; enlarged since 1980

TABLE 3. - (Continued)

Location and site number[a]	Date of subsidence	Damages involved	Suggested remedial action
29N-23E - 30			
*1551	Between 1972 and 1979	By 1982, 80-foot, circular collapse; covers 5,025 ft^2 (0.12 acre); water level 15 feet from surface; adjacent to large chat pile	Monitor; unstable; enlarged over 3 times since 1980; could be filled
29N-24E - 17			
1501	Before 1939	By 1982, 360- x 280-foot and 200- x 40-foot, elliptical collapse; covers 85,450 ft^2 (1.96 acres); water level 30 feet from surface	None; stable since 1979; could be fenced
29N-24E - 31			
*32	Before 1939	By 1982, 100-foot, circular collapse; covers 7,855 ft^2 (0.18 acre); water level 20 feet from surface	None; stable since 1952
KANSAS[b]			
35S-23E - 13			
1560	Between 1938 and 1950	By 1982, 140-foot circular collapse; covers an area of 15,394 ft^2 (0.35 acre); water level 60 feet from surface, debris floating in water; surrounded by trees and tall grass	Fence

[a]Location given in township, range, and section; site numbers correspond to numbers used on plate 2; 1,500 numbers used for non-shaft-related collapses.

[b]Site conditions and suggested remedial action provided by James R. McCauley, Kansas Geological Survey.

*On Indian restricted land.

TABLE 4. - Mine and mill waste (piles and ponds)

Name	Location and site number[a]	Present condition	Suggested remedial action
	28N-22E - 1		
Tailings pile	1	Completely removed; land surface restored; wheat field	None
Tailings pile	2	Partially removed; two small chat piles; locally thin veneer of chat; partially reclaimed area, supports trees and other vegetation	Limited commercial potential; removal of chat and revegetation program
Tailings pile	3	Small chat pile	Limited commercial potential
Tailings pile	4	Completely removed; locally thin veneer of chat; partially reclaimed area supports trees and other vegetation	Removal of thin chat veneer; revegetation program
Tailings pile	*5	Completely removed; locally thin veneer of chat; partially reclaimed area supports little vegetation	Removal of thin chat veneer; revegetation program
Tailings pile	6	Partially removed; locally thin veneer of chat; partially reclaimed area supports trees and other vegetation	Removal of thin chat veneer; level, grade, revegetate
Tailings pile	7	Completely removed; thin veneer of chat; small area supports bushes; local areas used as garbage dumps	Some leveling and regrading; revegetation program
Tailings pile	8	Completely removed; thin veneer of chat; locally reclaimed area supports little vegetation	Revegetation program
Tailings pile	9	Completely removed; locally thin veneer of chat; partially used as junkyard	Site suitable for junkyard expansion
Tailings pile	10	Completely removed; thin veneer of chat	Revegetation program
Tailings pile	11	Partially reclaimed; supports little vegetation	Revegetation program
Tailings pile	12	Completely removed and reclaimed; prairie grasslands	None
	28N-22E - 12		
Tailings pile	1	Mostly reclaimed, supports trees and other vegetation	None
	28N-23E - 1		
Tailings pile	1	Completely removed and reclaimed; prairie grasslands	None

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	28N-23E - 1		
Tailings pile	2	Small chat pile	Limited commercial potential
	28N-23E - 6		
Tailings pile	1	Completely removed and reclaimed; prairie grasslands	None
	28N-23E - 7		
Tailings pile	1	Completely removed; thin veneer of chat; light industrial use (storage yard); adjacent to former garbage dump	Portion might be suitable for light industrial use
	28N-24E - 6		
Tailings pile	1	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*2	Completely removed and reclaimed; prairie grasslands and some trees	None
	29N-22E - 13		
Tailings pile	*1	Large chat pile; thin veneer of chat covering several acres adjacent to chat pile	Chat has commercial potential; revegetation program adjacent to chat pile
	29N-22E - 23		
Tailings pile	*1	Large chat pile; no active mining	Commercial potential
	29N-22E - 24		
Tailings pile	*1	Completely removed; locally thin chat veneer; reclaimed area supports vegetation	Removal of chat veneer; revegetation program
Tailings pile	*2	Completely removed and reclaimed; other vegetation	None
	29N-22E - 25		
Tailings pile	1	Completely removed; locally thin veneer of chat; reclaimed area supports trees	Removal of chat veneer; revegetation program
Tailings pile	2	Completely removed; locally thin veneer of chat; reclaimed areas support trees and (or) other vegetation	None

