# Five-Year Review Report

## Third Five-Year Review Report
## for the
## Tar Creek Superfund Site
## Ottawa County, Oklahoma

September 2005

PREPARED BY:

CH2M HILL
Contract Number 68-W6-0036
Work Assignment Number 133-FRFE-06ZZ

PREPARED FOR:

Region 6
United States Environmental Protection Agency
Dallas, Texas

# THIRD FIVE-YEAR REVIEW
# Tar Creek Superfund Site
# EPA ID#OKD980629844
# Ottawa County, Oklahoma

This memorandum documents the United States Environmental Protection Agency's (EPA's) performance, determinations, and approval of the Tar Creek Superfund Site (site) third five-year review under Section 121(c) of the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA), 42 United States Code (USC) §9621(c), as provided in the attached Third Five-Year Review Report prepared by CH2M HILL, Inc., on behalf of EPA.

## Summary of Five-Year Review Findings

The third five-year review for this site indicates that the remedial actions set forth in the decision documents for this site continue to be implemented as planned. A Long-Term Monitoring program for the Roubidoux Aquifer is being conducted by the Oklahoma Department of Environmental Quality (ODEQ) to determine the effectiveness of the well plugging program as required by the Operable Unit (OU) 1 Record of Decision (ROD). Additional abandoned Roubidoux wells have been plugged by the ODEQ, and both the ODEQ and EPA continue to evaluate the need to plug abandoned Roubidoux wells, once identified and located, as required by the OU1 ROD. There are also several diversion channels and dikes, constructed as part of the surface water remedy for OU1, present at the site. As noted in previous five-year reviews, the discharges of acid mine water to Tar Creek have not decreased significantly since the construction of the dikes and diversion channels. This five-year review continues to find that the fund-balancing Applicable or Relevant and Appropriate Requirements (ARARs) waiver related to environmental risks, as determined by the OU1 ROD, is appropriate for the site. Additional hydrologic modeling and a passive treatment pilot study (through constructed wetlands) are being conducted that may address surface water issues at the site. Until the results of these efforts are available, a determination on the feasibility of passive treatment technology to address the environmental risks associated with surface water cannot be made. It would still be cost prohibitive to institute additional engineering remedies to address environmental risks, and this cost would potentially drain the Superfund and impact the EPA's ability to address other releases under CERCLA and the National Contingency Plan (NCP).

Residential yard and High Access Area remediation continues at the site as required by the OU2 ROD. The OU2 ROD stated that a five-year review for the Remedial Actions (RA) being implemented under the ROD will not be required. However, the EPA has issued an Explanation of Significant Difference (ESD) for the OU2 ROD that requires five-year reviews of the OU2 remedy.

OU3, regarding abandoned laboratory chemicals at the former Eagle-Picher Office Complex, located in Cardin, Oklahoma, was addressed through a removal response action. No further action is necessary.

The EPA has entered into an Administrative Order on Consent with three Potentially Responsible Parties (PRPs) to conduct a Remedial Investigation/Feasibility Study (RI/FS) for OU4. OU4 addresses the undeveloped rural and urban areas of the site where mine and mill residues and smelter wastes have been placed, deposited, stored, disposed of, or otherwise come to be located as a result of mining, milling, smelting, or related operations. OU4 includes rural residential yards located in Ottawa County outside of city or town limits except for yards that were addressed under OU2. In general, OU4 does not include roadways, alleyways, sinkholes, or mine shafts. The underground mine workings are not included as part of OU4, except as possible disposal locations for mining related wastes. After completion of the OU4 RI/FS and risk assessments, the EPA will evaluate the site condition and determine if any further actions are required. The EPA will perform the risk assessments (both human health and ecological) for OU4 using data gathered by the PRPs and by EPA.

Based on the data review, site inspection, interviews, and technical assessment, it appears the remedies are generally functioning as intended by the decision documents, except as noted above for OU1. To ensure continued protectiveness, seven issues are identified in the third five-year review for this site. These issues do not currently affect the protectiveness of the remedy, but need to be addressed to ensure continued protectiveness. These issues include:

(1) The ODEQ's Operation and Maintenance (O&M) Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy dates to 1987. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site. There is not an O&M Plan for the dikes and diversion channel constructed at the Muncie and Big John Mine Sites, located in the State of Kansas, although EPA plans to inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

(2) The second five-year review recommended that the EPA review the need for updated monitoring of the contamination of Tar Creek in order to confirm that contaminant concentrations have not increased and to evaluate human health impacts. Soil data from the Tar Creek flood plain was collected by the EPA in 2001. Sediment and surface water data has or will soon be collected from the Tar Creek watershed by the ODEQ and United States Geological Survey (USGS).

(3) The ODEQ conducted a fish tissue study in 2002-2003 to determine if fish from waters at the site and the Neosho and Spring Rivers are safe for consumption. This study was performed in response to concerns expressed by local residents and Native American Tribes. Native American Tribes from the Tar Creek area indicated that traditional local customs involve eating whole fish, including bones, which are prepared and canned by means of pressure cooking. Based on the results of the study, the ODEQ concluded that skinless fish fillets were safe to consume at a rate of up to six eight-ounce meals per month while bones from fish, whether whole-eviscerated or whole-uneviscerated, were not safe to consume. The ODEQ also recommended that another study be conducted, using lower detection limits, to verify the results of the initial study and to determine the downstream extent of metals uptake in fish. At the date of this Five-Year Review Report, the additional study had not yet been conducted. The ODEQ is pursuing plans to initiate the additional fish studies.

(4) The OU1 ROD called for monitoring of the Roubidoux Aquifer to evaluate the effectiveness of the well plugging activities at preventing acid mine water migration into the aquifer. Acid mine water has been detected at several Roubidoux wells. Data collected to date are inconclusive as to whether the cause of this influx of mine water is faulty well casings or represents more widespread infiltration of mine water into the Roubidoux Aquifer. The effectiveness of the well plugging program cannot be determined at this time because ground water monitoring continues to indicate exceedences of the secondary Maximum Contaminant Levels (MCLs), tolerance limits, or background concentrations for the indicator parameters (iron, sulfate, and zinc) used to monitor the Roubidoux Aquifer at some locations. It should be noted that neither the EPA nor ODEQ have identified any wells at the site that fail to meet the drinking water standards (known as MCLs) established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

(5) The OU1 ROD recognized that additional abandoned Roubidoux wells might be identified and require plugging in the future. This requirement remains an issue to be addressed in future five-year reviews.

(6) Remediation of residential yards and High Access Areas (HAAs) at the site is not yet complete. There are still properties remaining at the site where remediation is necessary. The residential yard remediation resumed in the summer of 2005 and is ongoing at the time of this Five-Year Review Report.

(7) The RI/FS, Baseline Human Health Risk Assessment (BHHRA), and ecological risk assessment (ERA) for OU4 are currently in the planning phase and have not yet been completed.

**Actions Needed**

To address the issues identified during the third five-year review, the following recommendations and follow-up actions have been identified for the site:

(1) The ODEQ has indicated that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987. This O&M Plan prepared for the Admiralty Mine Site should be updated. The ODEQ also indicated as part of this five-year review that the 20-year property easement for the dike and diversion channel at the Admiralty Mine Site should be extended and updated.

Regarding the Muncie and Big John Mine Sites, the EPA will inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

(2) As recommended by the Second Five-Year Review, the EPA should evaluate all current data collected from the Tar Creek watershed to determine if a potential threat to human health is posed by Tar Creek. If the available data are not sufficient for this evaluation, then additional data should be collected for this purpose. If this evaluation determines that a potential human

health risk is present, it is further recommended that the EPA evaluate the need to perform a BHHRA to quantify the risks.

(3) It is recommended that the ODEQ complete the additional fish tissue studies called for in its 2003 report in order to verify the results of the initial study and to determine if extension of the fish consumption advisory to areas further downstream is necessary. The ODEQ is pursuing plans to initiate the additional fish studies.

(4) The Long-Term Monitoring (LTM) program being implemented by the ODEQ should continue as planned to determine the effectiveness of the well plugging program at protecting the Roubidoux Aquifer from the acid mine water influx. In addition, the background reassessment proposed by the ODEQ should be completed to verify that the currently used indicator parameters, background concentrations, and tolerance limits are appropriate and correct. If the LTM program determines that the acid mine water infiltration detected at certain wells in the Roubidoux Aquifer is a more widespread problem, the need for additional activities (such as continued or widespread monitoring) should be evaluated. If it is determined by the LTM program or by additional monitoring that the Roubidoux Aquifer is no longer capable of meeting the primary drinking water standards, the need for additional remedial action will be reevaluated. It should be noted that neither the EPA nor ODEQ have identified any wells at the site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

(5) The well plugging program should continue. As additional abandonded Roubidoux wells are found in records, additional efforts will be made to locate the wells, determine whether the wells are completed in the Roubidoux Aquifer, and to plug those wells when it is deemed to be technically feasible.

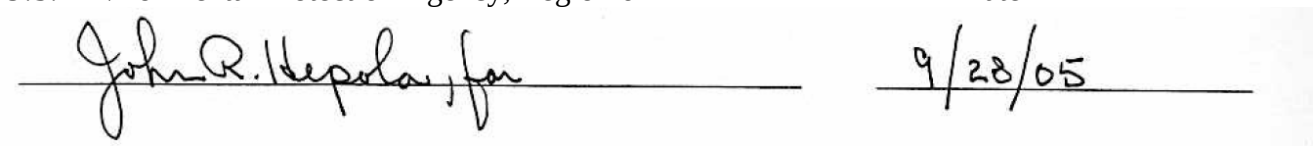
(6) The residential yard and high access area (HAA) remediation shall continue according to the requirements of the OU2 ROD.

(7) Efforts to complete the RI/FS, BHHRA, and ERA for OU4 should continue.

**Determinations**

I have determined that the remedy for the Tar Creek Superfund Site is protective of human health and the environment in the short term, and will remain so provided the action items identified in the Five-Year Review Report are addressed as described above.

Samuel Coleman, P.E.
Director, Superfund Division
U.S. Environmental Protection Agency, Region 6 Date



## CONCURRENCES

THIRD FIVE-YEAR REVIEW
Tar Creek Superfund Site
EPA ID# OKD980629844

By: _____ Date: 9/26/05
Ursula Lennox, U.S. EPA
Remedial Project Manager

By: _____ Date: 9/26/05
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By: _____ Date: 9/28/05
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By: _____ Date: 9/28/05
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Deputy Director, Superfund Division

# Table of Contents

## List of Tables



## List of Figures



## Attachments

# List of Acronyms

| | |
|---|---|
| AAM | After Action Monitoring |
| AOC | Administrative Order on Consent |
| ARARs | Applicable or Relevant and Appropriate Requirements |
| ATSDR | United States Agency for Toxic Substances and Disease Registry |
| BHHRA | Baseline Human Health Risk Assessment |
| BIA | United States Bureau of Indian Affairs |
| BMP | Best Management Practices |
| CAA | Clean Air Act |
| CDC | Centers for Disease Control |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CWA | Clean Water Act |
| DOI | United States Department of the Interior |
| ERA | Ecological Risk Assessment |
| EPA | United States Environmental Protection Agency |
| ERCS | Emergency Response Cleanup Services |
| ESD | Explanation of Significant Differences |
| FR | Federal Register |
| GGEDA | Grand Gateway Economic Development Association |
| GIS | Geographic Information System |
| HAAs | High Access Areas |
| HUD | United States Department of Housing and Urban Development |
| IAG | Inter-Agency Agreement |
| ITEC | Inter-Tribal Environmental Council |
| LTM | Long-Term Monitoring |
| MCL | Maximum Contaminant Level |
| MK | Morrison Knudson Corporation |
| MOU | Memorandum of Understanding |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NPL | National Priorities List |
| OAC | Oklahoma Administrative Code |
| OCC | Oklahoma Conservation Commission |
| ODEQ | Oklahoma Department of Environmental Quality |
| O&M | Operation and Maintenance |
| OSDH | Oklahoma State Department of Health |
| OUs | Operable Units |
| OWRB | Oklahoma Water Resources Board |
| PVC | Polyvinyl Chloride |
| ppm | parts per million |
| PRP | Potentially Responsible Parties |
| QAPP | Quality Assurance Project Plan |
| RD/RA | Remedial Design/Remedial Action |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |

| | |
|---|---|
| RPM | Remedial Project Manager |
| RSKERL | Robert S. Kerr Environmental Research Laboratory |
| RWD4 | Rural Water District Number 4 |
| SARA | Superfund Amendments and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| SHPO | State Historic Preservation Officer |
| SMCL | Secondary Maximum Contaminant Level |
| START | Superfund Technical Assessment and Response Team |
| TBCs | "To Be Considered" standards |
| USACE | United States Army Corps of Engineers |
| USC | United States Code |
| USDA | United States Department of Agriculture |
| µg/dl | micrograms per deciliter |
| USGS | United States Geological Survey |
| WIC | USDA's Women, Infant, and Children Program |

# Executive Summary

Pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation & Liability Act ("CERCLA" or " Superfund"), 42 United States Code (USC) § 9621(c), the third five-year review of the remedy in place at the Tar Creek Superfund Site ("site" or "Tar Creek site") located in Ottawa County, Oklahoma, was completed in September 2005. The results of the five-year review indicate that the remedy completed to date is currently protective of human health and the environment in the short term. Except as noted in this and previous five-year reviews regarding the ineffectiveness of the Operable Unit (OU) 1 remedy to decrease the acid mine water discharges to Tar Creek, the remedial actions performed appear to be functioning as designed, and the site has been maintained appropriately. No deficiencies were noted that currently impact the protectiveness of the remedy, although several issues were identified that require further action to ensure the continued protectiveness of the remedy.

Due to the complex nature of contamination associated with the Tar Creek site, remediation has been handled through various removal response actions and Remedial Actions (RA). Four OUs have been designated at the site. The four OUs include (a) OU1 (surface water/ground water); (b) OU2 (residential properties and High Access Areas [HAAs]); (c) OU3 (Eagle-Picher Office Complex – Abandoned Mining Chemicals); and (d) OU4 (Chat Piles, Mine and Mill Residue, Smelter Waste, and Flotation Ponds). Records of Decision (RODs) have been signed for OUs 1 and 2.

Through the RA defined by the ROD for OU1, dikes and diversion channels were constructed at three abandoned mine openings (identified as Muncie, Big John, and Admiralty) to prevent the inflow of surface water into the abandoned mine workings. In addition, abandoned wells completed in the Roubidoux Aquifer have been properly plugged to prevent migration of contaminated acid mine water from the mine workings into the underlying Roubidoux Aquifer. The Oklahoma Department of Environmental Quality (ODEQ) in cooperation with the EPA continues to evaluate the plugging of deep abandoned wells through the After Action Monitoring Program for OU1. Long-Term Monitoring (LTM) activities have been conducted to determine the effectiveness of the well plugging activities at preventing contamination of the Roubidoux Aquifer and evaluating the effectiveness of the dikes and diversion channels at lowering the water levels within the mine workings and eliminating the acid mine water discharges to Tar Creek.

OU2 was addressed through two removal response actions and a RA. The removal response actions included HAA and residential yard remediation and resulted in the remediation of 248 properties at the site. Through the RA defined by the ROD for OU2, contaminated soils at 1,818 residential properties and HAAs have been excavated to depths up to 18 inches to a remediation goal of 500 parts per million for lead. The excavated soil was disposed of at permanent on-site repositories, which are dry mining waste areas which are already contaminated.

Another removal response action resulted in the appropriate disposal of 120 containers of laboratory chemicals stored at the former Eagle-Picher Office Complex (OU3). As a result of the removal response action, the EPA determined that no further action was necessary to address OU3.

The Remedial Investigation/Feasibility Study (RI/FS) and risk assessments for OU4 are currently being completed.

Under the statutory requirements of Section 121(c) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), P.L. 99-499, and the subordinate provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.430(f)(4)(ii), performance of five-year reviews are required for sites where hazardous substances remain on-site above levels that allow for unrestricted use and unrestricted exposure. In addition, EPA policy, as stated in the current EPA five-year review guidance, states that five-year reviews will be conducted at sites where a pre-SARA remedial action leaves hazardous substances on-site above levels that allow for unrestricted use and unrestricted exposure, and five-year reviews will be conducted at pre or post-SARA sites where the RA, once completed, will not leave hazardous substances on-site above levels that allow for unrestricted use and unrestricted exposure but will require more than five years to complete. This situation applies to the Tar Creek site. The first five-year review at the Tar Creek site was completed in April 1994, and the second five-year review was completed in April 2000.

During the third five-year review period, Operations and Maintenance (O&M), LTM, and RA activities at the site have continued. O&M activities include inspection and maintenance of the dikes and diversion channels constructed as part of the OU1 remedy. LTM activities include the sampling of 11 public and private water supply wells and monitoring wells completed in the Roubidoux Aquifer at and near the site. O&M activities for the Admiralty Mine site dike and diversion channel are conducted and funded by the ODEQ. After-Action Monitoring (AAM) and LTM activities are conducted by the ODEQ through a Cooperative Agreement with the EPA. The dikes and diversion channels constructed around the Muncie and Big John Mine sites are located in the State of Kansas. RA activities at the site are conducted by the EPA. The EPA has signed an Administrative Order on Consent (AOC) with three Potentially Responsible Parties (PRPs), including the United States Department of the Interior (DOI), Blue Tee Corp., and Gold Fields Mining Corporation, to conduct the RI/FS for OU4. The EPA is responsible under the AOC for completing the risk assessments for OU4 based on data collected by the PRPs and EPA.

During the third five-year review, seven issues were identified that do not currently affect the protectiveness of the remedies for the site. The following recommendations and follow-up actions have been identified for the site to address these issues:

1. **Develop an O&M Plan for the dikes and diversion channels**. The ODEQ has indicated that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987. This O&M Plan prepared for the Admiralty Mine Site should be updated. The ODEQ also indicated as part of this five-year review that the 20-year property easement for the dike and diversion channel at the Admiralty Mine Site should be renewed and updated.

   Regarding the Muncie and Big John Mine Sites, the EPA will inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

2. **Collect and evaluate current and recent surface water and soil/sediment data to verify that no threat to human health exists in Tar Creek**. The second five-year review recommended that the EPA review the need for updated monitoring of the contamination in Tar Creek to evaluate human health impacts. The EPA has conducted soil sampling along the flood plain of Tar Creek to determine lead concentration trends within the flood plain. The ODEQ and United State Geological Survey (USGS) are currently conducting sampling of the sediments and surface water quality in Tar Creek. If these data are appropriate for the purpose of evaluating human health impacts, these data should be used for that purpose. If necessary, the EPA should collect enough additional data to determine if potential human health risks are posed by the surface water and sediments in Tar Creek. If it is determined that Tar Creek potentially poses a human health risk, then it is recommended that the EPA evaluate the need to conduct a Baseline Human Health Risk Assessment (BHHRA) to quantify the risks.

3. **Complete the additional fish tissue studies recommended by the ODEQ's 2003 report**. The ODEQ's 2003 fish tissue sampling report recommended that additional studies be conducted, using lower detection limits, to verify the results of the first study and to determine the downstream extent of the metals uptake in fish. This study was performed in response to concerns expressed by local residents and Native American Tribes. Native American Tribes from the Tar Creek area indicated that traditional local customs involve eating whole fish, including bones, which are prepared and canned by means of pressure cooking. The ODEQ issued a fish consumption advisory covering the waters within the Tar Creek site and the Neosho and Spring Rivers. The advisory states that skinless fish fillets are safe to eat, but it recommends that fish bones, whether from whole-eviscerated or whole-uneviscerated fish, should not be consumed. It is recommended that the ODEQ complete the additional recommended study to determine whether extension of the fish consumption advisory to areas further downstream is necessary. At the date of this Five-Year Review Report, the additional study had not yet been conducted. The ODEQ is pursuing plans to initiate the additional fish studies.

4. **Continue with the LTM program and background reassessment for the Roubidoux Aquifer**. It is recommended that the LTM program continue so that the effectiveness of the well plugging program can be determined. As part of the LTM program, it is further recommended that the Roubidoux background reassessment proposed by the ODEQ be conducted to verify that the indicator parameters, background concentrations, and tolerance limits used as triggers to indicate acid mine water influx from the Boone Aquifer to the Roubidoux Aquifer are appropriate. If it is determined through the LTM program that the acid mine water infiltration represents a more widespread regional problem, the need for additional activities (such as continued or more widespread monitoring) will be evaluated. If it is determined through the LTM program that the Roubidoux Aquifer is no longer capable of meeting the primary drinking water standards, the need for additional remedial actions will be reevaluated. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

5. **Continue plugging abandoned Roubidoux wells**. The OU1 ROD provided for plugging additional abandoned Roubidoux wells as they are identified at the site. These efforts should continue in order to prevent contamination from migrating from the Boone Aquifer into the Roubidoux Aquifer. As additional abandoned wells are identified, efforts should be undertaken to locate the well, determine that the well is completed in the Roubidoux aquifer, and plug those abandoned wells completed in the Roubidoux Aquifer where deemed technically feasible.

6. **Continue with the OU2 RA**. The residential yard and High Access Areas (HAAs) remediation as stated in the OU2 ROD should continue.

7. **Conduct the RI/FS, BHHRA, and Ecological Risk Assessment (ERA) for OU4**. Efforts to complete the RI/FS, BHHRA, and ERA for OU4 should continue. After completion, EPA will evaluate the site condition and determine whether any further actions are required.

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## Five-Year Review Summary Form

### SITE IDENTIFICATION

Site name (from WasteLAN): Tar Creek Superfund Site

**EPA ID (from WasteLAN):** OKD980629844

| **Region:** EPA Region 6 | State: Oklahoma | **City/County:** Ottawa County |
|---|---|---|

### SITE STATUS

NPL Status: ■ Final □ Deleted □ Other (specify):

Remediation status (choose all that apply): ■ Under Construction ■ Operating □ Complete

| Multiple OUs? ■ Yes □ No | Construction completion date: The OU1 dikes were completed in Dec. 1986 |
|---|---|

**Has site been put into reuse?** ■ Yes (partially) □ No

### REVIEW STATUS

Reviewing agency: ■ EPA □ State □ Tribe □ Other Federal Agency:

Author: EPA Region 6, with support from RAC6 contractor CH2M HILL, Inc.

Review period: April 2000 through July 2004

Date(s) of site inspection: June 29 and 30, 2004

Type of review:
□ Statutory
■ Policy
□ Post-SARA ■ Pre-SARA □ NPL-Removal only
□ Non-NPL Remedial Action Site □ NPL State/Tribe-lead
□ Regional Discretion

Review number: □ 1 (first) □ 2 (second) ■ 3 (third) □ Other (specify):

Triggering action:
■ Actual RA On-site Construction ■ Actual RA Start
□ Construction Completion □ Recommendation of Previous Five-Year Review Report
□ Other (specify):

Triggering action date (from WasteLAN): Construction completion for the OU1 dikes was achieved in December 1986.

Due date: EPA elected to conduct the first five-year review in 1994, as a matter of policy. The due date for the third-five year review is 2004.

# Five-Year Review Summary Form

**Issues:** Operations and Maintenance (O&M), long-term monitoring (LTM), and remedial actions (RA) are ongoing at the site, and based on the data review, site inspection, interviews, and technical assessment, it appears the remedy is functioning as intended by the decision documents, except as noted for OU1 in this Five-Year Review Report. To ensure continued protectiveness, seven issues were identified in the third five-year review for this site, as described in the following paragraphs. These issues do not currently affect the protectiveness of the remedy, although they need to be addressed to ensure continued protectiveness.

1. **No O&M Plan for the dikes and diversion channels**. The ODEQ's O&M Plan for the dikes and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy dates to 1987. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site. There is not an O&M Plan for the dikes and diversion channel constructed at the Muncie and Big John Mine Sites, located in the State of Kansas, although EPA plans to inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

2. **Evaluate current surface water and sediment data for Tar Creek**. A Baseline Human Health Risk Assessment (BHHRA) was not performed for OU1. Formal risk assessment guidance and procedures had not been developed at the time the OU1 Record of Decision (ROD) was written. The Second Five-Year Review Report stated that most of the surface water and sediment data for Tar Creek were 10 years old at the time the report was issued (April 2000), and called for the United States Environmental Protection Agency (EPA) to review the need for updated monitoring data from Tar Creek in order to confirm that contamination levels have not worsened, and to identify any human health impacts. Additional sediment and surface water data (including data collected by the ODEQ and USGS) are or will soon be available for these purposes.

3. **Status of recommendations from the ODEQ's 2002-2003 fish tissue study**. The ODEQ conducted fish tissue sampling in ponds from the Tar Creek site and from the Neosho and Spring Rivers. As part of this study, the ODEQ also calculated risk-based concentrations for lead, cadmium, and zinc in fish tissues for the purpose of determining safe consumption levels for fish caught in these waters. The report issued by the ODEQ documenting this study determined that consumption of fish fillets caught in these waters, at a rate up to six eight-ounce meals per month, were safe. The report also stated that whole-uneviscerated and whole-eviscerated fish caught from these waters should not be consumed. The report recommended that a new study be conducted, using lower detection limits, to verify the results of the first study. Also, the ODEQ recommended that additional sampling be conducted in areas downstream (including Grand Lake) from the locations sampled during the 2002-2003 study to determine the downstream extent of the metals uptake in fish. The recommended additional study had not been conducted at the time of this Five-Year Review report. The ODEQ is pursuing plans to initiate the additional fish studies.

4. **Complete the evaluation of the effectiveness of the well plugging program to prevent mine water infiltration into the Roubidoux Aquifer**. The two-year after action monitoring (AAM) and the second AAM program for the Roubidoux Aquifer have shown indications that the Roubidoux

Aquifer is impacted with acid mine water influx at several well locations. However, it is still unclear as to whether this influx was the result of faulty well casings or represents more widespread influx from the Boone to the Roubidoux Aquifer. Therefore, the effectiveness of the well plugging program cannot be determined at this time. The current LTM program is being conducted to make this determination. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

5. **Well plugging program for abandoned Roubidoux wells**. The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux Aquifer might be identified and require plugging in the future. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The need to plug additional Roubidoux wells as they were identified was also recommended in the First and Second Five-Year Review Reports. The ODEQ plugged one abandoned well in 2001 and 5 abandoned wells in April 2004. This requirement remains an issue to be addressed in future five-year reviews.

6. **Completion of the OU2 RA**. RA activities at the site are still ongoing. There are still residential properties at the site where assessment sampling has determined remediation is needed.

7. **Completion of the OU4 Remedial Investigation/Feasibility Study (RI/FS), BHHRA, and Ecological Risk Assessment (ERA)**. The EPA, ODEQ, and Quapaw Tribe are currently working with the Potentially Responsible Parties (PRPs) to plan and execute the RI/FS for OU4. The EPA is responsible for completing the BHHRA and ERA based on data collected by the PRPs and EPA.

**Recommendations and Follow-up Actions**: The following recommendations and follow-up actions have been defined for the site:

1. **Develop a new O&M Plan for the dikes and diversion channels**. The ODEQ has indicated that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987. The O&M Plan prepared for the Admiralty Mine Site should be updated. The ODEQ also indicated as part of this five-year review that the 20-year property easement for the dike and diversion channel at the Admiralty Mine Site should be updated.

The EPA will inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

2. **Collect and evaluate current and recent surface water and soil/sediment data to verify that no threat to human health exists in Tar Creek**. The second five-year review recommended that the EPA review the need for updated monitoring of the contamination in Tar Creek to evaluate human health impacts. The EPA has conducted soil sampling along the flood plain of Tar Creek to determine lead concentration trends within the flood plain. The ODEQ and United States Geological Survey (USGS) are currently conducting sampling of the sediments and surface water quality in Tar Creek. If these data are appropriate for the purpose of evaluating human health impacts, these data should be used for that purpose. If necessary, the EPA should collect enough additional data to determine if potential human health risks are posed by surface water and sediments in Tar Creek. If it

## Five-Year Review Summary Form

is determined that Tar Creek potentially poses a human health risk, then it is recommended that the EPA evaluate the need to conduct a BHHRA to quantify the risks.

3. **Complete the additional fish tissue study as recommended by the ODEQ's 2003 report**. The ODEQ's 2003 fish tissue sampling report recommended that additional studies be conducted, using lower detection limits, to verify the results of the first study and to determine the downstream extent of metals uptake in fish. The ODEQ issued a fish consumption advisory covering the waters within the Tar Creek site and the Neosho and Spring Rivers. The advisory states that skinless fish fillets are safe to eat, but it recommends that fish bones, whether from whole-eviscerated or whole-uneviscerated fish, should not be consumed. At the date of this Five-Year Review Report, the additional study had not yet been conducted. It is recommended the ODEQ complete the additional recommended study to determine if extension of the fish consumption advisory to areas further downstream is necessary. The ODEQ is pursuing plans to initiate the additional fish studies.

4. **Continue with the LTM program and background reassessment for the Roubidoux Aquifer**. It is recommended that the LTM program continue so that the effectiveness of the well plugging program can be determined. As part of the LTM program, it is further recommended that the Roubidoux background reassessment proposed by the ODEQ be conducted to verify that the indicator parameters, background concentrations, and tolerance limits used as triggers to indicate acid mine water influx from the Boone Aquifer to the Roubidoux Aquifer are appropriate. If it is determined through the LTM program that the acid mine water influx is a more widespread regional problem, the need for additional activities (such as continued or more widespread monitoring) will be evaluated. If it is determined through the LTM program that the Roubidoux Aquifer is no longer capable of meeting the primary drinking water standards, the need for additional remedial actions will be reevaluated. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

5. **Continue plugging abandoned Roubidoux wells**. The OU1 ROD provided for plugging additional abandoned Roubidoux wells as they are located at the site. These efforts should continue in order to prevent contamination from migrating from the Boone Aquifer into the Roubidoux Aquifer. As additional abandoned wells are located in records, efforts should be undertaken to locate the well, determine whether the well is completed in the Roubidoux aquifer, and plug those abandoned wells completed in the Roubidoux Aquifer where deemed technically feasible.

6. **Continue with the OU2 RA**. The residential yard and HAA remediation as described in the OU2 ROD should continue.

7. **Conduct the RI/FS, BHHRA, and ERA for OU4**. Efforts to complete the RI/FS, BHHRA, and ERA for OU4 should continue. After completion, EPA will evaluate the site condition and determine if any further actions are required.

# Five-Year Review Summary Form

**Protectiveness Statement(s)**: The remedies implemented for the Tar Creek site are considered protective of human health and the environment. The OU1 remedy addressed a primary route of potential human exposure associated with consumption of contaminated water from the Roubidoux Aquifer. Sampling data indicate that the Roubidoux Aquifer continues to meet all health-based primary drinking water standards. Although environmental components of the Water Quality Standards are not being met for Tar Creek, there is no indication that a threat to human health exists. However, efforts to evaluate current monitoring data from Tar Creek will be performed to verify previous determinations that no threat is posed to human health by Tar Creek. The OU1 ROD invoked a fund-balancing waiver for the ARARs regarding environmental risks. Additional hydrologic modeling and a passive treatment pilot study (through constructed wetlands) are being conducted to determine whether other techniques may be used to address surface water issues at the site. Until the results of these efforts are available, a determination regarding the feasibility of the use of passive treatment technology to address the environmental risks associated with surface water cannot be made. This third five-year review finds that the conditions that support the fund-balancing ARAR waiver made in the OU1 ROD have not substantially changed, and the waiver is still appropriate with respect to the environmental components of the Water Quality Standards for surface water at the site. Human health is protected by the remedy implemented for OU1. The EPA continues to find that, due to the potential drain on the Superfund and the impact that drain would have on the EPA's ability to address other releases under CERCLA and the NCP, it is not appropriate to address the environmental risks for surface water in Tar Creek.

In the remediated areas, the remedy being implemented for OU2 is protective of human health and the environment. A total of 2,072 properties have been remediated during the OU2 RA and during the removal actions on OU2. Additional properties continue to be identified and remediated, and the RA for OU2 is ongoing. Human health and the environment are being protected by the remedy for OU2.

The action implemented during the Removal Action for OU3 is protective of human health and the environment. The laboratory chemicals left at the former Eagle-Picher Office Complex were removed from the site and properly disposed of.

Since the completed remedial actions, LTM program, and O&M activities for the Tar Creek site are considered protective for the short term, the overall remedy for the site is protective of human health and the environment for the short term, and will continue to be protective. The action items identified in this five-year review should be addressed.

**Other Comments**: The RI/FS, BHHRA, and ERA for OU4 are currently being conducted. After completion of the RI/FS and risk assessments, the EPA will evaluate the site condition and determine if any further actions are required.

# Third Five-Year Review Report
# Tar Creek Superfund Site

The United States Environmental Protection Agency (EPA) Region 6 has conducted a third five-year review of the remedial actions implemented at the Tar Creek Superfund Site ("site" or "Tar Creek site"), for the period between April 2000 (when the second five-year review was completed) to September 2005. The purpose of a five-year review is to determine whether the remedy at a site remains protective of human health and the environment, and to document the methods, findings, and conclusions of the five-year review in a Five-Year Review Report. Five-Year Review Reports identify issues found during the review, if any, and make recommendations to address the issues. This Third Five-Year Review Report documents the results of the review for the Tar Creek Superfund site, conducted in accordance with EPA guidance on five-year reviews. EPA RAC6 contractor CH2M HILL, Inc. provided support for conducting this review and the preparation of this report.

