REPORT

TO

GOVERNOR KEATING'S TAR CREEK

SUPERFUND TASK FORCE

BY THE

SUBSIDENCE SUBCOMMITTEE

DATE

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CO - CHAIRS

ED KEHELEY

MARY ANN PRITCHARD

TABLE OF CONTENTS

SECTION **PAGE**

Summary……..... 4

Introduction……..... 11

Background……..... 13

- History of the Mining Area……...…….. 13
- History of Mine Subsidence……...……... 13
- Past Remediation Efforts……...……... 15

Socioeconomic Impact……... 16

Task 1…….. 17

- Characteristics of Subsidence Prone Areas……...…..... 17
- Information Sources for Risk Assessment……..... 18
- Subsidence Risk Assessment……..……..... 20
- Additional Areas of Subsidence……..... 21

Task 1 Recommendations……..... 22

Task 2……..... 23

- Mine Subsidence Abatement Techniques..... 23
  1. Addressing Areas of Potential Subsidence……..... 23
  2. Addressing Subsidence That Has Already Occurred……... 26

Review of Other State/Federal Programs for Mine Subsidence……..... 29

Laws/Regulations Related to Subsidence and Potential Funding Sources…..... 30

Land Ownership……..... 33

Area of Immediate Concern……..... 34

■State Line Road..... 34

Task 2 Recommendations……..... 35
References…… 37

Appendix……..

A. Subsidence Subcommittee Membership 39
B. Geophysical Methods 40
C. Potential Subsidence Sites……..... 43
D. Project Selection Matrix for Subsidence Prone Areas……..... 47
E. Project Selection Matrix for Existing Subsidence Areas……..... 50
F. Mine Subsidence Abatement Techniques..... 52
G. Environment Laws……..……..... 57
H. Map of Quapaw Tribal Lands in the Superfund Site…….....…....66
I. Description of State Line Road Potential Subsidence Area……..... 67

SUMMARY

Lead and zinc were discovered in Ottawa County, near the town of Peoria, Oklahoma in 1891. However, the richest lead and zinc ores were found near Picher, Oklahoma in 1912. Lead sulfide (galena) and zinc sulfide (sphalerite) were the primary metallic ores mined from the Mississippian age Boone Formation (also known as the Boone aquifer). As much as 13 million gallons of water per day were pumped from the mines in order to access the ore at depths of approximately 90 feet to more than 300 feet below ground. Mining was performed using the room and pillar method where columns of ore were left in place to support the roof of the mine. By 1918, it was estimated that over 200 mills had been built in the Picher Field to process the ore. As the mining progressed, the mine workings became interconnected caverns that extended from Commerce, Oklahoma northeast toward Joplin, Missouri. The caverns now contain approximately 76,000 acre feet of acid mine water (EPA Tar Creek Superfund Site Fact Sheet, 1999). Due to depressed metals markets, most mine operations were reduced in 1957. Limited mining continued until the early 1970's.

The mining era left a legacy of open mine shafts, acid mine water, large areas prone to subsidence, and hundreds of millions of tons of mining waste contaminated with lead, zinc and cadmium. The mining waste includes tailings that are primarily composed of fine, chert gravel (locally known as "chat"), flotation pond sediments, small boulder piles, and concrete mill remnants.

During the early days of the mining era, it was the practice of the mining companies to remove columns (pillars) which supported the mine roof before the mine was abandoned. During the last two decades of the mining era, "gougers" leased abandoned mines and/or mined without benefit of a lease. The gougers primarily removed ore from the columns that supported the roof of the mines. Removal of the columns made collapse of the mines a greater threat.

As of 1986, there were 59 major collapses greater than 95 ft. in diameter, due to underground mining in the Picher Field. Of these, 29 are major collapses associated with 34 mine shafts and 30 are non-shaft collapses (Luza 1986). Most of the collapses occurred prior to 1952. Approximately 47 surface acres have been disturbed as a result of collapses. Most of the non-shaft related collapses are located west of Cardin and Commerce, Oklahoma. Collapse features and shafts receiving surface water run-off are vulnerable to erosion and additional subsidence. The surface water captured by most collapses directly recharges the mines.

Fortunately, most major collapses have occurred in rural areas and very little destruction of buildings and roads has occurred. However, several collapses have occurred within the city limits of Picher and the town of Hockerville. Three have occurred within 1000 ft. of the Picher High School and Elementary School. One major collapse is within 50 ft. of the church in Hockerville, and another is within 500 ft. of the church. The largest collapse feature, located south of Cardin, is 560 ft. long and 400 ft. wide, covering 4.04 acres.

The impact these collapse features have on water quality, flooding and drainage, land use, safety, and the aesthetics of the area have not been adequately addressed. It is important to point out that it is somewhat difficult to assess the collapse features independently, without considering their relationship to water quality, mine shafts, and the drainage and flooding of the area.

Another problem associated with the abandoned mines is the potential for subsidence in undermined areas. Some areas, like the State Line Road near Baxter Springs, Kansas, pose a high risk to public safety due to deterioration of the mine roof and subsequent collapse. Variations in the risk of subsidence are associated with many factors, including: depth to the mine cavity, geometry of the mined out area, geology of overlying materials, groundwater movements and natural and man made seismic activity.

Several methods are available to assist in evaluating mine subsidence risk including: exploratory drilling, geophysical methods, infrared photography, historical information from former miners, mine maps, and land use maps. Although expensive, exploratory drilling used in conjunction with other methods remains the most reliable method for characterizing underground mines for subsidence prevention.

A program should be developed for the Tar Creek Site to record, store, retrieve and integrate data important to public health and safety. Data pertaining to subsidence, mine shafts, drainage, flooding, chat piles, mill ponds, former mill sites, water discharge sites and water quality, etc., should be maintained in an easily retrievable data base. Geographic Information Systems (GIS) are being used by various abandoned mine reclamation agencies in other states to evaluate the relative risk of public harm in the most efficient and cost effective manner possible. GIS is a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the earth. GIS can integrate historical information, existing geological and geophysical data, land use, transportation, development

and other characteristics to implement a subsidence risk assessment program and determine where subsidence control or reclamation efforts should be conducted.

In order to take advantage of their knowledge and experience, a series of interviews were conducted with former miners who had worked in the Picher Field. Emphasis was placed on their knowledge of areas mined which have the potential for future subsidence. Of particular importance was their knowledge of mines where large underground areas were mined close to the ground surface, thereby potentially weakening the mine roof and those mines where support pillars were removed, resulting in weakened roof structures.

Twenty potential subsidence sites were identified by the former miners. One site, located near the former Eagle-Picher shops in Cardin, OK is considered by the miners to have the greatest potential for subsidence. An area within the City of Picher, OK, behind the newspaper office on Connell Avenue was considered to pose the second highest risk of subsidence. The area behind the newspaper office is a large open area. There are no homes or businesses currently on the site; however, the public does have access to the area. Approximately 50 % of the sites, including the one near the Eagle-Picher shops in Cardin, are on Indian land.

A cursory review by the Subsidence Subcommittee indicates that at least 7 subsidence events have occurred since 1986. It is recognized that in addition to the seven identified, many more may have occurred in more remote areas and are yet to be reported. Many of the existing subsidence areas are continuing to enlarge in size due to surface water eroding the sides and unstable roof structures.

In 1983 and 1986 the Bureau of Mines, in cooperation with State Geological Surveys issued reports on “Stability Problems and Hazard Evaluation in the Oklahoma, Missouri and Kansas portions of the Tri-State Mining Area”. Among other things, these reports identified five methods of hazard abatement for mine subsidence: backfilling, grading to gentle slopes, fencing, controlled collapse with explosives and public education were all suggested. Around the nation, other methods have also been used for abating hazards associated with subsidence. These include backfilling mine workings using various methods of grouting, pneumatic stowing and hydraulic backfilling, enhancing roof support using reverse roof bolts or grout bags (artificial pillars) and reinforcing the ground surface using geotextile soil nets beneath the ground surface. Many of these methods are not viable in the Picher Mining Field due to the presence of water in the mines. All of the abatement methods addressed in the report are expensive due to the size and complexity of mine voids and subsidence areas. Luza (1986) observed that most subsidence was associated with deterioration of open shafts and suggested that the most effective way to prevent subsidence was to fill open shafts. The subcommittee found no evidence to contradict this suggestion.

There have been isolated efforts to fill some smaller subsidence pits associated with shafts. However, there has never been a formal program for dealing with subsidence in Ottawa County. In the past, individuals and local governments have filled subsidence pits with garbage, construction waste and other compressible or organic debris. Many of these materials will deteriorate resulting in future subsidence of the area. Others materials are hazardous to the environment and have a high probability of affecting groundwater quality.

Relocation has been used in some areas of the country to protect the public from extremely dangerous situations. Relocation costs for the Tar Creek Superfund area are estimated at $80,000-$100,000 per household. Relocation does not alleviate the problem, it only removes people from direct, daily contact with the hazard.

Surface backfilling has been used to close smaller pits and those with water standing in them. Surface backfilling is normally done using concrete, rock or soil materials in specified layers. Wood, metal and organic debris are not used because degradation of the materials results in voids in the fill, allowing water to enter and eventually causing further collapse of the filled pit. Many subsidence pits remain connected at their base to the abandoned mine workings, making it difficult to keep backfill materials from moving horizontally into the mine workings. One technique sometimes used to stabilize pit subsidence is to fill the bottom with large stones or concrete rubble, then cement the material into a plug with concrete grout. The cost of backfilling is highly variable, depending on the dimensions of the pit, the cost per ton of backfill material delivered to the site, and equipment costs for material placement.

Dry pits (no standing water in them) that have exhibited little change over time may be made less dangerous by grading or excavation to reduce side slopes. When this is done, surface water must be diverted away from the pit to avoid erosion and reopening of the connection to the mine workings. This method may be significantly less expensive than backfilling, but may be dangerous if the configuration of the mine workings and tunnels is unknown. The safety of grading work may be increased by using cranes, draglines and hydro seeding equipment to remotely rework and revegetate the side slopes without putting men within the hole.

Chat material has been used in some cases to backfill open mine pits. Chat tends to move into open mine workings if used without a more stable base material. If the bottom of the subsidence pit is sealed from the remaining mine workings, chat is an excellent fill material. Chat is also much cheaper to use as fill material than most other materials. Some concern exists regarding the potential health effects from placing chat underground due to the levels of lead, zinc and cadmium contained in the chat. Nevertheless, there are many advantages to using chat as a fill material.

Only a few states have addressed subsidence problems associated with non-coal mines in any large way. This is probably due to the limited availability of funding for non-coal problems.

For coal mine subsidence, state, federal, and tribal agencies have addressed subsidence in 27 states and on lands of six Indian Tribes.

While there are a large number of environmental laws that pertain to the Tar Creek Superfund Site, only a few have the potential as a basis to seek funding. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), The Clean Water Act and possibly The Safe Drinking Water Act may provide the avenue to seek federal funding for the Tar Creek Site. Considerable evidence is available to demonstrate that water quality has been adversely affected by the presence of water in the abandoned mines. Efforts should be made to assemble all available data and make a formal assessment of the impacts on water quality.

The federal Surface Mining Control and Reclamation Act (PL 95-87) established an AML Trust Fund through a tax on coal producers. States and tribes receive grants out of the AML Trust Fund from the U.S. Department of the Interior's Office of Surface Mining (OSM). Presently, approximately $274 million goes into the Trust Fund each year. For the last nine years, the states and tribes have received an average annual appropriation of only $134.5 million from Congress. At this time there is over $1.6 billion in the AML Trust Fund available for appropriation by Congress.

Section 409 of PL 95-87 allows for expenditures from the AML Trust Fund for certain types of non-coal AML problems. Section 409 (FILLING VOIDS AND SEALING TUNNELS) states that the Secretary of the Interior, at the request of the Governor of any State, is authorized to fill voids, seal abandoned tunnels, shafts, and entryways, and reclaim 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. A limited portion of Oklahoma's annual AML grant can be used for such projects. The Oklahoma FY 2000 AML funds are 100% obligated for coal reclamation projects (projects are contracted for construction).

Oklahoma already has $90 million of Priority 1 and 2 coal related AML hazards that have been approved by the OSM as eligible for funding from the AML Trust Fund. In 2004 the tax on coal will end unless Congress extends the fee collection. At the current funding rate of $1.5 million per year, there will be many unreclaimed coal problems at the end of AML Fee collections.

In 1990, PL 95-87 was amended (Sec.402(g)(8)), stating that the Secretary of the Interior shall allocate annually not less than $2 million to low coal producing states and tribes like Oklahoma for reclamation of Priority 1 and 2 AML hazards. For Fiscal Years 1992, 1993, and 1994, Oklahoma received $2 million each year. For the last six fiscal years, Congress has put "line item" language in OSM's appropriation bill limiting Oklahoma and the other minimum program states to only $1.5 million per year. As a result, Oklahoma has lost $3 million in grant funds that could have been used for mine reclamation.

Section 406 of PL 95-87 provides for the reclamation of rural lands affected by mining by making funds available to the Secretary of Agriculture from the Abandoned Mine Reclamation Fund (Fund). Section 401 (c)(2) provides that there will be an annual transfer of funds to the Secretary of Agriculture for expenditures from the Rural Abandoned Mine Program (RAMP). Furthermore, Section 402 (g) (2) specifies that 10% of the reclamation fees collected shall be allocated to the Secretary of Agriculture only for the purpose of satisfying this transfer. The Act directs the Secretary of Agriculture to utilize the Natural Resource Conservation Service (NRCS) to carry out the provision of Section 406. On average, NRCS received $500,000 per year for the Oklahoma RAMP. Congressional appropriation to RAMP ceased after 1995; however, fees have continued to accrue. The unappropriated portion of the Fund dedicated to reclamation through RAMP has grown to slightly over $254 million as of February 29, 2000.

The land ownership within the Tar Creek Superfund site is unique in that it is comprised of individual private land (fee simple), state land (Ottawa Reclamation Authority), and Indian Tribal Trust land (title held in trust by the United States for several Indian Tribes). There are eight federally recognized Tribes within the part of Ottawa County identified in the Superfund Site and Restricted Individual Indian Allotted Land (land under supervision of the Secretary of the Interior and administered by the Bureau of Indian Affairs, Field Office at Miami, Oklahoma).

A section of State Line Road, East of Highway 69A, on the Kansas/Oklahoma state line near Baxter Springs, Kansas has a high probability of subsiding in the future. State Line Road passes directly over some large, abandoned, underground mine workings that extend across the state line into Oklahoma. The section of State Line Road over mine workings has been slowly sinking the past few years. In addition, a small area (50 ft. diameter) adjacent to the road has collapsed in the last two years. Additional cracks have opened in the asphalt surface in the past two months. A natural gas pumping station adjacent to State Line Road sits atop the mined area. The pumping station is under 700 psi. pressure and is the only supply of natural gas to the city of Baxter Springs, Kansas. Electrical power lines run along the State Line Road on the south side within 50 feet of the gas pumping station. The combination of natural gas under high pressure and the electrical power lines as an ignition source provides an unsatisfactory accident scenario. Emergency vehicles and school buses use the road. Vehicle weight limit restrictions placed on the road by Ottawa County are routinely violated. Surface runoff along State Line Road flows into the mine opening. Oklahoma officials should work with Kansas officials to address this serious problem.