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-22E - 25		
Tailings pile	3	Completely removed; thin veneer of chat; partially reclaimed for wheat; large collapses within former chat-pile boundary	None
Tailings pile	4	Completely removed; partially reclaimed area supports vegetation; locally thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	5	Large chat pile; partially removed	Commercial potential
Tailings pile	6	Completely removed; thin veneer of chat; area supports some vegetation	Revegetation program
Tailings pile	7	Completely removed; thin veneer of chat; area supports little vegetation	Removal of chat veneer; revegetation program
Tailings pile	8	Completely removed; locally thin veneer of chat; reclaimed areas support some vegetation	Removal of chat veneer; revegetation program
Tailings pile	*9	Very large chat pile; partially removed; actively being mined; north of chat pile, behind embankment, thin veneer of tailings covering several acres	Removal of chat veneer; some leveling and grading; revegetation program
Tailings pond	*10	Filled with water	None
	29N-22E - 36		
Tailings pile	*1	Small chat pile; mostly removed; thin veneer of chat	Chat pile has limited commercial potential; removal of chat veneer; level, grade, revegetate
Tailings pile	*2	Small chat pile, mostly removed; thin veneer of chat	Removal of chat veneer; level, grade, revegetate; chat pile has limited commercial potential
Tailings pile	*3	Small chat pile	Limited commercial potential
Tailings pile	*4	Completely removed; thin veneer of chat, supports some vegetation	Removal of chat veneer; revegetation program
Tailings pile	*5	Completely removed; veneer of chat	Removal of chat veneer; level, grade, revegetate

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-22E - 36		
Tailings pile	*6	Completely removed; thin veneer of chat, supports some vegetation	Removal of chat veneer; revegetation program
Tailings pile	*7	Small chat pile; thin veneer of tailings south and east of chat pile	Limited commercial potential
Tailings pile	8	Completely removed; locally thin veneer of chat supporting vegetation	None
	29N-23E - 13		
Tailings pile	1	Large chat pile, partially removed; thin chat veneer supporting very little vegetation; veneer of tailings north of chat pile	Commercial potential
Tailings pile	2	Major chat pile, partially removed	Commercial potential
Tailings pond	3	Dry; thin veneer of fine-grained tailings; vegetation, small trees and shrubs, growing on embankments	Maintain embankments for erosion control; possible revegetation program
	29N-23E - 14		
Tailings pile	1	Totally removed; thin veneer of chat; small ponds of water present; few small trees present	Removal of chat veneer; level, grade, revegetate
Tailings pile	2	Small chat pile; thin veneer of chat	Limited commercial potential
Tailings pile	*3	Completely removed and reclaimed; trees present	None
Tailings pile	*4	Completely removed and reclaimed; supports trees and vegetation	None
Tailings pile	*5	Completely removed; locally thin veneer of chat; reclaimed area supports trees	Removal of chat veneer; revegetation program
Tailings pile	6	Completely removed and reclaimed; supports trees and other vegetation	None
	29N-23E - 15		
Tailings pile	1	Completely removed and reclaimed; supports small trees and other vegetation	None