The Tar Creek site is located in Ottawa County, Oklahoma. It consists of four Operable Units (OUs): OU1 (Surface Water/Groundwater); OU2 (Residential Areas); OU3 (Eagle-Picher Office Complex – Abandoned Mining Chemicals); OU4 (Chat Piles, Mine and Mill Residue, Smelter Waste, and Flotation Ponds).

EPA guidance on conducting five-year reviews is provided by OSWER Directive 9355.7-03B-P, *Comprehensive Five-Year Review Guidance* (EPA, 2001) (replaces and supercedes all previous guidance on conducting five-year reviews). EPA and contractor personnel followed the guidance provided in this OSWER directive in conducting the five-year review performed for the Tar Creek site.

## 1.0 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 United States Code (USC) §9601 et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300 et seq., call for five-year reviews of certain CERCLA remedial actions. EPA policy also calls for a five-year review of remedial actions in some other cases. The statutory requirement to conduct a five-year review was added to CERCLA as part of the Superfund Amendments and Reauthorization Act of 1986 (SARA), P.L. 99-499. The EPA classifies each five-year review as either "statutory" or "policy" depending on whether it is being required by statute or is being conducted as a matter of policy. The third five-year review for the Tar Creek site is a policy review.

The EPA Five-Year Review guidance specifies that five-year reviews are required or appropriate whenever a remedial action results in hazardous substances, pollutants, or contaminants remaining on-site at levels that will not allow for unrestricted use or unrestricted exposure. As specified by CERCLA and the NCP, statutory reviews are required for such sites if the Record of Decision (ROD) was signed on or after the effective date of SARA. CERCLA § 121(c), as amended, 42 USC §9621(c), states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.

The implementing provisions of the NCP, as set forth in the CFR, state at 40 CFR 300.430(f)(4)(ii):

> If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

The EPA five-year review guidance further states that a five year review should be conducted as a matter of policy for the following types of actions:

- A pre-SARA remedial action that leaves hazardous substances, pollutants, or contaminants on-site above levels that allow for unlimited use and unrestricted exposure;
- A pre or post SARA remedial action that, once completed, will not leave hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure but will require more than five years to complete; or,
- A removal-only site on the National Priorities List (NPL) where the removal action leaves hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure and no remedial action has or will be conducted.

The five-year review for the Tar Creek site is being conducted as a matter of EPA policy for two reasons. First, because the first ROD for the site, for OU 1 (Surface Water/Ground Water), was signed in 1984, before the effective date of SARA, and hazardous substances, pollutants, or contaminants remain onsite above levels that allow for unlimited use and unrestricted exposure, meeting the first criteria above. Also, a ROD for OU 2 (Residential Properties and HAAs) was signed in 1997 (after the effective date of SARA). This ROD states that a five-year review will not be required after completion of the Remedial Action (RA). However, the RA has required more than five years to complete (meeting the second criteria above). The EPA has completed an Explanation of Significant Difference (ESD) for the OU2 ROD that requires five-year reviews of the OU2 remedy. The ESD was signed July 1, 2005. Actions associated with OU3 and OU4 are also described by this five-year review report, as components of the Tar Creek site.

This is the third five-year review for the Tar Creek site. The first five-year review was completed in April 1994, and the second five-year review was completed in April 2000. EPA guidance indicates the triggering action date for a five-year review conducted as a matter of policy is typically the date at which construction completion is achieved. The dikes associated with OU1 were completed in 1986.

# 2.0 Site Chronology

A chronology of significant site events and dates is included in Table 1, provided at the end of the report text. Sources of this information are listed in Attachment 1, Documents Reviewed.

# 3.0 Background

This section describes the physical setting of the site, including a description of the land use, resource use, and environmental setting. This section also describes the history of contamination associated with the site, the initial response actions taken at the site, and the basis for each of the initial response

actions. Remedial actions performed subsequent to the initial response actions for each of the OUs defined for the site are described in Section 4.

## 3.1 Physical Characteristics

The Tar Creek Superfund site is located in Ottawa County, Oklahoma, in the far northeastern corner of the state (see Figure 1 for a site map). The Tar Creek site has no distinct boundaries, but it includes the Oklahoma portion of the Tri-State Mining District along with other areas in Ottawa County where mining waste has come to be located. The Tri-State Mining District is located in the border region of Kansas, Missouri, and Oklahoma. The Picher Field was the Oklahoma portion of the Tri-State Mining District centered on the town of Picher, Oklahoma. Extensive lead and zinc mining took place in the Picher Field between the early 1900's and the 1970's. The Tar Creek site is about 40 square miles in size. The principal communities within the mining area include Picher, Quapaw, Cardin, Commerce, and North Miami. The contamination at the site resulted from past mining activities. The Cherokee County and Oronogo-Duenweg Superfund sites comprise the Kansas and Missouri portions of the Tri-State Mining District respectively (EPA, 1994).

Tar Creek and its primary tributary Lytle Creek comprise the principal drainage system within the Picher Field. Tar Creek is characterized as a small ephemeral stream with standing pools. The headwaters of Tar Creek are located in Cherokee County, Kansas (located north of Ottawa County on the Kansas-Oklahoma border). Tar Creek then flows southward through the Picher Field between the towns of Picher and Cardin, to the east of Commerce and Miami, and it then flows to its confluence with the Neosho River. Tar Creek and Lytle Creek drain approximately 53 square miles. Other principal drainage features near the site in Ottawa County include the Neosho River (located south of the site), the Spring River (located east of the site), and Grand Lake (located in southern Ottawa County) (EPA, 1994).

The Picher Field (including most of the Tar Creek site) is located on the eastern edge of the Central Lowland Provinces. Eastern portions of the site are located in the Ozark Plateau. The Central Lowland Province is a nearly flat, treeless prairie. The Ozark Plateau is a broad, low structure dome centered in southwestern Missouri and northwestern Arkansas. The natural land surface at the site is mostly flat and gently slopes to the south towards the Neosho River, to the east towards the Spring River, and to the west towards Elm Creek. However, much of the land surface has been modified by the mining activities. There are numerous large tailings piles, composed of primarily limestone and chert, present on the land surface. In addition, numerous collapsed structures from subsidence and cave-ins of mine shafts are also present on the land surface (EPA, 1984).

Contaminated ground water at the site occurs within the Boone Formation (also known as the Boone Aquifer). The Boone Formation is composed primarily of limestone, dolomite, and chert, with lesser amounts of sandstone and shale. Lead and zinc ore were mined from various members of the Boone Formation. Within the mining area, water quality within the Boone Aquifer is poor due to acidity and high dissolved metals concentrations. The Boone Aquifer is not used as a primary source of drinking water at the site. However, information (primarily well completion depths) from water well databases maintained by the Oklahoma Water Resources Board (OWRB) and Oklahoma Department of Environmental Quality (ODEQ) indicates that some domestic wells at the site may be completed within the Boone Aquifer. Outside of the mining district, the Boone Aquifer is used as a primary

drinking water source. In areas where the Boone Formation outcrops at the surface, the aquifer is unconfined. Where the Boone Formation is overlain by confining strata, the aquifer is confined. At the Tar Creek site, the Boone Aquifer is confined. In the southern portion of the site, the potentiometric surface within the aquifer exceeds the land surface elevation. This results in artesian conditions, and ground water discharges from abandoned wells, boreholes, mine shafts, and collapse structures. This ground water is acidic and contains high metals concentrations, and hence it is referred to as acid mine drainage. This discharge then flows into Tar Creek (EPA, 1994).

Also of interest at the site is the Roubidoux Aquifer. The Roubidoux aquifer is composed of cherty limestone with several sand sequences near its base. The Roubidoux Aquifer lies beneath the Boone Aquifer, and the two are separated by 410 feet to 520 feet of limestone and shale of the Chattanooga Group, the Jefferson City Dolomite, and the Cotter Dolomite. These units act as an aquitard and restrict ground water flow between the Boone Aquifer and Roubidoux Aquifers. The Roubidoux Aquifer is a major source of drinking water in the area of the site (EPA, 1994). The cities of Picher, Quapaw, Cardin, Commerce, Miami (located south of the site), and several rural water districts obtain their water supplies from the Roubidoux Aquifer (EPA, 1984).

## 3.2 Land and Resource Use

Land ownership at the site can be classified as private or Indian-owned. Under an 1833 treaty, the United States set aside the Quapaw Reserve, located in Ottawa County, Oklahoma, consisting of approximately 12,600 acres of land. A majority of these lands are individually owned allotted lands with ‘restrictions against alienation.’ These lands are managed under the supervision of the United States Bureau of Indian Affairs (BIA) (BIA, 2005).

Due to the size of the site, land use is varied. The site encompasses residential, commercial, and industrial areas within the towns, while most of the land use outside of the towns is agricultural (EPA, 1997). Approximately 19,500 people live in the mining area or close proximity to the mining area (EPA, 2004). Tar Creek flows approximately through the center of the site, and it discharges into the Neosho River south of the site. The Neosho River discharges into Grand Lake in southern Ottawa County. Ground water under the site is found within both the Boone Aquifer and Roubidoux Aquifers. The Boone Aquifer at the site is not currently used as a drinking water supply, but there are some private wells completed within the Boone Aquifer. The Roubidoux Aquifer is regionally used as a water supply (EPA, 1994).

## 3.3 History of Contamination

Lead and zinc mining activities first began at the site in the early 1900’s. During the early mining period, most mining was conducted by small operators on 20 to 40 acre tracts. Each operator conducted their own mining, drilling, and milling activities (EPA, 1984). Mining activities occurred within a 50 to 150 thick ore bearing zone within the Boone Formation. The maximum depth of mining was approximately 385 feet below ground surface. Mining was accomplished using room and pillar techniques. To remove the ore, large rooms, some with ceilings as high as 100 feet, were connected by horizontal tunnels known as drifts. Pillars were left within the rooms to support the ceilings (EPA, 1994). The lead and zinc ores were milled locally and generally sent to locations outside of Ottawa County for smelting (the small smelter that operated in Hockerville is an exception)[SEE BELOW].

Rapid expansion of mining activities occurred during the 1920's, and mining activities reached their peak around 1925. Each mine holding usually had its own mill. During the 1930's, large central mills came into operation, and most mining operations ceased operating their own mills. During the peak of mining activities, 130,410 tons of lead and 749,254 tons of zinc were produced annually. Large scale underground mining activities ended in 1958 (Brown and Root, 1997). Smaller mining operations continued in the Picher Field through the 1960's, and all mining activities at the site ceased in the 1970's (EPA, 2000b).

Zinc smelting operations were not known to have occurred in the Tar Creek area. Lead smelting of the material mined in the Tar Creek area was dominated by the Eagle-Picher Company, which operated a smelter in nearby Joplin, Missouri. However, the Ontario Smelting Company did operate a lead smelter near Hockerville, Oklahoma. Ontario Smelting Company operated this smelter from 1918 until 1924. The smelter was then purchased by the Eagle-Picher Company, who operated the smelter until the early 1930's, when the smelting operations ceased. There were no other smelting operations known to have occurred in the Tar Creek area (USACE, 2002).

Ground water infiltration into the mines was a continual problem. This ground water inflow was controlled through the use of pumps (EPA, 1984). When mining operations ceased, it is estimated that underground cavities with a volume of 100,000 acre-feet (161,000,000 cubic yards) had been created. In addition, approximately 100,000 exploratory boreholes were located within the Picher Field, mostly in Oklahoma. 1,064 mine shafts existed within the Oklahoma portion of the mining district. In addition, numerous water wells, used for milling operations, were abandoned (EPA, 2000b).

During the active mining period, large scale pumping had created a large cone of depression, effectively dewatering the Boone Aquifer in the mining area. Exposed sulfide minerals, primarily marcasite and pyrite (both iron sulfide), were oxidized by exposure to the moist air in the mines. When mining activities ceased, pumping was also ceased, and the abandoned mines began to flood. The oxidized sulfide minerals were now much more soluble in water. As the mines filled with ground water, the oxidized sulfide minerals began to dissolve, generating acid mine water. The acid mine water then reacted with the surrounding rock, and many of the metals present began to leach from the rock into the ground water. As a result, the acid mine water contained high concentrations of zinc, lead, cadmium, sulfate, and iron (EPA, 1994).

In addition to the acid mine water, the mining activities at the site resulted in the accumulation on the ground surface of mining wastes. Large volume tailings piles (known locally as 'chat'), some as high as 200 feet, were left at the site. Many of the tailings piles are still present across the site, mostly around the towns of Picher and Cardin. In addition, numerous abandoned flotation ponds that have been filled with fine sediments are also present at the site (EPA, 2000b).

Three general types of mining wastes are present at the site. 'Development' rock is large diameter (4" to 2') rock that was generated during the opening of mine shafts or drifts. Development rock generally poses no contamination problem. ' Chat' is mine tailings from the milling process. Chat contains a mixture of gravel (typically 3/8" in diameter) and finer-grained materials. 'Fines' are the fine-grained sediments collected in the flotation ponds (EPA, 2000b).

The chat piles at the site contain approximately 67 million tons of waste. The chat has historically been used as a source material for the concrete and asphalt industries and as a gravel source. Other

uses of the chat have included railroad ballast, sandblasting and sandbag sand, roadway, driveway, alleyway, and parking lot aggregate, general fill material in residential areas, and impact absorbing material in playgrounds. Sales of chat have been a significant source of income in the local area. Based on estimates of historical aerial photographs, less than 50 percent of the original volume of chat remains in the area. The fines were collected into flotation ponds as part of the gravity separation milling process. Most of the ponds have since evaporated and are now dry. Based on examinations of historical maps, aerial photographs using a Geographic Information System (GIS), it was estimated that the flotation ponds and chat piles currently cover an approximately 1,444 acres at the site (EPA, 1997, and EPA, 2000b).

## 3.4 Initial Response

By 1979, the abandoned mines had become completely flooded due to ground water infiltration and due to surface water inflow into the abandoned mine shaft openings. In low-lying areas along the southern portion of the site (near Commerce), the potentiometric surface exceeded the ground surface. This resulted in the surface discharge of acid mine water from abandoned boreholes and mine shafts (EPA, 2000b). This surface discharge then emptied into Tar Creek. As a result, most of the downstream biota in Tar Creek were killed. The bottom of the creek became stained red due to ferric hydroxide deposition, and red stains appeared on bridge abutments and cliffs in the Neosho River downstream of its confluence with Tar Creek (EPA, 1994).

In 1980, the Governor of Oklahoma established the Tar Creek Task Force to investigate the effects of the acid mine drainage. The Task Force was composed of various local, state, and federal agencies. The Oklahoma Water Resources Board (OWRB) was appointed as the lead state agency. The initial investigations were conducted by the Task Force in 1980 and 1981. The conclusions from the Tar Creek Task Force's studies included the following:

- There were no significant health risks associated with the air pathway at the Tar Creek site;
- The Neosho River, Spring River, and Grand Lake could be used as a raw water source for public water supplies;
- The fish from areas sampled in these water bodies were safe for consumption; and,
- Most of the metals present in the acid mine water were precipitated out of the water and into the sediments in Tar Creek prior to its confluence with the Neosho River. The sediments in Tar Creek provided a long-term sink for metals that effectively removed them from most biological processes, and the sediments did not pose a health risk. Other than aesthetic alteration at the confluence of Tar Creek and the Neosho River, there was no impact on the Neosho River from the acid mine drainage in Tar Creek.

The Task Force identified the primary threat at the site as the potential for contamination of the Roubidoux Aquifer (EPA, 1994).

The EPA proposed the Tar Creek site to the NPL in July 1981, based on information from the Task Force's investigations. The NPL is the list, compiled by EPA, of uncontrolled hazardous substance releases in the United States that are priorities for long-term remedial evaluation and response. On June 16, 1982, the EPA provided funding through a Cooperative Assistance Agreement with the Oklahoma State Department of Health (OSDH) to conduct a Remedial Investigation/Feasibility Study

(RI/FS) at the site. The OSDH was the overall lead agency at the site for the State of Oklahoma. The OWRB, under an interagency agreement with the ODSH, conducted the RI/FS for the site. The site was listed on the NPL on September 8, 1983. The EPA signed a ROD for the site on June 6, 1984 (EPA, 1994). The remedy selected and implemented under the ROD is discussed in Section 4.

In 1994, the EPA conducted the first five-year review of the Tar Creek site. While conducting this five-year review, the Indian Health Service in Miami, Oklahoma, notified the EPA by letter of elevated blood lead levels in children routinely tested as part of their participation in the United States Department of Agriculture's (USDA) Women, Infant, and Children (WIC) program. The letter stated that 34% of the 192 children tested had blood lead levels above 10 micrograms per deciliter (µg/dl), which is the level above which the Centers for Disease Control (CDC) considers to be elevated in children. The letter stated that although location did not appear to be a factor, a majority of the children did live within 5 miles of a chat pile (IHS, 1994). Also, EPA Region 7 had been conducting investigations of the Cherokee County (Kansas), and the Oronogo-Duenweg (Missouri) Superfund sites. Data obtained from EPA Region 7's investigations indicated that mine wastes (including chat piles) represented an unacceptable risk to human health and the environment (EPA, 1994).

In the summary portion of the first five-year review, EPA stated that the studies conducted for the 1984 ROD did not include a risk assessment. Risk assessment guidance had not been developed at the time the 1984 ROD was signed, and the primary emphasis at the Tar Creek site was on ground water and surface water impacts related to the acid mine water. The first five-year review recommended that a second OU be designated at the site for the mining wastes. It was also recommended that studies be undertaken to determine the impacts of the chat piles and flotation ponds on human health and the environment. The studies were to include blood lead studies, environmental sampling of high access areas (HAAs) (HAAs are areas frequented or likely to be frequented by young children such as schools, playgrounds, day cares, etc.), mapping of all mine wastes, classification of surface mine wastes through environmental sampling and testing, sampling of leachate from mine wastes, and sampling of airborne particulates near mine wastes (EPA, 1994). As a result of the five-year review recommendations, surface and ground water contamination at the site became OU1, and impacts related to the mining waste, including HAAs and residential properties, became OU2 (EPA, 2000b).

EPA addressed HAAs and residential areas of OU2 first. From August 1994 through July 1995, the EPA conducted sampling through its removal program (the removal program is, generally speaking, the part of the Superfund program generally responsible for conducting emergency and early response activities) to determine the nature and extent of the contamination in residential areas of the site. The Phase I sampling addressed HAAs, and the Phase II sampling took place at residences that were inhabited or potentially inhabited by children. Twenty-eight HAAs and 2,070 residential properties were sampled as part of the site assessment. The data were used to complete the Baseline Human Health Risk Assessment (BHHRA) and Residential RI Reports. The BHHRA concluded that lead in soil was the primary contaminant of concern and that ingestion of contaminated soil was the only exposure pathway that posed a significant risk to human health. These activities led the EPA to conclude that the lead contaminated soil in residential areas posed an imminent and substantial endangerment to human health (EPA, 2000b).

Due to the concerns related to exposures to lead contaminated soil, the EPA issued an action memorandum on August 15, 1995, that authorized removal response actions at HAAs at the site

(EPA, 2000b). The removal response action began in September 1995 and was completed in December 1995. The removal response action for the HAAs was known as the Phase I removal action. The Phase I removal action was conducted by EPA through its Emergency Response Cleanup Services (ERCS) contractor, Reidel Environmental Services, and by its Superfund Technical Assessment and Response Team (START) contractor, Ecology and Environment, Inc. (Washington Group International, 2002).

The removal response action involved the excavation of lead and/or cadmium contaminated surface soils with concentrations exceeding 500 parts per million (ppm) and 100 ppm respectively from 0 to 12 inches in depth and 1,000 ppm lead and/or 100 ppm cadmium from 12 to 18 inches. This means that in areas where the lead concentration exceeded 500 ppm from 0 to 12 inches and/or the cadmium concentration exceeded 100 ppm, the soil was excavated. When the lead concentration exceeded 1,000 ppm and/or the cadmium concentration exceeded 100 ppm in the 12 to 18 inch interval, then soil from that interval was also excavated. On large properties where unauthorized excavation could be controlled, such as parks and schools, the criteria were modified to 500 ppm lead and/or 100 ppm cadmium from 0 to 12 inches in depth (the 12 to 18 inch increment was dropped). When contamination remained above the cleanup levels below 18 inches, a barrier (orange construction fence material) was place in the bottom of the excavation as a warning that contamination remained below the barrier. Each excavation was then backfilled with clean soil. Seventeen of the 28 HAAs that were evaluated required a response action (EPA, 2000b).

The EPA issued an action memorandum on March 21, 1996 that authorized a removal response action at residences at the site (EPA, 2000b). This removal response action was known as the Phase II removal action, and it included both residential properties and HAAs. The EPA signed an Interagency Agreement (IAG) with the United States Army Corps of Engineers (USACE) to conduct the Phase II removal action. The USACE contracted with Morrison Knudson Corporation (MK, which has since changed its corporate name to Washington Group International, Inc.) to complete the work (USACE, 2002).

This removal action was conducted in a similar manner to the HAAs, except that a cleanup level of 500 ppm for lead was chosen. This cleanup level was based on the BHHRA and EPA Region 6 experience at other lead cleanup sites. Approximately 2,070 residential homes in Picher, Cardin, Quapaw, Commerce, and North Miami were evaluated. The second five-year review stated that approximately 65% of these properties contained lead above 500 ppm in soil in at least one part of the yard. The Phase II removal response activities were conducted from June 1996 until December 1997. The following criteria were used to prioritize the properties:

- Top priority was given to homes with children less than 6 years of age who had blood lead levels in excess of 10 µg/dl, and where the soil lead concentrations had been determined to be a significant contributor to elevated blood lead levels; and,
- The next highest priority was given to homes where the soil lead concentration exceeded 1,500 ppm (EPA, 2000b).

During the Phase I (HAAs) and Phase II (residential properties) removal response actions, remediation was performed at 20 HAAs, one commercial property (used by the EPA, USACE, and their various contractors for on-site support facilities), and 227 residential properties. Approximately

84,417 cubic yards of soil were removed from these properties during the removal actions (E&E, 2000, USACE, 2002, and Washington Group International, 2002).

In September 1998, the Quapaw Tribe of Oklahoma requested assistance from the EPA to conduct response activities at an abandoned office complex located in Cardin, Oklahoma. The land was owned by the Quapaw tribe, and had been leased by Eagle-Picher Industries, Inc. from 1945 until 1981. A drum containing residual cyanide had been discovered in one of the site buildings during work conducted in 1998. EPA performed evaluations of the atmosphere inside this building and determined that no cyanide above background levels were present (EPA, 2000a).

In March 1999, the Inter-Tribal Environmental Council (ITEC) conducted a site reconnaissance of the property in advance of the completion of an RI/FS being conducted by the ITEC and Quapaw Tribe for the EPA. During this site reconnaissance, 120 containers of laboratory chemicals were discovered at the site. The EPA conducted a Hazardous Characterization, again at the request of the ITEC, in May and June 1999. These chemicals were inventoried, categorized, segregated, and overpacked in preparation of future disposal by the BIA. The BIA informed the EPA that it did not have the funding or expertise to remove the chemicals from the site (EPA, 2000a).

On March 2, 2000, an action memorandum was issued by EPA approving a time-critical removal action at the Eagle-Picher Office Complex – Abandoned Mining Chemicals. This portion of the site was designated OU3. The action memorandum determined that the chemicals posed an imminent and substantial endangerment to the public health or welfare or the environment. This determination was made on the basis that the containers in which the chemicals were stored had to be placed outside, where they were exposed to the elements. The EPA was concerned that eventually the containers would deteriorate, releasing the chemicals into the environment (EPA, 2000a).

On March 28, 2000, the emergency removal action was conducted. The laboratory chemicals were removed from the site and transported to facilities appropriate for their disposal. The EPA was unable to dispose of some low-level, radioactive uranyl acetate. The EPA remobilized to the site on May 23, 2000. This material was removed from the site and transported to an offsite location for treatment and disposal (EPA, 2000c, and EPA 2000d). The EPA determined that no further action was required in relation to OU3 (EPA, 2004).

## 3.5 Basis for Taking Action

The purpose of the response actions conducted at the Tar Creek site was to protect public health and welfare and the environment from releases or threatened releases of hazardous substances from the site. Discharges of acid mine water from the abandoned mines to surface water and possible direct migration to the underlying Roubidoux Aquifer threatened human health and the environment. In addition, exposure to lead contamination in residential soils was determined to be associated with human health risks higher than the acceptable range. The primary threats that the Tar Creek site posed to public health and safety were: potential contamination of water supply wells completed in the Roubidoux Aquifer from acid mine water; possible direct dermal contact with acid mine water where ground water discharges at the surface; severe ecological impacts to Tar Creek as a result of the acid mine water discharges; and oral ingestion of lead contaminated soils (EPA, 1984, and EPA, 1997).

# 4.0 Remedial Actions

This section provides a description of the remedy objectives, remedy selection, and remedy implementation for both of the two OUs for which RODs have been signed by EPA for the site. It also describes the ongoing O&M activities performed at the site in the period since completion of the second five-year review. The two OUs for which RODs have been signed are: (a) OU1 (ground and surface water); and (b) OU2 (lead contaminated surface soils in residential areas and HAAs). Two additional OUs have been designated at the site: (a) OU3 (abandoned mining chemicals at the Eagle-Picher Office Complex in Cardin, Oklahoma); and (b) OU4 (mining wastes including chat piles and flotation ponds). OU3 was addressed through a removal action, and the EPA has determined that no further action is necessary. Investigations related to OU4 are ongoing, and a ROD has not yet been signed.

## 4.1 Remedial Action Objectives

The specific remedial objectives of the OU1 remedial action were:

- Mitigate the potential threat to public health and the environment by preventing contamination of the Roubidoux Aquifer from acid mine water; and,
- Minimize the damage to Tar Creek from acid mine water discharges (EPA, 1994).

The specific remedial objective of the OU2 remedial action was:

- 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 (EPA, 1997).

## 4.2 Remedy Selection

Two RODs have been issued by EPA for the Tar Creek site. The OU1 ROD addressed the impacts associated with surface water discharges of acid mine water and through the migration of acid mine water from the Boone Aquifer to the underlying Roubidoux Aquifer. The ROD for OU2 addressed surface soil contamination in residential areas at the site. The site was also addressed through other response actions (the two removal response actions for OU2 and the removal action for OU3) as described in Section 3.4.

The ROD for OU1 was signed on June 6, 1984, to address the mitigation of surface and ground water discharges of acid mine water to Tar Creek and to prevent the potential contamination of the Roubidoux Aquifer through acid mine water migration from the overlying Boone Aquifer. Elements of OU1 included response actions to address contaminated ground water as a result of acid mine water seepage and contaminated surface water as a result of acid mine water discharges (EPA, 1984).

The remedy described in the 1984 ROD for OU1 consisted of the following elements:

- Abandoned wells completed in the Roubidoux Aquifer were to be plugged. Each well was to be cleared of obstructions. The wells were then to be plugged from the bottom to the surface using an acid resistant cement.

- Surface water diversion and diking structures were to be constructed around two major inflow areas to prevent surface water inflow into the abandoned mines. The two inflow areas were identified as the abandoned mine shafts called Muncie and Big John. These two inflow areas combined were thought to represent 75% of the total surface inflows into the abandoned mines. It was thought that the elimination of these inflow points would cause the ground water levels in the mines to drop and, as a result the amount of acid mine water discharged to the surface would be reduced or eliminated. It was predicted that the Admiralty location would become an inflow point after the initial diking and diversion work was completed, so the ROD allowed for additional diking and surface water diversion around this location if deemed necessary.
- A surface water and ground water monitoring program was to be conducted for two years. The purpose of the monitoring was to assess the effectiveness of the remedial actions at preventing contamination of the Roubidoux Aquifer and reducing the acid mine water discharges into Tar Creek (EPA, 1984).
- A fund-balancing waiver to certain Applicable or Relevant and Appropriate Requirements (ARARs) was granted. The waiver was invoked in the ROD declaration based on the prohibitively high costs that would be associated with other engineered solutions to address the surface water contamination in Tar Creek. It was determined that these costs would drain the Superfund and put at risk the EPA's ability to address other releases under CERCLA and the NCP (EPA, 1984, and EPA, 2000b).
- The ROD stated that future remedial actions would be required if the selected alternatives did not adequately mitigate the risk to human health (EPA, 1984).

The ROD for OU2, residential soils, was signed on August 27, 1997. This ROD addressed soils in residential yards and HAAs contaminated with lead (EPA, 1997).

The remedy described in the ROD for OU2 (residential soils) included the following elements:

- Excavation of soils in residential areas and HAAs containing lead with concentrations greater than or equal to 500 ppm to a depth of 18 inches. If lead concentrations exceed 500 ppm below 18 inches, a marker consisting of geotextile fabric or other suitable material would be placed in the excavation prior to backfilling to warn of contamination below the barrier. Each excavation was to be backfilled with clean top soil.
- Excavation of obvious hot spots (places where chat contamination was readily observable at the surface).
- Establishing new vegetation using sod or re-seeding.
- Backfilling of traffic areas and driveways with road base materials.
- On site disposal of excavated materials at a permanent long-term disposal area.
- Institutional controls which may include the following:

    1) Restrictions and management controls on unsafe uses of mine tailings;
    2) Restrictions and management controls on activities that would cause recontamination of remediated properties;
    3) Restrictions and management controls on activities that would contaminate clean site property with mine tailings;

4) Restrictions and management controls intended to prevent future exposure of children to unacceptable levels of lead in the soil at new residential developments that are located in areas with high lead levels in soil;
5) Restrictions and management controls on building and construction activities in order to prevent building and construction practices that would increase exposure to lead-contaminated soils;
6) Restrictions and management controls on access to contaminated property through physical barriers (e.g., fencing) or notices (e.g., warning signs);
7) Public health and environmental ordinances and controls related to lead exposure and management of mine tailings;
8) Placing notices in property deeds regarding contamination;
9) Sampling and analysis of lead sources;
10) Blood lead monitoring;
11) Health education; and,
12) Lead-contaminated dust reduction activities.

- Measures to prevent the recontamination of residential properties, or that would reduce the potential for recontamination of residential properties included:

1) Vegetating poorly vegetated or unvegetated areas;
2) Capping with soil;
3) Capping with base coarse material or paving;
4) Applying dust suppressants or other dust control measures;
5) Controlling drainage;
6) Consolidation of source materials;
7) Containment of source materials; and,
8) Abating lead sources to prevent releases into the environment that would recontaminate remediated areas.

The OU2 ROD also included several provisions to address lead contaminated soils at the Site and within Ottawa County. The ROD expanded the site to include all portions of Ottawa County that were impacted by mining wastes, including HAAs outside the mining area and the entire floodplain of Tar Creek. The ROD contained a provision to cover or replace chat material in alleyways, parking lots, roads, driveways, and other such areas located near residences with road base materials such as gravel or crushed limestone. The ROD called for expanding the use of physical barriers to restrict access to mining wastes located near residences as deemed appropriate.

The ROD provided for the establishment of ground cover, such as grass, in bare contaminated soils at certain residences, located generally outside the mining area but within Ottawa County. Finally, the ROD stipulated that, at certain residences located generally outside the mining area but within Ottawa County, where medical monitoring has found that a resident has elevated blood lead levels close to or above 10 µg/dl, and where the residential yard is contaminated with lead at concentrations at or above 500 ppm, the soil would be excavated and replaced as called for under the selected remedy.

## 4.3 Remedy Implementation

After signing the ROD for OU1, the surface water diversion and diking work at the Big John and Muncie Mine sites proceeded as part of the RA. It was also decided to proceed with the diking and diversion work at the Admiralty Mine site. The construction at these three sites was completed on December 22, 1986 (EPA, 1994).

The work to clear and plug the 66 abandoned Roubidoux wells identified in the ROD began in September 1985, when IT Corporation was contracted by the OWRB to conduct the work. Of the 66 identified wells, 4 wells could not be located, 7 wells were found to be shallow (not completed in the Roubidoux Aquifer), 3 wells were still in use, 2 wells had been properly plugged and abandoned, and access was not granted at one well location. In addition, 2 wells were not plugged due to high cost, and at 4 of the wells, it was not physically feasible to plug the entire well, so a cement plug was placed at the floor of the mine workings. The remaining 43 wells were properly plugged and abandoned (IT, 1985). After completion of the initial work, 17 additional wells were identified. The OWRB contracted with Engineering Enterprises, Inc. to conduct the additional work. Of the 17 wells, 13 were plugged and abandoned. Two wells were determined to be shallow vent holes or dewatering wells, and were not plugged. Two wells were not plugged due to technical difficulties. The additional work was completed in October 1986 (EEI, 1986).