The mining industry provided the largest employment in Ottawa County. In 1986 the second largest employer, the B. F. Goodrich Plant in Miami, moved to another state. Ottawa County has never recovered from the loss of the two major employers in the county. The largest economic growth in the county has been through the expansion of existing small businesses. Wages continue to be low in the area, with many jobs paying at minimum wage or slightly higher. The small towns in the former mining field have a difficult time funding basic infrastructure needs. Funding for other important community needs such as improving drainage and flooding and sealing mine shafts is simply not available. The local communities

are totally dependent on outside funding to address many health, safety, and environmental issues.

It is obvious that the local communities and the State of Oklahoma cannot provide the funding to fully address the issues of subsidence in the Tar Creek Superfund Site. Federal funding is imperative if any significant progress is to be made.

The legacy of mining has left a landscape that will take a long time and a lot of money to correct. However, there needs to be a starting point. GIS is essential for integrating the complex information critical to subsidence risk assessment and project selection. Fortunately, the technology is currently available to address mine subsidence, only the dollars to apply the technology are missing. The prevention of subsidence is expensive and cannot practically be applied on a large scale. Filling open mine shafts is the most affordable and effective way of reducing subsidence in the Tar Creek Superfund Site. The problem of open subsidence pits is not insurmountable, but may also be costly to address.

Chat can be used as a cost effective material to fill subsidence areas if certain stabilization techniques are used. In the early 1990's, the EPA Region VII utilized chat to fill mine shafts in Galena, Kansas in the Cherokee County, Kansas Superfund Site. The shafts were filled for engineering efficiency in mitigating the threatened release of hazardous substances in the surface mine wastes. The purpose of that cleanup action was to reduce the loading of heavy metals to ground water and surface bodies due to runoff and infiltration from the surface mine wastes in order to protect aquatic life. Also, by containing the surface mine wastes in shafts and subsidences, the direct contact threat to humans and terrestrial life due to exposure to hazardous substances in the waste was significantly reduced or eliminated. Their goal was not to fill shafts and subsidences to reduce the physical hazards associated with open mine shafts; however, such was a beneficial consequence of the work.

Other methods of damage prevention such as special building codes, city/county planning or relocation and demolition may have to be used where homes or businesses are being severely threatened by subsidence.

Funding sources fall into three areas: state funding, current funding under existing federal laws (i.e. CERCLA, Federal Surface Mining Law), and separate Congressional line item appropriations. It is obvious that state funding is limited. Therefore, increases in current appropriations must be sought along with new line item appropriations.

INTRODUCTION

On January 20, 2000, Governor Frank Keating established the Tar Creek Superfund Task Force because of the growing concern for the health and safety of the citizens of Ottawa County as a result of environmental and natural resource development and protection issues. Governor Keating wanted to assure that Oklahoma was proactive in assuming a vital leadership role in identifying solutions and resources available to address these issues. A ten-member Task Force was appointed with the Secretary of Environment serving as Chairman. The Task Force was directed to actively seek information and suggestions from local citizens in towns, colleges, universities, local governmental entities, and civic groups directly affected by the issues involved. The Task Force was further directed to request assistance in formulating issues and reaching conclusions for recommendation from various state and federal agencies.

The Task Force was assigned the following duties:

1. Examine, identify, and establish priorities regarding the health and environmental threats that exist within the boundaries of the former mining district, or as a result of activities conducted within the former mining district, with special emphasis on those threats found within the boundaries of the Tar Creek Superfund Site.
2. Make recommendations for the most feasible solutions to those threats, listing the major impediments to achieving satisfactory solutions.
3. Identify all potential resources available to assist in the recommended remediation efforts.
4. Make recommendations regarding any legal, legislative, or administrative actions that might be necessary to draw upon those resources.
5. Analyze the effectiveness of past and current activities to restore and protect human health, safety, and environmental quality.
6. Make recommendations for structural and operational changes, public-private partnerships, incentives, and other measures appropriate to protect the welfare of the local citizenry, environment, and natural resources.
7. Recommend methods necessary to improve coordination and communication between involved parties.

The Task Force Chairman was also given the authority to appoint subcommittees as necessary. On February 22, 2000, the Chairman appointed 8 subcommittees:

- Health Effects Subcommittee
- Mine Shaft Subcommittee
- Subsidence Subcommittee

- Chat Use Subcommittee
- Water Quality Subcommittee
- Native American Issues Subcommittee
- Drainage/Flooding Subcommittee
- NRDA Subcommittee

Each subcommittee was assigned an objective(s) and tasks to accomplish the objectives. In addition, each subcommittee was directed to prepare a written report to address each task assigned.

The Subsidence Subcommittee was assigned two tasks:

- **Develop an effective means for delineating areas susceptible to subsidence that exist within the immediate vicinity of the Tar Creek Superfund project area. The Subcommittee shall also identify the resources necessary to complete this effort, the entities responsible for performing the delineation, and the potential funding sources for the project.**

Report Due: May/June 2000

- **Explore alternatives for reducing safety and infrastructure threats from subsidence, including, but not limited to, abandoned mine stabilization techniques, voluntary relocation, and/or property condemnation. The Subcommittee shall draft a project proposal for each alternative that includes a scope of work, timeline, resource needs (both capital and personnel), and potential sources of funding for the project.**

Report Due: July/August 2000

This report addresses both tasks assigned to the Subsidence Subcommittee.

BACKGROUND

History of the Mining Area

Lead and zinc were discovered in Ottawa County, near the town of Peoria, Oklahoma in 1891. Ore was subsequently discovered in Lincolnville and Commerce, Oklahoma in 1902 and 1905, respectively. However, the richest lead and zinc ores were found near Picher, Oklahoma in 1912. In fact, the Oklahoma portion of the mining area is commonly referred to as the Picher Field. Lead sulfide (galena) and zinc sulfide (sphalerite) were the primary metallic ores mined from the Mississippian age Boone Formation (also known as the Boone aquifer). As much as 13 million gallons of water per day were pumped from the mines in order to access the ore at depths of approximately 90 feet to more than 300 feet below ground. Depths in the richest portions of the area were typically 180 to 250 feet below ground. As the mining progressed, the mine workings became interconnected caverns that extended from Commerce, Oklahoma northeast toward Joplin, Missouri. The caverns now contain approximately 76,000 acre feet of acid mine water (EPA Tar Creek Superfund Site Fact Sheet, 1999).

Mining was performed using the room and pillar method where columns of ore were left in place to support the roof of the mine. By 1918, there were over 200 mills that had been built in the Picher Field to process the ore. The mills located at each mine were abandoned during the 1930's when the Eagle-Picher Mining Company built a central mill. Hundreds of millions of tons of mining waste were left behind by the mining process. The mining waste includes tailings that are primarily composed of fine, chert gravel (locally known as "chat"), flotation pond sediments, small boulder piles, and concrete mill remnants. This waste contains variable concentrations of lead and zinc.

History of Mine Subsidence

Due to depressed metals markets, most mine operations were reduced in 1957 and all major mining operations were closed in 1958. Limited mining continued until the early 1970's. During the early days of the mining era, it was the practice of the mining companies to remove columns (pillars) which supported the mine roof before the mine was abandoned. During the last two decades of the mining era, "gougers" leased abandoned mines and/or mined without benefit of a lease. The gougers primarily removed ore from the columns that supported the roof of the mines. Removal of the columns made collapse of the mines a greater threat. In one instance, miners were killed when the mine collapsed as the columns were being removed.

As of 1986, there were 59 major collapses greater than 95 ft. in diameter, due to underground mining in the Picher Field. Of these, 29 are major collapses associated with 34 mine shafts and 30 are non-shaft collapses (Luza 1986). A total of 55 non-shaft related collapses were reported

by Luza. According to the Luza Report, approximately 481 abandoned mine shafts are in varying degrees of collapse. Therefore, approximately 88% of the collapses within the Tar Creek Superfund Site are related to deteriorating mine shafts. Most of the collapses occurred prior to 1952. Approximately 27 surface acres have been disturbed as a result of shaft-related collapses and approximately 20 surface acres have been disturbed by non-shaft related collapses. Most of the non-shaft related collapses are located west of Cardin and Commerce, Oklahoma. The non-shaft related collapses are likely the result of multiple mine levels, large stopes (cavern height), incompetent roof rock, and removal of roof support columns (gouging). Additional surface water is captured as the collapse is enlarged by erosion. Collapse features and shafts receiving surface water run-off are vulnerable to erosion and additional subsidence. The surface water captured by most collapses directly recharges the mines.

Fortunately, most major collapses have occurred in rural areas and very little destruction of buildings and roads has occurred. However, several collapses have occurred within the city limits of Picher and the town of Hockerville. Three have occurred within 1000 ft. of the Picher High School and Elementary School. One major collapse is within 50 ft. of the church in Hockerville, and another is within 500 ft. of the church. The largest collapse feature, located south of Cardin, is 560 ft. long and 400 ft. wide, covering 4.04 acres.

The impact these collapse features have on water quality, flooding and drainage, land use, safety, and the aesthetics of the area have not been adequately addressed. It is important to point out that it is somewhat difficult to assess the collapse features independently, without considering their relationship to water quality, mine shafts, and the drainage and flooding of the area.

Another problem associated with the abandoned mines is the potential for subsidence in undermined areas. All undermined areas that have not been backfilled are subject to some risk of subsidence. The subsidence risk is not the same in all undermined areas. Some areas, like the State Line Road near Baxter Springs, Kansas, pose a high risk of public harm due to deterioration of the mine roof and subsequent upward movement of an open void under the road surface. At some point, the remaining mine roof no longer is capable of supporting passing vehicles and collapses, causing damage to vehicles and injury or death to the passengers. Variations in the risk of subsidence are associated with many factors, including: depth to the mine cavity, geometry of the mined out area, geology of overlying materials, groundwater movements and natural and man made seismic activity. Ground subsidence may occur suddenly, leaving a vertical opening in the ground many feet deep or it may occur slowly and gradually, sagging the ground surface over time. Rapid subsidence may cause serious injury or death to the public and may cause thousands or millions of dollars in property damage to homes, businesses and public roads and utilities. Slow subsidence is less likely to cause injury or death, but may still cause serious and expensive damage to structures and public facilities and may rupture water and gas lines, resulting in lost services and safety hazards.

Sites also vary in their risk of injury to the public. Subsidence which results in a vertical sided sinkhole in an unpopulated area may pose a falling risk or even a drowning risk if someone encounters the sinkhole, but it poses little risk of damage to structures and the number of people exposed to the risk are few. Subsidence that occurs in residential or business areas exposes many more people to risk of injury and also exposes structures and utilities to damage. Subsidence under high speed roads pose greater risk of injury than subsidence under local routes.

Past Remediation Efforts

Past remediation efforts have focused on water quality rather than mine subsidence. Significant physical and environmental hazards continue to be present in the former mining area in the form of open mine shafts, subsided areas and unstable, undermined ground. In addition, the historical mining activity has resulted in several negative impacts on the environment and public health of the area. In 1979, the water level in the mines and the Boone Aquifer became higher than the ground surface and acid mine water began to discharge to Tar Creek at Douthat and Commerce, Oklahoma, severely impacting surface water quality in Tar Creek. The Oklahoma State Department of Health (OSDH) was the lead agency for Superfund programs that addressed abandoned hazardous waste sites in Oklahoma. Governor Nigh's earlier Task Force selected the Oklahoma Water Resources Board (OWRB) to be the state lead agency to address Tar Creek surface water problems. Therefore, the OWRB was contracted by the OSDH to address environmental problems in the Tar Creek area (EPA Five Year Review, 1994). The former mining area became a National Priority List (NPL) Superfund Site in 1983.

The first remediation efforts were completed in 1986. These efforts focused on surface water quality in Tar Creek and assessing and preventing contamination of the deep Roubidoux aquifer (the area's primary water supply). Large amounts of surface water were observed entering collapse features near Treece, Kansas. Therefore, the OWRB proposed diverting surface water from entering the collapse features in Kansas. This was intended to lower the water level in the interconnected mine workings and stop or greatly reduce the acid mine water discharge at Douthat and Commerce. The OWRB/EPA conceptual hydrological model of the mines is essentially " the less surface water entering the mines, the less acid mine water discharge". Thus, the first remedial actions performed by the OWRB and the EPA included diverting surface water from entering collapse features in Kansas and a potential surface water inflow by Lytle Creek (reducing water into the mines) and plugging 83 deep abandoned water wells.

In 1994, the EPA issued a five-year review of the remedial actions taken to address the acid mine water discharges. They determined that the surface water diversion project was not successful in lowering the water level in the mines and the amount of acid mine water discharge was not affected by the remediation. The OWRB then designated Tar Creek as irreparably damaged and changed the Tar Creek surface water quality standards to a fresh water habitat

not supportive of a warm water habitat. However, the surface water quality in Tar Creek continues to violate the OWRB relaxed water quality standards. To date, the EPA has not amended the original Record of Decision (ROD) to change the conceptual model of the mines nor conducted any other remedial activities to improve Tar Creek's surface water quality. Ground water monitoring conducted by the DEQ indicates that the Roubidoux aquifer has not been adversely impacted by the past mining activities.

In 1993, environmental programs became consolidated when the Oklahoma Department of Environmental Quality (DEQ) was established. The DEQ and EPA have focused their efforts primarily on removing lead contamination in residential soil and monitoring the Roubidoux aquifer. The EPA is the lead agency for residential yard cleanup and the DEQ is the lead agency for monitoring the Roubidoux aquifer.

There have been isolated efforts to fill some smaller subsidence pits associated with shafts. However, there has never been a formal program for dealing with subsidence in Ottawa County. In the past, individuals and local governments have filled subsidence pits with garbage, construction waste and other compressible or organic debris. Many of these materials will deteriorate, resulting in future subsidence of the area. Others materials are hazardous to the environment and have a high probability of affecting groundwater quality.

Socioeconomic Impact

Until the 1960s, the mining industry provided the highest employment and largest economic base in northern Ottawa County. When the mining industry entered its declining years 1957-1972, miners and their families began to move to other areas to seek employment. The county population declined significantly during these years. Many businesses which supported the mining industry also closed their doors as a result of the decline in mining. The B. F. Goodrich plant in Miami was the largest employer in the area following the closure of the mines. In 1986, B. F. Goodrich shut down and moved the plant operations to other states. Following closure of the plant, unemployment in the city of Miami increased to 25%.

Ottawa County has never fully recovered from the closure of the two major industries. The largest economic growth since the decline of the mining industry and the closure of B. F. Goodrich has been the expansion of local small businesses. The current unemployment rate in the Miami area is 5%. Wages continue to be low in the area, with many jobs paying at or slightly above the minimum wage. The lack of industry, low paying jobs, large amounts of land in agricultural use and large tracts of land under Indian Tribal ownership results in a low tax base for the area. As a result, the small towns in the former mining field have a difficult time funding basic infrastructure needs, such as streets, roads, water and sewer systems. Because of this difficulty, the infrastructure needs are primarily funded through federal and state grants. Funding for other important community needs, including drainage and flooding, is simply not available.

The local cities and towns are totally dependent on outside funding to address health, safety, and environmental issues.

