FIVE-YEAR REVIEW

TAR CREEK SUPERFUND SITE

OTTAWA COUNTY, OKLAHOMA

APRIL 2000

U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION 6

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I. BACKGROUND

A. Nature and Extent of Contamination

The Tar Creek Superfund Site (the "Site") is located in the northeastern portion of Ottawa County, Oklahoma. The Site is a former lead and zinc mining area. The Site includes the Oklahoma portion of the Tri-State mining district of northeastern Oklahoma, southeastern Kansas and southwestern Missouri. Mining began in Ottawa County in the early 1900's and continued until the 1970's. The Boone Formation was the source of the metal ore. The Boone Formation is also an aquifer. Due to the presence of the aquifer in the ore-producing Boone Formation, the mining companies were forced to pump large volumes of water from the extensive underground mine workings. Pumping continued until the mining ceased, at which time the aquifer, and hence the mines, began refilling. As water filled the mines, the native sulfide minerals, which had been oxidized by exposure to air, dissolved, creating acid mine water. By 1979, water levels had increased to the point that the acid mine water began discharging at the surface from several locations, severely impacting Tar Creek.

In addition, approximately 50 million tons of waste (i.e., mine tailings) leftover from the mining operations are present at the Site. These mine tailings deposited in hundreds of piles and ponds at the Site contain lead and other heavy metals. Some of the tailings piles approach 200 feet in height. Residential communities are located among the tailings piles. The tailings have been widely used locally as gravel for driveways and roads. Approximately 25 percent of the children living on the Site have elevated blood lead concentration levels, compared to a statewide average of 2 percent. Approximately 1,600 residential yards with unsafe concentration levels of lead have been identified. Five public water supply wells on the Site are impacted by acid mine water. These wells fail to meet secondary drinking water standards. The Site landscape is significantly scarred and disrupted by the past mining activities. In addition to Tar Creek, other Site-area creeks are contaminated with acid mine water that is draining from the underground mines, and with leachate and runoff from the large deposits of tailings. Traffic-generated dust from the tailings also poses problems.

B. Records of Decision and Remedial Actions

Operable Unit 1

The U.S. Environmental Protection Agency (EPA) issued its first Record of Decision (ROD) for the Site on June 6, 1984. The ROD addressed two concerns: 1) the surface water degradation of Tar Creek by the discharge of acid mine water; and 2) the threat of contamination of the Roubidoux Aquifer, the regional water supply, by downward migration of acid mine water from the overlying Boone Aquifer through abandoned wells connecting the two.

The 1984 ROD called for the elimination or reduction of the discharge of acid mine water by reducing surface recharge of the Boone Aquifer. At the time of the 1984 ROD, it was presumed that reducing the volume of surface water that flowed into the mines would reduce the underground water levels in the mines as surface discharge continued, and that this volume reduction would, eventually, eliminate the discharge. Under the 1984 ROD, surface recharge was to be reduced with dikes and diversion structures designed to stop surface water from entering the two collapsed mine shafts which were identified as the main inflow points, and to stop surface water from entering a third collapsed mine shaft which was considered a potential major inflow point. Additionally, the 1984 remedy called for preventing the downward migration of acid mine water into the Roubidoux Aquifer by plugging 66 abandoned wells. During remediation, an additional 17 wells were identified and plugged, bringing the total to 83 wells. Diversion and diking and the well-plugging activities at the 83 wells were finished by December 22, 1986. Later, an additional 15 abandoned Roubidoux wells were identified for plugging. These additional 15 well have not yet been plugged.

With the issuance of the 1994 Five-Year Review, additional contaminant threats were identified at the Site; consequently, in order to differentiate the areas of concern, in 1994 EPA began referring to the concerns addressed by the 1984 ROD as Operable Unit 1 (OU1). The releases of heavy metal contamination associated with the mining wastes deposited on the surface of the ground (i.e., chat piles and floatation ponds) have been termed Operable Unit 2 (OU2). Under the National Contingency Plan (NCP), operable unit means a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.

Operable Unit 2

OU2 addresses the contamination associated with the mining wastes deposited on the surface of the ground (i.e., chat piles and floatation ponds). The August 27, 1997, ROD addresses the residential areas of OU2. For remediation of the residential areas of OU2, the following Remedial Action Objective (RAO) is being utilized: Reduce ingestion by humans, especially children, of surface soil in residential areas contaminated with lead at a concentration greater than or equal to 500 parts per million parts soil (ppm). For metal concentrations in soil, 1 ppm means 1 part of metal in a million parts of soil. The main component of the remedy selected to achieve this RAO is soil excavation with a 500-ppm remediation goal. The EPA is also supplementing the active engineering measures of the remedy by providing funding to the Agency for Toxic Substances and Disease Registry (ATSDR) for an extensive lead education and blood lead screening program at the Site.

Future Response Actions

Future response actions include addressing remaining contamination in the nonresidential areas of OU2.

II. SUMMARY

A. OU1 Remediation

Surface Water

1. Effectiveness of Surface Water Remedial Action

The following summary of the review of the effectiveness of the surface water remedial action is based on post-construction monitoring that occurred in 1987 and 1988 after the diversion and diking structures were constructed as called for in the 1984 OU1 ROD. The available monitoring data was summarized and presented in the 1994 Five-Year Review. This data is referenced in this report but not repeated. The 1994 Five-Year Review Report recommended no additional monitoring.

The diking and diversion structures constructed pursuant to the OU1 ROD are operating as designed with regard to eliminating the major inflows into the mines. The major inflows that were eliminated were estimated in the OU1 ROD to represent approximately 75 percent of the total inflow into the mines. The diversion and diking constructed under the OU1 ROD did reduce the temporary rise in water levels in the mines that occurs in response to a given rainfall event. Since the outflow from the mines is hydraulically driven by the water level in the mines, reducing the temporary rise in the mine water level did reduce the peak outflows following a given rainfall event.

However, the average water level in the mines was not lowered significantly after the remedy was constructed according to the goal of the1984 ROD. The same study that concluded that the average water level in the mines had not been lowered, also indicates that the average volume of acid mine water discharging from the mines into Tar Creek is not significantly different from the amount of water that was discharging before the remedy was constructed. Therefore, the remedy did not significantly reduce the surface discharges of acid mine water.

Although the average discharge volume was not reduced, some reductions in the metal concentrations of the discharges were measured. These reductions in the metal concentrations of the discharges are possibly due to natural attenuation.

In summary, the OU 1 remedy was mostly ineffective in mitigating the environmental degradation of the surface waters of Tar Creek drainage basin.

2. Water Quality Standards Lowered

Subsequent to the issuance of the OU1 ROD, the State of Oklahoma concluded that the impacts to Tar Creek (i.e., impaired water chemistry and habitat) rendered the stream not adequate to support a "Warm Water Aquatic Community." The Oklahoma Water Resources Board (OWRB), the agency charged with setting Water Quality Standards for the State of Oklahoma, has also concluded that the impacts to Tar Creek are due to "irreversible man-made damages" resulting from past mining operations at the Site.

To reflect this conclusion, the OWRB in 1985 lowered the designated uses of Tar Creek to a habitat-limited fishery and to a secondary recreation water body. The OWRB's reference to "irreversible man-made damages" is a simplified rephrasing of the following language: "human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied." This wording is taken from paragraph 785:45-5-12 (b) (3) of the Oklahoma Water Quality Standards. Irreversible man-made conditions are one of the allowable justifications for lowering a stream's classification from warm water fishery to a habitat-limited fishery.

The secondary recreation water body designation allows for uses where ingestion of water is not anticipated (e.g., boating, fishing, or wading). The Water Quality Standards associated with these designated uses are not being met in Tar Creek at present. In particular, the pH standard and the numerical criteria for toxic substances (e.g., heavy metals) which apply to all fishery classifications, including habitat-limited fisheries, are not being met. (The pH relates to the acidity of the water. Lower pH means more acidic conditions. A pH of 7 is neutral, neither acidic nor alkaline.) Although the fishery-related standards would be considered ARARs (applicable, or relevant and appropriate requirements) under the NCP, as explained in section 3 below, the OU1 ROD invoked an ARAR waiver with regard to the environmental components of the Water Quality Standards under the Clean Water Act.

3. Waiver of ARARs for Protection of the Environment

The OU1 ROD used the Water Quality Standards as the criteria for assessing whether or not human health and the environment were being impacted by the surface water in Tar Creek. Table 2 in the OU1 ROD presented numerical information showing that the levels of metals discharging into Tar Creek from the abandoned mines exceeded the acute and chronic criteria of the Water Quality Standards.

The 1984 ROD for OU1 was issued under the 1982 National Contingency Plan (NCP). The provisions regarding the fund-balancing ARARs waiver are found in the 1982 NCP at what was then 40 CFR § 300.68(k). In the 1990 NCP, the fund-balancing ARARs waiver is codified at what is now 40 CFR § 300.430(f)(ii)(C)(6), and is similar to the 1982 NCP provision. The underlying statutory law upon which the 1982 NCP fund-balancing waiver is based is CERCLA Section 104(c)(4). The 1990 NCP waiver provision is based on CERCLA [as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA)] Section 121(d)(4)(F). The two statutory provisions call for a similar balancing test. Although there are distinctions between the statutory provisions, the distinctions are not so great that the 1984 waiver decision must be reexamined because the fund-balancing determination that was made in 1984 is essentially the same determination that would be made in 2000 under the 1990 NCP. Moreover, the economics of the situation have not changed. That is, the massive costs associated with any engineering solution for surface water contamination in the Tar Creek Basin are still prohibitively high, and expenditures to meet those costs would drain the Fund. In short, there is no reason to revisit the fund-balancing waiver that was made in the 1984 OU1 ROD.

The normal process for remedy selection for pre-SARA RODs, according to the 1982 NCP, was to select "the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment." The OU1 ROD declaration asserted that the "cost-effective remedy does comply with other environmental regulations" then added that alternative "future remedial actions may be required if selected alternatives do not adequately mitigate the risk to human health." These statements in the ROD declaration, in combination with the fund-balancing language, limit future actions to actions that may be needed to address "risk to human health." The ROD specifically limited the trigger for future remedial actions to inadequately mitigated human health risk, implicitly excluding inadequately mitigated environmental risks as a trigger for future remedial actions. That is, these provisions in the 1984 ROD provide a fund-balancing ARAR waiver for the environmental components of "other environmental regulations" -- in this case the environmental components of the Water Quality Standards.

4. Human Health

Although the environmental components of the Water Quality Standards are not being met, this does not pose a human health threat. The human health components of the Water Quality Standards concern human exposures that may occur during secondary body contact recreation (i.e., where the ingestion of water is not anticipated), and from the consumption of fish. The exposure routes whereby metals may enter the human body during secondary body contact with water in Tar Creek are incidental ingestion of sediments and dermal contact with the water. Ingestion of water while swimming, while not a secondary body contact exposure pathway, is nevertheless a possible exposure pathway that was also considered.

The available data for metals in sediment at Tar Creek indicates levels of lead that are generally below levels of concern for protection of human health. The Baseline Human Health Risk Assessment (BHHRA) for residential areas issued in August 1996 identified lead in soil (not sediment) as the only Site-related chemical of concern, and the BHHRA also identified oral ingestion of lead-contaminated soil as the only significant exposure route.

Exposure to sediment in creeks was not an exposure pathway considered in the BHHRA. However, the sediment is similar to the lead-contaminated soil in that it is soil-like, and it is contaminated with metals from the mines. Due to these similarities, the exposure pathways for residential soil and creek sediment are similar except for frequency of exposure. Recreational exposures to creek sediment are estimated to be 60 days per year compared to 350 days per year for residential soil. Therefore, in order for creek sediment lead concentrations to be of concern, they would have to reach levels that are significantly higher than the 500 ppm level that poses a serious health threat in residential area soils.   However, this is not the case. Available information on sediment in Tar Creek indicates that the average concentrations in typical exposure unit areas (e.g., 2500-square-foot areas for which 5-point composites samples were taken for the residential year cleanup) are generally below 500 ppm.

Another potential exposure pathway associated with recreational use of Tar Creek is dermal contact with creek water. The available data indicate that dermal contact with the creek does not pose a human health threat. The levels of metals in the stream are below levels of concern for dermal contact. Also, the median pH in the creek is not of concern for the type of body contact that occurs during recreational use.

Ingestion of water while swimming, is also a possible exposure pathway. The available data indicate that incidental ingestion of water while swimming does not pose a human health threat. The levels of metals in the stream are below levels of concern for incidental ingestion while swimming.