Following construction activities at OU1, a two-year monitoring and surveillance program was conducted to assess the effectiveness of the RA activities at mitigating the acid mine drainage discharges to Tar Creek and preventing the migration of the acid mine water to the Roubidoux Aquifer. Surface water flow measurements and water quality data were collected at locations along and near Tar Creek to determine if the pollutant loading to Tar Creek had changed as a result of the RA construction activities. Water levels were monitored in the Blue Goose Mine (considered to be indicative of the water levels within the Boone Aquifer and related to the discharge volumes from the mines to Tar Creek) to determine if the water levels within the Boone Aquifer and the mine workings had decreased. Finally, water quality data were collected from public water supply wells completed within the Roubidoux Aquifer to assess the water quality after completion of the well plugging activities. These monitoring activities were conducted in 1987 and 1988. The results of the monitoring and surveillance program were detailed in a report submitted by the OWRB to the EPA in 1991 and summarized in the first Five-Year Review Report (EPA, 1994). Further discussion regarding the results of this monitoring are provided in Section 4.5.

After signing the ROD for OU2, the removal actions being conducted for the HAAs and residential properties were transitioned into the RA for OU2. The EPA and the USACE signed an IAG in September 1999. The USACE conducted the Remedial Design (RD)/RA under the direction of the EPA. MK was the contractor selected by the USACE to perform the RD/RA for OU2 (USACE, 2002).

MK began remediation at the site in February 1998. During assessment activities conducted between 1996 and 2000, approximately 2,774 properties were identified that required assessment sampling for lead in soils. Of these properties, 2,380 were assessed for lead contamination, and 2,106 exceeded the 500 ppm remediation goal for lead (88% of the assessed properties) (Washington Group International, 2002). The USACE and MK conducted remediation at 1,300 properties during the RA. These 1,300

properties were the original properties identified by the OU2 ROD as requiring remediation. The USACE and MK completed the RA for the 1,300 properties identified at the time the OU2 ROD was signed in July 2000. MK and the USACE demobilized from the site in September, 2000 (USACE, 2002).

After July 2000, the EPA contracted directly with CH2M HILL, Inc. to complete the RA for the remaining 565 properties still to be addressed at the site. From July 2000 through July 2004, an additional 524 properties have been remediated. This number includes 105 properties administered by the BIA, 399 additional residential properties, and 12 additional HAAs (7 schools located in Miami, one school located in Picher, and 4 daycare facilities located in Miami). Through July 2004, a total of 2,072 residential properties and HAAs have been remediated as part of either the removal response actions or the OU2 RA (CH2M HILL, 2004).

## 4.4 Operations and Maintenance and Long-Term Monitoring

The State of Oklahoma, through the OWRB and, since 1993, the Oklahoma Department of Environmental Quality (ODEQ (the ODEQ was formed in 1993 and took over Superfund responsibilities in the State of Oklahoma from the ODSH and OWRB at that time), is responsible for conducting Long-Term Monitoring (LTM) activities, well plugging activities, and Operations and Maintenance (O&M) for OU1. These activities are conducted through a Cooperative Agreement between the ODEQ and EPA.

The ROD for OU1 does not specifically state what O&M activities were to occur at the site. However, the ROD does mention O&M and costs related to the dikes and diversion work. The ROD also stipulated that a two-year monitoring and surveillance program would be conducted after construction of the selected remedies to monitor the effectiveness of the well plugging program and the diking and diversion work (EPA, 1984). The results of the two-year monitoring and surveillance program were summarized and presented in the First Five-Year Review Report. After completion of the two-year monitoring program, it was determined that an After Action Monitoring (AAM) program would continue for OU1 to further investigate potential impacts to the Roubidoux Aquifer from acid mine water. The First Five-Year Review Report stated that after completion of this program, monitoring of the water quality in the Roubidoux Aquifer would be accomplished through the normal sampling conducted by the various water supply operators as required by the Safe Drinking Water Act (SWDA) (EPA, 1994). The AAM was conducted in two phases. Phase I activities were presented in the Second Five-Year Review Report (EPA, 2000b). The results of Phase II of the AAM are presented in Section 6.4.

Since completion of the Phase II AAM, the ODEQ has implemented the current LTM program with the approval of the EPA (see Section 6.4 for discussion of the ODEQ's recommendations resulting from the Phase II AAM). The ODEQ determined that the monitoring conducted by local water supply operators was inadequate for purposes of monitoring the water quality in the Roubidoux Aquifer. The ODEQ's reasons for this conclusion were: the analytical parameters and frequency of sampling vary between individual water suppliers; the sampling procedures are not consistent between water suppliers; and the sampling is conducted without an approved Quality Assurance Project Plan (QAPP). The ODEQ therefore recommended the LTM program to provide consistent analytical

testing procedures and sampling schedules and to ensure the quality and consistency of the data (ODEQ, 2002b).

The LTM program involves the sampling of 11 wells located at or near the site. These wells include 5 monitoring wells installed by the ODEQ during Phase II of the AAM, 5 municipal supply wells, and one private well. Each well is to be sampled twice per year for 5 years (ODEQ, 2002b, and ODEQ, 2004b). Sampling under the LTM program began in November 2003 (ODEQ, 2004d), and the results of the first sampling event are discussed in Section 6.4.

In addition, the ODEQ has proposed to conduct new Roubidoux background assessment sampling (see Section 6.4 for discussion of the ODEQ's recommendations resulting from the Phase II AAM). The purpose of the new background assessment is to confirm that the indicator parameters used to indicate acid mine water influx from the Boone Aquifer to in the Roubidoux Aquifer are appropriate. Also the background assessment will be used to confirm the background concentrations and tolerance limits used to evaluate acid mine water influx from the Boone Aquifer to the Roubidoux Aquifer. The ODEQ's current proposed plan is to collect samples at 12 Roubidoux wells located outside the mining area. The results will be used to confirm the current indicator parameters, background concentrations, and tolerance limits (ODEQ, 2002c, ODEQ, 2003a, and ODEQ, 2004b). It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

The ROD for OU1 recognized that additional abandoned Roubidoux wells might be identified in the future. The ROD contained provisions to evaluate the need and to plug additional wells if warranted (EPA, 1984). The ODEQ plugged and abandoned one well in 2001 and 5 wells in April 2004 (ODEQ, 2004c). The EPA and ODEQ continue to evaluate the need to plug abandoned Roubidoux wells when wells are identified and located.

The dikes and stream channel diversion work completed at the Muncie, Big John, and Admiralty sites have been inspected as part of the site inspection for each five-year review. As a result of these inspections, repairs to the dikes have been made when necessary to maintain the integrity of the dikes and diversion channels.

The OU2 ROD specifies O&M for OU2 to maintain the caps placed on the repositories used to dispose of excavated soils once the RA construction activities are completed. The OU2 ROD also stipulates that maintenance of supplemental institutional controls would be part of O&M after construction is completed (EPA, 1997). RA construction for OU2 is still ongoing. Therefore, no O&M activities are currently being conducted for OU2. Also, the EPA determined that no further action was warranted to address OU3, and O&M activities are not required for OU3 (EPA, 2000a).

## 4.5 Progress Since Initiation of Remedial Action

As discussed in Section 4.3, a two-year monitoring and surveillance program was conducted for the OU1 remedy during 1987 and 1988 by the OWRB. The data obtained from these activities were reviewed by the EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL). RSKERL

submitted a report in September 1989 (RSKERL, 1989). The OWRB documented the results and findings, including a summary of the conclusions of the RSKERL review, in a report submitted to the EPA in April 1991 (OWRB, 1991). The OWRB provided the following conclusions, which were summarized in the First Five-Year Review Report:

- The volume of the acid mine water discharged to Tar Creek was not significantly impacted by the OU1 remedial action;
- The concentrations of most constituents in the acid mine water discharges were decreasing. The cause of the decreasing concentrations was not known, but the OWRB stated the decreases were most likely the result of natural processes;
- The surface water quality was not significantly improved in Tar Creek, and the diking and diversion work was at best only partially effective; and,
- Although some public water supply wells in the Roubidoux Aquifer were affected by acid mine water, insufficient data existed to evaluate the effectiveness of the well plugging activities (EPA, 1994). It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

The EPA concurred with these findings.

The EPA in the First Five Year Review (1994) provided further findings and conclusions based on the data in the First Five-Year Review Report. These findings and conclusions included the following:

- The surface water data collected from Tar Creek were insufficient to perform statistical analysis due to the short monitoring period following construction;
- Monitoring data from the acid mine water discharges indicated that the contaminant concentrations were decreasing;
- The data indicated that the pollutant loading in Tar Creek was decreasing. The OWRB calculated that only 15% of the total metals loading to Tar Creek was from identified major discharges;
- The sediment data were erratic and conclusions on the effectiveness of the remediation could not be drawn; and,
- The data from the monitoring of water levels in the Blue Goose mine showed that overall, the long term average water level in the Boone Aquifer had not been reduced. However, the diking and diversion work had reduced short-term rises in water levels in the mines in response to precipitation events (EPA, 1994).

The EPA's overall conclusion in the First Five-Year Review was that other sources of recharge were contributing more to the acid mine water discharges to Tar Creek than previously estimated. The EPA concluded that the diking and diversion structures were effective at reducing surface water inflows into the mines in relation to specific precipitation events. However, the diking and diversion structures were at best only partially effective at achieving the remedial goal of decreasing the acid mine water discharges to Tar Creek.

The First Five-Year Review Report recommended that the post remediation ground water monitoring program be extended to evaluate the success of the well plugging program at preventing

contamination of the Roubidoux Aquifer (this program was already in progress). Also, 15 additional abandoned wells were identified after completion of the second well plugging program. The EPA recommended evaluating the need to plug these wells based on the results of the post remediation ground water monitoring program. Due to changes in the designated uses for Tar Creek, as stated in the Oklahoma Water Quality Standards (see discussion under Section 7.1), the EPA recommended no further remedial action or monitoring of Tar Creek. The other recommendations of the First Five-Year Review, related to OU2, are discussed in Section 3.4 (EPA, 1994).

The second ground water monitoring program, known as the Phase I AAM, was begun in 1991 to determine the quality of the water in the Roubidoux Aquifer and to assess the effectiveness of the well plugging activities. The goal of the program was to determine if acid mine water had contaminated the public water supply obtained from the Roubidoux Aquifer. The program included wellhead sampling of municipal supply wells and discrete sampling of the Roubidoux Aquifer. The wellhead sampling program was performed by the United States Geological Survey (USGS) for the OWRB between August 1992 and January 1993. Ten wells inside the mining area and one well outside the mining area (used to determine background concentrations) were sampled monthly during this period (EPA, 1994). The OU1 ROD did not set criteria to act as a "trigger" for action or decision regarding the effectiveness of the well plugging program. To provide such a trigger, in January 1993, an additional 10 wells outside the mining area were also sampled. By using wells outside the mining area, more statistically reliable data on background conditions could be gathered and indicator parameters that could be used to indicate the presence of acid mine water influx could be determined. Zinc, iron, and sulfate were chosen as indicator constituents of acid mine water influx due to large concentration differences for these constituents when comparing acid mine water to the background Roubidoux Aquifer concentrations (EPA, 1994). In addition to calculating background concentrations for the indicator parameters, the ODEQ established tolerance limits (statistically derived values representative of the upper limit of background concentrations) for each parameter (ODEQ, 1993). The background concentrations and tolerance limits for these indicator parameters are provided in Table 2. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

The results of the wellhead sampling were documented in an ODEQ report submitted in July 1993. The data showed that all 21 wells sampled were meeting the primary drinking water standards (primary drinking water standards are enforceable, health-based contaminant concentration limits established by EPA). However, five of the wells failed the secondary drinking water standards (secondary drinking water standards are non-enforceable standards established by EPA for aesthetic purposes such as taste or odor) for iron, and one of those wells also failed the secondary drinking water standard for sulfate. Three of the five wells were located in Picher, one well was located in Commerce, and one well was located in Quapaw. The analytical results for the indicator parameters from the Phase I AAM sampling are provided in Table 3. The EPA determined that these five wells were impacted by acid mine water from the Boone Aquifer, but it was not demonstrated if the impact was related to widespread infiltration of acid mine water into the Roubidoux from the Boone Aquifer or due to well integrity problems (ODEQ, 1993, and EPA, 1994).

Discrete sampling of the Roubidoux Aquifer was conducted by the ODEQ from 1996 until 2002. The ODEQ obtained samples from the impacted drinking water supply wells in Picher, Commerce, and

Quapaw. This sampling program was known as the Phase II AAM and is further discussed in Section 6.4 (ODEQ, 2002a).

For OU2, the USACE and MK completed remediation of the 1,300th property under the OU2 RA in July 2000. At the completion of the 1,300th property, 337,466 cubic yards of soil had been excavated at the site. This material was transported to a repository located at the former Eagle-Picher Central Mill site (located on County Road E40 between Commerce and Picher) and deposited in a dry former mill pond that was contaminated. A secondary repository has also been operated on land owned by the Ottawa County Reclamation Authority (located near the southwest corner of US Highway 69 and County Road E10) (USACE, 2002, and Washington Group International, 2002).

After July 2000, RA activities were no longer conducted by the USACE. Since July 2000, RA activities have been conducted by EPA contractor CH2M HILL, Inc. An additional 524 properties have been remediated through July 2004. The total number of residential properties and HAAs that have been remediated as part of the removal response actions and OU2 RA is 2,072 as of December 2004 (CH2M HILL, 2004). RA activities for OU2 are still ongoing.

Several surveys of blood lead concentrations have been conducted at the site since the early 1990's. A study conducted by the OSDH in 1995 in Picher, Oklahoma, found the percentage of children with elevated blood lead levels (above 10 µg/dl) similar to the levels predicted by the EPA's BHHRA (21.6%). Studies conducted by several mining companies in 1995 and 1996 determined that 38.3% of the children tested in Picher, 62.5% of the children tested in Cardin, and 13.4% of the children tested in Quapaw had blood lead levels in excess of 10 µg/dl (EPA, 1997). Independent studies comparing blood lead data collected in 1997 to data collected in 2000 demonstrated an approximate 50% decrease in the number of children between the ages of 1 and 6, with blood lead levels above the 10 µg/dl standard set by the CDC, living in Picher and Cardin. This reduction has been attributed to the residential yard remediation efforts and extensive educational efforts conducted by various federal, state, county, and tribal entities (EPA, 2004).

The United States Agency for Toxic Substances and Disease Registry (ATSDR) recently completed an assessment of blood lead levels in children at the site. This assessment compiled blood lead data collected at the site between January 1995 and February 2004. Based on an analysis performed on this data, the ATSDR determined that from 1995 to 2003, a decrease was observed in both the average blood lead levels and the percentage of elevated blood lead levels in children between the ages of 1 and 5 at the site who were tested for lead. Based on the data from 2003, the ATSDR stated that the data showed that among tested children between the ages of 1 and 5 at the site, 2.8% had elevated blood lead levels (above 10 µg/dl). The ATSDR concluded in their report that the two potential sources for lead in children at the site were mine tailings and lead-based paint. The ATSDR further concluded that the available evidence indicated that mine tailings in residential soils was the primary exposure pathway and source of lead in children's blood at the site prior to the EPA's implementation of the OU2 RA, but other potential exposure pathways needed further investigation (ATSDR, 2004).

On December 9, 2003, the EPA signed an Administrative Order on Consent (AOC) with the Potentially Responsible Parties (PRPs) including the United States Department of the Interior (DOI), Blue Tee Corporation, and Gold Fields Mining Corporation, to conduct the RI/FS for OU4. In the AOC, OU4 is defined as:

> "Operable Unit 4" or "OU4" means noncontiguous, asymmetrical parts of the Site(both urban and rural), that are not presently used for residential purposes or which are sparsely used for residential purposes, where mine and mill tailings have been deposited, stored, disposed of, placed, or otherwise come to be located as a result of mining, milling or related operations (e.g., in a rural Site area– an area with one or two residences per square mile, containing former flotation pond areas, chat bases or chat piles and associated transition zones; or, in an urban Site area– an empty lot containing former flotation pond areas, chat bases or chat piles and associated transition zones). Specifically excluded from OU4 are mine and mill tailings located on roadways or alleyways, or that has been physically transported to a location that is not contiguous with its original location by someone other than a mine or mill operator in connection with mining, milling or related operations. Excepted from the exclusion in the preceding sentence, and included in OU4, are unpaved roadways or alleyways that are built on or contiguous to chat piles, chat bases, or flotation ponds OU4 does not include mine shafts, or underground mine workings. OU4 is generally described on the attached Map (Attachment 3) entitled "Map of Operable Unit 4, Tar Creek Superfund Site;" however, the size and shape of OU4 may change somewhat as new information is gathered as the RI/FS proceeds (EPA, 2003).

The RI/FS will include activities to locate, investigate, and sample domestic wells at the site that may be completed within the Boone Aquifer. Under the AOC, the EPA retained responsibility to conduct the BHHRA and the ecological risk assessment (ERA) for OU4 (EPA, 2003). After completion of the RI/FS and risk assessments, EPA will evaluate the site condition and determine if any further actions are required.

The EPA has provided funding to the Quapaw Tribe and ITEC to conduct an RI/FS on two industrial properties located in Cardin and to conduct the Beaver Creek Watershed RI/FS project. The results from the work of the Quapaw Tribe and ITEC in Cardin and on Beaver Creek will be incorporated into OU4 activities. RI/FS and risk assessment activities are currently in the planning phase for OU4 (EPA, 2004).

## 4.6 Activities Conducted At The Site By Other Governmental Agencies

Various other Federal, Tribal, State, and local agencies are also performing work at the Tar Creek site to address various environmental, health, and safety risks associated with the site. These agencies include the USACE, USGS, ODEQ, the Oklahoma Conservation Commission (OCC), the University of Oklahoma, the Grand Gateway Economic Development Association (GGEDA), the Quapaw Tribe, and the ATSDR. The following paragraphs will describe the activities these various agencies are conducting, outside of the EPA's Superfund work, at the Tar Creek site.

In 2000, former Oklahoma Governor Frank Keating formed a Tar Creek Task Force to assess the extent of problems at the site that were not being addressed and to provide recommendations for addressing these problems. The work of this Task Force focused on eight areas of concern related to the site. These included health effects, mine shafts, subsidence, chat use, water quality, Native American issues, drainage and flooding, and natural resources damages. Each issue was addressed by a separate subcommittee. A final report was issued by the Task Force in October 2000. The report

recommended relocation of residents in the Picher-Cardin area and the construction of a passive treatment wetland (Office of the Secretary of State, 2000). Funds were not appropriated to address the recommendations of the Task Force. However, the recommendations of the Task Force resulted in much of the efforts that are described below.

The State of Oklahoma, through the cooperation of the ODEQ, Oklahoma Senator James Inhofe, the University of Oklahoma, and the Quapaw Tribe, has developed the Oklahoma Plan for Tar Creek. This plan was developed to provide a comprehensive long-term clean-up process to address problems at the site where no legal obstacles exist. The plan focuses on the perimeter areas of the site (Commerce, Miami, North Miami, and Quapaw), but steps would be taken to protect human health in the Picher/Cardin area. It is also stated in the plan that the parties to the plan would work towards removing legal obstacles that exist to implementing clean-up actions in the Picher/Cardin area of the site. The objectives, as stated in the plan, are to improve surface water quality, reduce exposure to lead dust, attenuate mine hazards, and perform land reclamation. The plan outlines several tasks/activities that are to be undertaken to achieve these objectives, which are described in the following paragraphs (ODEQ, the Quapaw Tribe, University of Oklahoma, and Senator James Inhofe, undated). Senator James Inhofe has secured $45 million in funding to implement the activities described in the plan.

The University of Oklahoma will perform three tasks/activities under the Oklahoma Plan for Tar Creek. The University of Oklahoma will construct a passive treatment system (constructed wetland) to treat acid mine discharges in the Commerce area and improve surface water quality in Tar Creek downstream of the treatment system. This project is being conducted as a pilot study to determine the feasibility of passive treatment of the acid mine discharges through the use of constructed wetlands. The University of Oklahoma will also perform a study to investigate the optimum chat-in-asphalt mix for paving roads at the site. The study will include environmental and engineering sampling and testing to monitor the performance of a test section of road paved with a chat-asphalt mix. The goal is to determine if encapsulating chat in asphalt reduces exposure and risk related to both chat piles and unpaved chat roads. The University of Oklahoma is currently working to implement both projects. The University of Oklahoma will also implement an environmental monitoring program to evaluate the results of work conducted under the plan. This monitoring will include monitoring surface water, ground water, and air quality. These monitoring efforts will be conducted site-wide and at implementation sites. Air quality monitoring will be augmented by ambient air quality monitoring being conducted by the Quapaw Tribe in the Picher/Cardin area. In addition, the University of Oklahoma will work with the USGS to expand on mine water and hydrologic modeling activities at the site (ODEQ, the Quapaw Tribe, University of Oklahoma, and Senator James Inhofe, undated). The modeling efforts will be used to provide adequate data for the use of constructed wetlands as a passive treatment technology for addressing the acid mine discharges at the site.

The ODEQ will also perform three tasks/activities under the Oklahoma Plan for Tar Creek. The ODEQ will perform work to remove chat and mine waste from stream channels at the site to improve surface water quality. The initial work will be conducted along streams in the North Miami/ Commerce area and in the Beaver Creek watershed. The ODEQ will perform paving of all unpaved roads at the Tar Creek site using chat-asphalt mixes designed based on the recommendations of the study performed by the University of Oklahoma. The ODEQ will also perform land reclamation and mine hazard attenuation activities under the plan. Land reclamation work will include removing chat

from scarred areas, grading of any remaining chat on the surface, and covering the surface with organic matter and revegetating. Mine hazard attenuation will include using chat and other fill materials to close mine shafts and fill subsidences (ODEQ, the Quapaw Tribe, University of Oklahoma, and Senator James Inhofe, undated).

The State of Oklahoma, through the ODEQ and the OCC, performed a restoration project on land located near Hockerville. This project included plugging seven mine shafts, removing one mill pond and a chat base to native soil, filling in two subsidences, and adding organic amendments to the soil to produce productive pasture land. The ODEQ has also performed land reclamation pilot studies at a site near Commerce. The ODEQ plowed under chat on the site, applied organic matter to the field, and then planted grass on the field. Testing revealed that the grass did not contain high concentrations of lead. The ODEQ performed similar work at the repository located on E40 Road (USACE, 2003). The ODEQ is planning to implement additional work plugging mine shafts and restoring mining impacted lands west of Commerce in 2004 (USACE, 2004).

The State of Oklahoma, through the OCC, performed a similar land reclamation project on a 14-acre site northwest of Commerce in August and September 2004. This project was funded by the USDA's Natural Resources Conservation Service. Approximately 27,000 cubic yards (up to two feet deep) of chat were removed from the site and deposited in a sinkhole on the southwest side of Commerce (OCC, 2004).

The State of Oklahoma, through the ODEQ, performed a study in 2002 and 2003 to determine the safety of consuming fish in Oklahoma waters affected by runoff from the Tri-State mining area (including the Tar Creek site). This study was conducted due to concerns expressed by the local community and several of the local Tribes. The local Tribes expressed concerns related to the custom of eating whole fish, which are prepared through canning by means of pressure cooking. The ODEQ performed the study and published the results in a report issued in July 2003 (ODEQ, 2003b).

As part of the study, the ODEQ collected fish samples from four ponds at the Tar Creek site and from three locations on the Neosho and Spring Rivers respectively, and the fish samples were analyzed for lead, cadmium, and zinc. The ODEQ prepared three separate types of samples for analysis: whole-uneviscerated fish, whole-eviscerated fish, and fillets. The whole-uneviscerated and whole-eviscerated samples were prepared to determine if fish prepared and consumed according to local tribal customs were safe. The ODEQ also calculated risk-based levels to determine safe consumption levels of lead, cadmium, and zinc in fish. Based on the results of this study, the ODEQ concluded that consumption of whole-eviscerated and whole-uneviscerated portions of all fish caught from the Oklahoma portions of the Neosho and Spring Rivers downstream to Grand Lake and fish caught from ponds in the Tri-State Mining area were not safe for consumption. The ODEQ did conclude that fillets of fish caught from these areas were safe to eat at rates up to six eight-ounce meals per month. Finally, the ODEQ recommended follow-up studies to verify the results of this study using lower analytical detection limits and to determine the downstream extent of the metals uptake in fish, specifically within Grand Lake (ODEQ, 2003b). On July 17, 2003, the ODEQ issued a fish consumption advisory for the Tar Creek area. The consumption advisory detailed the results of this study. The advisory further stated that only skinless fillets of fish caught in the Tar Creek area should be consumed. Finally, the advisory stated that people should avoid eating the bones of any fish, whether whole-eviscerated or whole-uneviscerated, from fish caught at the Tar Creek site and the Spring and Neosho Rivers (ODEQ, 2003c).

The USGS is currently working on several projects at the site. The USGS, in partnership with the ODEQ, is performing stream and sediment sampling along Tar Creek, the Spring River, the Neosho River, and Upper Grand Lake (see Section 5.3 for further discussion). The USGS is also conducting limited sampling of trace metals in water and sediments in Grand Lake in areas under the jurisdiction of the Seneca-Cayuga Tribe. This work is being conducted to compare the results to those obtained from a study the USGS performed in 2002 (USACE, 2003). Finally, the USGS is developing a preliminary hydrogeologic model of the Tar Creek Watershed as part of efforts to address the various flooding, environmental, and safety related issues at the Tar Creek site (USACE, 2004). The USGS performed sampling of several mineshafts at the site 2002. As part of the sampling effort, the USGS compared this data to data collected in previous studies. The USGS concluded that the 2002 sampling data demonstrated that the quality of water within the mine shafts had improved since 1976-1977 (USGS, 2003, and USGS 2004).

The ATSDR currently provides funding from EPA for the Ottawa County Health Department to conduct blood lead screening and to provide lead exposure prevention education at the site. The ATSDR is developing a protocol to test blood for lead isotopic ratios to determine the environmental source(s) of lead contributing to elevated blood lead levels in children (ATSDR, 2004). The ATSDR has developed an exposure evaluation tool for use by the local tribes at the site. This tool allows each tribe to evaluate environmental exposures based on cultural specific issues. The ATSDR has also begun working with the OSDH to evaluate health outcome data for the Tar Creek area.

The ATSDR recently completed an evaluation of the sources and pathways of exposure at the site. The major completed pathways identified by the ATSDR were residential soil, mine tailings, and lead-based paint. The ATSDR determined that the primary point of exposure was house dust and yard soil. Based on an evaluation of the blood lead level data collected at the site, the ATSDR concluded that in 2003, among children tested who lived at the site between the ages of 1 and 5, 2.8% had elevated blood lead levels (above 10 µg/dl). In the Picher/Cardin area of the site in 2003, 3.4% of the children tested between the ages of 1 and 5 had elevated blood lead levels. The ATSDR concluded that the available evidence suggested that the mine tailings in residential soils exposure pathway may have been the primary source of elevated blood lead levels in children prior to the OU2 RA (ATSDR, 2004).

The Quapaw Tribe is currently performing several activities at the Tar Creek site. The first activity is the Tar Creek Air Monitoring Project. This work involves the collection of air samples from four locations in the Picher/Cardin area near homes that are downwind of chat piles and one background location north of Miami, Oklahoma. This program began in October 2003 and will continue for 18 months. The purpose of the project is to determine if environmental concerns or health issues are present related to airborne contamination. The Quapaw Tribe is also conducting a Lead Baseline Assessment Project. For this project, lead-based paint inspections and risk assessments will be conducted at Native American households, daycare facilities, and schools located in Ottawa County. Samples of paint, dust, and soil will be collected to identify the source or potential sources of lead exposure. Finally, the Quapaw Tribe is currently in the process of developing Water Quality Standards within the exterior boundaries of the Quapaw Tribe reservation and trust lands (Quapaw Tribe of Oklahoma, 2004).

The GGEDA has been awarded a grant from the United States Department of Housing and Urban Development (HUD) to identify and control lead-based paint hazards at households in Ottawa County. The program will provide inspections to identify and control lead-based paint hazards for low-income residences in Ottawa County (USACE, 2003).

The USACE issued a draft Watershed Management Plan for Tar Creek and the Lower Spring River in August 2004. The public comment period for the draft Watershed Management Period ended on October 15, 2004. The purpose of the plan is to identify problems that affect residents and identify appropriate solutions for both watersheds. The plan recognizes that many government agencies, the tribes, and local community groups are conducting work at the site, including the EPA's work at the site and all the activities discussed above in Section 4.6. Due to all the ongoing activities that are being undertaken at the site, the USACE decided to identify additional short and long-term activities that would, along with the ongoing activities, provide a comprehensive solution to the many problems encountered at the site. Additional activities the USACE proposes in the draft Watershed Management Plan include:

- Addressing mine hazards, including subsidence problems in populated areas and along major road corridors;
- Addressing open and poorly sealed mine shafts and open boreholes;
- Assessing impacted stream corridors in the Picher/Cardin to address impacted ecosystems and flooding problems;
- Addressing the acid mine drainage problems in the area of the Tar Creek and Lytle Creek confluence; and,
- Addressing flooding problems along Tar Creek and the Neosho River in Miami (USACE, 2004c).

The draft Watershed Management Plan states that some of this work is an extension of existing activities into areas of the site that are not being addressed. Also, the draft Watershed Management Plan identifies various options for addressing the many problems listed above. However, the plan states that addressing these problems will be an iterative process. Additional work will have to build on the work currently being conducted at the site by the various federal, state, tribal, and local government agencies at the site (USACE, 2004c).

On May 1, 2003, the EPA, United States Department of the Army (through the USACE), and the DOI entered into a Memorandum of Understanding (MOU) for the Tar Creek site. The purpose of the MOU is to facilitate cooperation between each signatory and provide for coordinated response, reclamation, and restoration activities under the statutory authorities of each signatory to the MOU. Due to the complexity, size, and scope of the issues at the Tar Creek site, the MOU states that the signatory Agencies will work together to coordinate activities with the State, Tribes, local governments, and local community groups to develop and implement solutions that address the health, safety, and environmental issues at the Tar Creek site. The MOU called for the creation of a Federal Tar Creek Steering Committee to work with the Tribal, State, and local governments towards these goals (EPA, USA, and DOI, 2003). In January and February 2004, the signatories to the MOU held two coordination meetings as a result of the MOU. Also, a public meeting was held in Miami, Oklahoma in March 2004. Various Federal, State, and local governmental agencies and local community groups have participated in these meetings (USACE, 2004).

# 5.0 Progress Since the Second Five-Year Review

The second five-year review of the Tar Creek site was completed in April 2000, for the period from April 1994, when the first five-year review was completed, through April 2000. The findings of the second five-year review, the status of recommendations and follow-up actions, the results of implemented actions, and the status of any other issues are described in the following sections.

## 5.1 Protectiveness Statements from Second Five-Year Review

The Second Five-Year Review report concluded that the remedial actions implemented at the Tar Creek site were protective of human health. The Second Five-Year Review Report stated that for OU1, the Roubidoux Aquifer continued to meet all health-based primary drinking water standards. Also, although environmental components of the Water Quality Standards for Tar Creek were not being met, there was no threat to human health. The ROD for OU1 stipulated that future remedial actions would be required if the selected alternatives did not adequately mitigate the risk to human health. Regarding the environmental components of the Water Quality Standards, the Second Five-Year Review Report re-stated that the fund-balancing waiver invoked in the 1984 ROD was still appropriate for the site. Addressing the environmental impacts to Tar Creek would potentially drain the Superfund and impact EPA's ability to address other releases under CERCLA and the NCP. The Second Five-Year Review Report restated that it was therefore inappropriate to meet the environmental Water Quality Standards for surface water in Tar Creek. For OU2, the Second Five-Year Review Report stated that the OU2 remedy being implemented was protective of human health and the environment (EPA, 2000b).

## 5.2 Second Five-Year Review Recommendations and Follow-up Actions

The second five-year review of the Tar Creek site, completed in April 2000, recommended the following follow-up actions:

- A continuation of the ground water monitoring program (After Action Monitoring) for the Roubidoux Aquifer to evaluate whether the well plugging had successfully prevented contamination of the aquifer from the overlying Boone Aquifer. The discrete sampling of the Roubidoux Aquifer was being conducted by the ODEQ at the time of the second five-year review. At that time, the EPA and ODEQ were in the process of evaluating the initial results. The Second Five-Year Review Report stated that preliminary evaluation of the data indicated that acid mine water was infiltrating into the five impacted municipal supply wells through inadequate well integrity. The data from a monitor well installed in Picher indicated that the water quality within the Roubidoux Aquifer was good. The Second Five-Year Review Report additionally stated that once the discrete sampling was completed, monitoring of the Roubidoux Aquifer would be accomplished through the regular water quality testing conducted by water supply operators. Additional monitoring wells were to be installed in Picher and other communities where the public water supply was impacted by acid mine water infiltration. Finally, the report stated that if the Roubidoux Aquifer is no longer capable of meeting the primary drinking water standards, the need for additional actions would be evaluated.

- The 1984 ROD made allowances for the identification of additional abandoned Roubidoux wells and boreholes that would require plugging. The OWRB had identified 15 additional wells that might require plugging. The Second Five-Year Review Report concluded that the EPA would evaluate the need to plug the abandoned wells after the results of the discrete sampling effort had been evaluated.
- The second five-year review identified provisions in the ROD for OU2 that could be used to address potential problems that might arise for OU1. These provisions related to the institutional controls applicable to mining waste site-wide, and these provisions may be applied to protect humans exposed to surface water contamination as needed. The second five-year review identified the following institutional controls as being applicable for OU1:

    1) Implementation of restrictions or management controls on the unsafe uses of mining tailings.
    2) Construction of physical barriers (e.g., fencing) and warning signs around contaminated areas.
    3) Notifying prospective purchasers that property may be contaminated at depth, via deed notices.
    4) Education of site residents regarding the dangers of remaining contamination.