TASK 1

The primary emphasis of Task 1 is to develop an effective means for delineating areas susceptible to subsidence that exist within the Tar Creek Superfund project area. Work on the task began when the Subsidence Subcommittee held its first meeting on March 7, 2000. Prior to the meeting, those individuals whose names were provided to the Co-chairs by J. D. Strong were invited to attend. In addition, other individuals who had expressed interest and those Co-chairs felt would bring additional expertise to the subcommittee were also invited to attend. The subcommittee members are a diverse group with broad backgrounds. The following agencies, organizations and interest groups were represented on the subcommittee:

U.S. Office of Surface Mining
U. S. Army Corps of Engineers
U.S. Bureau of Indian Affairs
Oklahoma Department of Mines
Oklahoma Mining Commission
Oklahoma Conservation Commission
Oklahoma Dept. of Environmental Quality
Secretary of Environment's Office
Congressman Coburn's Office
Ottawa County Commissioner
Picher City Mayor
City of Miami
Retired miners and engineers
Quapaw Indian Tribe
Ottawa County Reclamation Authority
Interested citizens
Local contractors

A list of subcommittee members is provided in Appendix A.

A tour of several subsidence sites in the area was conducted as part of the first meeting to familiarize the members with the magnitude of the problem. The sites selected for the tour were representative of the size, geology, water table and proximity to residential areas of the subsidence features.

Characteristics of Subsidence Prone Areas

Former mine activities have resulted in several spectacular collapses of the land surface. Much of the former mining area has unstable ground and is subject to collapse. The following list of

subsidence prone areas was developed as a basis for the subcommittee to evaluate potential and existing collapse features:

Areas undermined with multiple levels of mine workings,

Areas where mining was shallow or with limited structurally competent limestone overlaying the drift (cavern),

Areas that were gouged (support columns removed),

Undermined areas with large structural loads such as chat piles,

Undermined areas under major roads,

Existing collapse features subject to surface water erosion, and

Mine shafts in varying states of erosion or collapse.

Information Sources for Risk Assessment

Risks of future subsidence are more difficult to assess and require expensive evaluation tools for accurate characterization. As found with sinkholes associated with coal mines, the location, accessibility and stability of the site are the primary factors in determining public risk. However, while location and accessibility are fairly simply assessed, stability is very hard to assess for abandoned mines that have not yet subsided. Various types of information are used by reclamation agencies to evaluate the mine subsidence risk to public safety and public or private property. Following is a list of some of these information sources.

Mine maps, old drill logs and mine or county production records
Geophysical Methods
Infrared Photography
Historical information from former miners and history books
Land use, transportation and planning maps
Exploratory Drilling

Mine Maps, Old Drill Logs and Production Records-Various state and federal agencies, university libraries, and the Picher Miner's Museum have available mine maps, drill logs, and production records which can be reviewed to gain a better understanding of the underground mine workings.

Individually, these information sources may be useful for understanding specific aspects of the mined area. However, single sources may provide incomplete or misleading pictures of either

the underground conditions or the potential for subsidence damage. For example, mine production records and mine maps were often kept up to date when the primary mining company operated a mine. The maps may tell room height and pillar location allowing a general understanding of the stability and geometry of a mine. However, in many cases, independent miners known as gougers went back into mines after the main company pulled out. These gougers removed additional pillars and worked additional ore bodies, changing the structural stability of the mined out areas. Therefore, old mine records and maps, by themselves, can be very poor predictors of subsidence activity and total reliance on such documents may lead to defective planning decisions.

Geophysical Methods-Geophysical methods such as ground penetrating radar, seismic reflection or refraction, micro-gravity variations, magnetics, resistivity, spectral analysis of seismic surface waves, and nuclear resonance have all been tried for use in locating and characterizing mine voids. These techniques have often been proposed as less expensive alternatives to exploratory drilling for characterization of geological conditions in mining areas. While some of these methods have been useful for extrapolating data between exploratory drill holes, the state reclamation programs have found that they do not provide consistent underground mine mapping at the depths encountered in the Tri-State Mining Area in the absence of an intensive drilling program. A more extensive discussion of these methods is provided in Appendix B.

Infrared Photography-Records indicate that over the past thirty years several flights have been made over the Picher Mining Field for the purpose of taking infrared photographs of the mine sites. Most of these photographs have been misplaced and were not retrievable by the Subsidence Subcommittee. Infrared spectrometry provides the capability of photographing images in the infrared light spectrum, thereby capturing the thermal gradients of the images being photographed. Discussions with the U.S. Geological Survey in Denver, Colorado and the Jet Propulsion Laboratory (JPL) in Pasadena, California, indicate that new technologies have been developed which provide greater capability of infrared imaging. It may indeed be possible to use infrared imaging in identifying open mine shafts that are concealed by brush and other debris, and to locate undetected, abandoned mine caverns near the ground surface. Scientists indicate that a low level flight (~12,000 ft.) using infrared imaging provides sufficient resolution to identify openings such as mine shafts. They indicate the best time for such flights is following a rain shower where there is a difference in the evaporation rate from ground surfaces. Infrared imaging utilized in conjunction with accurate mine maps may provide an additional tool to identify mine shafts as well as mine caverns which have the potential for subsidence. The use of infrared technology to update current conditions in the mining field should be given consideration by the Task Force. A program could be designed to maximize the effectiveness of infrared imaging in the Superfund Site. New infrared photographs could be compared to previous photographs of the area to locate open mine shafts and to possibly detect potential subsidence areas. The cost of infrared imaging would be less than $50,000.

Historical Information from Former Miners- In order to take advantage of their knowledge and experience, interviews were conducted with former miners who worked in the Picher Field. Emphasis was placed on their knowledge of areas mined which have the potential for future subsidence. Of particular importance was their knowledge of mines where large underground areas were mined close to the ground surface and those mines where support pillars were removed, resulting in weakened roof structures.

Due to advanced age, and in some cases, poor health, all the miners contacted were not able to provide pertinent information. Mining area maps were used during the personal interviews to ensure the accuracy of the locations discussed. These observations appear to be accurate since each miner was interviewed individually and the comments of other miners were not disclosed during each interview. The same general comments were noted by each miner for several of the locations.

Twenty potential subsidence sites were identified by the former miners. One site, located near the former Eagle-Picher shops in Cardin, OK , was considered by the miners to have the greatest potential for subsidence. An area within the City of Picher, OK, behind the newspaper office on Connell Avenue was considered to pose the second highest risk of subsidence. The area behind the newspaper office is a large open area. There are no homes or businesses currently on the site; however, the public does have access to the area. Approximately 50% of the sites, including the one near the Eagle-Picher shops in Cardin, are on Indian land. A list of these sites is also provided in Appendix C.

Land Use, Transportation and Planning Maps-Public agencies and private organizations have available digital maps showing roads, railroads, residential and commercial development, and other land use information which can be used in geographic information systems for hazard planning and mine subsidence prediction. This information is available in standard data formats and, in many cases, is available free of charge from government agencies.

Exploratory Drilling-Exploratory drilling can provide the most accurate picture of the geological setting and physical structure of mine workings, but drilling is too costly for large area characterization. It is time consuming and expensive, with costs ranging from $7 per foot for simple rotary drilling in soft materials to $35 per foot for core drilling or interior work. Drilling provides a vertical diagram of the subsurface makeup at the location of the drill hole. A combination of exploratory drilling using mine maps, drill logs, and GIS is the most effective method to determine the size and condition of underground mine workings that have not collapsed. Although expensive, exploratory drilling remains the most reliable method for characterizing underground mines for subsidence prevention and abatement.

Subsidence Risk Assessment

The information referenced above must be integrated in a comprehensive manner to determine the overall risk to the public posed by each undermined area. The subcommittee developed

a project selection matrix (Appendix D) to be used as an aid in identifying those potential subsidence areas presenting the greatest risk. It is recognized that the matrix is somewhat subjective. Nevertheless, it may prove helpful as an evaluation tool in conjunction with other data.

Geographic Information System (GIS)- Geographic Information Systems (GIS) are being used by various abandoned mine reclamation agencies in other states to evaluate the relative risk of public harm in the most efficient and cost effective manner possible. GIS is a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the earth. GIS can integrate historical information, existing geological and geophysical data, land use, transportation, development and other characteristics to implement a subsidence risk assessment program and determine where subsidence control or reclamation efforts should be conducted. Through GIS, information can be viewed and analyzed in a common platform even though the information 1) was produced by multiple agencies 2) resides in different and sometimes remote locations 3) has different formats/file types and 4) is in different coordinate systems. A program should be developed for the Tar Creek Site to record, store, retrieve and integrate data important to public health and safety. Data pertaining to subsidence, mine shafts, drainage, flooding, chat piles, mill ponds, former mill sites, water discharge sites and water quality, etc., should be maintained in an easily retrievable data base.

GIS allows planners to delineate areas where people are most likely to be exposed to subsidence hazards. Areas with high human activity like roads, residences, schools and commercial areas can be given a higher rating for attention than less developed areas. Historical mining information, which is somewhat more costly to obtain, may then be collected and used for rating these higher risk areas. Additional detailed information obtained from exploratory drilling and/or certain geophysical techniques may then be obtained for only the highest risk areas to develop even more detailed characterization of both subsidence risk and potential reclamation or protection techniques. Geographic information systems facilitate the efficient integration of these various data sources resulting in lower costs and more effective reclamation decisions.

Additional Areas of Subsidence

According to the Luza report (Luza 1986), no additional areas of subsidence had occurred since 1984. A cursory review by the Subsidence Subcommittee indicates that at least 8 subsidence events have occurred since 1986. It is recognized that, in addition to the seven listed below, many more may have occurred in more remote areas and are yet to be reported. Many of the existing subsidence areas are continuing to enlarge in size due to surface water eroding the sides and unstable roof structures.

- State Line Road dividing Kansas and Oklahoma near Baxter Springs, Kansas. Local residents indicate that until 1998 a metal pipe casing was visible above the area that

has collapsed. Mining maps do not show the existence of a shaft at the site. First noticed in November 1998.

- North side of “A” Street-1.5 miles east of Picher, Oklahoma- Approx. 1992

- Old Highway 66 Commerce (Intersection of current Main Street and “C” Street) leaving Commerce on south side drill hole in center of road (6 ft. wide x 22 ft. deep - Approx. 1994

- 300 ft. behind Police Station in Commerce - Cave in 50 ft. wide x 70 ft. long x 140 ft. deep - Approx. 1994-95

- Behind Commerce Police Station south of area listed above - Approx. 1994-95

- Cardin - Road 3/4 mile west of Eagle-Picher offices - north side of road - Approx. 1992

- Cave-in on Velie Lion northwest of Cardin - Approx. 1990-92

- Cave-in beneath a chat pile adjacent to Tar Creek on the north side of West “A” St. near Picher High School - 1997

The subcommittee also developed a project selection matrix (Appendix E) to be used as an evaluation tool to assess the relative risk of areas which have subsided.

Task 1 Recommendations

The Subcommittee strongly recommends that a GIS program be developed and maintained at the state level by a state office.

Use GIS to record and integrate all data associated with potential and existing subsidence areas in data layers to better manage information and select remediation projects.

Consider the use of infrared technology to update current conditions in the mining field.

Use the project selection matrixes included in Appendices D and E for determining the priority of projects for funding.

Task 2

Task 2 directed the subcommittee to explore alternatives for reducing safety and infrastructure threats from subsidence, including, but not limited to, abandoned mine stabilization techniques, voluntary relocation, and/or property condemnation.

Mine Subsidence Abatement Techniques

In 1983 and 1986 the Bureau of Mines, in cooperation with State Geological Surveys issued reports on Stability Problems and Hazard Evaluation in the Oklahoma, Missouri and Kansas portions of the Tri-State Mining Area. Among other things, these reports identified five methods of hazard abatement for mine subsidence: backfilling, grading to gentle slopes, fencing, controlled collapse with explosives, and public education were all suggested. Around the nation, other methods have also been used for abating hazards associated with subsidence. These include backfilling mine workings using various methods of grouting, pneumatic stowing and hydraulic backfilling, enhancing roof support using reverse roof bolts or grout bags (artificial pillars), and reinforcing the ground surface using geotextile soil nets beneath the ground surface.

Addressing Areas of Potential Subsidence

Luza (1986) found that most subsidence (surface collapse) sites in the Oklahoma portion of the Tri-State Mining District are associated with abandoned mine shafts. However, most large subsidence sites (greater than 95 ft. diameter) were not shaft related and appear to be the result of mining multiple ore zones. Subsidence begins with deterioration of mine cribbing at the top of the shaft and progresses through the shale, sandstone or other weathered materials near the surface (Luza 1986). Surface water inflow increases deterioration, causing rapid expansion of the collapse cone. Groundwater infiltration along the sides of the shaft may also weaken the surrounding materials and accelerate collapse. Closure of open mine shafts combined with diversion of surface water and control of underground seepage is probably the best and most efficient method of controlling future subsidence in the Oklahoma area of the Tri-State District. Mine shaft closure methods are presented in the report by the Mineshaft Subcommittee and will not be repeated here.

The Subsidence Subcommittee recognizes that the water currently filling the mining voids may play a vital role in preventing or prolonging further subsidence events. The subcommittee is not suggesting that the water in the mining field be reduced to a level which exposes the roof of the

mining voids. Significantly decreasing the water table could have an adverse effect on mine stability.

The following is a comprehensive list of subsidence control, protection, and prevention methods for situations where shaft closure will not, by itself, control the subsidence.

- Surface stabilization using geotextile soil nets
- Pneumatic stowing
- Hydraulic flushing
- Grouting
- Gravity grouting
- Pressure grouting
- Compaction grouting
- Grout bags
- Controlled collapse
- Reverse roof bolting
- Dynamic compaction
- Daylighting and backfilling
- Caissons, grade beams, soil nails, driven piers and rock anchors
- Relocation and demolition
- Zoning
- Special building codes

A more detailed description of these methods is provided in Appendix F. Many have been used in mine stabilization throughout the country. However, the presence of water filled mines in the Picher Mining Field eliminates the use of some of the methods and others have seen only limited application.

Cost Estimates for Preventing Subsidence - As a means of determining relative costs to protect people and structures from subsidence, several examples have been prepared.

Example

An area of town is known to have a high risk of subsidence. The mines were located 200 feet deep with 80% of the mine workings 25 feet tall and 20% being 90 feet tall. The extraction rate was 70%. There are 5 homes per surface acre. Houses measure 24 feet by 60 feet including a garage or carport.

Alternative 1 (Complete filling of the mine with concrete grout)

This option assumes that you will completely backfill the mine voids with concrete grout pumped from the surface. This option would completely stabilize the mine resulting in a permanent

resolution of the subsidence problem. Assuming a drilling cost of $15 per linear foot and a grout cost of $80 per yard, the total cost to fill the mine is $7.98 million per acre.

Alternative 2 (Targeted grouting under structures)

Under this option, 22 holes would be drilled around each residence on 10 foot centers. A curtain wall under the perimeter would be built using low slump grout injected into the 22 holes. Six additional holes would then be drilled and the remainder of the area under the house filled with a higher slump, lower cost grout. This would cost about $338,000 per residence or $1.69 million per acre.

Alternative 3 (Targeted backfilling with chat or stone)

As with the previous alternative, 22 holes would be drilled around each residence on 10 foot centers and a curtain wall would be created under the perimeter using low slump grout. However, the remainder of the underlying area would be filled with chat. Six additional holes would be drilled and chat in a water slurry would be injected into the mine. This would cost about $271,000 per residence or $1.35 million per acre. This alternative would not be as likely to achieve complete closure of the mine, resulting in a less than complete assurance of safety.