Available water quality information for metals and pH indicates that it is unlikely that the water quality of the creek is unsafe for recreational uses.

A final means by which humans may be exposed to contamination in Tar Creek is through ingestion of contaminated fish. Available data from analyses of fish fillet samples from fish taken at the mouth of Tar Creek and other locations in area do not indicate that the fish are unsafe for human consumption.

In summary, the available data do not indicate that recreational use of Tar Creek poses a human health threat. The criterion in the OU1 ROD for further remedial actions (i.e., human health risk not adequately mitigated) has not been triggered.

There are provisions in the OU2 ROD that can be used to address certain problems that might arise in OU1. Specifically, the OU2 residential ROD contains broad provisions for institutional controls that apply to mining waste Site-wide. The OU2 ROD provides the following specific institutional controls that may be applied to protect humans exposed to surface water contamination as needed:

-Restriction and management controls on unsafe uses of mine tailings
-Restriction and management controls on access to contaminated property through physical barriers (e.g., fencing) or notices (e.g., warning signs).
-Deed notices that alert future purchasers of contamination
-Health education

Most of the monitoring data on Tar Creek is at least 10 years old. Additional monitoring may be needed in order to confirm that contamination levels have not worsened. In the future, the

EPA should review the need for updated monitoring of the contamination of Tar Creek for human health impacts.

Ground Water

All public water supply wells tested in the area produce water from the Roubidoux Aquifer. Wellhead samples from all the Roubidoux water supply wells continue to meet primary drinking water standards, and the samples show that the water quality in the wells is protective of human health. However, monitoring which was conducted in the early 1990's at twenty-one wells producing water from the Roubidoux Aquifer supports the conclusion that five of the wells show some impact from acid mine water contamination. The five impacted wells fail the secondary drinking water standard for iron, and one of the five also fails the secondary standard for sulfate. Secondary drinking water standards are not health based, but rather are a function of aesthetics, taste and odor. Secondary drinking water standards are not enforceable, and neither iron nor sulfate are hazardous substances addressable by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §9601 et seq. EPA and the State of Oklahoma are conducting further investigations to determine whether the contamination in these five wells is due to inadequate well integrity (integrity failure may allow contaminated water from the Boone Aquifer to enter a well), or whether this represents direct contamination of the Roubidoux Aquifer.

Sampling of the five impacted wells since the 1994 Five-Year Review confirms that these wells continue to fail secondary drinking water standards. However, these wells still meet the primary drinking water standards. Since the 1994 Five-Year Review, discrete samples (i.e., samples not commingled with water from other formations) of Roubidoux water have been taken from the five public water supply wells that were impacted by infiltration of acid mine water and from a new monitoring well installed in Picher. Analysis of all the data collected from the five wells is incomplete, but a tentative analysis indicates that the infiltration of acid mine water is the result of inadequate well casings, and not the result of a general pollution of the Roubidoux. This analysis is supported by water samples taken from the new monitoring well in Picher which has state-of-the-art well casing. That is, the samples from the Picher well indicate that the Roubidoux water quality is good (i.e., meets both primary and secondary drinking water standards).

The preliminary results of the discrete sampling of the new well in Picher, in general, indicate that the water quality of the Roubidoux is good. As a side benefit of the public water supply monitoring program, the City of Picher tied into the new monitoring well as a primary water supply well. Use of this new well has significantly improved the quality of the City's drinking water.

The EPA will evaluate the need to continue to plug abandoned wells based upon the results of the discrete sampling efforts. Monitoring which is undertaken by public water supply operators on the Site as part of their regular operation should be adequate to determine future protectiveness of the ground water remedy. If it is later found that water from the Roubidoux

Aquifer is no longer capable of meeting primary drinking water standards, the need for additional corrective action will be reevaluated.

B. OU2 Remediation

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Residential Areas of OU2

The remediation of residential areas of OU2 began in June 1996 as a removal action and continued in January 1998 as a remedial action. Approximately 1,600 lead-contaminated residential yards will have been remediated by Spring 2000. More detailed design phase sampling indicates that about 500 additional residential yards that were not anticipated when the ROD was issued will also require remediation. This increases the total number of yards being addressed to 2,100. The additional 500 yards will probably add about another year to the remediation time frame. The completed portions of the remedy for the residential areas in OU2 are protective of human health and the environment.

Non-Residential Areas of OU2

The EPA entered into cooperative agreements in 1998 and 1999 with the Inter-Tribal Environmental Council of Oklahoma (ITEC), with the Quapaw Tribe, and with the Oklahoma Department of Environmental Quality (ODEQ) for the non-residential areas of OU2. These cooperative agreements provide funding for Remedial Investigations and Feasibility Studies (RI/FS) to support the development of protective remedies for the non-residential areas of OU2.

I. INTRODUCTION

A. Purpose

The U.S. Environmental Protection Agency (EPA) Region 6 conducted this Five-Year Review pursuant to Section 121 (c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The specific purpose of a five-year review is twofold: (1) to confirm that the remedy as spelled out in the ROD and/or remedial design remains effective at protecting human health and the environment (i.e., the remedy is operating and functioning as designed, institutional controls are in place and are protective), and (2) to evaluate whether original cleanup levels remain protective of human health and the environment. See OSWER Directive 9355.7-02 at 2. The Five-Year Review for the first Operable Unit (OU1) at the Tar Creek Superfund Site (the "Site") is considered a "policy review" because the review is required by EPA policy, but not by CERCLA. Policy reviews are conducted at sites where a remedy was selected prior to October 17, 1986–the effective data of SARA. The first ROD for the Site was signed on June 6, 1984. The latest ROD, which addresses contamination in the residential areas of OU2, was issued August 27, 1997, and it does not require a Five-Year Review. However, information on the OU2 residential remedial action is included in this report. This document will become a part of the Site file. The format for this Five-Year Review is appropriate for a site at which response is ongoing.

Under the National Contingency Plan (NCP), operable unit means a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site. At the Site, two operable units have been designated. Each operable unit addresses a discrete release, threat of release, or a pathway of exposure found at the Site. The first remediation work at the Site under the June 6, 1984, ROD, is referred to as Operable Unit 1 (OU1). The OU1 ROD addressed the surface water in the Tar Creek basin impacted by mine discharges, and also addressed the ground water on the Site. Operable Unit 2 (OU2) addressed the mining waste deposited on the ground surface (i.e., chat piles and floatation ponds). A ROD was issued in August 27, 1997, to address the residential area portion of OU2. Additional response actions will be required to address the remaining contamination in OU2 and in the rest of the Site.

B. Authority

Authority for conducting Five-Year Reviews is contained in section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9621, and section 300.430(f)(4)(ii) of the National Contingency Plan, 40 CFR §

300.430(f)(4)(ii). Guidance for planning and conducting these reviews is provided in "Structure and Components of Five-Year Reviews," OSWER Directive 9355.7-02, dated May 23, 1991, "Supplemental Five-Year Review Guidance," OSWER Directive 9355.7-02A, dated July 26, 1994, and "Second Supplemental Five-Year Review Guidance," OSWER Directive 9355.7-03A, dated December 21, 1995.

II. BACKGROUND

A. General

Site Name, Location, and Description

The Site is located in Ottawa County, Oklahoma, and is composed of the Oklahoma portion of the Tri-State Mining District. The Site consists of the areas of Ottawa County impacted by mining waste. The Site includes all of the area (approximately 40 square miles) in northern Ottawa County where lead and zinc mining operations were conducted (the "mining area"). The approximate boundaries of the mining area are shown on Figure 1. Figure 2 shows the underground mine workings in the portion of the Tri-State Mining District know as Picher Field which includes the mining area of the Site. Tar Creek is the principal drainage system for the Picher Field area, and is a small ephemeral stream characterized by standing pools. With its headwaters in Cherokee County, Kansas, Tar Creek flows southerly between Picher and Cardin, passes to the east of Commerce and Miami, and then flows on to its confluence with the Neosho River, one of the two major rivers in northeastern Oklahoma. Along with its major tributary Lytle Creek, Tar Creek drains an area of approximately 53 square miles.

The Tri-State Mining District covers hundreds of square miles in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma, but only the Oklahoma portion is part of the Site. The greatest volume of contamination on the Site is located within the mining areas of Ottawa County, but the Site also includes communities in Ottawa County outside the mining area that are contaminated with mining waste. The principal on-Site cities located in the mining area of Ottawa County are Picher, Cardin, Commerce, Quapaw, and North Miami. Other cities, including Miami, are located in proximity to the mining area, and these other cities have been impacted by the mining waste disposed of on the Site. Approximately 15,000 people live on-Site in the mining area and in communities in close proximity to the mining area.

Mining History

Lead and zinc mining first began at the Site in the 1900's and reached its peak in 1925. During peak production, maximum annual output for lead and zinc concentrates were 130,410 tons and 749,254 tons, respectively. In the early years, approximately 200 mills were operating at the Site. The ore removed from the mines was milled locally to produce ore concentrates, which were generally shipped to other locations outside of Ottawa County for smelting. Many of the mining operations were conducted underground at depths ranging from approximately 90 to

385 feet below ground surface (bgs). It has been estimated that lead and zinc mines underlie approximately 2,540 acres in Ottawa County, Oklahoma. Large scale mining activities ended in the mid 1960's.

The ore bearing strata were primarily located within a 50 to 150 feet thick zone of the Boone Formation, with maximum depths of mining reaching nearly 400 feet bgs. Mining was accomplished using room and pillar techniques. Large rooms, with ceilings up to 100 feet high, were connected by drifts (horizontal tunnels). The drifts contained more than 100 miles of roads.

When mining ceased, underground cavities with an approximate volume of 100,000 acre feet (161,000,000 cubic yards) had been created. An estimated 100,000 boreholes were located in the entire Picher Field (mostly in Oklahoma), and 1,064 mine shafts (typically 5' x 7' or 6' x 6') existed in the Oklahoma portion of the mining district. Also, numerous water wells, drilled for milling operations, have been abandoned.

The years of mining activities also resulted in the accumulation on the ground surface of a large volume of tailings and other mining wastes. The tailings, locally known as chat, were accumulated and stored in giant piles, the majority of which are located around the former mining towns of Picher and Cardin. An unknown quantity of finer sediments ("fines") in abandoned floatation ponds (i.e., sediment settling basins) are also present at many locations.

At least three types of mining wastes are present at the Site. "Development" rock, or "waste" rock, is large (4" - 2') diameter rock removed during the opening of the shaft or drifts (tunnels). Generally waste or development rock does not pose a contamination problem.

"Chat" is mine tailings from the milling process. Chat is a mixture of gravel (typically 3/8 of an inch in diameter) and finer-grained materials. The numerous chat piles in the area contain approximately 50 million tons of waste. The chat piles have been utilized for many years as a source of materials for the concrete and asphalt industry. Chat has also been used extensively as gravel. From a comparison of historical aerial photographs, conducted in the early 1980's, it was estimated that less than 50 percent of the original volume of chat produced still remains in the area. The sale of chat materials has been a significant source of income in the local area.

Floatation pond sediments, sometimes referred to as "tailings," are fine-grained sediments which originated in the gravity separation milling process, and which were disposed of in settling basins or ponds. The Oklahoma Geological Survey estimated that at least 16 major floatation ponds cover approximately 800 acres on the Site. Smaller tailings ponds were not inventoried. Most of the ponds are now dry.

Site Listing on NPL

The Site first came to the attention of the State of Oklahoma and EPA in 1979 when acid mine drainage began flowing to the Site surface from flooded underground lead and zinc mines through abandoned mine shafts and boreholes. The Governor of Oklahoma formed the Tar Creek Task Force (the "Task Force"), comprised of 24 local, state, and federal agencies, in order to investigate the effects of acid mine drainage on the area's surface and ground water. The Task Force investigated the problem initially in 1980 and 1981. The Task Force utilized Hittman Associates, Inc., to perform studies at the Site on the effects of the acid mine contamination on the area's surface and ground water. Hittman Associates submitted final reports in October 1981. The primary threat identified at the Site was the potential for contamination of the Roubidoux Aquifer, which is the primary drinking water supply in the area.

Based upon the information discovered by the Task Force, EPA proposed, in July 1981, to add the Site to the Superfund National Priorities List (NPL), 40 CFR Part 300, Appendix B. The NPL means the list, compiled by EPA pursuant to CERCLA section 105, 42 U.S.C. § 9605, of uncontrolled hazardous substance releases in the United States that are priorities for long-term remedial evaluation and response. To determine which releases should be placed on the NPL, the EPA uses the Hazard Ranking System (HRS). The Hazard Ranking System evaluates the relative potential of hazardous substance releases to cause health or safety problems, or to cause ecological or environmental damage. The HRS score calculated for the Site was 58.15. The Site was proposed to the NPL on July 27, 1981, and it was listed on the NPL on September 8, 1983.