- The Second Five-Year Review Report stated that most of the monitoring data for Tar Creek were at least 10 years old. The report stated that additional monitoring may be needed to confirm that contaminant concentrations have not increased. The report recommended that the EPA should review the need for updated monitoring of the contamination of Tar Creek for human health impacts.
- Continue the remediation of OU2 residential areas as stipulated in the ROD.
- Continue investigations initiated in 1998 and 1999 for the non-residential areas of OU2 to complete the development of protective remedies (EPA, 2000b).

## 5.3 Status of Recommended Actions

This section describes the current status of implementation of the recommendations included in the Second Five-Year Review Report.

The Second Five-Year Review Report recommended a continuation of the AAM for the Roubidoux Aquifer to evaluate whether the well plugging had successfully prevented contamination of the aquifer from the overlying Boone Aquifer. From 1996 through 2002, the ODEQ conducted Phase II of the AAM of the Roubidoux Aquifer as part of OU1. The Phase II AAM was conducted to determine if the 5 wells impacted by acid mine water represented widespread infiltration of acid mine water into the Roubidoux Aquifer or if the impacts were related to faulty well casings. During the Phase II AAM, discrete sampling was performed at the five impacted municipal wells to obtain water samples from the Roubidoux Aquifer. Each well was modified to isolate the portion of the well completed within the Roubidoux Aquifer from the upper portion of the well casing. The discrete samples were collected by installing inflatable packers or polyvinyl chloride (PVC) liners inside the wells to isolate the portion of the well completed in the Roubidoux Aquifer, such that water samples were collected from the Roubidoux Aquifer only. This work was conducted in 1996 and 1997. In

addition, the ODEQ has installed five monitoring wells (one in 1997 and four in 2000) using state-of-the-art well construction techniques to monitor the water quality within the Roubidoux Aquifer (ODEQ, 2002a). The results of the Phase I and II AAM are presented in Tables 3 and 4 and discussed in Section 6.4.

As a result of the Phase II AAM, the ODEQ has implemented an LTM program at the site to monitor the quality of the water in the Roubidoux Aquifer. The LTM program includes sampling of 11 wells located in or near the mining area. The results to-date of the LTM program are discussed in Section 6.4 and presented in Table 5.

The Second Five-Year Review Report recommended that the EPA evaluate the need to plug the 15 additional abandoned wells after the results of the discrete sampling effort had been evaluated. The ODEQ evaluated the need to plug these, and six wells were identified that required plugging. In 2001, the ODEQ plugged one well in Quapaw. In April 2004, the ODEQ plugged the other five wells at the site: three in Picher, one in Commerce, and one at the old Eagle Picher mill site (ODEQ, 2004b).

The Second Five-Year Review Report recommended that the EPA should review the need for updated monitoring of the contamination of Tar Creek for human health impacts. Soil sampling of the Tar Creek 100-year flood plain was conducted in July and August 2001. This work was conducted as part of the OU2 RA. This sampling was performed to evaluate whether surface water transport had resulted in contaminated sediments being deposited in the soils along downstream riverbanks and/or within the flood plain of Tar Creek. Samples were collected along Tar Creek from the 42nd Avenue (also known as D Street in Commerce) Bridge in Miami to the confluence of Tar Creek with the Neosho River. The samples were collected at 3,000 feet intervals along both creek banks. In addition, samples were collected along transects across the flood plain at three locations. Samples were also collected at the edge of the flood plain where tributary streams entered the flood plain, and sampling was conducted along the Belmont Run (a small tributary of Tar Creek in Miami). A total of 78 samples were collected and analyzed for lead. Additional details regarding the sampling event and sample collection procedures are documented in a Technical Memorandum prepared by II, Inc. to document the event (CH2M HILL, 2002c). The results of this sampling event are discussed in Section 6.4.

The EPA has not conducted surface water sampling in Tar Creek. However, the ODEQ, in conjunction with the USGS, is currently performing additional sampling of both the sediment and surface water in Tar Creek, the Spring River, the Neosho River, and Upper Grand Lake for general water quality, trace elements, and major ions. This study includes both high flow and low flow condition surface water sampling, collection of stream flow measurements, and sampling of the sediments in the Tar Creek flood plain. The purpose of this effort is to enhance the stream monitoring network in the Picher-Commerce and Miami area, provide estimates of heavy metals concentrations flowing downstream from the mining area, and determine water and sediment quality within the Grand-Neosho River Basin. Sampling efforts associated with this study were still ongoing at the time of this five-year review (USACE, 2004).

The ODEQ conducted a study to determine the levels of fish consumption that were safe for fish caught in the area of the Tar Creek site in 2002 and 2003. Based on this study, the ODEQ concluded that skinless fish fillets were safe to consume up to six eight-ounce meals per month. The ODEQ also

concluded that the bones of fish, whether whole-eviscerated or whole-uneviscerated, should not be consumed. Finally, the ODEQ recommended further study using lower detection limits to confirm the results of the first study, and the ODEQ recommended that fish from Grand Lake be tested to determine the downstream extent of the metals uptake in fish (ODEQ, 2003b). The ODEQ issued a fish consumption advisory based on the results of this study (ODEQ, 2003c).

The Second Five-Year Review Report recommended that remediation of residential yards continue as stipulated in the ROD for OU2. Remediation of residential properties as part of the OU2 RA has continued since completion of the second five-year review. From completion of the second five-year review through July 2004, 524 additional residential properties and HAAs have been remediated (CH2M HILL, 2004). RA activities associated with OU2 are still ongoing.

During March 2001, the EPA conducted screening level sampling for lead in the City of Miami. The purpose of this sampling was to assess if elevated levels of lead were present in areas where chat was visually identified. A total of 92 samples were collected from alleyways and parks. The 500 ppm action level for lead was exceeded in 71% of the samples (CH2M HILL, 2001). As a result of this sampling, the EPA decided to conduct further sampling of HAAs located in Ottawa County outside of the mining area.

Additional assessment sampling of HAAs located within Ottawa County was conducted in 2002. The purpose of these sampling efforts was to identify potential additional HAAs in other portions of Ottawa County that might require remediation. During February and March 2002, HAA sampling was conducted at 13 school facilities in Miami, Oklahoma and on property that was to be used as an extension at the Picher-Cardin Elementary School in Picher. During April and May 2002, sampling was conducted at 16 parks and 24 daycare facilities in Miami, Oklahoma. Finally, from April through August 2002, 8 schools, 12 parks, 9 daycares, and 7 Indian Tribal properties were sampled throughout other communities in Ottawa County (CH2M HILL, 2002a, CH2M HILL 2002b, and CH2M HILL, 2002d). The results of the additional HAA sampling are further discussed in Section 6.4.

Finally, the Second Five-Year Review Report recommended that the EPA continue investigations for the non-residential areas of OU2 to complete the development of protective remedies. Since completion of the second five-year review, the non-residential portions of the site, including the mining wastes (chat piles and flotation ponds), have been separated from OU2 and designated as OU4. The EPA has provided funding to the Quapaw Tribe and the ITEC to conduct RI/FS activities for two industrial properties located in Cardin and to prepare an RI/FS work plan for the Beaver Creek Watershed. The EPA has signed an AOC with the DOI and two mining companies to conduct the RI/FS for OU4. The EPA will be responsible for completing the BHHRA and the ERA for OU4 (EPA, 2003). The RI/FS and risk assessments for OU4 are currently being conducted.

# 6.0 Five-Year Review Process

This third five-year review for the site has been conducted in accordance with the EPA's Comprehensive Five-Year Review guidance dated June 2001 (EPA, 2001). Interviews were conducted with relevant parties; a site inspection was conducted; and applicable data and documentation covering the period of the review were evaluated. The activities conducted as part of this review and specific findings are described in the following paragraphs.

## 6.1 Administrative Components

The five-year review for this site was initiated by the EPA when EPA contractor CH2M HILL, Inc., was tasked to perform the technical components of the review. A public notice announcing initiation of the five-year review was published in the Miami News Record on July 23, 2004. The review team was led by the EPA Remedial Project Manager (RPM) for OUs 1 and 4 at this site, Ms. Ursula Lennox/EPA Region 6. Two ODEQ representatives, Mr. David Cates/ODEQ and Mr. Dennis Datin/ ODEQ, assisted the review team, providing information related to the Tar Creek site and assistance during the second five-year review site inspection. The components of the review included community involvement, document review, data review, a site inspection, interviews, and development of this Five-Year Review Report, as described in the following paragraphs.

## 6.2 Community Involvement

A public notice announcing initiation of the five-year review was published in the Miami News Record on July 23, 2004. Upon signature, the Third Five-Year Review Report will be placed in the information repositories for the site, both local to the site and at the EPA Region 6 office in Dallas, Texas. A notice will then be published in the Miami News Record to summarize the findings of the review and announce the availability of the report at the information repositories. Copies of the two public notices are provided as Attachment 5 to this report.

## 6.3 Document Review

This third five-year review for the site included a review of relevant site documents, including decision documents, construction and implementation reports, sampling reports, and related monitoring data. Documents reviewed are listed in Attachment 1.

## 6.4 Data Review

Ground water sampling results collected as part of the Phase II AAM and LTM program for the Roubidoux Aquifer were reviewed as part of this third five-year review. In addition, data collected as part of the additional HAA sampling activities in Ottawa County and the Tar Creek flood plain sampling were reviewed. These data consist of ground water and soil data. The results of this review are discussed in the following paragraphs.

During the Phase I AAM, it was determined that five municipal wells were potentially impacted by acid mine water. As part of the Phase I AAM, the ODEQ determined that zinc, iron, and sulfate were the three indicator parameters for determining whether a Roubidoux well was impacted by acid mine water. In addition, the ODEQ conducted sampling to determine background concentrations and tolerance limits for these three indicator parameters in the Roubidoux Aquifer. The background and tolerance limit values were determined using samples collected from municipal wells located outside of the mining area (ODEQ, 1993). These values are presented in Table 2. The results for zinc, iron, and sulfate samples collected during the Phase I AAM program sampling of the 5 potentially impacted municipal wells are included in Table 3. The Phase I AAM samples for these 5 wells were collected at the well-head (ODEQ, 2002a).

During the Phase II AAM, discrete samples were collected from the 5 municipal wells through the installation of packers or PVC sleeves. The purpose of the packers or PVC sleeves was to isolate the portion of the well open to the Roubidoux Aquifer from upper portions of the well, so that samples collected from the wells would be from the Roubidoux Aquifer only. Multiple samples were collected from each well during the period 1996 through 1999. The results of the Phase II AAM were documented by the ODEQ in a report submitted to the EPA in September 2002 (ODEQ, 2002a). The results of the Phase II AAM are included in Table 4. Table 4 also shows the average concentrations for sulfate, iron, and zinc from all samples collected during the Phase II AAM. Finally, Table 4 also includes the primary drinking water standards (expressed as Maximum Contaminant Levels or MCLs) and secondary drinking water standards (expressed as Secondary Maximum Contaminant Levels or SMCLs) for each analyte.

MCLs are enforceable health-based standards established under the SDWA. SMCLs are non-enforceable standards established under the SDWA for purposes such as aesthetics (taste, odor, color, etc.).

The data show that during the Phase I AAM sampling, the concentrations of all indicator parameters were above the tolerance limits, and all five municipal wells were considered potentially impacted by acid mine water (ODEQ, 2002a). The Phase II sample results show that the average iron and sulfate concentrations were similar to or higher than the Phase I sample results, but the average zinc concentrations were lower (Tables 3 and 4). The ODEQ September 2002 report stated that the concentrations of all three indicator parameters tended to increase with time after placement of the inflatable packers or PVC sleeves used to isolate the Roubidoux Aquifer. The ODEQ indicated that this suggested that either there was a failure to adequately isolate the Roubidoux Aquifer during the discrete sampling, or acid mine water had contaminated the Roubidoux Aquifer near these five wells (ODEQ, 2002a).

As a result of the Phase II AAM sampling at the five municipal supply wells, the ODEQ installed five monitoring wells to obtain more reliable and representative water quality data from the Roubidoux Aquifer. These monitoring wells were constructed using state-of-the-art well construction methods, and were constructed so that they could potentially be used as alternate water supply wells. These five monitoring wells were sampled multiple times between 1997 and 2002 (ODEQ, 2002a). The sample results from these five monitoring wells are also included in Table 4. The locations of the five municipal wells and five monitoring wells sampled during the AAM are presented on Figure 2.

The ODEQ used the following criteria when evaluating the data obtained from the new monitoring wells and the discrete sampling from the municipal wells:

- A well producing water with concentrations in excess of the tolerance limits for all three indicator parameters indicated the Roubidoux is impacted by acid mine water locally near the well site;
- A well producing water with concentrations in excess of the background concentrations for all three indicator parameters and above the tolerance limits for two of the indicator parameters indicated the Roubidoux Aquifer is probably impacted by acid mine water locally near the well site; and,

- A well producing water with concentrations in excess of the background concentrations for two of the three indicator parameters and above the tolerance limits for one of the indicator parameters indicated the Roubidoux Aquifer is possibly impacted by acid mine water locally near the well site (ODEQ, 2002a).

As the Phase II AAM data presented in Table 4 show, four of the municipal wells and two of the monitoring wells indicate the Roubidoux Aquifer to be locally impacted by acid mine water using these criteria. Also, one of the municipal wells indicates the Roubidoux Aquifer is probably impacted locally by acid mine water, and two monitoring wells indicate the Roubidoux Aquifer may possibly be impacted locally by acid mine water using these criteria. It is important to note that no primary drinking water standards are regularly exceeded, and that the mining related contaminants for which MCLs have been set (primarily lead, mercury, arsenic, and cadmium) were either not detected or detected near the analytical detection limits. One exceedance of the MCL was detected for selenium from the first Phase II AAM sample collected at the Picher #4 well. Selenium was not detected in all subsequent samples collected from this well during the Phase II AAM (ODEQ, 2002a).

The ODEQ recommended the following as a result of the Phase II AAM:

1. Implement a LTM program by sampling approximately 10 wells twice a year for five years. The purpose of the LTM program is to monitor the long-term effects of pumping the Roubidoux Aquifer from below the contaminated Boone Aquifer and the resultant concentration trends for the indicator parameters;
2. Perform a trend analysis using the data collected to-date. The results of the trend analysis would be used as a predictive tool for future decision making;
3. Plug all abandoned Roubidoux wells when identified as stipulated in the ROD; and,
4. Reevaluate the tolerance limits for the indicator parameters. New data would be collected through the sampling of approximately 10 wells located immediately outside the mining area in a program similar to the one conducted during the Phase I AAM (ODEQ, 2002a).

The first LTM sampling event was conducted in November 2003. Wells used in the LTM program include the five monitoring wells installed during the Phase II AAM, one municipal supply well located within the mining area (Cardin #1), four wells located on the edge of the mining area (Commerce #4, one private well, Quapaw #4, and the Rural Water District #4 Well #4 [RWD4 #4]), and one well located outside of the mining area (Miami #1). The private well is located at the former smelter location south of Hockerville. This well was reportedly used by the smelter, and is now used as a private water supply well. The locations of each well are shown on Figure 2 (ODEQ, 2004d). New municipal wells were chosen so that one well would be located within the mining area, three wells would be located on the edge of the mining area, and one well would be located outside the mining area (ODEQ, 2002b).

The results from the first LTM sampling event are included in Table 5. The private well was sampled on multiple occasions to determine the baseline conditions for the indicator parameters at that well. The Quapaw #5 MW well results show that the well is still impacted by acid mine water. Two of the wells (the private well and Picher #6 MW) are probably impacted by acid mine water. The results indicate that 4 wells (Cardin #1, Commerce #4, Picher #5 MW, and Picher #7 MW) are possibly impacted by acid mine water. A duplicate sample was collected at the Miami #1 well. The normal

sample shows results that indicate the well is possibly contaminated, while the duplicate sample indicates that the well is not impacted. The results indicate that 3 of the wells (RWD4 #4, Quapaw #4, and Commerce #5 MW) are not impacted by acid mine water. In general, the water quality conditions, as indicated by the concentrations of the 3 indicator parameters, have remained the same at four of the five monitoring wells since the Phase II AAM. However, at the Picher #6 MW well, the concentrations of each indicator parameter have decreased since the start of the Phase II AAM (see Tables 4 and 5). The ODEQ stated that the decrease may be due to the installation of a packer system in the well (indicating that the casing was leaking) or the use of shorter purge times for sampling (indicating the well was drawing in contaminated water from further away from the well) (ODEQ, 2004d).

Additional assessment sampling was conducted at HAAs located throughout Ottawa County during 2002. This sampling included 21 schools, 27 parks, 33 day care facilities, and 7 Indian Tribal properties located in Ottawa County outside of the mining area. In addition, one property in Picher, being considered for an extension of the Picher-Cardin Elementary School, was also sampled, and one park, located in Commerce, was sampled in an area where sampling was not previously conducted. Figure 3 provides a map of Ottawa County showing the locations of the various communities within the county. Sampling grids were established at each property that were no more than 2,500 square feet in area. Composite soil samples were collected from each grid in 6-inch intervals from 0 to 18 inches in depth and analyzed for lead. Lead concentrations above the 500 ppm remediation goal for soils were detected in at least one grid location at 9 schools (1 located in Picher and 8 located in Miami), 10 Parks (7 located in Miami and 1 each located in Commerce, Fairland, and Afton), and at 4 daycare facilities located in Miami (CH2M HILL, 2002a, CH2M HILL, 2002b, and CH2M HILL, 2002d).

As described in Section 5.3, soil sampling was conducted along the Tar Creek flood plain in July and August 2001. The objectives of the flood plain sampling were to determine if elevated concentrations of lead were present within the soils of the Tar Creek 100-year flood plain and to determine if lead concentrations detected in soils decreased in the downstream direction in the flood plain. Also, the data were to be used to determine if lead concentrations detected in soils along the banks of Tar Creek were similar to those detected from samples collected along transects extending out towards the edges of the flood plain. These samples were collected from 0 to 6 inches in depth and analyzed for lead only. A total of 78 samples were collected. Of the 78 samples, lead exceeded the 500 ppm remediation goal established for OU2 in 6 samples (CH2M HILL, 2002c).

Based on the analytical results, the following conclusions were drawn:

- The data do not exhibit an increasing or decreasing trend in soil lead concentrations from upstream to downstream areas along the 100-year floodplain;
- Lead soil concentrations tended to decrease away from the creek with distance along the three transects where samples were collected;
- Soil samples collected where tributaries entered the flood plain demonstrated lower lead concentrations than samples collected from the banks of Tar Creek; and,
- When evaluating potential exposure levels to the soils within the flood plain, soil lead data collected along the creek banks should yield a conservative estimate of risk (CH2M HILL, 2002c).

This sampling event was conducted along the Tar Creek flood plain from the southern edge of the mining district to the confluence of Tar Creek with the Neosho River. Where lead exceeded the 500 ppm remediation goal established by the ROD for OU2, the concentrations ranged from 609 to 1,120 ppm. Five of these samples were grab samples collected from the stream bank, while one sample was a composite sample collected from a 2,500 square foot area along the floodplain (this sample was collected in a manner similar to the residential yard assessment samples) (CH2M HILL, 2002c).

## 6.5 Interviews

During the course of this five-year review, interviews were conducted with several parties involved with the site: (1) Mr. David Cates of the ODEQ; (2) Mr. Tim Kent, Director of the Quapaw Tribe Environmental Department; (3) Mayor Jim Mullins, City of Commerce; (4) Mayor Sam Freeman, City of Picher; and (5) Mayor Neal Watson, City of Quapaw. Interview Record Forms which document the issues discussed during these interviews are provided in Attachment 2.

In general, the interviews noted an overall improvement in the activities related to the site since the previous five-year review. Most of the interviews indicated that the yard remediation work and community education efforts have had a positive impact on the surrounding communities. It was pointed out in all the interviews except one that the blood lead levels of children in the area had declined since the yard remediation work began. Mayor Freeman of Picher and Mr. Cates of the ODEQ both indicated that the work associated with OU1 to provide better water supplies to the local communities had been beneficial. Mr. Cates did express disappointment at the Quapaw #5 MW well producing poor quality water. He stated that the City of Quapaw was hoping the well could be used to replace several water supply wells that were producing poor quality water.

Mayor Freeman expressed disappointment that the yard remediation work was being stopped and put on hold again. Mayor Mullins of Commerce expressed that the City had concerns regarding drainage issues related to the yard remediation work. Mr. Tim Kent/Environmental Director for the Quapaw Tribe expressed concerns regarding the Tribe's involvement, as it relates to the requirements of CERCLA, at the site. In general, the interviews reflected that each party believed they were well informed about the activities occurring at the site.

## 6.6 Site Inspection

An inspection was conducted at the site on June 29 and 30, 2004. The completed site inspection checklist is provided in Attachment 3. Photographs taken during the Tar Creek site inspection are provided in Attachment 4.

During the site inspection, three of the five monitoring wells installed at the site by the ODEQ were inspected. Two of the wells (Picher #5 MW and Commerce #5 MW) had well houses constructed over the wells (Photographs 1 and 3). The Quapaw #5 MW did not have a well house (Photograph 51). Each well was in good condition and appropriately maintained. The Picher #5 MW well was connected to the City of Picher water supply system. The City of Commerce was preparing to connect the Commerce #5 MW well to its water supply system. The only noted problem was a cracked well pad at the Quapaw #5 MW (Photograph 52).

Two of the three diversion dikes constructed as part of the OU1 remedy were inspected. These dikes were constructed to divert surface water flow away from the Admiralty Mine subsidence and the Big John Mine subsidence. The dike at the Admiralty Mine site demonstrated one small area where the dike was collapsing (Photograph 5). A similar problem had been noted during the site inspection conducted as part of the second five-year review, and it had been repaired. The cause of the current collapse of the dike was not readily apparent. Mr. Cates/ODEQ indicated that the dike had partially been constructed along an old railroad embankment. He further stated that he thought the collapse on the dike was located where an old culvert had once existed for the railroad embankment. Vegetation was well established on the dike (Photographs 6 and 16). This dike was constructed near the confluence of Lytle Creek and Tar Creek. The Lytle Creek channel was diverted around the dike to the north and west (Photographs 7, 10, 11, 14, and 17). The diverted channel for Lytle Creek was clear of obstructions and free-flowing at the time of the site inspection (Photographs 11, 14, and 17). Acid mine water was observed discharging at the surface at several locations on the west side of the diversion dike (Photographs 8 and 9). The diversion dike and diversion channel for Lytle Creek moved the confluence of this stream with Tar Creek to a location upstream of the acid mine water discharges (Photographs 14 and 17). Except for the small collapse of the dike at the location noted above, the dike and diversion channel were both in overall good condition. During the site inspection, Mr. Cates indicated that the diversion channel for Lytle Creek had been cleared of obstructions after the second five-year review was completed.

There were no indications of failure noted on the dike constructed at the Big John Mine site. Vegetative growth was well established on the dike (Photographs 58-65). This dike was constructed to form a ring around the subsidence feature at the Big John Mine site (Photograph 59). The Tar Creek channel was diverted to the west of the subsidence feature (Photographs 59 and 67). Rock armor was present along the outside of the dike to protect it against erosion (Photographs 65-67). Water was present within the subsidence feature, and evidence that this location is used for swimming (a diving board) was observed (Photograph 60). The dike was noted to be in good condition during the site inspection.

Two soil repositories (locations where the soil from the OU2 RA yard remediation work is disposed) have been used at the site. One repository is located on private land on E40 Road, west of the Douthat Bridge (Photographs 21-26). This repository is located at the site of the former Eagle-Picher Central Mill. The soil from the yard remediation work has been used at this location to fill in and cover an old mill pond. The other repository (sometimes known as the North Repository) is located in Picher on Stateline Road, just west of U.S. Highway 69 (Photographs 68-72). Soil from yard remediation work had recently been placed at the repository on E40 Road (Photographs 24 and 26). Both repositories were secured with locked gates (Photographs 23 and 71-72) as required by the OU2 ROD.

A tour of the site was conducted to view representative OU2 properties where remediation was in progress, where remediation was complete, and where no remediation had yet been conducted (Photographs 27-45). This tour also included one school and one day care facility in Miami, Oklahoma (Photographs 27-29). For properties where remediation was in progress, the only work left to complete was to install sod (grass) at several locations (Photographs 32-33 and 35-36) and to complete some punch list items at one location (Photographs 39-40). (A “punch list” is a document used by engineers to identify tasks remaining at a construction site.) During the current phase of construction, it was discovered that a family had moved onto a property that had been a commercial

property (Photographs 35-36). The decision was made to complete remediation of this property since it was being used as a residence.

The soil borrow source location was also visited as part of the site inspection (Photographs 46-50). Material used as clean backfill in remediated yards is obtained from this property. At the time of the visit to the borrow source location, it had recently rained. Discoloration (due to silt) of the run-off in the drainage ditch along the roadway was observed (Photographs 47 and 48). This discoloration was traced back to the point where run-off water exits the property (Photographs 49 and 50). The silt curtain (used to remove silt from run-off water) erected across the discharge point had collapsed, allowing silt-laden runoff water to exit the property (Photograph 49). New silt curtains were installed by the burrow source operator to remedy the problem.

The mine discharges that occur in the area near the Douthat Bridge on E40 Road were viewed during the site inspection. Acid mine water was discharging from the subsidences upstream of this location (Photographs 8 and 9). These discharges enter Tar Creek via the old Lytle Creek channel, which enters Tar Creek at the Douthat Bridge (Photographs 74-76). At the Douthat Bridge, the water in Tar Creek becomes discolored (red and orange) as iron oxide precipitates out of the acid mine water that enters from the old Lytle Creek Channel (Photographs 74-76). Upstream of this location, the water in Tar Creek is not discolored (Photographs 14, 15, 17, and 73). Although too small to photograph, a few small fish were seen in Tar Creek at both the Douthat Bridge (on the upstream side) and at the confluence of the diverted Lytle Creek channel and Tar Creek.

# 7.0 Technical Assessment

The five-year review must determine whether the remedy at a site is protective of human health and the environment. The EPA guidance lists three questions used to provide a framework for organizing and evaluating data and information and to ensure all relevant issues are considered when determining the protectiveness of a remedy. These questions are answered for the site in the following paragraphs. At the end of the section is a summary of the technical assessment.

## 7.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The documents that memorialize the remedy selection decisions for the site are the June 1984 ROD for OU1, the August 1997 ROD for OU2, and the March 2, 2000 Action Memorandum for OU3. The ROD for OU1 discusses O&M costs related to the diking and diversion portion of the selected remedy. The OU1 ROD states that a LTM program would be implemented to determine the effectiveness of the remedy in terms of protection of the Roubidoux Aquifer and reducing the acid mine water discharges. The monitoring program for Tar Creek, related to the discharges from the mines to Tar Creek, was completed in 1988. The findings related to this monitoring are discussed in the First (1994) and Second (2000) Five-Year Review Reports.

The drinking water supplied from the Roubidoux Aquifer in the mining area meets the health-based primary drinking water standards (MCLs), and it is safe for use as a drinking water supply. Monitoring of the water quality in the Roubidoux Aquifer continues. There are indications that acid mine water may be present within the Roubidoux Aquifer at some well locations. If there is acid mine

water infiltration, its cause is unknown. The ODEQ is performing LTM monitoring to determine if the acid mine water infiltration is localized at certain wells or represents more widespread infiltration of acid mine water into the aquifer. However, O&M activities for the diversion dikes and diverted creek channels are ongoing at the site. Activities associated with the LTM program at the site are still ongoing. The RA for OU2 is still in progress. Based on the data review, the site inspection, and the interviews, it appears that the various Tar Creek site remedies selected in the OU1 and OU2 RODs are functioning as intended. However, as noted in both the first and second five-year reviews, the diking and diversion work performed as part of the OU1 remedy was not successful at reducing the discharges of acid mine water to Tar Creek. Opportunities for optimization, early indicators of potential remedy problems, and institutional controls are described below.

Opportunities for Optimization. The ODEQ is responsible for O&M of the dike and diversion channel at the Admiralty Mine Site. The ODEQ commented as part of this five-year review that the O&M Plan for this site dates to 1987 and should probably be updated. No O&M Plan document for the Big John and Muncie Mine Sites, which are located in Kansas, was found as part of the document review. The EPA will inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each Five-Year Review. Any noted problems will be reported to the State of Kansas. Opportunities to optimize O&M activities at OU1 were not examined due to the lack of an updated written plan. O&M for OU2 will begin once the RA construction activities are completed and the site repositories have been capped.

The LTM program for the Roubidoux Aquifer is now in its third phase. A new LTM plan was implemented in November 2003. This monitoring program includes a new list of wells to be sampled, based on the data obtained during previous phases and the availability of wells to be sampled. Also, the frequency of monitoring has been reduced from quarterly sampling to semi-annual sampling. No further optimization of the LTM program is recommended at this time.

Early Indicators of Potential Remedy Problems. As noted in Section 6.6, a small collapse had developed in the diversion dike at the Admiralty Mine site. No other problems were noted during the site inspection. The ODEQ repaired the collapse in the diversion dike in August 2004 and indicated that the repair was sufficient to prevent a reoccurrence of the collapse.

The LTM program for the Roubidoux Aquifer is in its third phase. The purpose of this program is to determine the effectiveness of the well plugging program at preventing migration of acid mine water to the Roubidoux Aquifer through the abandoned wells. Monitoring data have shown impacts due to acid mine water in the Roubidoux Aquifer in some areas. Several water supply wells at the site have been abandoned and plugged due to apparent acid mine water impacts. However, the data are inclusive as to whether the acid mine water impacts were the result of faulty well casings or represents a larger regional problem in the Roubidoux Aquifer. Two monitoring wells installed by the ODEQ are used by the cities of Picher and Cardin (Picher operates the water supply system for both towns), and Commerce has plans to connect the Commerce #5 MW well to their water supply system. In both cases, the use of the new monitoring wells has or will improve the quality of the water used for public water supply.

Institutional Controls. Institutional control options for the Tar Creek site are listed in the ROD for OU2. These OU2 institutional controls may include:

1) Restrictions and management controls on unsafe uses of mine tailings;
2) Restrictions and management controls on activities that would cause recontamination of remediated properties;
3) Restrictions and management controls on activities that would contaminate clean site property with mine tailings;
4) Restrictions and management controls intended to prevent future exposure of children to unacceptable levels of lead in the soil at new residential developments that are located in areas with high lead levels in soil;
5) Restrictions and management controls on building and construction activities in order to prevent building and construction practices that would increase exposure to lead-contaminated soils;
6) Restrictions and management controls on access to contaminated property through physical barriers (e.g., fencing) or notices (e.g., warning signs);
7) Public health and environmental ordinances and controls related to lead exposure and management of mine tailings;
8) Placing notices in property deeds regarding contamination;
9) Sampling and analysis of lead sources;
10) Blood lead monitoring;
11) Health education; and,
12) Lead-contaminated dust reduction activities (EPA, 1997).

The preceding institutional controls are optional under the OU2 ROD. The OU2 ROD stipulated that all institutional controls may not be necessary, or that some would only be used in special circumstances as dictated by conditions encountered at a specific property during the RA. In addition, the ROD stated that authorities of other government entities might be required to implement some of the institutional controls (e.g. zoning restrictions would require the municipal authority, lease restrictions might require DOI authority, etc). The ROD further stated that many institutional controls, such as community-wide health education, community-wide blood lead monitoring, and community-wide lead-contaminated dust reduction activities were appropriate for application in residential areas throughout Ottawa County (EPA, 1997).

Chat is viewed as a commercial resource in the community at the site. Commercial operations involving the sale of chat for uses outside of Ottawa County do occur at the site. The ODEQ has negotiated consent orders with chat washing facilities at the site that require the implementation of Best Management Practices (BMPs) in these operations. However, ODEQ's jurisdiction does not include chat on restricted Quapaw allotments. In about 1997, BIA banned chat sales on restricted Quapaw allotments. In 2005, however, the DOI is conducting a pilot project, under EPA authority, to study chat sales as part of the RI/FS. It is hoped that, if chat can be sold and used safely, chat sales may become a part of the selected remedy for OU4. Under the pilot project, chat sales on restricted Quapaw allotments will also be required to meet BMPs similar to those imposed by QDEQ on non-Indian land. The State of Oklahoma, through the University of Oklahoma, is currently conducting a study regarding the safe use of chat in asphalt paving (USACE, 2003). The EPA, Quapaw Tribe, and ODEQ have developed guidelines for safe uses of chat (EPA and Quapaw Tribe, 2002, and ODEQ, undated).

The institutional controls listed in items 9-12 above are currently being implemented either through an Interagency Agreement the EPA has signed with the ATSDR or as part of the OU2 RA. The ATSDR funds the Ottawa County Health Department to perform blood lead screening and health education activities at the site (ATSDR, 2004). During the site inspection conducted for this five-year review, it was noticed that numerous signs were posted in various public areas at the site warning of the dangers associated with lead contamination and chat. Sampling and analysis of residential yards and dust suppression activities have continued as part of the OU2 RA. Sampling and analysis of chat piles, and tailings ponds will be performed as part of the OU4 RI/FS (EPA, 2003). Outside of the RA work, lead-contaminated dust reduction activities are part of the community education efforts.