Other alternatives

It can be seen from these alternatives that closure of the mines is cost prohibitive and that, due to the size and depth of the mine workings, grouting is only appropriate in selected, high use and high value areas. Therefore, imposition of specialized building codes, city or county planning or buyout and relocation options may need to be considered in high risk subsidence areas. Buyout and relocation have been estimated to cost between $80,000 and $100,000 per residence. Building codes and planning restrictions have small direct costs, but they are often resisted by local landowners and developers. The social costs of these alternatives have not been estimated.

Addressing Subsidence That Has Already Occurred

Surface Backfilling Open Subsidence Pits - Surface backfilling has been used to close smaller pits and those with water standing in them. Surface backfilling is normally done using concrete, rock or soil materials in specified layers. Wood, metal and organic debris are not used because degradation of the materials results in voids in the fill, allowing water to enter and eventually causing further collapse of the filled pit. Many subsidence pits remain connected at their base to the abandoned mine workings, making it difficult to keep backfill materials from moving horizontally into the mine workings. One technique sometimes used to stabilize pit subsidence is to fill the bottom with large stones or concrete rubble, then cement the material into a plug with concrete grout. This plug is covered with finer backfill material to within six feet of the surface and covered with soil. Plugs have also been constructed with a light weight material called polyurethane foam. Because the foam expands, it has been shown to minimize leakage potential. Once a foam plug is constructed, concrete grout covered by rock, chat, and fill may be effective in stabilizing and filling subsidence holes. It is important to mound the fill and divert all surface water away from the backfilled area to prevent reopening of the pit by water infiltration. The cost of backfilling is highly variable, depending on the dimensions of the pit, the cost per ton of backfill material delivered to the site, and equipment costs for material placement. Backfilling costs from around the country range from hundreds of dollars for small projects to millions of dollars for large ones.

Dry pits (no standing water in them) that have exhibited little change over time may be made less dangerous by grading or excavation to reduce side slopes. When this is done, surface water must be diverted away from the pit to avoid erosion and reopening of the connection to the mine workings. This method may be significantly less expensive than backfilling, but may be dangerous if the configuration of the mine workings and tunnels is unknown. The pit may be dry because runoff entering it may quickly percolate into open mine stopes that may be tens or hundreds of feet deep. Operating equipment on such slopes without knowledge of the location of existing un-subsided stopes may place operators at risk of injury. The safety of grading work may be increased by using cranes, draglines and hydro seeding equipment to remotely rework and revegetate the side slopes without putting men within the hole. The cost of regrading is dependent on equipment and revegetation costs and is not likely to be used alone in Oklahoma since most large pits hold at least some water.

Use of Chat - Chat material has been used in some cases to backfill open mine pits. Chat is described as sand to gravel size waste rock (primarily chert) from the milling operations in the area

and is readily available in the vicinity of many subsidence pits. Chat has market value for certain applications and may cost approximately $5 per ton. However, in some areas landowners may be happy to get rid of chat piles and the material may be available at no cost.

In order for chat to be used effectively as fill material for mine shafts or collapsed areas, consideration must be given to several factors. First, chat has a high probability of moving into open mine workings at the bottom of the shaft or pit. Numerous examples exist in the Picher Mining Field where chat was used to fill open mine shafts and collapse pits only to find later that the chat had moved into the open mine workings at the bottom and reopened the shaft and pit.

Secondly, the connections to any open mine workings at the bottom of the pit must be sealed in order to use chat as a fill material. Since most mine shafts and collapsed areas now contain water, a diver or mobile underwater camera should be used to determine if any connections to the mine workings remain open. Any connections to the mine workings should be sealed to prevent the movement of the chat fill material. Sealing open mine connections could be accomplished by backfilling with mine debris (mill foundations and/or boulders) or using a fly ash/chat slurry. Some of the water in the collapse area may require removal prior to backfilling with chat to prevent overflow as chat is being added. Once filled near the surface, layers of clay and soil could be added and graded to prevent water from draining into the filled area.

Thirdly, the EPA and other agencies have expressed concerns about the environmental and health effects of placing chat materials underground or below the water table due to suspected high levels of lead, zinc and cadmium that may be released from the materials. Others believe that chat is a greater hazard left on the surface where rain and wind may continually move these materials into the environment. In addition, even with increased use of chat in asphalt and concrete, it will take many years to deplete the existing supply. Furthermore, much of the chat is not suitable for use in concrete or asphalt.

The advantages of using chat as a fill material are:

- Encapsulating large volumes of chat, thereby reducing the potential health hazard
- Trucking costs for chat would be minimal
- Preventing surface water from draining into the subsided areas
- Reducing the amount of acid water reaching the surface
- Providing a nearby location for disposal of chat fines which currently exist and for chat fines that may be generated in the future through chat washing/screening.
- Reclaiming many acres of land
- Providing a disposal location for materials removed from drainage channels (Tar and Lytle Creeks)

Cost Estimates for Filling Subsidence Areas - As a means of determining relative costs to fill subsidence areas, several examples have been prepared.

Example

Subsidence is 50 feet wide by 70 feet long and 140 feet deep. There is very little water in the bottom of the subsidence area. Reports from miners indicate that there were two drift tunnels going out from the subsidence area. It is assumed the overlying strata fell into the underground void and completely filled that cavern so that no voids are left under the floor of the subsidence area. That is to say the subsidence area has a solid floor. Also assume that the crater is approximately 1/3 full of refuse which will be left in place. The dimensions of the drift tunnels are not considered important since it is assumed that they were filled with subsided surface material and refuse. The goal is to keep people and water out of the subsidence area.

Alternative 1 (Fill with riprap)

Assuming that the refuse will compact to ½ its present volume from the weight of the rock dumped in the hole, the total volume to be filled would be 15,124 cubic yards (cu. yd.). If we fill with rock to within three (3) feet of the surface and then cap it with soil, the volumes of rock and soil would be 14,735 cu. yd. (~23,576 ton of riprap) and 389 cu. yd., respectively. With riprap at $12.00 per ton and soil at $6.00 per cu. yd., cost to fill the subsidence would be $285,246. The cost could be reduced by using less rock and more soil to fill the subsidence. However, increasing the amount of soil used will increase the amount of settlement that will occur for a year or more following the fill operation.

Alternative 2 (Fill with chat)

Same example as above, except chat is used in lieu of riprap. The volume of chat would be 22,003 tons. With chat at approximately $5.00 per ton and soil at $6.00 per cubic yard, cost to fill the subsidence would be $112,349. Costs of filling subsidence areas may be further reduced by using existing mine/mill debris (concrete pillars and boulder piles) to seal the bottom of the subsidence area.

Alternative 3 (Berm and Fence)

Construct a three (3) foot high dike around the perimeter of the subsidence leaving a 10 foot minimum width between the toe of the dike and the opening. This will prevent surface runoff water from entering the subsidence area. Also, construct an eight (8) foot high chain link fence with climb barrier around the perimeter of the dike. Estimated cost would be $10,000.

It can be seen from the examples above that large volumes of chat could be disposed of by encapsulation in existing subsidence features.

Fencing - Fencing has been used in the Tri-State Mining Area for many years to keep people out of subsidence areas. Fence is intended to deter public contact and exposure to the mine problem,

not to fix or stabilize it. The 1983 Bureau of Mines study of problems in the Kansas portion of the Tri-State area suggests that, where mines are in urban areas or near roads, six foot high cyclone fencing be installed with barb wire canted out at the top. A major problem of theft exists with fencing. Chain-link fencing, which has been installed in more remote areas, is often stolen within a few weeks of installation. The Bureau of Indian Affairs is currently considering using a stronger type of fencing which is less attractive for theft. Chain-link fencing used in public areas, such as downtown Picher, OK, survived for years without major damage or theft. Fences would allow authorized access. Warning signs would be used to deter unauthorized entry. Fences should be set back far enough from pit slopes that they are not undercut by future caving of the entry. Fences are visible today surrounding mine subsidence pits and mine shafts in the Tri-State Mining Area. Many of these are damaged, partially undercut by water or advanced subsidence, or weathered away. Fences may be a most cost effective method of protecting the public from the dangers of subsidence pits in many situations, but they must be erected with a plan for long term maintenance and monitoring. It must also be acknowledged that fences will not keep out determined explorers who wish to enter the subsidence pit area for mineral hunting, exploring, fishing or other water related activities. The costs of fencing are very dependent on local prices and on economies of scale.

REVIEW OF OTHER STATE AND FEDERAL PROGRAMS FOR MINE SUBSIDENCE

Millions of acres of land in the United States have been undermined due to the extraction of coal and mineral commodities. Underground mines occur in most states. Yet few states have attempted to address the public and private costs of mine subsidence.

Subsidence Reclamation on Non-coal Mines: The Federal Office of Surface Mining's (OSM's) Abandoned Mine Land Inventory System (AMLIS) indicates that four states and one Indian Tribe, Wyoming, Utah, New Mexico, Colorado, and the Navajo have completed subsidence abatement or protection projects on non-coal mines (AMLIS Report, May 8, 2000). However, because OSM's AMLIS system is primarily used for recording coal mine problems, completeness of information for non-coal mines is questionable. For additional information, we look at the 1988 Western Governor's Association report entitled "Cleaning Up Abandoned Mines: A Western Partnership". It reveals that, among 15 western states (not including Oklahoma), over 363,031 abandoned non-coal mine sites exist within their boundaries. Of these, 16,920 sites have been reclaimed. The report did not say how many of these sites contain subsidence problems or how many subsidence problems were reclaimed. However, based on literature reviews and discussion with state managers, we believe that most of these reclaimed sites involved open shafts and portals, and few involved subsidence. We must, therefore, look at the history of coal mine reclamation programs to get a picture of subsidence abatement across the nation.

Subsidence Reclamation on Coal Mines: Abandoned coal mine subsidence has been addressed by OSM or the state reclamation programs in 27 states and 6 Indian Tribes (AMLIS Report, May 8, 2000). OSM, the States and Tribes have taken various approaches to subsidence abatement and control. These follow three basic patterns which build on one another. They are (1) emergency response only, (2) subsidence insurance plus emergency response, and (3) subsidence prevention combined with subsidence insurance and/or emergency response. The degree of

response is usually related to the level of funding available to the state reclamation program which, in turn, is directly related to the amount of active coal mining occurring in that State or Tribe. These approaches are discussed in more detail below.

Emergency Response - Because so many acres of land are undermined, subsidence prediction is so extremely difficult, and because subsidence prevention is so very expensive, few states address subsidence before it occurs. Instead, OSM and most state reclamation programs address subsidence on an emergency response basis only. When subsidence is reported, the agency reacts quickly to reduce the damage to roads and structures and to protect public safety. Agencies may provide supplemental support to damaged structures and may take actions such as underground grouting or backfilling in the immediate vicinity of the damaged structure or road to prevent the damage from becoming worse. Emergency response projects rarely extend beyond a few tens or hundreds of feet from the actual subsidence event and few projects actually repair damages to roads or structures because of statutory prohibitions against using federal Abandoned Mine Land Reclamation Funds for repairs. Similar restrictions may not be in place for state appropriated funds in states that have them.

Subsidence Insurance and Emergency Response - Some states have developed subsidence insurance programs either independent of, or in cooperation with, the insurance industry within the state. Illinois has had the longest running subsidence insurance program in the Midwestern U.S. Subscribers pay an annual premium and the program pays for damages to private and public buildings when subsidence occurs. There is a $100,000 cap on payments for private residents. In most cases, emergency response programs work with the subsidence insurance program to ensure that damaged structures remain safe and habitable until subsidence movement has ceased and damages are completed. In many cases, it may take 6 months or more before ground movement ceases under a structure to the extent that repairs may be made. Once ground movement has ceased, the insurance fund assesses the damages and pays the homeowner or business the amount of damages, up to the mandatory cap. States may use up to $3,000,000 from the federal Abandoned Mine Land Reclamation Fund as seed money to start up a self-sustaining subsidence insurance fund, although the amount available to Oklahoma in any one year is only around $180,000. Colorado, Indiana, Kentucky, Ohio, West Virginia and Wyoming have used federal Abandoned Mine Reclamation Funds to establish subsidence insurance programs. Illinois and Pennsylvania have subsidence insurance programs established and administered outside the state reclamation program. Illinois makes subsidence insurance mandatory in certain counties heavily impacted by subsidence.

Subsidence Prevention Combined with the Subsidence Insurance And/or Emergency Response - A few states have the resources from the Abandoned Mine Land Reclamation Fund or other revenues to address subsidence on a preventative basis. Pennsylvania and Wyoming are two examples. These states have prioritized the underground mined areas for subsidence damage and have taken steps to reduce the incidence of subsidence. During 2000, Indiana is also considering methods for prioritizing potential subsidence areas, although no subsidence prevention projects have been conducted yet.

Summary: In summary, few states have addressed subsidence problems associated with non-coal mines in any large way. This is probably due to the limited availability of funding for non-coal problems. For coal mine subsidence, state, federal and tribal agencies have addressed subsidence in 27 states and on lands of 6 Indian Tribes. Agencies are using different approaches to protect the public from adverse effects of mine subsidence, depending on the level of funding available and the availability of subsidence insurance. Various combinations of emergency response, subsidence insurance and subsidence prevention techniques provide different levels of protection to the public, depending primarily on the amount of money available to the state or Tribe for reclamation of abandoned mines and on the ability of the state to support an insurance program.

LAWS/REGULATIONS RELATED TO SUBSIDENCE AND POTENTIAL FUNDING SOURCES

Both the State of Oklahoma and the United States through their respective environmental and abandoned mine land (AML) reclamation laws can provide both legal and financial help to communities with public health, safety, and environmental problems. These problems may range from dangerous highwalls and water-filled strip pits to open mine shafts, acid mine drainage, mine collapse features, acid mine drainage, dilapidated mine structures and land and water contamination from mining operations. The environmental laws provide for the cleanup of contaminated sites when public health or the environment are threatened by improperly handled or abandoned hazardous substances while the AML laws primarily address hazards related specifically to mining operations. Both the environmental and AML laws have a direct application to the Tar Creek Superfund Site. Difficulty arises in obtaining the necessary funding to enforce the laws. Appendix G provides specific information pertaining to the environmental laws listed below.

Environmental Laws

The federal government has the *Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986*, popularly known as the Superfund program. This law can be used for enforcement and funding.

The State of Oklahoma through the Oklahoma Department of Environmental Quality has the *State of Oklahoma Environmental Quality Code*. This law can be used for enforcement and funding.

The Clean Water Act (CWA); 33 U.S.C. s/s 121 et seq. (1977), is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. This law gives EPA the authority to set effluent standards on an industry basis (technology-based) and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person

to discharge any pollutant from a point source into navigable waters unless a permit (NPDES) is obtained under the Act.

The Safe Drinking Water Act (SDWA); 42 U.S.C. s/s 300f et seq. (1974), was established to protect the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources.

Abandoned Mine Land Reclamation Laws

AML Trust Fund

The Surface Mining Control and Reclamation Act (PL 95-87) established an AML Trust Fund through a tax on coal producers. States and tribes received grants out of the AML Trust Fund from the U.S. Department of the Interior's Office of Surface Mining (OSM). Presently, approximately $274 million goes into the Trust Fund each year. For the last nine years the states and tribes have received an average annual appropriation of only $134.5 million from Congress. At this time, there is over $1.6 billion in the AML Trust Fund available for appropriation by Congress.