B. OU1 Investigations

Overview

The OU1 response actions at the Site were conducted as a State-lead project, with the EPA acting as the support agency. Until July 1, 1993, the lead State technical agency for the Site was the Oklahoma Water Resources Board (OWRB), and the lead State administrative agency was the Oklahoma State Department of Health (OSDH). Both agencies were jointly responsible for implementation of the project. On July 1, 1993, State responsibility for all aspects of the project was consolidated when the project was transferred to the then newly created Oklahoma Department of Environmental Quality (ODEQ). ODEQ remains the lead agency for OU1 activities at the Site.

A Cooperative Agreement between EPA and OSDH to conduct the OU1 Remedial Investigation/Feasibility Study (RI/FS) was signed on June 16, 1982. The scope of work for the OU1 RI included the following items:

1. An investigation of the potential for contaminated water to migrate from the Boone Aquifer to the Roubidoux Aquifer.
2. An investigation of surface water contamination.

3. A analysis of water quality in wells completed in the Boone Aquifer, based on sampling data.
4. An inventory of milling waste (tailings) piles.
5. An investigation of the leachate and fugitive dust emissions from chat piles.

The scope of work for the FS called for the identification and evaluation of remedial alternatives. Under an interagency agreement, OSDH subcontracted with the OWRB to conduct the RI/FS, which was completed in December 1983. Many of the reports produced by the Tar Creek Task Force were incorporated into the RI/FS. The Task Force remained involved with project oversight through December 22, 1986–the end of the construction phase. However, an additional 15 abandoned Roubidoux wells were identified for plugging after that date. These 15 additional wells have not yet been plugged.

Source of Acid Mine Drainage Problem

The Boone Formation is an aquifer, which in areas where the Boone is overlain by the Krebs group, acts as a confined or artesian aquifer, with sufficient potentiometric pressure such that wells tapping the formation would flow at the ground surface. During mining operations, inflows of ground water into the mine workings were removed by large scale pumping, creating a large cone of depression which dewatered the Boone Aquifer. The exposed sulfide minerals (primarily marcasite and pyrite, both FeS_2) in the mine cavities became oxidized from contact with moist air. Upon cessation of mining activities, pumping ceased, and the drifts and shafts of the abandoned workings began to flood. The oxidized minerals were much more soluble than the original form so they dissolved in the water, producing acid mine water. The acid water reacted with the surrounding rock, leaching many of the other metals present. Thus, the acid mine water contains high concentrations of zinc, lead, cadmium, sulfate, and iron.

The majority of the mine workings were flooded by 1979 due to ground water infiltration and surface water inflow. Since the potentiometric level (i.e., artesian level) exceeded the ground surface elevation in low lying areas along Tar Creek in the far southern portions of the Picher Field (near Commerce), acid mine water discharged to the surface through abandoned mine shaft openings and boreholes. This process is shown schematically in Figure 3.

Geological Site Characterization

The geological strata of interest at the Site are those of the Ordovician and Mississippian age. The Ordovician sequence, from oldest (and deepest) to youngest (and shallowest), consists of the Roubidoux Formation (105 to 190 feet thick), the Jefferson City Dolomite (270 to 340 feet thick), and the Cotter Dolomite (143 to 183 feet thick). The Roubidoux Formation, also known as the Roubidoux Aquifer, is a cherty limestone with several sandy sequences near the base, and it is the major source of drinking water in the region. These three formations are similar in appearance and difficult to separate in drilling cuttings. Above the Ordovician strata, scattered remnants of the Chattanooga Shale are present, separating the Cotter Formation from the overlying Mississippian age formations.

The Mississippian formation of primary interest is the Boone Formation. The Boone Formation, also known as the Boone Aquifer, ranges in thickness from 329 to 393 feet. Lead and zinc ore mined in the Picher Field was located in various members of the Boone. Within the mining district, the ground water within the Boone is of poor quality, due mainly to acidity and high dissolved metals concentrations. Outside of the mining area, the Boone Aquifer is used as a potable water source.

The most prominent surface features at the Site are large chat piles, collapse features, (i.e., mine subsidence areas commonly referred to as sinkholes) and caved-in mine shafts. Topography is generally flat, with a gentle drop to the south.

In areas where the Boone Formation outcrops, the Boone acts as an unconfined aquifer and direct recharge occurs. In some areas west of the Spring River, the Boone is overlain by undifferentiated Mississippian and Pennsylvanian strata, including shales, which cause the Boone to act as a confined aquifer. In the southern portion of the mining area, the potentiometric surface of the Boone Aquifer exceeds the land surface elevation and causes the acid mine water to flow out of abandoned wells, boreholes, mine shafts and collapse structures, and into Tar Creek.

C. <u>OU2 Investigations</u>

General

Additional information on mining wastes on the land surface was provided by EPA Region 7 prior to the first Five-Year Review of 1994. Investigations of the Cherokee County Superfund Site, which represents the Kansas portion of the Tri-State mining district, indicated that mining wastes in Kansas contain elevated concentration levels of lead and cadmium. The lead concentrations were as high as 13,000 parts per million (ppm) and the cadmium concentrations were as high as 540 ppm. For metal concentrations in soil, 1 ppm means 1 part of metal in a million parts of soil. These types of wastes were not significantly investigated during the Tar Creek OU1 Remedial Investigation, as the focus at that time was on water quality.

The U.S. Public Health Service's Indian Health Service, just prior to issuance of the first Five-Year Review Report, informed EPA that 34 percent of 192 Native American children tested had blood lead levels in excess of the 10 microgram per deciliter (ug/dL) standard. The Centers for Disease Control (CDC) says that blood lead levels at least as low as 10 ug/dL are associated with adverse health effects in children (CDC, 1991).

The first Five-Year Review recommended that an investigation should be conducted to evaluate the impact of mining wastes (i.e., chat piles and floatation ponds) on human health and the environment, and to determine whether additional remedial action is warranted. Suggested actions included:

1. Designation of a second operable unit at the Site for mining wastes.

2. Initiation of a study of blood lead concentrations in Native American and other children living in the area.

3. Environmental sampling in high access areas (e.g., school yards, day-cares, playgrounds) to assess potential sources of exposure to lead.

4. Mapping of all mine wastes (i.e., chat piles, excavated chat piles, and floatation ponds) by the use of aerial photographs or other remote sensing techniques.

5. Classification of surface mine wastes utilizing a field portable x-ray fluorescence unit.

6. Field sampling of a representative portion (approximately 10 percent) of mine wastes and affected media to confirm x-ray fluorescence unit performance.

7. Sampling of leachate from mine wastes.

8. Sampling of airborne particulates near mine wastes.

Prioritization Guidelines

Due to the very large size of the Site and the very large volume of waste, it was necessary, for resource considerations, to prioritize the areas of the Site where response action was to be taken. In order to conserve resources, certain guidelines were utilized after the first Five-Year Review in order to prioritize response actions. Areas with the greatest concentrations of sensitive populations were targeted to be addressed first. Human health impacts are given priority over ecological impacts. The most sensitive human populations (young children and women of childbearing age) are given greater priority. Land areas are addressed primarily according to land usage. That is, land with the greatest percentage of the sensitive human population (e.g., residential areas) receives the highest priority. For a given area or land usage, the higher contaminant concentrations are generally addressed first. Also, for a given area of contaminated land, if there is a significant and immediate recontamination potential, the source of the potential recontamination (e.g., runoff from a nearby chat pile) is addressed first or at the same time that EPA addresses the contaminated land in question. Finally, areas where the technically feasible remediation technologies are very expensive receive lower priority because of a lower cost benefit ratio.

Site Assessment of Residential Areas

The first parts of OU2 to be addressed were the residential areas. From August 1994 through July 1995, EPA, through its removal program (the removal program is generally the part of the Superfund program that conducts emergency or early response activities, whereas the remedial program is the part which conducts long-term response activities), conducted sampling in order to determine the nature and extent of contamination at the residential areas of the Site. Sampling was generally divided into two phases. The first phase (Phase I) of sampling took place in High Access Areas (HAAs) which are places frequented by children such as day-care centers, playgrounds, and schoolyards. The second phase (Phase II) of sampling took place in residential properties on the Site.

The site assessment activities were concentrated at HAAs and residential properties since mining wastes had been observed in many of these locations throughout the Site. Moreover, the HAAs are frequented by young children, the residential properties are inhabited or potentially inhabited by young children, and young children are the segment of the population most susceptible to lead poisoning. A total of 28 HAAs and 2,070 residential properties were sampled during the site assessment. The site assessment data was the basis for EPA's Baseline Human Health Risk Assessment issued in August 1996 (hereinafter BHHRA Report) and for EPA's Residential RI Report issued in January 1997.

The EPA’s site assessment investigations explored the possibility that humans living on the residential areas of the Site may be exposed to contamination through various exposure pathways including ingestion of contaminated soil, surface water or ground water, inhalation of contaminated dust in the air, and dermal contact with contaminated water or soil. However, EPA studies found that, under the conditions found in the residential areas of the Site, ingestion of contaminated soil was the only exposure pathway that posed a significant risk to human health.

The EPA’s site assessment investigations, including the BHHRA, led EPA to the conclusion that lead contamination in soil in residential areas on the Site posed an imminent and substantial endangerment to human health--especially to children’s health; consequently, EPA conducted the removal actions described in the Section of this report entitled “OU2 Removal Actions” which is part of Section IV (“Remedial Objectives”). This same endangerment, in Site locations that the removal actions did not address, is addressed by the remedial action selected for the remediation of the residential areas of the Site and described in the 1997 ROD.

Nature and Extent of Contamination

Characterization of the nature and extent of contamination for the residential areas of the Site is presented in the Residential RI Report and in the BHHRA Report. During the site assessment, field investigations consisted of the following main sampling elements:

1. Sampling of Study Area Homes - The Study Area means the mining area of Ottawa County which was the subject of the BHHRA.

2. Sampling of Study Group Homes - The Study Group is the 100 homes in Picher where multimedia environmental samples were taken.

3. Sampling of Reference Area/Background Homes - The Reference Area/Background homes are 15 homes in Afton, Oklahoma. These 15 homes are outside of the mining area. The EPA took multimedia environmental samples at these homes so that the samples could be compared to samples taken within the mining area.

4. Ambient air sampling.

The Study Area consisted of the residential areas of Picher, Cardin, Quapaw, Commerce, and portions of North Miami. During this investigation, EPA collected site-specific sampling data at residential homes in Picher (Study Group) in order to evaluate the long-term risk associated with exposure to Site contaminants.

Samples were also collected from homes in Afton, Oklahoma, as a background reference to compare with the samples taken from the mining area. Afton is outside of the mining area and generally does not have the mining waste contamination found in the mining area on the Site.

Ambient air samples were taken during a 3-month period from 5 monitoring stations located in Picher. A background air monitoring station was located 3 miles west of Picher. Air monitoring indicated that contaminant concentration levels in the ambient air were not above health-risk-derived levels. None of the lead concentrations in ambient air exceeded the National Ambient Air Quality Standard for lead of 1.5 micrograms per cubic meter (ug/m^3) (maximum quarterly average).

The average concentrations of lead in the yard soil and garden soil samples taken at the Study Group homes in Picher were found to be approximately 10 times greater than the average lead concentrations in the yard soil and garden soil samples taken at the Reference Area homes in Afton. For the garden produce, differences in lead content between the Study Group samples and the Reference Area samples were less than 1 percent.

<u>III. PUBLIC HEALTH AND ENVIRONMENTAL PROBLEMS</u>

A. <u>General</u>

The principal public health threat at the Site related to OU1 as identified in the HRS report and the RI/FS report was the potential for the contamination of the public water supply wells producing from the Roubidoux Aquifer. The principal environmental concern at the Site for OU1 has been the ecological degradation of Tar Creek. The OU1 RI/FS did not address possible human health risk associated with direct exposure to mining waste, although limited air sampling was conducted. The OU2 studies are addressing the human health and environmental threats associated with the mining waste on the ground surface.