Once the RA activities for OU2 are completed, the EPA will work with the various authorities (city, county, state, and federal) to implement any of the additional listed institutional controls necessary to maintain the protectiveness of the remedy.

## 7.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Used at the Time of the Remedy Selection Still Valid?

The purpose of this question is to evaluate the effects of any significant changes in standards or assumptions used at the time of remedy selection. Changes in promulgated standards or “to be considereds” (TBCs) and assumptions used in the original definition of the remedial action may indicate an adjustment in the remedy is necessary to ensure the protectiveness of the remedy.

**Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics**. There have been no changes in exposure pathways for the Tar Creek site since completion of the Second Five-Year Review. As described below, the OWRB lowered the designated use of Tar Creek. In addition, no new contaminants or routes of exposure have been identified for OUs 1, 2, or 3 as part of this five-year review. There have been no new changes in toxicity factors or other contaminant characteristics. Finally, risk assessment methodology has not changed significantly since issuance of the ROD for OU2 in August 1997. The RI/FS is not yet complete for OU4. A risk assessment will be completed as part of the RI/FS process, and the RI/FS may conclude that additional responses are required at the site to address OU4 (EPA, 2003).

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. (EPA, 2000b).

**Changes in ARARs**. ARARs for this site were identified in both RODs. This five-year review for the site included identification of and evaluation of changes in the ROD-specified ARARs and TBCs to determine whether such changes may affect the protectiveness of the selected remedy. The ARARs and TBCs identified by the RODs for the Tar Creek site include chemical-, action- and location-requirements. These ARARs and TBCs are described below.

## OU1 ROD (signed on June 6, 1984)

**Chemical-Specific Requirements**: No contaminant-specific requirements were identified in the ROD.

**Action-Specific Requirements**: No action-specific requirements were identified in the ROD.

**Location-Specific Requirements**:
1. Executive Order on Floodplain Management, Executive Order No. 11988.
2. Executive Order on Protection of Wetlands, Executive Order No. 11990.

The First Five-Year Review Report identified the additional following ARARs for the OU1 remedy:

**Chemical-Specific Requirements**:
1. Oklahoma Water Quality Standards, Oklahoma Administrative Code (OAC) 785:45.
2. Regulations regarding the discharge of wastewater to surface waters, Water Quality Criteria, 40 CFR 131.
3. National Primary Drinking Water Standards, 40 CFR 141.
4. National Secondary Drinking Water Standards, 40 CFR 143.

## OU2 ROD (signed on August 27, 1997)

**Chemical-Specific Requirements**:
No chemical-specific requirements were identified in the ROD.

**Action-Specific Requirements**:

1. Regulations regarding the transportation of hazardous materials, 49 CFR 107, and 171-177.
2. Clean Water Act (CWA) requirements regarding the use of BMPs and monitoring of discharges to assure compliance with effluent discharge limitations, 40 CFR 122.41 and 125.100.
3. Clean Air Act (CAA) requirements to control particulate emissions to ambient air, 40 CFR 50 and 60.

**Location-Specific Requirements**:

1. National Historic Preservation Act requirements to minimize effects to historic landmarks and to coordinate activities with the State Historic Preservation Officer (SHPO), 16 USC 470, et. Seq, and 40 CFR 6.301.
2. Archeological and Historic Preservation Act requirements to minimize effects on historical and archeological data and to coordinate activities with the SHPO, 16 USC 469, 40 CFR 6.301(b), and 36 CFR 800.
3. Historic Sites, Buildings, and Antiquities Act requirements to avoid undesirable impacts to such landmarks and to coordinate activities with the SHPO, 16 USC 461-467, and 40 CFR 6.301(a).
4. Endangered Species Act of 1973, Federal Migratory Bird Act, and Oklahoma Wildlife Statutes regulations and requirements requiring that endangered species and their habitat be conserved, and that consultation occur with the DOI and the Oklahoma State Department of Wildlife if such areas are affected, 16 USC 1531-1543, 50 CFR Parts 17 and 402, 40 CFR 6.302(h), 16 USC 703-712, and Oklahoma Statutes Title 29, Section 5-412.
5. Oklahoma Water Statutes limitations on the placement or discharge of deleterious, noxious, or toxic substances into affected waters of Oklahoma, Oklahoma Statutes Title 29, Section 7-401.
6. Rivers and Harbors Act of 1899 and CWA Section 404 requirements related to the Nationwide Permit for discharge of dredged or fill materials, 33 CFR 330 and 33 USC 1344.

**ARARs Involving Activities that are No Longer Occurring**. The requirements listed below, which were previously identified as ARARs, apply to activities that are not currently taking place at the site or conditions that do not currently exist. Therefore, as a practical matter, they are not applicable to site remediation. However, should additional construction activities occur that affects flood plains or wetlands, these ARARs may be applicable.

The following ARARs are only applicable to the construction of the diking and diversion structures, and this construction is no longer occurring at the site.

1. Executive Order on Floodplain Management, Executive Order No. 11988.
2. Executive Order on Protection of Wetlands, Executive Order No. 11990.

**Interpretation, Changes, and Revisions to Guidance and Regulations**. The ODEQ, OWRB, and the Federal regulations have not been revised to the extent that the effectiveness of the remedy at the site would be called into question. No new regulations have been issued by the State of Oklahoma or the Federal government that would call into question the effectiveness of the remedy.

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.

In 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 2005 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 area would 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.

In addition, as noted in the Second Five-Year Review Report, the 1984 ROD for OU1 contains several statements in the declaration section that are relevant to environmental impacts associated with the surface water in Tar Creek. The ROD stated that the selected remedy does comply with other environmental regulations, but future remedial actions may be required if the selected remedy does not adequately mitigate the risk to human health. The Second Five-Year Review Report states that the OU1 ROD, through these statements and the fund-balancing ARARs waiver, limited the trigger for additional remedial actions at the site for OU1 to inadequately mitigated risks to human health, and that these provisions in the ROD provide the fund-balancing ARARs waiver for environmental components of the Water Quality Standards only. The Second Five-Year Review Report concluded that there were no unacceptable human-health risks posed by the surface water contamination in Tar

Creek based on the current designated use of Tar Creek (secondary recreation water body) (EPA, 2000b).

The EPA removed and reserved the regulations regarding BMPs at 40 CFR 125.100. Notice of the change was provided in the Federal Register (FR) on May 15, 2000 (see 65 FR 94 30886-30913). The EPA removed these regulations because the provisions under 40 CFR 125 Subpart K had never been activated. Also, the EPA determined that the requirements for implementing BMPs were better accomplished under the regulations at 40 CFR 122.44(k). The requirements of this regulation are applicable to the RA for OU2 at the site in regards to the use of BMPs to limit storm water discharges of pollutants.

## 7.3 Question C: Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

The type of other information that might call into question the protectiveness of the remedy include potential future land use changes in the vicinity of the site or other expected changes in site conditions or exposure pathways. As discussed in Section 4.6, July 2003 the ODEQ completed fish tissue studies based on samples collected in several ponds at the site as well as the Neosho and Spring rivers. The study resulted in the conclusion that skinless fish fillets were safe limited for consumption, but whole-eviscerated and whole un-eviscerated fish were determined to not be safe for consumption. The ODEQ issued a fish consumption advisory for the Tar Creek site and the Neosho and Grand Rivers based on the findings of this study (ODEQ, 2003c). Previous determinations that fish at the site were safe for consumption were based on older data. The ODEQ study represents new data for the site. Sections 8 and 9 discuss additional issues and follow-up actions recommended by this five-year review as a result of this study.

No other information has come to light as part of this third five-year review for the site that would call into question the protectiveness of the site remedy. The RI/FS, BHHRA, and ERA for OU4 may identify additional exposure pathways at the site. Issues identified during the RI/FS, BHHRA, and ERA for OU4 will be addressed in the ROD issued for OU4.

## 7.4 Summary of the Technical Assessment

The technical assessment, based on the data review, site inspection, technical evaluation, and interviews indicates that the remedial actions selected for the Tar Creek site have been implemented as intended by the decision documents. The RI/FS and risk assessments (BHHRA and ERA) for OU4 will address the chat piles, mine and mill residue, smelter waste, and flotation ponds. After completion of the RI/FS, EPA will evaluate the site condition and determine if any further actions are required. Various other Federal, State, Tribal, and local government agencies are conducting studies and carrying out actions at the site to address the many environmental, health, and safety concerns associated with the site. The MOU signed between the USEPA, the USACE, and the DOI has brought together the Federal, State, Tribal, and local government and community stakeholders at the site. This has resulted in better communication and coordination of site activities between the various stakeholders to address the various issues associated with the Tar Creek site. The cooperation of the various governmental agencies has led to coordinated use of the statutory and regulatory authorities of each to better address the complex issues at the site.

As stated in the First and Second Five-Year Review Reports, the dikes and diversion channels constructed as part of the OU1 remedy were not effective at reducing the discharges of acid mine water to Tar Creek. However, the OU1 ROD only allows additional remedial actions at the site to address unmitigated risks to human health. The designated use for Tar Creek is currently secondary recreation water body. The second five-year review concluded that based on the designated use, the available data did not indicate a human health threat was posed by the recreational use of Tar Creek. However, the second five-year review also stated that the EPA should review the need for updated monitoring data from Tar Creek for human health impacts. Several studies of the surface water and sediments in Tar Creek and the Tar Creek flood plain have been or are currently being conducted. In addition, the ODEQ conducted fish tissue sampling from several ponds at the site and the Neosho and Spring Rivers. The data indicated that whole-eviscerated and whole-uneviscerated fish should not be consumed, and the ODEQ issued a fish consumption advisory based on the findings of the study.

The drinking water supplied from the Roubidoux Aquifer in the mining area meets the health-based primary drinking water standards (MCLs), and it is safe for use as a drinking water supply. The LTM program for the Roubidoux Aquifer is currently in its third phase. The data were gathered to evaluate the effectiveness of the well plugging portion of the OU1 remedy at preventing acid mine water migration from the Boone Aquifer to the Roubidoux Aquifer. The data gathered since completion of the RA show indications that some wells completed in the Roubidoux Aquifer are impacted by acid mine water. Data obtained from the previous AAM monitoring were inconclusive as to whether the wells were impacted due to faulty well casings, or if the presence of parameters represents more wide-spread infiltration of mine water into the Roubidoux Aquifer. The data obtained from the current LTM program will be used to assess data trends and evaluate the source(s) of the acid mine water infiltration in the Roubidoux Aquifer. In addition, the OU1 ROD did not establish triggers that would indicate acid mine water has impacted the Roubidoux Aquifer. Background concentration and tolerance limit values for three indicator parameters were determined during the Phase I AAM for the Roubidoux. The ODEQ has proposed that these values be reassessed through additional sampling of wells located in areas outside of the mining area. This reassessment would be used to verify that the indicator parameters, background concentrations, and tolerance limit values established for the Roubidoux Aquifer are accurate.

The OU1 ROD stipulated that the EPA would evaluate the need to plug additional abandoned wells at the site as they were identified. The ODEQ evaluated the need to plug the 15 abandoned wells identified in the First and Second Five-Year Review Reports. As a result, the ODEQ plugged one abandoned well in 2001 and 5 abandoned wells in April 2004. Several of these wells were the water supply wells determined to be impacted by acid mine water during the Phase II AAM and removed from service and abandoned by the Cities. Mr. Cates/ODEQ indicated in his interview that many wells, when identified, are difficult to locate, and that once a well is located, it can be difficult to determine the type of well (abandoned Roubidoux Well, abandoned Boone Aquifer dewatering well, exploratory borehole, etc.). Mr. Cates stated that efforts to plug abandoned Roubidoux wells should continue, and that part of this effort should include better developing methods for locating and verifying the depths of wells as part of the plugging process.

At the time of the site inspection, one area of collapse was observed on the dike constructed at the Admiralty Mine site. This collapse was not large enough to allow water to pass through the dike at the time of the site inspection. A similar collapse was noted during the site inspection conducted as part

of the second five-year review. Mr. Cates indicated that the collapse was repaired in August 2004. The O&M Plan for this site dates to 1987, and Mr. Cates commented that the plan should be updated. Mr. Cates also commented that the 20-year easement for the property at this location should be updated. Currently, there is no written O&M Plan for the dikes and diversion channels at these two sites. The EPA will inspect these two locations as part of each five-year review conducted for the site. Observed problems with the dikes and diversion channels will be reported to the State of Kansas for action.

The residential yard and HAA remediation work conducted under the RA for OU2 is ongoing. Also, community education efforts are conducted at the site to alert the local residents to the health risks associated with lead contamination. The ATSDR study indicates that in 2003, 2.8% of children at the site have blood lead levels above 10 µg/dl (ATSDR, 2004). The OU2 ROD states that the 500 ppm lead remediation goal for soil was selected such that a typical child or group of children would have an estimated risk of no more than 5% exceeding a blood lead concentration of 10 µg/dl (EPA, 1997).

# 8.0 Issues

The OU2 RA, and O&M and the LTM program for OU1 are ongoing at the site. Based on the data review, site inspection, interviews and technology assessment, it appears the selected remedies are functioning in a manner that is consistent with the decision documents (except as noted regarding the dikes and diversion work portions of the OU1 remedy which are not significantly reducing the acid mine water discharges to Tar Creek). To ensure continued protectiveness, seven issues are identified in the following paragraphs. These issues do not currently affect the protectiveness of the remedy, but they should be addressed to ensure continued protectiveness of the selected remedies.

1. **No O&M Plans exist for the dikes and diversion channels**. The ODEQ's Operation and Maintenance (O&M) Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy dates to 1987. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site. There is not an O&M Plan for the dikes and diversion channel constructed at the Muncie and Big John Mine Sites, located in the State of Kansas, although EPA plans to inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

2. **Evaluate current surface water and sediment data for Tar Creek**. A BHHRA was not performed for OU1 because formal risk assessment guidance and procedures had not been developed at the time the OU1 ROD was written. The Second Five-Year Review Report stated that most of the surface water and sediment data for Tar Creek were 10 years old at the time the report was issued (April 2000). The report recommended that EPA review the need for updated monitoring data from Tar Creek in order to confirm that contamination levels have not worsened, and in order to determine whether there are any effects on human health.

3. **Status of recommendations from the ODEQ's 2002-2003 fish tissue study**. The ODEQ collected fish tissue samples from ponds on the Tar Creek site and from the Neosho and Spring Rivers. As part of this study, the ODEQ also calculated the concentrations of lead, cadmium, and zinc in the collected fish tissues in order to determine safe consumption levels

for fish caught at and near the site. The report issued by the ODEQ documenting this fish tissue study determined that consumption of fish fillets caught in Oklahoma waters affected by the Tri-State Mining area, at a rate up to six eight-ounce meals per month, was safe. The report also stated that whole-uneviscerated and whole-eviscerated fish caught from these waters should not be consumed. The report recommended that a new study be conducted, using equipment with lower detection limits, to verify the results of the first study. Also, the ODEQ recommended that sampling be conducted in areas downstream (including Grand Lake) from the locations sampled during the 2002-2003 study to determine the downstream extent of the metals uptake in fish. At the date of this Five-Year Review Report, this study had not been conducted. The ODEQ is pursuing plans to initiate the additional fish studies.

4. **Complete the evaluation of the effectiveness of the well plugging program that is intended to prevent mine water infiltration into the Roubidoux Aquifer**. The two-year after action monitoring and the second AAM program for the Roubidoux Aquifer have shown indications that the Roubidoux Aquifer is impacted by acid mine water at several well locations. However, it is still unclear as to whether this mine water influx was the result of faulty well casings or represents more widespread influx of mine water from the Boone Aquifer into the Roubidoux Aquifer. Therefore, the effectiveness of the well plugging program cannot be determined at this time. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

5. **Well plugging program for abandoned Roubidoux wells**. The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux Aquifer might be identified after completion of the RA. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The need to plug additional Roubidoux wells as they were identified was also recommended in the First and Second Five-Year Review Reports. The ODEQ plugged one abandoned well in 2001 and 5 abandoned wells in April 2004. This requirement remains an issue to be addressed in future five-year reviews.

6. **Completion of the OU2 RA**. RA activities at the site are still ongoing. There are still residential properties at the site where assessment sampling has determined remediation is needed.

7. **Completion of the OU4 RI/FS, BHHRA, and ERA**. The EPA, ODEQ, and Quapaw Tribe are currently working with the PRPs to plan and execute the RI/FS for OU4. The EPA is responsible for completing the BHHRA and the ERA based on data collected by the PRPs and EPA.

# 9.0 Recommendations and Follow-up Actions

As described in the previous section, seven issues were identified during the third five-year review for this site. To address these issues, the following recommendations and follow-up actions have been defined.

1. **Develop an O&M Plan for the dikes and diversion channels**. The ODEQ has indicated that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987. The O&M Plan prepared for the Admiralty Mine Site should be updated. The ODEQ also indicated as part of this five-year review that the 20-year property easement for the dike and diversion channel at the Admiralty Mine Site should be extended and updated.

   Regarding the Muncie and Big John Mine Sites, the EPA will inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection will be reported to the State of Kansas for appropriate action.

2. **Collect and evaluate current and recent surface water and soil/sediment data to verify that no threat to human health exists in Tar Creek**. The second five-year review recommended that the EPA review the need for updated monitoring of the contamination in Tar Creek to evaluate human health impacts. The EPA has conducted soil sampling along the flood plain of Tar Creek to determine lead concentration trends within the flood plain. The ODEQ and USGS are currently conducting sampling of the sediments and surface water quality in Tar Creek. If these data are appropriate for the purpose of evaluating human health impacts, these data should be used for that purpose. If necessary, the EPA should collect enough additional data to determine if potential human health risks are posed by the surface water and sediments in Tar Creek. If it is determined that Tar Creek potentially poses a human health risk, then it is recommended that the EPA evaluate the need to conduct a BHHRA to quantify the risks.

3. **Complete the additional fish tissues studies as recommended by the ODEQ's 2003 report**. As discussed in Section 4.6, in July 2003 the ODEQ completed fish tissue studies based on samples collected in several ponds at the site as well as the Neosho and Spring rivers. The study resulted in the conclusion that skinless fish fillets were safe limited for consumption, but whole-eviscerated and whole un-eviscerated fish were determined to not be safe for consumption. The ODEQ issued a fish consumption advisory for the Tar Creek site and the Neosho and Grand Rivers based on the findings of this study (ODEQ, 2003c). Previous determinations that fish at the site were safe for consumption were based on older data. The ODEQ's 2003 fish tissue sampling report recommended that additional studies be conducted, equipment with lower detection limits, to verify the results of the first study and to determine the downstream extent of the metals uptake in fish. It is recommended that the ODEQ to complete the additional recommended study to determine if extension of the fish consumption advisory to areas further downstream is necessary. The ODEQ is pursuing plans to initiate the additional fish studies.

4. **Continue with the LTM program and background reassessment for the Roubidoux Aquifer**. It is recommended that the LTM program continue so that the effectiveness of the well plugging program can be determined. As part of the LTM program, it is further recommended that the Roubidoux background reassessment proposed by the ODEQ be conducted to verify that the indicator parameters, background concentrations, and tolerance limits used as triggers to indicate acid mine water influx from the Boone Aquifer to the

Roubidoux Aquifer are appropriate. If it is determined through the LTM program that the acid mine water influx represents a more widespread regional problem, the need for additional activities (such as continued or more widespread monitoring) will be evaluated. If it is determined through the LTM program that the Roubidoux Aquifer is no longer capable of meeting the primary drinking water standards, the need for additional remedial actions will be reevaluated. It should be noted that neither the EPA nor ODEQ have identified any wells at the Site that fail to meet the MCLs established under the Safe Drinking Water Act. That is, the drinking water at the Site is safe for all uses.

5. **Continue plugging abandoned Roubidoux wells**. The OU1 ROD provided for plugging additional abandoned Roubidoux wells as they are identified at the site. These efforts should continue in order to prevent contamination from migrating from the Boone Aquifer into the Roubidoux Aquifer. As additional abandoned wells are identified, efforts should be undertaken to locate the well, determine that the well is completed in the Roubidoux aquifer, and plug those abandoned wells completed in the Roubidoux Aquifer where deemed technically feasible.

6. **Continue with the OU2 RA**. The residential yard and HAA remediation as stated in the OU2 ROD should continue. The residential yard remediation is now underway.

7. **Conduct the RI/FS, BHHRA, and ERA for OU4**. Efforts to complete the RI/FS, BHHRA, and ERA to address the remaining mining wastes at the site for OU4 should continue.

# 10.0 Protectiveness Statement

The remedies implemented for the Tar Creek site are protective of human health and the environment. The OU1 remedy addressed the primary route of potential human exposure by protecting the Roubidoux Aquifer, and, in this way preventing the possibility that hazardous substances would be ingested in drinking water. Sampling data indicate that the Roubidoux Aquifer continues to meet all health-based primary drinking water standards. Although environmental components of the Water Quality Standards are not being met for Tar Creek, there is no indication that a threat to human health exists. Current data from Tar Creek should be evaluated to verify previous determinations that no threat is posed to human health by Tar Creek. The ODEQ has issued a fish consumption advisory for waters within the Tar Creek site as well as the Neosho and Grand Rivers. Hydrologic modeling and a passive treatment pilot study (through constructed wetlands) are being conducted that may address surface water issues at the site. Until the results of these surface water treatment studies are available, a determination regarding the feasibility of using passive treatment technology to address the environmental risks associated with surface water cannot be made. The OU1 ROD invoked a fund-balancing waiver for the ARARs regarding the environmental risks related to surface water. This third five-year review finds that the conditions regarding this waiver have not substantially changed, and the waiver is still appropriate for the site. The State-designated used of Tar Creek surface water do not pose a risk to human health. Human health is protected by the remedy implemented for OU1. The EPA continues to find that, due to the potential drain on the Superfund and due to the impact that drain would have on the EPA's ability to address other releases under CERCLA and the NCP, it is not appropriate to address environmental risks for surface water in Tar Creek.

In the remediated areas, the remedy being implemented for OU2 is protective of human health and the environment. A total of 2,072 properties have been remediated during the OU2 RA and the removal actions that preceded the RA. Additional properties continue to be identified and remediated, and the RA for OU2 is ongoing. Human health and the environment are being protected by the remedy for OU2.

The action implemented during the Removal Action for OU3 is protective of human health and the environment. The laboratory chemicals left at the former Eagle-Picher Office Complex were removed from the site and properly disposed of.

The RI/FS, BHHRA, and ERA for OU4 are currently being conducted. With the exceptions noted above, the environmental components of the Water Quality Standards for OU1, the completed remedial actions, LTM program, and O&M activities for the Tar Creek site are all protective for the short term. The overall remedy for the site is protective of human health and the environment for the short term, and will continue to be protective if the action items identified in this five-year review are addressed.

# 11.0 Next Review

The next five-year review, the fourth for the site, should be completed during or before September 2009.

**Table 1**
**Chronology of Site Events**
*Tar Creek Superfund Site*
*Third Five-Year Review Report*

| Date | Event |
|---|---|
| Early 1900's | Lead and zinc mining activities began in the Picher field of the Tri-State Mining District. |
| 1970's | Mining activities ceased in the Picher field. |
| November 1979 | Acid mine water began flowing to the surface and draining into Tar Creek. |
| June 1980 | Governor of Oklahoma appointed the Tar Creek Task Force to investigate the environmental impacts associated with the acid mine drainage. |
| 1980 and 1981 | First investigations conducted by several government agencies under the Tar Creek Task Force to assess the environmental impacts associated with the acid mine drainage at the site. |
| July 27, 1981 | The Tar Creek site is proposed to the National Priorities List (NPL). October 1981 Report submitted to the Tar Creek Task Force documenting the impacts of acid mine drainage within the Tar Creek basin. |
| June 16, 1982 | EPA signs a Cooperative Agreement with the OSDH to conduct the RI/FS for OU1. |
| July 1982-March 1983 | The Remedial Investigation for OU1 is conducted. |
| May-December 1983 | The Feasibility Study for OU1 is conducted. |
| September 8, 1983 | The Tar Creek site is formally added to the NPL. |
| June 6, 1984 | A ROD for OU1 is signed. The selected remedy included surface water diversion and construction of dikes at 3 locations, plugging abandoned Roubidoux wells, and a 2 year after action monitoring program to evaluate the effectiveness of the selected remedies. |
| June 15, 1984 | The EPA sends RD/RA notice letters to 7 companies and 8 individuals as PRPs to allow them to complete the RD/RA for OU1. |
| 1985 | The OWRB lowers the designated use of Tar Creek to habitat-limited fishery and secondary recreation water body. |
| September 1985 – October 1986 | OU1 RA activities for plugging abandoned Roubidoux Aquifer wells are conducted by the OWRB. |
| December 22, 1986 | RA construction for OU1 is completed. |
| 1987 - 1988 | A two year surface and ground water monitoring program is implemented by the OWRB to assess the effectiveness of the OU1 remedy. |
| December 30, 1987 | EPA signs a referral to the US Department of Justice to implement cost recovery against 7 companies identified as PRPs. |
| 1991 | A second ground water monitoring program (known as After Action Monitoring) is begun at the site by the OWRB to assess potential impacts of acid mine water on the Roubidoux Aquifer. |
| June 10, 1991 | EPA enters into a Consent Decree with 6 PRPs to recover costs related to the RI/FS, ROD, and emergency response actions related to OU1. |
| January 21, 1994 | US Public Health Service's Indian Health Service notifies EPA by letter that 34% of children routinely tested near the Tar Creek site have blood lead levels that exceed the CDC's level of 10 µg/dl. |

**Table 1**
**Chronology of Site Events**
*Tar Creek Superfund Site*
*Third Five-Year Review Report*

| Date | Event |
|---|---|
| April 1994 | EPA completes the first five-year review for the Tar Creek site. The first five-year review recommends continuing the after-action monitoring of the Roubidoux Aquifer. Also, the creation of a second OU is recommended to address human health concerns related to mining wastes. |
| August 1994 – July 1995 | EPA conducts sampling at the Tar Creek site in support of a Baseline Human Health Risk Assessment and RI/FS for the residential portion of OU2. |
| August 15, 1995 | EPA issues an action memorandum authorizing a removal response action to address lead contaminated soils at High Access Areas. |
| August 25, 1995 | EPA issues notice to the PRPs and DOI providing them the opportunity to conduct or finance the removal action at the High Access Areas. |
| September – December 1995 | EPA conducts removal response action at HAAs. |
| November 17, 1995 | EPA issues Special Notices to PRPs providing them the opportunity to undertake the RI/FS/RD for the residential portion of OU2. |
| March 21, 1996 | EPA issues an action memorandum authorizing a removal response action to address lead contaminated soils at 300 residential properties. |
| June 1996 – December 1997 | Remediation of HAAs and residences conducted as a removal response action by the USACE. |
| August 1996 | EPA issues the Baseline Human Health Risk Assessment for OU2. It indicates that lead in soil is the primary contaminant of concern and oral ingestion of soil is the primary exposure route of concern. |
| January 1997 | EPA issues RI report for residential portion of OU2. |
| February 1997 | EPA issues FS report for residential portion of OU2. |
| August 27, 1997 | A ROD for OU2 is signed. The selected remedy included excavation of soils in residential yards contaminated with lead above 500 ppm down to a depth of 18 inches, replacement of the contaminated soil with clean backfill, and disposal of the contaminated soil in an onsite repository. |
| January 1998 | Removal action for remediation of the High Access Areas and residential yards continues as a Remedial Action conducted by the USACE. |
| 1998 & 1999 | EPA enters into cooperative agreements with the ITEC, Quapaw Tribe, and ODEQ to provide funding for RI/FS activities for non-residential portions of OU2. |
| March 2, 2000 | EPA issues an action memorandum authorizing a removal response action to remove laboratory chemicals stored at the Eagle-Picher Office Complex in Cardin, Oklahoma, and designates this response as OU3. |
| March 28 – May 23, 2000 | EPA conducts the removal response for OU3. EPA determines that No Further Action is warranted to address OU3. |
| April 2000 | The EPA completes the second five-year review for the Tar Creek site. |
| July 2000 | The USACE completes remediation of the 1,300th residential property under the RA for OU2. The USACE work for OU2 is completed. The EPA hires contractor CH2M HILL to continue the residential yard remediation work for the OU2 RA. |

**Table 1**
**Chronology of Site Events**
*Tar Creek Superfund Site*
*Third Five-Year Review Report*

| Date | Event |
|---|---|
| September 2002 | The ODEQ issues report documenting results of the Phase I and II After Action Monitoring of the Roubidoux Aquifer for OU1. |
| May 1, 2003 | The EPA, USACE, and DOI sign a Memorandum of Understanding for the Tar Creek site. |
| November 2003 | The ODEQ begins the Long-Term Monitoring program for the Roubidoux Aquifer. |
| December 9, 2003 | An AOC is signed with the DOI and 2 mining companies to conduct the RI/FS for OU4. |
| April 2004 | The ODEQ plugs 5 abandoned Roubidoux wells at the site. |
| June 2004 | The EPA begins the third five-year review for the Tar Creek site. |

**Table 2**
**Background Concentrations, Tolerance Limits, and Secondary MCLs for Indicator Parameters in the Roubidoux Aquifer**
**Phase I AAM Program**
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Parameter: | Zinc | | Iron | | Sulfate | |
|---|---|---|---|---|---|---|
| Unit: | mg/L | µg/L | mg/L | µg/L | mg/L | µg/L |
| Background Concentration | 0.0088 | 8.8 | 0.0615 | 61.5 | 25 | 25000 |
| Tolerance Limit | 0.043 | 43 | 0.207 | 207 | 82 | 82000 |
| SMCL | 5 | 5000 | 0.300 | 300 | 250 | 250000 |

Notes:
SMCL - Secondary Maximum Contaminant Limit
AAM - After Action Monitoring
mg/L - milligrams per liter
µg/L - micrograms per liter

**Table 3**
**Analytical Results for Indicator Parameters**
**Phase I AAM Program**
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Well ID | Zinc (µg/L) | Iron (µg/L) | Sulfate (mg/L) |
|---|---|---|---|
| Picher #2 | 150 | 441 | 122 |
| Picher #3 | 65 | 407 | 202 |
| Picher #4 | 129 | 894 | 289 |
| Quapaw #2 | 45 | 932 | 187 |
| Commerce #4 | 51 | 397 | 122 |

Notes:
AAM - After Action Monitoring
µg/L - micrograms per liter
mg/L - milligrams per liter