AML Funding to Oklahoma

There are two sections (409 and 411) of PL 95-87 that allow for expenditure from the AML Trust Fund for non-coal AML problems. Section 409 of PL 95-87 (FILLING VOIDS AND SEALING TUNNELS) states that the Secretary of the Interior, at the request of the Governor of any State, is authorized to fill voids, seal abandoned tunnels, shafts, and entryways, and reclaim 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. Funds would be limited according to provisions in paragraphs (1) and (5) of section 402(g). These two paragraphs involve a formula that uses historic coal production and Oklahoma's 50% share of the coal tax collected annually. For the calendar year 1999 this amount was about $500,000. The Oklahoma FY 2000 AML funds are 100% obligated (projects are contracted for construction).

Section 411 of PL 95-87 (CERTIFICATION) states that the Governor may certify to the Secretary of the Interior that all of the coal abandoned mine land problems have been completed in the state. If the Secretary concurs, then the state may proceed with non-coal AML problems.

Oklahoma already has $90 million of Priority 1 and 2 AML hazards that have been approved by the OSM as eligible for funding from the AML Trust Fund. In 2004 the tax on coal will end unless Congress extends the fee collection.

In 1990, PL 95-87 was amended (Sec.402(g)(8)), stating that the Secretary of the Interior shall allocate annually not less than $2 million to low coal producing states and tribes like Oklahoma for reclamation of Priority 1 and 2 AML hazards. For Fiscal Years 1992, 1993, and 1994, Oklahoma received $2 million each year. For the last six fiscal years, Congress has put "line item" language in OSM's appropriation bill limiting Oklahoma and the other minimum program states to only $1.5 million per year. As a result, Oklahoma has lost $3 million.

PL 95-87 prohibits using AML funds for problems listed for remediation under Superfund. Problems like subsidence and mine shafts that may exist within the boundaries of the Superfund Site, but are

not listed for remediation, may be eligible for AML funding. Close coordination with EPA and the State DEQ are required to make this eligibility determination.

Rural Abandoned Mine Program (RAMP)

Section 406 of the Act provides for the reclamation of rural lands affected by mining by making funds available to the Secretary of Agriculture from the Abandoned Mine Reclamation Fund (Fund). Section 401 (c) (2) of the Act provides that there will be an annual transfer of funds to the Secretary of Agriculture for this purpose. Furthermore, Section 402 (g) (2) specifies that 10% of the reclamation fees collected shall be allocated to the Secretary of Agriculture only for the purpose of satisfying this transfer. The Act directs the Secretary of Agriculture to utilize the Natural Resource Conservation Service (NRCS) to carry out the provision of Section 406. On average, NRCS received $500,000 per year for the Oklahoma RAMP. Congressional appropriation to RAMP ceased after 1995, so the portion of the Fund dedicated to reclamation through RAMP has grown to slightly over $254 million as of February 29, 2000.

Congressional Line-Item Appropriation

Obviously, this could be one of the more difficult options. However, consistent with applicable laws, it is possible to make a strong case to Congress for appropriation of additional money to address the issues in the Tar Creek Superfund Site. While the various mining laws discussed above do not provide broad opportunities to obtain additional federal funding, it appears that a prudent course of action would be to pursue funding under the various laws. It may mean that priorities for existing projects could be revised and that the state and congressional delegations may need to prepare an appropriations package.

H. R. 2753 Abandoned Mine Restoration Act of 1999

This bill authorizes the Secretary of the Army through the Corps of Engineers (COE) to assist stewards of federal and non-federal lands to address environmental and water quality problems caused by drainage and related activities from abandoned, inactive, and post-production noncoal mines. The language in the bill, according to some sources, may be unclear as to whether it applies to non-federal lands. If so, this could be clarified in committee. On non-federal lands, the COE would cost share 65% of the project cost with the other 35% coming from non-federal entities. The non-federal entity, aside from direct cash matching funds, can receive credit for in-kind services including design and construction activities. Operation and maintenance of the project after implementation is 100% the responsibility of the non-federal entity. This bill currently authorizes $45 million for the program, with no more than $10 million for a single locality.

The Oklahoma AML Program has had discussions with the Tulsa District COE with regard to a very similar cost share program involving coal mine related acid mine drainage in the Gowen area. The COE has been very willing to allow the Conservation Commission to contract with them for a majority of the design and construction of the project, but a major obstacle has arisen due to an

indemnification clause in the COE contract which essentially relieves the COE of any liability should any lawsuits arise out of the reclamation activities. The Oklahoma Attorney General's office has been involved in lawsuits where this has been an issue. It might be wise to visit with them concerning this aspect of dealing with COE contracts and what, if anything, can be done to address the problem.

LAND OWNERSHIP

The land ownership within the Tar Creek Superfund Site is unique in that it is comprised of individual private land (fee simple), state land (Ottawa Reclamation Authority), and Indian Tribal Trust land (title held in trust by the United States for several Indian Tribes). There are eight federally recognized Tribes within the part of Ottawa County identified in the Superfund Site, and Restricted Individual Indian Allotted Land (land under supervision of the Secretary of the Interior and administered by the Bureau of Indian Affairs, Field Office at Miami, Oklahoma).

Approximately 45% of the land in the former mining district is on Restricted Indian Allotted Lands. Appendix H is a map showing both Allotted Lands and Tribal Lands. It became apparent early in the Subsidence Subcommittee meetings that representatives from the Bureau of Indian Affairs, as well as representatives from the Tribes, would need to be consulted concerning access to Indian lands before gaining access for evaluating the mining area on these Indian lands. As a result, the Subsidence Committee did not attempt to assess or validate any subsidence features on Indian lands. However, it was agreed that the subcommittee would work in parallel with the Department of the Interior and the Tribes and that mutual sharing of information would be a positive step in addressing subsidence issues.

It does not appear that the Task Force, Ottawa Reclamation Authority, Department of Interior, or any of the Indian Tribes would be in competition for the same federal dollars. Working in parallel with these other two entities may be the appropriate course of action. Consideration should be given to identifying some sort of mutual process whereby joint pilot remediation projects could be selected which address issues common to all groups and joint federal funding is sought. This would require a mutual teaming arrangement between the Indian Tribes, Department of Interior, and state and local officials to select, seek funding, and manage the project.

AREA OF IMMEDIATE CONCERN

1. State Line Road

There is a site where additional subsidence has a high probability of occurring. The site is located on State Line Road, East of Highway 69A, on the Kansas/Oklahoma state line near Baxter Springs, Kansas. Appendix I provides additional details of the site, including drilling reports and a map of the area identifying the site and the surrounding underground mine workings. It should be noted that State Line Road passes directly over some large, abandoned underground mine workings. These mine workings extend across the state line into Oklahoma.

Several aspects contribute to a very high hazard. The elevation of State Line Road has been slowly decreasing the past few years. In addition, a small area (50 ft. diameter) adjacent to the road has collapsed in the last two years. Additional cracks have opened in the asphalt surface in the past two months. A natural gas pumping station adjacent to State Line Road sits atop the mined area. The pumping station is under 700 psi. pressure and is the only supply of natural gas to the city of Baxter Springs, Kansas. Electrical power lines run along the State Line Road on the south side within 50 feet of the gas pumping station. The combination of natural gas under high pressure and the electrical power lines as an ignition source provides an unsatisfactory accident scenario.

Emergency vehicles and school buses use the road. Vehicle weight limit restrictions placed on the road by Ottawa County are routinely violated. Surface runoff along State Line Road flows into the mine opening.

Discussions with the EPA indicate that an assessment of the road safety and associated corrective actions are not included in the Tar Creek Superfund Project. In order to obtain federal funding, it may be necessary to determine if the ground water quality is being affected by the surface water running into the mine workings. This may provide information in determining the applicability of the Clean Water Act provisions. The Surface Mining Control and Reclamation Act of 1977 should also be reviewed for its applicability. If the State Line Road health and safety issues cannot be tied directly to a federal law or act, state funding may be the only source of funding to address the problem. Additional drilling is necessary to assess the costs of improving road stability. Officials may find that it is less expensive to relocate the road in the area, but this will not stabilize the gas pipeline. The cost to seal the eroded mine opening should not exceed $20,000.

Recommendations for Task 2:

Immediate investigation of the State Line Road is an appropriate course of action. Oklahoma State/County officials should contact Kansas officials and determine a course of action. Geologists, highway engineers, and elected officials should review the existing data and determine the next course of action. Recent information indicates that Kansas elected officials are asking for a more thorough review of the road conditions. As a minimum, the eroded mine opening should be sealed to prevent surface water runoff from entering the mine workings.

All potential funding sources should be identified at the federal and state levels and a concerted effort made to acquire the necessary funding. The state and local participants should work closely with the Indian Tribes and federal agencies to address environmental, safety, and health hazards associated with mine subsidence in the Superfund Site.

The Subcommittee Reports should be reviewed from a standpoint of determining the application of CERCLA and The Clean Water Act to the hazards existing within the Superfund Site. Discussions should be held with the EPA to determine applicability and potential avenues for funding under CERCLA and The Clean Water Act.

Use GIS to inform the public of areas with higher or lower risk of subsidence. Implement specialized building codes to protect occupant safety and building integrity for areas with higher subsidence risk.

Consider less expensive alternatives to underground stabilization (i.e. relocation/buyout, fencing and zoning) for inhabited areas where the subsidence risk is high.

Fill selected open mine shafts to reduce the occurrence of new subsidence in the Tar Creek Superfund Site.

The use of chat should be given serious consideration for backfilling subsidence features.

Discuss with our congressional delegation, OSM and USDA the feasibility of using the Rural Abandoned Mine Program (RAMP) as a mechanism of channeling a congressional appropriation from the RAMP portion of the Fund to Oklahoma (or the three states in the Tri-State Mining District).

Contact the Oklahoma Attorney General's office to determine if anything can be done to address the indemnification clause in the Corps of Engineers contract for work performed under the Abandoned Mine Restoration Act of 1999.

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APPENDIX A

Members of the Subsidence Subcommittee

Ernest R. Achterberg
Oklahoma Mining Commission

David Cates
Oklahoma Department of Environmental Quality

David Cohenour
Caldwell Environmental Associates, Inc.

Joe Crawford
Ottawa County Commissioner

John Dalgarn
Bureau of Indian Affairs

Dennis Datin
Oklahoma Department of Environmental Quality

Bill Erdner
U.S. Army Corps of Engineers

Sam Freeman, Mayor
City of Picher

Meredith Garvin
Quapaw Tribe of Oklahoma

James Graves
Grand Gateway EDA

Mike Kastl
Oklahoma Conservation Commission

Ed Keheley
Co-Chair

Pat L. Lair
Oklahoma Mining Commission

Len Meier
U.S. Office of Surface Mining

Mary Ann Pritchard, Co-Chair
Oklahoma Department of Mines

Jo Rainbolt
Office of Congressman Tom A. Coburn

Mike Sharp
Oklahoma Conservation Commission

A.L. Suman
Retired Miner

Jim Thompson
City of Miami

Michael C. Wolfrom
U.S. Office of Surface Mining

Nelson Weaver
Retired Miner

Frank Wood
Metallurgist

Geophysical Methods - Geophysical methods such as ground penetrating radar, seismic reflection or refraction, micro-gravity variations, magnetics, resistivity, EM, spectral analysis of seismic surface waves, and nuclear resonance have all been tried for use in locating and characterizing mine voids. While some of these methods have been useful for extrapolating data between exploratory drill holes, the state reclamation programs have found that they do not provide consistent underground mine mapping at the depths encountered in the Tri-State Mining Area in the absence of an intensive drilling program.

Considerable literature exists regarding attempts to use geophysical methods to identify abandoned mines; however, most literature focuses on abandoned coal mines. There are few examples where geophysical methods have been used to locate abandoned lead and zinc mines. In general, geophysical methods have not shown great promise in detecting abandoned lead and zinc mines. Some examples of the use of these methods are described below.

The Missouri Department of Transportation (MDOT) has used seismic, ground penetrating radar and magnetrometer methods in attempts to identify and characterize lead and zinc mine shafts in the vicinity of Joplin, Missouri. Seismic tests along 5 miles of highway footprint did a poor job of identifying mine shafts or mine workings. It was not a reliable predictor of mine features by itself. However, when used in conjunction with mine maps and other geotechnical data, it can be useful for identifying areas of higher risk for subsidence. Ground Penetrating Radar (GPR) did a good job of identifying the chat/soil boundary on chat disposal areas but did not identify mine shafts well. GPR was only effective to a few meters deep. It was thought that the magnetrometer would be useful for identifying junk filled shafts, but it also did not work well for that purpose. MDOT was not optimistic about the effectiveness of geophysical methods for open shaft and mine cavity detection.

The Office of Surface Mining has used various methods in attempts to identify coal mine shafts and mine cavities with varying levels of success. As an example, during 1997, OSM contracted to have a geophysical survey done at a residential property in Des Moines, Iowa to locate a suspected 150 foot deep coal mine shaft that was causing damage to a ranch style home. Old mine maps placed the shaft location somewhere in the vicinity of the home. Seismic Refraction Profiling and Microgravity Mapping were used. The study results predicted that the mine shaft would be located in the front yard, outside the footprint of the house. Two drill holes placed within the predicted area did not intercept the mine shaft. Angle holes drilled under the home, away from the target area, intercepted the mine shaft approximately 5 feet under the house footprint, and outside the target area. The OSM project manager concluded that the geophysical study was not effective in locating the partially filled mine shaft.

Seismic reflection has been successful in some applications by OSM for locating voids and rubble zones associated with coal mines and mine subsidence. However, it has not matched the results of exploratory drilling with enough consistency to be used on its own without extensive verification drilling, for mine void detection and subsidence prediction. In recent years, Richard Miller and Don Steeples, both of the University of Kansas, Lawrence, have been refining the use of shallow seismic reflection (using surface waves instead of P waves) to detect mine voids and rubblized zones in the southeast Kansas coal fields and in the Joplin area of the Tri-State Lead-Zinc mining area. Mr. Miller reports that this method can reliably identify mine voids and rubble at depths of 10 to 200 feet. Several technical papers resulting from that work are attached. Neither the Kansas or Missouri Abandoned Mine Land Program use the technology for abandoned mine applications at this time.

OSM and the Ohio DOT used soil borings to identify areas of slow subsidence. Ohio also used GPR, seismic refraction and electromagnetic conductivity in an attempt to identify and map subsurface voids and geology beneath the roadway. GPR identified anomalies that were thought to be small voids. However, verification drilling did not reveal any voids at those locations. Seismic and Electromagnetic systems did not reveal mine shafts or undermined areas.

During an April 26, 2000, presentation at the Kansas Department of Transportation Mine Rehabilitation Workshop in Kansas City, Missouri, Jeff Daniels of SoftEarth Associates, Inc. gave a presentation on geophysical methods for mine detection under highways. He identified the range of geophysical methods: gravity, magnetics, resistivity, EM, seismic refraction, seismic reflection, ground penetrating radar, spectral analysis of seismic surface waves, and nuclear resonance. After initial analysis, they concluded that only seismic reflection using shear waves and ground penetrating radar (GPR) had possible applications for highway use. Further evaluation of surface GPR revealed that it was highly susceptible to clay content in the soil, equipment variation, and operator variability. It also has only a shallow range, on the order of 3 to 5 meters. Standard GPR was enhanced by using the cross pole configuration of wave generator/receiver units. Side looking GPR provided better detail and may detect shallow subsurface mine features if large enough, but required a trench to be dug along both sides of the roadway so the radar unit could be drug along the roadway below the road surface. He concluded that seismic reflection using shear waves is able to detect slumps in the strata, but was still unsure whether it could detect and accurately predict the presence and dimensions of mine voids.

