APPENDIX C

Remediation Plan

STATE OF ARKANSAS
ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

REMEDIAL ACTION DECISION DOCUMENT

Dresser Industries-Magcobar Mine Site
Magnet Cove, Hot Spring County, Arkansas
DATE

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List of Acronyms/Abbreviations

ADEQ	Arkansas Department of Environmental Quality
APC&EC	Arkansas Pollution Control and Ecology Commission
ARARs	Applicable and/or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
CAO	Consent Administrative Order
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPCs	Constituents of Potential Concern
COCs	Constituents of Concern
EIP	Environmental Improvement Project
EMP	Effectiveness Monitoring Plan
EPA	United States Environmental Protection Agency
FS	Feasibility Study
HQ	Hazardous Quotient
IC	Institutional Control
IRM	Interim Remedial Measure
LOAEL	Lowest Observed Adverse Effects Level
MCL	Maximum Contaminant Level
NOAEL	No Observed Adverse Effects Level
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria (USEPA)
PRG	Preliminary Remediation Goal
RADD	Remedial Action Decision Document
RAIWP	Remedial Action Implementation Work Plan
RAO	Remedial Action Objective
RDP	Remedial Design Plan
SI	Site Investigation
SRAC	Selected Remedial Alternative Combination
SSP	Site Study Plan
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TRV	Toxicity Reference Value
UAA	Use Attainability Analysis
WTP	Water Treatment Plant
WTS	Water Treatment System

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Remedial Action Decision Document (RADD)
For Dresser Industries-Magcobar Mine Site

1.0 INTRODUCTION

This Remedial Action Decision Document (RADD) is written for the Dresser Industries-Magcobar Mine Site ("Site"). Located in Hot Spring County, the Site is situated on approximately six hundred (600) acres one mile northeast of Magnet Cove, Arkansas **(Figure 1)**. The property is bounded on the north by Rusher Creek. Baroid Road makes up the western boundary. Scull Creek and Clearwater Lake are on the eastern edge of the Site and the southern boundary is approximated by Stone Quarry Creek. An operating facility (Halliburton Energy Services, Inc.'s Duratone Plant) east of the mine pit is not part of the remedial area. Most of the property surrounding the site is undeveloped.

This RADD describes alternatives for remedial action regarding potentially hazardous substances that are a result of past activities at the Site. This document also describes the remedial alternatives selection process used by the Arkansas Department of Environmental Quality (ADEQ) for this Site. The Selected Remedy/Site Plan and its implementation schedule are set forth in Section 10.0. The general public is afforded an opportunity to comment on the decisions made in this document.

2.0 SITE BACKGROUND

Underground and open-pit mining for barite ore began at the Site in 1939 and continued until 1977 creating a large excavation that has filled with water since mining activity ended. Milling operations at the Site ceased in 1982. Two companies historically operated at the Site: National Lead (N.L.) Industries Incorporated - Baroid Division ("Baroid") and Magnet Cove Barium Corporation ("Magcobar"). Halliburton Energy Services (Halliburton) and TRE Management Company (the Companies) eventually became operators at the Site.

2.1 Current Site Description

At present, the Site consists of a pit approximately ninety (90) acres in areal extent and approximately four hundred eighty (480) feet deep filled with about 3.7 billion gallons of water (Pit Lake). Spoil piles border the pit on the north, east and west sides. These piles are made up of overburden removed during open-pit mining. Pyrite-rich shale from the Stanley Formation comprises most of the approximately twenty million cubic yards of spoil.

Tailings impoundments, the remnants of buildings, a water treatment plant and alkaline sludge impoundments make up the remainder of the Site. Some of the area is leased for deer hunting, and ATV riders illegally utilize parts of the Site. Two reservoirs, Lucinda Lake and Clearwater Lake were created in association with mining activities at the Site.

After mining and associated dewatering activities at the Site ended in 1977, the open pit filled with water. The water that filled the pit is acidic as a result of precipitation infiltrating through adjacent spoil piles before entering the pit. Miners refer to this phenomenon as acid rock drainage (ARD). As rain water filters through spoil piles, in this case pyrite-rich shale, sulfide from pyrite associates with water and oxygen to form sulfuric acid. The acid in turn mobilizes soluble metals and minerals in surrounding rocks causing surface water and potential groundwater contamination. **Table 1** summarizes the potential sources of contamination on site.

2.1.1 Hydrology

Located in a topographically high area, the Site is situated on a drainage divide with five related basins **(Figure 2)**. These drainage basins are associated with Chamberlain Creek, Rusher Creek (drains to Lucinda Creek), Scull Creek (includes Clearwater Lake), Reyburn Creek, and Stone Quarry Creek. The Mine Pit Lake sub-watershed is located at the head of the Chamberlain Creek watershed. A majority of the excavated mine spoil is present in the Chamberlain Creek/Pit Lake watershed, with lesser amounts in the Rusher Creek and Scull Creek watersheds. Tailings impoundments are associated with the Reyburn Creek watershed, and to a lesser extent, the Stone Quarry Creek watershed. Cove Creek which ultimately flows to the Ouachita River receives discharge from Rusher Creek, Lucinda Creek, and Chamberlain Creek watersheds. Scull Creek flows into Reyburn Creek which flows into Francois Creek and ultimately to the other major drainage in the region, the Saline River. The creeks near the Site are mostly intermittent, Cove Creek and part of Reyburn Creek being exceptions that flow perennially.

2.1.2 Geology

The Magcobar Mine Site resides in a structurally folded area of the Ouachita Mountains made up of anticlines (upward folds) and synclines (troughs) that trend generally northeast to southwest. Pit Lake and most of the spoil piles are located in a structure known as the Chamberlain Creek Syncline that plunges toward the southwest. Sedimentary rocks exposed at the Site, from oldest to youngest, include: the Ordovician-aged Big Fork Chert and Polk Creek Shale; the Silurian-aged Blaylock Sandstone and Missouri Mountain Shale; the Mississippian/Devonian-aged Arkansas Novaculite; and the Mississippian-aged Stanley Formation (Scull, 1958). The Stanley Formation is present at the core or center of the Chamberlain Creek Syncline and represents most of the overburden rock (spoil) that was excavated during open-pit and underground mining operations. Pyrite-rich shale makes up most of the Stanley Formation.

2.1.3 Hydrogeology

Groundwater flow from most of the Site (including Pit Lake and most of the spoil piles) is influenced by Site topography and geologic structure. Groundwater flows to the southwest along the axis of the Chamberlain Creek Syncline. Most of the Site is topographically situated at the head of the Chamberlain Creek drainage which flows west. Geologically, the upturned bedding of the Chamberlain Creek Syncline minimizes groundwater flow from Pit Lake to the north, east or south. Two groundwater zones have been identified in the vicinity of the Site. A shallow zone exists in the near-surface soil.

A deeper groundwater system exists in bedrock residuum and fractured bedrock. This deeper zone is known as the bedrock system. The shallow zone is relatively thin and of low permeability. The deep bedrock system within the Chamberlain Creek Syncline was historically used as a source of drinking water, with a number of potable water wells located several thousand feet west of the Site, within the syncline. A municipal water system was installed for this area in 2005 and residents are currently using water from this system.

2.2 Summary of Site Investigation

By the mid-1990s, the deserted mine pit was full of acidic water and overflow of this liquid into surrounding drainages became an environmental concern. The Companies and ADEQ entered an Administrative Settlement (LIS 00-126) effective July 7, 2000 including: (1) Interim Remedial Measures (IRMs); (2) Site Investigation (SI); and (3) Feasibility Study (FS). Full reference to these documents is included in Section 14 of this document.

Interim remedial measures were implemented shortly after the Administrative Settlement was signed prompting the construction of Levee #1 to provide additional freeboard to the Pit Lake. Additional IRMs were implemented from 2000 to 2003 for the construction of Levees #2 and #3 and of a Water Treatment System (WTS) to allow a controlled discharge from the flooded mine pit thereby improving the quality of water discharged to Chamberlain Creek. A Consent Administrative Order (CAO) LIS 03-061 was signed in May 2003 prompting water treatment operations to begin in July 2003. An additional IRM was implemented in late 2005 to extend the discharge point for treated water to a point approximately a thousand feet downstream on Chamberlain Creek so that the treated, discharged water is less affected by acidic groundwater potentially entering Chamberlain Creek from the shallow groundwater system. This second IRM also established a system that collects water from the Chamberlain Creek channel and returns it to the Pit Lake. Both 2005 IRM systems were implemented to reduce the extent to which previously treated water mixes with shallow acidic groundwater that has been contaminated from the Site.

With authorization from the ADEQ, several investigation activities were conducted prior to the approval of a Site Study Plan (SSP) to help ensure that a full range of seasonal data was collected in the time allotted for a Site Investigation. Approval of the SSP was granted by the ADEQ in a letter dated October 11, 2001. The remaining field activities were initiated and completed thereafter. The revised Final Site Investigation report, dated April 19, 2007, was conditionally approved by ADEQ on June 15, 2007.

2.3 Regulatory Background

In July 2000, Halliburton and TRE Management entered into an Administrative Settlement (LIS 00-126) with the ADEQ. The Administrative Settlement outlined requirements for Interim Remedial Measures, a Site Investigation and a Feasibility Study.

The IRMs included construction of a water treatment plant and three levees around the Pit Lake to minimize the risk of overflow of acidic water from the lake.

In October 2001 a plan was submitted for the construction and operation of an interim water treatment system to treat and discharge water from Pit Lake. The purpose of the water treatment system is to remove dissolved metals from Pit Lake water and adjust the pH of the water to between 6.0 and 9.0 before discharging it to Chamberlain Creek to meet the limitations of NPDES Permit No. AR0049794.

In May of 2003, ADEQ issued Consent Administrative Order (CAO) LIS No. 03-061. This CAO outlines requirements for completion and operation of the WTS, temporary modified permit limits, 24-month water quality and biological monitoring, and financial assurances. During the summer of 2003, a capture/pump water treatment system began operating on Chamberlain Creek to collect acidic, metal-rich runoff and seepage from mine spoil infiltration. This contaminated water is routed to the mine Pit Lake.

In 2004, ADEQ placed a 9.6 mile segment of Cove Creek, from the mouth of Cove Creek to its confluence with Chamberlain Creek, on the Impaired Water Bodies List (303(d) list) as not attaining its Fisheries Designated Use due to low pH and metals toxicity (copper and zinc). In 2006, the same 9.6 mile segment of Cove Creek was listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to depressed pH, high sulfate (SO_4) content, excessive concentrations of Total Dissolved Solids (TDS), zinc (Zn), beryllium (Be), and copper (Cu).

In 2008, the same 9.6 mile segment of Cove Creek was listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to high SO_4, excessive concentrations of TDS, Zn and Be. During the 2008 assessment, the standards for pH and copper in Cove Creek were assessed as being attained.

In 2006 and 2008, a 2.5 mile segment of Chamberlain Creek from its headwater to its confluence with Cove Creek was listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to low pH, and high chlorine (Cl), sulfate, TDS, cadmium (Cd), Zn, Be, and Cu content.

In 2006 and 2008, a 2.2 mile segment of Lucinda Creek from its headwater to its confluence with Cove Creek was also listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to depressed pH and elevated concentrations of sulfate, Zn, and Be. These streams have been negatively affected by contaminated water emanating from the Magcobar Mine Site.

3.0 SUMMARY OF SITE RISKS

Contaminated surface waters leaving the Magcobar Site are a primary concern. This contamination is mainly the result of infiltration of rain water through spoil piles causing ARD. Much of the ARD drains to Pit Lake, but some amount drains directly to surrounding local drainage basins. It is not known at this time exactly how much acidic water leaves Pit Lake as groundwater, but some amount resurfaces in the Cove Creek watershed presumably from seepage. Pit Lake potentially loses as much as forty (40) gallons of water per minute to the bedrock groundwater system.

Theoretical excess lifetime cancer risks and noncarcinogenic hazards are acceptable for relevant human receptors to environmental media affected by the Dresser Industries-Magcobar Mine Site. Because these theoretical lifetime cancer risks and non-carcinogenic hazards are acceptable, no remedial activities are required to protect human receptors.

Risks to aquatic communities in some of the off-site creeks are unacceptable. Adverse effects on aquatic receptors have been observed in Cove, Scull, Reyburn, Lucinda, and Chamberlain Creeks and Clearwater Lake. These adverse aquatic effects are driven by depressed pH, which increases mobilization of metals from soils and spoil, and increases the bioavailability and toxicity of metals in the water. The depressed pH in the site's surface waters results from ARD seepage and infiltration from mine spoil piles and tailings.

3.1 Human Health Risks

Relevant potential human receptors for on-Site and off-Site areas include the current/future trespassing ATV rider, the future construction worker, adult and child swimmers in Clearwater Lake, and the adult swimmer in Pit Lake.

Trespassing ATV riders were assumed to be exposed to constituents in surface soil primarily through incidental ingestion, dermal contact, and inhalation of particles from the surface soil. A future construction worker was assumed to be exposed to contaminants in on-Site surface and subsurface soils through incidental ingestion, dermal contact, and inhalation of particles from the soils. Adult and child swimmers were assumed to have potential exposure to contaminants in surface water through incidental ingestion and dermal contact pathways while swimming in Clearwater Lake. In addition, a child swimmer was assumed to be exposed to contaminants in sediment through incidental ingestion and dermal contact with contaminants in the sediment of Clearwater Lake. An adult swimmer was assumed to be exposed to contaminants in surface water of Pit Lake via the incidental ingestion and dermal contact pathways. Theoretical excess lifetime cancer risks and non-carcinogenic hazards are considered acceptable for these human receptors and pathways.

Currently, the shallow groundwater zone does not pose a risk to human health because it is not considered a reasonable source as a drinking water supply. However, future use of this shallow groundwater source could pose risks to human health through ingestion. In the bedrock groundwater system, acidic water leakage from Pit Lake contributes to exceedances of National Secondary Maximum Contaminant Levels (MCLs) and thus has degraded the aesthetic quality of the groundwater system deeper within the Chamberlain Creek Syncline. Federal Primary MCLs are not exceeded in the deeper zone based on the available information. Groundwater from the bedrock zone has been used in the past as a drinking water source and could be considered a future source of drinking water. Currently, existing area residents have been connected to the local municipal water system and new residents to the area will be added to the municipal water system. Confirmation of these connections will be documented.

3.2 Ecological Risks

3.2.1 Surface Water – Aquatic Receptors

Surface water bodies not including Pit Lake affected by activities at the Site are currently or potentially considered areas of concern. These include Chamberlain Creek, Cove Creek, Lucinda Creek, Rusher Creek, Reyburn Creek, Scull Creek, Clearwater Lake, and Stone Quarry Creek. These water bodies are not a risk to human health, but do pose potential risks to aquatic receptors. Concentrations of aluminum, barium, beryllium, cadmium, cobalt, copper, iron, manganese, nickel, zinc, and sulfate resulted in a Hazard Quotient (HQ) greater than one (1) for aquatic receptors in at least one of these surface water bodies.

3.2.2 Sediment – Aquatic Receptors

Surface water bodies on the Site, not including Pit Lake, in which sediment is of concern include Chamberlain Creek, Cove Creek, Lucinda Creek, Reyburn Creek, Scull Creek, Stone Quarry Creek, and Clearwater Lake. Sediments in these water bodies are not a risk to human health, but do pose potential risks to aquatic receptors. Arsenic, barium, beryllium, cadmium, cobalt, copper, manganese, nickel, and zinc concentrations resulted in an HQ greater than one (1) for aquatic receptors in the sediment of at least one of these surface water bodies.

Though the estimated risks in the sediment of surface waters are unacceptable, they are low and the potential for adverse effects is small. In addition, though the abundance and diversity of benthic macroinvertebrates are affected by former activities at the Site, these animals are present in the surface waters of the Site. In view of the low estimated level of risk posed by sediment at the Site and the potential harm to or destruction of the existing benthic macroinvertebrate community posed by the sediment removal process, removal is not recommended. By implementing remedial actions in the headwaters however, it is very likely sediment quality will improve.

3.2.3 Terrestrial – Spoil Piles and Tailings Impoundments

No-Observed-Adverse-Effects-Level (NOAEL)-based HQs for the deer mouse in the mine spoil areas and tailings impoundments were one (1) and two (2), respectively. This small potential for adverse effects to the deer mouse is the result of a highly conservative estimation of the toxicity of barium at the site. Because of this conservatism, no appreciable risks are likely to occur to terrestrial receptors in the mine spoil areas or the tailings impoundments. Furthermore, the Lowest-Observed-Adverse-Effects-Level (LOAEL)-based HQs are well below one (1).

3.2.4 Terrestrial – Sludge Ponds

NOAEL-based HQs for several terrestrial receptors exposed to the sludge ponds resulted in an HQ greater than one (1). These risks are due to the presence of metals (barium, cadmium, cobalt, manganese, and zinc) in the sludge. The sludge ponds are a relatively small area capable of supporting only a limited number of individual receptors. This area is also unlikely to be exceptionally attractive to terrestrial receptors and, therefore, would not represent disproportionately high risk in relation to the surrounding area.

3.2.5 Riparian Wildlife

Risks were assessed for the belted kingfisher and raccoon receptors in riparian areas along Cove Creek, Lucinda Creek, Reyburn Creek, and Stone Quarry Creek.

<u>Cove Creek</u>
NOAEL-based HQs greater than one (1) were calculated for the raccoon for arsenic (HQ=5), cobalt (HQ=2), copper (HQ=2), and manganese (HQ=13). A NOAEL-based HQ greater than 1 was calculated for the kingfisher for zinc only (HQ=5). No LOAEL-based HQs greater than 1 were calculated for the kingfisher. Although, the NOAEL-based HQs indicate there is a small potential for adverse effects to the raccoon, it is assumed that 100 percent of its diet comes from Cove Creek. In addition, bioaccumulation factors used in calculating risks were generic rather than site-specific. Although results indicate a small risk for adverse effects, these risks are likely overestimated and not considered significant.

<u>Lucinda Creek</u>
NOAEL-based HQs greater than one (1) were calculated for the raccoon for arsenic (HQ=4), copper (HQ=2), and manganese (HQ= 5). No LOAEL-based HQs exceeded 1 for the raccoon. No NOAEL or LOAEL-based HQs exceeded 1 for the kingfisher. Based on these results, there is not a significant risk for riparian wildlife at Lucinda Creek.

<u>Reyburn Creek</u>
NOAEL-based HQs greater than 1 were calculated for the raccoon for arsenic (HQ=5), cobalt (HQ=2), copper (HQ=2), and manganese (HQ=13). A LOAEL-based HQ exceeded 1 for the raccoon for copper (HQ=2). No NOAEL or LOAEL-based HQs exceeded 1 for the kingfisher at Reyburn Creek. Although these results indicate a small potential for adverse effects to the raccoon from copper, it is assumed 100 percent of food ingested is from Reyburn Creek. In addition, bioaccumulation factors used in calculating risks were generic rather than site-specific. Although results indicate a small risk for adverse effects, these risks are likely overestimated and not considered significant.

<u>Stone Quarry Creek</u>
NOAEL-based HQs greater than one (1) were calculated for the raccoon at Stone Quarry Creek for arsenic (HQ=10) and manganese (HQ=9). A LOAEL-based HQ greater than one (1) was calculated for the raccoon for manganese (HQ=3). A NOAEL-based HQ greater than 1 was also calculated for the kingfisher from potential exposure to zinc (HQ=2) in Stone Quarry Creek. No LOAEL-based HQ exceeded 1 for the kingfisher.