B. OU1 Human Health and Environmental Impacts

General

Public health and environmental data were generated through the studies conducted by the Tar Creek Task Force, and by EPA's Superfund Program. The Health Effects Subcommittee of the Tar Creek Task Force evaluated data with respect to adverse human health problems and submitted a final report in March 1983. The areas investigated included the Grand Lake system (Tar Creek drainage system, Neosho River, Spring River, and Grand Lake), wells in the mining area, and selected mines. Air monitoring was also performed. The Environmental Effects Subcommittee of the Tar Creek Task Force investigated the short term and long term environmental effects of acid mine drainage on the Grand Lake System, and submitted a final report in April 1983. The following discussion of the major public health and environmental effects at the Site is based on the findings by the Task Force and on the subsequent monitoring activities as reported in the 1994 Five-Year Review Report.

Potential Contamination of the Roubidoux Wells

There are three potential pathways for contamination to reach the public water supply wells that are completed in the Roubidoux Aquifer (the "Roubidoux"). The first potential pathway is the migration of contaminated mine water through the intervening strata into the Roubidoux aquifer. The second potential pathway is the migration of contaminated mine water through abandoned wells or boreholes into the Roubidoux. The third potential pathway is contaminated mine water entering the wells directly, through failed or inadequate well casing, without actually migrating down into the Roubidoux Aquifer. These three pathways of contamination are discussed below:

1. Migration through intervening strata. Acid mine water could reach the Roubidoux Aquifer from the Boone Aquifer (the "Boone") by migrating through the intervening Cotter and Jefferson City Dolomites. Hydraulic conductivity studies conducted on core sections revealed very low values of 0.32 feet per year (fpy) and 0.001 fpy, for the Cotter and Jefferson City dolomites, respectively. However, these low permeabilities may be misleading, as evidence of fracturing is clearly present in much of the excavated rock. This fracturing is probably offset by natural secondary mineralization, which is also clearly present. That is, as ground water flows through any fractures that may exist, minerals in the water leave a residue that will tend to plug the fractures. This natural mineralization may be supplemented by a self plugging mechanism caused by chemical precipitation of insoluble metal hydroxides as the acid mine water reacts with the dolomite and limestone in these formations. The resultant neutralization of acid causes precipitation of insoluble minerals, possibly plugging the openings and preventing further migration. There would be some potential for flow of mine water downward if the fractures in the Boone formation, the fractures in the Cotter and Jefferson City formations which overlie the Roubidoux, and the fractures in the Roubidoux are all interconnected. However, the Task

Force concluded it is unlikely that any interconnection spans the entire 300-400 feet distance between the Boone and the Roubidoux Aquifers.

2. Abandoned wells and boreholes. The most likely route by which the acid mine water could reach the Roubidoux Aquifer is direct access through abandoned deep wells and boreholes. The U. S. Geological Survey (USGS) conducted studies in March 1981 on two of the abandoned wells, and showed that water was flowing downward. As a part of the OU1 remedial action, 83 wells have been plugged. Since the end of the construction, approximately 15 more abandoned Roubidoux wells have been identified for plugging. These 15 additional wells have not yet been plugged. It is not known how many more of these wells may exist.

3. Inadequate well casings. Most of the documented cases of contamination of Roubidoux water supply wells have been attributed to failed or inadequate well casings. Corroded/deteriorated casings have allowed poor quality mine water from the Boone to infiltrate the wells. When the casings were repaired or replaced, the quality of the water being pumped was restored. Also, in some instances, mine water has entered the wells below the bottom of the casing. This can occur when water migrates behind and under the casing, or when water migrates into the Cotter Dolomite and then moves laterally into the uncased portion of the well in question. When sufficiently deep casings were installed, the water quality of the wells was restored.

In the early 1990's, an evaluation of the public water supply in the mining areas was begun by the ODEQ. The purpose of this monitoring project is to determine whether the poor water quality of some of the public water supply wells in the mining area is due to direct impacts on the Roubidoux Aquifer or if it is due to inadequate well integrity. The ODEQ ground water monitoring is described in the Section of this report entitled “Public Water Supply Monitoring” which is part of Section VII (“Present Activities”).

Environmental Degradation of Tar Creek

The primary known points at which acid mine water discharges into the Tar Creek watershed are monitoring sites 4s and 14 as shown on the map that is Figure 4. Site 14 is identified as site 14s on this map. Acid mine discharge site 4s is a weir which measures discharges from springs south of Lytle Creek. Data on the acid mine discharges from the 1980's which was included in the 1994 Five-Year Review Report indicated the following:

1. Flow at site 4s is intermittent with an average discharge rate of 1.04 cubic feet per second (cfs) when flowing. The flow has a pH ranging from 4.4 to 5.5. Lower pH means more acidic conditions. A pH of 7 is neutral, neither acidic or alkaline.

2. Acid mine discharge site 14 is a spring which is the southernmost known acid mine discharge point. Site 14 discharges all year long at an average flow of 0.31 cfs and a pH ranging from 5.0 to 6.7.

3. Based on the post-construction monitoring data (i.e., data gathered after the dikes were constructed), typical average concentrations of heavy metals in water that discharges from the mines are as follows (expressed in micrograms of metals per liter of water (µg/l)):

Constituent	Site 4s	Site 14
Iron	170,033	288,300
Zinc	62,161	19,072
Cadmium	19	13
Lead	65	57

Another source of the contamination in Tar Creek is leachate from the tailing piles. Contamination levels in the creek routinely exceed the water quality standards as a result of the acid mine drainage, and as a result of the leachate from the tailings piles. Leachate from the tailings piles was determined by the Tar Creek Task Force report to be insignificant in comparison to the acid mine water discharges. However, this may not be true, as only 15 percent of the loading to Tar Creek has been accounted for in the measured discharges of acid mine drainage, based on an estimate presented in the "Tar Creek After Action Monitoring Report" prepared and submitted in April 1991 by the OWRB (hereinafter After Action Report). The After Action Report was included as Appendix C to the 1994 Five-Year Review Report.

The State of Oklahoma Water Quality Standards identify Tar Creek as having the designated beneficial uses of 1) a habitat-limited aquatic community, and 2) secondary body contact recreation. The habitat-limited aquatic community designation is applied to waters which will not support a warm water aquatic community. These designations comply with the Oklahoma Water Quality Standards (Oklahoma Administrative Code, Chapter 45, Subchapter 5, Section 785:45-5-12(b)(3)), which state that a habitat-limited aquatic community may be designated when "human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place." The Water Quality Standards for Tar Creek were lowered because of impacts from irreversible man-made conditions created by historical mining activities at the Site.

Observations regarding surface water quality from the post-construction monitoring data presented in the 1994 Five-Year Review Report are as follows:

1. Metals concentrations in surface water were compared with acute toxicity numerical criteria for toxic substances. Under these criteria, the chronic category for metals consists of the maximum levels which aquatic organisms can be safely exposed to indefinitely. This comparison indicated that chronic toxicity criteria were exceeded by two orders of magnitude for zinc, one order of magnitude for cadmium, and also one order of magnitude for lead. (An order of magnitude is a multiple of ten. When a concentration exceeds a criterion by one order of magnitude, that means that it is ten times the level considered

safe. When a concentration exceeds a criterion by two orders of magnitude it is 100 times the safe level.)

2. The average pH for surface water ranged from 5.2 to 6.6. The pH for Oklahoma waters designated for fish and wildlife propagation should be between 6.5 and 9.0. The pH is below the acceptable range for certain segments of Tar Creek.

Tar Creek can best be characterized as having high metals concentrations, high hardness, and low pH. In order to support a fish population, surface water must have a certain concentration of dissolved oxygen. This concentration is referred to as the dissolved oxygen standard. The dissolved oxygen standard is sometimes not met in Tar Creek due to consumption of oxygen by the oxidation process. Because of the low flow rate for Tar Creek most of the year, and because of its low buffering capacity, the environmental impact from the acid mine discharges is readily apparent. The Tar Creek Field Investigation Report (Task I.1) reported the mine drainage has had a severe impact on Tar Creek since 1979. Soon after discharge commenced, most of the downstream biota in the creek were killed, the banks and bottom of the creek turned red due to ferric hydroxide deposition, and red stains appeared on bridge abutments and cliffs in the Neosho River, downstream from its confluence with Tar Creek. The sediments in Tar Creek contain lead, zinc, cadmium, and iron.

Oklahoma's current designated beneficial use for Tar Creek as a habitat-limited aquatic community is a designation that is applied to waters which will not support a warm water aquatic community. Despite this designation, aquatic biota sampling in Tar Creek in October 1989 did confirm that a restricted aquatic community is present. The 1989 sampling showed that the quality of the aquatic community increases as the stream approaches its confluence with the Neosho River.

Impacts on Neosho River, Spring River, and Grand Lake

The Health Effects Sub-Committee of the Tar Creek Task Force concluded that the Neosho River, Spring River, and Grand Lake can be safely used as a raw water source for public water supplies. Fish sample studies were also conducted, and it was concluded that fish from the areas sampled in these water bodies are safe for human consumption. Most of the metals present in the acid mine water are precipitated out of the water and into the Tar Creek stream sediments before the confluence of Tar Creek and the Neosho River. Although the acid mine water discharges to Tar Creek provide a concentrated source of metals, the head waters of the Neosho River, and especially the upper reaches of the Spring River, also contribute large quantities of metals. Comparison of metals concentrations in stream sediments above and below the confluence of Tar Creek and the Neosho River show no significant increase, except for zinc. The Spring River is fed by tributaries that flow through the Galena, Kansas, area. Extensive lead and zinc mining also occurred there.

It was concluded by the Tar Creek Task Force Environmental Effects Sub-Committee that the sediments provide an effective long-term sink for metals and should effectively remove them from most biological processes. The Neosho River has received little impact from the acid mine drainage into Tar Creek other than aesthetic alteration at the Tar Creek confluence.

C. OU2 Human Health and Environmental Impacts

Human Health Risk Assessment

The EPA's BHHRA Report for the Site identified lead as the only Site-related chemical of concern in the residential areas of OU2. Oral ingestion was identified as the only significant exposure route. An exposure route (e.g., oral ingestion, inhalation, or dermal contact) is the way in which contaminants come in contact with the body or enter the body.

Cadmium and zinc are also Site-related chemicals, but the concentrations of cadmium and zinc in the different media (soil, air, drinking water, etc.) were not high enough to present a risk to the population. The EPA's risk evaluations show that the soil lead contamination at the Site poses a significant risk to human health. The soil in the mining region and in portions of Ottawa County is contaminated from mine tailings, principally chat.

The BHHRA predicted that 21 percent of the children in a group of homes studied in Picher could have blood lead levels at or exceeding 10 micrograms per deciliter (ug/dL). EPA recommends that soil lead cleanup levels be determined so that a typical child or group of children exposed to lead at the site in question would have an estimated risk of no more than 5 percent of exceeding a blood lead level of 10 ug/dL) (U.S. EPA, 1998 - hereinafter this 5 percent risk is referred to as the 5 percent benchmark). The Centers for Disease Control (CDC) says that blood lead levels at least as low as 10 ug/dL are associated with adverse health effects in children (CDC, 1991).

The BHHRA showed that the residential soil lead concentrations at the study group homes in Picher were approximately 10 times greater than the residential soil lead concentrations at the reference area homes in Afton, Oklahoma. The BHHRA also indicated that, in most cases, the elevated blood lead levels are due primarily to elevated concentrations of lead in outdoor soil, although indoor dust also contributes significantly in many cases (of course, a primary source of indoor dust may be contaminated outdoor soil tracked into the home).

Blood Lead Surveys

In a blood lead survey conducted in Picher, Oklahoma in 1995, the OSDH found a percentage of young children with elevated blood lead levels (10 ug/dL or greater) similar to the percentage predicted in EPA's BHHRA for the Picher Study Group (the OSDH survey was an actual measurement of lead in children's blood and not a prediction). Later surveys conducted in August 1996 and September 1996, on behalf of certain mining companies, which once operated at the Site, found that 38.3 percent (31 of 81) of the children tested in Picher had blood lead concentrations exceeding 10 ug/dL, that 62.5 percent (10 of 16) of the children tested in Cardin had blood lead concentrations exceeding 10 ug/dL, and that 13.4 percent (nine of 67) of the children tested in Quapaw had blood lead levels which exceeded 10 ug/dL. These findings contrast sharply with the statewide average blood lead concentration in children of 2 percent reported by OSDH. These findings were consistent with the BHHRA. Preliminary data being gathered by the University of Oklahoma Health Sciences Center show that in conjunction with EPA's remediation efforts the percentage of children with elevated blood lead levels at the Site is beginning to decrease.

Air Exposure Pathway

For both the OU1 and OU2 investigations, air samples were collected near the chat piles at Picher, Oklahoma. For both investigations, the air pathway was found to be insignificant with respect to human health. The Health Effects Sub-Committee of the Tar Creek Task Force for OU1 concluded that the observed concentrations of toxic metals in airborne particulates were not significant and should not pose a significant health problem for people living in the area. The OU2 BHHRA arrived at the same conclusion.