During the same April 26, 2000, presentation at the Kansas Department of Transportation Mine Rehabilitation Workshop in Kansas City, Missouri, Mr. Wilson Blake, a consulting mining engineer, reported on microseismic detection to predict subsidence of mines. This technique uses geophones to listen for natural sounds emitted by rocks under stress. Increases in the sound levels (cracking and popping) indicate that subsidence may be imminent. This method is used in many active mines and may be applicable in structures where subsidence is suspected to be fairly active.

However, it is likely to be a usable method for detecting subsidence prone areas over the large area of the Tri-State District.

APPENDIX B

Also at the April 26, 2000, presentation at the Kansas Department of Transportation Mine Rehabilitation Workshop in Kansas City, Missouri, Charles Dowding and Kevin O'Connor discussed the use of time domain reflectometry (TDR), which uses boreholes drilled into an area of high risk, or an area where subsidence is suspected, to monitor for ground movement. It can be hooked up live to monitor all the time or can be checked periodically and results of each data run charted against each other for comparison. This method has been used to monitor the proposed site for a new school in Illinois, the results of which revealed that, over 2 years, the proposed site was subsiding slowly. This may have application for monitoring high risk road and building areas in the Tri-State, but is not a large area analytical tool because it requires that holes be drilled, monitors be permanently installed, and equipment be monitored regularly. Automated systems could be used for continuous monitoring of high risk areas.

APPENDIX C

Potential Subsidence Sites

The locations of the 20 potential subsidence sites, identified by former miners, are provided below. The sites are not listed in order of priority. Site number 4 was considered by the miners to have the greatest potential for subsidence. Site number 1 was considered to pose the second highest risk of subsidence. Approximately 50% of sites are located on Indian land.

1. TRI-STATE TRIBUNE newspaper office in Picher on Connell Avenue - behind the office there is a major underground rock fall which travels back west to the old baseball field between Connell Avenue and Main Street. On the west edge of the baseball field there is a shaft that was filled with wood timbers and dirt many years ago.

2. BLACK HAWK MINE - Street Northeast of old U.S. 69 and present U.S. 69 junction in Picher, near the present business of the Picher Express - pillars were shot away in later years. There is a pull drift leading west from the mine to R. Harrell Park on S. Main Street, under which there is an unsupported cavern that the Astrodome would fit into. Miners consider this area more hazardous than the area on N. Main Street that was condemned decades ago.

3. OLD BALL PARK - Center field area located directly west of Item 1 above - large underground rock fall, roof height 100 ft. plus.

1. JOHN BEAVER-CRYSTAL-RITZ MINES up to VELIE LION-E-P Cardin shops location, north and northwest of shops - all of these workings were mined to a very high roof. Sheet ground (shale rock) in upper levels is very unstable plus lower levels made unstable by tar seams. This collective area was considered the most dangerous to work in by the miners because of rock falls from the roof. Their opinions agree with that reported by Ken Luza.

4. SYNDICATE MINE - Northwest of Picher High School toward Treece, Kansas, on the east side of Tar Creek - very bad rock strata throughout, with very thin or no upper limestone supporting roof.

5. PIOKEE MINE (later named DEW DROP) - one block north of Picher High School - had pillars removed by gouger mine operators in later years; a cave-in exists on the east side of the mine, with residence within 100 ft. of the cave-in.

6. LUCKY BILL to RIALTO #1 and #2 - LUCKY BILL MINES: one block south of S570R and E30R roads, RIALTO #1: east of Cardin on old U.S. 69 highway at College Street. junction, RIALTO #2 southeast of LUCKY BILL ¼ mile-pillars were removed and totally mined out especially around the shafts for a 200 yd. radius. The roof gets higher from the RIALTO #2 toward the ADMIRALTY due south, where it was necessary to drill from 75 ft. high towers to reach the upper mine working face. One miner exhibited a photograph of a miner standing on a 100 ft. tall ladder removing rock from the roof. Another had a photo of the drilling tower as it was used in many mines having a high roof.

7. HUMBLE GRAVEL PLANT - Intersection of S. College Street in Picher and old U.S. 69 Hwy - former location of RIALTO #3 mill shaft site area under the Humble Gravel chat pile - lacks support due to the absence of supporting limestone, and was mined up to the shale formation in many areas. Reported early day cave-in before 1940 on the south side of the chat pile adjacent to the highway which filled itself in with chat from the chat pile.

8. ADMIRALTY #1, 2, and 3 MINES - East and southeast of Douthat, #2 is north of Douthat Rd, #1 and #3 are south of the road and connected underground to the SKELTON MINE - An unusual geological feature is found in these workings. The Miami Fault Line anticline was visible in the mine near #1. Faults are known for slippage, especially during seismic activity. All of these workings are located in sheet ground (shale) and were well known for dangerous underground cave-ins due to instability of the roof. The deep water well casing was blasted and broken, permitting mine water to penetrate to the lower Roubideaux formation. The condition of the well casing at the surface is unknown. The well was located at the junction of the SKELTON AND ADMIRALTY leases.

9. BECK MINE - Southward across East A Street in Picher to HUDSON MINE(11.), 1.5 mi. east of A Street - Connell Avenue junction. A cave-in on north side of road and connected underground to location where A Street caved in several years ago, resulting in one fatality. Unstable rock strata with signs of surface sinking in the paved road.

10. HUDSON MINE (see item 10 above)

11. BLUE GOOSE #2 MINE - West side of mine, 0.5 mi. north of Central Mill site -caved in through the chat pile years ago, workings unstable and had many roof rock slabs fall during operating years.

12. GOODEAGLE MINE - 0.75 mi. north, 0.25 mi. east of Central Mill - Although not connected underground to other mines, it was mined on multiple levels to a very high roof resulting in instability. This type of mining without pillar support was most common in the Commerce area.

13. BENDALARI and CHEROKEE MINES - 2 mi. west on 19th Street in Kansas - mine leases in this area were very unstable. The former shaft was re-cribbed at the top five times due to poor stability of the upper rock strata. Close to Tar Creek.

14. FEDERAL LUCKY MINE - Just west across Tar Creek from SYNDICATE on west side of the creek - same problems as reported for the SYNDICATE MINE.

15. HOWE MINE - Northwest of PIOKEE and south of SYNDICATE on west side of Tar Creek approx. 10 blocks from Picher High School-had very thin upper strata of limestone and poses a threat to Tar Creek if it subsides, since most of the creek would then run into the cave-in.

16. NEW PICHER BALL PARK - West two blocks on West A Street, south side of Netta Street and West A Street corner - improperly filled shaft over a cavernous underground area not supported by pillars. In a residential area.

17. DAVIS BIG CHIEF MINE and DAVIS WHITE MINE - 0.5mi. north of U.S. 69-A Street, junction then 300 yds. West in Picher - these workings northward toward the KS-OK state line and southwestward were unstable due to tar seams and tar deposits all the way up to the "E" Boone formation. Miners report that the highway at the state line junction would be a very likely future subsidence location. They report that they could hear trucks on the highway above them.

18. EMMA GORDON MINE - 0.25 mi. west of Main Street in Commerce - mining generally in the Commerce area was in very narrow drifts due to the nature of the ore deposits and lack of sound rock strata overhead for roof support. Room and pillar mining method less used in the Commerce area and as a result, there have been several collapses over the years.

19. CATUS to JONES & GOLDBERG MINES - south edge of Commerce on old U.S. 66 Hwy - there is a shaft of unknown condition between these two mines not shown on the maps; its location is on the R22E-R23E section line. Mined area of these two mines was at a shallow depth and not in sound rock formation. Probably accounts for some of the past subsidence in this area.

Other mines, which have the potential for subsidence, but were not well documented by the miners were:

Picher area: SWIFT, KENOYER, PREMIER, SKELTON, SCOTT, and SUNFLOWER;
Cardin: BABY JIM; **Commerce**: NEVER SWEAT, LAST CHANCE, and COMMERCE MINING & ROYALTY; **Lincolnville**: PETERSBURG, ROMO, and SILVER STREAK. Very little information was obtained on mines in the Quapaw (Lincolnville) area.

APPENDIX D

PROJECT SELECTION MATRIX - SUBSIDENCE PRONE AREAS (revision 2)

Total Points _____

Site Name: _____

Location: _____

The following factors should be considered when prioritizing for reclamation subsidence prone areas. The definition of a subsidence prone area is a geographically delineated area that has a risk of subsidence occurring. The final assessment of points and ranking of projects or areas should be done by a team comprising a cross-section of individuals who are knowledgeable about the mining conditions of the region. For the sake of consistency, it is recommended that the integrity of the team be maintained throughout the evaluation and selection process for the entire mining district. The point values are listed to the right of each item.

Physical Conditions (Maximum points = 60)

A. What degree of risk can be assigned to the area based on existing knowledge of mine conditions and past mining activity? Please consider in your evaluation factors related to the geology of the subsidence prone area, information obtained from mining records and maps, and information gained from interviews of former miners who may have knowledge of the underground conditions.

Slight	_____	10
Moderate	_____	15
Severe	_____	30

Comments

B. Is there evidence that subsidence is starting to occur?

Slight	_____	10
Moderate	_____	20
Severe	_____	30

<u>Human Exposure</u> (Maximum points = 120)

C. Does a heavily traveled road pass through or within 100 feet of the subsidence prone area?

Yes	_____	20
No	_____	0

D. If the area were to subside, what impact would it have on essential public utilities?

Slight	_____	5
Moderate	_____	10
Severe	_____	20

E. If the area were to subside, would any facilities be impacted which would result in a catastrophic situation affecting the community? Examples: Natural gas distribution station, propane storage facility, fuel storage area such as a service station, water tower, sewage disposal facility.

Yes	_____	20
No	_____	0

F. Is the subsidence prone area near or include a school, daycare facility or a residential area? If so, what is the number of people impacted within a 0.25 mile radius?

1-5	_____	5
6-10	_____	7
11-25	_____	10
>25	_____	30

G. If the area were to subside, would access to emergency services be impacted?

No	_____	0
Moderate	_____	10
Severe	_____	20

H. Is the subsidence prone area in or near a public use area?

Yes	____	10
No	____	0

<u>Environmental</u> (Maximum points = 20)

I. If the area were to subside, would surface water enter the subsided area?

No	____	0
Yes	____	10
Yes and located in the flood plain	____	15
Yes and located in the stream bed	_____	20

Comments: _____

_____

_____

_____

Evaluator: _____ Date: _____

Evaluator: _____ Date: _____

Evaluator: _____ Date: _____

Evaluator: _____ Date: _____

Evaluator: _____ Date: _____

APPENDIX E

PROJECT SELECTION MATRIX-EXISTING SUBSIDENCE AREAS

TOTAL POINTS_____

SITE NAME:_____

LOCATION:_____

An existing subsidence area is one that is presently subsided and has not been successfully reclaimed. The following factors should be considered when prioritizing for reclamation.

PHYSICAL CONDITIONS (MAXIMUM POINTS = 92)

A. Size: 0.1-0.5 acres _____ 5
0.5-2.0 acres _____ 6
larger than 2.0 acres _____ 7

B. Condition Dry _____ 0
Water filled _____ 5

C. What degree of risk can be assigned to the area based on existing knowledge and field observations?

20. Is there evidence that additional subsidence is starting to occur or has occurred recently?

Slight _____10
Moderate _____20
Severe _____30

21. Does the water shed drain into the subsidence area?

Slight _____5
Moderate _____10
Severe _____20

3. High risk based on miner's interview _____30

APPENDIX E

HUMAN EXPOSURE (Maximum points=60)

D. If the area were to further subside, what impact would it have on essential existing public utilities?

Slight	_____ 5
Moderate	_____10
Severe	_____20

E. Does the location of the subsided area impact the general public?

Rural location	_____ 5
Within city limits	_____10
Near highway, road, street	_____15
Near public school	_____20

F. Is the subsided area used for disposal of items such as household garbage, dead animals and other refuse?

No	____ 0
Yes	_____10

G. Are existing physical restraints, if present, such as fences, or barricades degraded?

No	_____ 0
Yes	_____10

Total Points_____

Comments:_____

_____

_____

Evaluator:_____Date:_____

Evaluator:_____Date:_____

APPENDIX F

Mine Subsidence Abatement Techniques

Following is a summary of subsidence control, protection, and prevention methods for situations where shaft closure will not, by itself, control the subsidence.

Surface stabilization using geotextile soil nets - Geotextile materials such as high strength webs and nets have been used to reduce the risk of catastrophic ground failure under roads. The Kansas Department of Transportation is currently considering using this method to stabilize a road on the state line between Pitcher, OK and Baxter Springs, KS. The method involves excavation of the soil material under the area to be protected to a depth several feet below final grade. The geotextile is unrolled and anchored along the edges, then backfill materials are placed over the material and compacted. It has been suggested, in some cases, that the ground be excavated to a solid geologic formation and the geotextile deep anchored to increase stability.

Pneumatic Stowing is the filling of mine voids with granular materials transported by air. This method is most effective when direct access to the mine workings is available to workers. However, remote pneumatic stowing has been used successfully to inject airborne granular materials into mines. When mines are open and unobstructed, this method can result in up to 100% of void fill, effectively eliminating the risk of future subsidence. Complete fill is verified either by personnel working in the mine or by drilling confirmation holes from the surface after completion of work to determine if roof contact is made. This method has been used in coal mines effectively because of the even mine roof conditions. Pneumatic stowing is less expensive than grouting for filling large areas but may not be effective in northeast Oklahoma where mine workings have tall or uneven roofs and roof contact is unpredictable. In addition, the method can only be used in dry mines.

Hydraulic Flushing is filling of mine voids with granular materials transported in a water slurry. Material placement is controlled by use of grout curtains or aggregate bulkheads constructed remotely from the surface through drill holes. When mines are open and unobstructed, this method can result in up to 100% of void fill, effectively eliminating the risk of future subsidence. Complete fill is verified either by personnel working in the mine or by drilling confirmation holes from the surface after completion of work to determine if roof contact is made. This method has been used in Wyoming and other states to backfill coal mines under entire subdivisions. However, the process requires large volumes of material and water.

APPENDIX F

Grouting is the process of placing a mixture of cementitious material and fine aggregate as a fill material into the mine void. The grout is placed at a low volume rate. Many states and the Office of Surface Mining (OSM) use gravity grouting to stabilize coal mines that begin to subside under homes, buildings and roads. This is often a cost-effective method of ground stabilization where mine voids are not too tall (less than 8 feet) and the area to be stabilized is limited to structures or roads. However, it can be used in mine voids of nearly any size and configuration. Cost may become a problem for larger mine areas.

A. Gravity Grouting consists of placing a mixture of cementing agent (generally Portland cement) and fine aggregate into the mine level by means of a borehole. The most commonly used combination for mine grouting in the Midwest is a mixture of sand, Portland cement and Type-F fly ash. The pressure of the gravity head is the driving force used to place the grout. This is used frequently for abatement of subsidence under roads and structures associated with abandoned coal mine sites in Kansas and Missouri and would be effective in certain situations in the Tri-State lead/zinc mines.

B. Pressure Grouting is the process of pumping the grout mix into the mine area and overburden. Packers are used to seal the borehole so that pressure can be exerted on the grout. Pressures range from one-half to one psi per foot thickness of overburden. This is used frequently for abatement of subsidence under roads and structures associated with abandoned coal mine sites and would be effective in certain situations in the Tri-State lead/zinc mines. Pressure grouting enables the operator to force grout into fractured and rubblized zones, providing enhanced protection from subsidence.