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 15		
Tailings pile	2	Completely removed and reclaimed; supports trees and other vegetation	None
Tailings pile	3	Completely removed and reclaimed; prairie grasslands	None
Tailings pile	4	Completely removed and reclaimed; supports trees and other vegetation	None
Tailings pile	5	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	6	Very large chat pile, partially removed; locally thin veneer of chat; thin veneer of tailings west of chat pile	Commercial potential; actively being mined
Tailings pond	7	Mostly dry; thin veneer of fine-grained tailings; used to hold waste water from chat-processing plant	Maintain embankments for erosion control; possible revegetation program
Tailings pile	8	Completely removed and reclaimed; supports trees and other vegetation; home site at location	None
Tailings pile	9	Small chat pile	Limited commercial potential
Tailings pile	10	Small chat pile	Limited commercial potential
Tailings pile	11	Moderate-sized chat pile	Commercial potential
Tailings pile	12	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; a few, small ponds present in reclaimed area (in Lytle Creek)	None
Tailings pile	13	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports shrubs	Limited commercial potential
Tailings pile	14	Small chat pile, partially removed and reclaimed; reclaimed area supports trees and other vegetation	Limited commercial potential
	29N-23E - 16		
Tailings pile	*1	Very large chat pile; thin veneer of tailings south and west of chat pile; reclaimed area of tailings supports few small trees	Commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 16		
Tailings pile	*2	Small chat pile	Limited commercial potential
Tailings pile	*3	Completely removed; locally thin veneer of chat; reclaimed area supports shrubs and grasses	Removal of chat veneer; revegetation program
Tailings pile	*4	Completely removed; locally thin veneer of chat; reclaimed area supports few small trees	Removal of chat veneer; revegetation program
Tailings pile	*5	Completely removed; thin veneer of chat; thin veneer of tailings south of area	Removal of chat veneer; revegetation program
Tailings pile	*6	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports trees	Limited commercial potential
Tailings pile	*7	Two small chat piles, partially removed; thin veneer of chat supports very few shrubs; small pond west of larger chat pile; thin veneer of tailings south and east of larger chat pile	Limited commercial potential
Tailings pond	*8	Dry; thin veneer of fine-grained tailings	Maintain embankments for erosion control; possible revegetation program
Tailings pile	*9	Completely removed and reclaimed; supports trees; houses and street built on site	None
Tailings pile	*10	Completely removed and reclaimed; supports trees and other vegetation; small pond present; light industrial buildings built on site	None
Tailings pile	*11	Very small chat pile, mostly removed; thin veneer of chat supports few trees	Limited commercial potential
	29N-23E - 17		
Tailings pile	*1	Two small chat piles, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	*2	Completely removed; thin veneer of chat supports trees	Removal of chat veneer; revegetation program
Tailings pond	*3	Mostly dry; locally thick accumulations of fine-grained tailings; supports trees on embankments and wet area	Maintain embankments for erosion control; possible revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 17		
Tailings pile	4	Completely removed; locally thin veneer of chat; reclaimed area supports trees; pond in reclaimed area	Removal of chat veneer; revegetation program
Tailings pile	5	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	6	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; street and light industrial buildings built on chat veneer	None
Tailings pile	*7	Completely removed; locally thin veneer of chat; supports trees and other vegetation; baseball diamond built on site	None
Tailings pile	8	Completely removed; supports trees; part of site occupied by former tailings pond (dry)	None
Tailings pile	9	Three chat piles (two small, one large), partially removed; locally thin veneer of chat; dry, fine-grained tailings veneer south of site	Commercial potential; periodically being mined; maintain embankments adjacent to tailings pile for erosion control; possible revegetation program for former tailings pond
Tailings pile	*10	Small chat pile	Limited commercial potential
Tailings pile	*11	Completely removed; locally thin veneer of chat; supports few trees	Remove chat veneer; revegetation program
Tailings pile	*12	Moderate-sized chat pile, partially removed; locally thin veneer of chat	Limited commercial potential
Tailings pile	*13	Small chat pile, mostly removed; thin veneer of chat supports few trees	Limited commercial potential
Tailings pile	*14	Completely removed	Revegetation program
Tailings pile	*15	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*16	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 18		
Tailings pile	1	Two chat piles (one small, one large), partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	*2	Completely removed; locally thin veneer of chat; little vegetation	Limited commercial potential
Tailings pile	3	Small chat pile, partially removed; locally thin veneer of chat, supports few small trees	Limited commercial potential
Tailings pile	4	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	5	Moderate-sized chat pile, partially removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Limited commercial potential
Tailings pile	6	Completely removed; thin veneer of chat, supports few small trees	Removal of chat veneer; revegetation program
Tailings pile	7	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
	29N-23E - 19		
Tailings pile	*1	Completely removed; locally thin veneer of chat; reclaimed area supports vegetation	Removal of chat veneer; revegetation program
Tailings pile	*2	Completely removed; locally thin veneer of chat; reclaimed area supports trees; few small ponds in reclaimed area; thin veneer of tailings south and east of site	Removal of chat veneer; revegetation program; removal of tailings veneer; possible revegetation program for former tailings ponds; maintain embankments for erosion control
Tailings pile	*3	Completely removed and reclaimed; supports vegetation; small pond on site	None
Tailings pile	*4	Completely removed and reclaimed; supports trees and other vegetation; small roads built on site	None
Tailings pile	*5	Completely removed; thin veneer of chat, supports few small trees	Removal of chat veneer; revegetation program
Tailings pile	*6	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 19		
Tailings pile	*7	Very large chat pile, partially removed; thin veneer of chat, supports few small trees	Commercial potential
Tailings pile	*8	Large chat pile, partially removed; thin veneer of chat, supports few small trees	Commercial potential
Tailings pond	*9	Mostly dry; thin veneer of fine-grained tailings, supports few small trees	Maintain embankments for erosion control; possible revegetation program
Tailings pile	*10	Completely removed; thin veneer of chat, supports few shrubs; 100-foot-diameter, water-filled collapse on site	Removal of chat veneer; revegetation program
Tailings pile	*11	Two small chat piles, mostly removed; reclaimed area supports trees; several small ponds on site; locally thin veneer of chat	Limited commercial potential
Tailings pile	*12	Completely removed and reclaimed; supports trees	None
Tailings pile	*13	Completely removed; locally thin veneer of chat; supports few trees and other vegetation; 350- x 225-foot, water-filled collapse on site	Removal of chat veneer; revegetation program
	29N-23E - 20		