Environmental Risks

The residential areas at the Site are not associated with exposed ecological communities. The residential areas do not support wildlife or wild species of flora. Without receptors of ecological concern, the residential area represents an incomplete ecological risk pathway. That is, there is no identified exposure pathway along which the contaminants of concern could travel to reach wild flora or fauna, and cause a detrimental effect. Because there is no relevant completed exposure pathway associated with the residential properties, an evaluation of ecological risk at the residential areas of the Site was not considered appropriate. However, for the non-residential portions of the OU2 investigations, environmental risk will be included as appropriate in the remedial investigations that are being undertaken by the State and Tribal agencies.

IV. REMEDIAL OBJECTIVES

A. OU1 Remedial Action

General

The remedial objectives of the 1984 ROD were to mitigate the potential threat to public health and the environment by preventing contamination of the Roubidoux Aquifer, and by minimizing damage to Tar Creek from acid mine drainage. The scope of the 1984 ROD did not address public health concerns related to direct exposure to the mining waste located on the ground surface. The States of Oklahoma and Kansas agreed with the selected remedial alternative for OU1 as described in the 1984 ROD. The remedy selected in the 1984 ROD included diversion of surface flows at three mine collapse features, and also included the plugging of 66 Roubidoux wells (later increased to 83 during construction). The 1984 ROD also called for monitoring to assess the effectiveness of the well plugging, and to assess the effectiveness of the surface diversion and diking. Construction activities at the Site under the OU1 ROD were completed on December 22, 1986. However, following construction, an additional 15 abandoned Roubidoux wells were later identified. These 15 additional wells have not yet been plugged. Also following construction, surface water and ground water monitoring was conducted for a period of two years. Due to inadequacies in the ground water monitoring data, a second ground water monitoring program was begun in 1991. The wellhead sampling portion of the second monitoring program has been completed and a discrete sampling (i.e., samples not commingled with water from other formations) phase is in progress.

OU1 Remedial Action Construction

The OU1 remedial action includes the following construction activities:

1. Plugging Abandoned Roubidoux Wells. The well-plugging activity completed at the Site included clearing the well holes of obstructions and setting an acid resistant cement plug in the well, from bottom to top, for each of the 83 abandoned Roubidoux wells in Kansas and Oklahoma.

2. Surface Diversion. Surface water diversion and diking structures were constructed to prevent surface water from draining into certain mine shafts, subsidence areas, and open boreholes. The action targeted three major inflow areas identified as the Muncie, Big John, and Admiralty mines. It was believed at that time that, combined, these three inflow areas represented approximately 75 percent of the yearly surface inflows into the mine tunnels and workings. The Admiralty location was an outflow point but it was projected that after the water level in the mines was lowered (as a result of the remediation) it would become a major inflow point. It was projected that reducing the surface water inflow into the mines by what was estimated to be approximately 75 percent (approximately 4,000 acre-feet/year) would eliminate or reduce by a significant amount the 1,000 acre-feet/year of surface discharges of acid mine water. It was also projected that reducing the surface

water inflow would cause the ground water levels in the mines to drop by a significant amount. However, the OU1 ROD did not quantify cleanup goals, including projected reductions in the ground water level in the mines.

OU1 Remedial Action Monitoring

A two-year program for monitoring and surveillance of surface water and ground water was conducted to assess the effectiveness of the OU1 remedial actions in mitigating contamination of Tar Creek and in preventing degradation of the Roubidoux Aquifer. This post-construction monitoring was conducted from 1987-1988. For surface water, flow measurements were made and water quality data was collected to determine whether the pollutant loading to Tar Creek was reduced after construction of the diversion and diking structures. Also, water levels in the Blue Goose Mine, which are considered indicative of the potentiometric surface of the Boone aquifer, and thus indicative of discharge volumes of acid mine water into Tar Creek, were monitored. For the Roubidoux Aquifer, water quality data was collected from public water supply wells in order to assess water quality following the well plugging activities. Details of the monitoring program are presented in the After Action Report. The After Action Report made the following conclusions:

1. Concentrations of most constituents in the acid mine water discharges were decreasing. Although it is not possible to identify the cause of this decrease, it is likely that the decrease is a naturally occurring phenomenon (i.e., natural attenuation).

2. The volume of the acid mine water discharged to Tar Creek was not significantly impacted by the remedial action.

3. Surface water quality was not significantly improved, and the diking and diversion remedial action was at best only partially effective.

4. Although some public water supply wells in the Roubidoux aquifer are impacted by acid mine water, insufficient data existed to evaluate the effectiveness of the well plugging operations.

The EPA concurred in the reports which reached these conclusions. In order to assess the status of the Roubidoux aquifer in light of these conclusions, a second ground water monitoring plan was developed beginning in 1991. The plan was also intended to assess whether the well plugging operations had succeeded in preventing the contamination of the Roubidoux. A two-phased approach was developed beginning with a wellhead monitoring phase, and concluding with discrete sampling of the Roubidoux Aquifer itself. This program is currently in progress and is described in the Section of this report entitled "Public Water Supply Monitoring" which is part of Section VII ("Present Activities").

B. OU2 Removal and Remedial Actions

OU2 Removal Actions

Based on the Phase I site assessment sampling (August 1994 to October 1994), EPA began removal actions at various HAAs on the Site. Removal actions are generally the early response actions taken by the Superfund program to address the most immediate and highest risk first. The EPA action memorandum authorizing the removal response action at the HAAs was issued August 15, 1995. The removal action at HAAs was triggered by widespread surface soil contamination greater than or equal to 500 ppm lead and/or 100 ppm cadmium. Excavations at HAAs vary in depth as well as in the cleanup level selected. The excavation criteria utilized during the HAA response were 500 ppm lead and/or 100 ppm cadmium from 0 to 12 inches of soil depth, and 1000 ppm lead and/or 100 ppm cadmium from 12 to 18 inches of soil depth (maximum excavation depth of 18 inches). That is, if lead or cadmium were found at concentration levels which exceeded 500 ppm and 100 ppm, respectively, in the first 12 inches of soil, that soil was excavated, and, if lead or cadmium were found in soil at depth ranges of 12 to 18 inches at concentration levels which exceeded 1000 ppm or 100 ppm, respectively, then that soil was excavated. At locations where the contamination levels exceeded the cleanup level at 18-inches, a barrier (e.g., orange construction fence material) was placed in the excavated area prior to backfilling in order to warn of existing contamination below that level. All excavated areas were backfilled with clean soil. On large properties, such as schools and parks, where unauthorized private excavation could be easily controlled, the excavation criteria were modified. The excavation criteria for these school and park areas were modified to 500 ppm lead and/or 100 ppm cadmium from 0 to 12 inches soil depth (maximum excavation depth of 12 inches). A total of 28 HAAs were evaluated. Seventeen of the 28 HAAs were determined to potentially require some sort of EPA response action. The EPA initiated response actions at HAAs in September 1995. The removal actions taken during this HAA response eliminated or reduced direct contact with contaminated surface soil at these HAAs. The continued effectiveness of the removal actions taken at HAAs depends on future prevention of earthmoving activity that could disturb the surface layer of clean soil thereby exposing elevated concentrations of contaminants at depth.

Based on the Phase II removal site assessment sampling (April 1995 to July 1995), EPA began removal actions at certain residential properties on the Site. The action memorandum authorizing this additional removal response action for residential areas on the Site was issued on March 21, 1996. The EPA selected a cleanup level for lead in soil of 500 ppm for the removal response action at the residential areas. This cleanup level was determined by EPA to be protective of human health. This cleanup level was based upon EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model for lead in young children, utilizing site-specific sampling information obtained for the preparation of the BHHRA, and also upon EPA Region 6 experience with large-area lead cleanups.

As part of Phase II sampling, a total of 2,055 residential homes in Picher, Cardin, Quapaw, Commerce, and North Miami were evaluated. Approximately 65 percent of these homes had concentrations of lead, in at least one part of the yard, at or above 500 ppm.

The EPA Emergency Response Team conducted removal response activities at the residences from June 1996 through December 1997. Approximately 300 residences were addressed during the Phase II removal response activities (just as Phase II sampling took place in Site residential areas, Phase II removal activities address contamination in Site residential areas). The homes included in the Phase II removal response met the following conditions:

1. Homes with children less than 72 months of age who had blood lead levels at or exceeding 10 ug/dL, and where soil lead concentrations had been determined to be the significant contributors to elevated blood lead levels; and,

2. Homes with soil lead concentrations greater than or equal to 1,500 ppm lead.

The response actions conducted on these properties under Phase II of the removal response consisted primarily of excavation of lead-contaminated soil, backfilling excavated areas with clean topsoil, and revegetating the backfilled areas with grass sod or seed.

OU2 Remedial Action

Based on the remedy for OU2 for the residential areas of the Site memorialized in the 1997 ROD, the remedial action began in January 1998.

For remediation of the residential areas, the following Remedial Action Objective is being utilized:

> **Reduce ingestion by humans, especially children, of surface soil in residential areas contaminated with lead at a concentration greater than or equal to 500 ppm.**

The 500 ppm soil lead cleanup level is based upon the BHHRA, EPA's Integrated Exposure Uptake Biokinetic Model, and EPA Region 6 experience with other soil lead remediation sites.

The selected remedy for OU2 for the residential areas of the Site is **Soil Excavation with a 500 ppm Remediation Goal** and includes the following:

1. Surface soil contaminated with lead above 500 ppm is being excavated to a maximum depth of 18-inches at all residential properties within the mining area or within the Tar Creek floodplain (including the floodplain in Miami). This excavation of surface soil also applies to all HAAs in the other portions of Ottawa County.

2. Where soil lead concentrations exceed 500 ppm at 18 inches of excavation depth, a marker (e.g., orange construction fence material) is being placed in the excavation prior to backfilling in order to warn of remaining contamination below that level.

3. The excavated areas are being backfilled with clean soil and the remediated areas are being restored. Grass is typically being reestablished using sodding and/or seeding.

4. Water is sprayed in construction areas to suppress dust during excavation of contaminated soil. Dump trucks used to transport contaminated soil are equipped with covers to prevent dust from blowing. To assure that the dust suppression activities are adequate to protect residents and workers, an air monitoring program has been implemented.

5. Excavated soil is being disposed of on-Site in dry areas, that were already contaminated with mining waste, remote from the residential areas.

6. Institutional controls will be implemented for Ottawa County including areas outside the mining area. The institutional controls include: health education programs that address lead poisoning and its prevention; actions to reduce lead-contaminated dust indoors; and blood lead monitoring. For indoor dust reduction, high efficiency particulate vacuum cleaners (HEPA VAC) are being loaned to Ottawa County residents.

7. Road base material (e.g., gravel or crushed limestone) is being used to cover or replace chat material in alleyways, parking lots, roads, driveways, and other similar improved surface areas near residences. This response action is being implemented in the mining area and will also be implemented in Ottawa County outside the mining area where appropriate.

8. Physical barriers (e.g., fences and warning signs) will be used, as appropriate, to restrict access to mining waste which is located near residences in Ottawa County.

9. For certain residential properties generally outside the mining area, but within Ottawa County, establishment or improvement of ground cover (e.g., grass) will be used to address bare lead-contaminated soil areas. Vegetative cover limits direct exposure to soil.

10. Where medical monitoring within Ottawa County has found that an individual living in the county has an elevated blood lead concentration level close to or greater than 10 ug/dL, the soil in the individual's yard is tested. If the individual's yard is found to be contaminated with lead-contaminated soil with concentrations at or above 500 ppm, the soil is excavated and replaced. The excavation and replacement of soil are conducted in the same manner as described below for the yards in the mining area.

Yard Remediation Procedures

Under the Phase II removal response and under the residential remedial action, excavations at residences are conducted in 6-inch lifts until samples reveal concentrations less than 500 ppm lead. If samples in a given yard area (e.g., front yard, back yard, driveway, etc.) reveal that the top 6 inches of soil in the yard area in question is not contaminated with lead concentrations which exceed 500 ppm, then the yard area that was sampled is considered clean and the soil in that area of the yard is not excavated. If, on the other hand, samples reveal that the top 6 inches of residential soil is contaminated with lead concentrations which exceed 500 ppm for an area of a given yard, then six inches of soil are removed in each area of the yard where soil lead concentrations exceed 500 ppm. The remaining soil (i.e., the soil at the bottom of the excavated area) in each excavated area is then tested in place. This process is continued until soil is found in place which has concentrations of lead which do not exceed 500 ppm, or until 18 inches of soil depth is reached, whichever is sooner. If, at 18 inches, the samples indicate soil lead concentrations greater than or equal to 500 ppm, then a barrier (e.g., orange construction fence material) is placed in the excavated area prior to backfilling at that location in order to warn that contamination exists below that level. All sampling is typically conducted using a 2500-square-foot grid pattern with a 5-point composite sample for each grid.