**Table 4**
Analytical Results
Phase II AAM Program
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Well ID | Date | Total or Dissolved Concentration | Specific Conductance uS/cm | pH | Alkalinity (as $CaCO_3$) mg/L | Chloride mg/L | **Sulfate** mg/L | TDS mg/L | Hardness (as $CaCO_3$) mg/L | Calcium mg/L | Magnesium mg/L | Sodium mg/L | Potassium mg/L | Antimony mg/L | Arsenic mg/L | Cadmium mg/L | Chromium mg/L | **Iron** mg/L | Lead mg/L | Manganese mg/L | Mercury mg/L | Nickel mg/L | Selenium mg/L | Thallium mg/L | **Zinc** mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCL (mg/L) | | | | | | | | | | | | | | 0.006 | 0.010 | 0.005 | 0.100 | | 0.015 | 0.050 | 0.002 | 0.100 | 0.050 | 0.002 | |
| SMCL (mg/L) | | | | | | 250 | 250 | 500 | | | | | | | | | | 0.300 | | | | | | | 5.0 |
| Commerce #3 | 10/14/1996 | Total | 840 | 7.55 | 147.46 | 115.56 | **90.7** | 527 | 328.35 | 75 | 29 | 65 | 6 | <.002 | <.002 | <.002 | 0.013 | **0.307** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.038** |
| | | Dissolved | | | | | | | | 75 | 29 | 66 | 6 | <.002 | <.002 | <.002 | 0.012 | **0.281** | <0.005 | NA | <0.0005 | <0.010 | 0.010 | <0.001 | **<0.010** |
| | 12/11/1996 | Total | 800 | 7.04 | 165.17 | 75.62 | **221.8** | 665 | 400 | 109 | 39 | 47 | 6 | <.002 | <.002 | <.002 | <0.010 | **0.269** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.052** |
| | | Dissolved | | | | | | | | 109 | 38 | 48 | 6 | <.002 | <.002 | <.002 | <0.010 | **0.264** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.018** |
| | 01/10/1997 | Total | 700 | 6.71 | 146 | 62.43 | **139.5** | 510 | 336 | 84 | 32 | 41 | 5 | <.002 | <.002 | <.002 | <0.010 | **0.210** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.036** |
| | | Dissolved | | | | | | | | 83 | 32 | 40 | 5 | <.002 | <.002 | <.002 | <0.010 | **0.197** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.065** |
| | 04/17/1997 | Total | 675 | 6.89 | 177 | 59.4 | **182.3** | 486 | 298 | 81 | 30 | 36 | 3 | <.002 | <.002 | <.002 | 0.012 | **0.354** | <0.005 | NA | <0.0008 | <0.010 | <0.010 | <0.001 | **0.040** |
| | | Dissolved | | | | | | | | 80 | 30 | 37 | 3 | <.002 | <.002 | <.002 | 0.011 | **0.352** | <0.005 | NA | <0.0008 | <0.010 | <0.010 | <0.001 | **0.015** |
| | 04/17/1997* | Total | | | 175 | 63.4 | **182.9** | 490 | 308 | 76 | 28 | 34 | 3 | <.002 | <.002 | <.002 | 0.011 | **0.338** | <0.005 | NA | <0.0008 | <0.010 | <0.010 | <0.001 | **0.039** |
| | | Dissolved | | | | | | | | 80 | 30 | 37 | 3 | <.002 | <.002 | <.002 | 0.011 | **0.346** | <0.005 | NA | <0.0008 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 07/23/1997 | Total | 700 | 6.98 | 157 | 62 | **153.1** | 466 | 232 | 73 | 27 | 32 | <2 | <.002 | <.002 | <.002 | <0.010 | **0.862** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.030** |
| | | Dissolved | | | | | | | | 73 | 27 | 32 | <2 | <.002 | <.002 | <.002 | <0.010 | **0.859** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 11/06/1997 | Total | 600 | 7.14 | 154 | 47.8 | **126.3** | 480 | 118 | 71 | 26 | 31 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.575** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.030** |
| | | Dissolved | | | | | | | | 72 | 26 | 32 | 4 | <.002 | <.002 | <.002 | <0.010 | **0.568** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Commerce #3 Averages | | Total | | | | | **156.7** | | | | | | | | | | | **0.416** | | | | | | | **0.038** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.410** | | | | | | | **0.020** |
| Commerce #5 MW | 10/13/2000 | Total | 333 | 7.68 | 113 | 16.1 | **11** | 179 | 129 | NA | NA | 11 | NA | <.002 | <.002 | <.002 | <0.010 | **0.208** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 10/13/2000* | Total | 333 | 7.68 | 112 | 15.7 | **10.3** | 174 | 129 | 28 | 14 | 12 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.220** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 27 | 14 | 11 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.178** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 03/09/2001 | Total | 296 | 7.75 | 118 | 13 | **12.4** | 165 | 125 | 28 | 14 | 10 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.197** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 28 | 14 | 10 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.137** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/13/2001 | Total | 282 | 7.48 | 119 | 9.2 | **40.9** | 123 | 126 | 27 | 13 | 10 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.159** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 27 | 13 | 10 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.120** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/18/2002 | Total | 294 | 7.5 | 109 | 15 | **11.6** | 149 | 128 | 28 | 14 | 11 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.116** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 27 | 14 | 10 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.082** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Commerce #5 Averages | | Total | | | | | **17.2** | | | | | | | | | | | **0.180** | | | | | | | **<0.010** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.129** | | | | | | | **<0.010** |
| Picher #2 | 10/01/1996 | Total | 490 | 6.87 | 145 | 13.93 | **151** | 369 | 266.66 | 61 | 27 | 14 | 4 | <.002 | <.002 | <.002 | <0.010 | **0.440** | <0.005 | NA | <0.0005 | 0.010 | <0.010 | <0.001 | **0.270** |
| | | Dissolved | | | | | | | | 59 | 26 | 14 | 4 | <.002 | <.002 | <.002 | <0.010 | **0.376** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.172** |
| | 10/25/1996 | Total | 500 | 7.38 | 127.76 | 19.91 | **121** | 366 | 278.6 | 62 | 27 | 14 | 4 | <.002 | <.002 | <.002 | <0.010 | **0.181** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 63 | 27 | 13 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.171** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/09/1997 | Total | 625 | 7.08 | 145 | 25 | **200.4** | 490 | 188 | 88 | 35 | 17 | 3 | <.002 | <.002 | <.002 | 0.010 | **0.745** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.028** |
| | | Dissolved | | | | | | | | 86 | 35 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.719** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.027** |
| | 07/15/1997 | Total | 455 | 6.95 | 125 | 23.2 | **121** | 300 | 240 | 53 | 22 | 13 | <2 | <.002 | <.002 | <.002 | <0.010 | **0.277** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 53 | 22 | 12 | <2 | <.002 | <.002 | <.002 | <0.010 | **0.267** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 11/06/1997 | Total | 305 | 7.31 | 128 | 12.6 | **44.3** | 252 | 177 | 40 | 17 | 11 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.225** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.014** |
| | | Dissolved | | | | | | | | 39 | 17 | 11 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.138** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 08/12/1999 | Total | 620 | 7.2 | 191 | 8.5 | **182** | 100 | 322 | 79 | 33 | 17 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.674** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 78 | 33 | 18 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.639** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #2 Averages | | Total | | | | | **136.6** | | | | | | | | | | | **0.424** | | | | | | | **0.057** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.385** | | | | | | | **0.040** |
| Picher #3 | 09/23/1996 | Total | 800 | 6.7 | 174.44 | 19.9 | **245.5** | 646 | 457.7 | 115 | 46 | 21 | 5 | <.002 | <.002 | <.002 | <0.010 | **0.377** | <0.005 | NA | <0.0005 | 0.013 | <0.010 | <0.001 | **0.093** |
| | | Dissolved | | | | | | | | 110 | 44 | 20 | 5 | <.002 | <.002 | <.002 | <0.010 | **0.264** | <0.005 | NA | <0.0005 | 0.012 | <0.010 | <0.001 | **0.089** |
| | 06/06/1997 | Total | 975 | 6.92 | 193 | 18 | **245.5** | 739 | 482 | 133 | 49 | 21 | 4 | <.002 | 0.002 | <.002 | <0.010 | **0.468** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.052** |
| | | Dissolved | | | | | | | | 131 | 48 | 21 | 4 | <.002 | 0.002 | <.002 | <0.010 | **0.444** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.063** |
| | 07/15/1997 | Total | 850 | 6.89 | 173 | 25.1 | **291.8** | 630 | 242 | 117 | 42 | 19 | <2 | <.002 | 0.002 | <.002 | 0.014 | **0.803** | <0.005 | NA | <0.0005 | 0.014 | <0.010 | <0.001 | **0.025** |
| | | Dissolved | | | | | | | | 114 | 41 | 19 | <2 | <.002 | 0.002 | <.002 | 0.012 | **0.778** | <0.005 | NA | <0.0005 | 0.014 | <0.010 | <0.001 | **0.025** |
| | 11/06/1997 | Total | 600 | 7.01 | 156 | 15.8 | **139** | 493 | 382 | 83 | 32 | 16 | 3 | <.002 | <.002 | <.002 | <0.010 | **1.116** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.016** |
| | | Dissolved | | | | | | | | 82 | 31 | 16 | 2 | <.002 | <.002 | <.002 | <0.010 | **1.024** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #3 Averages | | Total | | | | | **230.5** | | | | | | | | | | | **0.691** | | | | | | | **0.047** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.628** | | | | | | | **0.047** |

**Table 4**
Analytical Results
Phase II AAM Program
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Well ID | Date | Total or Dissolved Concentration | Specific Conductance uS/cm | pH | Alkalinity (as $CaCO_3$) mg/L | Chloride mg/L | **Sulfate** mg/L | TDS mg/L | Hardness (as $CaCO_3$) mg/L | Calcium mg/L | Magnesium mg/L | Sodium mg/L | Potassium mg/L | Antimony mg/L | Arsenic mg/L | Cadmium mg/L | Chromium mg/L | **Iron** mg/L | Lead mg/L | Manganese mg/L | Mercury mg/L | Nickel mg/L | Selenium mg/L | Thallium mg/L | **Zinc** mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCL (mg/L) | | | | | | | | | | | | | | 0.006 | 0.010 | 0.005 | 0.100 | | 0.015 | 0.050 | 0.002 | 0.100 | 0.050 | 0.002 | |
| SMCL (mg/L) | | | | | | 250 | 250 | 500 | | | | | | | | | | 0.300 | | | | | | | 5.0 |
| Picher #4 | 09/16/1996 | Total | 1120 | 7.03 | 223 | 24.83 | **410** | 920.88 | 660 | 163 | 53 | 27 | 6 | <.002 | 0.003 | <.002 | 0.017 | **7.174** | <0.005 | NA | <0.0005 | 0.067 | 0.095 | <0.001 | **2.430** |
| | | Dissolved | | | | | | | | 171 | 53 | 25 | 5 | <.002 | <.002 | <.002 | 0.016 | **3.212** | <0.005 | NA | <0.0005 | 0.041 | 0.024 | <0.001 | **0.104** |
| | 10/08/1996 | Total | 725 | 6.88 | 152.25 | 27.89 | **197.6** | 545 | 358.2 | 90 | 35 | 15 | 4 | <.002 | <.002 | <.002 | 0.013 | **0.279** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 90 | 35 | 15 | 4 | <.002 | <.002 | <.002 | 0.012 | **0.247** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/09/1997 | Total | 700 | 6.82 | 147 | 32 | **223** | 543 | 222 | 98 | 38 | 18 | 3 | <.002 | <.002 | <.002 | 0.010 | **2.566** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.011** |
| | | Dissolved | | | | | | | | 99 | 38 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **2.539** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 08/28/1997 | Total | 715 | 6.9 | 181 | 30.9 | **248.4** | 510 | 394 | 95 | 36 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.709** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.015** |
| | | Dissolved | | | | | | | | 96 | 36 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.659** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 09/16/1997 | Total | 700 | 6.89 | 158 | 24.5 | **211.6** | 211 | 367 | 81 | 32 | 15 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.404** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 81 | 32 | 15 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.380** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/11/1997 | Total | 630 | 6.92 | 145 | 33.2 | **181.6** | 508 | 339 | 85 | 35 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.716** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.022** |
| | | Dissolved | | | | | | | | 81 | 34 | 17 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.568** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #4 Averages | | Total | | | | | **245.4** | | | | | | | | | | | **1.975** | | | | | | | **0.416** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **1.268** | | | | | | | **0.026** |
| Picher #5 MW | 07/30/1997 | Total | 470 | 7.04 | 137 | 52 | **82** | 310 | 248 | NA | NA | 17 | NA | <.002 | <.002 | <.002 | <0.010 | **0.230** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 08/15/1997 | Total | 550 | 7.3 | 131 | 44 | **117** | 375 | 248 | 60 | 27 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.145** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 59 | 26 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.069** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 09/16/1997 | Total | 550 | 6.94 | 130 | 31.7 | **105.3** | 371 | 283 | 57 | 26 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.136** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 55 | 25 | 16 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.133** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/04/1997 | Total | 400 | 7.17 | 124 | 34.5 | **41.1** | 271 | 220 | 49 | 21 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.080** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 48 | 21 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.075** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/04/1997* | Total | | | 128 | 34.7 | **13.1** | 269 | 214 | 48 | 21 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.084** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 49 | 22 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.063** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 03/20/1998 | Total | 325 | 7.05 | 109 | 59.7 | **29.9** | 72 | 180 | 39 | 18 | 19 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.096** | <0.005 | NA | <0.0005 | <0.025 | <0.010 | <0.001 | **<0.005** |
| | | Dissolved | | | | | | | | 38 | 17 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.058** | <0.005 | NA | <0.0005 | <0.025 | <0.010 | <0.001 | **<0.005** |
| | 07/31/1998 | Total | 485 | 6.85 | 185 | 31.7 | **38** | 352 | 260 | 57 | 27 | 19 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.080** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 57 | 27 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.064** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 08/25/1998 | Total | 480 | 7.06 | 108 | 37.1 | **60** | 345 | 236 | 55 | 25 | 19 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.122** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 55 | 25 | 19 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.069** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/15/1998 | Total | 380 | 7.18 | 117 | 36.5 | **34** | 273 | 191.7 | 40 | 19 | 19 | 1.3 | <.002 | <.002 | <.002 | <0.010 | **0.068** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 40 | 19 | 19 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.044** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/15/1998* | Total | | | 123 | 34.9 | **33.8** | 245 | 182.2 | 40 | 19 | 20 | 2.7 | <.002 | <.002 | <.002 | <0.010 | **0.087** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 40 | 18 | 19 | 1.2 | <.002 | <.002 | <.002 | <0.010 | **0.034** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 03/25/1999 | Total | 440 | 7.04 | 125 | 30.4 | **107** | 342 | 292 | 55 | 26 | 19 | 2.7 | <.002 | <.002 | <.002 | <0.010 | **0.210** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 55 | 25 | 18 | 2.7 | <.002 | <.002 | <.002 | <0.010 | **<0.010** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 07/22/1999 | Total | 490 | 7.05 | 135 | 24.5 | **120** | 370 | 262 | 64 | 29 | 22 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.146** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 64 | 29 | 21 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.116** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 07/22/1999* | Total | | | 129 | 23.1 | **119** | 371 | 262 | 64 | 29 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.155** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 63 | 29 | 19 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.129** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 08/12/1999 | Total | 550 | 7.45 | 178 | 23.9 | **118** | 106 | 268 | 62 | 28 | 19 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.169** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 02/25/2000 | Total | 621 | 7.07 | 153 | 30 | **129** | 379 | 284 | 60 | 28 | 19 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.223** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 59 | 28 | 18 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.216** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 10/11/2000 | Total | 571 | 7.15 | 134 | 24.3 | **101** | 366 | 280 | 55 | 27 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.218** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 56 | 27 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.206** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 03/09/2001 | Total | 580 | 7.22 | 151 | 24.3 | **119** | 375 | 266 | 58 | 28 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.176** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 57 | 28 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.156** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/13/2001 | Total | 527 | 7.21 | 134 | 35.6 | **94.8** | 429 | 216 | 49 | 24 | 23 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.540** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 49 | 24 | 23 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.393** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/18/2002 | Total | 591 | 7.11 | 136 | 25 | **121** | 377 | 271 | 62 | 29 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.332** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 62 | 29 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.323** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #5 MW Averages | | Total | | | | | **83.3** | | | | | | | | | | | **0.174** | | | | | | | **<.010** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.127** | | | | | | | **<.010** |

**Table 4**
Analytical Results
Phase II AAM Program
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Well ID | Date | Total or Dissolved Concentration | Specific Conductance uS/cm | pH | Alkalinity (as $CaCO_3$) mg/L | Chloride mg/L | **Sulfate** mg/L | TDS mg/L | Hardness (as $CaCO_3$) mg/L | Calcium mg/L | Magnesium mg/L | Sodium mg/L | Potassium mg/L | Antimony mg/L | Arsenic mg/L | Cadmium mg/L | Chromium mg/L | **Iron** mg/L | Lead mg/L | Manganese mg/L | Mercury mg/L | Nickel mg/L | Selenium mg/L | Thallium mg/L | **Zinc** mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MCL (mg/L) | | | | | | | | | | | | | | 0.006 | 0.010 | 0.005 | 0.100 | | 0.015 | 0.050 | 0.002 | 0.100 | 0.050 | 0.002 | |
| SMCL (mg/L) | | | | | | 250 | 250 | 500 | | | | | | | | | | 0.300 | | | | | | | 5.0 |
| Picher #6 MW | 10/12/2000 | Total | 980 | 7.05 | 220 | 6.8 | **294** | 842 | 973 | NA | NA | 19 | NA | <.002 | <.002 | <.002 | <0.010 | **2.288** | <0.005 | 0.032 | <0.0005 | 0.026 | <0.010 | <0.001 | **0.098** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 10/17/2000 | Total | 900 | 6.94 | 207 | 6.7 | **307** | 836 | 874 | 153 | 57 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **2.304** | <0.005 | 0.027 | <0.0005 | 0.030 | <0.010 | <0.001 | **0.110** |
| | | Dissolved | | | | | | | | 152 | 57 | 17 | 3 | <.002 | <.002 | <.002 | <0.010 | **2.295** | <0.005 | 0.028 | <0.0005 | 0.033 | <0.010 | <0.001 | **0.112** |
| | 02/26/2001 | Total | 863 | 7.08 | 191 | 8.8 | **358** | 623 | 493 | 111 | 42 | 16 | 3 | <.002 | <.002 | <.002 | <0.010 | **1.669** | <0.005 | 0.024 | <0.0005 | 0.032 | <0.010 | <0.001 | **0.079** |
| | | Dissolved | | | | | | | | 111 | 42 | 16 | 3 | <.002 | <.002 | <.002 | <0.010 | **1.659** | <0.005 | 0.025 | <0.0005 | 0.032 | <0.010 | <0.001 | **0.078** |
| | 12/13/2004 | Total | 569 | 7.13 | 149 | 6.7 | **152** | 370 | 276 | 65 | 27 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.677** | <0.005 | 0.012 | <0.0005 | 0.010 | <0.010 | <0.001 | **0.016** |
| | | Dissolved | | | | | | | | 65 | 27 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.653** | <0.005 | 0.012 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.016** |
| | 04/18/2002 | Total | 565 | 7.24 | 142 | 7.1 | **86** | 364 | 280 | 63 | 27 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.600** | <0.005 | 0.011 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.015** |
| | | Dissolved | | | | | | | | 65 | 27 | 12 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.563** | <0.005 | 0.011 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.017** |
| Picher #6 MW Averages | | Total | | | | | **239.4** | | | | | | | | | | | **1.885** | | | | | | | **0.064** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **1.293** | | | | | | | **0.056** |
| Picher #7 MW | 10/13/2000 | Total | 495 | 7.59 | 124 | 14.3 | **89.1** | 313 | 244 | NA | NA | 14 | NA | <.002 | <.002 | <.002 | <0.010 | **0.348** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 10/17/2000 | Total | 453 | 7.25 | 120 | 15.7 | **71.1** | 282 | 215 | 45 | 22 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.163** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 45 | 22 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.159** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 10/17/2000* | Total | | | 117 | 15.6 | **68.4** | 277 | 216 | 46 | 23 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.180** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 45 | 23 | 12 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.164** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 03/09/2001 | Total | 546 | 7.48 | 174 | 14.6 | **121** | 351 | 257 | 55 | 28 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.173** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 54 | 28 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.160** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/13/2001 | Total | 455 | 7.6 | 131 | 18 | **93.3** | 241 | 211 | 45 | 23 | 14 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.063** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 45 | 23 | 13 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.049** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 12/13/2001* | Total | | | 131 | 15.8 | **93.7** | 253 | 203 | 47 | 23 | 14 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.074** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 46 | 23 | 14 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.048** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/19/2002 | Total | 525 | 7.38 | 132 | 14.1 | **112** | 332 | 255 | 54 | 27 | 13 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.092** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 53 | 27 | 13 | 2 | <.002 | <.002 | <.002 | <0.010 | **0.073** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 04/19/2002* | Total | | | 132 | 14.2 | **91** | 338 | 255 | 54 | 28 | 13 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.111** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 55 | 28 | 13 | 3 | <.002 | <.002 | <.002 | <0.010 | **0.079** | <0.005 | <0.010 | <0.0005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #7 MW Averages | | Total | | | | | **92.5** | | | | | | | | | | | **0.151** | | | | | | | **<.010** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **0.105** | | | | | | | **<.010** |
| Quapaw #2 | 10/14/1996 | Total | 600 | 7.22 | 151.5 | 31.87 | **121.9** | 452 | 228.85 | 74 | 31 | 22 | 5 | <.002 | 0.003 | <.002 | 0.015 | **1.707** | <0.005 | NA | 0.001 | <0.010 | <0.010 | <0.001 | **0.146** |
| | | Dissolved | | | | | | | | 74 | 31 | 21 | 5 | <.002 | 0.002 | <.002 | 0.013 | **1.566** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.029** |
| | 02/04/1997 | Total | 700 | 7.13 | 193.8 | 44.63 | **212.1** | 607 | 322 | 86 | 39 | 25 | 5 | <.002 | <.002 | <.002 | 0.014 | **1.335** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.044** |
| | | Dissolved | | | | | | | | 88 | 40 | 25 | <1 | <.002 | <.002 | <.002 | 0.013 | **1.336** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.043** |
| | 07/17/1997 | Total | 950 | 6.85 | 205 | 65.6 | **269** | 713 | 457 | 114 | 46 | 33 | 3 | <.002 | 0.002 | <.002 | 0.015 | **1.807** | <0.005 | NA | <0.0005 | 0.010 | <0.010 | <0.001 | **0.063** |
| | | Dissolved | | | | | | | | 115 | 46 | 33 | 3 | <.002 | 0.002 | <.002 | 0.015 | **1.765** | <0.005 | NA | <0.0005 | 0.010 | <0.010 | <0.001 | **0.060** |
| | 11/06/1997 | Total | 875 | 6.91 | 210 | 59.4 | **243.6** | 774 | 410 | 114 | 47 | 33 | 5 | <.002 | <.002 | <.002 | <0.010 | **1.688** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.061** |
| | | Dissolved | | | | | | | | 113 | 47 | 33 | 4 | <.002 | <.002 | <.002 | <0.010 | **1.653** | <0.005 | NA | <0.0005 | <0.010 | <0.010 | <0.001 | **0.059** |
| Quapaw #2 Averages | | Total | | | | | **211.7** | | | | | | | | | | | **1.634** | | | | | | | **0.079** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **1.580** | | | | | | | **0.048** |
| Quapaw #5 MW | 10/13/2000 | Total | 1166 | 7.02 | 221 | 71.3 | **279** | 825 | 907 | NA | NA | 42 | NA | <.002 | 0.003 | <.002 | <0.010 | **2.832** | <0.005 | 0.036 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.132** |
| | | Dissolved | | | | | | | | NA | NA | NA | NA | NA | NA | NA | NA | **NA** | NA | NA | NA | NA | NA | NA | **NA** |
| | 03/09/2001 | Total | 1144 | 7.0 | 224 | 69.2 | **293** | 814 | 558 | 124 | 57 | 41 | 6 | <.002 | 0.003 | <.002 | <0.010 | **2.325** | <0.005 | 0.036 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.118** |
| | | Dissolved | | | | | | | | 148 | 74 | 33 | 3 | <.002 | 0.003 | <.002 | <0.010 | **2.599** | <0.005 | 0.036 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.115** |
| | 03/09/2001* | Total | | | 226 | 68.3 | **290** | 809 | 555 | 149 | 74 | 33 | 3 | <.002 | 0.003 | <.002 | <0.010 | **2.855** | <0.005 | 0.036 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.113** |
| | | Dissolved | | | | | | | | 125 | 57 | 40 | 6 | <.002 | 0.003 | <.002 | <0.010 | **2.082** | <0.005 | 0.035 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.109** |
| | 12/14/2001 | Total | 1237 | 6.96 | 234 | 80.3 | **376** | 828 | 610 | 133 | 61 | 49 | 7 | <.002 | 0.003 | <.002 | <0.010 | **2.762** | 0.012 | 0.037 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.135** |
| | | Dissolved | | | | | | | | 126 | 59 | 48 | 7 | <.002 | 0.004 | <.002 | <0.010 | **2.619** | <0.005 | 0.037 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.141** |
| | 04/18/2002 | Total | 1231 | 6.77 | 224 | 86.6 | **305** | 890 | 665 | 135 | 63 | 47 | 7 | <.002 | 0.003 | <.002 | <0.010 | **3.072** | <0.005 | 0.037 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.080** |
| | | Dissolved | | | | | | | | 130 | 61 | 46 | 7 | <.002 | 0.003 | <.002 | <0.010 | **2.943** | <0.005 | 0.037 | <0.0005 | <0.010 | <0.010 | <0.001 | **0.080** |
| Quapaw #5 MW Averages | | Total | | | | | **308.6** | | | | | | | | | | | **2.769** | | | | | | | **0.116** |
| | | Dissolved | | | | | **NA** | | | | | | | | | | | **2.561** | | | | | | | **0.111** |

Notes:
* - indicates duplicate sample
Results for the indicator parameters (sulfate, iron, and zinc) are in **BOLD**
- yellow shading indicates an exceedence of the MLC or SMCL
- green shading indicates an exceedence of the calculated tolerance limit
- blue shading indicates an exceedence of the calculated background value
Abbreviations - uS/cm - microseimens per centimeter, $CaCO_3$ - calcium carbonate, mg/L - milligrams per liter, TDS - total dissolved solids, NA - not analyzed, MCL - Maximum Contaminant Level, SMCL - Secondary Maximum Contaminant Level

**Table 5**
Analytical Results
Long-Term Monitoring Program
*Third Five-Year Review*
*Tar Creek Superfund Site, Ottawa County, Oklahoma*

| Well ID | Date | Total or Dissolved Concentration | Specific Conductance uS/cm | pH | Alkalinity (as $CaCO_3$) mg/L | Chloride mg/L | **Sulfate** mg/L | TDS mg/L | Hardness (as $CaCO_3$) mg/L | Calcium mg/L | Magnesium mg/L | Sodium mg/L | Potassium mg/L | Antimony mg/L | Arsenic mg/L | Cadmium mg/L | Chromium mg/L | **Iron** mg/L | Lead mg/L | Manganese mg/L | Mercury mg/L | Nickel mg/L | Selenium mg/L | Thallium mg/L | **Zinc** mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MCL (mg/L) | | | | | | | | | | | | 0.006 | 0.010 | 0.005 | 0.100 | | 0.015 | 0.050 | 0.002 | 0.100 | 0.050 | 0.002 | |
| | | SMCL (mg/L) | | | | 250 | 250 | 500 | | | | | | | | | | 0.300 | | | | | | | 5.0 |
| Cardin #1 | 11/06/2003 | Total | 595 | 6.47 | 149 | 27.1 | **134** | 388 | 281 | 61 | 30 | 17 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.101** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.022** |
| | | Dissolved | | | | | | | | 61 | 30 | 17 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.098** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Commerce #4 | 11/06/2003 | Total | 615 | 6.42 | 150 | 37.9 | **119** | 383 | 260 | 61 | 26 | 28 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.095** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 57 | 25 | 27 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.086** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Commerce #5 MW | 11/06/2003 | Total | 294 | 7.29 | 112 | 15.6 | **12** | 155 | 127 | 26 | 13 | 11 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.080** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 26 | 13 | 11 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.045** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.010** |
| Private Well | 07/30/2003 | | 370 | 8.19 | 145 | 11.1 | **126** | 368 | NA | 60 | 29 | 8 | 2 | NA | NA | NA | NA | **0.410** | 0.056 | <0.010 | NA | <0.010 | NA | NA | **0.239** |
| | 10/06/2003 | Total | 257 | 7.08 | 98.9 | <10.0 | **14** | 148 | 124 | 26 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.208** | 0.017 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.050** |
| | | Dissolved | | | | | | | | 26 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.288** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.067** |
| | 10/06/2003* | Total | 257 | 7.08 | 98.6 | <10.0 | **16.4** | 132 | 126 | 26 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.287** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.065** |
| | | Dissolved | | | | | | | | 26 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.224** | 0.008 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.033** |
| | 11/04/2003 | Total | 252 | 7.83 | 114 | <10.0 | **16.4** | 138 | 126 | 27 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.316** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.083** |
| | | Dissolved | | | | | | | | 27 | 14 | 5 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.246** | 0.013 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.070** |
| | 12/19/2003 | Total | 415 | 6.64 | 147 | <10.0 | **85.5** | 274 | 213 | 46 | 23 | 8 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.319** | 0.026 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.236** |
| | | Dissolved | | | | | | | | 46 | 24 | 8 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.464** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.464** |
| Miami #1 | 11/04/2003 | Total | 500 | 7.15 | 117 | 83.6 | **12.4** | 262 | 133 | 30 | 15 | 50 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.372** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.010** |
| | | Dissolved | | | | | | | | 30 | 15 | 50 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.062** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 11/04/2003* | Total | 500 | 7.15 | 116 | 84.5 | **12.5** | 264 | 135 | 29 | 14 | 49 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.057** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 30 | 15 | 50 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **<0.020** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #5 MW | 11/05/2003 | Total | 590 | 6.52 | 140 | 25.6 | **135** | 381 | 278 | 61 | 29 | 18 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.232** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 59 | 28 | 18 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.213** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Picher #6 MW | 12/09/2003 | Total | 537 | 6.83 | 143 | <10.0 | **150** | 380 | 280 | 65 | 29 | 13 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.464** | <0.005 | 0.013 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.016** |
| | | Dissolved | | | | | | | | 60 | 27 | 12 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.337** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.015** |
| | 12/09/2003* | Total | | | 142 | <10.0 | **150** | 381 | 277 | 64 | 29 | 13 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.460** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.014** |
| | | Dissolved | | | | | | | | 61 | 27 | 12 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.337** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.016** |
| Picher #7 MW | 11/05/2003 | Total | 563 | 6.89 | 145 | <10.0 | **141** | 374 | 284 | 60 | 31 | 12 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.166** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 59 | 31 | 12 | 3 | <0.002 | <0.002 | <0.002 | <0.010 | **0.160** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Quapaw #4 | 11/06/2003 | Total | 249 | 7.03 | 109 | <10.0 | **11.1** | 129 | 120 | 25 | 13 | 5 | 1 | <0.002 | <0.002 | <0.002 | <0.010 | **<0.020** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 24 | 13 | 5 | 1 | <0.002 | <0.002 | <0.002 | <0.010 | **<0.020** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 11/06/2003* | Total | | | 109 | <10.0 | **11.1** | 131 | 121 | 24 | 13 | 5 | 1 | <0.002 | <0.002 | <0.002 | <0.010 | **<0.020** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 25 | 13 | 5 | 1 | <0.002 | <0.002 | <0.002 | <0.010 | **<0.020** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| Qaupaw #5 MW | 11/06/2003 | Total | 1427 | 6.41 | 250 | 102 | **401** | 1050 | 751 | 146 | 70 | 58 | 8 | <0.002 | 0.005 | <0.002 | <0.010 | **3.720** | <0.005 | 0.046 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.222** |
| | | Dissolved | | | | | | | | 147 | 71 | 59 | 8 | <0.002 | 0.005 | <0.002 | <0.010 | **3.690** | <0.005 | 0.047 | <0.00005 | <0.010 | <0.010 | <0.001 | **0.213** |
| RWD4 #4 | 11/07/2003 | Total | 283 | 6.65 | 114 | 14.8 | **<10.0** | 133 | 135 | 27 | 15 | 6 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.044** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 27 | 15 | 6 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.038** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | 11/07/2003* | Total | | | 114 | 14.6 | **<10.0** | 136 | 134 | 27 | 16 | 6 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.045** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |
| | | Dissolved | | | | | | | | 27 | 16 | 6 | 2 | <0.002 | <0.002 | <0.002 | <0.010 | **0.038** | <0.005 | <0.010 | <0.00005 | <0.010 | <0.010 | <0.001 | **<0.010** |

Notes:
* - indicates duplicate sample
Results for the indicator parameters (sulfate, iron, and zinc) are in **BOLD**
- yellow shading indicates an exceedence of the MCL or SMCL
- green shading indicates an exceedence of the calculated tolerance limit
- blue shading indicates an exceedence of the calculated background value
Abbreviations - uS/cm - microseimens per centimeter, $CaCO_3$ - calcium carbonate, mg/L - milligrams per liter, TDS - total dissolved solids, NA - not analyzed, RWD4 - Rural Water District #4, MCL - Maximum Contaminant Level, SMCL - Secondary Maximum Contaminant Level