Tailings pile	1	Completely removed; locally thin veneer of chat; supports few small trees and other vegetation; 75-foot-diameter, water-filled collapse on site	Removal of chat veneer; revegetation program
Tailings pile	2	Completely removed and reclaimed; supports small trees and other vegetation; small pond on site	None
Tailings pile	3	Completely removed and reclaimed; supports small trees and other vegetation	None
Tailings pile	4	Completely removed; locally thin veneer of chat; reclaimed area supports trees and vegetation	Removal of chat veneer; revegetation program
Tailings pile	5	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*6	Small chat pile	Limited commercial potential
Tailings pile	*7	Small chat pile	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 20		
Tailings pile	*8	Very large chat pile	Commercial potential
Tailings pile	*9	Small chat pile; periodically being mined	Limited commercial potential
Tailings pile	*10	Moderate-sized chat pile	Commercial potential
Tailings pile	*11	Large chat pile	Commercial potential
Tailings pile	12	Large chat pile, partially removed; thin veneer of chat; actively being mined; tailings pond, with some water, east of site	Commercial potential
Tailings pile	13	Moderate-sized chat pile; dry; fine-grained veneer of tailings west of site	Limited commercial potential; maintain embankments for erosion control; possible revegetation program for former tailings pond
Tailings pile	14	Small chat pile	Limited commercial potential
Tailings pile	15	Small chat pile, partially removed; thin veneer of chat; small industrial building on chat veneer	Limited commercial potential
Tailings pile	16	Three chat piles (two small, one moderate sized), partially mined; thin veneer of chat; small pond on veneer (natural part of Tar Creek)	Commercial potential
Tailings pile	17	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	18	Small chat pile	Limited commercial potential
Tailings pile	19	Small chat pile	Limited commercial potential
Tailings pile	20	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	21	Moderate-sized chat pile; 100-foot, water-filled collapse on northern edge of chat pile	Commercial potential
Tailings pile	22	Small chat pile	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 20		
Tailings pile	23	Completely removed; thin veneer of chat supports few small trees	Removal of chat veneer; revegetation program
	29N-23E - 21		
Tailings pile	*1	Large chat pile	Commercial potential
Tailings pile	*2	Small chat pile, partially mined; thin veneer of chat supports few small trees	Limited commercial potential
Tailings pile	*3	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	*4	Completely removed and reclaimed; supports trees	None
Tailings pile	*5	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	*6	Completely removed and reclaimed; supports small trees and other vegetation	None
Tailings pile	*7	Completely removed and reclaimed; supports trees and other vegetation; small roads passing through site	None
Tailings pile	8	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; road passing through site	Removal of thin veneer; revegetation program
Tailings pile	9	Small chat pile, mostly removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Limited commercial potential
Tailings pile	10	Small chat pile, mostly removed; locally thin veneer of chat; reclaimed area supports few shrubs; small industrial buildings on site	Limited commercial potential
Tailings pile	11	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	12	Two small chat piles, partially removed; locally thin veneer of chat; reclaimed area supports trees	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 21		
Tailings pile	13	Completely removed; locally thin veneer of chat; reclaimed area supports small trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	14	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	15	Completely removed and reclaimed; housing development on site	None
	29N-23E - 22		
Tailings pile	1	Completely removed and reclaimed; area supports small trees and other vegetation; small road on site	None
Tailings pile	2	Completely removed and reclaimed; area supports few trees	None
Tailings pile	3	Completely removed and reclaimed; area supports trees and other vegetation	None
Tailings pile	4	Very small chat pile	Limited commercial potential
Tailings pile	5	Very small chat pile	Limited commercial potential
Tailings pile	6	Moderate-sized chat pile; tailings ponds, with some water on north, east, and west sides of site; reclaimed areas of tailings ponds support trees and other vegetation	Limited commercial potential
Tailings pile	7	Large chat pile	Commercial potential
Tailings pile	8	Completely removed and reclaimed; supporting small trees and other vegetation	None
	29N-23E - 23		
Tailings pile	1	Completely removed and reclaimed; junkyard on site	None
Tailings pile	2	Small chat pile; mostly removed; locally thin veneer of chat; reclaimed area supports few shrubs and other vegetation; light industrial buildings on site	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 23		
Tailings pile	3	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports trees	Limited commercial potential
Tailings pile	4	Completely removed; thin veneer of chat; small industrial buildings on site	Removal of chat veneer; revegetation program
Tailings pile	5	Small chat pile	Limited commercial potential
Tailings pile	6	Completely removed; locally thin veneer of chat; reclaimed area supports trees and grasses	Removal of chat veneer; revegetation program
Tailings pile	7	Completely removed and reclaimed; area supports trees	None
Tailings pile	8	Completely removed and reclaimed; area supports shrubs and grasses; pond on site	None
Tailings pile	9	Completely removed and reclaimed; area supports trees and other vegetation	None
Tailings pile	10	Completely removed and reclaimed; area supports trees and other vegetation	None
Tailings pile	11	Small chat pile, mostly removed; thin veneer of chat; area supports few trees; mostly dry, reclaimed tailings ponds south and west of chat pile; reclaimed ponds support small trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	12	Completely removed; locally thin veneer of chat; reclaimed area supports few trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	13	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
	29N-23E - 24		
Tailings pile	1	Large chat pile; tailings pond, with some water, east of chat pile	Commercial potential
Tailings pile	2	Large chat pile, partially removed; thin veneer of chat	Commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 24		
Tailings pile	3	Completely removed; thin veneer of chat; two shallow, 50-foot collapses on site	Removal of chat veneer; level, grade, revegetate
	29N-23E - 25		
Tailings pile	1	Completely removed and reclaimed; supports few trees; former water impoundment on site	None
	29N-23E - 26		
Tailings pile	1	Small chat piles; partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	*2	Small chat pile, mostly removed; locally thin veneer of chat; reclaimed area supports few shrubs and other vegetation	Limited commercial potential
Tailings pile	*3	Small chat pile, partially removed and reclaimed; reclaimed area supports trees and other vegetation	Limited commercial potential
Tailings pile	*4	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports few shrubs	Limited commercial potential
	29N-23E - 27		
Tailings pile	1	Completely removed and reclaimed; area supports small trees and other vegetation	None
Tailings pile	2	Completely removed; locally thin veneer of chat; reclaimed area supports few small trees	Removal of chat veneer; revegetation program
Tailings pile	3	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
	29N-23E - 28		
Tailings pile	1	Completely removed and reclaimed; supports trees and other vegetation	None