Although these results indicate a small potential for adverse effects to the raccoon from manganese, it is assumed 100 percent of food ingested is from Stone Quarry Creek. In addition, bioaccumulation factors used in calculating risks were generic rather than site-specific. Although results indicate a small risk for adverse effects, these risks are likely overestimated and not considered significant. No risks were predicted to the kingfisher at Stone Quarry Creek since LOAEL-based HQs are less than one (1).

4.0 SUMMARY OF REMEDIAL APPROACH

The Arkansas Department of Environmental Quality has determined that releases of hazardous substances at the Magcobar Mine Site must be addressed through remedial action to be protective of the environment. Due to the large physical scale of this site, remedial activities will be applied to specific areas within the Site. For use in this document, the Site is divided into two general areas that are further subdivided. An area consisting of the Pit Lake/Chamberlain Creek Watershed includes, Pit Lake, most of the spoil piles, the shallow and bedrock groundwater systems, the sludge ponds and the Chamberlain Creek watershed. A second area consists of features outside of the Pit Lake/Chamberlain Creek Watershed including the tailings impoundments, Clearwater Lake and five streams affected by the Site outside of the Pit Lake/Chamberlain Creek watershed.

4.1 Areas within the Pit Lake/Chamberlain Creek Watershed

4.1.1 Pit Lake

Pit Lake dominates surface water at the Site. There is a high correlation between measured precipitation amounts and measured changes in the Pit Lake surface elevation, indicating that little water is flowing out of Pit Lake via seepage to the bedrock and/or shallow groundwater systems. Historical rise in the Pit Lake surface elevation in response to precipitation necessitated interim remedial measures (levee construction and installation of a water treatment system) to eliminate the possibility of uncontrolled acidic water discharge from Pit Lake.

The physical/chemical structure of Pit Lake is that of a permanently stratified lake that contains three distinct layers. A top layer, with a thickness of approximately seventy (70) to eighty (80) feet, is separated from a bottom layer over three hundred (300) feet thick by a transition layer that is approximately sixty (60) feet thick. Mixing between the layers occurs only minimally and only at layer interfaces. The bottom layer contains the highest concentration of dissolved minerals and is, therefore, the densest of the three layers.

Depletion of acid in surrounding spoil and corresponding reductions in ARD loadings to Pit Lake have contributed to a trend of decreasing concentrations of metals and rise of general water quality, primarily in the lake's upper layer. Concentrations of several metals in the lower layer have decreased relative to historically measured concentrations as the likely result of biologically mediated sulfate reduction. This biologic effect results in the formation of dissolved sulfide ions and subsequent precipitation of metal sulfide minerals to the pit floor.

Sheer size will be a primary influence in determining a remedial approach to surface water in Pit Lake. Currently, Pit Lake holds around 3.7 billion (3,700,000,000) gallons of water due to lowering of its elevation through use of a water treatment system that treats and discharges water to Chamberlain Creek.

4.1.2 Spoil Piles

Spoil piles are located to the northeast, west and south of the Pit Lake. This spoil is the overburden stripped off to expose barite ore. It consists mostly of pyrite-rich shale that when exposed to oxygen and water produces sulfuric acid. The spoil piles are the source of acid that mobilizes metals in surrounding rock that contaminate the Site. Approximately, twenty million five hundred thousand (20,500,000) cubic yards of spoil surround the Site. There is currently a good cover of vegetation on much of the spoil. Any disturbance of the spoil will produce more acidic water; therefore the remedy chosen for this area needs to be minimally invasive and sequential.

4.1.3 Shallow Groundwater System

Groundwater wells installed on-Site screened in the shallow groundwater system down gradient but adjacent to the mine spoil in the western portion of the Site produced samples that contained ARD-affected groundwater. Concentrations of beryllium and cadmium in this groundwater exceed National Primary Maximum Contaminant Levels (MCLs are also referenced as drinking water standards). Federal Action Levels for concentrations of copper and lead are also exceeded in the shallow groundwater. Thus, at this time, four metals comprise the COPCs for shallow groundwater at the Site. Based on groundwater flow velocity estimates and additional wells placed on-Site in the Chamberlain Creek area, ARD-affected shallow groundwater is limited to areas immediately down gradient from the spoil piles. A portion of this acidic groundwater discharges to Chamberlain Creek within a short distance of the spoil piles.

4.1.4 Bedrock Groundwater System

The Site Investigation (SI) has concluded that the bedrock groundwater system is generally confined within the Chamberlain Creek Syncline. Data from the SI indicates that concentrations of COPCs in the bedrock groundwater system within the eastern portion of the syncline meet National Primary MCLs. This groundwater does not however, meet aesthetic-based National Secondary MCLs for iron, manganese, sulfate, and Total Dissolved Solids (TDS) due, in part, to leakage from Pit Lake. These parameters (Fe, Mn, SO_4, TDS) comprise the COPCs for the bedrock groundwater system. Bedrock groundwater in this area does not pose a human health risk per se because the Primary MCLs are met. However, action is necessary to ensure that any persons residing in this area have access to the municipal water supply.

4.1.5 Sludge Ponds

A series of sludge ponds occupies an area just west of Pit Lake. The sludge formed when water from the mine was treated before being discharged to the local watershed. Metals in mine water fell out of solution when the pH of the water was neutralized. These metals fell to the bottom of a treatment pond and make up much of the sludge in the ponds. Little or no water is retained in these former sludge pond areas.

4.1.6 Chamberlain and Cove Creek Watersheds

Chamberlain Creek is an intermittent stream that represents the main drainage from the Site. This watershed drains an area of eleven hundred thirty (1130) acres and receives depressed-pH water from the spoil piles and Pit Lake. Poor water quality (i.e. low pH and elevated concentrations of dissolved metals) in Chamberlain Creek can adversely affect water in Cove Creek a perennial stream that enters the Ouachita River which is the dominant regional drainage. The water treatment system that became operational in June 2003 has helped improve water quality in Chamberlain and Cove Creeks. As noted in Section 4.1.3 above, there is a groundwater component that adversely affects surface water quality in Chamberlain Creek and Cove Creek.

4.2 Areas Outside Pit Lake/Chamberlain Creek Watershed

4.2.1 Tailings Impoundments

Most of the tailings are impounded by dams in the Reyburn Creek watershed. Some of these dams are mantled with a thin veneer of jig tailings produced by the ore milling operation. Precipitation infiltrates the spoils and tailings at the head of Reyburn Creek and further lowers the pH and raises metals concentrations in the water of Reyburn Creek.

4.2.2 Affected Streams

Rusher Creek, Lucinda Creek, Stone Quarry Creek, Reyburn Creek and Scull Creek/Clearwater Lake make up the surface water bodies currently or potentially affected by activities at the Site but are outside the Pit Lake/Chamberlain Creek watershed.

Rusher Creek drains a basin of one hundred sixty (160) acres due north of Pit Lake. This stream is divided into two forks, East Rusher Creek and West Rusher Creek. Much of the runoff and seepage from the northern spoil piles enters the Rusher Creek drainage basin. Acid Rock Drainage has depressed the pH in Rusher Creek waters from less than 4.0 in the western fork of the stream to between 4.0 and 5.0 in the eastern fork. Constituents of potential concern in Rusher Creek include high metals concentrations. Both forks of this creek drain into Lucinda Creek.

Lucinda Creek is an intermittent drainage northeast of Pit Lake with a watershed of six hundred forty (640) acres. Lucinda Creek drains directly into Cove Creek. Lucinda Creek receives ARD from spoil piles and also receives water with depressed pH and high concentrations of dissolved metals from Rusher Creek. Lucinda Creek basin contains Lucinda Lake, a reservoir constructed for use in milling operations at the site. Lucinda Lake is located up gradient from the site and is not affected by contaminants from the Site at this time.

Upper Stone Quarry Creek has a sub-basin that drains four hundred sixty (460) acres. This part of the stream was affected by mining activities. Arsenic, manganese and zinc are constituents of concern in Stone Quarry Creek.

The Upper Reyburn Creek sub-basin drains an area of four hundred seventy five (475) acres including the majority of the tailings impoundment area. Drainage from the Scull Creek/Clearwater Lake basin enters Reyburn Creek southeast of the Mine Site. Reyburn Creek becomes perennial at this point flowing into Francois Creek which flows into the Saline River, a regional drainage. Constituents of Potential Concern (COPCs) in Reyburn Creek include high concentrations of metals that are a result of depressed pH in contributing waters.

4.2.3 Clearwater Lake/Scull Creek

Scull Creek drains an area of seven hundred ninety (790) acres. This intermittent stream collects ARD runoff and seepage from the northeast spoil piles causing its waters to have a pH between 2.8 and 3.0. Scull Creek ultimately flows into Clearwater Lake another reservoir constructed for use in the milling and mining operations at the Site. Clearwater Lake covers approximately sixty two (62) acres with a maximum depth of thirty five (35) feet. The lake’s water has a pH of 4.5 with elevated metals concentrations.

5.0 SUMMARY OF REMEDIAL ALTERNATIVES

5.1 Area-Specific Alternatives – Pit Lake/Chamberlain Creek Watershed

This section identifies remedial alternatives for six (6) specific areas of concern within the Pit Lake/Chamberlain Creek watershed. The alpha-numeric labeling system used to designate the alternatives in this RADD match the remedial alternatives designations in the Feasibility Study as applicable. Details of costs and other specifics of proposed remedial alternatives are found in the FS and the correlation of labels between this RADD and the FS will make reference to particular alternatives convenient. The six specific areas of concern are as follows:

- Pit Lake,
- spoil piles,
- shallow groundwater,
- bedrock groundwater,
- sludge ponds, and
- Chamberlain Creek.

5.1.1 Pit Lake Alternatives

Pit Lake is the dominant feature at the Site containing around three billion seven hundred million (3.7 billion) gallons of acidic water with elevated metals and minerals concentrations. There are five (5) remedial alternatives identified for Pit Lake: No Action (PL1); Operate Existing WTS and Maintain Pit Lake Water Level with a change in the water quality standards for minerals through the Use Attainability Analysis (UAA) process (PL2); Operate Existing WTS and Maintain Pit Lake Water Level with temporary water quality standards for minerals as part of the Environmental Improvement Project (EIP) process (PL2-modified). In Situ Neutralization and Maintain Pit Lake Water Level (PL3); and Operate Existing WTS and Drain Pit (PL4). These alternatives are described and evaluated in the following subsections (5.1.1.1 through 5.1.1.5).

5.1.1.1 PL1 – No Action

The "No Action" alternative for Pit Lake (PL1) would include cessation of pumping and treating Pit Lake's water. Existing levees installed as IRMs would remain in place. This alternative would result in continued natural filling of the Pit Lake due to direct precipitation, runoff, and seepage from the surrounding spoil piles, culminating in an uncontrolled discharge of Pit Lake water into the headwaters of Chamberlain Creek via a surface discharge. Groundwater would likely be negatively affected by choosing this alternative as well.

5.1.1.2 PL2 – Operate Existing WTS and Maintain Pit Lake Water Level with a Change in the Water Quality Standards for Minerals through the UAA Process

The "Operate Existing WTS and Maintain Pit Lake Water Level" alternative for Pit Lake (PL2) would entail continued pumping and treating of Pit Lake waters along with continued pumping of the collected groundwater from the Chamberlain Creek headwaters to the Pit Lake. To maintain a target surface elevation for Pit Lake, the volume of water treated (on an annual basis) would be approximately equivalent to the net volume added to Pit Lake by precipitation, runoff/seepage from adjacent areas during a given year and water captured in the Chamberlain Creek basin and pumped back into Pit Lake. The lake's target surface elevation would be lower than the lowest bedrock elevation along the rim of the pit to minimize ARD seepage through the base of the adjacent spoil piles.

A Pit Lake surface elevation of approximately five hundred ninety-five (595) feet is expected to eliminate much ARD seepage and to also provide approximately ten (10) feet of free board in the event that an upset of the WTS occurs (i.e., the Pit Lake surface could rise for a year or more while repairs or adjustments are made without the development of seepage through the spoil piles). Pit Lake discharge rates would continue to be hydrographically-controlled (dependent on the receiving stream flow rate) as per the existing treatment IRM. The WTS discharge would be expected to continue to meet NPDES permit limits as modified. Modification of the standards for sulfate, chloride, and TDS would be sought through a (UAA) process.

5.1.1.3 PL2-modified - Operate Existing WTS and Maintain Pit Lake Water Level with a Temporary Change in the Water Quality Standards for Minerals through the EIP Process

The "Operate Existing WTS and Maintain Pit Lake Water Level" alternative for Pit Lake (PL2-modified) would entail continued pumping and treating of Pit Lake waters along with continued pumping of the collected groundwater from the Chamberlain Creek headwaters to the Pit Lake. To maintain a target surface elevation for Pit Lake, the volume of water treated (on an annual basis) would be approximately equivalent to the net volume added to Pit Lake by precipitation, runoff/seepage from adjacent areas during a given year and water captured in the Chamberlain Creek basin and pumped back into Pit Lake. The lake's target surface elevation would be lower than the lowest bedrock elevation along the rim of the pit to minimize ARD seepage through the base of the adjacent spoil piles.

A Pit Lake surface elevation of approximately five hundred ninety-five (595) feet is expected to eliminate much ARD seepage and to also provide approximately ten (10) feet of free board in the event that a temporary cessation of the WTS occurs (i.e., the Pit Lake surface could rise for at least several years while repairs or adjustments are made without the development of seepage through the spoil piles). Pit Lake discharge rates would continue to be hydrographically-controlled (dependent on the receiving stream flow rate) as per the existing treatment IRM. The WTS discharge would be expected to meet NPDES permit limits as modified. Temporary modification of the standards for sulfate, chloride, and TDS would be sought as part of the EIP process.

5.1.1.4 PL3 – In Situ Neutralization and Maintain Pit Lake Water Level

Alternative PL3, "In Situ Neutralization and Maintain Pit Lake Water Level" would entail in situ chemical treatment using hydrated lime to neutralize the pH of Pit Lake's upper layer. Addition of fertilizer to promote biological treatment mechanisms, and gravity discharge of treated water into the headwaters of Chamberlain Creek via a surface discharge would be other aspects of PL3. Existing levees installed as IRMs would remain in place however operation of the existing WTS would be discontinued.

Though neutralization of the upper layer of Pit Lake has the potential to reduce metal concentrations to levels that would allow discharge in accordance with approved limits, concentration levels of other minerals in the neutralized water would be unaffected. Therefore, the discharge rate of the neutralized water would need to be hydrographically controlled according to the flow rate in the receiving stream (Chamberlain Creek). Continued dilution by rainwater could eventually decrease the minerals concentrations in the upper layer to the point where a hydrographically controlled release is no longer needed, provided the current temporary minerals standards are permanently adopted.

In situ chemical treatment would not only neutralize the Pit Lake water but also precipitate/co-precipitate COPCs which would ultimately settle to the bottom of Pit Lake creating a sediment/sludge bed. Care would need to be taken as the lime is added to the upper layer of the Pit Lake to ensure that the stratification of Pit Lake is not disturbed and/or that hydrogen sulfide gas potentially generated by fertilizer addition does not present a risk. It is unlikely that the pH of the upper layer of Pit Lake's water would remain neutral for more than a few years if acidic inputs from the spoil piles were to continue. Therefore, periodic chemical treatment to maintain a neutral pH would likely be required if the spoil piles remain in place.

5.1.1.5 PL4 – Operate Existing WTS, Drain Pit

The "Operate Existing WTS and Drain Pit" alternative for the Pit Lake (PL4) entails the continuation of pumping and treating of the Pit Lake water. The WTS would treat and discharge the maximum allowable flow rate (hydrographically-controlled) until the Pit Lake is nearly or completely empty. This would be implemented in conjunction with spoil pile and tailings impoundment alternatives that would relocate these materials to the drained Pit Lake. A simple draining model was developed for the FS to estimate the amount of time that would be required to drain the Pit Lake. Due to the large volume of water within the Pit Lake (~3.7 billion gallons) and the hydrographically-controlled release complete draining of Pit Lake would require a minimum of several decades (~60 years) and may not even be possible.

5.1.2 Spoil Piles Alternatives

Mine spoil on the Site is primarily comprised of black marine shale from the Stanley Formation that was stripped as overburden from the mine pit to expose the barite ore body. The spoil contains material ranging in size from boulders to clay-sized particles and was placed around the pit in three major areas: the northeast, the northwest, and the southwest spoil areas. This material contains a significant amount of pyrite (iron sulfide) that, when weathered, produces sulfuric acid which in turn leaches and mobilizes naturally occurring metals and other minerals from the spoil. Fifty (50) to seventy (70) percent of the spoil is now covered in varying densities of vegetation (mostly pine). Little to no grading was performed during or after spoil placement leaving many of the spoil pile faces at the angle of repose. The vast majority of the spoil piles are located within the Pit Lake/Chamberlain Creek Watershed. However, smaller amounts of spoil extend into the Rusher Creek and Scull Creek/Clearwater Lake watersheds and affect surface water quality in those areas.

There are four (4) remedial alternatives considered for the spoil piles: No Action (SP1); Selective Regrading, Augment Vegetation, and Capture ARD (SP2); Extensive Regrading, Soil Cover, and Revegetation (SP3); Remove and Dispose in Drained Pit Lake (SP4). These alternatives are described and evaluated in the following Sections (5.1.2.1 through 5.1.2.4).

5.1.2.1 SP1 – No Action

The "No Action" alternative for the spoil piles (SP1) entails leaving the piles in their current configuration and state of vegetation. Where present, the vegetation would continue to build a thicker litter layer consisting of mostly pine needles while the angle-of-repose faces would continue to weather and erode. Direct precipitation on the spoil piles would result in runoff and infiltration generating acid and dissolved metals that ultimately enter Pit Lake, Chamberlain Creek, the shallow groundwater within the Chamberlain Creek Syncline, and off-site creeks.

5.1.2.2 SP2 – Selective Regrading, Augment Vegetation, and Capture Acid Rock Drainage

Alternative SP2 for the spoil piles," Selective Regrading, Augment Vegetation, and Capture ARD" would build upon and enhance the natural reclamation of the spoil that has occurred since mining ceased over thirty (30) years ago. This includes the development of a good coniferous forest over much of the spoil as well as the weathering (oxidation) of the spoil pile surfaces. Alternative SP2 would entail selective regrading, where practical, to aid in reducing erosional transport of particles, directing surface runoff toward Pit Lake, and reducing infiltration. This alternative would also include the addition of soil amendments, where appropriate, to further reduce the acid generating potential of the spoil. The specific areas to be regraded, amended, and planted would be selected based on their potential to release contaminants via seepage or infiltration as well as the extent to which they may contribute ARD to areas outside of the Pit Lake/Chamberlain Creek Watersheds.

In addition to selective regrading and vegetation augmentation, SP2 would also include collecting runoff and shallow groundwater emanating from the northeastern spoil piles outside of the Pit Lake/Chamberlain Creek Watersheds and treating it prior to discharge. Such collection would involve repair of the existing surface water diversion channel in the northeast portion of the Site that was constructed while mining was active. Use of this channel would allow collection of ARD before it impacts the Scull Creek/Clearwater Lake area. The channel would deliver the collected runoff to the headwaters of East Rusher Creek where it would either be treated or pumped to the Pit Lake for treatment.

5.1.2.3 SP3– Extensive Regrading, Amendment, Soil Cover, Revegetation

The "Extensive Regrading, Soil Cover, and Revegetation" alternative for the spoil piles (SP3) would entail:

(1) Regrading and/or moving the spoil piles so that the total surface area is minimized and slopes are reduced;
(2) Adding soil amendments to eliminate further acid generation;
(3) Applying a soil cover to the consolidated spoil to reduce infiltration, and
(4) Revegetating the consolidated spoil.