The EPA attempts to restore residential yards to conditions that approximate pre-excavation conditions. All shrubbery removed during the course of a response is replaced according to agreements made between EPA and the individual property owners. Initially EPA waters the grass or seed which EPA places on the excavated areas. After the initial watering, however, EPA does not generally provide maintenance.

The soil removed from the residential areas of the Site is being disposed of on dry contaminated areas which once contained mill ponds. The primary disposal area is located between Picher and Commerce on County Road E40 near the location of the old Eagle-Picher Central Mill. A secondary disposal area is located on Ottawa County Reclamation Authority land near the southwest corner of Highway 69 and County Road E10. Access to the disposal areas is controlled by barbed wire fencing and gates. Signs are posted on the gates. The material is being spread over the former mill pond and chat contaminated areas. Following the completion of the EPA response actions in the area, the disposal areas will be turfed.

The EPA is spraying excavation sites with water for dust suppression during excavation of the contaminated soil. Dump trucks used to excavate contaminated soil are equipped with covers to prevent dust from blowing out of the trucks. To assure that the dust suppression activities are adequate to protect residents and workers, EPA is conducting an extensive air monitoring program. The program consists of real time dust monitoring as well as air sampling. “Real time” monitoring means that EPA does not have to wait to get the results of its air monitoring, but instead the monitoring equipment keeps EPA informed of the concentration levels of airborne contaminants at all times. In this manner, EPA is made aware of any airborne releases as they occur.

V. POST-CONSTRUCTION MONITORING FOR OU1

A. General

A summary of the post-construction monitoring that was conducted in 1987-1988 is presented in this section. This information is largely excerpted from the 1994 Five-Year Review Report and represents a summary of the available surface water monitoring data for OU1.

The purposes of the after action monitoring activities were as follows: 1) to determine whether the pollution of Tar Creek caused by the acid mine drainage had been reduced since the diversion and diking structures were completed, and 2) to determine the effectiveness of the well plugging in reducing the potential for contamination of the Roubidoux Aquifer. To monitor surface water, flow measurements were made and surface water quality samples were collected. The purpose of collecting these surface water data was to determine if the pollutant loading to Tar Creek had decreased since construction of the diversion and diking structures.

The available surface and ground water monitoring data collected during the after action monitoring period was reviewed and analyzed by Robert S. Kerr Environmental Research Laboratory (RSKERL). The resulting report by RSKERL entitled "Report on the Effectiveness of Remediation on the Tar Creek Superfund Site," dated September 1989 (hereinafter the RSKERL 1989 Report), is Appendix B of the Five-Year Review Report of April 1994. The OWRB produced a report summarizing the results of the monitoring. The report is entitled "Tar Creek After Action Monitoring Report" (hereinafter After Action Report), which was received by EPA on April 5, 1991, and which is Appendix C of the Five-Year Review Report of April 1994. Data from the After Action Report are also summarized in the Five-Year Review Report of April 1994. For a summary of the available surface water monitoring data for Tar Creek that is more detailed than the summary presented below, please see the 1994 Five-Year Review Report.

B. Surface Water Monitoring

Surface Water Contaminant Concentrations

In the After Action Report, OWRB concluded that the available data from monitoring the surface water of Tar Creek indicated that contaminant concentrations in Tar Creek due to acid mine drainage were decreasing. EPA noted in the 1994 Five-Year Review Report, however, that water quality measured at 22nd Avenue NE (monitoring site 20) located downstream from all know acid mine discharges and at the farthest downstream location at Highway 10 (monitoring site 22) indicated that average constituent concentrations of many metals increased. This increase in the concentration of metals may indicate an increased volume of discharge, or it may indicate that metals are dissolving into the water column from stream bed sediments. Further, the 1994 Five-Year Review Report stated that it was difficult to explain why some constituents were decreasing while others were increasing. EPA concluded that the data was not sufficient for statistical analysis, in part because of the short period of post-construction monitoring. However, the available data indicate that stream water quality continues to be severely impacted. The Water

Quality Standards are not being met. In particular, the numerical criteria for toxic substances applicable to all fishery classifications are still being exceeded and the pH is below the acceptable range for fisheries in certain segments.

Acid Mine Discharge Concentrations

Using data gathered from samples taken directly in acid mine discharges, OWRB reported in the After Action Report that concentrations of toxic substances in the acid mine discharges were much higher than in Tar Creek, as would be expected, and greatly exceeded the numerical criteria for toxic substances applicable to all fishery classifications. However, the available monitoring data also indicated that overall the contaminant concentrations in the acid mine discharges decreased after completion of the remedial action.

Sediment Contaminant Concentrations

After the construction of the diversion and diking structures as called for in the 1984 ROD, the average concentrations of selected metals in sediments decreased compared to the pre-construction period. It was observed that, after the construction, iron concentrations increased by an order of magnitude (an increase by an order of magnitude is a tenfold increase) downstream from acid mine discharges. This finding is consistent with the visual observations of red staining in Tar Creek downstream from the Douthat Bridge (located near the Tar Creek - Lytle Creek confluence) to the Neosho River, while very little iron staining is observed upstream from the Douthat Bridge. In the part of Tar Creek that is upstream from the discharges, the average iron concentration in the sediment was 4,743 milligrams per kilogram (mg/kg). Downstream from the discharges, the average concentration was 67,742 mg/kg. However, the data was erratic, and it was difficult to draw any conclusions as to the effects of the remediation. The Tar Creek Task Force concluded that the sediments provide an effective long-term sink for metals and should effectively remove them from most biological processes.

Water Level in Mines

With regard to the diversion and diking, it was expected that a reduction of surface inflow into the mines would correspondingly reduce the water level in the mines, thereby reducing the outflow. Water level measurements were taken prior to the construction of the diversion and diking structures, and were also taken post-construction at the Blue Goose mine which is located between Picher and Cardin just north of the old Eagle-Picher Central Mill location. Based on the water level measurements taken at the Blue Goose mine, EPA concluded that the average water level after construction was not statistically different from the average water level before construction. These measurements indicated that the discharge of acid mine water was not significantly reduced after construction of the diversion and diking structures.

C. Ground Water Monitoring

Acid mine water could reach water supply wells completed in the Roubidoux by the following pathways: (1) inflow through deteriorated casings; (2) inflow underneath shallow casings; (3) migration through intervening strata; or (4) migration from abandoned wells or boreholes which have not been plugged. The OU1 Tar Creek Feasibility Study (Task II. 1. B. d.) reported that the cities of Cardin, Commerce and Picher were able to alleviate water quality problems by replacing corroded well casings.

The purpose of the past well-plugging operations, conducted under the 1984 ROD, was to prevent contaminated mine water from migrating into the Roubidoux Aquifer through abandoned wells or boreholes. The RSKERL 1989 Report, prepared after a review of all the available Roubidoux water supply data through 1988, concluded that, due to deficiencies in the existing data, and due to the short period of post-construction sampling, the effectiveness of the well plugging remedy implemented under the 1984 ROD could not be established. EPA and the State of Oklahoma are currently conducting further investigations to determine the water quality of the Roubidoux aquifer. Details of these monitoring efforts are described in the Section of this report entitled "Public Water Supply Monitoring" which is part of Section VII ("Present Activities").

VI. REMEDIAL ACTION STATUS

A. OU1 Remedial Status

Surface Water

The objective of the OU1 ROD was to have the diversion and diking structures reduce surface inflows to the mines by approximately 75 percent or about 4,000 acre-feet/year. A 75 percent reduction would have eliminated the acid mine water discharges (which were estimated at 1,000 acre-feet/year). Based on the monitoring data, EPA concluded that the volume of acid mine discharges has not been significantly reduced. However, the sampling indicated that contaminant concentrations in the discharges of acid mine water appear to have decreased. Additionally, the diversion structures have been successful in preventing the surface water from flowing into the mines, which keeps more water in the creek. The reduction in the concentrations of metals in the discharges may be related to the remediation activities; however, these reductions are more likely to be due to natural attenuation processes. OWRB speculated in the After Action Report that, as long as significant acid mine discharges continue, surface water contamination concentration levels will not decrease, in the foreseeable future, to levels below the water quality standards.

EPA also notes the After Action Report said that only 15 percent of the total metals loading to Tar Creek was calculated to be contributed by the known major discharges. If, based on the After Action Report, 85 percent of metals loading to Tar Creek is from unidentifiable sources, collecting and treating the know discharges may not significantly reduce the concentration of toxic metals in Tar Creek.

Ground Water

Presently, several of the Roubidoux wells do not meet secondary drinking water standards for iron and sulfate, due to contamination from mine water. Secondary standards are not health based. The most current data indicate that all wells sampled in the area are in compliance with the primary drinking water standards. However, the previous monitoring data obtained during the 2-year post-construction monitoring period was inconsistent and inconclusive. EPA and the State of Oklahoma are currently conducting further investigations to determine the water quality of the Roubidoux aquifer. Details of these monitoring efforts are described in the Section of this report entitled "Public Water Supply Monitoring" which is part of Section VII ("Present Activities").

B. OU2 Remedial Status

Completion of the remedial action, called for in the 1997 ROD, for the approximately 500 additional residential yards remaining to be remediated within the mining area is anticipated to take about another year. Completion of the residential remedial action outside the mining area is likely to take an additional two years. Work plans for remediation studies in the non-residential areas of OU2 are scheduled to be submitted to EPA in 2000. Remedial studies will be undertaken to identify remedies that can be used to address the contamination in the non-residential areas of OU2. Since the contaminated non-residential areas of OU2 are so large, remediation is likely to take several years.

VII. PRESENT ACTIVITIES

A. OU1 Activities

Public Water Supply Monitoring

In the early 1990's, the EPA, the OSDH, the OWRB, and later the ODEQ reviewed the existing Roubidoux Aquifer data. Based on this review, EPA concluded that the monitoring data was inadequate to determine the effectiveness of the well-plugging remedy carried out under the 1984 ROD. EPA, OWRB, OSDH and USGS developed a revised monitoring program in order to provide reliable and statistically sound data that can be used to determine whether acid mine water has contaminated the public water supply obtained from the Roubidoux Aquifer. The monitoring program is also designed to establish a supportable baseline from which to measure future changes in Roubidoux water quality. The monitoring program includes the following:

1. Wellhead sampling of municipal water supply wells
2. Discrete sampling of the Roubidoux Aquifer

The field activities associated with the wellhead sampling portion of this monitoring program were completed by the USGS under the technical direction of the OWRB. However, as previously mentioned, control of this project was transferred to the ODEQ on July 1, 1993. ODEQ developed the Technical Memorandum describing the results of the wellhead sampling, and ODEQ is also directing the discrete sampling portion of this monitoring program.

Wellhead Sampling

The wellhead sampling portion of the program has been completed. Twenty-one public water supply wells located in Ottawa County that are producing water from the Roubidoux Aquifer were sampled. ODEQ's report, "Technical Memorandum - Sampling Results of Public Water Wells, August 1992 to January 1993, Tar Creek Superfund Site," was included as Appendix E to the 1994 Five-Year Review. Ten wells inside the mining area and one well considered to represent background conditions were sampled once a month for each of the six months from August 1992 through January 1993. Additionally, in January 1993, ten wells outside the mining area were sampled in order to increase the data set for background Roubidoux Aquifer water quality. Both filtered (dissolved constituents) and unfiltered (total of dissolved and suspended constituents) samples were taken.

Discrete Sampling

The ODEQ began field investigations in 1996 to determine whether the Roubidoux Aquifer is being impacted by acid mine water or if inadequate water well casings are allowing intrusion of acid mine water from the Boone formation into the wells. The municipal drinking water wells in the area, which are about 1000 feet in depth, produce from the Roubidoux formation. The Boone formation, which is cased off, is the ore bearing formation that was mined. The Boone is located several hundred feet above the Roubidoux.

In 1996 and 1997, ODEQ obtained isolated, discrete samples of Roubidoux water from certain drinking water wells in Picher, Commerce, and Quapaw that had been impacted by acid mine water. The discrete samples were obtained by the following procedure:

1. The impacted wells were disassembled
2. A downhole inflatable packer was installed just above the Roubidoux, but below the Boone, to seal off any downward flow of mine water.
3. The pump was reinstalled below the packer with the production pipe and electrical cables extended through the packer.
4. After reassembly, the well was pumped in order to collect discrete water quality samples from the Roubidoux at the wellhead.