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 28		
Tailings pile	2	Small chat pile, mostly removed; thin veneer of chat, supports few small trees	Limited commercial potential
Tailings pile	3	Completely removed; locally thin veneer of chat; reclaimed area supports small trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	4	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	5	Completely removed; locally thin veneer of chat; reclaimed area supports few trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	*6	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	7	Completely removed; thin veneer of chat	Removal of chat veneer, revegetation program
Tailings pile	8	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	9	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	10	Moderate-sized chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	11	Completely removed; locally thin veneer of chat; reclaimed area supports trees	Removal of chat veneer; revegetation program
Tailings pile	12	Large chat pile, partially removed; thin veneer of chat; mostly dry tailings ponds south and east of chat pile; reclaimed ponds and embankments support trees	Commercial potential; maintain embankments for erosion control; possible revegetation program for pond sites
Tailings pile	13	Completely removed; locally thin layer of chat; reclaimed area supports little vegetation	Removal of chat veneer; revegetation program
Tailings pile	14	Completely removed and reclaimed; supports trees and other vegetation	None

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 29		
Tailings pile	1	Completely removed; locally thin veneer of chat; reclaimed area supports small trees	Removal of chat veneer; revegetation program
Tailings pile	2	Two large chat piles, partially removed; thin veneer of chat; dry tailings ponds north and west of site; smaller chat pile being actively mined	Commercial potential; maintain embankments for erosion control; possible revegetation program for ponds
Tailings pile	3	Moderate-sized chat pile; partially removed; thin veneer of chat	Some commercial potential
Tailings pond	4	Dry; thin veneer of fine-grained tailings	Maintain embankments for erosion control; possible revegetation program
Tailings pond	5	Mostly dry; thin veneer of fine-grained tailings	Maintain embankments for erosion control; possible revegetation program
Tailings pile	6	Small chat pile	Limited commercial potential
Tailings pile	7	Small chat pile	Some commercial potential
Tailings pile	8	Large chat pile; tailings pond, with some water, north of site	Commercial potential
Tailings pile	9	Completely removed; thin veneer of chat, supports few trees	Removal of chat veneer; revegetation program
Tailings pile	10	Completely removed; locally thin veneer of chat; reclaimed area supports shrubs and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	11	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	12	Completely removed; thin veneer of chat along with residual chat pile	Removal of chat veneer; revegetation program
Tailings pile	13	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	14	Large chat pile	Commercial potential
Tailings pile	15	Completely removed; thin veneer of chat; dry tailings pond west of site	Removal of chat veneer; revegetation program; maintain embankments for erosion control; possible revegetation program for pond sites