For the purposes of this RADD it is assumed that the spoil would be consolidated in a single repository located within the Chamberlain Creek syncline west of the Pit Lake, between the WTS and Baroid Road, and that the spoil would be amended (treated) with an alkaline material as it is being placed in a repository. This would be implemented by placing the spoil in lifts that are a few feet thick, applying alkaline material to the lift surface, and incorporating the alkaline material into the spoil lift by plowing or ripping with construction equipment. This repository site would require the relocation of approximately fourteen (14) million cubic yards of spoil because approximately six and a half (6.5) million cubic yards of spoil are already present in the repository footprint area. Areas from which the spoil had been removed would also be amended (treated) with alkaline material to mitigate any further ARD production. These actions would eliminate further ARD inputs to Pit Lake. This alternative would require removal of the current coniferous forest from the spoil material before it is relocated and/or regraded.

5.1.2.4 SP4 – Remove and Dispose in Drained Pit Lake

Alternative SP4 "Remove and Dispose in the Drained Pit Lake" alternative entails excavating all of the spoil material and placing it within the existing mine pit once the pit is drained. This alternative is only an option if alternative PL4 (Section 5.1.1.4) is implemented for Pit Lake. Once Pit Lake is drained (this could take decades if it is even possible; see Section 5.1.1.4), the spoil piles would be excavated and used to backfill the pit. Once the spoil is in place as fill, a soil cover would be used to isolate the spoil material to reduce mobility of contaminants in the acidic fill.

Due to swelling or bulking of the spoil resulting from excavation, the backfilled pit surface would likely be mounded. Runoff from the mounded area would flow to the Chamberlain Creek Watershed. Due to consolidation, the surface area of the spoil material would be reduced by approximately half, thereby reducing infiltration through the spoil.

During excavation and backfilling, risk to the environment would be increased due to exposure of fresh spoil surfaces to precipitation and infiltration that creates ARD. Material in the backfilled pit would eventually become saturated with groundwater that would resume its westward flow within the Chamberlain Creek Syncline once the effects of pit dewatering have dissipated and a natural flow regime is established. The water that would emanate from the saturated, backfilled pit would be of poor quality (acidic, with elevated metals and TDS concentrations) given the amount of reactive surface area available in the broken up spoil material and the presence of soluble metals in the spoil. Low quality water would emanate from the backfilled pit as deep groundwater, shallow groundwater, and possibly as seeps over the long-term.

5.1.3 Shallow Groundwater Alternatives

The shallow groundwater zone within the Pit Lake/Chamberlain Creek Watershed is present within the confines of the Chamberlain Creek Syncline down gradient from Pit Lake, along Chamberlain Creek, and is underlain by the bedrock groundwater zone. Chamberlain Creek is hydraulically connected to the shallow groundwater zone and this stream gains discharge from input of the shallow groundwater system throughout this portion of the Site. There are three (3) alternatives considered for the shallow groundwater zone: No Action (SGW1); Operate Existing Capture/Treatment System (SGW2); and Expanded Capture/Treatment System (SGW3). These alternatives are discussed in detail in the following sections (5.1.3.1 through 5.1.3.3).

5.1.3.1 SGW1 – No Action

Alternative SGW1 "No Action" entails discontinuing the existing capture/treatment system that collects shallow groundwater and pumps it into Pit Lake. This would allow increased seepage from the southwest spoil area to enter the headwaters of Chamberlain Creek. This acidic seepage with elevated metals concentrations will further impact

Chamberlain Creek and not only transport metals and acidity downstream but also precipitate metal hydroxides in and on top of the creek's sediment.

5.1.3.2 SGW2 – Operate Existing Capture/Treatment System

The "Operate Existing Capture/Treatment System" alternative (SGW2) would entail continuing operation of the existing system that collects shallow groundwater near the headwaters of Chamberlain Creek and pumps it back to Pit Lake. This system reduces the acidic water and COPCs that enter into Chamberlain Creek and are ultimately transported downstream to Cove Creek. However, the current system captures only a portion of the acidic shallow groundwater that enters Chamberlain Creek. This alternative is only viable when combined with Pit Lake alternatives that include treatment and discharge (e.g. PL2 and PL3; Sections 5.1.1.2 and 5.1.1.3, respectively).

5.1.3.3 SGW3 – Expanded Capture/Treatment System

Alternative SGW3 "Expanded Capture/Treatment System" would entail extending the existing capture system, or installing a new, larger system, to intercept a larger portion of impacted shallow groundwater that would otherwise flow to Chamberlain Creek. The expanded system would include French drains to collect groundwater that would be pumped to Pit Lake. This alternative is only viable when combined with Pit Lake alternatives that include treatment and discharge (e.g. PL2 and PL3; Sections 5.1.1.2 and 5.1.1.3, respectively).

5.1.4 Bedrock Groundwater Alternatives

The bedrock groundwater zone in the Pit Lake/Chamberlain Creek Watershed occurs mainly within the Chamberlain Creek Syncline. Groundwater within the syncline flows primarily through the Stanley Formation from Pit Lake to the southwest, along the plunge of the syncline. Bedrock groundwater samples from wells within the syncline have shown evidence of neutralized Pit Lake water with exceedances of aesthetic-based secondary MCLs but no exceedances of primary MCLs. There are three (3) alternatives considered for the bedrock groundwater zone: No Action (BGW1); Verify Connection to Municipal Water System (BGW2); and Drain and Backfill Mine Pit (BGW3). These alternatives are discussed in detail in the following Sections (5.1.4.1 through 5.1.4.3).

5.1.4.1 BGW1 – No Action

Alternative BGW1 "No Action" entails no additional activity to address bedrock groundwater that is affected by the Site.

5.1.4.2 BGW2 – Verify Connection to Municipal Water System

The "Verify Connection to Municipal System" alternative (BGW2) entails verifying that all of the residential properties within the affected or potentially affected Chamberlain Creek Syncline are connected to the existing municipal water supply system that traverses the area. Connection to a municipal water system by existing area residences will be confirmed and new residents in the municipal supply connection area depicted in **Figure 3** will be informed of local hydrologic conditions and connected to the municipal system.

5.1.4.3 BGW3 – Drain and Backfill Mine Pit

Alternative (BGW3) "Drain and Backfill Mine Pit" entails draining Pit Lake and backfilling it with mine spoil and tailings. It reflects the combination of Pit Lake alternative PL4 (Section 5.1.1.4), spoil alternative SP4 (Section 5.1.2.4) and tailings impoundment alternative TI3 (Section 5.2.1.3). Implementation would take decades because of the time it would take to drain Pit Lake, backfill it, and allow the water table to rebound within the backfilled material. As discussed in Section 5.1.2.4, pore water within the backfilled material would be of poor quality and would continue to impact the bedrock groundwater system and possibly the shallow groundwater system.

5.1.5 Sludge Ponds Alternatives

When mining was active at the site, a lime neutralization treatment process was utilized to remove metals from water pumped from the mine pit prior to its discharge. This process used impoundments (settling ponds) to settle and store the precipitates (sludge) from the treatment process. When the settling ponds were full, the sludge was relocated to depressions on top of the adjacent spoil pile (southwest spoil area) where the sludge drained and consolidated. Three 'sludge ponds' were used for drying and storage. It is estimated that these three sludge ponds cover approximately four point six (4.6) acres and comprise approximately four thousand (4,000) cubic yards of dry metal-bearing hydroxide sludge containing the highest metals concentrations of any solid media at the Site.

There are four (4) remedial alternatives considered for the sludge ponds: No Action (SLU1); Soil Cover and Revegetate (SLU2); Removal with On-Site Disposal (SLU3); and Removal with Off-Site Disposal (SLU4). These alternatives are discussed in detail in the following Sections (5.1.5.1 through 5.1.5.4).

5.1.5.1 SLU1 – No Action

Alternative SLU1, "No Action" would entail performing no activities at the three sludge ponds. Metals present in the dry sludge would remain and continue to pose unacceptable risks to small terrestrial receptors that have limited geographic ranges.

5.1.5.2 SLU2 – Soil Cover, Revegetate

The "Soil Cover and Revegetate" alternative (SLU2) entails placing a vegetated soil cover over the three sludge ponds.

5.1.5.3 SLU3 – Removal with On-Site Disposal

Alternative SLU3 is "Removal with On-Site Disposal" and would relocate the sludge to a different part of the Site.

5.1.5.4 SLU4 – Removal with Off-Site Disposal

The "Removal with Off-Site Disposal" alternative (SLU4) entails excavating the sludge from the three ponds and transporting it off-Site to an appropriate disposal facility. The appropriate repository type would depend on the toxicity characteristics of the sludge (as determined by the toxicity characteristic leaching procedure ["TCLP"] analysis). If it fails the TCLP test, then the sludge would be transported to a hazardous waste landfill, otherwise a non-hazardous waste landfill would suffice for disposal. Preliminary evaluations suggest that the sludge does not exhibit the toxicity characteristic and testing during a Site Investigation indicated that the sludge is not particularly prone to leaching.

5.1.6 Chamberlain Creek Watershed Alternatives

Chamberlain Creek emanates from the southwest spoil area and flows west-southwest from the Site to a confluence with Cove Creek. Chamberlain Creek is a gaining stream in the vicinity of the Site meaning that it adds groundwater to its discharge along its flow path. Interim Remedial Measures (groundwater capture system and WTS discharge) have reduced the loading and transport of COPCs from Chamberlain Creek to Cove Creek. The remaining poor water quality inputs to Chamberlain Creek are from surface runoff and groundwater emanating from the spoil piles. There are three alternatives considered for Chamberlain Creek: No Action (CHM1); Source Control (CHM2); and Source Control and Sediment Removal (CHM3). These alternatives are discussed in detail in the following sections (5.1.6.1 through 5.1.6.3).

5.1.6.1 CHM1 – No Action

Alternative CHM1, “No Action” would entail performing no activities with regard to Chamberlain Creek.

5.1.6.2 CHM2 – Source Control

The “Source Control” alternative (CHM2) would include portions of many other area-specific alternatives such as Pit Lake alternatives (PL2 or PL3), spoil pile alternatives (SP2 or SP3), and shallow groundwater alternatives (SGW2 or SGW3). All of these associated alternatives would provide varying degrees of source control for the Chamberlain Creek area. For instance, the spoil piles that are contributing runoff to Chamberlain Creek could be selectively regraded and amended or completely regraded, selectively amended, capped, and vegetated. Each alternative would have a different effect on Chamberlain Creek water quality.

5.1.6.3 CHM3 – Source Control and Sediment Removal

Alternative CHM3, “Source Control and Sediment Removal” would include source control measures in areas affecting Chamberlain Creek’s water quality, as discussed in the preceding section, as well as removal and disposal (on-site or off-site) of impacted sediments from and adjacent to the creek channel. The removal of creek sediments would initially destroy any benthic macroinvertebrate communities present in Chamberlain Creek. If the associated alternatives chosen for the creek’s headwaters area do not effectively reduce the loading of contaminants to Chamberlain Creek, then re-accumulation of contaminants in the sediments could occur over the long-term.

5.2 Area-Specific Alternatives Outside of Pit Lake/Chamberlain Creek Watershed

Remedial alternatives developed for the portion of the Site outside of the Pit Lake/ Chamberlain Creek Watershed will be discussed on an area-specific basis. The three areas discussed (and the number of alternatives developed) include:

- Tailings Impoundments (3 alternatives);
- Affected Streams (3 alternatives); and
- Clearwater Lake (3 alternatives).

5.2.1 Tailings Impoundments Alternatives

There are four (4) mill tailings impoundments on the Site (TP1 through TP4). These impoundments are comprised primarily of flotation mill tailings (generally fine grained), however, there are some jig tailings (gravel-sized) present near TP1 and on the faces of the TP3 and TP4 east (TP4E) dams. All of the impoundments contain both tailings and standing water with good vegetation cover over the dry tailings in most areas. Three of the impoundments are within the Reyburn Creek Watershed however TP4 has two dams since it straddles two drainages (Reyburn Creek and Stone Quarry Creek). Based on geotechnical analyses presented in the Site Investigation Report, the majority of the tailings impoundment embankments are only marginally stable against slope failure. Only the TP4 west (TP4W) embankment, in the headwaters of Stone Quarry Creek, was found to be acceptably stable in its current state.

In total, the tailings impoundments cover approximately eighty (80) acres and contain approximately three point nine (3.9) million cubic yards of tailings and forty-nine (49) million gallons of moderately acidic water (pH~3.6). There are three (3) alternatives considered for the tailings impoundments: No Action (TI1); Regrade, Stabilize Dams, and Revegetate (TI2); and Remove and Dispose in Drained Pit Lake (TI3). These alternatives are discussed in detail in the following Sections (5.2.1.1 through 5.2.1.3)

5.2.1.1 TI1 – No Action

Alternative TI1, “No Action” would entail no activities on the tailings impoundments.

5.2.1.2 TI2 – Regrade, Stabilize Dams, Revegetate

The “Regrade, Stabilize Dams, and Revegetate” alternative (TI2) calls for regrading the tailings to eliminate surface water storage, stabilizing the dams to increase factors of safety with respect to slope stability, and revegetating the disturbed portions of the tailings impoundments. Regrading of the tailings impoundments would reduce the amount of moderately acidic water seeping from the tailings dams. Improvement in dam stability would be achieved by reducing the currently steep dam slopes by either laying back the existing slopes or by buttressing the slopes with additional soil material. A geotechnical investigation during a remedial design phase would be required to determine the most appropriate approach.

5.2.1.3 TI3 – Remove and Dispose in Drained Pit Lake

Alternative TI3, “Remove and Dispose in Drained Pit Lake”, would require excavating and transporting all tailings (3.9 million cubic yards) into the drained Pit Lake, regrading the tailings impoundment area to match pre-mining topography, and replanting the area.

5.2.2 Affected Streams Alternatives

Affected or potentially affected streams outside of the Pit Lake/Chamberlain Creek Watershed include Rusher Creek, Lucinda Creek, Scull Creek, Stone Quarry Creek and Reyburn Creek. Runoff from the northern and northwestern spoil piles drains into Rusher Creek (which flows into Lucinda Creek) while runoff from the northeastern spoil piles drains to Scull Creek (which flows into Clearwater Lake and ultimately Reyburn Creek). During the Site Investigation, Rusher Creek was determined to be ephemeral and therefore cannot support aquatic life, though its waters flow into Lucinda Creek and can affect water quality in that stream.

Acid Rock Drainage runoff and seepage emanating from the northeast spoil piles, impact the headwaters of Scull Creek before it enters Clearwater Lake. The Reyburn Creek drainage receives water from the majority of the tailings impoundment area. Reyburn Creek immediately below the impoundment area is a very small channeled stream with heavily cemented and embedded substrates. Stone Quarry Creek has limited contact with Tailings Pond 4. There are three alternatives considered for the affected streams: No Action (AS1); Source Control (AS2); and Source Control and Sediment Removal (AS3). These alternatives are discussed in detail in the following Sections (5.2.2.1 through 5.2.2.3).

5.2.2.1 AS1 – No Action

The "No Action" alternative (AS1) entails no activities on streams or associated sources of COPCs (runoff from the spoil piles and tailings impoundments).

5.2.2.2 AS2 – Source Control

Alternative AS2, "Source Control", includes reducing or minimizing contact between runoff and spoil piles or tailings impoundments to minimize impact to off-site streams. As such, the effectiveness of this alternative (AS2) relies on area-specific alternatives that would be implemented for the spoil piles and the tailings impoundments (see Sections 6.1.2 and 6.2.1, respectively). With regard to Rusher Creek and Scull Creek (and Clearwater Lake), specific source control options could include: (1) localized treatment of runoff and seeps emanating from the spoil piles, (2) rerouting of runoff and seeps toward Pit Lake, (3) collecting runoff and shallow groundwater emanating from the spoil piles outside of the Pit Lake/Chamberlain Creek Watersheds and treating it prior to discharge, and/or (4) regrading the spoil piles such that runoff and seepage flows to the Chamberlain Creek/Pit Lake Watershed (Alternative SP3).

5.2.2.3 AS3 – Source Control and Sediment Removal

The "Source Control and Sediment Removal" alternative (AS3) includes minimizing contact between runoff and spoil piles or tailings impoundments, as discussed for the Source Control alternative in the previous subsection, coupled with sediment removal in the affected streams.

5.2.3 Clearwater Lake Alternatives

Clearwater Lake is located east of the Site and was constructed in 1941-42 as part of the mining and milling operations. The lake was used as a fresh water reservoir for make-up water within the milling operations. It covers approximately sixty two (62) acres with a maximum depth of approximately thirty five (35) feet. Clearwater Lake is fed by a number of small tributaries with Scull Creek as the primary tributary. The tributaries west of the lake originate on or near the Site, specifically near the spoil piles, and then flow through undeveloped areas. Tributaries east of the lake originate and flow through largely undeveloped areas that are not impacted by the past mining operation. The only significant activity in the undeveloped watershed areas of Clearwater Lake, other than some mine spoil deposition, was logging. Due to the contribution of ARD from the spoil piles, the pH within Clearwater Lake is acidic (~4.5) and concentrations of certain metals are elevated in the lake sediments. There are three alternatives considered for Clearwater Lake: No Action (CWL1); Source Control (CWL2); and Source Control and Sediment Removal for Clearwater Lake (CWL3) as described in sections 5.2.3.1 through 5.2.3.3.

5.2.3.1 CWL1 – No Action

The "No Action" alternative (CWL1) for Clearwater Lake calls for no action on the lake or on Site materials that are sources of ARD to the lake.

5.2.3.2 CWL2 – Source Control

Alternative CWL2 for Clearwater Lake, "Source Control", entails source control actions to reduce the quantity of ARD and/or improve the quality of ARD that enters upper Scull Creek. Various source control options for the spoil piles could be implemented to achieve source control. Section 5.1.2 discusses alternatives for spoil piles that may impact Scull Creek and Clearwater Lake.

5.2.3.3 CWL3 – Source Control and Sediment Removal

The "Source Control and Sediment Removal" alternative (CWL3) would require elements of alternative CWL2 adding the removal of sediments from the lake that have high metals concentrations that pose potential risk.

6.0 PROPOSED/RECOMMENDED ALTERNATIVES FROM FS

This section has been removed from the final RADD.

7.0 EVALUATION AND SCREENING OF AREA-SPECIFIC ALTERNATIVES

Remedial action alternatives were considered in association with the Interim Remedial Measures already implemented at the Site. In particular, levees and the Water Treatment Plant constructed to prevent Pit Lake from overflowing. All alternatives considered must be protective of human health and the environment and be in compliance with the applicable or relevant and appropriate requirements (ARARs).

7.1 Evaluation and Screening of Area-Specific Alternatives within the Pit Lake/Chamberlain Creek Watershed

This section evaluates and screens remedial alternatives for six specific areas of concern within the Pit Lake/Chamberlain Creek Watershed. Table 7.1 summarizes the remedial alternatives considered for areas of concern within the Pit Lake/ Chamberlain Creek watershed.

- Pit Lake,
- spoil piles,
- shallow groundwater,
- bedrock groundwater,
- sludge ponds, and
- Chamberlain Creek.

The screening process involves evaluating defined remedial alternatives against broad criteria of relative effectiveness, implementability, and cost. The objective of the screening process is to eliminate alternatives of relatively low effectiveness and low implementability, with some consideration for relative costs.

7.1.1 Pit Lake Alternatives

There are five (5) remedial alternatives identified for Pit Lake: No Action (PL1); Operate Existing WTS and Maintain Pit Level with a change in the water quality standards for minerals through the Use Attainability Analysis (UAA) process (PL2); Operate Existing WTS and Maintain Pit Lake Water Level with temporary water quality standards for minerals as part of the Environmental Improvement Project (EIP) process (PL2-modified); In-Situ Neutralization and Maintain Pit Level (PL3); and Operate Existing WTS and Drain Pit (PL4).