N

1" = 2 Miles

Approximate Extent of Tar Creek Site

TO JOPLIN, MISSOURI

TO TULSA, OKLAHOMA

**Figure 1 - Site Map**
**Tar Creek Superfund Site**
**Ottawa County, Oklahoma**
**Third Five Year Review Report**

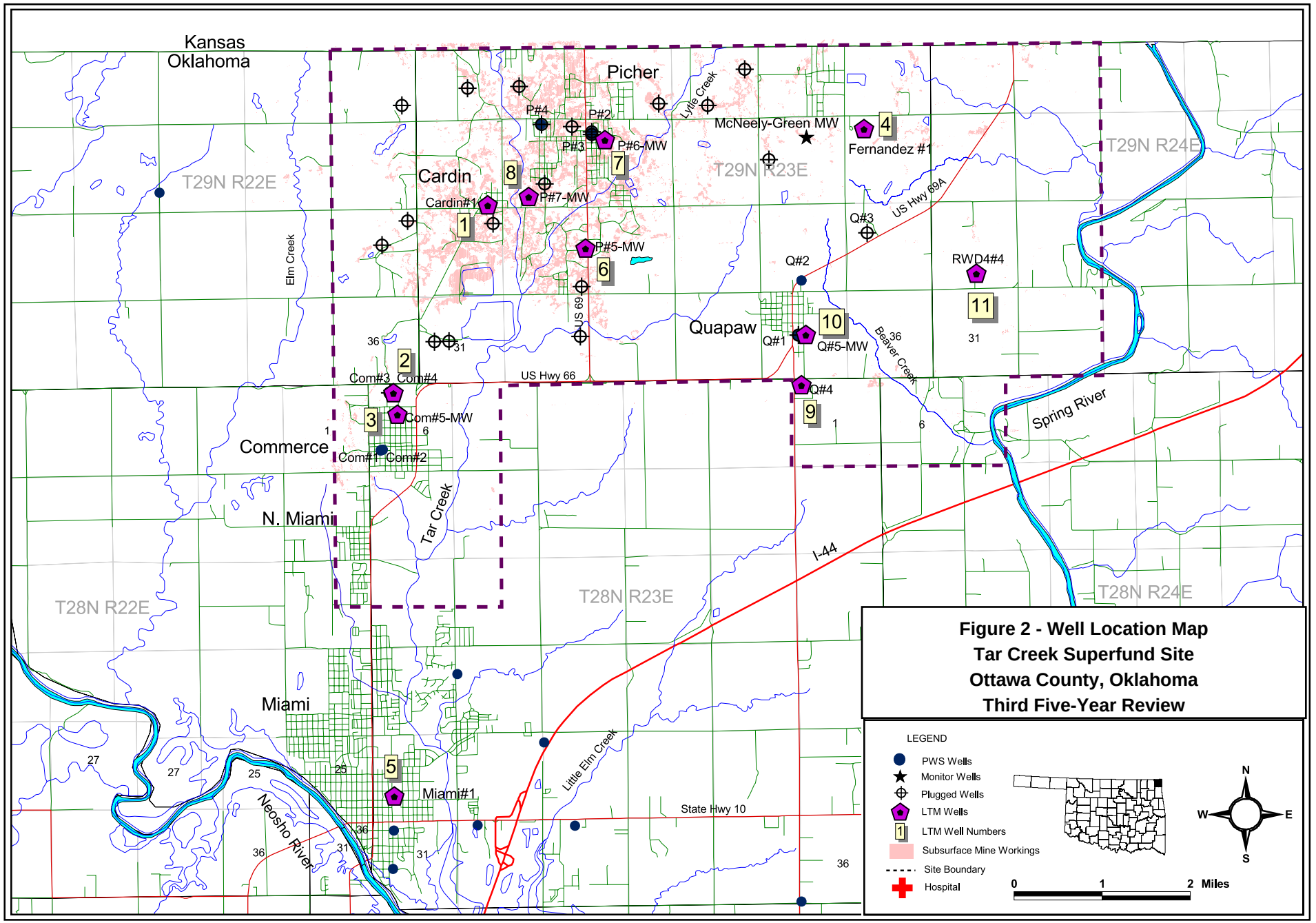
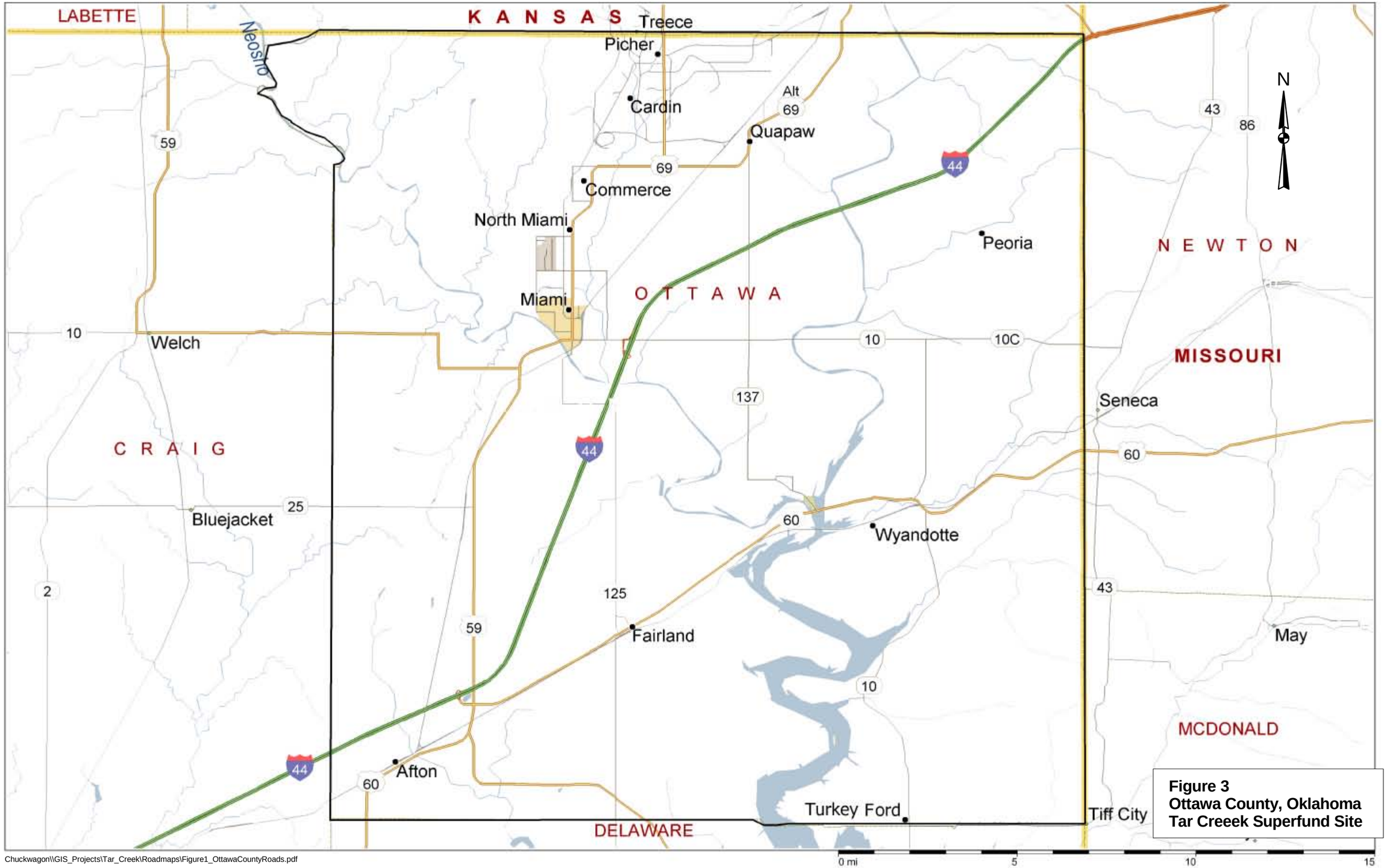



**Figure reproduced from ODEQ, 2004c**




Chuckwagon\\GIS_Projects\Tar_Creek\Roadmaps\Figure1_OttawaCountyRoads.pdf

**Figure 3**
**Ottawa County, Oklahoma**
**Tar Creeek Superfund Site**

CH2MHILL

# Attachment 1

# Documents Reviewed

# Attachment 1
# List of Documents Reviewed

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# Attachment 2

# Interview Record Forms

| **Five-Year Review Interview Record**<br>Tar Creek Superfund Site<br>Ottawa County, Oklahoma | **Interviewee:** Tim Kent/Quapaw Tribe of Oklahoma, Environmental Director<br>Phone: 918-542-1853<br>E-mail: tkent@quapawtribe.com |
|---|---|

| **Site Name** | **EPA ID No.** | **Date of Interview** | **Interview Method** |
|---|---|---|---|
| Tar Creek Superfund Site | EPA ID# OKD980629844 | 6-30-2004 | In person |

| **Interview Contacts** | **Organization** | **Phone** | **Email** | **Address** |
|---|---|---|---|---|
| Ursula Lennox | EPA Region 6 | 214-665-6743 | Lennox.ursula@epa.gov | 1445 Ross Ave<br>Dallas, Texas 75202-2733 |
| Margaret O'Hare | CH2M HILL, as rep of EPA | 972-980-2170 | mohare@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |
| Darren Davis | CH2M HILL, as rep of EPA | 972-980-2170 | ddavis9@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |

**Interview Questions**

**1. What is your overall impression of the work conducted at the site since the second Five-Year Review period (i.e. after April 2000)?**

**Response:** Mr. Kent stated that the Quapaw Tribe was disappointed that OU1 had, in their opinion, been closed and written off. He stated that the diversion structures did not achieve the goals of eliminating the mine water discharges, and the tribes felt that there were existing technologies that should be explored that could deal with the major discharges of mine water, especially at the Douthat Bridge. He further stated that he was concerned mine water might be migrating into the Roubidoux Aquifer through means other than faulty well casings and that protection of the deeper aquifer was a concern to the Quapaw Tribe.

Mr. Kent commented that the Tribe was very satisfied with the yard remediation work. He stated that there are occasionally complaints related to drainage problems that he forwards to the EPA and CH2M HILL. He did indicate that there were problems at the borrow source area used to supply clean backfill for the yard remediation. He indicated that no storm water controls were being used at the site. He indicated that there was sediment running off the site into a tributary that drains into Beaver Creek. He stated that he had also passed this concern on to the EPA.

Mr. Kent indicated that the definition of OU4 was to narrow. He stated that the OU4 RI/FS would only deal with the chat piles and not address other issues related to the site that are not addressed under previous OUs. He also stated that because of this, the RI/FS was not complete because it would not fully address the fate and transport of or fully characterize all wastes. He stated that the Tribe would like to see the sediment issues at the site split off into a separate OU.

**2. From your perspective, what effect have continued remedial operations at the site had on the surrounding community? Are you aware of any ongoing community concerns regarding the site or its operation and maintenance?**

**Response:** Mr. Kent stated that there has been a documented reduction in the blood lead levels in children at the site. It was his opinion that this was attributable to the yard remediation work and community education efforts. He stated that the work has benefited the community.

**3. Are you aware of any ongoing community concerns regarding the site or its administration?**

**Response:** Mr. Kent stated that many people in the community express concerns related to a potential buyout of the property owners at the site. He further indicated, that as far as Tribal lands were concerned, this would not work. Mr. Kent stated that the Tribal lands were held in trust, and an Act of Congress would be required to buy out the Tribal owned lands at the site.

**4. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by the City regarding the site? If so, please describe the purpose and results.**

**Response:** Mr. Kent stated that he is in close contact with all parties involved at the site. He noted that there are many public meetings conducted at the site.

**5. Are you aware of any events, incidents, or activities that have occurred related to the site that required a response by your office, if applicable? If so, please give details of the events and results of the responses.**

**Response:** Mr. Kent stated that he frequently gets requests from Tribal members to have their properties tested for lead. He stated that these requests are forwarded to EPA.

Mr. Kent expressed concerns regarding being informed when work is performed on Tribal property. He has requested that he be contacted whenever work is being performed on Tribal land. He stated that sometimes this is not done.

**6. Is your office aware of any changes in land use at the site or portions of the site?**

**Response:** He stated that he was not aware of any formal land use changes at the site. He did, however, indicate that frequently, unzoned vacant land would go from unoccupied to occupied overnight. The lot will be empty one day, and the next day someone has moved in a trailer, or has moved a trailer onto the property and started living on previously unoccupied land. He stated that it is often not recorded when this is done, and that there should be more control over this activity.

**7. Do you feel well informed about the site's activities and progress?**

**Response:** Mr. Kent indicated that he is well informed about what is being done at the site. He stated that it was his opinion that the Tribe should be involved in everything being done at the site and not just the work associated with OU4. He stated that the Tribe has a Cooperative Agreement with the EPA, but that there are disputes as to what work he is allowed to perform under the agreement. He stated that under CERCLA, the Tribe has the same participatory rights as the State, and that the Tribe is guaranteed more involvement under CERCLA than is currently being provided. He did, however, indicate that he was currently working through this issue with the EPA, and he felt that these issues would be worked out.

**8. Do you have any comments, suggestions, or recommendations regarding the site?**

**Response:** Mr. Kent stated that the Tribe would like to see a separate OU to address sediment issues at the site. He further stated that the Tribe would like to see OU1 reopened with regards to the surface water issues. He again stated that it was the Tribe's opinion that technologies to address the surface water issues for OU1 should be examined.

Mr. Kent expressed his desire for the EPA and the Quapaw Tribe to sign a formal Memorandum of Agreement (MOA) that would outline the framework under which the Tribe and EPA would operate cooperatively at the site. He stated that he believed this to be a requirement under CERCLA and has made a request that an MOA be reached.

Mr. Kent stated that, regarding work on Tribal lands, the Tribe should be involved in managing the work and be given the resources to do that.

Finally, Mr. Kent indicated that the Quapaw Tribe was in the process of developing water quality standards for Tribal lands. He indicated that these standards would become ARARs for the site once they were enacted. He indicated that the Tribe was currently in the process of addressing public comments received on the water quality standards.

| **Five-Year Review Interview Record**<br>Tar Creek Superfund Site<br>Ottawa County, Oklahoma | **Interviewee:** David Cates/ODEQ<br>Phone: 405-702-5133<br>E-mail: David.Cates@deq.state.ok.us |
|---|---|

| **Site Name** | **EPA ID No.** | **Date of Interview** | **Interview Method** |
|---|---|---|---|
| Tar Creek Superfund Site | EPA ID# OKD980629844 | June 29 and 30, 2004 | In person |

| **Interview Contacts** | **Organization** | **Phone** | **Email** | **Address** |
|---|---|---|---|---|
| Ursula Lennox | EPA Region 6 | 214-665-6743 | Lennox.ursula@epa.gov | 1445 Ross Ave<br>Dallas, Texas 75202-2733 |
| Margaret O'Hare | CH2M HILL, as rep of EPA | 972-980-2170 | mohare@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |
| Darren Davis | CH2M HILL, as rep of EPA | 972-980-2170 | ddavis9@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |

## Interview Questions

**1. What is your overall impression of the work conducted at the site since the second Five-Year Review period (i.e. after April 2000)?**

**Response:** Mr. Cates responded that in his opinion, the work conducted to monitor the water quality within the Roubidoux Aquifer is on the right track as far as protecting the public health. He noted that there continues to be no detected exceedences of the MCLs in any public water supply wells. Mr. Cates stated that the program to plug abandoned Roubidoux wells should continue. He stated that allowing the cities to turn the monitor wells into public supply wells was a win/win situation for all parties involved.

**2. From your perspective, what effect have continued remedial operations at the site had on the surrounding community? Are you aware of any ongoing community concerns regarding the site or its operation and maintenance?**

**Response:** Mr. Cates indicated that providing the city the use of the installed monitor wells for public water supply was beneficial. He noted that this was unsuccessful in Quapaw due to the installed monitor well producing poor quality water, and he noted that one well in Picher had a similar problem. The City of Picher had already run water lines to the well in question. The quality of the water has improved with time, but it is not being used. An abandoned municipal Roubidoux well near the Quapaw monitoring well (MW) was plugged but no improvements in water quality have been observed. He noted that alternative water supplies are not yet required, but that Picher and Cardin have taken advantage of the use of the new wells to improve the quality of their water supplies. The City of Commerce plans to tie the Commerce #5 MW into their public water supply in the near future. He also noted that the well drilling work showed that well installations through the Boone Aquifer (where the mine workings are located) could be completed and produced successfully.

**3. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by your office regarding the site? If so, please describe purpose and results.**

**Response:** Personnel from the ODEQ are at the site at least twice per month. The ODEQ currently performs the Long-Term Monitoring sampling twice per year. This keeps the ODEQ in contact with the local towns and cities to maintain the wells. Also, supply wells are inspected by the ODEQ Water Quality Program and monitored under the Safe Drinking Water Act requirements. Mr. Cates indicated that the sampling conducted under this program did not meet the requirements and protocols of Superfund and were not completely adequate to meet the data needs of Superfund. He stated that he does look at the data obtained from this program, but that his review was limited.

**4. Are you aware of any events, incidents, or activities that have occurred at the site, such as dumping, vandalism, or anything that required emergency response from local authorities? If so, please give details.**

**Response:** Mr. Cates stated that there was a local police response in one of the towns where an illegal methamphetamine laboratory had dumped chemicals down an old mineshaft. He stated that there is lots of dumping in the area into sinkholes and that several are full of tires. He was not aware of any releases that affected the drinking water supply.

**5. Have there been any complaints, violations, or other incidents related to the site that required a response by your office? If so, please summarize the events and result.**

**Response:** Mr. Cates indicated that he received complaints about iron in the water supply in the City of Picher after the Picher #5 MW was connected to the water supply. He stated that he sampled the water supply at the wellhead, and no iron was detected in the sample. He indicated that he did not sample any faucets.

Mr. Cates indicated that several property owners have complained about their properties being re-contaminated after remediation. In each case, the properties have been resampled and found to be clean.

Mr. Cates stated that there are occasional complaints about blowing dust in the area. Also, there are complaints about chat haulers not covering their loads.

**6. Are you aware of any problems or difficulties encountered since the second Five-Year Review which have impacted progress or resulted in a change in O&M procedures? Please describe changes and impacts.**

**Response:** Mr. Cates indicated that he was not aware of any difficulties or problems that had occurred that have impacted progress at the site.

**7. Have there been any changes in state or federal environmental standards since the second five-year review period which may call into question the current protectiveness or effectiveness of the remedial action?**

**Response:** Mr. Cates indicated that he was not aware of any changes to State or Federal regulations or standards that impact or calls into question the protectiveness or effectiveness of the remedy.

**8. The second five-year review recommended that the need for additional stream sampling of Tar Creek be evaluated. Has such an evaluation been conducted, and if so, what were the results?**

**Response:** Mr. Cates stated that the ODEQ was currently conducting a Total Maximum Daily Load study for the Spring River, Neosho River, Upper Grand Lake, and Tar Creek. The sampling includes stream water and sediment sampling for metals. The sampling is to be conducted at locations common to the sampling conducted for the site under Superfund in the 1980s. He indicated that this work is being conducted by the ODEQ Water Quality Division and the USGS. The ODEQ was collecting the measurements during base flow conditions, while the USGS was performing the same measurements during high flow conditions. Mr. Cates stated that this work was being driven by the requirements of the Clean Water Act, and he stated that Tar Creek was included on the State of Oklahoma's 303(d) list under the Clean Water Act. He indicated that the study will evaluate what could be done to remedy the problems along Tar Creek, and that there would possibly be some comparisons of the new data with the old data.

**9. Do you know of opportunities to optimize the operation, maintenance, or sampling efforts at the site, and have such changes been adopted?**

**Response:** Mr. Cates indicated that the sampling conducted for the Long-Term Monitoring Program had been reduced from quarterly to semi-annual sampling.

**10. Do you feel well informed about the site's activities and progress?**

**Response:** Mr. Cates indicated that he is well informed about site activities and progress.

**11. Do you have any comments, suggestions, or recommendations regarding the site?**

**Response:** Mr. Cates made several recommendations. These included continue the monitoring of the Roubidoux under the Long-Term Monitoring Program. He stated that the background reevaluation for the indicator parameters used to determine if mine water has impacted wells completed in the Roubidoux Aquifer should be conducted. He also recommended that additional testing be performed in the Roubidoux Aquifer around Quapaw (specifically related to a soon-to-be-installed well by the USGS) to determine the extent of the ground water contamination near Quapaw. Mr. Cates stated that the Quapaw #1, #2, #3, and #5 MW wells all indicate that water quality in this area is impacted. He stated that it was inconclusive based on the data as to whether the Roubidoux Aquifer was regionally or locally impacted in this area. Finally, Mr. Cates stated that the well plugging activities should continue as additional abandoned wells are identified. He indicated that frequently, identified wells must be further investigated to determine that they are indeed completed within the Roubidoux Aquifer. He indicated that any future well plugging work should include a task to investigate identified wells to make this determination. He also indicated that location information for wells is frequently in error, and that a task for properly locating identified wells should be included in any future work.

| **Five-Year Review Interview Record**<br>Tar Creek Superfund Site<br>Ottawa County, Oklahoma | **Interviewee:** Mayor Sam Freeman<br>City of Picher, Oklahoma<br>Phone: 918-673-1765<br>email: |
|---|---|

| **Site Name** | **EPA ID No.** | **Date of Interview** | **Interview Method** |
|---|---|---|---|
| Tar Creek Superfund Site | EPA ID# OKD980629844 | 6-29-2004 | In person |

| **Interview Contacts** | **Organization** | **Phone** | **Email** | **Address** |
|---|---|---|---|---|
| Ursula Lennox | EPA Region 6 | 214-665-6743 | Lennox.ursula@epa.gov | 1445 Ross Ave<br>Dallas, Texas 75202-2733 |
| Margaret O'Hare | CH2M HILL, as rep of EPA | 972-980-2170 | mohare@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |
| Darren Davis | CH2M HILL, as rep of EPA | 972-980-2170 | ddavis9@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |

**Interview Questions**

**1. What is your overall impression of the work conducted at the site since the second Five-Year Review period (i.e. after April 2000)?**

**Response:** Mayor Freeman expressed concerns related to unresolved issues and damage claims property owners had with work completed at the site, mostly related to when Morrison Knudson was the contractor working on OU2. He stated that there were still some drainage problems related to the yard remediation. He did express that since the USACE/Morrison Knudson left the project, he felt that claims had been adequately addressed, and he stated that CH2M HILL had worked excellently with the City of Picher to resolve issues and complaints.

Mayor Freeman also expressed concerns that the work for OU2 was being stopped to soon. He noted that there were several properties located in Picher that still required remediation. He expressed his opinion that it would be better to finish the work now rather than putting the work on hold and having to remobilize the contractors at a later date to complete the unfinished work. He also expressed concerns the City of Picher had regarding potential liability associated with several City owned properties that had not yet been remediated.

**2. From your perspective, what effect have continued remedial operations at the site had on the surrounding community?**

**Response:** Mayor Freeman stated that he felt the work associated with OU2 has had a very positive effect on the community. He stated that, in relation to OU1, there were no concerns that had not been addressed by the EPA or ODEQ. He was pleased that the City had been able to use two of the monitor wells installed by the ODEQ as supply wells. He anticipated being able to hook a third well into the City water supply soon, if the data continued to show improving water quality at that well location.

**3. Are you aware of any ongoing community concerns regarding the site or its administration?**

**Response:** Mayor Freeman stated that he thought there were more identified wells that were completed within the Roubidoux Aquifer that should be plugged.

**4. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by the City regarding the site? If so, please describe the purpose and results.**

**Response:** Mayor Freeman stated that the City communicates regularly with the ODEQ concerning the water supply wells and sampling activities associated with the wells. He also stated that he has regular contact with the EPA and CH2M HILL regarding the yard remediation work. Mayor Freeman indicated that he felt communication with the EPA, ODEQ, and contractors had improved.

**5. Are you aware of any events, incidents, or activities that have occurred related to the site that required a response by your office, if applicable? If so, please give details of the events and results of the responses.**

**Response:** Mayor Freeman stated that the only events that have occurred that required a response by the City were related to water lines being broken during the yard remediation. The City has had to respond occasionally to repair these lines when they were broken.

**6. Is your office aware of any changes in land use at the site or portions of the site?**

**Response:** Mayor Freeman indicated that there have been no changes in land use at the site. He further stated that most land within the City of Picher is administered by the Bureau of Indian Affairs (BIA). He stated that the City has a problem in that there is a lack of residential property available in the City. Mayor Freeman indicated that the City has tried to redevelop some property (an old railroad right-of-way), but that he could not get the State to agree to remediating the property to the residential clean-up levels that would be necessary to redevelop the property.

**7. Do you feel well-informed about the site's activities and progress?**

**Response:** Mayor Freeman indicated that he was well-informed about what was occurring at the site, and he stated that he felt he was more informed now than in the early years of the work at the site.

**8. Do you have any comments, suggestions, or recommendations regarding the site?**

**Response:** Mayor Freeman expressed that he felt in some instances that money and time were being wasted conducting pilot projects and studies at the site in areas that are uninhabited. He felt that these projects should be used to benefit people more, and that this type of work should be conducted in inhabited areas of the site. He went further to state that as soon as these types of projects were completed, the results should be used to implement work in inhabited areas at the site. Finally, Mayor Freeman again expressed his disappointment that work related to the yard remediation at the site was being put on hold.

| **Five-Year Review Interview Record**<br>Tar Creek Superfund Site<br>Ottawa County, Oklahoma | | | **Interviewee:** Mayor Neal Watson<br>City of Quapaw, Oklahoma<br>Phone: 918-674-2525<br>email: | | |
|---|---|---|---|---|---|
| **Site Name** | | **EPA ID No.** | | **Date of Interview** | **Interview Method** |
| Tar Creek Superfund Site | | EPA ID# OKD980629844 | | July 1, 2004 | Via telephone |
| **Interview Contacts** | **Organization** | **Phone** | **Email** | **Address** | |
| Ursula Lennox | EPA Region 6 | 214-665-6743 | Lennox.ursula@epa.gov | 1445 Ross Ave<br>Dallas, Texas 75202-2733 | |
| Margaret O'Hare | CH2M HILL, as rep of EPA | 972-980-2170 | mohare@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 | |
| Darren Davis | CH2M HILL, as rep of EPA | 972-980-2170 | ddavis9@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 | |

**Interview Questions**

**1. What is your overall impression of the work conducted at the site since the second Five-Year Review period (i.e. after April 2000)?**

**Response:** Mayor Watson indicated that overall, he is satisfied with the work performed so far at the site.

**2. From your perspective, what effect have continued remedial operations at the site had on the surrounding community? Are you aware of any ongoing community concerns regarding the site or its operation and maintenance?**

**Response:** Mayor Watson stated that the ongoing work at the site has had no effect at all on the community. All that has been done is remove and replace soil. He also stated that he was not aware of any complaints regarding the site.

**3. Are you aware of any ongoing community concerns regarding the site or its administration?**

**Response:** Mayor Watson indicated that he was not aware of any ongoing concerns in Quapaw.

**4. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by the City regarding the site? If so, please describe the purpose and results.**

**Response:** The City has not had any routine communications or activities related to the site.

**5. Are you aware of any events, incidents, or activities that have occurred related to the site that required a response by your office, if applicable? If so, please give details of the events and results of the responses.**

**Response:** Mayor Watson indicated that he was not aware of any incidents related to the site that required a response by the City of Quapaw.

**6. Is your office aware of any changes in land use at the site or portions of the site?**

**Response:** There were no changes in land use at the site in the City of Quapaw.

**7. Do you feel well-informed about the site's activities and progress?**

**Response:** Mayor Watson stated that he was well informed concerning activities and progress at the site.

**8. Do you have any comments, suggestions, or recommendations regarding the site?**

**Response:** Mayor Watson had no additional comments regarding the site.

| **Five-Year Review Interview Record**<br>Tar Creek Superfund Site<br>Ottawa County, Oklahoma | **Interviewee:** Mayor Jim Mullins<br>City of Commerce, OK.<br>Phone: 918-675-4373<br>email: |
|---|---|

| **Site Name** | **EPA ID No.** | **Date of Interview** | **Interview Method** |
|---|---|---|---|
| Tar Creek Superfund Site | EPA ID# OKD980629844 | Interview questions provided on 6-29-2004 | faxed response – received on 7-10-2004 |

| **Interview Contacts** | **Organization** | **Phone** | **Email** | **Address** |
|---|---|---|---|---|
| Ursula Lennox | EPA Region 6 | 214-665-6743 | Lennox.ursula@epa.gov | 1445 Ross Ave<br>Dallas, Texas 75202-2733 |
| Margaret O'Hare | CH2M HILL, as rep of EPA | 972-980-2170 | mohare@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |
| Darren Davis | CH2M HILL, as rep of EPA | 972-980-2170 | ddavis9@ch2m.com | 12377 Merit, Suite 1000<br>Dallas, Texas 75251 |

**Interview Questions**

**1. What is your overall impression of the work conducted at the site since the second Five-Year Review period (i.e. after April 2000)?**

**Response:** Mayor Mullins indicated that there has been improvement with the work over the last five years but that there is still room for further improvement. He indicated that there has been good communication over the last 60 days regarding work being done on drainage ditches within the City.

**2. From your perspective, what effect have continued remedial operations at the site had on the surrounding community? Are you aware of any ongoing community concerns regarding the site or its operation and maintenance?**

**Response:** Mayor Mullins indicated that there had been a large decrease in the blood lead levels in children. He also indicated that the City still had issues regarding drainage that still need to be addressed. Mayor Mullins also responded clay should stop being used as backfill in yards.

**3. Are you aware of any ongoing community concerns regarding the site or its administration?**

**Response:** Mayor Mullins responded that it takes much too long to address problems.

**4. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by the City regarding the site? If so, please describe the purpose and results.**

**Response:** Mayor Mullins indicated that the City had been permitted to become involved with issues related to drainage and ditch work in the City. He responded that the purpose of this work is to correct drainage problems in the City, but that no results had occurred to date.

**5. Are you aware of any events, incidents, or activities that have occurred related to the site that required a response by your office, if applicable? If so, please give details of the events and results of the responses.**

**Response:** Mayor Mullins responded that the City has had to correct drainage problems created by work at the site at City Expense, and that there had not been a satisfactory response regarding this issue to-date.

**6. Is your office aware of any changes in land use at the site or portions of the site?**

**Response:** Mayor Mullins indicated that there had been a land-use change at the new City Park.

**7. Do you feel well-informed about the site's activities and progress?**

**Response:** Mayor Mullins indicated that over the last 60 days, he has had satisfactory information regarding the site, but he also indicated that this was due to the persistence of the City.

**8. Do you have any comments, suggestions, or recommendations regarding the site?**

**Response:** Mayor Mullins responded that the issues regarding alleys had been recently resolved. He further replied that clay should stop being used as backfill in remediated yards and that black top soil should be used instead.

# Attachment 3

# Site Inspection Checklist

# Tar Creek, Ottawa County, Oklahoma
# Five-Year Review Site Inspection Checklist

Please note that "O&M" is referred to throughout this checklist. At sites where Long-Term Response Actions are in progress, O&M activities may be referred to as "system operations" since these sites are not considered to be in the O&M phase while being remediated under the Superfund program. N/A means "not applicable".

| I. SITE INFORMATION | |
|---|---|
| Site Name: Tar Creek Superfund Site | EPA ID: OKD980629844 |
| City/State: Ottawa County, Oklahoma | Date of Inspection: 6-29-04 and 6-30-04 |
| Agency Completing 5 Year Review: EPA | Weather/temperature: Mostly cloudy both days, Temperatures were in the 70's, Rained on 6-30-04 |

Remedy Includes: (Check all that apply)
- ☐ Landfill cover/containment
- ☐ Access controls
- ☒ Institutional controls
- ☐ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☒ Other:

Attachments: ☒ Inspection team roster attached ☒ Site map attached

## II. INTERVIEWS (Check all that apply)

1. O&M site manager:
   Name: David Cates/ODEQ
   Title: Professional Engineer
   Date: 6-30-04
   Interviewed: ☒ at site ☐ at office ☐ by phone Phone Number: 405-702-5124
   Problems, suggestions: ☒ Additional report attached (if additional space required).

2. O&M staff: NA
   Name:
   Title:
   Date:
   Interviewed: ☐ at site ☐ at office ☐ by phone Phone Number:
   Problems, suggestions: ☐ Additional report attached (if additional space required).

3. Local regulatory authorities and response agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency: Quapaw Tribe
Contact:
Name: Tim Kent
Title: Environmental Director
Date: 6-30-04
Phone Number: 918-542-1853
Problems, suggestions: ☒ Additional report attached (if additional space required).

Agency: City of Picher
Contact:
Name: Sam Freeman
Title: Mayor
Date: 6-29-04
Phone Number: 918-673-1765
Problems, suggestions: ☒ Additional report attached (if additional space required).

Agency: City of Commerce
Contact:
Name: Jim Mullins
Title: Mayor
Date: Mailed in responses to interview questions – Response received on July 10, 2004
Phone Number: 918-675-4373
Problems, suggestions: ☒ Additional report attached (if additional space required).

Agency: City of Quapaw
Contact:
Name: Neal Watson
Title: Mayor
Date: via telephone – 7-1-04
Phone Number: 918-674-2525
Problems, suggestions: ☒ Additional report attached (if additional space required).

4. Other interviews (optional) ☒ N/A ☐ Additional report attached (if additional space required).

## III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents
   - ☐ O&M Manuals — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ As-Built Drawings — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ Maintenance Logs — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

2. Health and Safety Plan Documents
   - ☐ Site-Specific Health and Safety Plan — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ Contingency plan/emergency response plan — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks: O&M activities conducted by ODEQ using their standard procedures

3. O&M and OSHA Training Records — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

4. Permits and Service Agreements
   - ☐ Air discharge permit — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ Effluent discharge — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ Waste disposal, POTW — ☐ Readily available — ☐ Up to date — ☒ N/A
   - ☐ Other permits — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

5. Gas Generation Records — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

6. Settlement Monument Records — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

7. Groundwater Monitoring Records — ☒ Readily available — ☒ Up to date — ☐ N/A

   Remarks: Ground water monitoring data retained by the ODEQ. Copies are submitted to EPA

8. Leachate Extraction Records — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

9. Discharge Compliance Records — ☐ Readily available — ☐ Up to date — ☒ N/A

   Remarks:

10. Daily Access/Security Logs — ☐ Readily available — ☐ Up to date — ☒ N/A

    Remarks:

## IV. O&M Costs ☐ Applicable ☒ N/A

1. O&M Organization
   ☒ State in-house ☐ Contractor for State
   ☐ PRP in-house ☐ Contractor for PRP
   ☐ Other:

2. O&M Cost Records
   ☐ Readily available ☐ Up to date ☒ Funding mechanism/agreement in place
   Original O&M cost estimate: O&M conducted by ODEQ under Cooperative Agreement with EPA ☐ Breakdown attached

   Total annual cost by year for review period if available

| From (Date): | To (Date): | Total cost: | ☐ Breakdown attached |
|---|---|---|---|
| From (Date): | To (Date): | Total cost: | ☐ Breakdown attached |
| From (Date): | To (Date): | Total cost: | ☐ Breakdown attached |
| From (Date): | To (Date): | Total cost: | ☐ Breakdown attached |
| From (Date): | To (Date): | Total cost: | ☐ Breakdown attached |

3. Unanticipated or Unusually High O&M Costs During Review Period ☒ N/A
   Describe costs and reasons:

## V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

1. Fencing

1. Fencing damaged ☐ Location shown on site map ☐ Gates secured ☒ N/A
   Remarks:

2. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on site map ☒ N/A
   Remarks:

3. Institutional Controls

1. Implementation and enforcement
Site conditions imply ICs not properly implemented: ☐ Yes ☐ No ☒ N/A
Site conditions imply ICs not being fully enforced: ☐ Yes ☐ No ☒ N/A
Type of monitoring (e.g., self-reporting, drive by):
Frequency:
Responsible party/agency:
Contact:
Name:
Title:
Date:
Phone Number:
Reporting is up-to-date: ☐ Yes ☐ No ☐ N/A
Reports are verified by the lead agency: ☐ Yes ☐ No ☐ N/A
Specific requirements in deed or decision documents have been met: ☐ Yes ☐ No ☐ N/A
Violations have been reported: ☐ Yes ☐ No ☐ N/A
Other problems or suggestions: ☐ Additional report attached (if additional space required).