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 29		
Tailings pile	16	Moderate-sized chat pile; dry tailings ponds south and east of site	Some commercial potential; maintain embankments for erosion control; possible revegetation program for pond sites
Tailings pile	17	Large chat pile, partially removed; 4-acre, water-filled collapse west of site	Commercial potential
Tailings pile	18	Small chat pile, mostly removed; thin veneer of chat	Limited commercial potential
	29N-23E - 30		
Tailings pile	*1	Completely removed; locally thin veneer of chat; reclaimed area supports trees	Removal of chat veneer; revegetation program
Tailings pile	*2	Small chat pile, mostly removed; thin veneer of chat, supports little vegetation	Removal of chat veneer; revegetation program
Tailings pile	*3	Moderate-sized chat pile, partially removed; thin veneer of chat	Some commercial potential
Tailings pond	*4	Dry; thin veneer of fine-grained tailings, supports few bushes	Maintain embankments for erosion control; possible revegetation program
Tailings pile	*5	Moderate-sized chat pile	Some commercial potential
Tailings pile	*6	Small chat pile	Limited commercial potential
Tailings pile	*7	Very large chat pile; dry tailings ponds north and south of site with fine-grained tailings	Commercial potential; maintain embankments for erosion control; possible revegetation program for ponds
Tailings pond	*8	Dry; thin veneer of fine-grained tailings; small pool of standing water in northeast corner; entire pond 79 acres in area	Maintain embankments for erosion control; possible revegetation program for pond site
Tailings pile	*9	Small chat pile, mostly removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; few small ponds on site	Limited commercial potential
Tailings pile	*10	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports little vegetation	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 30		
Tailings pile	*11	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	*12	Completely removed; locally thin veneer of chat; reclaimed area supports small trees and other vegetation	None
Tailings pile	*13	Very large chat pile, actively being mined, partially removed; thin veneer of chat; one 190-foot and one 450- x 320-foot collapse on site	Commercial potential
Tailings pile	*14	Small chat pile	Limited commercial potential
Tailings pond	*15	Dry; thin veneer of fine-grained tailings	Maintain embankments for erosion control; possible revegetation program
	29N-23E - 31		
Tailings pile	*1	Large chat pile, actively being mined, partially removed; thin veneer of chat; dry; former tailings ponds, with locally thin veneer of fine-grained tailings adjacent to pile; trees and bushes north and west of site (as of June 1982 chat pile was almost completely removed)	Commercial potential; maintain embankments of tailings ponds for erosion control; possible revegetation program for tailings ponds
Tailings pond	*2	Filled with water	None
Tailings pond	*3	Filled with water	None
Tailings pond	*4	Dry; locally thin veneer of fine-grained tailings; reclaimed area supports trees and other vegetation; 148 acres in area	Maintain embankments for erosion control; possible revegetation program
	29N-23E - 32		
Tailings pile	*1	Completely removed and reclaimed; supports trees and other vegetation	None
Tailings pile	*2	Two small and one moderate-sized chat piles, mostly removed; locally thin veneer of chat; reclaimed area supports little vegetation	Commercial potential
Tailings pile	*3	Completely removed; locally thin veneer of chat; reclaimed area supports trees	Removal of chat veneer; revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 33		
Tailings pile	*1	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	*2	Completely removed; locally thin veneer of chat; reclaimed area supports few trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	*3	Completely removed; locally thin veneer of chat; reclaimed area supports few trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	*4	Small chat pile, mostly removed; thin veneer of chat supports few trees	Removal of chat veneer; revegetation program
Tailings pile	*5	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*6	Completely removed and reclaimed; area supports trees and other vegetation	None
	29N-23E - 35		
Tailings pile	*1	Small chat pile	Limited commercial potential
	29N-23E - 36		
Tailings pile	1	Completely removed; locally thin veneer of chat; reclaimed area supports few trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	2	Small chat pile, partially removed; thin veneer of chat	Limited commercial potential
Tailings pile	3	Small chat pile	Limited commercial potential
Tailings pile	4	Small chat pile	Limited commercial potential
Tailings pile	5	Small chat pile	Limited commercial potential
Tailings pile	6	Small chat pile, supports few trees	Limited commercial potential
Tailings pile	7	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	8	Completely removed; thin veneer of chat, supports few trees	Removal of chat veneer; revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-23E - 36		
Tailings pile	9	Small chat pile, mostly removed; thin veneer of chat	Limited commercial potential
Tailings pile	10	Completely removed; thin veneer of chat, supports few trees	Removal of chat veneer; revegetation program
	29N-24E - 17		
Tailings pile	1	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	2	Completely removed; locally thin veneer of chat; reclaimed area supports grasses	Removal of chat veneer; revegetation program
	29N-24E - 18		
Tailings pile	1	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	2	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; small pond on site	Removal of chat veneer; revegetation program
	29N-24E - 19		
Tailings pile	1	Small chat pile, mostly removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	2	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation; small pond on site	Removal of chat veneer; revegetation program
Tailings pile	3	Completely removed and reclaimed; prairie grasslands	None
Tailings pile	4	Small chat pile	Limited commercial potential
	29N-24E - 30		
Tailings pile	1	Large chat pile	Commercial potential
Tailings pile	2	Completely removed and reclaimed; prairie grasslands	None
Tailings pile	3	Very small chat pile	Limited commercial potential
Tailings pile	4	Small chat pile	Limited commercial potential