A “No Action” alternative for Pit Lake (PL1) would not be effective at reducing risk to human health or the environment and the remaining risk would be unacceptable. Therefore, this alternative has not been selected.

The “Operate Existing WTS and Drain Pit” alternative for the Pit Lake (PL4) would be effective at reducing the risk that Pit Lake poses to human health and the environment because it would eliminate the possibility of an uncontrolled release of overflowing Pit Lake water. However, higher mineral concentrations in the lower layer of the Pit Lake, relative to mineral concentrations in the upper layer, would decrease the rate of water withdrawal allowed in order to maintain compliance with discharge requirements. Therefore, eventually it may not be possible to withdraw water faster than it recharges with precipitation, making it impossible to entirely drain the lake. At the very least, it would take several decades (~60 years) to implement this alternative. The cost of this alternative would be very high. Based on these factors, this alternative has not been selected.

The treatment technology for Alternative PL3 (neutralization through lime addition) has been identified as being potentially effective on water from mine pit lakes with a significantly smaller water mass than this site's Pit Lake. Effectiveness of the PL3 alternative for a water body of this size (~3.7 billion gallons) in terms of consistently meeting permit limits is unknown. In-situ neutralization was investigated in 2001 as a possible alternative to active treatment in a WTS prior to WTS construction; however, in-situ neutralization was not selected at that time due to its uncertain effectiveness ("Site Study Plan", MFG, 2001b). Further, it is possible that the addition of fertilizer to the upper layer of the Pit Lake could result in collateral effects such as elevated total suspended solids, nutrients, and biological oxygen demand that would limit the ability to discharge the neutralized water without further treatment. The cost of this alternative is moderate to high, depending on the required frequency for periodic treatments to maintain suitable water quality and whether polishing and/or diversion of the neutralized water would be required. Based on these factors this alternative has not been selected.

Alternative PL2 for Pit Lake, "Operate Existing WTS and Maintain Pit Level with a change in the water quality standards for minerals through the UAA process" and Alternative PL2-modified, "Operate Existing WTS and Maintain Pit Lake Water Level with temporary water quality standards for minerals as part of the EIP process" can be effective at reducing risk to human health and the environment. The water level in Pit Lake must be maintained to prevent overflow and to prevent additional exposure of acid-producing rock in the pit walls. These alternatives will effectively accomplish this requirement. Also, the treatment component of these alternatives has already been implemented (i.e., the capital costs have been expended) and the cost to continue its operation is moderate. Because PL2-modified has the advantage of providing temporary modified water quality criteria, if the EIP is approved, during remedy implementation, it is selected for inclusion in the remedy.

7.1.2 Spoil Piles Alternatives

There are four (4) alternatives considered for the spoil piles: No Action (SP1); Selective Regrading, Augment Vegetation, and Capture ARD (SP2); Extensive Regrading, Soil Cover, and Revegetation (SP3); and Remove and Dispose in Drained Pit Lake (SP4).

Continued weathering and oxidation of the spoil may cause ARD generation to lessen in the future, but unlikely to the point where impacts to local streams would become acceptable. The SP1 Alternative would not significantly reduce the generation of ARD. Therefore, this alternative is not selected.

The SP4 alternative would have low effectiveness in terms of reducing ARD over the long-term. This alternative would be moderately difficult to implement due to the large quantity of spoil to be handled. The cost of this alternative would be high due to the large volume of spoil (~20.5 million cubic yards) that would be excavated and moved into the pit. This alternative would first require draining the Pit Lake which has been rejected as a remedy. Therefore, this alternative is not selected.

In the short term, with Alternative SP3, the acidic/metal loading from the spoil would significantly increase due to the loss of evapotranspiration (after removal of the current vegetation is complete) and the exposure of fresh, reactive spoil particle surfaces during spoil relocation/regrading. However, the long-term effectiveness would be high due to the treatment of the spoil with alkaline material, containment of the contaminants below a soil cover, and corresponding significant reductions in ARD generation associated with runoff and infiltration. The SP3 alternative would be effective, in the long term, in reducing the risk to the environment; however, short-term effectiveness would be lower than other spoil pile alternatives due to the large quantities of material that would need to be handled. This alternative would be implementable using standard construction methods but the cost would be high. Therefore, this alternative is not selected.

The “selective regrading and augment vegetation” portion of the SP2 Alternative would be moderately effective at reducing ARD generation. In the short term, ARD generation may increase in those areas where regrading occurs due to the reduction of water being transpired by the pine trees and other existing vegetation. Acid Rock Drainage would be substantially reduced in the long term due to less infiltration and a thicker soil profile that may eventually function as a cap for the spoil. ARD that is not mitigated by regraded and vegetation augmentation would be captured for subsequent treatment with the groundwater interceptor trench in Alternative SGW3. The complete extent of Alternative SP2 would, therefore, be effective at preventing ARD from impacting surface water below the interceptor trench. Therefore, this alternative has been selected.

7.1.3 Shallow Groundwater System Alternatives

There are three (3) alternatives considered for the shallow groundwater zone: No Action (SGW1); Operate Existing Capture/Treatment System (SGW2); and Expanded Capture/Treatment System (SGW3).

The SGW1 alternative is not effective at reducing the unacceptable risks to the environment. Therefore, this alternative is not selected.

Alternative SGW2 is of moderate effectiveness in terms of reducing the risk posed by the contaminants to human health and the environment because it captures only a portion of the acidic shallow groundwater inputs into Chamberlain Creek. This alternative has been implemented and the cost would be low, comprising only maintenance of the existing system. This alternative is not selected because unacceptable impacts to downstream surface water would continue.

Alternative SGW3 would be effective at reducing the risks to human health and the environment because it will significantly reduce the amount of impacted shallow groundwater that makes its way into Chamberlain Creek. This alternative is implementable because the depth to weathered bed rock (approximately 30 to 35 feet in this area) is within the range of specialized trenching equipment. The cost would be moderate. This alternative is selected for inclusion in the remedy.

7.1.4 Bedrock Groundwater System Alternatives

There are three (3) alternatives considered for the bedrock groundwater zone: No Action (BGW1); Verify Connection to Municipal System (BGW2); and Drain and Backfill Mine Pit (BGW3).

A "No Action" alternative for the bedrock groundwater system is designated BGW1. The most recent sampling from two bedrock groundwater system monitoring wells within the Chamberlain Creek Syncline indicated that primary MCLs were not exceeded; however, secondary MCLs (iron, manganese, and sulfate) were exceeded. Exceedance of these secondary MCLs does not pose risks to human health, but they do create objectionable odor and taste in the groundwater. Therefore, this alternative is not selected.

Alternative BGW3 would not be effective in terms of reducing ARD inputs to bedrock groundwater, would be difficult to implement, and would be of high cost. Therefore, this alternative is not selected.

The BGW2 alternative will be effective in terms of providing an aesthetically acceptable water supply. This alternative would be easy to implement and cost would be low to moderate depending on the number of residents and their distances to existing municipal supply lines. This alternative is selected for inclusion in the remedy.

7.1.5 Sludge Ponds Alternatives

There are four (4) alternatives considered for the sludge ponds: No Action (SLU1); Soil Cover and Revegetate (SLU2); Removal with On-Site Disposal (SLU3); and Removal with Off-Site Disposal (SLU4).

A "No Action" (SLU1) alternative would not be effective at reducing the risk posed by the sludge to the environment. Therefore, this alternative is not selected.

Alternative SLU3 would be effective and it is readily implementable. Exposure during removal would increase in the short term. However, there are no disposal areas within the Site that would be more suitable than the current locations of the sludge ponds and thus the additional costs of relocation cannot be justified relative to closing the sludge ponds in place with a revegetated soil cover (alternative SLU2). Therefore, this alternative is not selected.

The SLU4 alternative would be effective at eliminating the risk posed by the sludge to the environment in both the short-term and the long-term. This alternative could be implemented but the cost may be moderate to high, depending on the actual toxicity characteristics of the sludge. Exposure to the sludge during removal would increase risk in the short term. Given that the exposure pathways to the sludge can effectively be eliminated using an on-site soil cover (alternative SLU2) at a lower cost than off-site disposal, this alternative is not selected.

With Alternative SLU2, a soil cover will isolate the sludge from contact by terrestrial receptors, thus effectively eliminating the risk posed by the sludge to the environment in both the short-term and the long-term. Revegetation will limit erosion of the soil cover and maintenance of the cover would be required. This alternative would be effective, readily implementable, and the cost would be low. This alternative is selected for inclusion in the remedy.

7.1.6 Chamberlain Creek Alternatives

There are three (3) alternatives considered for Chamberlain Creek: No Action (CHM1); Source Control (CHM2); and Source Control and Sediment Removal (CHM3).

Alternative CHM1 would not be effective at reducing the risk to the environment if implemented with No Action alternatives for spoil piles and the Pit Lake. Therefore, this alternative is not selected.

Alternative CHM3 which includes the removal of sediments from Chamberlain Creek could theoretically enhance the effectiveness of Alternative CHM2. However, in view of the low estimated level of risk posed by the sediment (one metal with a hazard quotient equal to 2) and the fact that removal of the sediment would destroy the existing benthic macroinvertebrate community, removal of the sediment from Chamberlain Creek could cause greater harm to the environment relative to leaving the sediment in place. For this reason, this alternative is not selected.

Alternative CHM2, "Source Control" is a combination of Alternatives PL2, SP2, and SGW3. This alternative is selected for inclusion in the remedy as it is the most effective in the short and long term.

7.2 Evaluation of Area-Specific Alternatives Outside of Pit Lake/Chamberlain Creek Watershed

This section evaluates and screens remedial alternatives for three specific areas of concern outside of the Pit Lake/Chamberlain Creek Watershed. Table 7.2 summarizes the remedial alternatives considered for areas of concern outside of the Pit Lake/ Chamberlain Creek watershed.

7.2.1 Tailings Impoundments Alternatives

There are three (3) alternatives considered for the tailings impoundments: No Action (TI1); Regrade, Stabilize Dams, and Revegetate (TI2); and Remove and Dispose in Drained Pit Lake (TI3).

With "No Action", moderately acidic discharge water would continue to enter the headwaters of Reyburn Creek and the dams/levees would continue to pose a potential risk of slope failure that could result in releasing water and/or tailings into the Reyburn Creek drainage. Therefore, Alternative TI1 is not effective in reducing the risk to the environment and is not selected.

Alternative TI3 would be effective at reducing the risks to the environment posed by the tailings impoundments. This alternative is implementable but the relative cost would be very high due to the quantity of water and tailings that would require handling. However, drainage of the Pit Lake has been screened out from further consideration, as discussed in Section 7.1.1. Therefore, this alternative is not selected.

Alternative TI2 would be effective at reducing the risk posed by the tailings impoundments to the environment. This alternative can be implemented using standard construction techniques. The cost is expected to be moderate, depending on the quantity of earthwork involved. This alternative is selected for inclusion in the remedy.

7.2.2 Affected Streams Alternatives

There are three (3) alternatives considered for the affected streams: No Action (AS1); Source Control (AS2); and Source Control and Sediment Removal (AS3).

Alternative AS1 would not be effective at reducing the risk that the contaminants pose to the environment. Therefore, this alternative is not selected.

The removal of sediments from affected streams could theoretically enhance the effectiveness of Alternative AS3 relative to Alternative AS2. However, in view of the low estimated level of risk posed by the sediment and the fact that removal of the sediment would destroy the existing benthic macroinvertebrate community. Removal of sediment from the affected streams could cause greater harm to the environment relative to leaving the sediment in place. For this reason, this alternative is not selected.

The effectiveness of Alternative AS2 relies on the effectiveness of area-specific alternatives to be implemented for the spoil piles (SP2) and the tailings impoundments (TI2). Specific source control options that could benefit the streams include:

(1) Localized treatment and/or capture of runoff and seeps emanating from the north and northeast spoil piles,
(2) Rerouting of runoff and seeps toward the Pit Lake, and
(3) Regrading the spoil piles such that runoff and seepage flows to the Pit Lake watershed.

This alternative (AS2) is selected for inclusion in the remedy.

7.2.3 Clearwater Lake Alternatives

There are three alternatives considered for Clearwater Lake: No Action (CWL1); Source Control (CWL2); and Source Control and Sediment Removal (CWL3).

Alternative CWL1 would not be effective at reducing the risk posed by Clearwater Lake sediment and water to aquatic biota. Therefore, this alternative is not selected.

Removal of sediments from Clearwater Lake could theoretically enhance the effectiveness of Alternative CWL3 relative to Alternative CWL2. However, in view of the low estimated level of risk posed by the sediment and the fact that removal of the sediment would destroy the existing benthic macroinvertebrate community, removal of the sediment from the lake could cause greater harm to the environment relative to leaving the sediment in place. For this reason, this alternative is not selected.

Effectiveness of Alternative CWL2 relies on the effectiveness of area-specific alternatives to be implemented for the spoil piles (SP2) and the tailings impoundments (TI2). Specific source control options that could benefit Clearwater Lake include:

(1) Localized treatment and/or capture of runoff and seeps emanating from the north and northeast spoil piles,

(2) Rerouting of runoff and seeps toward the Pit Lake, and

(3) Regrading the spoil piles such that runoff and seepage reports to the Pit Lake watershed.

This alternative (CWL2) is selected for inclusion in the remedy.

8.0 REMEDIAL ACTION LEVELS

This RADD will consider Toxicity Reference Values (TRVs) to be the Remedial Action Levels for surface water. These TRVs are derived primarily from Arkansas' water quality standards (Arkansas Pollution Control and Ecology Commission, Regulation No. 2, *Regulation Establishing Water Quality Standards for Surface Waters for the State of Arkansas*). Where Arkansas standards are not available, United States Environmental Protection Agency-*National Recommended Water Quality Criteria* (USEPA-NRWQC) are being used. In some cases, USEPA-NRWQC were also not available; therefore, chronic values derived by Suter & Tsao (1996) or Michigan Department of Environmental Quality are being used. These standards will be the Remedial Action Levels applicable to Clearwater Lake and the segments of Chamberlain Creek, Cove Creek, Lucinda Creek, Scull Creek, Stone Quarry Creek, Rusher Creek and Reyburn Creek that are affected by the Site. Those segments are located as follows:

- Chamberlain Creek: from the current headwaters in the western part of the Site to the confluence with Cove Creek,
- Cove Creek: from the confluence with Chamberlain Creek to the Ouachita River,
- Lucinda Creek: from the Rusher Creek confluence to the confluence with Chamberlain Creek,
- Rusher Creek from confluence of East Fork and West Fork to confluence with Lucinda Creek,
- Scull Creek: from headwaters to Clearwater Lake and from Clearwater Lake dam to confluence with Reyburn Creek,
- Stone Quarry Creek from headwaters to the Ouachita River,
- Reyburn Creek: from headwaters in the southeastern part of the Site to confluence with Francois Creek.

TRVs for cadmium, copper, lead, nickel, and zinc are chronic hardness-based standards and are to be derived using the equations in Arkansas' Regulation No. 2 (http://www.adeq.state.ar.us/regs/files/reg02_final_071125.pdf).

The TRV for iron is from USEPA NRWQC Correction document (2009) (http://www.epa.gov/waterscience/criteria/wqctable/nrwqc-2009.pdf).

Aluminum TRVs are from two different sources. The first source is USEPA's-NRWQC (1988) for all waters where pH levels are in a range of 6.5 – 9. For waters where pH falls below 6.5, Canadian water quality guidelines are used. (Butcher, G.A. Water quality Criteria for Aluminum-Technical Appendix, Ministry of Environment and Parks, British Columbia (1988))

The TRVs for cobalt and manganese are the Final Chronic Tier II Value from Michigan Department of Environmental Quality, Rule 57 Tier II Water Quality Values (2002) (http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html)

The TRV for barium is hardness dependent and is calculated using the equation from Michigan DEQ Rule 57 guideline.

The TRV for pH is a range between 6.0 and 9.0 according to Arkansas Regulation No. 2, Reg. 2.504 (http://www.adeq.state.ar.us/regs/files/reg02_final_101029.pdf).

The TRV for beryllium is 4.0 ug/L according to Arkansas Regulation No. 2, Reg. 2.508 (http://www.adeq.state.ar.us/regs/files/reg02_final_101029.pdf).

The TRVs for sulfates, chloride, and TDS are the Ecoregion Reference Stream Values for the Ouachita Mountains Ecoregion in Arkansas' Regulation No. 2, Reg. 2.511(B) or as may be temporarily modified through the Environmental Improvement Project (EIP) if approved. (http://www.adeq.state.ar.us/regs/files/reg02_final_101029.pdf).

8.1 Remedial Action Summary Table

The following table summarizes Remedial Action Levels for Clearwater Lake and the segments of Chamberlain Creek, Cove Creek, Lucinda Creek, Reyburn Creek, Rusher Creek, Scull Creek, and Stone Quarry Creek that may be affected by the Site:

Chemical	Surface Water Toxicity Reference Values (mg/l)	
	Chronic Value	Source
Aluminum (pH 6.5 – 9)	0.087	b
Aluminum (pH < 6.5)	pH dependent; calculate using equation from Canadian water quality guidelines	c
Barium	Hardness dependent; calculate using equation from Michigan DEQ Rule 57 guideline	d
Beryllium	4 ug/L	a
Cadmium	Hardness dependent; calculate using equation from Arkansas Regulation No. 2	a
Cobalt	0.1	d
Copper	Hardness dependent; calculate using equation from Arkansas Regulation No. 2	a

Chemical	Surface Water Toxicity Reference Values (mg/l)	
	Chronic Value	Source
Iron	1	b
Lead	Hardness dependent; calculate using equation from Arkansas Regulation No. 2	a
Manganese	Hardness dependent; calculate using equation from Michigan DEQ Rule 57 guideline	d
pH	6.0 – 9.0	a
Chloride	15*	a
TDS	142*	a
Sulfates	20*	a
Nickel	Hardness dependent; calculate using equation from Arkansas Regulation No. 2	a
Zinc	Hardness dependent; calculate using equation from Arkansas Regulation No. 2	a

Sources:
(a) Arkansas Pollution Control and Ecology Commission, Regulation No. 2, *Regulation Establishing Water Quality Standards for Surface Waters for the State of Arkansas*
(b) US EPA-*NRWQC (1988) (for Aluminum for all waters where pH levels are in a range from 6.5 to 9.0); US EPA-NEWQC (2009) for iron*
(c) Canadian Ambient Water Quality Criteria for Aluminum Butcher, G.A. Water quality Criteria for Aluminum-Technical Appendix, Ministry of Environment and Parks, British Columbia (1988)
(d) Michigan Department of Environmental Quality Rule 57 Tier II values (2002)
(e) Federal Safe Drinking Water Act
*Except as may be temporarily modified through the Environmental Improvement Project (EIP) if approved.

9.0 JUSTIFICATION FOR SELECTIONS OF REMEDIAL ALTERNATIVES

An overall Remedial Alternative for the Dresser Industries-Magcobar Mine Site is a combination of the following selected, area-specific alternatives:

- Pit Lake – PL2 modified – Operate Existing WTS, Maintain Pit Lake Water Level with temporary water quality standards for minerals as part of the EIP process
- Spoil Pile – SP2 – Selective Regrading, Augment Vegetation, and ARD Capture
- Shallow Groundwater System – SGW3 – Expanded ARD Capture/Treatment System
- Bedrock Groundwater – BGW2 – Verify Connection to Municipal Water System
- Sludge Ponds – SLU2 – Soil Cover, Revegetate
- Chamberlain Creek – CHM2 – Source Control
- Tailings Impoundments – TI2 – Regrade, Stabilize Dams, Revegetate
- Affected Streams – AS2 – Source Control
- Clearwater Lake – CWL2 – Source Control

This combination would meet the Remedial Action Levels in off-Site streams, would reduce identified risks to acceptable levels and is implementable at a reasonable cost. Thus, this Selected Remedial Alternative Combination (SRAC) provides overall protection of human health and the environment and high levels of short-term and long-term effectiveness. This SRAC will also promote the reduction of toxicity and mobility of Site contaminants and the measures are implementable in terms of technical feasibility and the availability of goods and services. Cost of the selected remedial alternative combination is comparable to or less than the other alternatives considered.