C. Compaction Grouting is the injection of a stiff (low slump) grout at high pressure, up to 500 psi. The grout forms a ball at the point of injection and compacts the surrounding material. This method is being used to stiffen foundation soils which have lost strength and bulk due to subsidence. It is also being used to compact unstable fill in old mine shafts which were filled with trash or poorly backfilled in the past. It is cost effective for poorly filled mine shafts and structure-size stabilization projects, but is not suited for area wide projects.

Grout Bags are heavy fabric bags designed to be placed through a borehole, then filled with grout to build artificial mine pillars. As the bags fill, they form a column in the mine void to add additional support to the mine roof, reducing the risk of subsidence. They have been used successfully in Pennsylvania where abandoned coal mine roof heights may reach 16 feet.

Dennis Boehm of Hayward Baker, Inc. speculated that grout bags may be effective in mine rooms

up to 30 feet tall (KDOT Abandoned Mines Workshop, April 27, 2000). We understand that grout bags are being considered for use in 2000 by the Kansas DOT for stabilization of a road along the state line between Picher, and Baxter Springs, KS. This method may also be used to construct underground barrier walls to contain pumped grout or hydraulic backfill materials.

Controlled Collapse uses explosives to collapse the mine roof in a predictable manner. Collapsed areas are normally backfilled afterward. This technique has been used in the Tri-State Mining Area at least once, according to the 1983 BOM Study of Kansas. According to the report, in the late 1950's, the Kansas Department of Transportation had a situation where a partially collapsed mine was open to the surface. Contractors used a small bulldozer to push dumped fill into the uncollapsed portion of the mine room to reduce the height of the planned roof fall. The roof was drilled and shot down with a series of timed delays between the lines of holes to prevent vibration damage to adjacent buildings. The KDOT decided not to use the method on another area at that time because the mine roof was 80 feet above the floor, and it was feared that the hydraulic ram effect of the falling rock might collapse mine openings off the road right-of- way.

Concerns about using this method in populated areas stem both from the possibility of setting up a hydraulic ram effect in flooded mines and the possibility that vibrations from the blast might collapse other portions of the mine. The 1983 BOM study states, “in general, there are few other places where blasting could be used without incurring possible liability and is not recommended”. A recent discussion with a Missouri DOT geotechnical engineer working on Range Line Road around Joplin stated that they are not using controlled blasting to collapse the mines for similar reasons.

Reverse Roof Bolting attempts to increase the stability of an undermined area by drilling from the surface and installing roof bolts into the mine roof strata, tying the roof rock to the overlying layers. Information regarding this method was not reviewed, but we understand that it is being considered for use in 2000 by the Kansas DOT for stabilization of a road along the state line north of Picher, OK. Possible drawbacks of the method include increasing the rate of water infiltration due to the drilling and installation of roof bolts, which might lead to increased erosion and reduced stability of the mine.

Dynamic Compaction is a process for compacting soils at depth. The process involves dropping a weight in excess of 10 tons on a grid pattern, from a given height. This method is sometimes used for highway work and may have application for stabilizing abandoned

exploratory holes dug by early miners. The method has the potential to induce subsidence in areas where mine roof structure has deteriorated substantially, so thorough knowledge of geologic conditions is important when planning its implementation. The Missouri Department of Transportation is currently considering the use of dynamic compaction for the Range Line Road project at Joplin, Missouri.

APPENDIX F

Daylighting and Backfilling is used where mines are shallow and where roof rock is thin or soft. This method utilizes excavation equipment to remove the geologic materials overlying the worked-out mine, then fill in the mine workings from the surface to the ground surface level. This method results in 100% closure of the mine with only a risk of soil settlement to deal with. Because large voids are positively eliminated, the risk of catastrophic collapse is nearly eliminated.

Caissons, Grade Beams, Soil Nails, Driven Piers and Rock Anchors are all methods that may be used to stabilize structures built over subsidence prone areas. They may reduce dangers of building collapse and costs of repairs after minor subsidence events occur. However, these do little to stabilize the ground and do not stop or slow the progress of subsidence events.

Relocation and Demolition - Relocation has been used in a few situations across the country where no other alternative existed to protect the public from extremely dangerous situations. Love Canal and Times Beach hazardous materials sites and the Centralia, PA mine fire are useful examples to study. Relocation does not alleviate the problem, it only removes people from direct, daily access to it. Relocation has several inherent problems. It results in “off-limits” areas in communities where no development or activity can occur. This tends to bring down nearby property values and reduce the tax base of the area. Relocation costs for the Tar Creek Site are estimated to be between $80,000-$100,000 per home. The costs of residential buyout are often small compared to the legal costs of condemnation. Public participation is often not complete or enthusiastic. Therefore, while many homeowners may voluntarily participate in a buyout, there are often a few that refuse to leave, making the process very long and expensive. After relocation, the risk of ground subsidence remains, leaving a government agency with the liability if someone is injured or killed as a result of a subsidence event.

Zoning - Zoning laws may be very effective at reducing new public exposure to subsidence prone areas. With reliable mapping of subsidence risk areas, zoning can be used to designate areas suitable for new developments of various types. Zoning based on risk maps can designate the highest risk areas as off limit areas, lower risk areas for open space uses and still lower areas for parking lots or commercial developments where structural considerations make development a low risk issue. Areas with the lowest risk for

subsidence may be zoned residential and retail. Zoning will not eliminate the possibility of subsidence, but it can reduce the public and private costs when subsidence does occur.

APPENDIX F

Special Building Codes - The safety and structural integrity of buildings constructed over subsidence prone areas may be significantly improved by using certain construction practices. Counties and local governments can implement building codes that require these practices for new construction in subsidence risk areas. Similar to zoning in that it does not eliminate the possibility of subsidence, special building codes differ in that they allow for more construction and development in higher risk subsidence areas.

APPENDIX G

Environmental Laws for the United States of America

The mining waste at the site contains lead and other hazardous substances as defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C.§§ 9601 to 9675, also known as the Superfund Law. Mining waste at the site contains CERCLA hazardous substances, but the waste is not a hazardous waste under the Resource Conservation and Recovery Act (RCRA), Subtitle C. The mining wastes at the Site are solid waste from the extraction, beneficiation, and processing of ores and minerals which are excluded from regulation as a hazardous waste under RCRA, Subtitle C, according to 40 CFR § 261.4(b)(7). This exclusion was based on the Bevill Amendment to RCRA. However, chat does fall under the authority of Superfund since it contains CERCLA hazardous substances. Although chat is not regulated by federal hazardous waste management laws (i.e., RCRA, Subtitle C) designed to prevent releases into the environment, Superfund authorizes EPA to clean up material like chat that is contaminated with hazardous substances. Under Superfund, the term “release” means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding or barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant).

CERCLA Overview

Congress enacted CERCLA, commonly known as Superfund, on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites.

CERCLA:

- established prohibitions and requirements concerning closed and abandoned hazardous waste sites;

- provided for liability of persons responsible for releases of hazardous waste at these sites; and
- established a trust fund to provide for cleanup when no responsible party could be identified.

APPENDIX G

The law authorizes two kinds of response actions:

- short-term removals where actions may be taken to address releases or threatened releases requiring prompt response.
- long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on EPA's National Priorities List (NPL)

CERCLA also enabled the revision of the National Contingency Plan (NCP). The NCP provided the guidelines and procedures needed to respond to releases and threatened releases of hazardous substances, pollutants, or contaminants. The NCP also established the NPL.

The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan or NCP, is the federal government's blueprint for responding to both oil spills and hazardous substance releases. The National Contingency Plan is the result of our country's efforts to develop a national response capability and promote overall coordination among the hierarchy of responders and contingency plans.

CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986. SARA reflected EPA's experience in administering the complex Superfund program during its first six years and made several important changes and additions to the program. SARA:

- stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites;
- required Superfund actions to consider the standards and requirements found in other state and federal environmental laws and regulations;
- provided new enforcement authorities and settlement tools;
- increased state involvement in every phase of the Superfund program;
- increased the focus on human health problems posed by hazardous waste sites;

- encouraged greater citizen participation in making decisions on how sites should be cleaned up; and
- increased the size of the trust fund to $8.5 billion.

APPENDIX G

CERCLA covers all environmental media: air, surface water, ground water, and soils. It also can apply to any type of industrial, commercial or noncommercial facility regardless of whether there are specific regulations affecting that type of facility or how that facility might affect the environment. These are called applicable or relevant and appropriate requirements (ARARs) of other environmental laws.

Specific information that concerns the CERCLA Law

CERCLA § 104 (42 U.S.C. § 9604) authorizes the federal government to respond to releases of hazardous substances and pollutants or contaminants into the environment.

CERCLA § 105 (42 U.S.C. § 9605) requires that EPA identify uncontrolled or abandoned hazardous waste sites and prioritize them for cleanup. The high priority sites are placed on a National Priorities List (NPL) enabling EPA to use Trust Fund monies to clean up the sites. The Tar Creek Superfund Site was placed on the NPL on September 8, 1983. If a site is placed on the NPL, then EPA can use the Trust Fund monies to clean up the site.

CERCLA § 111 (Title 42 U.S.C. § 9611) allows the Hazardous Substances Trust Fund monies to be used for any necessary costs incurred as a result of cleaning up a site. The state must match this with 10 percent.

CERCLA § 118 (Title 42 U.S.C. § 9618) places a high priority for drinking water supplies where the release of hazardous substances or pollutants or contaminants has resulted in the closing of drinking water wells or has contaminated a principal drinking water supply.

CERCLA § 123 (Title 42 U.S.C. § 9623) allows for reimbursement to local governments affected by a release or threatened release at any facility. The monies will be paid for any expenses incurred in carrying out temporary emergency measures necessary to prevent or mitigate injury to human health or the environment associated

with the release or threatened release of any hazardous substance, pollutant, or contaminant.

Information that includes the Army Corps of Engineers

Section 22 Planning Assistance to States (PAS) Program of *the Water Resources Development Act of 1974* gives the COE authority to use its technical expertise in water and related resource management to help states and Native American Tribes with their water resource problems. This requires a 50% match by the state or tribe.

Section 206 Aquatic Ecosystem Restoration Program of *the Water Resources Development Act of 1974* authorizes the COE to carry out aquatic ecosystem

restoration projects if they will improve environmental quality, are in the public interest, and are cost effective. The cost share is 65% federal with a 35% nonfederal match.

The *Abandoned Mine Restoration Act of 1999* authorizes the Secretary of the Army through the Corps of Engineer (COE) to assist stewards of federal and non-federal lands to address environmental and water quality problems caused by drainage and related activities from abandoned, inactive, and post-production noncoal mines. On non-federal lands, the COE would cost share 65% of the project cost with the other 35% coming from non-federal entities.

Specific information that concerns mining laws

The Oklahoma Conservation Commission (OCC) is responsible for reclaiming over 32,000 acres of surface coal mines and another 40,000 acres of underground coal mines in a 16-county area of eastern Oklahoma. *The Surface Mining Control and Reclamation Act (PL 95-87)* set up an abandoned mine land (AML) trust fund paid for through a tax on coal producers. Even though this money is set aside for coal mines, some of this money may be used for the hard rock (zinc and lead) mines in Ottawa County.

Section 406 of the Act provides for the reclamation of rural lands affected by mining by making money available to the Secretary of Agriculture. The Natural Resource Conservation Service (NRCS) is the agency used to carry out these provisions. Section 409 of this law states that the Secretary of Interior, at the request of the Governor of any State, is authorized to fill voids, seal abandoned tunnels, shafts, and entryways caused by underground or surface mines. The ones selected are those that the Secretary determines could endanger life and property, constitute a hazard to the public health and safety, or degrade the environment.

Section 411 may be used once the Governor can certify to the Secretary of the Interior that all of the coal abandoned mine land problems have been completed in the state. This has not occurred in Oklahoma at the current time.

Environmental Laws for the State of Oklahoma

The Waste Management Division of the Oklahoma Department of the Environmental Quality has the responsibility to carry out activities as required by the State of Oklahoma Environmental Quality Code and the CERCLA Laws. These programs provide for the cleanup of contaminated sites when public health or the environment are threatened by improperly handled or abandoned hazardous substances.

APPENDIX G

The creation of the Oklahoma Department of Environmental Quality can be found in §27A-2-3-101 of the Environmental Quality Code. It reads as follows:

§27A-2-3-101.

A. There is hereby created the Department of Environmental Quality.

B. Within its jurisdictional areas of environmental responsibility, the Department of Environmental Quality, through its duly designated employees or representatives, shall have the power and duty to:

22. Perform such duties as required by law; and

23. Be the official agency of the State of Oklahoma, as designated by law, to cooperate with federal agencies for point source pollution, solid waste, hazardous materials, pollution, Superfund, water quality, hazardous waste, radioactive waste, air quality, drinking water supplies, wastewater treatment and any other program authorized by law or executive order.

The enforcement concerning the restriction of the use of chat is based upon the public nuisance law, which can be found in the water quality section of the Environmental Quality Code § 27A-2-6-105. This is entitled *Pollution of state air, land or waters - Order to cease*. This law reads as follows:

§27A-2-6-105

1. It shall be unlawful for any person to cause pollution of any waters of the state or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any air, land or waters of the state. Any such action is hereby declared to be a public nuisance.

2. If the Executive Director finds that any of the air, land or waters of the state have been, or are being, polluted, the Executive Director shall make an order requiring such

pollution to cease within a reasonable time, or requiring such manner of treatment or of disposition of the sewage or other polluting material as may in his judgment be necessary to prevent further pollution. It shall be the duty of the person to whom such order is directed to fully comply with the order of the Executive Director.

APPENDIX G

Some of the funding available from the State of Oklahoma can be found in Environmental Quality Code §27A-2-7-121 and §27A-2-10-802.

§27A-2-7-121.

E. All fees and other monies received by the Department pursuant to the provisions of this section shall be expended solely for the purposes specified in this section.

24. Ten percent (10%) of the fees collected from an off-site hazardous waste facility pursuant to the provisions of this section shall be deposited to the credit of the Special Economic Development Trust Funds. The funds for the Trusts accruing pursuant to the provisions of this section shall be distributed to each Trust established in proportion to the fees generated by the off-site hazardous waste facilities within the Trust area.

2. The Department shall expend monies received pursuant to the provisions of this section for one or more of the following purposes:
   a. the administration of the provisions of the Oklahoma Hazardous Waste Management Act,
   b. the development of an inventory of hazardous wastes currently produced in Oklahoma and management needs for the identified wastes,
   c the implementation of information exchange, technical assistance, public information, and educational programs,
   d. the development and encouragement of waste reduction plans for Oklahoma waste generators, or
   e. increased inspection of hazardous waste facilities which may include full time inspectors at off-site hazardous waste facilities.

F. To the extent that fees received pursuant to this section shall exceed the purposes specified in subsection E of this section, the Department shall only expend such funds for one or more of the following purposes:

25. Contributions required from the state pursuant to the federal Comprehensive Environmental Response, Compensation and Liability Act for remediation or related action upon a site within the state;

26. Response, including but not limited to containment and removal, to emergency situations involving spillage, leakage, emissions or other discharge of hazardous waste or hazardous waste constituents to the environment where a responsible party cannot be timely identified or

found or compelled to take appropriate emergency action to adequately protect human health and the environment;

27. State-funded remediation of sites contaminated by hazardous waste or hazardous waste constituents so as to present a threat to human health or the environment, to the extent that a responsible party cannot be timely identified or found or compelled to take such action, or is unable to take such action;

28. Costs incurred in pursuing an enforcement action to compel a responsible party to undertake appropriate response or remedial actions, or to recover from a responsible party monies expended by the state, as described in paragraphs 1 through 3 of this subsection; or

5. Financial assistance to municipalities or counties for the purposes and under the conditions specified in Section 2-7-305 of this title.