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks: There is still evidence of recreational use of the chat piles (numerous tire tracks on the piles). However, signs were noted at many locations within the area warning people not to "play on the chat".

4. General

1. Vandalism/trespassing ☐ Location shown on site map ☒ No vandalism evident
Remarks:

2. Land use changes onsite ☒ N/A
Remarks: Site comprises approximately 40 square miles in area, and includes both rural areas and several small towns.

3. Land use changes offsite ☒ N/A
Remarks: Site is approximately 40 square miles in area. Interviews did indicate that vacant properties can become occupied without the knowledge of the local city governments. However, no mayors indicated that any land use changes (i. e. property use changing from commercial/industrial use to residential use) had occurred at the site.

## VI. GENERAL SITE CONDITIONS

1. Roads ☐ Applicable ☒ N/A

1. Roads damaged ☐ Location shown on site map ☐ Roads adequate ☒ N/A
Remarks: All roads present at the site are maintained by the local towns, county, or State of Oklahoma

2. Other Site Conditions

Remarks: None.

## VII. LANDFILL COVERS ☐ Applicable ☒ N/A

1. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Areal extent: Depth:
Remarks:

2. Cracks ☐ Location shown on site map ☐ Cracking not evident
Lengths: Widths: Depths:
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Areal extent: Depth:
Remarks:

4. Holes ☐ Location shown on site map ☐ Holes not evident
Areal extent: Depth:
Remarks:

5. Vegetative Cover
☐ Cover properly established ☐ No signs of stress ☐ Grass ☐ Trees/Shrubs
Remarks:

6. Alternative Cover (armored rock, concrete, etc.) ☐ N/A
Remarks:

7. Bulges ☐ Location shown on site map ☐ Bulges not evident
Areal extent: Height:
Remarks:

8. Wet Areas/Water Damage ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent:
☐ Ponding ☐ Location shown on site map Areal extent:
☐ Seeps ☐ Location shown on site map Areal extent:
☐ Soft subgrade ☐ Location shown on site map Areal extent:
Remarks:

9. Slope Instability ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability
Areal extent:
Remarks:

| | | | |
|---|---|---|---|
| 2. | Benches<br>(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.) | ☐ Applicable ☐ N/A | |
| 1. | Flows Bypass Bench<br>Remarks: | ☐ Location shown on site map | ☐ N/A or okay |
| 2. | Bench Breached<br>Remarks: | ☐ Location shown on site map | ☐ N/A or okay |
| 3. | Bench Overtopped<br>Remarks: | ☐ Location shown on site map | ☐ N/A or okay |
| 3. | Letdown Channels | ☐ Applicable ☐ N/A | |
| 1. | Settlement<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Depth: | ☐ No evidence of settlement |
| 2. | Material Degradation<br>Material type:<br>Remarks: | ☐ Location shown on site map<br>Areal extent: | ☐ No evidence of degradation |
| 3. | Erosion<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Depth: | ☐ No evidence of erosion |
| 4. | Undercutting<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Depth: | ☐ No evidence of undercutting |
| 5. | Obstructions<br>Type:<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br><br>Height: | ☐ N/A |
| 6. | Excessive Vegetative Growth<br>☐ Evidence of excessive growth<br>☐ Location shown on site map<br>Remarks: | ☐ No evidence of excessive growth<br>☐ Vegetation in channels but does not obstruct flow<br>Areal extent: | |

4. Cover Penetrations ☐ Applicable ☐ N/A

1. Gas Vents ☐ N/A
☐ Active ☐ Passive ☐ Routinely sampled
☐ Properly secured/locked ☐ Functioning ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O& M
Remarks:

2. Gas Monitoring Probes ☐ N/A
☐ Routinely sampled
☐ Properly secured/locked ☐ Functioning ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M
Remarks:

3. Monitoring Wells (within surface area of landfill) ☐ N/A
☐ Routinely sampled
☐ Properly secured/locked ☐ Functioning ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M
Remarks:

4. Leachate Extraction Wells ☐ N/A
☐ Routinely sampled
☐ Properly secured/locked ☐ Functioning ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M
Remarks:

5. Settlement Monuments ☐ Located ☐ Routinely surveyed ☐ N/A
Remarks:

5. Gas Collection and Treatment ☐ Applicable ☐ N/A

1. Gas Treatment Facilities ☐ N/A
☐ Flaring ☐ Thermal destruction ☐ Collection for reuse
☐ Good condition ☐ Needs O& M
Remarks:

2. Gas Collection Wells, Manifolds and Piping ☐ N/A
☐ Good condition ☐ Needs O& M
Remarks:

3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings) ☐ N/A
☐ Good condition ☐ Needs O& M
Remarks:

6. Cover Drainage Layer ☐ Applicable ☐ N/A

1. Outlet Pipes Inspected ☐ Functioning ☐ N/A
Remarks:

| | | | |
|---|---|---|---|
| 2. | Outlet Rock Inspected<br>Remarks: | ☐ Functioning | ☐ N/A |
| 7. | Detention/Sedimentation Ponds | ☐ Applicable | ☐ N/A |
| 1. | Siltation<br>Areal extent:<br>Remarks: | ☐ Siltation evident<br>Depth: | ☐ N/A |
| 2. | Erosion<br>Areal extent:<br>Remarks: | ☐ Erosion evident<br>Depth: | ☐ N/A |
| 3. | Outlet Works<br>Remarks: | ☐ Functioning | ☐ N/A |
| 4. | Dam<br>Remarks: | ☐ Functioning | ☐ N/A |
| 8. | Retaining Walls | ☐ Applicable | ☐ N/A |
| 1. | Deformations<br>Horizontal displacement:<br>Remarks: | ☐ Location shown on site map<br>Vertical displacement: | ☐ Deformation not evident<br>Rotational displacement: |
| 2. | Degradation<br>Remarks: | ☐ Location shown on site map | ☐ Degradation not evident |
| 1. | Perimeter Ditches/Off-site discharge | ☐ Applicable | ☐ N/A |
| 1. | Siltation<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Depth: | ☐ Siltation not evident |
| 2. | Vegetative Growth<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Type: | ☐ Vegetation does not impede flow |
| 3. | Erosion<br>Areal extent:<br>Remarks: | ☐ Location shown on site map<br>Depth: | ☐ Erosion not evident |
| 4. | Discharge Structure<br>☐ Functioning ☐ Good Condition<br>Remarks: | ☐ Location shown on site map | ☐ N/A |

## VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A

1. Settlement ☐ Location shown on site map ☐ Settlement not evident
   Areal extent: Depth:
   Remarks:

2. Performance Monitoring ☐ N/A
   ☐ Performance not monitored
   ☐ Performance monitored Frequency:
   ☐ Evidence of breaching Head differential:
   Remarks:

## IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A

1. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A

1. Pumps, Wellhead Plumbing, and Electrical ☐ N/A
   ☐ All required wells located ☐ Good condition ☐ Needs O& M
   Remarks:

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances ☐ N/A
   ☐ System located ☐ Good condition ☐ Needs O& M
   Remarks:

3. Spare Parts and Equipment ☐ N/A
   ☐ Readily available ☐ Good condition
   ☐ Requires Upgrade ☐ Needs to be provided
   Remarks:

2. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A

1. Collection Structures, Pumps, and Electrical ☐ N/A
   ☐ Good condition ☐ Needs O& M
   Remarks:

2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances ☐ N/A
   ☐ Good condition ☐ Needs O& M
   Remarks: Not observed.

3. Spare Parts and Equipment ☐ N/A
   ☐ Readily available ☐ Good condition
   ☐ Requires Upgrade ☐ Needs to be provided
   Remarks:

3. Treatment System ☐ Applicable ☒ N/A

1. Treatment Train (Check components that apply)
   - ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
   - ☐ Air stripping ☐ Carbon adsorbers ☐ Filters (list type):
   - ☐ Additive (list type, e.g., chelation agent, flocculent)
   - ☐ Others (list):
   - ☐ Good condition ☐ Needs O&M
   - ☐ Sampling ports properly marked and functional
   - ☐ Sampling/maintenance log displayed and up to date
   - ☐ Equipment properly identified
   - ☐ Quantity of groundwater treated annually (list volume):
   - ☐ Quantity of surface water treated annually (list volume):

   Remarks:

2. Electrical Enclosures and Panels (properly rated and functional) ☐ N/A
   - ☐ Good condition ☐ Needs O& M

   Remarks:

3. Tanks, Vaults, Storage Vessels ☐ N/A
   - ☐ Good condition ☐ Proper secondary containment ☐ Needs O&M

   Remarks:

4. Discharge Structure and Appurtenances ☐ N/A
   - ☐ Good condition ☐ Needs O& M

   Remarks:

5. Treatment Building(s) ☐ N/A
   - ☐ Good condition (esp. roof and doorways) ☐ Needs Repair
   - ☐ Chemicals and equipment properly stored

   Remarks:

6. Monitoring Wells (pump and treatment remedy) ☐ N/A
   - ☐ All required wells located ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled
   - ☐ Good condition ☐ Needs O&M

   Remarks:

4. Monitored Natural Attenuation ☐ Applicable ☒ N/A

1. Monitoring Wells (natural attenuation remedy) ☐ N/A
   - ☐ All required wells located ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled
   - ☐ Good condition ☐ Needs O&M

   Remarks:

5. Long Term Monitoring ☒ Applicable ☐ N/A

2. Monitoring Wells ☐ N/A
☐ All required wells located ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled
☒ Good condition ☐ Needs O&M
Remarks: The ODEQ currently monitors 5 monitor wells and 6 water supply wells at the site. Each monitor well was constructed in a manner similar to a municipal supply wells, and one is being used for that purpose. Each observed well was in good condition, secured behind fences with locked gates, or located within a locked well houses.

## X. OTHER REMEDIES ☒ Applicable ☐ N/A

Three dikes/diversion structures were constructed along Tar Creek to divert surface water away from subsidence structures. The dike at the Admiralty site was partially constructed along a railroad embankment. A portion of this dike has collapsed. It was not possible to determine if this collapse occurred along the railroad embankment or along the constructed dike, but the ODEQ believed that the collapse was around an area were a culvert had existed in the railroad embankment. The dikes were overgrown with vegetation. There was evidence of swimming within the subsidence feature inside the dike at the Big John site.

As indicated by the first and second five-year reviews, the dikes and diversions on Lytle and Tar Creeks did not result in stopping the discharges from the mines. Mine water discharges were observed in the area at the confluence of Tar Creek and Lytle Creek at the Douthat Bridge near the site repository (former Eagle-Picher Central Mill site).

For OU2, representative properties were examined that had been remediated, were not remediated, and were in the process of remediation. Contaminated soil removed from the yards is sent to two repositories. Both repositories were visited during the site inspection. Both are maintained in accordance with the requirements of the OU2 ROD. EPA remediation contractor CH2M HILL obtains backfill soil from a vendor whose burrow source is located on S 20 Road, located southeast of Quapaw near Beaver Creek. It was raining at the time this location was visited. Silt laden runoff was observed discharging from this site into the roadway drainage ditch at this property, and the silt curtain constructed across the discharge point had fallen down (this silt is used as backfill in remediated areas).

## XI. OVERALL OBSERVATIONS

1. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.)

The OU1 remedy was to achieve two goals: reduce or eliminate the discharge of acid mine water to Tar Creek, and protect the Roubidoux Aquifer from contamination by downward migration of acid mine water through abandoned wells and boreholes.

Dikes were constructed along Tar Creek at the Muncie, Big John, and Admiralty mine sites to divert Tar Creek and Lytle Creek around these openings to the mines. It was thought at the time of the ROD that diverting the creeks around these mine openings would reduce the recharge to the mines, lower the water levels within the mines, and reduce or eliminate the discharges of acid mine water. The first and second five year reviews concluded that the diking and diversion work did reduce the amount of recharge received by the mines in response to precipitation events, but the discharges of acid mine water from the mines were not eliminated and the volume of the discharges was not decreased. It was concluded that the constructed portions of the OU1 remedy were at best only partially effective. This conclusion remains valid based on the observed discharges of acid mine water occurring during the site inspection for this Five-Year Review. Many abandoned wells completed in the Roubidoux Aquifer have been plugged since the OU1 ROD was signed. The EPA and ODEQ are still evaluating how the effective the well plugging activities have been at preventing the acid mine water from contaminating the Roubidoux Aquifer.

The goal of the OU2 remedy was to reduce ingestion of surface soils in residential areas contaminated with lead at a concentration equal to or greater than 500 ppm. To meet this objective, soils at residential properties are tested for lead. Where lead concentrations are determined to be greater than 500 ppm, the soils in those areas are removed, down to a depth determined by the sampling, but no greater than a depth of 18 inches. Replacement soil is then placed in the excavated portions of each yard.

Based on the interviews and various blood lead studies conducted at the site, the residential yard remediation has been successful.

2. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

For OU1, the only O&M procedures involve inspections and maintenance of the diversion dikes. Also, ground water monitoring is being conducted as part of the Long-Term Monitoring program. This monitoring is related to the protection of the drinking water supply at the site. Monitoring of the ground water used as the primary drinking water supply at the site shows no exceedances of primary drinking water standards (health-based standards). Exceedances of secondary (non-health based) standards do occur in some wells. The ODEQ is monitoring the water supplies to determine if these exceedances are an indication that acid mine water is migrating into the Roubidoux Aquifer from the overlying mines. Inspection and maintenance of the dikes and diverted creek channels is adequate to ensure that recharge to the mines at these sites is not occurring.

| 3. Early Indicators of Potential Remedy Failure |
|---|
| Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.<br><br>As stated in item 1, the EPA and ODEQ have already concluded that the diking and diversion work was at best only partially effective at achieving the remedial goals for OU1. The State of Oklahoma has down-graded the designated beneficial uses for Tar Creek, but water quality data collected during the 1980s indicated that the surface water does not meet the environmental components of the water quality standards established for the down-graded beneficial use. The ODEQ and the USGS are currently conducting additional sampling of the surface water and sediments in Tar Creek, the Spring River, and the Neosho River. This data should help in assessing whether the current water quality conditions in Tar Creek are improving, and if current conditions are protective of human health. In addition, the EPA concluded in the second five-year review that the water quality in Tar Creek did not pose a risk to human health based on the secondary recreation water body designated use. The ROD for OU1 only allows for additional response activities to be conducted addressing surface water and sediment contamination in Tar Creek if there is a threat to human health.<br><br>Ground water monitoring for OU1 continues to be protective of human health. There have been no detected exceedances of the MCLs in samples collected from the Roubidoux Aquifer.<br><br>During the site inspection interviews, all interviewees stated that they were pleased with the residential yard remediation work. Many interviewees noted several studies that showed a reduction in the blood-lead levels in children since the start of the yard remediation work. This portion of the remedy is protective of human health and will remain so as long as yards are not recontaminated. |
| 4. Opportunities for Optimization |
| Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.<br><br>No opportunities to optimize monitoring tasks were noted that haven't already been addressed. The ODEQ has reduced the Long-Term Monitoring frequency from quarterly to semi-annual sampling of the Roubidoux Aquifer. |

## Tar Creek Site Inspection – Inspection Team Roster

## Date of Site Inspection – June 29 – 30, 2004

| Name | Organization | Title |
|---|---|---|
| Ursula Lennox | USEPA | Remedial Project Manager |
| Margaret O'Hare | CH2M HILL | Project Manager |
| David Cates | ODEQ | Professional Engineer |
| Dennis Datin | ODEQ | Professional Engineer |
| Darren Davis | CH2M HILL | Staff Consultant |

# Attachment 4

# Site Inspection Photographs


[filename: TC_DCP 4526.jpg]

Photo 1: View of the Commerce #5 MW. The City of Commerce has erected a well house over the well-head in preparation for connecting the well to the public water supply.


Photo 2: View of the plugged Commerce #3 well (blue arrow). White tank in background receives and stores water from the Commerce #4 well (located to the east of this location). Building at left is where chlorine is added to the water prior to entry into drinking water system.

[filename: TC_DCP 4527.jpg]


[filename: TC_DCP 4528.jpg]

Photo 3: View of the Picher #5 MW. The City of Picher has erected a well house over the well-head and connected this well to the City water supply.


[filename: TC_DCP 4529.jpg]

Photo 4: View inside the well house of the Picher #5 MW. Faucet used for sample collection is shown at black arrow.


[filename: TC_DCP 4530.jpg]

Photo 5: View of collapse feature on dike at the Admiralty Mine site. This dike is located east of the Douthat Bridge on E40 Road near the confluence of Tar Creek and Lytle Creek.


[filename: TC_DCP 4531.jpg]

Photo 6: View of vegetative growth on top of the dike at the Admiralty Mine site.


[filename: TC_DCP 4532.jpg]

Photo 7: View of diverted Lytle Creek from on top of the dike at the Admiralty Mine site. View is towards the east.


[filename: TC_DCP 4533.jpg]

Photo 8: View of subsidence features from dike at the Admiralty Mine Site. Mine water is discharging from the subsidence on the other side of the brush at blue arrow (note orange color of the water).


[filename: TC_DCP 4534.jpg]

Photo 9: View of mine water discharging from a subsidence feature at the Admiralty Mine site. Note orange water at blue arrow.


[filename: TC_DCP 4535.jpg]

Photo 10: View along dike at the Admiralty Mine site. View is to the northwest. The diverted Lytle Creek channel is located at the black arrow.


[filename: TC_DCP 4536.jpg]

Photo 11: Close-up view of the diverted Lytle Creek channel (green arrow) at the Admiralty Mine site.


Photo 12: View along the south side of the diversion dike at the Admiralty Mine site.

[filename: TC_DCP 4537.jpg]


[filename: TC_DCP 4538.jpg]

Photo 13: View of diverted Lytle Creek Channel from the diversion dike at the Admiralty Mine Site (at blue arrow).


[filename: TC_DCP 4539.jpg]

Photo 14: Confluence of Tar Creek and the diverted Lytle Creek channel (Lytle Creek is at the green arrow).


[filename: TC_DCP 4540.jpg]

Photo 15: Tar Creek immediately downstream of confluence with the diverted Lytle Creek. Gravel on left creek bank is composed primarily of chat. Chat piles are visible in the left and right background.

Photograph 15 of 76


[filename: TC_DCP 4541.jpg]

Photo 16: View of diversion dike looking east from Tar Creek.


[filename: TC_DCP 4542.jpg]

Photo 17: View of diversion dike (green arrow) at Admiralty Mine site from the top of a chat pile located west of Tar Creek. Tar Creek flows along the base of the chat pile (blue arrow). The diverted Lytle Creek channel is located at the black arrow.


[filename: TC_DCP 4543.jpg]

Photo 18: View of the Tar Creek site, facing northwest, from the top of a chat pile located west of the Douthat Bridge.


[filename: TC_DCP 4544.jpg]

Photo 19: View of the Tar Creek site, facing north, from the top of a chat pile located west of the Douthat Bridge.


[filename: TC_DCP 4545.jpg]

Photo 20: View of the Tar Creek site, facing northeast, from the top of a chat pile located west of the Douthat Bridge.


[filename: TC_DCP 4546.jpg]

Photo 21: View looking west from the top of a chat pile located near the Douthat Bridge. The repository located on E40 Road is located at the blue arrow.


[filename: TC_DCP 4547.jpg]

Photo 22: View of repository (blue arrow) on E40 Road from the top of a chat pile. View is facing west.


[filename: TC_DCP 4548.jpg]

Photo 23: View of repository facing south. Gate in background is exit onto E40 Road.


[filename: TC_DCP 4549.jpg]

Photo 24: View of recently deposited soil at repository on E40 Road. Lead contaminated soil from residential yards is used at the repository to fill in an old mill pond.


[filename: TC_DCP 4550.jpg]

Photo 25: View of repository on E40 Road facing east.


[filename: TC_DCP 4551.jpg]

Photo 26: View of recently deposited soil at the repository on E40 Road. Lead contaminated soil from residential yards is used at the repository to fill in an old mill pond.


[filename: TC_DCP 4552.jpg]

Photo 27: View of remediated area on play ground at Washington Elementary School, Miami, Oklahoma.


[filename: TC_DCP 4553.jpg]

Photo 28: View of remediated area on play ground at Washington Elementary School, Miami, Oklahoma.


[filename: TC_DCP 4554.jpg]

Photo 29: View of remediated area on play ground at a daycare facility, Miami, Oklahoma.


[filename: TC_DCP 4555.jpg]

Photo 30: View of remediated property in North Miami, Oklahoma.


[filename: TC_DCP 4557.jpg]

Photo 31: View of unremediated property in North Miami, Oklahoma.


[filename: TC_DCP 4558.jpg]

Photo 32: View of property in North Miami, Oklahoma. Construction was not complete at the time of the site inspection. Replacement sod has been placed on the portion of the property in the center of the photo.


[filename: TC_DCP 4559.jpg]

Photo 33: View of property in North Miami, Oklahoma. Construction was not complete at the time of the site inspection. Area in the foreground is where replacement sod has not yet been placed.


[filename: TC_DCP 4560.jpg]

Photo 34: View of remediated residential property located in Commerce, Oklahoma.


[filename: TC_DCP 4561.jpg]

Photo 35: View of property in Commerce, Oklahoma. Construction was not complete at the time of the site inspection. Remediated portion of the yard (bare area in middle of photograph) is awaiting the placement of sod.


[filename: TC_DCP 4562.jpg]

Photo 36: View of property in Commerce, Oklahoma. Construction was not complete at the time of the site inspection. Remediated portion of the yard (bare area in middle of photograph) is awaiting the placement of sod.


[filename: TC_DCP 4563.jpg]

Photo 37: View of unremediated properties on Vine Street in Commerce, Oklahoma (view is to the south). Chat is present in the driveway in the center of the photo (blue arrow).


[filename: TC_DCP 4564.jpg]

Photo 38: View of unremediated property located in Cardin, Oklahoma.


[filename: TC_DCP 4565.jpg]

Photo 39: View of property under construction in Cardin, Oklahoma. There were still a few remaining items to complete on this property at the time of the site inspection.


[filename: TC_DCP 4566.jpg]

Photo 40: View of property under construction in Cardin, Oklahoma. There were still a few remaining items to complete on this property at the time of the site inspection.


[filename: TC_DCP 4567.jpg]

Photo 41: View of remediated properties on Wade Street in Cardin, Oklahoma. The view is facing to the south.


[filename: TC_DCP 4568.jpg]

Photo 42: View of unremediated property located in Picher, Oklahoma.


[filename: TC_DCP 4570.jpg]

Photo 43: View of unremediated property located in Quapaw, Oklahoma.


[filename: TC_DCP 4571.jpg]

Photo 44: View of unremediated properties along Quapaw Street in Quapaw, Oklahoma. The view is facing southeast.


[filename: TC_DCP 4572.jpg]

Photo 45: View of remediated properties located along Quapaw Street in Quapaw, Oklahoma. This photo view is to the right of Photograph 45, and the view is facing south.


[filename: TC_DCP 4573.jpg]

Photo 46: View of front gate at borrow source. Material from this location is used as clean backfill for remediated residential yards.


Photo 47: View upstream in the drainage ditch and culvert at entrance to borrow source. Runoff water in the drainage ditch is discolored from silt.

[filename: TC_DCP 4574.jpg]


Photo 48: View downstream in the drainage ditch and culvert at entrance to borrow source. Runoff water in the drainage ditch is discolored from silt.

[filename: TC_DCP 4575.jpg]

Photo 49: View of drainage ditch and runoff discharge point from borrow source property. The silt curtain erected across the discharge point has collapsed (black arrow). Water in the drainage ditch becomes discolored where runoff enters from the borrow source property (blue arrow).

[filename: TC_DCP 4576.jpg]


[filename: TC_DCP 4577.jpg]

Photo 50: View of drainage ditch where runoff enters from the borrow source property. Discoloration of the runoff in the drainage ditch is apparent where the runoff enters the ditch (blue arrow).

[filename: TC_037A.jpg]

Photo 51: View of Quapaw #5 MW. Sampling tube is located at green arrow.

[filename: TC_036A.jpg]

Photo 52: View of well pad for Quapaw #5 MW. Well pad is cracked (blue arrow).


[filename: TC_035A.jpg]

Photo 53: View of Quapaw #2 well location. Well is located inside shed at right (blue arrow).

Photo 54: View of pilot project location. This project was executed by the State of Oklahoma and involved the removal of chat at the surface, placing the chat within subsidences and abandoned mine shafts, and the filling in of a mill pond. This photo shows the surface after the project was completed.

[filename: TC_034A.jpg]

Photo 55: View of pilot project location. This project was executed by the State of Oklahoma and involved the removal of chat at the surface, placing the chat within subsidences and abandoned mine shafts, and the filling in of a mill pond. This photo shows the surface after the project was completed.

[filename: TC_033A.jpg]

Photo 56: View of pilot project location. This project was executed by the State of Oklahoma and involved the removal of chat at the surface, placing the chat within subsidences and abandoned mine shafts, and the filling in of a mill pond. This photo shows the surface after the project was completed.

[filename: TC_032A.jpg]

Photo 57: View of pilot project location. This project was executed by the State of Oklahoma and involved the removal of chat at the surface, placing the chat within subsidences and abandoned mine shafts, and the filling in of a mill pond. This photo shows the surface after the project was completed.

[filename: TC_031A.jpg]

[filename: TC_030A.jpg]

Photo 58: View of diversion dike at the Big John Mine site, located in Kansas.

Photo 59: View of subsidence at the Big John Mine site, located in Kansas, facing northwest. This subsidence feature is surrounded by a diversion dike to prevent inflow of water into the mines. Tar Creek was diverted around the subsidence to the west (behind dike in background at blue arrow).

[filename: TC_029A.jpg]

Photo 60: View inside subsidence at the Big John Mine site, located in Kansas. A diving board is visible in the center of the picture (at blue arrow). ODEQ noted that this location is frequented by swimmers.

[filename: TC_028A.jpg]

[filename: TC_027A.jpg]

Photo 61: View of vegetation on the diversion dike at the Big John Mine site, located in Kansas.

[filename: TC_026A.jpg]

Photo 62: View of diversion dike at the Big John Mine site, located in Kansas. The subsidence feature is located to the left of this view.

[filename: TC_025A.jpg]

Photo 63: View facing northeast from diversion dike at the Big John Mine site, located in Kansas. Concrete structure at the left (blue arrow) was part of a mill.

[filename: TC_024A.jpg]

Photo 64: View of diversion dike at the Big John Mine site, located in Kansas. The subsidence feature is located to the right of this view.

Photo 65: View of diversion dike at the Big John Mine site, located in Kansas. The subsidence feature is located to the right of this view. Large rocks were put in place to protect against erosion.

[filename: TC_023A.jpg]

[filename: TC_022A.jpg]

Photo 66: View of road on south side of diversion dike at Big John Mine site, located in Kansas. The backside of the diversion dike is barely visible through the trees (at blue arrow). The bridge is where the old Tar Creek channel used to flow.

Photo 67: View of the bridge over the old Tar Creek channel at the Big John Mine site, located in Kansas (facing northwest). The backside of the diversion dike is barely visible above the bridge (at the blue arrow). Tar Creek has been diverted away from this location. The new channel is located in the trees in the background (at black arrow).

[filename: TC_021A.jpg]

Photo 68: View of the north repository, located just west of US Highway 69 in Picher. Piled dirt in background is an old chat pile.

[filename: TC_020A.jpg]

Photo 69: View of the north repository, located just west of US Highway 69 in Picher. Piled dirt is an old chat pile.

[filename: TC_019A.jpg]

Photo 70: View of the north repository, located just west of US Highway 69 in Picher. [filename: TC_018A.jpg]

Photo 71: View of front gate at the north repository, located just west of US Highway 69 in Picher.

[filename: TC_017A.jpg]

Photo 72: View of front gate at the north repository, located just west of US Highway 69 in Picher.

[filename: TC_016A.jpg]

Photo 73: View of Tar Creek, facing upstream (north), at the Douthat Bridge on E40 Road. The confluence of the diverted Lytle Creek channel and Tar Creek is located at the base of the chat pile in the background (blue arrow). The old Lytle Creek channel enters Tar Creek immediately to the right of the lower right hand corner of this photo (green arrow).

[filename: TC_015A.jpg]

Photo 74: View of Tar Creek at the Douthat Bridge. This picture was taken of the upstream side of the creek. Note the red tint to the water from iron oxide precipitation. This location is where acid mine water starts to enter Tar Creek.

[filename: TC_014A.jpg]

Photo 75: View of old Lytle Creek channel, just prior to its confluence with Tar Creek. Photo taken from the Douthat Bridge. Red staining is iron oxide deposition. The iron oxide precipitates out of the water and is deposited in the stream bed.

[filename: TC_013A.jpg]

Photo 76: View of the downstream side of Tar Creek at the Douthat Bridge. The color of the water in the stream is red and orange from iron oxide precipitating out of solution in the water. Note the red staining on the shore, where the iron oxide has been deposited by the stream.

[filename: TC_012A.jpg]

# Attachment 5

# Notices to the Public Regarding the Five-Year Review

**BERNARD HODES GROUP**
220 East 42nd Street

**PROOF OF INSERTION**

**AT64318**

Client: CH2MHILL
Publication: Miami News-Record - ROP
Insertion Dates: Fri, Jul 23, 2004

64318

**TAR CREEK SUPERFUND SITE PUBLIC NOTICE**
**U.S. EPA Region 6 Conducts**
**Five-Year Review of Site Remedy**
**July 2004**

The U.S. Environmental Protection Agency Region 6 (EPA) is conducting the third Five-Year Review of remedial actions for the Tar Creek Superfund Site in Ottawa County, Oklahoma. The review will evaluate the ability of the remedy to protect public health and the environment. The Site is part of the Tri-State Mining District which includes northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. Specifically, the Site includes the Old Picher Field lead and zinc mining area located in northeastern Ottawa County.

Once completed, the results of the Five-Year Review will be made available to the public at the following information repository:

**Miami Public Library**
**200 North Main Street**
**Miami, OK 74354**
**Phone: 918-541-2292**

For more information about the Site, contact Ursula Lennox, Remedial Project Manager, at (214) 665-6743 or 1-800-533-3508 (toll-free) or by e-mail at lennox.ursula@epa.gov. Information about the Tar Creek Site also is available on the Internet at www.epa.gov/region6/superfund.

# TAR CREEK SUPERFUND SITE PUBLIC NOTICE
## U.S. EPA Region 6 Completes Five-Year Review of Site Remedy

**November 2005**

In September 2005, the U.S. Environmental Protection Agency Region 6 (EPA) completed the third Five-Year Review of remedial actions for the Tar Creek Superfund Site in Ottawa County, Oklahoma. The review evaluated the ability of the remedy to protect public health and the environment. The Site is part of the Tri-State Mining District which includes northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. Specifically, the Site includes the Old Picher Field lead and zinc mining area located in northeastern Ottawa County.

### Results of the Five-Year Review

The results of the five-year review indicate that the remedy completed to date is currently protective of human health and the environment in the short term. Except as noted in this and previous five-year reviews regarding the ineffectiveness of the Operable Unit (OU) 1 remedy to decrease the acid mine water discharges to Tar Creek, the remedial actions performed are protective and appear to be functioning as designed, and the site has been maintained appropriately. No deficiencies were noted that currently impact the protectiveness of the remedy. Information about several issues that require further action to ensure the continued protectiveness of the remedy can be found in the Five-Year Review Report.

The Five-Year Review Report is available to the public at the following information repository:

**Miami Public Library**
**200 North Main Street**
**Miami, OK 74354**
**Phone: 918-541-2292**

**or on the Internet at:**

**http://www.epa.gov/earth1r6/6sf/6sf-5_year_reviews.htm**

For more information about the Site, contact Ursula Lennox, Remedial Project Manager, at (214) 665-6743 or 1-800-533-3508 (toll-free) or by e-mail at lennox.ursula@epa.gov. Information about the Tar Creek Site also can be found on the Internet at www.epa.gov/earth1r6/6sf/pdffiles/0601269.pdf.

For publication in the Miami News Record