10.0 SELECTED REMEDY/SITE PLAN

The overall remedy selected for this RADD is designed to be protective of human health and the environment. Selected remedies for individual areas of concern are detailed in this section. An implementation schedule is set forth at **Table 10**. In the event that temporary modified water quality standards are not approved through the EIP process, the Responsible Party will prepare a supplement to the Feasibility Study, within 180 days of denial of EIP approval, to identify alternatives, if any, that can meet existing standards and this RADD shall be modified as appropriate. The Responsible Party shall be defined in the Consent Administrative Order governing the implementation of the RADD.

10.1 Selected Remedies for Area-Specific Alternatives for Pit Lake/Chamberlain Creek Watershed

10.1.1 Pit Lake

Operate Existing Water Treatment System and Maintain the Pit Lake Water Level with temporary water quality standards for minerals as approved through the EIP process (PL2 - modified). This is the preferred remedial alternative for Pit Lake. Operation of the Water Treatment System will assure that water discharged from Pit Lake meets limits established in the appropriate Permit, as modified to reflect temporary standards established as part of the EIP process. Maintaining an optimum water level in Pit Lake minimizes production of ARD from the walls of Pit Lake. Temporary modification of the standards for sulfate, chloride, and TDS will be sought as part of the EIP process.

10.1.2 Spoil Piles

Selective Regrading, Augment Vegetation, and Capture ARD (SP2) – This remedial alternative proscribes routing ARD created in the spoil to the Pit Lake with minimum disturbance to the spoil piles thereby minimizing further production of ARD.

10.1.3 Shallow Groundwater System

Expanded Capture/Treatment System (SGW3) – French drainage systems will capture low-pH groundwater exiting the Site and a pumping system will return it to Pit Lake for treatment. This alternative will improve quality of water in the gaining streams (i.e. Chamberlain Creek) draining the Site.

10.1.4 Bedrock Groundwater System

Verify Municipal Water System Connections (BGW2) – An Institutional Control informing the local population as to the situation at the Pit Lake and connecting residents in the municipal supply connection area depicted in **Figure 3** (Municipal Water System

Map) to the local municipal water system. This alternative will eliminate concerns about objectionable smell and taste.

10.1.5 Sludge Ponds

Soil Cover and Revegetate (SLU2) – This alternative will protect small terrestrial animals from the risk associated with the metal-rich sludge.

10.1.6 Chamberlain Creek

Source Control (CHM2) – In conjunction with the selected remedies for the spoil piles (SP2) and Pit Lake (PL2 - modified), this alternative will minimize ARD to Chamberlain Creek improving its overall water quality and protecting downstream ecology.

10.2 Selected Remedies for Area-Specific Alternatives Outside of Pit Lake/Chamberlain Creek Watershed

10.2.1 Tailings Impoundments

Regrade, Stabilize Dams, and Revegetate (TI2) – This alternative will reduce acid drainage from the tailings and ensure that the tailings slopes are stable.

10.2.2 Affected Streams

Source Control (AS2) – Along with selected alternative remedies for the spoil piles (SP2) and tailings impoundments (TI2), this alternative will reduce the amount of ARD leaving the Site. As a result, water quality in the streams outside the Chamberlain Creek/Pit Lake watershed will improve.

10.2.3 Clearwater Lake

Source Control (CWL2) – This alternative minimizes ARD to Clearwater Lake by diversion, capture and/or treatment of water infiltrating the spoil piles and tailings.

11.0 EFFECTIVENESS MONITORING PROGRAM

This section addresses how well the chosen remedies are working during and after implementation. An Effectiveness Monitoring Plan (EMP) that addresses each area of concern shall be submitted by the Responsible Party and will include, at a minimum, sampling locations, sampling frequency, analytical parameters, and the sampling and analytical methods that will be used.

The purpose of effectiveness monitoring is to demonstrate and document that the implemented remedies are achieving progress toward compliance with remedial action levels. If compliance or progress toward compliance, to include obtaining the necessary access agreements and/ or institutional controls, is not demonstrated, the RADD may be modified so that additional remedial alternatives can be considered, evaluated, and implemented in a reasonable time frame.

The Responsible Party shall investigate, as appropriate, technologies that become commercially available to facilitate the identification and consideration of additional remedial alternatives to affect permanent control, abatement, prevention, treatment or containment of releases and threatened releases at the Site.

It is anticipated that the sampling will be more frequent during active remediation, and that the frequency will be re-evaluated and potentially reduced as warranted based on the monitoring data. The EMP shall address monitoring at each of the following areas of concern.

11.1 Surface Water Monitoring

11.1.1 Pit Lake Elevation Monitoring

It has been proposed that a Pit Lake surface elevation of approximately five hundred ninety-five (595) feet above mean sea level will eliminate seepage through the base of the adjacent spoil piles and provide approximately ten (10) feet of freeboard in the event of an upset of the WTS. The elevation of the surface of the Pit Lake shall be measured and tracked relative to the currently proposed target elevation of approximately 595 feet. The amount of water withdrawn from the Pit Lake shall be adjusted in order to maintain the currently proposed target elevation, or any revised target elevation proposed and agreed upon in the future between ADEQ and the responsible parties.

It should be noted that the volume of water discharged into the Pit Lake will be increasing due to additions from the following sources: the surface water diversion channel and groundwater cutoff trench in the northeast spoil area; the expanded groundwater collection system near Chamberlain Creek in the western portion of the site; and additional runoff from the regraded spoil piles. This will likely require increased pumping and treatment of Pit Lake water in order to maintain the target elevation of 595 feet. The capacity of the WTS must be able to handle inflow increases.

11.1.2 Monitoring During Remedial Construction Activity

While the construction phase of the selected remedy/site plan is underway, at minimum quarterly sampling will include but not be limited to the following locations: Lucinda Creek upstream of confluence with Cove Creek; Chamberlain Creek; Cove Creek downstream of confluence of Chamberlain Creek and Reyburn Creek downstream of the confluences of drainages from tailings ponds and Clearwater Lake. Quarterly sampling will also occur but not be limited to the locations of: Scull Creek upstream of Clearwater Lake; East Rusher Creek; Stone Quarry Creek downstream of the drainages from the tailings ponds and Chamberlain Creek downstream of the French drain that is being constructed to intercept shallow groundwater.

11.1.3 Monitoring Upon Completion of Construction Activities

Once the construction phase of the selected remedy/site plan is complete, sampling of surface waters will take place at minimum, quarterly and will include but not be limited to the following locations: Lucinda Creek upstream of confluence with Cove Creek; upstream and downstream of any selected remedy in Chamberlain Creek; Cove Creek downstream of confluence of Chamberlain Creek; Reyburn Creek downstream of the confluences of drainages from tailings ponds and Clearwater Lake and Stone Quarry Creek downstream of the drainages from the tailings ponds

To ensure a comprehensive sampling regimen, one quarterly sampling event should be conducted during a storm event during the spring, one quarterly sampling event should be conducted during a storm event during the fall and one quarterly sampling event should be conducted during low flow conditions. Opportunity to request modifications of the sampling frequency and locations will be incorporated in the EMP.

11.1.4 Biological Sampling

Monitoring the health of the affected biological community after the initiation of construction activities will take place at a minimum of every five (5) years. Sampling of the local fish population will take place during the summer. The macroinvertebrate community will be sampled during the spring and fall seasons. The areas where biological sampling will take place will include but not be limited to: Lucinda Creek upstream of confluence with Cove Creek; Chamberlain Creek; Cove Creek downstream of confluence of Chamberlain Creek; Reyburn Creek downstream of the confluences of drainages from tailings ponds and Clearwater Lake, and Stone Quarry Creek downstream of the drainages from the tailings ponds.

11.2 Groundwater Monitoring

11.2.1 Shallow Groundwater System

The effectiveness of the shallow groundwater cutoff trench in the northeast spoil area and the shallow groundwater collection system near Chamberlain Creek in the western portion of the site shall be demonstrated by monitoring groundwater quality and the elevation of the groundwater table. Monitoring of water table elevations and chemical analysis of water quality parameters will be used to demonstrate groundwater capture.

11.2.2 Bedrock Groundwater System

The remedial action objective for both shallow and deep off-site groundwater focuses on preventing groundwater use as a domestic water supply. Accordingly, the Responsible Party shall demonstrate that all surrounding residences within the municipal supply connection area depicted in **Figure 3** are connected to the public water supply.

Seepage from the Pit Lake contributes to the contamination in the bedrock groundwater system. The potential exists for the chemistry of the Pit Lake water and in turn the bedrock groundwater to change during the remediation process. In order to evaluate the effectiveness of the groundwater use restriction, groundwater well(s) downgradient of the shallow remediation system shall be monitored as identified in the EMP.

11.3 Accumulated Sludge Volume and Sludge Profiling

Operation of the WTS for a hundred (100) years or more will generate a significant volume of sludge which may exceed the volume containable by the curtain wall system currently in place in Pit Lake. The ultimate volume of sludge generated shall be estimated and the capacity of the curtain wall system evaluated to ensure that the sludge will be adequately contained in perpetuity. If it is determined that the curtain wall system is not a feasible containment for the generated sludge, then feasible alternative on-site sludge containment systems shall be evaluated and addressed in the final remedial design.

11.4 Site Security Plan

A site security plan will be submitted with the Remedial Action Implementation Work Plan. This plan should include means to minimize trespassing and mitigate potential exposure to any human receptors.

12.0 COMMUNITY PARTICIPATION

The administrative record for Magcobar Mine Site may be reviewed at:

Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, Arkansas 72118-5317
(501) 682-0744

Or at:

Hot Spring County Public Library
202 East Third Street
Malvern, Arkansas 72104
(501) 332-5441

13.0 COORDINATION WITH OTHER DIVISIONS/AGENCIES

It is important to involve/inform other divisions of Arkansas Department of Environmental Quality and other agencies as applicable, in the development of a Remedial Action Decision Document.

Internal Coordination

ADEQ Divisions	Consulted/Informed	Sent Notice of Decision
Water	Yes	Yes
NPDES	No	Yes
Air	No	No
Solid Waste	No	No
Regulated Storage Tanks	No	No
Environmental Preservation and Technical Services	Yes	Yes
Mining	Yes	Yes

External Coordination

Other State and Federal Organizations	Consulted/Informed	Sent Notice of Decision
U.S. EPA, Region 6	Yes	Yes
AR Office of Emergency Services	No	No
AR Dept. of Health	No	Yes
AR State Clearinghouse	No	No
AR State Historic Preservation	No	No
AR Natural Heritage Commission	No	No
AR Game and Fish Commission	No	No
U. S. Army Corps of Engineers	No	No

14.0 LIST OF REFERENCES USED TO PREPARE RADD

1. *Revised Final Site Investigation Report. Dresser Industries – Magcobar Mine Site, Magnet Cove, Arkansas,* NewFields, April 2007.

2. *Feasibility Study Report Dresser Industries – Magcobar Mine Site, Hot Spring County, Arkansas*, NewFields, August 2009.

3. *Initial Alternatives Screening Document Dresser Industries- Magcobar Mine Site, Hot Spring County, AR*, NewFields, November 2008.

4. *Regulation Establishing Water Quality Standards for Surface Water in the State of Arkansas, Regulation No. 2*, Arkansas Department of Pollution Control and Ecology, November 2007 (http://www.adeq.state.ar.us/regs/files/reg02_final_071125.pdf).

5. *National Recommended Water Quality Criteria*, USEPA, 2003 (http://www.epa.gov/waterscience/criteria/wqctable/1999table.pdf).

6. Consent Administrative Order LIS 03-061, ADEQ, May 2003.

7. Administrative Settlement LIS 00-126, ADEQ, July 2000.

8. *Michigan Rule 57 Tier II Water Quality Values*, Michigan Department of Environmental Quality, 2002 (http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383-- ,00.html).

9. *Butcher, G. A., Water Quality Criteria for Aluminum-Technical Appendix, Ministry of Environment and Parks, British Columbia (1988).*

10. Suter, G. W., and C. L. Tsao, 1996, Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota, 1996 Revision, Risk Assessment Program, Health Sciences Research Division, Oak Ridge, TN.

15.0 RESPONSIVENESS SUMMARY

RESPONSE TO COMMENTS
&
FINAL DECISION
on the
REMEDIAL ACTION DECISION DOCUMENT (RADD)

Dresser Industries Magcobar Mine Site

Magnet Cove
Hot Spring County
Arkansas

AFIN: 30-00331

A. INTRODUCTION.

On September 1, 2010, the Arkansas Department of Environmental Quality – Hazardous Waste Division (ADEQ) proposed a Remedial Action Decision Document (RADD) for the Magcobar Mine site located a mile northeast of Magnet Cove, Hot Spring County, Arkansas. This RADD outlined the proposed remedy for the property.

This Response to Comments and Final Decision addresses and documents for the public record the comments and issues raised concerning the notice of the RADD, provides the Department's response to the issues raised during the public participation process; and sets forth the final decision and approval of the RADD attached herein.

B. SELECTED REMEDY.

The selected remedy for the Magcobar Mine site is set forth in the attached final Remedial Action Decision Document (RADD).

Within thirty (30) days of completing all activities outlined in the RADD, the Responsible Party for the Magcobar Mine Site shall submit to ADEQ for review and approval a completion report. The completion report shall include information to document that no unacceptable risks, as described in A.C.A. § 8-7-502, remain on-site as a result of the release of hazardous substances, and that the site has been remediated in accordance with the provisions set forth in the RADD. The completion report shall be reviewed and approved by ADEQ.

C. PUBLIC PARTICIPATION ACTIVITIES.

The ADEQ issued a public notice of the RADD on September 1, 2010. Notice was published in the Malvern Daily Record on September 1, 2010, and comments were accepted for a 30-day period. The public comment period closed on October 1, 2010. A public meeting and hearing was held on September 16, 2010. Five (5) comments (two verbal and three written) were received prior to the end of the comment period.

D. PUBLIC COMMENTS AND THE DEPARTMENT'S RESPONSE.

ADEQ received the following comments concerning the Remedial Action Decision Document for the Magcobar Mine Site.

Written Comments from Formation Environmental for Halliburton Energy Services, Inc. (HESI)

1. Cover Page. Please correct "Hot Springs County" to "Hot Spring County."

Response: This correction has been made.

2. Page 1, Paragraph 1 of Section 1.0. The text states: "*The property is bounded on the north by Rusher Creek. Baroid Road makes up the western boundary. Scull Creek and Clearwater Lake are on the eastern edge of the Site and the southern boundary is approximated by Stone Quarry Creek."*

This area includes Halliburton Energy Services, Inc.'s (HESI) operating Duratone Plant, which was specifically excluded from the Site Investigation and Feasibility Study. Please amend the Remedial Action Decision Document (RADD) to note that the operating Duratone Plant is excluded from the Dresser Industries-Magcobar (DIM) Mine Site.

Response: The description of the property boundaries has been changed to eliminate the Duratone Plant Site from inside the Remedial Site boundaries.

3. Page 1, Section 2.0. The paragraph concludes with this sentence: "*Halliburton Energy Services (Halliburton) and TRE Management Company (the Companies) eventually became owners of the Site.*"

HESI notes that several other private entities own property within the 600-acre Site, as defined by ADEQ, and that implementation of the final remedy will require the cooperation of the various owners. HESI therefore requests that the referenced sentence be modified as follows:

"*Halliburton Energy Services (Halliburton) and TRE Management Company (the Companies) eventually became owners <u>of a portion</u> of the Site.*"

Response: This correction has been made.
4. Page 1, Paragraph 2 of Section 2.1. The text states: *"Tailings impoundments, the remnants of buildings, a water treatment plant and alkaline sludge impoundments make up the remainder of the Site. A small area within the Site is utilized by Halliburton, some of the area is leased for deer hunting, and four wheelers illegally utilize parts of the Site" (emphasis added).*

The underlined portion of this text appears to refer to the operating Duratone Plant which, as noted in Comment No. 2, is not part of the DIM Mine Site. Please delete the underlined text.

Response: The whole sentence including the underlined section has been deleted and a new sentence added: *Some acreage within the Site is leased to hunters and ATV riders illegally utilize parts of the Site.*

5. Page 2, Section 2.1.1. Please insert the word "Quarry" after the word "Stone" in line 8.

Response: The word "Quarry" has been added in line 8.

6. Page 2, Section 2.1.1. With regard to the Site hydrology, it should also be pointed out that Scull Creek flows into Reyburn Creek, which ultimately enters Francois Creek and thence the Saline River.

Response: This oversight has been corrected.

7. Page 3, Section 2.2. Please revise the title of this section to "Summary of Site Investigation" to be consistent with the Administrative Settlement. Also, HESI suggests that the Site Investigation (SI) Report be referenced in this section:

> NewFields 2007. Revised Final Site Investigation Report. Dress Industries-Magcobar Mine Site, Magnet Cove, Arkansas. Prepared for Halliburton and TRE Management Company. April 19.

Response: A change to the title of this section has been effected and a reference to the Site Investigation report has been added to the RADD in Section 14. The following text has also been added: "The Revised Final Site Investigation report, dated April 19, 2007 was conditionally approved by ADEQ June 15, 2007".

8. Page 4, final two paragraphs of Section 2.3. The text states: "*In 2004, ADEQ placed a 9.6 mile segment of Cove Creek, from the mouth of Cove Creek to its confluence with Chamberlain Creek, on the Impaired Water Bodies List (303(d) list) as not attaining its Fisheries Designated Use due to low pH and metals toxicity (copper and zinc). In 2006, the same 9.6 mile segment of Cove Creek was listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to depressed pH, high sulfate (SO_4) content, excessive*

concentrations of Total Dissolved Solids (TDS), zinc (Zn), beryllium (Be), and copper (Cu). Additionally two other creeks in the watershed were added to the 303(d) list. These contaminants originate at the Site.

A 2.5 mile segment of Chamberlain Creek from its headwater to its confluence with Cove Creek was listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to low pH, and high chlorine (Cl), sulfate, TDS, cadmium (Cd), Zn, Be, and Cu content. A 2.2 mile segment of Lucinda Creek from its headwater to its confluence with Cove Creek was also listed as not attaining its Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses due to depressed pH and elevated concentrations of sulfate, Zn, and Be. These streams have been negatively affected by contaminated water emanating from the Magcobar Mine Site."

HESI notes that the alleged non-attainment statements in the above excerpt are taken from now outdated Arkansas 303(d) lists and are based on water quality data that were collected prior to construction and operation of the Site water treatment system. Conditions in both Chamberlain Creek and Cove Creek have improved since the water treatment system commenced operation. HESI recommends that ADEQ consider the most recent (2010) 303(d) list and revise this paragraph, as follows:

"*In 2010, ADEQ placed a 9.6 mile segment of Cove Creek, from the mouth of Cove Creek to its confluence with Chamberlain Creek, on the Impaired Water Bodies List (303(d) list) as not attaining its Fisheries, Domestic, Industrial, and Agricultural Water Supply Uses due to depressed pH, high sulfate (SO_4) content and Total Dissolved Solids (TDS). Additionally two other creeks in the watershed were added to the 303(d) list.*

A 2.5 mile segment of Chamberlain Creek from its headwater to its confluence with Cove Creek was listed as not attaining its Fisheries, Domestic, Industrial, and Agricultural Water Supply Uses due to low pH, and high sulfate, TDS, cadmium (Cd), Zn, and Cu content. A 2.2 mile segment of Lucinda Creek from its headwater to its confluence with Cove Creek was also listed as not attaining its Fisheries Use due to depressed pH and elevated concentrations of sulfate, Zn, and Be. "

Response: Since Section 2.3 is titled "Regulatory Background" it is appropriate to include the 303(d) list data from 2004 and 2006. At this time it is not appropriate to include the Draft 2010 303(d) list data because the list has not been finalized. The 2010 303(d) list is still under EPA review. Upon completion of EPA review the 2010 303(d) list data could be included.