The downhole inflatable packers were set at a depth of approximately 800 feet in the wells in Picher and Quapaw. In lieu of a downhole packer to obtain discrete water samples from the Commerce well, a plastic sleeve was cemented into the Commerce well to a depth of approximately 800 feet. The use of packers or the sleeve was intended to prevent infiltration of mine water into the Roubidoux wells from leaky or shallow casings. See Section VIII ("Summary") for a presentation of the results of the discrete sampling.

Monitoring Wells

As part of the public water supply monitoring program, a Roubidoux monitoring well was installed in Picher. The monitoring well was constructed like a municipal water supply well and cased through the mine workings to a depth of approximately 850 feet. The casing and cementing techniques used were state-of-the-art to ensure that mine water did not infiltrate the well. The City of Picher has tied into the new monitoring well, and used the well as a primary water supply well. This new well has significantly improved the quality of the drinking water in Picher.

ODEQ plans to install additional Roubidoux monitoring wells. These additional wells will be installed in Picher and in the other communities where the public water supply has been impacted by mine water infiltration. As with the first monitoring well, the additional monitoring wells will be installed with state-of-the-art casing to prevent mine water infiltration. If the well water meets drinking water standards, the local communities will be allowed to use these wells to replace their contaminated wells.

Additional Well Plugging

Approximately 15 additional abandoned wells that are penetrating into the Roubidoux have been identified. Following the completion of the discrete sampling of local drinking water wells, ODEQ and EPA will be evaluating the need to plug these additional wells.

Inspection of Diversion and Diking Structures

The diversion and diking structures constructed under the OU1 ROD were inspected in July 1998, and a report was issued in July 1999. The inspection indicated that the diversion and diking structures are functioning as designed. EPA and ODEQ officials visually inspected these structures in 1998. These structures appear to be adequately maintained except for the dike that diverts Lytle Creek away from the collapsed features at the old Admiralty Mine location near the confluence of Lytle Creek and Tar Creek. The eastern section of the Lytle Creek diversion dike had a hole about 5 feet deep by 5 feet wide by 12 feet long on the upstream side of the dike. The hole extended about halfway through the dike. The hole appeared to be caused by the collapse of a tunnel created by burrowing animals. A few other tunnels from burrowing animals were noticed in the same area of the dike. The hole was repaired in April 1999. The State, also as an activity under its operation and maintenance responsibilities for OU1, cleaned out the diverted Lytle Creek channel on the north side of the Admiralty Mine diversion to help alleviate some of the flooding problems that have occurred in Picher.

B. <u>OU2 Activities</u>

General

The OU2 response activities address the large quantity of mine waste materials located on the ground surface in Ottawa County. The mining waste is contained in chat piles, floatation ponds, and other areas where it has been widely used in the construction of roads, driveways, and for other purposes. To date, approximately 2100 residential yards (including the approximately 500 additional yards identified during post ROD detailed design phase sampling) have been found to have lead contamination above 500 ppm. The sources of mining waste represent a potential health risk, particularly to children, due to direct exposure. Contaminants of concern are lead and perhaps other metals.

Residential Areas

The remediation of residential areas of OU2 began in June 1996 as a removal action and continued in January 1998 as a remedial action. Approximately 1,600 lead-contaminated residential yards are to be remediated by Spring 2000. More detailed design phase sampling indicates that about 500 additional residential yards that were not anticipated when the ROD was issued will also require remediation. This increases the total number of yards being addressed to 2,100. The additional 500 yards will probably add about another year to the remediation time frame. The completed portions of the remedy for the residential areas in OU2 are protective of human health and the environment. EPA is providing the Agency for Toxic Substances and Disease Registry (ATSDR) with funding for an extensive lead education and blood lead screening program at the Site.

Non-Residential Areas

The following actions are underway to address the non-residential areas:

1. In September 1998, a pilot project was initiated with the Inter-Tribal Environmental Council of Oklahoma (ITEC) and with the Quapaw Tribe. The purpose of the project is to enhance tribal involvement in the Superfund program. Under the pilot project, ITEC and the Quapaw Tribe will be conducting remediation studies for two industrial properties owned by the Quapaws. A work plan for the remediation studies is scheduled to be submitted to EPA in 2000. Approximately $122,000 has been provided to ITEC to date for this project. Management assistance funding has also been provided to the Quapaw Tribe for the project.

2. In January 1999, ITEC and the Quapaws were awarded funding for an additional project. The purpose of this project is to investigate mining waste impacting Beaver Creek. Beaver Creek flows through the Quapaw campgrounds and powwow grounds. A work plan for the remediation studies is scheduled to be submitted to EPA in 2000. Approximately $36,000 has been provided to ITEC to date for this project. Management assistance funding has also been provided to the Quapaw Tribe for the project.

3. In January 1999, the State of Oklahoma was awarded $150,000 funding to develop plans for remediation studies to address the mine tailings remaining at the Site. The State

will be focusing on institutional controls (e.g., restrictions on chat usage) and other measures (e.g., dust suppression and erosion control) to address potential exposures to the tailings. A work plan for the remediation studies is scheduled to be submitted to EPA in 2000.

The remediation studies described above will identify remedies for each of these three areas of concern. The studies will each take about two years to complete. Once remedies for these three areas of concern are identified, an estimated completion time for the remediation of these areas can be determined. Since these three areas are so large, remediation is likely to take several years.

VIII. SUMMARY

A. OU1 Conclusions

Diversion and Diking

Based on this Five-Year Review of the Tar Creek Superfund Site the following conclusions are made regarding the diversion and diking:

1. The diversion and diking structures are functioning as designed.

2. The goal of the diversion and diking of the two major surface water inflow points was to reduce water inflow into the mines by approximately 75 percent, thereby eliminating or reducing acid mine discharges by a significant amount. Available monitoring data obtained prior to and summarized in the 1994 Five-Year Review indicates that, although the diversion and diking remedy was successful in preventing surface water inflow at these two locations, and although it has been successful in reducing the temporary rise in water levels in response to a given precipitation event, the remedy did not significantly reduce the surface discharges of acid mine water.

3. One possible reason for the failure of the OU1 remedy to eliminate or reduce the discharge of acid mine water is that the initial evaluation of the sources of recharge for the Boone Aquifer grossly underestimated the number of sources. It now appears likely that the two inflow points that EPA diked provide a much smaller part of the total recharge than the EPA estimated in 1984. Sources of recharge other that the two inflow points that EPA diked are apparently capable of sustaining the water level in the Boone Aquifer. These other sources are also capable of sustaining the discharge of acid mine water. (See Five-Year Review Report, EPA 1994)

4. One estimate indicates up to 100,000 open boreholes into the Boone Formation may be present in Ottawa County. Those boreholes in which the potentiometric

surface of the Boone Aquifer is below the top of the Boone Formation are possibly acting as a source of recharge, either from direct infiltration of rainwater or through the presence of an unconfined aquifer in the unconsolidated surficial sediments. Similarly, for those boreholes which are located in areas where the potentiometric surface of the Boone Aquifer is higher than the top of the Boone Formation, contaminated mine water is possibly moving upward and into the unconsolidated surficial sediments. This water may then be moving laterally through the sediments and discharging into Tar Creek. This discharge flow possibly establishes a portion of the base flow in Tar Creek. (See Five-Year Review Report, EPA 1994)

Water Quality in Tar Creek

1. Data from the two-year monitoring program established by the ROD indicates that the contaminant concentrations in the acid mine discharges, and in Tar Creek, may be decreasing. However, surface water monitoring to date has been insufficient to adequately establish trends. Monitoring data has been erratic, finding increases and decreases in contaminant concentrations occurring with no apparent pattern. The general reduction of contaminant concentrations in the discharges from the mines may be related to the diversion and diking activities, although this has not been confirmed. Alternatively, a natural attenuation process, whereby the material available for leaching may become depleted, may be occurring. (See Five-Year Review Report, EPA 1994)

2. The After Action Report states that only 15 percent of the total metals loading to Tar Creek is contributed by the known major discharges, and that 85 percent of metals loading to Tar Creek is from unidentified sources. If the After Action Report is accurate, collecting, and treating the known discharges may not significantly reduce the concentration of toxic metals in Tar Creek. (See Five-Year Review Report, EPA 1994)

3. The State of Oklahoma has established, in the Water Quality Standards for Tar Creek, the designated beneficial uses of 1) a Habitat Limited Aquatic Community, and 2) secondary body contact recreation. The Water Quality Standards are not being met. In particular, the statewide numerical criteria for the toxic substances cadmium, lead, and zinc, and the pH standard applicable to all fishery classifications, including the habitat limited classification for Tar Creek, are not being met. (See Five-Year Review Report, EPA 1994)

4. The Tar Creek Task Force concluded in April 1983 that the sediments in Tar Creek provide an effective long-term sink for metals, and should effectively remove the metals from most biological processes. Concentrations of metals in sediments in the Neosho River are essentially unchanged above and below its confluence with Tar Creek. (See Five-Year Review Report, EPA 1994)

Roubidoux Well Plugging

Ground Water

All public water supply wells tested in the Site area produce water from the Roubidoux Aquifer. Wellhead samples from all the Roubidoux water supply wells continue to meet primary drinking water standards and are protective of human health. However, in the early 1990's, an analysis based on monitoring of twenty-one wells producing water from the Roubidoux Aquifer came to the conclusion that five of the wells show some impact of acid mine water contamination. The five impacted wells failed the secondary drinking water standard for iron. One of the five also failed the secondary standard for sulfate. Secondary drinking water standards are not health based, but rather are a function of aesthetics, taste, and odor. Neither iron nor sulfate are hazardous substances addressable by CERCLA. EPA and the State of Oklahoma are conducting further investigations to determine whether the contamination in these five wells is due to inadequate well integrity (allowing contaminated water from the Boone Aquifer to enter the well) or whether there is direct contamination of the Roubidoux Aquifer.

The five impacted wells have been sampled since the 1994 Five-Year Review. Recent sampling confirms that these wells fail secondary drinking water standards. However, this recent sampling found that these wells still meet the primary drinking water standards. Since the 1994 Five-Year Review, discrete samples of Roubidoux water have been taken from the five public water supply wells that were impacted by infiltration of acid mine water, and from a new monitoring well installed in Picher. Analysis of all the data collected from the five wells is incomplete, but a tentative analysis indicates acid mine water is infiltrating through inadequate casings, and this infiltration is the source of the contamination. Water samples from the new monitoring well in Picher, with state-of-the-art casing, indicates that the Roubidoux water quality is good (i.e., meets both primary and secondary drinking water standards).

The preliminary results of the discrete sampling, in general, indicate that the water quality of the Roubidoux underlying the Site is good and is similar to the quality of Roubidoux water sampled outside the mining area. As a side benefit of the public water supply monitoring program, the City of Picher tied into the new monitoring well. The City now uses the monitoring well as a primary water supply well. Use of this well has significantly improved the quality of the City's drinking water.

The EPA will evaluate whether it is necessary to plug more abandoned wells based upon the results of the discrete sampling efforts. Monitoring which is undertaken by public water supply operators on the Site as part of their regular operation should be adequate to determine future protectiveness of the ground water remedy. If it is later found that water from the Roubidoux Aquifer is no longer capable of meeting primary drinking water standards, the need for additional corrective action will be reevaluated.

B. OU2 Conclusions

Residential Areas

The EPA's Baseline Human Health Risk Assessment Report (August 1996) came to the following conclusions regarding contamination in the residential areas of OU2:

1. Lead was identified as the only Site-related chemical of concern.

2. Oral ingestion was identified as the only significant exposure route.

3. Cadmium and zinc were identified as Site-related contaminants, but the concentrations of cadmium and zinc in the various Site media (soil, air, drinking water, etc.) were not high enough to present a risk to human health.

4. Risk evaluations concluded that the soil lead contamination at the Site poses a significant risk to human health. The soil in the mining region and in portions of Ottawa County is contaminated with mine tailings, principally chat.

The EPA's remediation of the residential areas of OU2 is described in the August 1997 Record of Decision (ROD) for the residential areas of the Site. A review of the residential remedial action currently in progress led to the following conclusions:

1. The EPA's current remediation of the residential areas of OU2 which started as a removal action and which continues as a remedial action is eliminating the risks associated with exposure to mining-waste-contaminated soil .