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	29N-24E - 30		
Tailings pile	5	Completely removed; locally thin veneer of chat; reclaimed area supports trees and other vegetation	Removal of chat veneer; revegetation program
Tailings pile	6	Completely removed; locally thin veneer of chat; reclaimed area supports little vegetation	Removal of chat veneer; revegetation program
Tailings pile	7	Small chat pile, partially removed; locally thin veneer of chat; reclaimed area supports little vegetation	Limited commercial potential
Tailings pile	8	Small chat pile	Limited commercial potential
	29N-24E - 31		
Tailings pile	1	Small chat pile	Limited commercial potential
Tailings pile	2	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*3	Small chat pile	Limited commercial potential
Tailings pile	4	Small chat pile	Limited commercial potential
Tailings pile	5	Small chat pile, mostly removed; thin veneer of chat	Limited commercial potential
	29N-24E - 32		
Tailings pile	*1	Small chat pile	Limited commercial potential
Tailings pile	*2	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*3	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*4	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*5	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program
Tailings pile	*6	Completely removed; thin veneer of chat	Removal of chat veneer; revegetation program

TABLE 4. - (Continued)

Name	Location and site number[a]	Present condition	Suggested remedial action
	KANSAS[b]		
	35S-23E - 14		
Tailings pond	11	Mostly dry; thin veneer of fine-grained tailings, supports some vegetation	Maintain embankments for erosion control; revegetation program
Tailings pile	16	Large chat pile, mostly removed; partially reclaimed	Removal of chat veneer; revegetation program
	35S-23E - 18		
Tailings pond	18	Filled with water, shallow	None
	35S-24E - 13		
Tailings pile	19	Small chat pile, partially reclaimed	Limited commercial potential

[a]Location given in township, range, and section; site numbers correspond to numbers used on plate 3.

[b]Site conditions and suggested remedial action provided by James R. McCauley, Kansas Geological Survey; only major features inventoried.

*On Indian restricted lands.

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