ADEQ has included the following revisions to Section 2.3 to take into account the 2008 303(d) list.

Added after Paragraph 4, a new Paragraph 5 has been inserted – "In 2008, this 9.6 mile segment was listed as not attaining its "Aquatic Life, Domestic, Industrial, and Agricultural Water Supply Uses" due to high sulfate content, excessive concentrations of TDS, Zn, and Be. During the 2008 assessment, the standards for pH and copper in Cove Creek were assessed as being attained. In 2006, two other creeks in the watershed were added to the 303(d) list. These contaminants originate at the Site."
Added to Paragraph 6 - "In 2006 and 2008, a 2.5 mile…"
Added toParagraph 7 – "In 2006 and 2008, a 2.2 mile segment of Lucinda Creek…"

9. Page 4, Paragraph 1 of Section 3.0. The text states: "*It is not known at this time exactly how much acidic water leaves Pit Lake as groundwater, but some amount resurfaces in the Cove Creek watershed presumably from seepage and potentially as much as 60,000 gallons per day are reaching the bedrock aquifer.*"

HESI notes that the SI Report contains no information to suggest that seepage from the Pit Lake resurfaces in the Cove Creek watershed. An igneous intrusive body cross cuts the Chamberlain Creek syncline approximately 1.5 miles west of the Site that likely restricts bedrock flow from the syncline area to the Cove Creek drainage. HESI therefore suggests that the referenced text be replaced with the following:

"The Site Investigation determined that approximately 40 gallons per minute (60,000 gallons per day) of water seeps from Pit Lake to the bedrock groundwater system."

Response: The RADD will be changed to read: "Pit Lake potentially loses forty (40) gallons of water per minute to the bedrock groundwater system". ADEQ does not agree with the reference to an igneous pluton that "restricts bedrock flow from the syncline area to the Cove Creek drainage". The pluton referred to may divert or deflect groundwater movement, but that deflection is at least partially into the Cove Creek drainage.

10. Page 5, Paragraph 3 of Section 3.1. The text states: "*For these reasons, local citizens with wells installed in the bedrock system have been connected to the local municipal water system at the expense of the responsible party. Any new residents to the area will be added to the municipal water system at the expense of the responsible party.*"

It is HESI's understanding that local citizens have been connected to the local municipal system, but not at the expense of the responsible parties. In addition, Alternative BGW2 of the Feasibility Study (FS) Report consists of verifying connection of existing residences in the area to the municipal water system. Any current residences in the affected area that are not connected to the municipal system would be provided with a connection to the municipal system. The alternative does not entail connecting any future residences in the area (see Section 5.1.4.2 of the FS). HESI therefore suggests that this text be replaced with the following:

"A municipal water system line was installed across the area where bedrock groundwater may be affected by seepage from the Mine Pit (i.e., within the Chamberlain Creek syncline to the west of the Mine Pit). Many existing residences within this area are already connected to the municipal water system. Existing residences that are not currently connected will be connected to the municipal system."

Response: Reference to the "responsible parties" paying for municipal water system connections has been deleted.

11. Pages 5 and 6, Section 3.2.1. HESI suggests that this section be amended to note that not all of the listed surface water bodies have risks due to all of the contaminants of concern (COCs). Furthermore, characterizing risks as present simply because COCs exhibit hazard quotients (HQs) greater than 1 does not consider the inherent uncertainties of toxicity reference values (TRVs) that may over predict risks for certain COCs. For example, barium HQs in surface waters exceed 1 for only two surface waters, Basin Creek (the background location), and Stone Quarry Creek. As stated on pages 7-6 and 7-7 of the Baseline Ecological Risk Assessment (BERA; Appendix B of the SI Report), geochemical conditions prevail that indicate barium is present as barium sulfate, a highly insoluble and non-bioavailable compound. Despite HQs greater than 1 for barium, healthy aquatic communities are found at the background location confirming that risks using the selected barium TRV are over predicted. Beryllium risks (predicted for all locations) were similarly indicated to be over predicted due to a conservative TRV (Tier 2) and detection limits that were above the predicted level of effects (at less than 1 ug/l). Again, for beryllium, significant acute effects were predicted at the background location, while healthy aquatic communities were found.

This section would therefore benefit from the addition of a paragraph that highlights the COCs posing potential risks for each of the water bodies, as follows.

"For surface waters at various locations associated with the Site, risks were predicted for the following COCs in each of the specific water bodies:

- *Chamberlain Creek - aluminum, cadmium, cobalt, copper, iron, manganese, nickel, zinc, sulfate, and pH;*
- *Cove Creek – aluminum, manganese, zinc and pH;*
- *Lucinda Creek – aluminum, copper, manganese, zinc, and pH;*
- *Rusher Creek – aluminum, copper, manganese, nickel, and pH;*
- *Reyburn Creek – aluminum, manganese, zinc, and pH;*
- *Scull Creek – aluminum, cobalt, manganese, zinc, and pH; and*

• *Clearwater Lake – aluminum, manganese, and pH"*

In addition, the BERA concluded that Stone Quarry Creek is not significantly affected by the Site. HESI suggests deleting Stone Quarry Creek from the list of water bodies considered areas of concern at the Site.

Response: The first sentence of Section 3.2.1 has been changed to include, "or of potential concern". This language reflects the overall purpose of the RADD which is to protect human health and the environment from contamination or potential contamination from environmentally harmful substances. Constituents of Concern may change at the Site especially during remedial construction activities. The RADD is designed to be flexible in the event that COCs or concentrations thereof change over the course of remediation. The headwaters of Stone Quarry Creek are just below a tailings impoundment dam making the creek potentially sensitive to contaminants originating at the Site.

12. Page 6, Paragraph 1 of Section 3.2.2. Similar to the preceding comment, HESI suggests that this paragraph be revised as follows to reinforce that listed surface water bodies have very low sediment risks, and that risks that are present are due to small number of the contaminants of concern (COCs).

"Surface water bodies with identified COCs on the Site, not including Pit Lake, where sediment is of concern include Chamberlain Creek (cadmium), Cove Creek (manganese and nickel), Reyburn Creek (manganese and nickel), Scull Creek (manganese), Stone Quarry Creek (manganese), and Clearwater Lake (nickel). Sediment in these water bodies is not a risk to human health, but do pose potential risks to aquatic receptors where sediment HQs are greater than 1. While HQs for barium are greater than 1, barium risks are over predicted. Barium is not an issue of concern in the off-site sediments because elevated natural background concentrations of barium occur at sites with apparently healthy biotic communities. In addition, the low toxicity potential, low solubility, high complexation potential with sulfates, and low bioavailability of barium under ambient conditions at the Site has been documented in the SI Report."

Response: Constituents of Concern or COC concentrations may change over time due to implementation of the remedies. It is the intention of this RADD to have the flexibility to manage changes at the Site or in regulations over time. No change has been made to the document.

13. Page 8, Paragraph 1 of Section 4.0. The text states: *"The Arkansas Department of Environmental Quality has determined that releases of hazardous substances at the Magcobar Mine Site must be addressed through remedial action to be protective of human health and the environment"* (emphasis added).

As stated in Section 3.0, Paragraph 2 of the RADD, and as supported by the Baseline Human Health Risk Assessment (Appendix A of the SI Report), theoretical lifetime cancer risks and noncarinogenic hazards at the Site are acceptable, and therefore *"…no remedial activities are required to protect human receptors."*

Response: The statement, "of human health" will not be removed. In general all ADEQ RADDs by definition are written to protect human health and the environment. Concentrations of specific COCs at this site are currently not considered dangerous to human health. However, as remediation proceeds concentrations of the known COCs may increase to levels potentially dangerous to human health. No change has been made to the document.

14. Page 8, Paragraph 1 of Section 4.1.1. The text states: "*However, the volume of water in Pit Lake is so large, that even a small amount of seepage from the lake could adversely affect the comparatively small, indigenous drainage systems.*"

HESI notes that any potentially adverse effects on the drainage systems are not related to the volume of the Pit Lake but are instead related to the amount of seepage from the Pit Lake, the water quality of the seepage, and any chemical changes to the seepage that occurs during along the groundwater flow path. Further, ADEQ discusses the effects of Pit Lake seepage in Section 4.1.4 of the RADD. HESI therefore recommends deletion of this sentence.

Response: The sentence has been deleted.

15. Page 10, Section 4.2.1. The text states: "*Most of the tailings ponds are in the Reyburn Creek drainage and are impounded by jig tailings produced from the ore milling operation."*

Appendix H of the SI Report provides a detailed geotechnical evaluation for each of the tailings dams at the Site that include interpretation of subsurface data from boreholes. The dams are variously characterized as consisting of silty gravel to silty clay and sand. Jig tailings were only noted to mantle the downstream faces of Tailings Ponds 3 and 4E dams as a thin veneer (see also Section 5.2.1 of the RADD). HESI therefore suggests that the referenced sentence be replaced with the following:

"*Most of the tailings ponds are in the Reyburn Creek drainage and are impounded by dams. Some of these tailings dams are mantled with a thin veneer of jig tailings produced from the ore milling operation.*"

Response: The above change has been made to the RADD

16. Pages 10 and 11, Paragraphs 1 and 4 of Section 4.2.2. As discussed in Comment No. 11, the BERA (Appendix B of the SI Report) concluded that Stone Quarry Creek is not significantly affected by the Site. HESI suggests deleting Stone Quarry Creek from the list of water bodies considered areas of concern at

the Site.

Response: The RADD is concerned with current and **potential** danger to human health and the environment. Stone Quarry Creek is listed in the FS as having Manganese as a COC. No change to the document has been made.

17. Page 14, Paragraph 2 of Section 5.1.2. HESI notes that four (4) remedial alternatives were developed for the spoil piles in the FS Report rather than five (5), as indicated in this section of the RADD. Please revise this text accordingly and delete *"…and Chemical Stabilization/Neutralization of Potential Acidity (SP5)."*

Response: SP5 – *Chemical Stabilization/Neutralization of Potential Acidity* has been deleted.

18. Page 12, Paragraph 2 of Section 5.1.1.2. The text states: "*A Pit Lake surface elevation of approximately five hundred ninety-five (595) feet is expected to eliminate much ARD seepage and to also provide approximately ten (10) feet of free board in the event that an upset of the WTS occurs (i.e., the Pit Lake surface could rise for a year or more while repairs or adjustments are made without the development of seepage through the spoil piles).*"

HESI notes that the referenced 595-foot elevation for the Pit Lake surface is simply a goal and that elevations slightly higher than 595 feet are equally effective in terms of eliminating seepage over the bedrock rim of the Pit Lake and through the basal portions of the adjacent spoil piles.

Response: The term "approximately" should make clear that an elevation of exactly 595 feet is not necessary to maintain the conditions that minimize ARD to Pit Lake. No change has been made to the document.

19. Page 14, Paragraphs 1 and 2 of Section 5.1.2.2. Paragraph 1 of this section includes the misspelled word "*egarded*" at two locations. This should be replaced with the word "*regrading*" or "*regraded*," as appropriate. A global search for this misspelling should be made throughout the RADD because it appears at several other locations. In the first line of Paragraph 2, the word "*regraded*" should be replaced with "*regrading*."

Response: Corrections have been made for the term "egarded".

20. Page 16, Paragraph 2 of Section 5.1.2.4. The text states: "*The water that would emanate from the saturated, backfilled pit would be of poor quality (acidic, with elevated metals and TDS concentrations) given the amount of reactive surface area available in the broken up spoil material and the presence of <u>dissolved metals</u> in the spoil*" (emphasis added).

HESI notes that dissolved metals are not present in the spoil material itself, but in through-flowing water that can leach metals from the spoil. HESI recommends that the word "*dissolved*" be replaced with "*soluble*."

Response: "Dissolved" has been changed to "soluble".

21. Page 17, Section 5.1.4.2. The text states: "*Any residences in the affected area that are not connected to the municipal system would be provided with a connection at the expense of the responsible party.*"

Please insert the phrase "*current or existing*" between "*Any*" and "*residences*." In addition, for the reasons noted above in HESI's Comment No. 10, HESI recommends that the phrase "*…at the expense of the responsible party*" be deleted.

Response: "existing" has been inserted into text and "…at the expense of the responsible party" has been deleted.

22. Page 21, Section 5.2.1. As discussed in Comment No. 10, the BERA (Appendix B of the SI Report) concluded that Stone Quarry Creek is not significantly affected by the Site. HESI suggests deleting Stone Quarry Creek from the list of water bodies considered areas of concern at the Site.

Response: Stone Quarry Creek is **potentially** affected. The intention of this RADD is to have the flexibility to manage changes at the Site or in the regulations regarding COCs at the Site. No change has been made to the document.

23. Page 23, Section 6.0 (Proposed/Recommended Alternatives) and Page 24, Section 7.0 (Evaluation and Screening of Area-Specific Alternatives). HESI concurs with ADEQ's Proposed/Recommended Alternatives. However, it appears that the presentation order of these sections is reversed. The evaluation and screening of the alternatives would best be presented before the proposed/recommended alternatives.

Response: This is the format used in ADEQ Remedial Action Decision Documents. No change has been made to the document.

24. Page 31, Paragraph 3 of Section 8.0. The text states: "*The TRV for iron is from USEPA's (1999) NRWQC Correction document (http://www.epa.gov/waterscience/criteria/wqctable/1999table.pdf).*"

HESI recommends that this reference be updated to the 2009 table. The value is the same as in 1999, but the most current reference, which should be included in the RADD, is as follows:
http://www.epa.gov/waterscience/criteria/wqctable/nrwqc-2009.pdf

Response: An updated reference citation has been inserted.

25. Page 31, Paragraph 5 of Section 8.0. The text states: "*TRVs for barium, beryllium, cobalt, and manganese are Final Chronic Tier II Values from Michigan Department of Environmental Quality. Barium, beryllium, and manganese are hardness-based standards and are derived using the equations from Michigan's Rule 57 Water Quality Values http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html).*"

As noted in Comment No.11, barium is not expected to pose a risk in surface waters. It is a naturally elevated metal with low solubility, low bioavailability and low toxicity. Likewise, beryllium concentrations were very low and inclusion as a risk potential which needs to be mitigated is not consistent with the Site–specific evidence that concentrations are low, detection limits were above the TRV, and beryllium is not significantly different at locations downstream of the Site than those found at background locations.

Response: The RADD is meant to protect human health and the environment from existing or **potential** contamination. Changes have been made in the Remedial Action Summary Table values for Barium, Beryllium, and Manganese.

26. Page 31, Paragraph 7 of Section 8.0. The text states: "*The TRV for sulfates is the Ecoregion Reference Stream Value for the Ouachita Mountains Ecoregion in Arkansas' Regulation No. 2 (http://www.adeq.state.ar.us/regs/files/reg02_final_071125.pdf).*"

HESI notes that the background value such as the Ecoregion Reference value is not an appropriate remedial action level for this Site. This is acknowledged by ADEQ in Section 5.1.1.2 of the RADD, which states the following regarding the selected Pit Lake remedial alternative: *"…but the current temporary standards for minerals in Chamberlain and Cove Creeks would need to be maintained or modified through the Use Attainability Analysis (UAA) process, as contemplated in the Feasibility Study."*

The Ecoregion Reference value reflects a natural background concentration for an unmineralized area. Such a concentration may never be achieved at a site affected by ARD given that such drainage is produced by natural processes. A toxicity based TRV, similar to that used for other COCs, is appropriate for use as an Action Level. As indicated in the BERA (Appendix B of the SI Report), beginning on page 7-19, sulfate is the least toxic of common ions that make up total dissolved solids. The Consent Administrative Order (CAO) value for Cove Creek downstream of Chamberlain Creek is 860 mg/l. The value of 860 mg/l was also used as the screening level for sulfate in the BERA. Sufficient data are presented in the BERA to indicate sulfate concentrations higher than the value of 860 mg/l can cause toxicity. In fact, initial (2003) sulfate levels in the water treatment system discharge were on the order of 1,400 to 1,500 mg/l and these levels were shown to be non-toxic to water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*).

Response: ADEQ acknowledges that the Site is situated in a mineralized mining district but does not agree that ecoregion reference values are inappropriate for the Site. Section 5.1.1.2 describes one of the proposed remedies in Section 5.0 which is "Summary of Remedial Alternatives". Section 10, "Selected Remedy/Site Plan " describes the individual remedies chosen for the RADD.

27. Page 32, Section 8.1. Regarding barium and beryllium, please see Comment No. 25. Regarding sulfate, please see Comment No. 26.

Response: ADEQ believes that all existing and **potential** Constituents of Concern should be listed in the RADD. COCs or COC concentrations may change over time and it is the intention of this RADD to have the flexibility to manage changes at the Site or changes in the regulations over time. Changes have been made in the Remedial Action Summary Table values for Barium, Beryllium, and Manganese.

28. Page 33, Section 10. The text states: "*The overall remedy selected for this RADD is confined to existing technologies and does not address an end to remedial activities. It is an objective of this RADD to promote future technologies and methodologies that will eventually allow the Site to be useful. A periodic report will be submitted to ADEQ detailing the research efforts of the responsible party toward a complete mitigation of the Magcobar Site.*"

HESI notes that the completion of remedial activities at the Site (with the exception of any ongoing operation and maintenance activities) will be triggered by achievement of the Remedial Action Levels, as set forth in the RADD. The RADD is issued pursuant to the Arkansas Remedial Action Trust Fund (RATFA) which authorizes ADEQ to conduct or order remedial action, as necessary, "*to investigate, control, prevent, abate, treat, or contain any releases or threatened releases of hazardous substances*" from a site. A.C.A. §8-7-508(a)(1). The term "remedial action" is defined by RATFA as action "*necessary to affect permanent control, abatement, prevention, treatment, or containment of releases and threatened releases….*" A.C.A. §8-7-503 (10). Nowhere in the statute is ADEQ authorized to require responsible parties to "*promote future technologies and methodologies*" to allow a site to become "*useful*." Moreover, ADEQ does not have the authority to require responsible parties to conduct research designed to identify a "*complete mitigation*" of impacts at a site.

For the above reasons, HESI recommends deletion of the referenced language from the RADD.

Response: It is an objective of the Arkansas Department of Environmental Quality to end the threat to the environment posed by conditions at the Magcobar

Mine Site and the Department believes that all involved parties are interested in attaining this objective. ADEQ has modified the text in Section 10 and 11 to specify periodic reviews to evaluate the effectiveness of the chosen remedial action and consider pertinent, feasible remedial alternatives that may arise in the future.

29. Page 34, Section 10.2.1. The text states: "*Regrade, Stabilize Dams, and Revegetate (TI1) – This alternative will reduce acid drainage from the tailings and ensure that the tailings slopes are stable <u>and contact with precipitation is prevented</u>*" (emphasis added).

HESI notes that Alternative TI1 consists only of regrading, slope stabilization of the dams, and revegetation. The tailings will still be subject to contact with precipitation, but the regraded tailings surfaces will not allow water to accumulate as it currently does. Therefore, HESI recommends that the underlined text in the above excerpt be deleted from the RADD.