2. Risks are also being addressed though supplemental health education efforts.

Non-Residential Areas

For the non-residential areas of OU2, remediation studies were initiated in September 1998 and January 1999.

IX. PROTECTIVENESS OF REMEDY

A. OU1 Protectiveness

Based on the available post-remediation monitoring data and the Five-Year Review, it cannot be concluded that the goals in the OU1 ROD have been met. The reasons for this statement are:

1. Twenty-one municipal water supply wells that are producing from the Roubidoux Aquifer were tested. Five of these wells, while currently meeting primary drinking water standards, appear to be clearly impacted by acid mine water. Although preliminary monitoring data indicate that the probable source of contamination is inadequate well integrity, the source of this contamination has not conclusively been determined.

2. The surface water in Tar Creek continues to be severely contaminated. Acid mine water discharges have not been abated. However, a before-and-after remediation comparison of the concentration of metals in the acid mine water discharges did indicate some decrease in metal concentrations.

While the OU1 remedy may not have met the all the goals established in the ROD, the remedy is protective of human health with respect to the primary pathway of exposure addressed by the ROD--drinking water from the Roubidoux Aquifer. The Roubidoux Aquifer is meeting all health based primary drinking water standards. Although the surface water of Tar Creek does not meet the Water Quality Standards, the condition of the surface water does not represent a human health threat. As discussed below, rather than meet the environmental components of the Water Quality Standards for Tar Creek, EPA invoked a fund-balancing ARARs (applicable, or relevant and appropriate requirements) waiver.

Water Quality Standards Lowered

Subsequent to the issuance of the OU1 ROD, the State of Oklahoma concluded that the impacts to Tar Creek (i.e., impaired water chemistry and impaired habitat) rendered the stream not adequate to support a "Warm Water Aquatic Community." The Oklahoma Water Resources Board (OWRB), the agency charged with setting Water Quality Standards for the State of Oklahoma, has also concluded that the impacts to Tar Creek are due to "irreversible man-made damages" resulting from past mining operations at the Site.

To reflect this conclusion, in 1985 the OWRB lowered the Water Quality Standards for Tar Creek. Under the lower standards, Tar Creek was designated as a habitat-limited fishery and as a secondary recreation water body. The OWRB's reference to "irreversible man-made damages" is a simplified rephrasing of the following language: "human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied." This wording is taken from paragraph 785:45-5-12 (b) (3) of the Oklahoma Water Quality Standards. Irreversible man-made conditions are one of the allowable justifications for lowering a stream's classification from warm water fishery to a habitat-limited fishery.

The secondary recreation water body designation allows for uses where ingestion of water is not anticipated (e.g., boating, fishing, or wading). The Water Quality Standards associated with these designated uses are not being met in Tar Creek at present. In particular, the pH standard and the numerical criteria for toxic substances (e.g., heavy metals) which apply to all fishery classifications, including the habitat-limited classification, are not being met. Although the fishery-related standards would be considered ARARs under the NCP, as explained below, the OU1 ROD invoked an ARAR waiver regarding the environmental components of the Water Quality Standards under the Clean Water Act.

Waiver of ARARs for Protection of the Environment

The OU1 ROD used the Water Quality Standards as the criteria for assessing whether or not human health and the environment were being impacted by the surface water in Tar Creek. Table 2 in the OU1 ROD presented numerical information showing that the levels of metals discharging into Tar Creek from the abandoned mines exceeded the acute and chronic criteria of the Water Quality Standards.

The 1984 ROD for OU1 was issued under the 1982 National Contingency Plan (NCP). The provisions regarding the fund-balancing ARARs waiver are found in the 1982 NCP at what was then 40 CFR § 300.68(k). In the 1990 NCP, the fund-balancing ARARs waiver provision is codified at what is now 40 CFR § 300.430(f)(ii)(C)(6), and is similar to the 1982 NCP provision. The underlying statutory law upon which the 1982 NCP fund-balancing waiver is based is CERCLA Section 104(c)(4). The 1990 NCP waiver provision is based on CERCLA (as amended by SARA) Section 121(d)(4)(F). The two statutory provisions call for a similar balancing test. Although there are distinctions between the statutory provisions, the distinctions are not so great that EPA's 1984 waiver decision must be reexamined because the fund-balancing determination that was made in 1984 is essentially the same determination that would be made in 2000 under the 1990 NCP. Moreover, the economics of the situation have not changed. That is, the massive costs associated with any engineering remedy for surface water contamination in the Tar Creek Basin are still prohibitively high, and expenditures to meet those costs would drain the Fund. In short, there is no reason to revisit the fund-balancing waiver that was made in the 1984 OU1 ROD.

The normal process for remedy selection for pre-SARA RODs, according to the 1982 NCP, was to select "the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment." The OU1 ROD declaration asserted that the "cost-effective remedy does comply with other environmental regulations," then the OU1 ROD added that alternative "future remedial actions may be required if selected alternatives do not adequately mitigate the risk to human health." These statements in the ROD declaration, in combination with the fund-balancing waiver language, limit future actions to actions that may be needed to address "risk to human health." The ROD specifically limited the trigger for future remedial actions to inadequately mitigated human health risk, implicitly excluding inadequately mitigated environmental risks as a trigger for future remedial actions. That is, these provisions in the 1984 ROD provide a fund-balancing ARAR waiver for the environmental components of "other environmental regulations"--in this case the environmental components of the Water Quality Standards.

Human Health

Although the environmental components of the Water Quality Standards are not being met, this does not pose a human health threat. The human health components of the Water Quality Standards concern human exposures that may occur during secondary body contact recreation (i.e., where the ingestion of water is not anticipated), and from the consumption of fish. The exposure routes whereby metals may enter the human body during secondary body contact with water in Tar Creek are incidental ingestion of sediments and dermal contact with the water. Ingestion of water while swimming, while not a secondary body contact exposure pathway, is nevertheless a possible exposure pathway that was also considered.

The available data for metals in sediment at Tar Creek indicates levels of lead that are generally below levels of concern for protection of human health. The Baseline Human Health Risk Assessment (BHHRA) for residential areas issued in August 1996 identified lead in soil (not sediment) as the only Site-related chemical of concern, and the BHHRA also identified oral ingestion of lead-contaminated soil as the only significant exposure route.

Exposure to sediment in creeks was not an exposure pathway considered in the BHHRA. However, the sediment is similar to the lead-contaminated soil in that it is soil-like, and it is contaminated with metals from the mines. Due to these similarities, the exposure pathways for residential soil and creek sediment are similar except for frequency of exposure. Recreational exposures to creek sediment are estimated to be 60 days per year compared to 350 days per year for residential soil. Therefore, in order for creek sediment lead concentrations to be of concern, they would have to reach levels that are significantly higher than the 500 ppm level that poses a serious health threat in residential area soils. However, this is not the case. Available information on sediment in Tar Creek indicates that the average concentrations in typical exposure unit areas (e.g., 2500-square-foot areas for which 5-point composite samples were taken for the residential yard cleanup) are generally below 500 ppm.

Another potential exposure pathway associated with recreation use of Tar Creek is dermal contact with creek water. The available data indicate that dermal contact with the creek does not pose a human health threat. The levels of metals in the stream are below levels of concern for dermal contact. Also, the median pH in the creek is not of concern for the type of body contact that occurs during recreational use.

Ingestion of water while swimming, is also a possible exposure pathway. The available data indicate that incidental ingestion of water while swimming does not pose a human health threat. The levels of metals in the stream are below levels of concern for incidental ingestion while swimming.

Available water quality information for metals and pH indicates that it is unlikely that the water quality of the creek is unsafe for recreational uses.

A final means by which humans may be exposed to contamination in Tar Creek is through ingestion of contaminated fish. Available data from analyses of fish fillet samples from fish taken at the mouth of Tar Creek and other locations in area do not indicate that the fish are unsafe for human consumption.

In summary, the available data do not indicate that recreational use of Tar Creek poses a human health threat. Under the OU1 ROD, human health concern is the trigger for additional action. No further remedial action is planned regarding Tar Creek surface water.

B. <u>OU2 Protectiveness</u>

The 1997 ROD for the residential area of OU2 prescribed a remedy that is protective of human health and the environment. The remedy has been completed for only a portion of the residential areas of the Site. The portions of the remedy that are completed are protective of human health and the environment.

As far as the nonresidential areas are concerned, studies that were initiated in September 1998 and in January 1999 mark the beginning of the remedy-development process for these areas.

X. RECOMMENDATIONS

A. OU1 Recommendations

Based on the Five-Year Review of the Tar Creek Superfund Site, the following recommendations are made with respect to OU1:

1. A continuation of the ground water monitoring program is recommended to evaluate whether the well plugging has successfully prevented contamination of the Roubidoux Aquifer. The first step in the implementation of this recommendation is already being taken. That first step is the discrete sampling of the Roubidoux Aquifer which is being conducted by ODEQ and EPA. Upon conclusion of the discrete sampling, the long term monitoring of the Roubidoux Aquifer will be accomplished by water supply operators as part of their regular water quality testing routine. Additional ground water monitoring wells will be installed in Picher and in the other communities where the public water supply has been impacted by mine water infiltration. If it is found that the Roubidoux Aquifer is no longer capable of meeting primary drinking water standards, the need for additional corrective action will be reevaluated.

2. The 1984 ROD envisioned that additional abandoned Roubidoux wells and boreholes would be located and plugged. OWRB has located approximately 15 additional wells that may require plugging. EPA will evaluate the need to continue to plug abandoned wells, after it evaluates the results of the discrete sampling efforts.

3. There are provisions in the OU2 ROD that can be used to address certain problems that might arise in OU1. Specifically, the OU2 residential ROD contains broad provisions for institutional controls that apply to mining waste Site-wide. The OU2 ROD provides the following specific institutional controls that may be applied to protect humans exposed to surface water contamination as needed:

-Implementation of restrictions or management controls on the unsafe uses of mine tailings. EPA is coordinating the implementation of these restrictions with ODEQ for the non-Indian land and with the local Indian Tribes and the U.S. Department of the Interior for the Indian land.

-Construction of physical barriers (e.g., fencing) and warning signs around contaminated areas.

-Notifying prospective purchasers that property may be contaminated at depth, via deed notices.

-Education of Site residents regarding the dangers of remaining contamination.

Most of the monitoring data concerning Tar Creek is at least 10 years old. Additional monitoring may be needed in order to confirm that contaminant concentration levels have not increased. In the future, the EPA should review the need for updated monitoring of the contamination of Tar Creek for human health impacts.

B. OU2 Recommendations

1. For the residential areas of OU2, continue remediation as prescribed in the 1997 ROD.

2. For the non-residential areas of OU2, continue investigations initiated in 1998 and 1999 leading toward development of protective remedies.

XI. STATEMENT OF PROTECTIVENESS

I certify that human health and the environment are being protected by the remedial action being implemented at the Site except as stated below:

A. OU1 Protectiveness

The OU1 remedy has successfully addressed the primary potential route of exposure–the potential contamination of drinking water taken from the Roubidoux Aquifer. Discrete sampling of the Roubidoux Aquifer shows that it is meeting all health-based primary drinking water standards. Although environmental components of the Water Quality Standards for Tar Creek are not being met, this condition does not pose a human health threat. Regarding the environmental components of the Water Quality Standards, the 1984 OU1 ROD invokes a fund-balancing waiver regarding these environmental standards. This Five-Year Review finds that the facts supporting this waiver have not substantially changed. Accordingly, EPA stands by this waiver. In short, human health is being protected by the remedial action being implemented for OU1, but EPA has decided that, considering the potential drain on the Superfund and the impact that drain would have on EPA's ability to fulfill its mission at other releases under CERCLA and the NCP, it is not appropriate to meet the environmental Water Quality Standards for surface water in Tar Creek.

B. OU2 Protectiveness

Approximately 1,600 lead-contaminated residential yards will have been remediated by Spring 2000. More detailed design phase sampling indicates that about 500 additional residential yards that were not anticipated when the ROD was issued will also require remediation. This increases the total number of yards being addressed to 2,100. The additional 500 yards will probably add about another year to the remediation time frame. In the remediated areas, the OU2 remedy is protective of human health and the environment. That is, human health and the environment are being protected by the remedial action being implemented in OU2.

As far as the nonresidential areas of the Site are concerned, studies that were initiated in September 1998 and in January 1999 mark the beginning of the remedy development process for these areas.

XII. NEXT FIVE-YEAR REVIEW

Region 6 EPA will conduct the next Five-Year Review in 2005.

Myron O. Knudson

Myron O. Knudson, P.E.
Director
Superfund Division

4/11/00
Date