§27A-2-10-802

A. 1. Owners or operators of landfill disposal sites which are not generator owned and operated nonhazardous industrial waste monofills shall install scales by January 1, 1996. Such scales shall be installed on or within five (5) miles of the landfill disposal site and shall be tested and certified as required by Section 5-61e of Title 2 of the Oklahoma Statutes relating to the authority of the Board of Agriculture to test annually the standards of weights and measures used by any city or county within the state and to approve if found to be correct.

Except as otherwise provided by this subsection, on and after January 1, 1996:

B. 1. a. Owners and operators of landfill disposal sites which receive an average of less than one hundred (100) tons of solid waste per operating day shall assess a fee of One Dollar and fifty cents ($1.50) per ton of solid waste received for disposal. A total of fifty cents ($.50) per ton of such fee shall be retained by the owner or operator and used exclusively for capital improvement to their facilities and for the projects required pursuant to the Oklahoma Solid Waste Management Act or the disposal site's permit for such period of time necessary to recoup a capital investment, plus the interest costs expended in purchasing the scales, of a total of Forty Thousand Dollars ($40,000.00),

b. When the owner or operators have recouped a capital investment of the total specified in subparagraph a of this paragraph, the fee to be assessed shall be One Dollar and twenty-five cents ($1.25) per ton of solid waste received for

disposal. At such time, for a return with remittance filed on or before the due date, the owner or operator may deduct and retain ten percent (10%) of the fees collected, and

c. Records documenting the projects and use of the funds shall be included with each return.

2. a. Owners and operators of landfill disposal sites which receive an average of more than one hundred (100) tons of solid waste per operating day shall assess a fee of One Dollar and fifty cents ($1.50) per ton of solid waste received for disposal, retaining twenty-five cents ($0.25) per ton for a period of time necessary to recoup a capital investment, plus the interest costs expended in purchasing the scales, of Forty Thousand Dollars ($40,000.00). At the end of such period the fee shall revert to One Dollar and twenty-five cents ($1.25) per ton. For a return with remittance filed on or before the due date, the owner or operator may deduct and retain ten percent (10%) of the fees collected.

b. Records documenting the capital investment and the use of the funds shall be included with each return.

C. 1. The Department shall expend funds collected pursuant to the provisions of this section solely for the administration and enforcement of the provisions of the Oklahoma Solid Waste Management Act and for the development of solid waste technical assistance programs, solid waste public environmental education programs and educational curricula, solid waste studies, development of a statewide solid waste plan, solid waste recycling and litter prevention programs, and other environmental improvements.

5. a. The Department, in conjunction with the Corporation Commission, the Oklahoma Energy Resources Board and the Oklahoma Conservation Commission, may develop a plan to use suitable portions of the solid waste stream to reclaim Oklahoma lands damaged by oil and gas exploration and production or by surface mining activities.

APPENDIX G

ADDITIONAL ENVIRONMENTAL LAWS THAT THE ENVIRONMENTAL PROTECTION AGENCY (EPA) USES TO CARRY OUT ITS WORK

Among the environmental laws enacted by Congress through which EPA carries out its efforts are:

1938 Federal Food, Drug, and Cosmetic Act
1947 Federal Insecticide, Fungicide, and Rodenticide Act
1948 Federal Water Pollution Control Act (also known as the Clean Water Act)
1955 Clean Air Act
1965 Shoreline Erosion Protection Act
1965 Solid Waste Disposal Act
1970 National Environmental Policy Act
1970 Pollution Prevention Packaging Act
1970 Resource Recovery Act
1971 Lead-Based Paint Poisoning Prevention Act
1972 Coastal Zone Management Act
1972 Marine Protection, Research, and Sanctuaries Act
1972 Ocean Dumping Act
1973 Endangered Species Act
1974 Safe Drinking Water Act
1974 Shoreline Erosion Control Demonstration Act
1975 Hazardous Materials Transportation Act
1976 Resource Conservation and Recovery Act
1976 Toxic Substances Control Act
1977 Surface Mining Control and Reclamation Act
1978 Uranium Mill-Tailings Radiation Control Act
1980 Asbestos School Hazard Detection and Control Act
1980 Comprehensive Environmental Response, Compensation, and Liability Act
1982 Nuclear Waste Policy Act
1984 Asbestos School Hazard Abatement Act
1986 Asbestos Hazard Emergency Response Act
1986 Emergency Planning and Community Right to Know Act
1988 Indoor Radon Abatement Act
1988 Lead Contamination Control Act
1988 Medical Waste Tracking Act
1988 Ocean Dumping Ban Act
1988 Shore Protection Act
1990 National Environmental Education Act

State Line Road

Several aspects make this a very vulnerable site. The current Cherokee County, Kansas, engineer, Fred M. Graham, was the County Road Foreman in 1990 when the road was first paved. Mr. Graham remembers that while paving the road, the sound made by the asphalt lay down machine changed significantly when the machine passed over the underground mine workings. He stated that the lay down machine vibrated significantly more as it passed over the mine workings and that the pitch of the sound made by the machine changed as well. According to Mr. Graham, 3" of asphalt were laid on the road during the paving project. Elevations were taken before and after the paving project. When the paving project was finished, the elevation was the same as prior to paving the road. His conclusion was that during the paving project the road actually settled by the same amount as the thickness of the asphalt applied. Subsequent elevation surveys of the road by Mr. Graham indicate that the road is continuing to settle. There are noticeable cracks in the asphalt and along the road shoulder over the mine workings.

There is a collapsed area at the intersection of Roberts Road and State Line Road, approximately 50 feet in diameter, extending from the surface down through a shale layer and limestone bedrock into the underground mine. The collapsed area is 20 feet north of State Line Road. One can actually stand at the rim of the collapsed area and look directly down into the mine. Several factors contribute to the continual erosion of the collapsed area. According to local residents, the collapsed area was originally a drill hole with a metal casing extending above ground. Approximately two years ago the drill hole began to collapse. During rainy weather, surface runoff flows down State Line Road to the west for a distance of approximately ¾ mile and dumps directly into the collapsed area. In the past 14 months, the collapsed area has increased in size from 10 feet to 50 feet. The water level in the mine workings fluctuates with the amount of rain and surface runoff. In the wet months, the mine workings are completely filled with water and tend to be almost dry during the less wet months.

One critical element , which adds a great deal of seriousness to the situation, is a high pressure natural gas pumping station within 40 feet of the collapsed area. The pumping station is under 700 psi. pressure and includes a large underground tank. The gas supply line crosses State Line Road from the Oklahoma side and is the only natural gas supply for the city of Baxter Springs. High power electrical supply lines running parallel to State Line Road could be a source for ignition in the event of a major collapse of the mine workings. In the event of a major collapse, the gas line would likely rupture and be easily ignited by an electrical spark from damaged or broken power lines.

APPENDIX I

As a result of the concern over the possible collapse of State Line Road, officials in Cherokee County, Kansas contracted to perform some exploratory drilling along the roadway. Nelson Brothers Quarries of Quapaw, Oklahoma, were contracted to drill a series of test holes to determine the depth of bedrock under the road. Copies of the two drilling reports are included in this Appendix. Twelve test holes were drilled in April of 1999. The initial hole was located on State Line Road at the intersection of Roberts Road and State Line Road. Subsequent holes were drilled in increments headed eastward along the centerline of State Line Road. Each test hole was drilled to a depth of 19 feet. In most test holes a mixture of chat, clay, sandstone and shale were present to a depth of 12-14 feet and with a brown colored limestone and/or a hard limestone to a depth of 19 feet. The drilling company report stated that in nearly every hole, after hitting limestone, particularly after drilling through the off-colored brown limestone, the underlying limestone appeared to drill as a very sound, seamless, strong limestone.

Since the results of the first test drilling appeared to be inconclusive, Cherokee County decided to have the drilling company return for a second exploratory drilling episode. The purpose of the second test drilling was to ascertain, to a greater degree, the geological properties underlying the road and to determine the structural integrity of the formation as well as the depth of the roof of the underlying mine. The drilling company did not repeat the first 19 feet in the test since that had already been determined. Four test holes were drilled, the deepest being 77 feet. In the other three holes, limestone and chert were present from19 -30 feet, with water apparent at 24 feet. Between 30 - 41 feet, the material was fairly solid, except for a seam of loose limestone-chert. From 41 feet down, the limestone-chert mix became less dense. The mine roof was penetrated at depths of 53 feet and 58 feet in three of the holes. The fourth hole was drilled to a depth of 77 feet without encountering the mine roof. The mine cavity was full of water at the time of the drilling. According to Mr. Graham, Cherokee County Engineer, during the normal course of drilling, air was injected through the drill bit, causing water to be ejected from the drill holes when the drill penetrated the mine cavity. In addition, he stated that air bubbles could be seen being ejected in the standing water in the field just south of the drill site.

APPENDIX I

NELSON BROS. QUARRIES
63651 E. 5O RD.
QUAPAW, OKLAHOMA 74363

April 23. 1999

Fred M. Graham
Office of the County Engineer
Cherokee County, Kansas

RE: Drill Log, Stateline Road
Cherokee County, Kansas

Dear Mr. Graham,

The following is an accounting of what was discovered during an exploratory drilling episode of Stateline Road, Cherokee County, just south of Baxter Springs, Kansas. The initial hole was located on Stateline Road just at the Roberts Road intersection and subsequent holes were drilled in twenty -five foot increments headed eastward along the center of Stateline Road.

Test Hole # I From surface, mix of chat, sandstone, shale, and clay down to 12 feet, then a mix of shale and mostly limestone down to 19 feet.

Test Hole #2 From surface, mix of chat, sandstone, shale, and clay down to 11 feet, then mainly limestone down to 19 feet.

Test Hole # 3 From surface, mix of chat, sandstone, shale, and clay down to 12 feet, then mainly limestone down to 19 feet.

Test Hole # 4 This hole was skipped over due to the close proximity of a gas line.

Test Hole # 5 From surface, some chat and then black dirt turning to mud due to some water being present in this hole down to 16 feet, then a brown colored poorer quality limestone down to 19 feet.

Test Hole # 6 From surface; mix of chat, clay, sandstone, black dirt down to 14 feet, then a sandstone brown colored limestone mix down to 16 feet, then limestone down to 19 feet.

APPENDIX I

Test Hole # 7 From surface, mix of chat, clay to about 3 feet, then mainly black dirt down to 13 feet, then a hard clay down to 14 1/2 feet, then limestone down to 19 feet.

Test Hole # *8* From surface, mix of chat, clay, then black dirt down to 13 feet. then a brown colored limestone to 15 feet, then limestone down to 19 feet.

Test Hole # 9 From surface, mix of chat, clay, sandstone, shale, then black dirt and shale down to 13 feet, then limestone down to 17 feet, then a seam of clay to 18 feet, then limestone down to 19 feet.

Test Hole # 10 From surface, mix of chat, more of a red colored clay than previous few holes down to 10 feet, then starting with a brown colored limestone for about 1 1/2 feet then a better quality limestone on down to 19 feet.

Test Hole # 11 From surface, a mix of chat and clay, then red clay down to 10 feet, then a brown colored limestone down to 12 feet, then a better quality limestone down to 19 feet.

Test Hole # 12 From surface, some chat and clay mix down to about 8 feet, then some brown colored limestone to 9 feet, then limestone down to 19 feet.

Test Hole # 13 From surface, some chat and clay down to about 7 feet, from 7 to 8 feet a brown colored limestone, then limestone on down to 19 feet.

In nearly every hole, after hitting limestone, particularly after drilling through the off colored brown limestone, the limestone appears to drill as a very sound, seamless, strong limestone formation. Test hole # *5* appears to be the thinnest limestone layer under the road. This hole has the less dense black dirt mix and water and therefore, in our opinion, probably the weakest point in the road found of all the test holes. It is, however, still 19 feet of material under the road with no apparent voids.

Mr. Graham, we hope this report is of assistance to you in determining the safety of this road. We do recommend that all test holes be plugged and sealed to prevent erosion and water damage to the roadbed. And we thank you for being on site providing site safety and assistance while the test drilling was in progress.

Thank You,
Paul M. (Dusty) Nelson, President
Nelson Bros. Quarries

APPENDIX I

NELSON BROS. QUARRIES
63651 E 5O RD.
QUAPAW, OKLAHOMA *74363*

April 29. 1999

Fred M. Graham
Office of the County Engineer
Cherokee County, Kansas

RE: Drill Log, Stateline Road
Cherokee County, Kansas

Dear Mr. Graham.

The following is an accounting of what was discovered during the second exploratory drilling episode of Stateline Road, Cherokee County, just south of Baxter Springs, Kansas. The first test drilling took place approximately one week prior to this episode. The purpose of this test drilling was to ascertain to a deeper depth the geological properties underlying the road in question, and to determine the structural integrity of the formation as well as the depth of the roof of the underlying mine. We will not repeat the first 19 feet in this test because that has already been determined. Therefore, in order to get the total picture of our findings, one should consult the first test report as well as this report.

Test Hole # 1 Located between test holes 4 and 5 of the first test. From 19 down to 30 feet, limestone and chert mix. Water became apparent at 24 foot level. Chert was also more present after the 24 foot level. Chert became more heavily concentrated below the 41 foot level. From 41 feet down, the limestone chert mix became not as dense, with loose nodules coming out of the hole in larger pieces, indicating that the drill bit had just knocked the large piece loose from the wall of the test hole. This test hole was halted at the 58 foot level due to the large amount of loose material caving in on the drill rod and making cleaning of the hole impossible. It can be determined from this that below 58 foot the geological formation is loose and not sound.

Test Hole # 2 Located between test holes 6 and 7 of the first test. From 19 down to 30 feet limestone and chert mix with chert and water apparent at the 24 foot level and below. From 30 feet down to 41 feet, fairly solid except for a seam of loose limestone/chert from 39 to 40 feet. At the 48 foot level, the material being ejected out of the test hole was largely loose material that was penetrated very easy down to about the 53 foot level where we seemed to break into a large cavity and had no more drill resistance noted on down to 65 foot level. However,

water was still being ejected out the top of the hole so that it is apparent that water from the cavity rose up the hole and was ejected by air pressure from the drill.

Test Hole # *3* Located about 8 feet north of hole #2 . This hole is fairly consistent with the hole #2 as above; however, we did not break into the large cavity until the 58 foot level. Again, water was still being ejected out of the test hole even after the cavity had been breached, indicating that the water in the cavity rose up into the test hole.

Test Hole # 4 Located between holes 8 and 9 of the first test. This test hole was the most sound formation, as less dirt, clay, and sandstone was encountered and more limestone and chert were present. Water and chert were again more prevalent at the 24 foot level, and a better grade of limestone seemed to be present. This formation seemed to be not as loose as previous holes. We drilled down to the 77 foot level and never encountered the large cavity as in previous holes.

Mr. Graham, again, we hope this report helps you in determining the safety of this road. Again we recommend that all test holes be plugged to prevent road damage and erosion.

Yours Truly,

Paul M, (Dusty) Nelson, President
Nelson Bros. Quarries