Response: These changes have been made to the document.

30. Page 35, Paragraph 2 of Section 11.1. The text states: *"It has been proposed that a Pit Lake surface elevation of five hundred ninety-five (595) feet will eliminate seepage through the base of the adjacent spoil piles and provide approximately ten (10) feet of freeboard in the event of an upset of the WTS. The elevation of the surface of the Pit Lake shall be measured and tracked relative to the currently proposed target elevation of 595 feet. The amount of water withdrawn from the Pit Lake shall be adjusted in order to maintain the currently proposed target elevation, or any revised target elevation which may be proposed in the future."*

As noted in Comment No. 18, elevations slightly higher and lower than 595 feet will be equally effective at eliminating seepage through the base of the adjacent spoil piles. Therefore, HESI recommends that this paragraph be rewritten, as follows:

"The FS Report indicates that a Pit Lake surface elevation of five hundred ninety-five (595) feet will eliminate seepage through the base of the adjacent spoil piles and provide approximately ten (10) feet of freeboard in the event of an upset of the WTS. The elevation of the surface of the Pit Lake shall be measured and tracked relative to a target elevation goal of 595 feet while recognizing that the Pit Lake surface can vary by as much as three to four feet above this elevation goal while maintaining an effective and acceptable freeboard. The amount of water withdrawn from the Pit Lake shall be adjusted in order to maintain the Pit Lake elevation in the 595 to 599 foot range, or any revised target elevation which may be agreed to by the responsible party and ADEQ in the future."

Response: The text has been changed to "…a Pit Lake surface elevation of

approximately five hundred ninety-five (595) feet. The last sentence will be changed to read: "…or any revised target elevation proposed and agreed upon in the future by ADEQ and the responsible parties".

31. Page 36, Section 11.1.1. The text states: "*Quarterly sampling will also occur but not be limited to the locations of: <u>Reyburn Creek</u> upstream of Clearwater Lake;* <u>East Reyburn Creek</u> *downstream of Temporary Holding Pond when/if overflow occurs; Stone Quarry <u>Creek</u> downstream of the drainages from the tailings ponds and Chamberlain Creek downstream of the French drain that is being constructed to intercept shallow groundwater*" (emphasis added).

The reference to "*Reyburn Creek*" should be changed to "*Scull Creek*' and the reference to "*East Reyburn Creek*" should be changed to "*East Rusher Creek*." It should be noted that the Temporary Holding Pond has not yet been constructed and is a feature that will be addressed in the design for the final remedy.

Response: These changes have been made to the document.

Page 37, Section 11.2.2. The text states: "*It shall be demonstrated that all surrounding residences underlain by shallow or deep groundwater potentially impacted by the site are connected to the public water supply. This will include, at a minimum, the methods used to identify all surrounding residents and the locations of all surrounding residents relative to the down gradient extent of impacted groundwater. <u>This requires that the groundwater flow direction and the down gradient extent of impacted groundwater have been adequately delineated through the use of properly designed and constructed monitoring wells"</u>* (emphasis added).

HESI notes that the SI Report clearly establishes that the extent of bedrock groundwater affected by the Pit Lake is restricted to the interior of the Chamberlain Creek syncline (see, for example, Section 2.2.3.1 of the SI Report). As noted in the RADD at Section 2.1.3, "*groundwater flows to the southwest along the axis of the Chamberlain Creek syncline*" and at Section 5.1.4, "*groundwater within the syncline flows primarily through the Stanley Formation from Pit Lake to the southwest, along the plunge of the syncline.*" HESI agrees with these characterizations and, thus, the flow direction in the bedrock groundwater system affected by the Pit Lake is known. It is understood that the down gradient extent of any such impacts would be limited by the igneous pluton that cross-cuts the Chamberlain Creek syncline approximately 1.5 miles west of the Pit Lake (see Figure 2-1 of the SI Report).

Based on this characterization, HESI supports the connection of existing residents within the Chamberlain Creek syncline between the Site and the igneous pluton to the existing municipal water system if they are not already connected. HESI believes that connecting residents to the municipal water system provides an appropriate level of protection of human health and further represents a more efficient use of resources when compared to the installation of costly bedrock wells for the sole purpose of identifying the extent of groundwater that may exceed aesthetics-based Secondary Drinking Water Standards. HESI therefore recommends that the underlined portion in the above excerpted text be deleted from the RADD.

Response: The specifics for this monitoring will be included in the Effectiveness Monitoring Plan. ADEQ is concerned that dissolved solids, in particular sulfates are entering the bedrock aquifer from Pit Lake. The extent of this contamination is not known and down gradient monitoring wells would delineate the contaminant plume. ADEQ does not agree that the igneous pluton "limits down gradient impacts to groundwater". The pluton redirects or deflects bedrock groundwater flow, the water must go somewhere when it hits the pluton. No change has been made to the document.

33. Page 37, Section 11.3. The text states: "*If it is determined that the curtain wall system is not a feasible containment for the generated sludge, then* <u>*alternative sludge containment systems*</u> *shall be evaluated and addressed in the final remedial design*" (emphasis added).

HESI recommends that the underlined text in the above excerpt be modified to "*feasible alternative on-site sludge containment systems.*"

Response: This change has been made to the document.

34. Figure 1. Please see Comment No. 2. HESI agrees with this depiction of the Site boundary which excludes the operating Duratone Plant.

Response: ADEQ recognizes that the Duratone Plant is not part of the Site. No change has been made to the document.

Written Comments from Robert J. Balhorn

1. **Purpose –** These comments are intended for the use of the Arkansas Department of Environmental Quality (ADEQ) in determining the best course of action to remediate the contaminated water contained in the Magcobar Mine site located at Magnet Cove, AR. Global Resources Development, LLC (GRD) is prepared to demonstrate that the contaminates (sic) can be neutralized so as to enhance the maintenance of the water contained within Pit Lake. The water level can be maintained with controlled releases of water with acceptable levels of contaminates (sic).

   Response: The water level of Pit Lake is already being maintained by a Water Treatment System that releases treated water as necessary.

2. **Background –** The ADEQ Remedial Action Decision Document presents the situation very well and contains valuable information that can be used in determining the best course of action. As presented at the hearing, I understand that the present process of treating the water in settlement ponds and providing controlled releases of treated water will continue until a better process is discovered. GRD is the sole representative of Solar Sonic Laboratories International which has developed a process using satellite and solar technology capable of manipulating the atomic structure of dissolved state particles in water into a non-soluble form. The particles will then drop to the bottom of the lake or pond. The water which is then at an acceptable quality can be drained to maintain an acceptable depth.

   Response: The current water treatment process includes neutralizing pH in a water treatment plant with lime and soda ash, releasing it into holding ponds before release into Chamberlain Creek. There are no settling ponds involved in the treatment.

   ADEQ is interested in proven technology. Documentation of successful remediation activities or a successful pilot study would be necessary for an alternative to be considered. Any pilot studies would have to be negotiated with the party responsible for the clean up, not ADEQ. The ADEQ would evaluate results of such studies before considering any new technology.

3. **Proposal –** GRD is prepared to negotiate a contract with the ADEQ or it's designated contractor or the owners of the Magcobar Mine site to neutralize the contaminates (sic) to a condition acceptable to ADEQ. In addition to neutralizing the water, GRD will entertain the possibility of neutralizing the spoil piles to limit the recontamination of the lake and surrounding watershed. Further analysis of the soil (sic) piles and tailings may be necessary. Treatments can be tailored to the various contaminates (sic).

   Response: At this site, the Responsible Parties would be responsible for negotiating a contract, not ADEQ.

   The alternative chosen for the spoil piles is selective and sequential regrading with as little disruption to the overlying vegetation as possible. Details of the SSLI process would have to be forthcoming to explain how the vegetative cover on spoil piles would be maintained while acres of spoil were being neutralized.

4. **Conclusion –** GRD will meet with you and/or your contractors and/or the owners of the Magcobar Mine site to discuss the possibilities of using the SSLI processes to clean the site. Contract provisions may also be considered at any time.

   Response: ADEQ appreciates your interest in the Magcobar Mine Site Remedial Action Decision Document process. The Responsible Party would be responsible for deciding any alternative technologies they wanted to pursue.

Written Comments from Poseidon Energy Services

Mr. Rhodes,

I write to comment on the Draft Remedial Action Decision Document (RADD). In reviewing the draft RADD, you note that the cost of Spoil Pile Alternatives 7.1.2 "extensive regrading amendment soil cover and revegetation " has an estimated cost of over $276 million while you classify the "removal and disposal of the spoil piles in the drained pit lake" as "high" in cost and "unknown" in its protectiveness of human health. Is the aforementioned estimated cost higher than the stated cost of SP3? How is SP4 not protective of human health?

Response: Paragraph 1, 2nd Sentence - The RADD does not use dollar amounts to describe costs, the figure $276 million for Alternative SP3 comes from the Feasibility Study.

Paragraph 1, 3rd Sentence – No cost is stated for Alternative SP4 but it would require the inclusion of draining Pit Lake and the cost would be high, but total cost has not been calculated since draining the pit is not being considered.

Paragraph 1, 4th Sentence – At the close of pit drainage, water and sludge will remain in the pit with the exact nature of its toxicity an unknown, but it is suspected it will be harmful to human health and the environment. Based on information in the Site Investigation report, if the pit was drained and filled with the spoil, a large amount of the soil and rock would not fit into the pit because of the expanded nature of the spoil. Groundwater would begin flowing through pyritic spoil in the pit becoming acidic and dissolving metals into the groundwater causing a threat to the environment.

On the sections dealing with pit lake alternatives, was PL4 designated "not implementable" because UIC was not considered as a drain option? What were the drainage options considered? What is considered "high" as the potential cost of PL4?

Paragraph 2, 1st Sentence – Alternative PL4 was not considered implementable because it would take approximately sixty (60) years to implement and the results are unknown as ARD would become more pronounced and the water at the end of the drainage period would likely be a hazardous waste along with the sludge in the bottom of the pit.

UIC disposal was considered in the Initial Alternatives Screening Document but was rejected for a number of reasons including capacity/logistic issues. The UIC alternative considered was for wells on or near the site as a matter of logistics. Low iron concentrations are typically necessary for successful UIC injection and Pit Lake water has a high content of iron. The high sulfate content of Pit Lake water could possibly produce gypsum that would form a crust, clogging the system.

Pit Lake has an average inflow over a twenty-year period of five hundred thousand (500,000) gallons per day. If 5,000 gallon capacity trucks were used to haul water from the pit, one hundred (100) trips per day would be required to keep Pit Lake at its current elevation. A water treatment system is currently in place to maintain the water level.

Paragraph 2, 2nd Sentence – Drainage options for Pit Lake are limited because the only practical drainage is a controlled outflow to the local watershed of Chambelain Creek. This creek can receive only a limited amount of water due to its small discharge profile. The Feasibility Study explores two models for draining the pit. Both drainage models estimate around sixty (60) years to treat and drain the water from Pit Lake. No other feasible or proven drainage options are known at this point.

I suggest that you NOT eliminate PL4 or SP4 from the final RADD. The Department and the Hazardous Waste Division should propose a solution that is the best for the preservation and protection of the Natural State and then insist that the responsible parties commit to that solution. Please do not eliminate the real solutions in favor of "kicking the can down the road" to another generation. Poseidon Energy Services, LLC can drain the pit in ten years and then dispose of the spoil piles in the drained pit. While this solution would have a cost attached, it would give the local community and the citizens of our state clarity of environmental response and provide a permanent and complete solution that is most protective of our natural environment. The decision to drain the pit and dispose of the spoil piles in the drained pit would reflect very well on you, the Division and the Department charged with preserving and protecting our Natural environment. We all know that the decision to drain the pit and dispose of the spoil piles in the drained pit will have to be done at some point. This decision is the inevitable solution, please make it now.

Paragraph 3, 3rd Sentence – Draining the Pit in ten years would require ~ 1.5 million gallons per day to be moved. Trucks couldn't do this and no feasible proximal location has been determined for installation of multiple UICs.

Paragraph 3 – ADEQ and PRPs have been investigating remediation of this site for ten years and are satisfied that all viable options have been scrutinized at this time. The RADD is written to ensure that any future technologies that may benefit remediation of the site are explored and implemented if practical.

Verbal Comments from – Mr. Bob Balhorn

Thank you. My name is Bob Balhorn, I am a registered lobbyist with the state government and tonight I'm going to present to you (indistinguishable) involved with the Remedial Decision. And, uh, we want to end the permanent work on this particular issue. Uh, as everybody has seen (indistinguishable) this is a particularly difficult issue to resolve and, uh and at this time there are no answers I can see, I've studied the, uh proposal and, uh and I have to agree with the staff, there is no (indistinguishable) solution at this point. We'd like to be a part of that though and uh, part of the interim solution as far as the water treatment is concerned. We have a method and uh, of purifying that water, dropping out all of the metals and minerals so that you have a pH of seven, I believe is the number that is (indistinguishable). And uh, we can do that so that uh, that, uh, drainage from the lake can go immediately into the creek. Uh, now as stated, the water will re-acidify in the lake. Uh, we don't know how long that will take, hopefully a number of years so that you don't have to keep treating it every year. But, uh, our method will do that and uh, I'll be happy to discuss it uh, (indistinguishable) proposal for the department and for the contractors involved uh, in the water treatment system and I thank you for the opportunity to make this (indistinguishable).

Response: The Arkansas Department of Environmental Quality (ADEQ) has the mission of protecting human health and the environment for all Arkansans. To that end, ADEQ only permits proven technologies to be used in remediation activities at contaminated sites. The ADEQ however, is always open to new ideas provided proper testing and pilot projects have been completed.

Verbal Comments from – Ms. Shirley Frazier

My comment will be very brief. Frankly, I don't know a great deal about the scientific however to this or how they plan to implore it. I (indistinguishable) people who have lived here a long time have been concerned about it. I spoke to the county judge about this. I frankly hadn't thought about an earthquake at all until I talked to Bill (indistinguishable). He said he had talked about this with people from the (indistinguishable) and that made me wonder if there would be any possibility that there could be any breach up there, uh, caused by earthquakes or anything else. He wondered if there was a plan in place. What would happen to the water if it did begin to leak? Is there a plan to address that? I don't know that there is one. I don't know what we would do in that case. I just don't want it to further pollute the community. I want standards to be applied (indistinguishable) so that the water (indistinguishable). I just don't want to see the environment contaminated more than it is already. Thank you.

Response: There have been only five (5) small earthquakes within five (5) miles of the area in the last five (5) years, none strong enough to affect Pit Lake. The water in Pit Lake is **not** impounded. There are no damns that would break even if a large earthquake did hit the area. The water is confined by bedrock and there is no way for Pit Lake to discharge its water to the surface in a short time. If a large earthquake did hit the area, the only damage that could occur at Pit Lake would be large scale fracturing in the bedrock of the pit. This exigency might allow Pit Lake water to enter the bedrock groundwater system at a more rapid rate. However, data provided in the Site Investigation report indicates that the water in Pit Lake is **not** harmful to human health. If more of the Pit Lake water was to enter the environment it is not dangerous to humans but might be harmful to other smaller animals and some plants.

A large earthquake in the area might cause minor slides to occur on the spoil piles which would only be dangerous to someone on site. The most dangerous scenario posed by an earthquake is the failure of one of the tailings impoundment dams and the amounts of water involved are small, not enough to cause significant flooding downstream, but if someone was to be in front of or on top of one of these collapsing dams during an earthquake, that person might be in danger, otherwise, danger to humans due to an earthquake near the Magcobar Mine Site is minimal.

E. FUTURE ACTIONS.

Effective with this Decision, the final Remedial Action Decision Document is incorporated into and becomes a condition of the Consent Administrative Order (CAO) between XXX and ADEQ, LIS #___ as though set forth therein line for line and word for word.

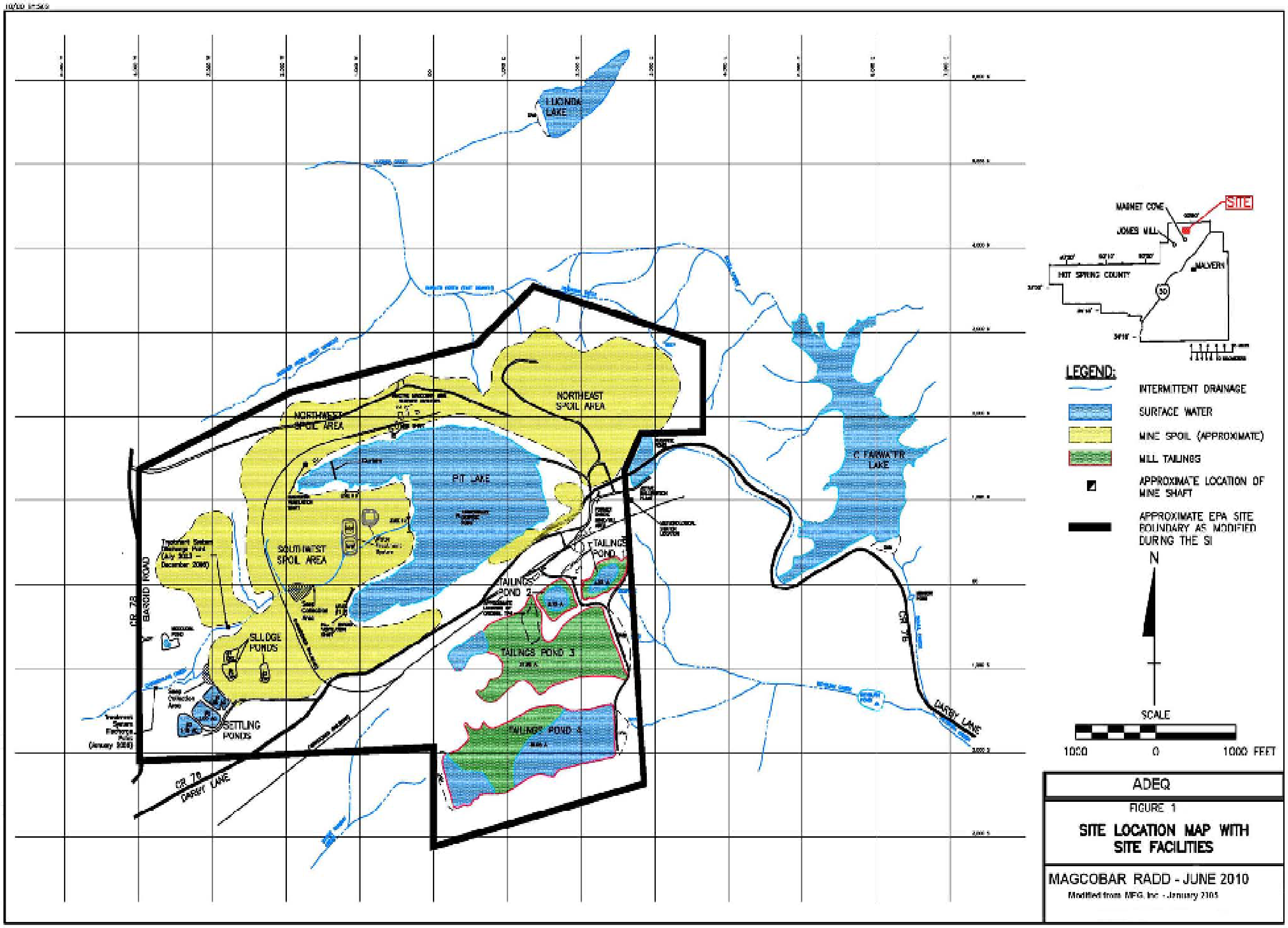
F. DECLARATIONS.

ADEQ believes that the remedy proposed in the Remedial Action Report submitted for the Magcobar Mine Site in Magnet Cove, Arkansas and as approved and set forth in this RADD is appropriate, technically feasible, reliable, and cost effective. With respect to risk management decisions made by ADEQ, these remedies are deemed acceptable, and to be protective of human health and the environment.

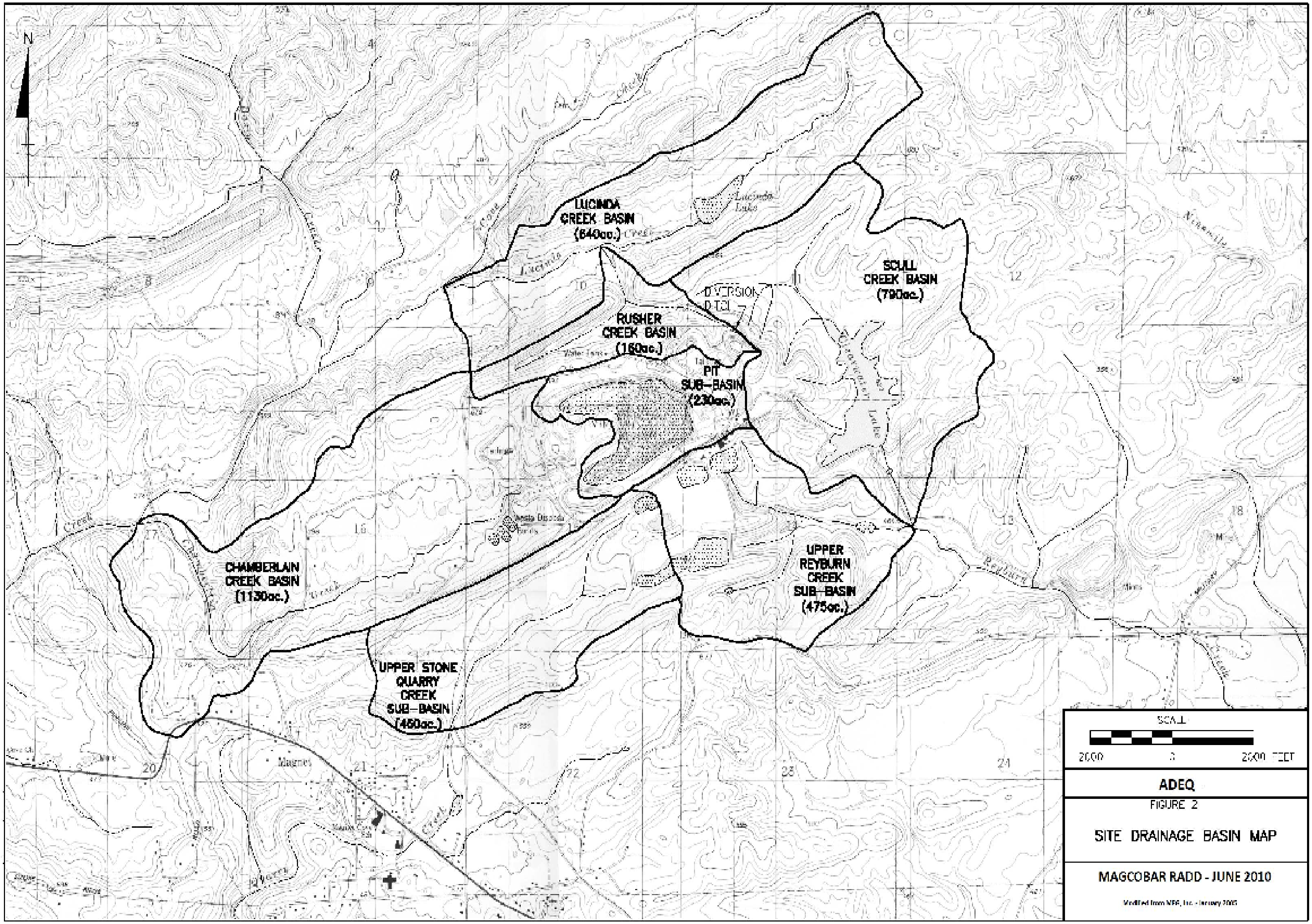
_________________________________ ____________________

Tammie J. Hynum (Date)
Chief
Hazardous Waste Division
Arkansas Department of Environmental Quality

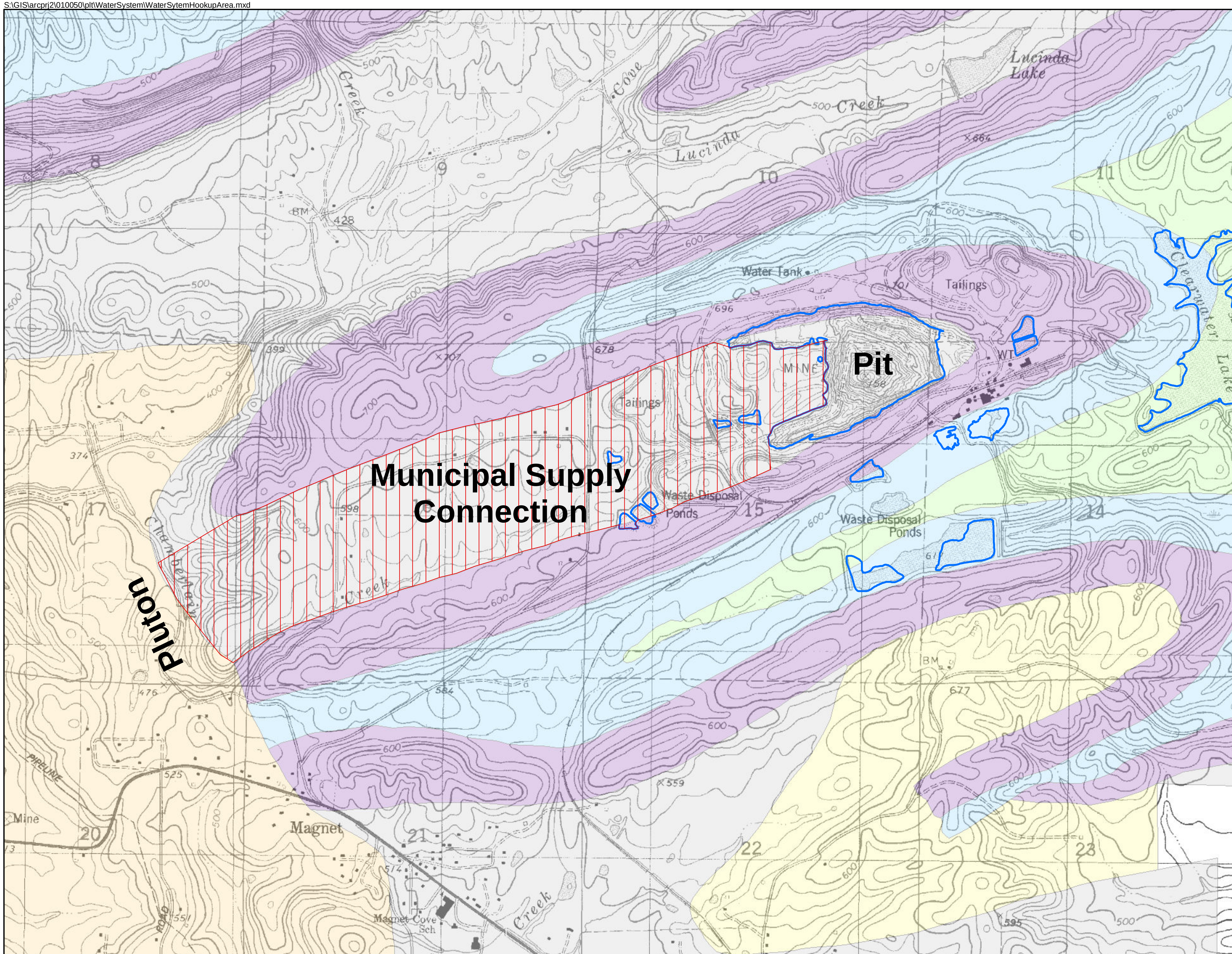
Enclosure:
Final RADD


LUCINDA LAKE
NORTHEAST SPOIL AREA
NORTHWEST SPOIL AREA
PIT LAKE
SOUTHWEST SPOIL AREA
SLUDGE PONDS
SETTLING PONDS
TAILINGS POND 1
TAILINGS POND 2
TAILINGS POND 3
TAILINGS POND 4
CLEARWATER LAKE
CR 78
BASOID ROAD
CR 79
DARBY LANE
CR 76
MAGNET COVE
JONES MILL
SITE
MALVERN
HOT SPRING COUNTY
LEGEND:
INTERMITTENT DRAINAGE
SURFACE WATER
MINE SPOIL (APPROXIMATE)
MILL TAILINGS
APPROXIMATE LOCATION OF MINE SHAFT
APPROXIMATE EPA SITE BOUNDARY AS MODIFIED DURING THE SI
N
SCALE
1000 0 1000 FEET
ADEQ
FIGURE 1
SITE LOCATION MAP WITH SITE FACILITIES
MAGCOBAR RADD - JUNE 2010
Modified from MFG, Inc. - January 2005

603379666.5


N
LUCINDA CREEK BASIN (640ac.)
SCULL CREEK BASIN (790ac.)
DIVERSION DITCH
RUSHER CREEK BASIN (160ac.)
PIT SUB-BASIN (230ac.)
CHAMBERLAIN CREEK BASIN (1130ac.)
UPPER REYBURN CREEK SUB-BASIN (475ac.)
UPPER STONE QUARRY CREEK SUB-BASIN (460ac.)
SCALE
2000 0 2000 FEET
ADEQ
FIGURE 2
SITE DRAINAGE BASIN MAP
MAGCOBAR RADD - JUNE 2010
Modified from NEA, Inc. - January 2005

S:\GIS\arcprj2\010050\plt\WaterSystem\WaterSytemHookupArea.mxd



Legend

- Tt - TERTIARY TERRACE GRAVEL
- Ki - IGNEOUS INTRUSIVE ROCKS
- Ms - STANLEY FORMATION
- MDa - ARKANSAS NOVACULITE
- OSu - UNDIFFERENTIATED, INCLUDES MISSOURI MOUNTAIN SHALE, BLAYLOCK SANDSTONE AND POLK CREEK SHALE
- Ob - BIGFORK CHERT
- Municipal Supply Connection Area
- Ponds

All geologic contacts are approximately located based on: Scull (1958)

Scull, B.J., 1958. Origin and Occurrence of Barite in Arkansas. Arkansas Geological and Conservation Commission, Information Circular 18. Little Rock, AR. 101pp.

0 1,500 3,000
Feet

N

HALLIBURTON ENERGY SERVICES, INC.

DRESSER INDUSTRIES - MAGCOBAR MINE SITE

FIGURE 3

MUNICIPAL WATER SYSTEM MAP DEPICTING AREA TO SUPPLY HOOK-UP TO RESIDENCES

DATE: JUN, 20, 2011		FORMATION ENVIRONMENTAL
BY: CRL	FOR: BGH	

Table 1
KEY STATISTICS FOR SITE FACILITIES
DRESSER INDUSTRIES - MAGCOBAR MINE SITE INVESTIGATION REPORT

Facility	Year Constructed	Area (acres)	Depth (feet)	Estimated Volumes Solids (cubic yards)	Estimated Volumes Water (gallons)	Notes
Mine Pit	1939 - 1969	90	455 - 525	Contains some sediment and sludge	4.35 billion (October 2002)	Total pit volume = approx. 23.4 to 23.9 million cy.
Spoil Piles						
Southwest Area	1939 - about 1947	≈ 130	120 max.	*	—	* Combined spoil volume is estimated to be approximately 20.5 million cy.
Northwest Area	1939? - 1973	< 10	40 max.	*	—	
Northeast Area	1947 - 1977	≈ 45	100 max.	*	—	
Low-Grade Ore Pile	post 1947	≈ 4	20 max.	75,000	—	
Tailings Impoundments						
Tailings Pond No.1	1941-42	4.3	25 max.	7,000	14 million	Impoundment tailings reprocessed in about 1979-80.
Tailings Pond No.2	1941-42	3.7	20 max.?	100,000	2.4 million	Impoundment tailings partially reprocessed in about 1979-80.
Tailings Pond No.3	About 1945	32.0	70 max.	2.0 million	1.4 million	Last used in 1960.
Tailings Pond No.4	About 1960	39.0	50 max.	1.8 million	33 million	Only partially filled with tailings.
Settling Ponds						
Settling Pond No.1	About 1972	1.55	10-20	12,100	2.4 million	Ponds have 1 to 5 foot thick clay liner.
Settling Pond No.2	About 1972	2.00	10-20	11,600	3.9 million	
Settling Pond No.3	1975 - 76	1.10	10-20	7,100	2.2 million	
Sludge Ponds	1970s	<2 comb.	<3			
Sludge Pond No.1		—	—	1,400 minmum	nil	
Sludge Pond No.2		—	—	1,500 minmum	nil	
Sludge Pond No.3		—	—	1,100 minmum	nil	
Underground Mines	Magcobar 1947 - 1973	na	na	na	10 - 20 million	One main shaft and two ventilation shafts (one in pit).
	Baroid 1961 - 1977	na	na	na	5 - 10 million	Three levels w/ portals at 350', 200' and about 160' AMSL.
Lakes						
Clearwater Lake	Beginning ~ 1941-42	62	20 - 25 max.	—	200 million	Process water supply; dam raised to 516.0 feet-AMSL in 1949, current crest elevation is approximately 528 feet-AMSL.
Lucinda Lake	1956	8	abt. 10 max.	—	2.6 million	Built for stormwater control; used later for process water supply.

Table 7.1 Remedial Alternatives
Area-Specific within Pit Lake/Chamberlain Creek Watershed

Pit Lake Alternatives 7.1.1					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (PL1)	Unacceptable	Not Effective	Not Effective	NA	None
Operate Existing WTS and Maintain Pit Level (PL2)	Acceptable	Effective	Effective	Implementable	$6,905,234
Operate Existing WTS and Maintain Pit Level (PL2-modified)	Acceptable	Effective	Effective	Implementable	$6,905,234
In-Situ Neutralization and Maintain Pit Level (PL3)	Unknown	Unknown	Unknown	Implementable	$4,793,762
Operate Existing WTS and Drain Pit (PL4)	Unknown	Not Effective	Effective	Questionable	High

Spoil Piles Alternatives 7.1.2					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (SP1)	Unacceptable	Not Effective	Not Effective	NA	None
Selective Regrading, Augment Vegetation (SP2)	Acceptable	Moderately Effective	Effective	Implementable	$5,891,017
Extensive Regrading, Amendment, Soil Cover, Revegetation (SP3)	Acceptable	Low Effectiveness	Effective	Implementable	$276,973,436
Remove and Dispose in Drained Pit Lake (SP4)	Unknown	Not Effective	Effective	Questionable	High

Table 7.1 Remedial Alternatives
Area-Specific within Pit Lake/Chamberlain Creek Watershed
Continued

Shallow Groundwater Alternatives 7.1.3					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (SGW1)	Unacceptable	Not Effective	Not Effective	NA	None
Operate Existing Capture/Treatment Systems (SGW2)	Unacceptable	Low Effectiveness	Low Effectiveness	Implementable	Low
Expanded Capture/Treatment System (SGW3)	Acceptable	Effective	Effective	Implementable	$711,229

Bedrock Groundwater Alternatives 7.1.4					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (BGW1)	Unacceptable	Not Effective	Not Effective	NA	None
Verify Connection to Municipal System (BGW2)	Acceptable	Effective	Effective	Implementable	$201,163
Drain and Backfill Mine Pit (BGW3)	Unacceptable	Not Effective	Not Effective	Difficult	High

Sludge Ponds Alternatives 7.1.5					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (SLU1)	Unacceptable	Not Effective	Not Effective	NA	None
Soil Cover and Revegetate (SLU2)	Acceptable	Effective	Effective	Implementable	$644,405
Removal With On-Site Disposal (SLU3)	Acceptable	Moderately Effective	Effective	Not Implementable	Moderate
Removal With Off-Site Disposal (SLU4)	Acceptable	Effective	Effective	Questionable	High

Table 7.1 Remedial Alternatives
Area-Specific within Pit Lake/Chamberlain Creek Watershed
Continued

Chamberlain Creek Alternatives 7.1.6					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (CHM1)	Unacceptable	Not Effective	Not Effective	NA	None
Source Control (CHM2)	Acceptable	Effective	Effective	Implementable	NA
Source Control and Sediment Removal (CHM3)	Unacceptable	Not Effective	Effective	Implementable	High

* Dollar amounts in this column represent a total of capital, operation & maintenance, and periodic costs. A detailed cost analysis of alternatives is available in the FS.

Table 7.2 Remedial Alternatives
Area-Specific Outside Pit Lake/Chamberlain Creek Watershed

Tailings Impoundments Alternatives 7.2.1					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (TI1)	Unacceptable	Not Effective	Not Effective	NA	None
Regrade, Stabilize Dams, and Revegetate (TI2)	Acceptable	Effective	Effective	Implementable	$4,052,003
Remove and Dispose in Drained Pit Lake (TI3)	Unknown	Not Effective	Effective	Questionable	High
Affected Streams Alternatives 7.2.2					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (AS1)	Unacceptable	Not Effective	Not Effective	NA	None
Source Control (AS2)	Acceptable	Effective	Effective	Implementable	NA
Source Control and Sediment Removal (AS3)	Unacceptable	Not Effective	Effective	Implementable	High
Clearwater Lake Alternatives 7.2.3					
Remedy Alternatives	**Protection of Human Health and the Environment**	**Short Term Effectiveness**	**Long Term Effectiveness**	**Implementability**	**Cost ***
No Action (CWL1)	Unacceptable	Not Effective	Not Effective	NA	None
Source Control (CWL2)	Acceptable	Effective	Effective	Implementable	NA
Source Control and Sediment Removal (CWL3)	Unacceptable	Not Effective	Effective	Difficult	High

* Dollar amounts in this column represent total capital, operations & maintenance, and periodic costs. A detailed cost analysis of alternatives is available in the FS.

Table 10 Implementation Schedule*

Schedule	Activity
Within 3 months of CAO effective date	Verification report for connection status of residents submitted to ADEQ.
Within 9 months of CAO effective date	Draft remedial design for sludge ponds submitted to ADEQ for review and approval.
Within 12 months of CAO effective date	Identified, unconnected residents connected to public water system if authorization is given.
Within 13 months of CAO effective date	Final remedial design for sludge ponds submitted to ADEQ.
Within 18 months of CAO effective date	Remediation of sludge ponds completed.
Within 2 months of EIP approval	Draft EMP submitted to ADEQ for review and approval.
Within 4 months of receipt of ADEQ comments on draft EMP	Final EMP submitted to ADEQ.
Within 6 months of ADEQ approval of final EMP	Draft RDP submitted to ADEQ for review and approval.
Within 4 months of receipt of ADEQ comments on draft RDP	Final RDP submitted to ADEQ.
Within 6 months of ADEQ approval of final RDP	Draft RAIWP submitted to ADEQ for review and approval.
Within 6 months of receipt of ADEQ comments on draft RAIWP	Final RAIWP submitted to ADEQ.
Within 48 months of ADEQ approval of final RAIWP	Remediation construction activities completed.
Within 160 months of EIP approval**	Post-project water quality standards become effective.

*This schedule is tentative and is dependent on the effective date of the CAO or EIP (as noted). The schedule is contingent on construction occurring during the summer months. The schedule also assumes that ADEQ comments will be received within 2 months of each submittal.

**Basis for the total time frame is included in the EIP NOI.